PN-ACN-366

EARTHQUAKE HISTORY SEISMICITY and TECTONICS of the REGIONS OF AFGHANISTAN

Seismological Center
Faculty of Engineering
Kabul University

November 1970

Printed by USAID/A Communications Media

EARTHQUAKE HISTORY

SEISMICITY

TECTONICS

Afghanistan

Earthquake Damage in Rustak - 1969

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EARTHQUAKE HISTORY SEISMICITY and TECTONICS of the REGIONS OF AFGHANISTAN

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ACKNOWLEDGEMENTS

This report has been made possible through the support of the United States AID Mission to Afghanistan and the cooperation of the United States Engineering Team; the authors gratefully acknowledge this assistance.

Throughout the past two years many individuals, groups and organizations have contributed, directly or indirectly, to the production of this report and to its contents. In particular, the authors extend their appreciation to:

- Dr. Edwin L. Martin, Chief of the Education Division, USAID/Kabul, for his continued interest and support;

- Dr. A.G. Qaissaunee, Dean of the Faculty of Engineering, for his encouragement and assistance;

- the United States Coast and Geodetic Survey and Mr. James N. Jordan, Chief of the Seismology Division, for supplying the computerized printout of the regional USC&GS hypocentral data and for forwarding, on request, copies of many scientific papers related to the subject;

- Dr. Paul Bernard, Director of the Délégation Archéologique Francaise en Afghanistan, for his informative discussions and for his permission to publish the material on Aikhanum which appears in Figs. 7, 8 and 9 of the report;

- the British Embassy in Kabul for granting access to the Residency Library wherein the bulk of the 19th century earthquake data was found, and, in particular, for permitting the rare lithographs illustrating the 1842 earthquake damage in Jalalabad (Figs. 10 to 13) to be photographed; and, to Mr. Jeffrey James, Oriental Secretary, for his helpful assistance;

- the Kabul Public Library for permission to search the files of all past newspapers;

- Dr. Klaus Krumsiek of the Geological Institute of Bonn University, for providing many scientific references related to the geology of Afghanistan and for the original copy of the Geological Map of Afghanistan used for Fig. 2 of the report;

- Mr. Abdul Rahim Karrokhi, Research Assistant, Seismological Center, who faithfully researched over 100 years of newspapers at the Kabul Public Library and assisted greatly in many phases of the data reduction and in the preparation of the figures;

- Mr. Abdul Karim Karrokhi, freshman student in the Faculty of Agriculture, for his excellent work in plotting and drawing the seismicity maps;

- Mr. Fred Tangco and his staff of the USAID/A Communications Media, for printing the report;

- Mrs. J.M. Heuckroth for her many contributions which included typing both the original and final manuscripts, assisting in the data reduction and in the preparation of the figures, and collating the report; and,

- the Kabul University for providing the funds to cover the cost of reducing the large-scale maps at the Cartographic Institute.

The initial phases of the research were supported by the Kabul University Research Foundation.

ABSTRACT

A detailed and documented research into the earthquake history of the regions of Afghanistan has been made. The investigation is concerned with both non-instrumental intensity reports and recorded instrumental data. The history is presented by a chronological catalogue of nearly 500 earthquake intensity reports spanning the past 2,000 years, and also by chronological listings of nearly 2,000 recorded earthquake events during the past 70 plus, years. Where possible, correlation between the instrumental and non-instrumental data is given.

Based on the instrumental history, seismicity maps for the broad region, defined by 27° to 40°N and 58° to 76°E, for the time period 1893 to 1969, have been drawn and are presented. A detailed seismicity analysis of the northeastern sector of the broad region has been undertaken, and by a series of depth-restricted seismicity maps, the well-known source of intermediate-depth Hindu Kush earthquakes is revealed with exceptional clarity. Also, based on the non-instrumental data, an intensity zone map has been constructed and is presented.

Appropriate information on the latest concepts of global and continental tectonics is included for the purpose of acquiring a better insight into the regional tectonic mechanisms. Maps of the regional fault systems are presented and a number of postulations are submitted in an attempt to relate the observed regional tectonic patterns to the global and continental systems. Some information on the geology and geography of the country is also presented.

A seismo-tectonic analysis has been made and the first seismo-tectonic map for Afghanistan is included with the report.

By the synthesis of all the information presented in the report, a preliminary seismic risk map for Afghanistan has been drawn. The format adopted is such that the map will provide the basis for the future establishment and adoption of earthquake-resistant building codes tailored to the needs of Afghanistan.

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NOTE: Enlarged copies of FIGS. 1 & 35 are included in back cover pocket.

1. INTRODUCTION

Throughout recorded history there are innumerable entries relating man's struggle for existence against his natural enemies of pestilence, famine and earthquakes. To control and prevent the occurrence of these natural tragedies has been one of the goals of man ever since he was able to overcome his superstitious inhibitions. The massive accumulation of knowledge through the 19th and 20th centuries has provided man with the ability to reduce and even eliminate many of these hazards. Certainly, for the present at least, man's endeavors to eradicate pestilence and famine have been partially successful, but the losses resulting from earthquakes remain as real today as at the time of the Greek Empire. The recent Peruvian Earthquake of May 31, 1970, in which 50,000 people lost their lives, is a clear manifestation that modern science has yet to come to grips with the problem of controlling and preventing earthquakes.

Owing to the incompleteness and inaccuracies of historical records, it is quite impossible to account for the losses in life and property which have been inflicted by earthquakes. The data compiled during the 20th century does however provide a small sampling (in terms of time) of earthquake effects. According to J.H. Hodgson[1], during the second quarter of this century, a total of 350,000 people were killed and property damage amounted to 10 billion dollars. Quoted on an annual basis these statistics yield a yearly loss of life of 14,000 people and yearly property damage in the order of 400 million dollars. Although these numbers are reasonably representative it is quite possible they are conservative. Statistics for the first quarter of the century, although less complete, show that in five major earthquakes alone nearly 500,000 people were killed. During the third quarter of this century, despite the impressive and unequalled advancements in the sciences, earthquake losses continue unabated. Within the last ten years the earthquakes in Morocco, Yugoslavia, Iran, Turkey and Peru have claimed nearly 100,000 lives.

It is the wishful hope of many seismologists that it will be possible, in the future, to predict, control and even prevent the occurrence of earthquakes. This aspiration, although it has some support in view of the recent improvements in the understanding of earthquake mechanisms and earthquake detection instrumentation, is still very premature. Through the careful studies of past earthquake activity it is now possible to make crude predictions about the reoccurrence of earthquakes in a given region. The quality of such predictions however is extremely broad in time and has little practical significance if the prediction is to be used with the idea of alerting a community to an imminent earthquake disaster. The more ambitious approach to reducing earthquake losses, that is, by controlling and/or preventing earthquakes, is unlikely to be successfully achieved within this century, if at all. As expressed by the eminent seismologist C.F. Richter[2], the goal of eventually preventing earthquakes with the present state of information and techniques "is about as remote as Alpha Centauri."

Regardless of the present inability of science to deal directly with the causes of earthquake disasters, effective measures can and are being adopted to reduce the losses. These measures involve a complete seismic investigation of a given region utilizing all historical information available and acquiring all instrumental data produced by seismographic observatories which pertain to the region. When possible such an investigation should also include information about the geological and tectonic characteristics of the region. By proper interpretation of such data, the region can be delineated into zones reflecting various levels of probable seismic risks. With the seismic zones established it is then possible to formulate realistic earthquake building codes which incorporate additional structural requirements tailored to meet the possible dynamical forces which can result from the expected level of seismic activity. An optimum earthquake-resistant design is not, however, one which renders a building free from damage during an earthquake, but rather safe from collapse. A damage-proof building would entail prohibitive increases in construction costs. The primary objective of an earthquake building code is to prevent building collapses through minimal increases in construction expenditures and thereby avoid the great losses in life. It is well known from the past that in most major earthquakes the greatest loss of life has resulted from the collapse of buildings.

The value of knowing the seismic risks of a given area and tailoring building construction to meet these risks can be demonstrated by comparing the effects of the Iranian Earthquake[3] of August 31, 1968 and the Alaskan Earthquake[4] of March 27, 1964. Both earthquakes were shallow and extensive fractures were observed in each case; the Alaskan Earthquake however was vastly greater being assigned a magnitude of 8.4 on the Richter Scale as compared with 7.3 for the Iranian Earthquake. If this difference in magnitude is converted into terms of energy released, the Alaskan Earthquake would be rated as nearly 100 times greater than the Iranian Earthquake. Casualty figures, despite similar population densities, show that the Alaskan Earthquake caused only 9 deaths (115 were killed later by a seismic sea wave) whereas the Iranian Earthquake claimed a staggering toll of 12,000 people. Clearly, the loss of life is unrelated to the energy released, but the explanation to this apparent anomoly is straightforward. The seismic nature of Alaska was well understood and most of the buildings had been erected along sound earthquake engineering principles. Although extensive property damage occurred, complete building failures were rare. In contrast, the level of seismic activity in the affected northeastern regions of Iran was almost unknown and accordingly no precautions were exercised in the building construction. The majority of the homes were mud-walled structures topped with massive domes made from interlocking mud bricks. This type of indigenous structure is highly susceptible to collapse during an earthquake and this accounted for the large number of fatalities.

The comparison of the Alaskan and Iranian Earthquake disasters is an excellent example of what man, with his present level of technology, can do to reduce earthquake losses. The Iranian incident is not an isolated event; there are still many places in the world where the earthquake risks are high, but poorly defined, and accordingly, no regard is given to the construction of buildings. Many of these uninvestigated seismically active zones fall within the regions of developing countries and understandably these countries have, in the past, lacked the needed resources to provide for the installation of seismological instrumentation and the training of qualified personnel. As these countries begin to emerge with the associated expansion in population, homes, industry and power and irrigation projects, it is essential that seismic investigations be initiated and earthquake-resistant building codes established.

Afghanistan is one of the countries of the world where development is rapidly taking place but within a region which is known to be seismically active. To date the level of activity has not been systematically investigated. In view of the Iranian disaster which bordered the regions of Afghanistan, it is clear that investigations into the earthquake hazards within Afghanistan are essential.

The need for seismic investigations pertaining to Afghanistan has been apparent for many years. No concentrated effort however was forthcoming to meet this requirement until the establishment of the Kabul University Seismological Observatory in 1968 through the joint efforts of the Royal Government of Afghanistan, the United States Agency for International Development and the United States Coast and Geodetic Survey. In conjunction with the Observatory, the Seismological Center at the Faculty of Engineering, Kabul University, was created for the purpose of collecting, analysing and categorizing all earthquake information pertaining to the country as generated either by the Observatory or received from neighboring countries and international seismological organizations. Through the existence of the Seismological Center and the Kabul University Seismological Observatory the gap in seismological data for the regions of Afghanistan is being closed.

Although the Kabul Observatory has produced a large amount of seismic data during the first two years of operation, and will continue to compile further data, seismic investigations of a region must nevertheless be based also on past earthquake activity. For seismicity studies, the broader the period of observations, the more reliable will be the assignment of earthquake risks. Aware of this, the Seismological Center, during the past two years, collected all available recorded data related to earthquakes and their effects within or near to the regions of Afghanistan. This earthquake information was separated into two major categories; namely, instrumental data as recorded by existing world seismic stations, and non-instrumental data as recorded in local newspapers, books and historical papers. The latter type of information, although less precise than the instrumental data, is extremely valuable in assessing the expected effects of earthquakes for a given region. Also important, is that prior to the 20th century, seismic instrumentation did not exist and for the regions of Afghanistan, instrumental data remained sparse until after 1950. Consequently, prior to 1950 much of the known earthquake activity must be based on documented human observations and certainly, prior to 1900 the earthquake history is almost solely based on non-scientific historical documents. The categorizing of all previous earthquake data is an arduous task but when properly reduced and interpreted the information provides the groundwork and direction for all future seismological observations and investigations.

This report presents the results obtained from two years of research into the earthquake history and seismicity of Afghanistan. The information presented spans the time period from the earliest known earthquake activity (50 B.C. to 50 A.D.) up to, but not including the present year 1970. In part, the report could be considered as a catalogue or atlas of earthquakes in Afghanistan, in that extensive tables listing all instrumental data and non-instrumental reports, in chronological order, are included. The report however goes beyond this. Appropriate information and discussion on global and continental tectonic patterns, and also on the geology and tectonic aspects of the region are presented. From the listings of earthquake activity, seismicity and intensity maps have been constructed to show the distribution of earthquakes with respect to location, time and depth, and to show the zones of various levels of earthquake effects. Based on all available information, a preliminary seismic risk analysis is performed and a map showing the zones of various seismic risks is presented.

It should be clearly noted that the present study, although very complete, can only be considered as a preliminary analysis with regard to the regionalization of the country into zones of seismic risks. Continuous efforts should be made to improve the reliability of the seismic risk map and this will be possible through the inclusion of new seismological and geological information as it becomes available and by more refined zoning techniques as these are developed. The primary object of this report is to take the first step towards defining the seismically active zones in the country and thereby provide the impetus for future studies directed towards achieving the ultimate goal of establishing, realistic, earthquake-resistant building codes for Afghanistan.

2. AFGHANISTAN, AN EARTHQUAKE COUNTRY

Analysis of the seismographic records produced by the Kabul Seismological Observatory over the past two years, has clearly established that Afghanistan is a region of high seismic activity. The frequency of earthquake disturbances occurring within, or near to the borders of Afghanistan and detectable by the high-gain World-Wide Standard Seismographic System operating with a ground magnification of 400,000, is in the order of 5,000 events per year. Of this large number at least 500 would be classified as significant earthquakes; significant meaning that, the earthquake would be recorded by other seismic stations located outside of Afghanistan. Owing to the lack of a sufficient number of high-gain seismic stations in the region, it is not possible at present to make epicentral determinations for all significant earthquakes. In 1969, the National Earthquake Information Center, operated by the United States Coast and Geodetic Survey (USC&GS), using data received from contributing seismic stations around the world, was able to determine epicenters for nearly 100 of the stronger earthquakes. By comparison of these statistics with other seismic regions of the world, Afghanistan would be classified as a very active zone. If the comparison however is restricted to only regions located 100 km or more within the continental regions, Afghanistan, and in particular the northeastern section, would be rated as one of the most active continental seismic zones in the world.

The well-known world seismicity studies undertaken by Gutenberg and Richter[5] and published in 1949 gave the first broad circulation to the fact that Afghanistan occupies a portion of the broad trans-Asiastic seismic zone. This extended zone, now known as the Alpide Belt, stretches from the Azores in the Atlantic, through the northern Mediterranean areas of Europe, across Iran and Afghanistan, along the Himalayan Range into Burma, and down through the Indonesian Peninsula where it joins the Circum-Pacific Belt, the other major seismic zone of the world. From the relatively sparse instrumental data which had been collected up to 1949, Gutenberg and Richter observed the existence of a "remarkably persistent source" of earthquakes located in Afghanistan under the Hindu Kush Range at about 36.5°N and 70.5°E and at depths of about 230 kilometers. Many of the recorded Hindu Kush earthquakes were classified as large with some being rated as having destructive proportions. The identification of this source of deep earthquakes well within a continental block was considered a unique phenomenon which could not be explained by the simple source mechanisms accepted for most earthquakes. Even today, despite the collection of much more extensive and accurate seismic data, the Hindu Kush source of earthquakes is not clearly understood. Regardless of the uncertainty of the focal mechanism, it was clear to Gutenberg and Richter that the regions of Afghanistan were susceptible to frequent and strong earthquakes.

The fact that Afghanistan is a region where earthquakes occur frequently need not be based alone on the information produced by sensitive seismographs. A great many of the earthquakes are sufficiently strong to allow human observation and many of these reach destructive levels. During 1969 for example, nearly twenty earthquakes originating in Afghanistan were felt in the city of Kabul. Of this group, the earthquake which took place north of Jalalabad on May 15, near the little village of Nurgal, caused considerable damage and claimed the life of one person. This 1969 sampling is by no means unusual, and actually, as it will be shown in this report, in many previous years the level of earthquake activity greatly exceeded this level. A search through the local newspapers of the past forty years reveals numerous reports of human experiences associated with earthquake disturbances. For any local observer residing in Afghanistan, the numerous seismic sensations which are continually occurring would soon provide the conclusion that the region is a seismically active one.

Although recent seismic activity provides an insight into past activity and also what might be expected in the future, it is by no means a reliable guide. Most seismologists believe that earthquakes in a given region probably occur on a periodic basis but the cycle however may be as short or shorter than one year, or as long or longer than one millenium. Clearly then the question to be resolved, if possible, is whether or not the present level of earthquake activity in Afghanistan, as observed during the last forty years when local newspapers existed and an adequate number of world seismic stations were operative, is representative of earthquake activity in former years or even centuries? In other words, is the frequency, location and size of earthquakes as recorded or documented recently, typical of past activity in the region? Simply stated, has Afghanistan always been an earthquake country?

The answer to the above question should not be difficult for a country with the antiquity of Afghanistan. It is well known that organized civilizations occupied the regions of Afghanistan as far back as the second millenium B.C. when the region was part of ancient Aryana. Through the conquests of Alexander the Great in the 4th century B.C. the region became part of the Greek Empire and Greek influence prevailed for several centuries. Later civilizations followed in the order of the Kushans, the Scissanians, the White Huns and finally the Moslems with various successive dynasties. Although many of these civilizations attained a high cultural development, few historical records remain today. The invasion of the Mongols under Ghenghiz Khan in the 13th century left the country in complete ruin and the cultural centers of Balkh and Herat, along with their libraries and centers of learning, were completely destroyed. A century before the Mongol sweep the Ghorids had plundered and burned the famous Ghaznavid centers of Ghazni and Bust. Consequently, if any records which relate to life in Afghanistan are to be found within the country they would be of the post-Mongol era, that is, 15th century or later.

The first evidence of earthquake activity to be recorded by an inhabitant of Afghanistan was the great earthquake of July 5, 1505. The chronicler in this case was Emperor Babur, the first of the great Mughal rulers, who, throughout his lifetime had been a productive writer. In his Memoirs[6], Babur relates the great earthquake which took place while he was residing in Kabul. According to his description the epicenter was probably near Paghman as this village was totally destroyed and considerable damage occurred in Kabul. Babur also observed and described extensive surface faulting and numerous aftershocks associated with this disturbance. Although Babur's account was brief, the facts presented clearly indicate that this was a major earthquake* compared with modern day standards. Of particular importance is that this earthquake is the only known earthquake of destructive proportions to have occurred near to the city of Kabul. As will be seen later in this report the instrumental data for the past 70 years does not include any epicenter near the regions of Paghman. This is an excellent example of the need to acquire as broad a period in time for seismological observation as is possible.

Much, if not all, of the history of Afghanistan comes from sources outside of the country. In many instances the present day regions at various periods formed only a part of larger empires, the capitals of which were not subjected to such complete destruction as Herat, Balkh and Ghazni. Also, because Afghanistan occupied a section of the ancient east-west caravan trade routes, many of the early events in the country were transported either by word or written documents, to distant lands. It seems likely that the latter would be a reasonable explanation for the source of earthquake information used by Jelal'ed'din As-Soyuti, an Egyptian polygrapher, who prepared a catalogue of earthquakes for the regions of southwest Asia covering the broad time period of 628 A.D. to 1500 A.D. This 15th century Arabic manuscript was first discovered in 1842 but was only correctly translated by N.N. Ambraseys[7] in 1961. Although many of the entries pertain to regions west of Afghanistan the catalogue does include descriptions of three earthquakes within the country.

The first entry of importance to Afghanistan in As-Soyuti's catalogue, is an earthquake which took place in the year 203 A.H. in the Mohammedan Calendar (As-Soyuti listed only the Mohammedan Calendar years

*--A footnote inserted by the translators of Babur's Memoirs indicated that this was probably the earthquake felt in Agra, India on the same day.

for the event) or sometime between July 9, 818 to June 27, 819 A.D. The area affected was the historic city of Balkh. "Earthquakes shook the city for 70 days and the mosque together with one-quarter of the houses were destroyed." This is the oldest known documented earthquake in Afghanistan.

Thirty years later, 848 to 849 A.D., As-Soyuti lists an earthquake in Herat which destroyed many houses. This record of earthquake damage is extremely unique. As will be shown later, based on recorded data, the regions surrounding Herat are quite aseismic and there is no other record which indicates that Herat was ever affected seriously by an earthquake.

The third event occurred in the years of 1052 to 1053 A.D. As-Soyuti records only that a destructive earthquake hit the town of Urgun; this town is located in the middle, extreme eastern portion of the country.

Certainly As-Soyuti's listing is incomplete and although his description of the events are terse the information is nevertheless valuable. Most important is that these listings extend the recorded earthquake data for the regions of Afghanistan by nearly 700 years. In the few previous studies related to the seismic history of Afghanistan, Babur's account was considered to be the first known documented earthquake. Also important is that some of the information pertains to regions where, during recent times, earthquake activity has not been reported.

Inasmuch as the Balkh earthquake of 818-819 A.D. is the oldest documented earthquake it does not represent the oldest known earthquake activity in Afghanistan. Through collaboration with Dr. P. Bernard of the Délégation Archéologique Francaise en Afghanistan, evidence has been uncovered which indicates that the ancient Greco-Bactrian city, located near the village of Aikhanum and situated at the confluence point of the Amu Darya (Oxus) and Kokcha Rivers, sustained earthquake damage. Although excavations have been conducted for the past six years, the work to uncover this important chapter in Afghan history has really only begun. Results from the early campaigns substantiate that the city was designed and built in Greek style and that the construction was superior for that period of time. To date, sufficient evidence is lacking to identify the ancient name of the city or what role it played in the Bactrian Empire, but, through the finding of a well-preserved inscription the date of the city at its heyday has been fixed at some time in the 3rd century B.C., that is, shortly after the passage of Alexander. It appears that the city was sacked and abandoned in the 2nd century B.C. and, except for temporary settlements of nomadic tribes, the site remained uninhabited.

The important aspect for the present discussion is the state in which the ruined and decayed structures at Aikhanum were found. Inspection of the extensive information gathered by the DAFA indicated that two complexes appeared to have been destroyed by earthquakes. The first was the Palace which was built in the classic Hellenistic style of stone columns enclosing a courtyard. The columns, made from stone cylindrical sections, were all found in complete havoc; but by careful reconstitution of the component parts it was found that there seemed to be a preferred orientation for the direction of the fallen columns. Although this would have been a necessary condition for an earthquake destruction explanation, closer inspections of the columns showed that the bottom cylinder in each column had a notch chiselled into its side and this overpoweringly suggested that the columns had been pulled down by human hands, probably for the purpose of acquiring the metal brackets which held the stone sections of the bases together; none of these brackets were found.

The ruins of the second structure, called the Temple, cannot however be explained on the basis of pillage. The Temple was built from first-class quality mud bricks and was adorned with an overhanging double cornice of kilned bricks on three sides. The mud brick walls were decayed substantially but the cornice fragments were uncovered quite intact. The amazing observation is that large sections of the cornices were found at considerable distances from the base of the walls and in each of these sections the fragments were aligned in a very orderly manner. This condition suggests that the cornices were thrown down by some considerable force. The additional fact that the fragments were all found on the same excavation level eliminates the explanation of prolonged and natural decay. That the cornice bricks, which would have had great value for the surrounding nomadic tribes, were found at all rules out the possibility of destruction by human means. The most plausible explanation (the arguments and evidence supporting this conclusion are fully presented in Sec. 6.4) is that the structure was destroyed by an earthquake. According to Dr. Bernard, the destruction of the Temple occurred after the city had been abandoned and suggests the possible date of 50 B.C. to 50 A.D. Based on this unique result it appears that earthquakes were as much a part of life in Afghanistan 2,000 years ago as they are today.

The three events listed by As-Soyuti and the apparent earthquake damage at Aikhanum are the only known testimonies to the occurrence of earthquakes in Afghanistan prior to Babur's early 16th century account. With the exception of Babur's second account of a violent earthquake which he felt in the year 1519 in the Jandol Valley north of Peshawar, no further seismic evidence is available until the 19th century and then considerable information is forthcoming. The explanation for the sudden availability of seismic information from the complete void which followed Babur's chronicles is as a result of the encroachment of the British East-India Empire on the frontiers of Afghanistan. Although the British appeared in India in the early 17th century it was not until the 19th century that their influence spread to the environs of Afghanistan. With this expansion, British agents, soldiers and travellers began to appear in Afghanistan from 1830 onwards. Many of these early Englishmen were prolific writers and from the detailed accounts of their experiences, a great many of which were published, significant information regarding earthquake phenomena can be extracted.

The first record of 19th century earthquakes by an on-the-spot observer appears in the four volume writings of Charles Masson[8], a British correspondent of the East-India Company, who travelled extensively through Balochistan, Afghanistan and the Punjab in the 1830's. During his sojourn in Kabul in 1832 and 1833, he recorded a slight earthquake on April 17, 1833 followed by a "very smart one" on April 19. Masson, by going on to describe that he "had become somewhat accustomed to these phenomena", clearly implies that earthquakes were a frequent occurrence in the region at that time.

An earlier event, but recorded after the fact, was documented by G.T. Vigne[9], a British traveller who visited Ghazni and Kabul in the summer and early fall of 1836. On his travels to Afghanistan over the Sulaiman Range he reported that the village of Derabund (Daraband, 31.7°N, 71.3°E) at the foot of the mountains was severely injured by an earthquake early in the spring of 1831. The shaking of the ground was so intense that camels and horses could not stand. The ground surface in the vicinity of Darabund was fractured and springs appeared. Although this earthquake was in the regions of present day Pakistan it would have been felt in the eastern regions of Afghanistan which are only 40 kilometers away. While Vigne resided in Kabul (July to October) he did observe several weak shocks of an earthquake and stated that, "there are usually about a dozen in the course of a year."

In 1837 a small British expedition was sent to Kabul under the leadership of Lieut. Col. Sir Alexander Burnes. While Burnes remained in Kabul, Capt. John Wood undertook an exploratory mission to the north of Afghanistan to chart the regions of the upper Oxus River (Amu Darya). Although the length of stay in Afghanistan was only in the order of eight months, both, in books which were published later describing their experiences, presented information about earthquake activity. Burnes[10] relates the occurrence of three earthquakes felt in Kabul on December 14, 1837 and mentions that many before or after that day had been registered. In particular, Burnes refers to a severe earthquake which took place in Kabul six years earlier but gives no further details; however, as discussed by Capt. Wood[11] in his account, this event must have been the major earthquake of January 1832 which rendered extensive destruction in the Badakhshan area. Burnes casually estimated that "shocks happen as frequently as twice or thrice in a month" and summed up his earthquake experiences in Kabul with the statement that, "Convulsions of nature are exceedingly common in this part of the world."

Wood's narrative[11] on his journey to the source of the Oxus provides an extremely valuable account of earthquake activity in the Badakhshan area of the country. Wood resided for several months in the small town of Jurm which, as will be shown in this report, lies almost directly above the most active source of earthquake activity in the country. It is not surprising then that Wood would have experienced the seismic disturbances which he related occurred on January 7 and January 8, 1838, and sent the inhabitants fleeing from their houses. As Wood explains, the entire community had remained in a state of caution ever since the great earthquake of January 1832 had struck the area.

The most important aspect of Wood's account with respect to the present subject, is that he identified and roughly dated the occurrence of the earlier major 1832 earthquake and gave considerable information about the damage produced. Although Wood arrived six years after the fact, he points out that many geological effects such as landslides, collapse of mountains and torn strata were still very much in evidence. Numerous houses and fortresses still lay in ruins and from a sampling of the valleys which he visited, it appears that at least 50 percent of the people who were living in the immediate area of the epicenter were killed.

Wood also stated that the earthquake was felt as far away as Lahore. It happens, however, that Alexander Burnes, while on a previous mission in the early 1830's, was actually in Lahore at the time of this earthquake. In his three volume account[12] of his travels to Bokhara in 1832, he wrote that near midnight on January 22 he was alarmed by an earthquake which shook Lahore violently for ten seconds. Later that year, while travelling through Afghanistan near Badakhshan, Burnes observed the vast destruction of the January 1832 earthquake and confirmed that the time of the Badakhshan disaster was indeed the same time at which the seismic disturbance was felt in Lahore. Without Wood's account and the correlating observations of Burnes, very little would be known of this great earthquake today. Compared to modern day earthquakes it must be rated as one of the great earthquakes known to have taken place in the country.

Ten years after the great 1832 earthquake, Afghanistan was again severely shaken by another major seismic disturbance which, after its occurrence on February 19, 1842, the region remained in an unsettled state for the remainder of that year. The chroniclers for this event were again residing Englishmen, and in particular, Lady Sale[13], who was the wife of General Sir Robert Sale, gave an excellent account of the entire calamity. Actually, Lady Sale's description of this earthquake and the extensive aftershock activity which lasted for six months, is the most detailed account of any earthquake which has taken place in Afghanistan up to the present. Lieut. Vincent Eyre[14] also documented this earthquake but his account was less complete.

This earthquake took place during the First Anglo-Afghan War and shortly after the catastrophic retreat of the British forces from Kabul in January. Both Lady Sale and Capt. Eyre, who survived the disastrous retreat, were being held in custody in an Afghan fort eight miles northeast of Tigri (Alingar Valley) when the earthquake occurred. Both were eye witnesses to the event, the epicenter of which seems to have been just to the north of their location as based on the description of the near total destruction of all forts and houses in the Alingar Valley. The destruction also extended to the Jalalabad regions where the town of Jalalabad was in British control under the command of General Sir Robert Sale. The earthquake rendered great havoc to the defenses of the town and everyone in the area suffered heavily. Excellent accounts of the disaster are given by Major-General A. Abbott[15] who was present at the time and by Rev. G.R. Gleig[16]. In particular, the portfolio of sketches showing the destruction of the walls as prepared by General Sir Robert Sale[17], is excellent testimony to the force of this earthquake. A recently published book entitled, "The Fierce Pawns"[18] also gives some facts about the magnitude of the destruction at Jalalabad.

The extensive destruction in the Alingar Valley, the destruction in Jalalabad where the town occupied by the British was severely damaged, the great loss of life and the countless number of aftershocks all indicate that this was an earthquake of major proportions. Again it should be noted that without the accounts of Lady Sale, Major-General A. Abbott and the others mentioned, the extent of this earthquake would not be known today and the seismic risks would accordingly be underestimated.

Following the First Anglo-Afghan War there was an obvious absence of British residents in Afghanistan and hence a void in seismic information which lasted until 1857 when a British political mission, which included H.W. Bellew, a medical officer, crossed into Afghanistan via the Kurram Valley (south of Jalalabad). During a short stay in the Kurram area, Bellew[19] recorded a "smart shock of earthquake" on March 27, 1857. On questioning the people of the area he remarks that "earthquakes are said to be of very frequent occurrence here, three or four being generally felt every year." Of particular interest is that while Bellew was residing in Kandahar in the summer of 1857 he felt and recorded an earthquake. This was a rare observation because, as it will be shown in this report, Kandahar falls within the near aseismic regions of the country. Quite possibly this was a strong earthquake originating in the Chaman-Quetta area rather than in the Kandahar region.

For thirty years following Bellew's visit to Afghanistan very little recorded seismic information* can be found despite the presence of British forces during the Second Anglo-Afghan War in 1879. During this interval however the third major earthquake of the 19th century occurred. Unfortunately no detailed account of this event is available. M. de Ballore[21] in his book entitled, "Géographie Séismologique", however, gives some information about the earthquake. The date of the event was 1874 and the center of destruction was Jabal-us-Siraj. According to M. de Ballore the ruins extended to Kandahar but this extent of destruction is subject to question. Prof. Edward Stenz[22], who resided in Kabul during the early 1940's, took the opportunity to interrogate some of the older inhabitants of the Jabal-us-Siraj area. He acquired the further information that the time was approximately in the first half of August 1874 and the towns of Jabal-us-Siraj, Gulbahar and most regions of the Kohistan Valley were completely destroyed and many casualties resulted. Ground cracks were also observed. Seismic data for the 20th century reveals nothing comparable to this 1874 disturbance in the Jabal-us-Siraj area. This again clearly demonstrates the value of collecting information on past earthquakes.

During the years of 1889 to 1891 Dr. John Gray, an English doctor, served as a surgeon to Amir Abdurrahman. In a book[23] relating his experiences, Dr. Gray recorded several earthquakes which he felt while residing in Kabul and Mazar-i-Sharif. The Kabul earthquakes were particularly strong and Dr. Gray acknowledged some very anxious moments. An interesting feature of the narrative is a short discussion on the construction technique used for Amir Abdurrahman's pavillion in Kabul. Apparently Amir Abdurrahman was very much aware of the earthquake hazards in Kabul and as an experiment he had endeavored to make the pavillion earthquake-proof by bracing it with iron bands. The manner in which the bands were employed is not mentioned but if they were incorporated to carry the earthquake loads as interpreted by the Amir, it is doubtful that they would have been very effective. In a discussion with Dr. Gray, Amir Abdurrahman informed him that, "the motion of the earth in an earthquake, at any given spot was in a vertical, not a horizontal direction. Were it in a horizontal direction, the very mountains would fall." Regardless of Amir

*--Sir Louis Cavagnari[20] during his short but fateful residence in Kabul in 1879 reported a violent earthquake on the evening of July 31, 1879.

Abdurrahman's understanding of seismic forces, his pavillion was probably the first building in the country to be designed for the eventualities of earthquakes and it further illustrates that earthquakes were prevalent in the 19th century.

A final testimony to seismic activity during the 19th century can be found in the writings of Lieut. O. Olufsen[24] of the Danish Army. He led two Danish scientific expeditions into the Pamirs during the years of 1896 to 1899. In the winter of 1898 to 1899, during the second expedition, Olufsen records that his lodgings in Khorog (Russian border town on the Ab-i-Panj River) were "now and again shaken by earthquakes to a most disagreeable extent." He also testified that "earthquakes are very frequent everywhere in the valleys of the Pamir" and although he gives no exact dates he mentions that during 1896 to 1899 his expedition experienced some violent shocks which caused building damage in the regions near to the most northerly portions of the Badakhshan province.

During the first quarter of the present century, although more recent in time, detailed information about seismic events in the country is sparse. A.C. Jewett, an American engineer, who undertook the project of installing the first hydroelectric plant in the country and resided for eight years at Jabal-us-Siraj, from 1911 to 1919, provided some observations[25]. He comments that, "hardly a month goes by without a small zilzila (earthquake). Only once has the tremor been severe enough to cause one to seek safety and this did no damage, bar shaking down a mud wall or two." Jewett also gave mention to tales of a big earthquake in Kohistan seventy to eighty years preceding his presence; this could well have been the 1832 or 1842 earthquake. Surprisingly he does not mention the 1874 earthquake which had destroyed the very village in which he lived. Another interesting comment is his reference to an old legend that the ancient city of Parwan (Alexandria-Under-the-Caucasus, near or on the present site of Jabal-us-Siraj) was destroyed by a large earthquake very long ago. Although Jewett gives no account of a strong earthquake, he did document that seismic activity was a common event in the early portion of the 20th century.

Shortly after Jewett's presence in the country, the well-known American author Lowell Thomas visited Kabul in the summer of 1923. His length of stay was only in the order of one month but during that brief exposure he witnessed a number of earthquakes. As he writes[26], "We encountered more than enough earthquakes in Afghanistan to satisfy us for the rest of our lives." He sums up his account of seismic activity with the impression, "It seems that Kabul is in an earthquake belt."

From the evidence presented, the conclusion that the regions of Afghanistan have always been seismically active, is inescapable. The apparent earthquake building damage at Aikhanum, the entries in As-Soyuti's catalogue and the accounts of Babur, although extremely sparse for the broad time period covered, substantiate the occurrence of earthquakes in the ancient and medieval periods. The English and American writers of the 19th and early 20th centuries all portray the fact that earthquakes were a common and frequent event associated with life in the regions of Afghanistan. The descriptions of the major earthquakes of 1505, 1832, 1842 and 1874, convey the evidence that in addition to the continuous occurrence of small and intermediate shocks, the region has also been susceptible to catastrophic seismic events. The present level of seismic activity as recorded by the Kabul Seismological Observatory is probably quite representative of many years in the past, but it is by no means an indication of what could be expected. Major events have taken place and there is no argument against the prediction that they will happen again. Afghanistan has been and will continue to be an earthquake country. The need for detailed seismic investigations is apparent.

3. SYNOPSIS OF PREVIOUS EARTHQUAKE STUDIES

The seismic nature of Afghanistan has been noted by many people; however, up to the beginning of the 20th century all observations pertaining to the occurrence of earthquakes in the country were documented, essentially by chance, and accordingly these seismic reports were included only as small sub-topics in various documents of broad and diversified subjects. All the information which was presented in the previous section was of this type. Organized investigations into the subject of the seismicity (see Sec. 8 for definition of seismicity) of Afghanistan began to appear only at the turn of the present century.

The first scientific document to deal with the subject of earthquakes in Afghanistan was written by Montessus de Ballore[21] and included within his larger treatise entitled, "Géographie Séismologique" published in 1906. M. de Ballore discusses only three earthquakes, the 1832 and 1874 earthquakes briefly, and to a greater extent the 1892 Chaman earthquake*. For the more recent Chaman earthquake much more information was available and a reasonable understanding of the event could be reconstructed along with its geological implications. Regardless of the brevity, the inclusion of the 1874 earthquake was important in that the event became documented in scientific literature.

The next contribution to the subject came from Raymond Furon, a Frenchman involved in geological research who spent two years in Afghanistan from 1922 to 1924. Furon did not attempt to research the seismic history of the country but he did prepare a list of over forty earthquakes which he published in 1925[27]. Owing to the sparsity of instrumental data in 1923 and 1924, Furon's list of felt earthquakes is of particular importance. In a book entitled, "L'Afghanistan" printed in 1926[28] Furon discussed the seismicity of the country in general, but presented no new details.

Despite Furon's lengthy list of felt earthquakes during 1923 and 1924 it appears that his list is not complete. During Furon's time, a German geologist, Emil Trinkler[29], conducted a survey through the center of Afghanistan. He spent four months in Kabul from December 1923 to March 1924 and observed many earthquakes which seem to be in agreement with Furon's listings. However, on March 18 as he was leaving Afghanistan he spent one night in Jalalabad and during the evening he experienced what he described as the worst earthquake he had felt in Afghanistan. The

*--A brief discussion of the Chaman earthquake, analysed in terms of modern seismological concepts, is given by C.F. Richter[30].

Bagh-i-Shah Palace in which he was staying suffered damage and there was a general exodus of all the inhabitants. This earthquake was felt in Peshawar and even as far as Delhi. This significant event was not listed by Furon.

The paper entitled, "Strong Earthquakes in Afghanistan" written by Prof. Edward Stenz[22] in 1945 is the first article which appears after Furon's work. Stenz's report was and still is one of the most significant contributions to the subject. During the five years (1939 to 1944) which he resided in Afghanistan, he made considerable effort to collect all known seismic data, in addition to maintaining his own record of earthquakes felt during his period of stay. Stenz's list includes 60 strong earthquakes covering the time period of 1505 to July of 1944. For each entry an estimate of the intensity based on the Modified Mercalli Scale is given but, owing to the lack of seismological data at that time, a number of epicenters are quoted and often only estimated on a regional basis. Stenz did have access to some instrumental data but this was minimal; the unavailability of instrumental information for most of the strong earthquakes which he recorded was a handicap to his work. Despite this, Stenz was able to establish a schematic seismicity map for the country based on the results of the sixty earthquakes. Also important is that Stenz was able to uncover some details of former earthquakes which, if they had not been recorded then, would have been lost forever.

In 1949 Gutenberg and Richter published their extensive catalogue of world earthquakes[5]. For this monumental work they extracted and compiled all reliable seismic data available up to that time. A second edition which appeared in 1954 updated the information to 1952. Of great importance was that the seismic regions of Afghanistan were clearly related to the overall global seismic zones, and the level of seismic activity was put into the proper perspective as compared to the rest of the world. The document was also the first publication to give extensive circulation to the instrumentally located epicenters of many known significant earthquakes which had occurred within or near to Afghanistan. Although it is not possible to perform a detailed seismicity analysis based only on Gutenberg and Richter's data, the major active zones can be roughly delineated.

Following his contribution to the "Seismicity of the Earth", C.F. Richter in 1958 published his now well-known book, "Elementary Seismology"[30]. In addition to presenting an extensive treatment of the principles of seismology it also included considerable discussion on global seismic geography and past major earthquakes. Although not directed particularly to Afghanistan the book does contain some information related to the seismicity of the region.

The extensive seismic data published in 1962[31] in the "Atlas of Earthquakes in the U.S.S.R.", presented a vast amount of earthquake instrumental data covering the time period of 1911 to 1957. Although the data was compiled for the region of the U.S.S.R., the portion of Afghanistan north of the 36° latitude was included. The information collected was based on data produced by the U.S.S.R. seismological network, of which a large number of the stations were or are located just north of the borders of Afghanistan. Although the Atlas does not cover the entire region of

Afghanistan, it nevertheless presents a very detailed analysis of the northeastern portion of the country and in particular the highly active zone of deep earthquakes centered around 36.5°N and 70.5°E. The Atlas also includes considerable data on large earthquakes from 1893 to 1952 which did not appear in the works of Richter and Gutenberg. For the present seismic investigation, the Atlas is an important source for instrumental data; a great number of the earthquakes listed can be found in no other reference.

The first and to date the only detailed scientific investigation pertaining exclusively to the seismicity of Afghanistan was performed by A.P. Solovyova[32] in 1966. This treatment is primarily associated with instrumental data although some discussion is presented on the effects of past major earthquakes but this is based entirely on Stenz's listing. No felt data is included for any event past 1943. Solovyova did have access to some old Russian papers and he did provide some additional information on the 1832 Badakhshan earthquake. The most significant aspect of this paper is the seismicity map which was produced using data compiled from the bulletins of the U.S.S.R. seismic stations during the time period of 1939 to 1962. The map clearly illustrates that the northeastern sector of the country is highly active and a detailed plot, similar to that given in the Atlas of U.S.S.R. Earthquakes[31], is included. This localized seismicity analysis is lacking in that differentiation on the basis of depth has not been included. The conclusions drawn resulting from this study are quite general in scope, but the object of the paper was only to present the overall nature of seismic activity in the country and this was accomplished.

A somewhat more recent analysis was given by M. Niazi et al[33] in 1968. In this paper, the seismicity of the broad region extending from Turkey to Pakistan and from the southern portion of Russia to the Indian Ocean was studied for the time period of 1957 to 1967. The epicentral data used for the investigation was obtained from the files of the U.S. Coast and Geodetic Survey. The extent of the region considered precluded a detailed study of any particular zone. The object of the paper was to survey a section of the Alpide Belt and identify the most active zones of the past ten years. The analysis was unique in that the seismicity of the region was presented in the form of strain energy release per half degree quadrangles. This approach has the advantage of providing more clarity to the tectonic nature of the regions than is achieved in a conventional plot of earthquake epicenters. For detailed seismic studies of a region the conventional technique used in this report, is preferable. The feature of the paper as related to the present studies was to demonstrate that the concentration of strain energy release in the Hindu Kush exceeded any other area in the regional investigation.

Following the format adopted by Stenz, S.M. Hosseini[34] in 1968 published a list of felt earthquakes in Afghanistan. The list is actually a continuation of Stenz's data and includes no new information for the time period investigated by Stenz. Essentially the list extends the work done by Stenz by 14 years, that is, up to 1958. The information collected is entirely from Afghan newspaper reports and based on these, estimated Modified Mercalli intensity ratings are given. Despite the availability of instrumental data, no effort was made to correlate and verify the felt earthquake information with epicentral data published by international seismological societies. Some information on two major earthquakes which occurred in 1949 and 1956 is given. Even though new regions were affected by the earthquakes of 1949 to 1958 no consideration was given to updating Stenz's seismicity map.

Some information on the seismicity of Afghanistan can also be found in a recently released (1970) six volume report[35] on the Survey of Land and Water Resources for Afghanistan produced by the United Nations. This extensive set of documents contains a five page discussion, in the geology section (Vol. II), on the seismic nature of the country. The analysis presented is based primarily on the results of Richter and Gutenberg[5] and no regard is given to the earthquake activity of the past twenty years. Consequently, the postulated limits of the zone wherein severe earthquakes can take place are exceedingly conservative. In particular the major earthquake of 1956 which affected the Kahmard-Sayghan regions north of Bamiyan has been overlooked and accordingly this region is shown as lying outside the high, seismic risk zones. A line of argument is also presented to suggest that possibly all major earthquakes which have affected the country had epicenters outside the regions of Afghanistan. Careful analysis of the descriptions of the earthquakes of 1505, 1832, 1842 and 1874 clearly contradict this argument. The conclusions suggested, regarding the seismic risks, are simply based on too little data and accordingly the seismic activity is seriously underestimated.

This review of the scientific literature elucidates the sparse information available on the seismicity of Afghanistan. The very limited number of articles, alone, manifests the scarcity of material. The papers by Stenz and Solovyova are excellent contributions to the subject but, either taken alone or together, they do not provide sufficient information to perform a detailed study of the region. In all cases the greatest deficiency is that all the investigations have concentrated either on instrumental data or on non-instrumental data. To date the correlation of this information has not been attempted and this of course is important in order to make the best possible delineation of the seismic zones. Also important is the correlation of seismic data with the tectonics of the region as indicated by the known fault systems in the country. For the regions of Afghanistan such a study has also not been presented to date. The existing reports are each, at best, only small parts of the whole subject; in order to acquire a proper understanding of the region, all information available must be combined, updated and analysed in totality. This present report is an attempt to approach the subject in this manner.

4. GEOGRAPHICAL AND GEOLOGICAL SETTINGS

It is not the intention of this report to give an extensive and detailed account of the geographical and geological features of Afghanistan; emphasis on these topics would be beyond the scope of the present subject. On the other hand, it is quite impossible to divorce completely the subjects of earthquakes and seismicity from the geographical and geological characteristics of any region. The science of seismology draws heavily on the evidence produced by topographical and geological surveys and there is an increasing need for further interplay between these sciences. The modern approach to ascertaining the seismic risk zones in a region is to base the analysis both on the distribution and frequency of earthquake epicenters (seismicity), and on the regional geological structure, with particular emphasis on the active fault systems (tectonics). The correlation of seismicity and tectonics is referred to as a seismic-tectonic analysis. The discussion on the tectonics of the region, however, will be withheld until Sec. 5 in order to relate the regional patterns with the global and continental tectonic patterns.

The following discussions, although brief, will present sufficient information so that at least a preliminary correlation between seismicity and the geography and geology of the region will be possible.

4.1 Geography

Afghanistan is a completely landlocked country with the closest point to an oceanic system being the southern border which is 450 km from the Arabian Sea. The total area of 655,000 km^2 is bounded by Iran on the west, Pakistan on the south and east and Russia on the north. A short 80 km section of the borders of the Wakhan panhandle are shared with China. The position of the country relative to its neighbors and some of the major physiographical features are illustrated on the map, "The Regions of Afghanistan" identified as Fig. 1. For increased detail and ease of reference a larger reproduction of this map is included in the pocket on the inside back cover of this report.

The salient aspect of the topography is certainly the vast regions which contain high mountains, deep valleys and rushing rivers. Nearly 40 percent of the land areas are at elevations greater than 2,000 meters and these high mountainous plateau regions occupy most of the central, northeastern and eastern parts of the country. Low elevations of 200 to 500 meters are found in the southwest around the deserts of the Helmand and Farah River basins (Sistan region) and in the north around the Amu Darya or Oxus River basin. In a broad sense the topography could be described as having the appearance of a lava flow which has its source in the northeastern corner of the country and from there fans out symmetrically about a line having a southwest direction.

The dominant feature in the country is the Hindu Kush mountain range which strikes southwest to northeast and demarcates the north of the country from the south. In the northeast, this range ties into the Pamir Knot on the north, and the southeast striking Himalayan and Karakoram Ranges on the south. In this region elevations of 5,000 - 6,000 meters are common with some peaks topping 7,000 meters. To the southwest, the Hindu Kush takes on a more westerly strike and actually lines up with the Paropamisus Range on the western side of the country. These two ranges taken together form a sinuous arc which is convex to the north in the west and convex to the south in the east. Attached to this cross-country mountain system are numerous spur ranges such as the Band-i-Turkestan, the Khwaga Muhammad and the mountains of Nuristan in the east.

The second major mountain system is the Koh-i-Baba in the central highlands which lies south of and runs parallel to the western end of the Hindu Kush. Some of the mountains in this range have heights approaching or exceeding 5,000 meters. The westerly end of the Koh-i-Baba lines up with the Safed Koh and Siah Koh Ranges which lie south of the Paropamisus. Numerous other mountain ranges fan out to the south and west from this system. The eastern regions of the country are also mountainous but the relief is less dynamic with the exception of the Safed Koh Range which lies south of Jalalabad.

The river systems of the country divide primarily into those which empty into the Oxus River basin in the north and those which empty into the Sistan swampy regions in the southwest corner of the country. The Hari Rud and Murghab Rivers which flow primarily to the west within the country, turn northward and disappear in the deserts of Turkmenistan. Interestingly, the only water which falls onto Afghanistan and is returned to the oceans is that which is caught in the catchment areas of the rivers in the northeast regions; the most important are the Kabul and Kurram watersheds which drain into the Indus River. The major rivers within the country are the Helmand in the south, the Hari Rud in the west, the Kabul River with its Panjshir and Kunar tributaries in the east and the Kunduz and Kokcha Rivers in the north. Certainly the largest and most famous river is the Amu Darya or Oxus which forms the northern boundary between Russia and Afghanistan. The upper portion of the Oxus, from the point where the Kokcha River joins to its source in the Wakhan, is known as the Ab-i-Panj. The length of this river from its source to its terminus in the Aral Sea is more than 2,000 km.

Throughout the high elevation regions the rivers run through slender and often precipitous valleys. The population in these regions is almost totally confined to the green belts of the narrow valley floors. The valleys of Panjshir, Ghorband, Andarab, Kahmard and the very large Kunar River valley are of particular importance for the present report because in each case there are known faults which follow or closely follow the course of these valleys. The broad valleys of the upper Kabul River on which the city of Kabul is built and the large Koh Damon valley north of Kabul include sections of the large fault which extends south all the way to and beyond Chaman. The lower Kabul River valley, in the vicinity of Jalalabad, is also known to have fault systems traversing its base. The important aspect of the geography of the country with regard to the subject of seismic risks, is that the population is concentrated within the narrow valleys and these valleys with their concomitant fault systems have the potential of producing considerable seismic activity.

4.2 Geology

Detailed information on the geological and stratigraphical features for all the regions of Afghanistan does not exist. During the past ten years considerable progress has been made and certain regions have been mapped in detail. The very rugged terrain, which in many places is exceedingly difficult to gain access, has been a great handicap. The Fairchild and Russian aerial surveys conducted in the late 1950's were a major step forward and since that time Afghan, Russian, German and UN geological teams have been gathering considerable data. For geological information as known up to 1954, reference should be made to the work of S.A. Popal and S.W. Tromp[36]. Some information on the recent investigations of the German Geological Mission can be found in Ref. 37 and the geological information as compiled by the UN is given in Vol. II of the Survey of Land and Water Resources for Afghanistan[35]. A brief but comprehensive review of the geology of the country has been prepared by A. Nassery[38] of the Faculty of Science at Kabul University. The most recent geological map, published in 1969, is included in this report as Fig. 2 and the present discussion will be based primarily on this map.

The most striking feature of the stratigraphy of the country is the broad belt of Paleozoic and older rocks which occupies the entire northeastern corner of the country as far south as the Safed Koh Range and strikes southwest, thinning and disappearing just north of the Khajaki Reservoir. Throughout this belt large granitic intrusions are found. The oldest known rocks in this belt are the Crystalline Shists of Proterozoic Age. A second belt of similar composition and age, separates in the central part of the country from the broad SW-NE formation and strikes to the west. This more narrow belt clearly follows the Hari Rud valleys and continues west through the Paropamisus mountain range. It can be clearly seen that this belt demarcates the northern geology of the country from the southern. To the north are found, primarily, Cretaceous to Paleocene limestones and red sandstones, while to the south are older Jurassic to Cretaceous limestones and sandstones.

Throughout the mountainous regions which coincide with the two belts of Paleozoic and older stratigraphy, extensive fault systems are evident. Clearly, the predominant strike of the faults follows the direction of the mountain systems. Some faults however do run traverse to the general orientation of the physiographical and geological structures. On the whole the fault system is quite complex particularly in the central and northeastern regions. A more detailed discussion on the fault systems of the area will be reserved for Sec. 5 where the global, continental and regional tectonics will be presented.

The second salient feature of the stratigraphy appears in the southeastern portion of the country and concerns the geology of the eastern Baluchistan-Indus block as compared with the central Afghan block; these are delineated by the Chaman fault line up to just south of Ghazni, and then by the fault which bifurcates and strikes towards the Safed Koh Range. The older Jurassic to Cretaceous rock compositions of the eastern edges of the central block are contrasted to the Paleocene limestones, sandstones and shales of the eastern block. Another important observation in the comparison of these two blocks is the presence of granitic bodies on the west side of the fault and the total absence of any granitic bodies on the east side. As will be discussed in Sec. 5 this fault may well form a portion of the edge of the continental Indian-Australian crustal block.

Vast regions of the country are composed of Neogene conglomerates, sandstones, and siltstones. These are prevalent in the Sistan region of the country in the southwest and also appear in the northern regions approaching the Oxus River basin. Other significant zones are the Tarnak River regions and the area between the Safed Koh mountains and Jalalabad.

Quaternary deposits such as gravels, sands, loess, etc. are found throughout the country. These predominate in the northern regions around the Oxus River basin, the western areas and in the south. They are also prevalent throughout the interior mountain basins with the Kabul valley and the Koh Damon valley being excellent examples. The thickness of these deposits can be excessive; for example, in the regions of Kabul City the alluvial reaches depths in the order of 1,500 meters. These deep alluvial regions are of particular importance to the study of seismic risks. It is well known that unconsolidated regions greatly amplify the effects of seismic disturbances and increase the level of earthquake damage. The deep alluvium on which Kabul is built is one of the major reasons why so many earthquakes are felt in the city.

Although there are no active volcanoes within or near to the regions of Afghanistan there is broad and extensive evidence that the region was active throughout the Triassic to the early Quaternary periods with intense activity[38] in the Triassic-Jurassic period and the Oligocene epoch. The western portion of the country contains many volcanic eruptive complexes of Oligocene age; these extend into the western regions of Iran. Quaternary volcanism is found in the regions of the Dasht-i-Nawar, west of Ghazni, and on the southern borders of the country just north of the Chagi Hills. The latter is probably the most recent volcanic activity in the region.

Geological evidence gathered in the Sayghan-Doab regions[37] has contributed to identifying the Hindu Kush orogenic process on a temporal scale. Throughout the Paleozoic era, Afghanistan was largely marine. At the end of the Triassic, early Alpine, tectonic movements occurred and the en bloc uplift of the Hindu Kush ridge was started; this was accompanied with the intense volcanic activity of Triassic-Jurassic as previously mentioned. This early uplift divided the region into a North-Afghanistan epicontinental sea and a Central Afghan Sea; these were connected by channels through the Hindu Kush ridge until Upper Cretaceous. New and massive uplifting of the Hindu Kush ridge started in Oligocene (Middle Alpine) and this was accompanied again with intense volcanism along faults and fissures. The major uplifting of the Hindu Kush corresponded in time with the rise of the Himilayas. Significant additional uplifting continued into Miocene or early Pliocene based on marine deposits. The regions around Herat were probably uplifted and folded during the Pliocene. Intermittent vertical movements continued into the Pleistocene and subrecent time which is evident by the terrace formations in the river valleys of the Hindu Kush region. Faulting in the region is believed[38] to be younger than the Oligocene orogeny and probably during the late Pliocene to early Pleistocene.

In view of the relatively young age of the mountain systems in Afghanistan it is evident that tectonic processes are still continuing. The level of seismic activity which has been recorded during the past 70 years substantiates this statement. The nature of the tectonic movements which are still active is open to question and certainly will not be resolved in this report; however, the following section will present and discuss the tectonics of the regions as established by the ground and aerial survey available to date. This information, when combined with the seismicity data, will provide a reasonable understanding of the presently active tectonic regions in Afghanistan.

5. TECTONICS - GLOBAL, CONTINENTAL AND REGIONAL

There is unanimous agreement among seismologists and geophysicists that earthquakes are a manifestation of tectonic processes within the earth's crust and upper mantle. These tectonic processes involve the accumulation of tremendous forces which are capable of moving continents, building mountains, creating oceanic trenches and fracturing the crust of the earth. Reid's[30] observations of the San Andreas faulting which occurred in the 1906 San Francisco earthquake, and his hypothesis that the energy of an earthquake derives from the accumulation of strain energy which is released suddenly when the material strength of the earth's crust or mantle is exceeded, forms the basis for all modern interpretations of seismic phenomena. Although very few earthquakes are accompanied with visible surface fracturing, as in the case of the San Andreas fault, there is strong evidence to support the existence of sub-terranian or sub-oceanic fault planes with all earthquakes. The established inseparable relationship between tectonic processes and earthquakes has provided a great insight into the mechanism of earthquakes and also into the evolution of the earth's continents and oceans. It should be noted, however, that although there is unanimous agreement on the tectonic aspect of earthquakes, there is no uniform agreement on the origin of the forces which are promoting the tectonic processes or for that matter the manner in which the forces are applied, single couple, double couple, etc.

If the seismic nature of a region is very well understood then of course the tectonics of the region could be inferred. On the other hand, if the tectonic patterns of a region are well known then the seismic characteristics could be ascertained. Unfortunately a complete knowledge of either the seismicity or the tectonics of a region is quite unattainable, at least with the present state of research techniques in the earth sciences. The approach to acquiring the best understanding of a region must be one of combining the information available on seismicity and tectonics. In particular the supplementing of seismic observations with tectonic data greatly broadens the time scale of seismicity investigations. Reliable seismic observations have only been made during this century and on a geological time scale this is nothing more than a tick of the clock. Tectonic observations are not restricted to recent or current events. Through the careful studies of such things as topography, stratigraphy, bathymetry, gravity anomolies and magnetic anomolies, tectonic processes, dating from the Paleozoic or earlier to the recent can be identified. For the present study the tectonic processes of interest are those which are currently active and are responsible for the shaping of the earth's surface as known today.

The tectonics of the regions of Afghanistan are not well understood but this situation is changing rapidly. Recent investigations and theories on the global tectonic mechanisms and regional studies of the active fault systems have provided a more lucid insight into the geodynamics of the country than ever before. The primary object of this section of the report is to summarize the information which is currently available on the tectonics of the region; this however will be preceded by a discussion of the latest concepts of global tectonic patterns with special emphasis on the tectonics of the Indian-Australian crustal block. Some of the regional tectonic processes will be inferred from the envisaged global and continental mechanisms. Certainly the tectonic information which will be presented here is far from complete but it will provide a background for a better interpretation of the regional seismic data.

5.1 Global Tectonics

Throughout the current century one of the greatest scientific controversies has been the origin of the continents. Alfred Wegener, who revived and extended previous interpretations and findings on the shape of the continents, set the stage for the 20th century controversy with his published theory of continental drift. Because of the lack of corroborating evidence and decisive tests, the theory was virtually abandoned until the mid-1950's. New scientific evidence which became available as the result of recent and improved research techniques revived the theory and currently it is gathering ever increasing support. For some of the most important contributions to this subject, up to 1965, reference should be made to the books entitled, "Continental Drift"[39] and "Symposium on Continental Drift"[40].

Some of the most convincing evidence buttressing the theory of continental drift has been supplied by seismology. During the past ten years as a result of the great increase in the number of seismic stations throughout the world, improved instrumentation and the use of computers for epicentral determinations, there has been a tremendous increase in both the quantity and quality of earthquake data. As a result, regions of the world which had been too remote for detecting earthquakes, unless of course the event was of major proportions, are now being monitored. This explosion of seismic data has provided the means for delineating the seismic zones of the world with an accuracy and completeness which could not have been obtained prior to 1960. This improved world seismicity data is supplying some of the evidence necessary for devising an improved interpretation of the global tectonic patterns.

One of the most recent versions of seismicity maps (see Sec. 8 for general definition of seismicity map) for the earth was published in 1969 by M. Barazangi and J. Dorman[41]. The information for compiling these maps was obtained from the earthquake hypocentral data files of the USC&GS and covered the seven years from 1961 to 1967. Nearly 30,000 epicenters were plotted. The handling of such a vast amount of data was only possible with present day technology through the use of computer-plotting machine facilities. At the time of writing this report however the USC&GS has published a new 1961-1969 world seismicity map using the same procedure. The results of Barazangi et al and the USC&GS have been combined in the preparation of Fig. 3 in this report. In this type of seismicity plot no distinction is made between earthquakes of different magnitudes. The important features which are being illustrated are the spatial distribution of epicenters and the distribution as related to the depth of focii. In Fig. 3 the depths have been divided into three zones; namely, shallow (0-70 km), intermediate (71-300 km) and deep (301-700 km).

The most striking features of the world seismicity as shown in Fig. 3, are the well-defined narrow belts of earthquake activity. As seen, the greatest distribution of epicenters follows the continental edges of the Pacific and this is the well-known Circum Pacific Belt. It is estimated that nearly 90 percent of all the earthquakes in the world occur within this region. The second major belt, the Alpide Belt (described in Sec. 2), has a more irregular pattern and is not very well delineated. In particular, the belt appears to have an interruption in the western regions of Afghanistan. Although only nine years of information are represented, the discontinuity seems to suggest that the Alpide Belt, as previously envisaged, is actually composed of two distinct segments with the western segment being controlled by probably quite a different tectonic pattern from the eastern segment (see Sec. 5.3). The extreme eastern portion of the Alpide Belt, through the Indonesian Archipelago does however exhibit the more typical pattern of narrow epicentral belts.

Although on a secondary level in terms of activity, the earthquake belts within the oceanic regions are clearly visible and this is one of the most revealing results demonstrated by the recent superior quality of epicentral determinations. The Mid-Atlantic Belt is clearly the most well developed and complete throughout its entire length. The belts in the Pacific and particularly that of the South Pacific have the poorest definitions but nevertheless the trends are very evident. The regions of the Indian Ocean, which have the greatest bearing on the present study, exhibit nearly the same quality of sharply defined belts as that in the Atlantic. Although the northern extending belt seems to continue into the Gulf of Aden there is evidence of a continuation of activity in the direction approaching the coastal regions of West Pakistan (this observation will be further developed in Sec. 5.2). The important aspect of all these oceanic earthquake belts is that they coincide completely in all areas with the well-mapped oceanic ridges and this phenomenon forms one of the cornerstones for the modern interpretation of the mechanism of continental drift.

It will be noticed that not all epicenters fall within the narrow zones of intense activity. The west-central and eastern regions of United States contain a consierable number of epicenters. Also the lower eastern sector of the African continent displays some activity but most of this is associated with the Great African Rift Valley. Certainly the most extensive region outside the narrow belts is the triangular zone stretching up through China, Mongolia and Siberia with its apex near Lake Baikal and its base stretched along the Himalayan Mountain Range. The edges of this triangular region are particularly active in comparison to the central portions. In addition to these regions, it can be seen that isolated, randomly located epicenters exist throughout most of the regions of the world. This observation carries the conclusion that earthquakes can probably occur anywhere in the world, but in the broad regions outside of the active zones discussed, the frequency of occurrence is very low and accordingly the seismic risks are not great.

The second feature of the world seismicity map is the distribution patterns of shallow, intermediate and deep earthquakes. The deepest earthquakes, 300 to 700 km in depth, occur exclusively within or near to the deep trench areas of the oceans with the one exception of a small pocket in the Mediterrean Sea between Sicily and Italy. The greatest density of deep earthquakes appears to the west of the Tonga Trench followed by the western flanks of the Phillipine, Izu, Japan and Kurile trenches. The other region of deep earthquakes associated with the Circum Pacific Belt is within the western regions of South America, parallel to the Peru-Chile trench. In the Indian Ocean regions deep earthquakes are found on the northern sides of the Java and New Britain trenches and to the east of the New Hebrides trench. The association of these deep earthquakes with the trenches of the oceans is another observation which is used to support the new theories of continental drift.

It is clear from Fig. 3 that shallow earthquakes predominate. According to Richter and Gutenberg[5], shallow earthquakes account for roughly 85 percent of the energy released by all earthquakes; deep earthquakes only contribute 2.5 percent in terms of energy. In all the seismic regions of the world shallow earthquakes are found to occur. The mid-ocean belts are completely composed of only shallow earthquakes. Also, within most continental regions only shallow earthquakes are recorded but there are notable exceptions where intermediate earthquakes are prevalent. In particular, the western coasts of the Central and South Americas display a great density of intermediate shocks. With the exception of a small zone of intermediate shocks in the Mediterrean the only other regions in the world where intermediate-depth earthquakes occur within continental masses are along the northwestern borders of Burma and the very dense pocket in the northeastern corners of Afghanistan. The existence of these unique intermediate-depth earthquakes establishes Afghanistan as a complex tectonic zone.

Intermediate-depth earthquakes are also found in the trench regions of the oceans but they are not randomly distributed about these zones. It can be seen in Fig. 3 that the intermediate shocks are always located between the deep earthquakes and the shallow earthquake belts, all which run parallel to the strike of the trench. This is a characteristic feature of seismic activity associated with trenches and it is now strongly believed (H. Benioff[39]) that this consistent distribution of earthquake depths indicates that there are fault planes running nearly parallel to the trenches but dipping at steep angles from the trench opening to deep within the upper mantle. The deep earthquakes in the interior of South America are accordingly an extension of the dipping fault plane originating in the Peru-Chile trench. This aspect of dipping or plunging fault planes in trench regions is an important observation which further supports the recent concepts of continental drift presented next.

The overall appearance of the world seismicity as presented in Fig. 3 strongly supports the latest global tectonic interpretations which envisage that the earth's crust is divided into what is termed crustal plates. These plates are not fixed in position but are actually moving about by floating on the upper strata of the mantle called the asthenosphere. The plates react with one another at their common edges and this of course is an obvious source of earthquakes and accordingly the edges of the plates should be identified by belts of seismic activities. On this premise, inspection of Fig. 3 provides the definition of the crustal plates. Clearly the largest plate is the Pacific Ocean block outlined by the trench systems on the west and north, the coasts of America on the northeast and the Pacific oceanic ridges on the southeast and south. The second largest plate is defined by the western coasts of the North and South American continents and the mid-Atlantic ridge. The other major plates are the African block and the Indian-Australian block which of course is the most directly related to the present investigations. Smaller plates, such as the block of the west coast of South America and the Arabian Peninsula block can be seen. The massive Eurasian and Antartica blocks are considered in most interpretations to be relatively stable masses in comparison to the other plates.

The concept of gigantic crustal plates floating about on the mantle is difficult to accept solely by itself, but the hypothesis becomes more tenable in light of the recent evidence produced by the earth sciences[41a]; this information when taken together provides a plausible mechanism for the global movement of the plates. It is now believed that the ridge areas of the oceans are actually openings in the crust from which lavas from within the mantle are outpouring and thereby creating new crustal material. This creation of crustal surface on the ridges of oceans produces the result of ocean floor spreading and the most well understood example of this is the separation of the Americas from the European and African continents about the mid-Atlantic ridge. In addition to the great similarity of the two coast lines, which of course was the original evidence that inspired the early theories of continental drift, the similarity of fossils and rock structures, as compared on the basis of establishing the best fit between the two coast lines, has been established.

Direct evidence supporting sea floor spreading has been recently obtained by on-the-spot explorations of the mid-Atlantic ridges. These investigations have included the measurements of abnormally high heat flow rates, of decreasing thicknesses of sedimentary deposits and of decreasing fossil ages, all on the basis of approaching the ridge zones. Possibly, the most convincing information however has come from magnetic anomaly measurements. These anomalies are in the form of magnetic reversals in the remanent magnetism of the crustal rocks. This remanent magnetism is a clear indication of the earth's magnetic field which existed at the time when the lava cooled through its Curie point. It is now well known that the earth's field has periodically changed polarity and by dating continental rocks showing normal and reversed magnetism, a geomagnetic time scale has been established[42]. Based on this geological pattern of periodic magnetic reversals, G.O. Dickson et al[43] have established that there are elongated and parallel magnetic anomaly patterns with remarkable symmetry about the ridges of the South Atlantic Ocean. By measuring the displacements of the anomalies from the ridges and utilizing the established magnetic reversal history, a maximum spreading velocity of 2.0 cm/yr was estimated for the regions investigated. Similar magnetic anamaly studies have been performed for both the Pacific[44] and Indian Oceans[45], and in each case parallel and symmetrical magnetic anomalies about the ridges were detected and accordingly sea floor spreading established.

If sea floor spreading is accepted, and the evidence for this is very strong, then the obvious question is how does the earth's surface adjust to this continual creation of surface area. If the principle of conservation of surface area is accepted (an expanding earth is difficult to detect and justify) then there must be places where surface area is disappearing. Two possibilities for this exist; namely, the trench and mountain systems of the world. In the case of the trenches it is believed that the crust is being thrust down through the trench into the upper mantle; the trench is thus acting as the sink counterpart to the oceanic ridge sources. The world seismicity presented in Fig. 3, showing the variation in depth of earthquake focii in the trench zones, supports this concept. The mountain systems are regions where compressive forces are causing wrinkling in the topography and this represents an accumulation of crustal material and is in effect another type of sink. The Zagros mountains in Iran and the Himalayas fit this concept very well.

These zones of sources and sinks, where crustal area is being created and destroyed, form the boundaries of the crustal plates. Along these zones the plates are interacting. In oceanic ridge zones the plates are being pulled or pushed (?) apart and this could be thought of as a tensile interaction although the forces applied to the edges of the plates are probably compressive. In the trench and mountain regions the plates are being pushed together to produce a compressional interaction. In both these cases the motion of the plates are orthogonal to the boundary. A third type of boundary also exists which is the case where two plates move parallel to the boundary either in opposing directions or at different rates in the same direction. The interaction in this case is of the shearing type and these would be represented by the transcurrent or strike-slip fault systems of the world (along fault boundaries, area is neither created or destroyed). The most well-known example of a fault boundary is the San Andreas fault. Based on the crustal plate model, it follows that tectonic processes are a manifestation of the interaction of the boundaries which involve the accumulation of compressive and shearing forces. If this crustal plate model is accepted then the world seismicity data shown in Fig. 3 is an a priori result.

The major difficulty in the plate theory as presently envisaged is the formulation of a suitable explanation to account for the origin of the forces motivating the plates. Although there is no substantiating evidence many tectonophysicists[39,40] believe there are thermal convection cells within the mantle which rise up under the ridge zones of the oceans and descend under the continents. As the plastic mantle material traverses from the ridges to the continents, viscous forces are imparted to the overlaying plates and hence the driving mechanism. The model of convection cells is clearly one which has been devised to best suit some of the present day observations.

The actual manner by which the crustal plates move is of course a very complex problem. Certainly if a dynamical analysis of the motion is to be made it cannot be based on planar considerations. The crustal plates are vast in dimensions and the curvature of the earth cannot be disregarded. Obviously the problem is one of spherical geometry. Recourse to a theorem of Euler provides the statement that the motion of rigid blocks if constrained to the surface of a sphere must be such that the motion can be described by simple rotation about some axis which passes through the center of the sphere. For example, if the motion of a crustal plate was in the east-west direction, then the axis of rotation would be identical to the earth's axis of rotation which is defined by a line passing through the north and south poles and the center of the earth. For this special case the motion of any point on the plate would be along lines of constant geographic latitude. Although all points on the plate have the same angular velocity the absolute motion is not uniform; points near the equator would experience the greatest translations and those near the pole the least. In the general case when the motion is other than in an east-west direction, the problem is one of determining the appropriate poles of rotation.

There is strong evidence supporting the motion of the earth's crustal plates on the basis of simple rotations about appropriate poles. By magnetic anomaly measurements it has been found that the spreading rates along the mid-oceanic ridge systems are not uniform. For example[42,43], along the mid-Atlantic ridge the spreading velocity is maximum around 25°S and decreases from this point either to the north or south. The unequal spreading rates about the ridges has produced large fracture zones perpendicular to the axis of the ridges. Presumably the variation in spreading velocity along a ridge is actually achieved in a discontinuous manner between the blocks of crust separated by successive fracture zones. The imperfect variation of spreading velocities has resulted in producing ridge axes which have the appearance of discontinuous segments bounded by the fracture zones. The major earthquake activity in the ridge areas occurs along that segment of the fracture zones which offsets the axis of the ridge. This type of faulting is known as transform faulting as compared to strike-slip faulting. Seismic investigations have thoroughly established this result[41a].

Based on measured ocean floor spreading velocities and on the strike directions of the fracture zones (these are perpendicular to the ridge axes) the hypothesis of crustal plate movements on the basis of simple rotation has been tested. The test involves determining whether or not a single pole of rotation can be found which suits the spreading velocity data and the strike of the fracture zones as known along an entire ridge. This analysis has been performed for all the ridge areas of the oceans and the results[42,43,44,45,46] support the hypothesis very well. For the Atlantic and Pacific plates the best fitting poles of rotation were found to be nearly coincident, and located in the Labrador Sea. Thus the axis of rotation for these plates is only slightly inclined to the earth's rotational axis and the movements are very much in east-west directions. The results for the Indian-Australian plate were not as favorable primarily because the spreading of the Indian Ocean is vastly more complex (see Sec. 5.2 for more detailed discussion) than either the Atlantic or the Pacific Oceans. Nevertheless, a pole of rotation was calculated (based on the characteristics of the northwest branch of the ridge) and it was located in Libya with its antipode lying in the Pacific Ocean northeast of New Zealand. This axis of rotation is very much inclined to that of the Atlantic and Pacific plates and it is such that movement of the Indian-Australian plate on the north side of the ridge is primarily in a northward direction. It should be clearly noted that these rotational axes were established using magnetic anomaly data from middle Meocene (20 million years) or later. Also the calculations were based on the premise that the crustal plates are completely rigid so that no warping or distortion within the plate surface exists. From bathymetric studies the known smoothness of the ocean floors away from ridge and trench boundaries of the ocean blocks seems to justify this assumption of rigidity.

The observations, measurements and proposed theories which have occurred during the past five years have produced a revolution in the earth sciences. The concepts of crustal plates bounded by ridges, trenches, mountains and transcurrent faults, of the formation of crustal area in the oceanic ridge areas, producing ocean floor spreading, of the elimination of crustal area in oceanic trenches and mountain systems, of the movement of the crustal plates from the ridges towards the trenches and the mountain systems on the basis of a simple rotation about an axis through the earth's center, and of the a posteriori existence of thermal convective cells within the mantle as the overall driving mechanism, are indeed bold steps toward achieving the ultimate goal of developing an integrated model for tectonic processes on a global scale. As further evidence is forthcoming the model will undoubtedly be refined and some of the less well understood regions of the world will be brought into the global pattern. Even if the present model is incorrect the recent information from seismology, paleontology, geology, geomagnetism and bathymetric measurements have clearly put to rest many of the older models which still had support up to the present decade.

5.2 Continental Tectonics - Indian-Australian Crustal Plate

The foregoing discussion on global tectonics has shown that the tectonic mechanisms within the earth's crust are primarily confined to the narrow zones associated with the edges of the envisaged crustal plates. It follows then that the level of seismic activity for a given region will very much depend on the location of the region with respect to the boundaries of the plates and also on the type of boundary, that is, a fault system, a trench system, or a folded mountain system. Inspection of the world seismicity, Fig. 3, shows that the regions of Afghanistan are straddling the upper northwesterly corner of the massive Indian-Australian crustal plate. This important observation provides a fundamental insight into the tectonic and seismicity characteristics of the country. If the hypothesis of shifting crustal plates is a valid one then clearly the tectonics and seismicity of the regions of Afghanistan will be very much influenced by the movement of the Indian-Australian crustal block which in turn is governed by the nature of ocean floor spreading in the Indian Ocean. The strong evidence supporting ocean floor spreading will be considered in this report as sufficient to justify an interpretation and discussion of the tectonics of the regions based on the movement of the Indian-Australian plate.

The Indian-Australian crustal plate is well defined by the world seismicity data shown in Fig. 3. The boundaries of the plate are however also well defined by very definite physiographic features and these are shown in Fig. 4 which presents a map of that portion of the world encompassing the Indian-Australian block and its adjacent regions. As seen, the extreme easterly boundary of the plate passes through the length of New Zealand including the Kermadec and Tonga trenches on the north and the Macquarie Rise on the south. Within the New Zealand area the boundary is defined by the Alpine fault which according to H.W. Wellman[47], is a dextral transcurrent* fault. The southerly boundary follows the mid-oceanic ridges of the Indian Ocean from the Macquarie Rise to the Rodriguez fracture zone.

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*--A dextral transcurrent (strike-slip) fault is one in which the shearing forces produce a clockwise couple about the fault line when viewed from above; a sinistral transcurrent fault produces a counterclockwise couple.

This section of the ridge shows discontinuities in the fracture zones south of Australia and in the Amsterdam fracture zone, due south of Ceylon. From the Rodriguez fracture zone the western face of the plate follows the short section of ridge up to the Vema trench, and the Carlsberg ridge north to the Owen fracture zone. Although there is a continuation of the ridge physiography into the Red Sea the northwestern edge of the plate follows the NNE strike of the Owen fracture zone to the point where it disappears on the continental shelf of the Arabian Sea. From this point north the boundary of the plate becomes less well defined particularly in the Baluchistan areas of West Pakistan; this section however will be discussed separately after the other more well-defined boundaries are presented.

The northern end of the Indian-Australian plate contains the entire continental zone of northern India and it is the total length of the Himalayan mountain range which establishes the most northerly edge. From the eastern end of the Himalayas the boundary dips south following the strike of the Patkai Hills and the Arakan mountains in Burma. After passing through the Andaman and Nicobar Islands the northern edge becomes again very well defined by the great Java trench. From here the boundary appears to pass through New Guinea (Fig. 3), then through the New Britain and New Hebrides trenches and closes on the Tonga trench.

The only edge of the Indian-Australian plate which remains to be defined is the section which must link the northern end of the Owen fracture zone with the western end of the Himalayas. From Fig. 3 it is seen that this section is defined by a broad belt of earthquake activity which extends in width from the western edges of the Indus basin to the eastern regions of Afghanistan. The question to be considered is, are there any salient physiographical features in this region which could be defined as the boundary? Certainly the western edge of the Indus basin in the form of the north-south striking mountain ranges such as the Sulaiman Range (see Fig. 1) appears as a good possibility. However, in view of the northward movement of the Indian-Australian plate (to be discussed shortly), the required north-south boundary should be defined by a significant transcurrent fault system having a sinistral sense; that is, it must have the opposite sense to the dextral NS Alpine fault. Based on this premise, it seems very logical to select the well-known Chaman fault which strikes NNE and is sinistral in sense. This major fault has been carefully investigated by H.W. Wellman[47,48] and he has estimated the total length to be in the order of 800 km extending from 300 km north of the Arabian Sea to the Hindu Kush. The arguments supporting the Chaman fault are that (a) it has the proper sinistral sense; (b) it has the proper strike and actually lines up with the Owen fracture zone; (c) it has the appropriate large dimensions; and, (d) it separates two blocks of entirely different geology (see Sec. 4.2 and Fig. 2). The only argument against the Chaman fault, is that according to Wellman's investigation, it does not extend to the Arabian Sea as would be expected. There are however some en echelon fault systems to the east of the Chaman fault which run north to south and almost reach the Sea. It may well be that these secondary faults complete the system. In any event, because the arguments for the Chaman fault are strong, it will be assumed in this report that this fault does form the northwestern boundary of the Indian-Australian plate; however, in Sec. 5.3 and Sec. 9 some modification to this assumption will be presented.

The vast dimensions of the Indian-Australian plate along with its highly complex shape renders any mechanical analysis of its motion, at best, only an attempt. This plate, unlike the other major plates of the earth's surface, possesses all four types of boundaries; that is, (1) the ridge systems of the Indian Ocean, (2) the trench systems of the Java and North Australian regions, (3) the mountain systems of the Himalayas and those in Burma, and (4) the transcurrent fault systems of Afghanistan and New Zealand. Furthermore, the floor of the Indian Odean within the plate is not free of distortion but possesses some major formations, in particular, the Ninetyeast ridge and the Diamentia trench. Despite all these complicating factors considerable information about the movement of this plate has been deduced by X. Le Pichon et al[45] and a review of their research is worthwhile.

From magnetic anomaly measurements for five traverses over the mid-oceanic ridges, extending from the Owen fracture zone to east of the Amsterdam fracture zone, Le Pichon et al were able to determine the spreading rates of the Indian Ocean floor. The ridge points explored are identified as C, D, E, F and G in Fig. 4. The results, averaged over the last 10 million years, gave spreading rates* of 1.5 cm/yr for the Carlsberg ridge, an average of 2.3 cm/yr for the ridge sector between the Rodriguez and Amsterdam fracture zones and the higher rate of 3.0 cm/yr for the southeast ridge. Based on the rotational hypothesis for crustal plates, it would seem that this variation in the determined spreading rates is appropriate. Le Pichon et al put this to test by determining a pole of rotation based on the known strike of the fracture zones in the Arabian Sea and Gulf of Aden regions. The pole so determined was located at 26°N and 21°E with the antipode at 26°S and 159°W. By accepting the data produced by A.S. Laughton for the Gulf of Aden and Red Sea (the spreading rates from this paper are shown in Fig. 4 as points A and B) which showed a rotation of the Arabian Peninsula away from the African continent in the amount of 7° during the last 20 million years, spreading rates were calculated using the pole positions and compared with the measured rates. The agreement was surprisingly good for the ridges west of the Amsterdam fracture zone but the calculated rates were very low for the eastern ridges. The important conclusion drawn from this result is that although some error surely exists in the calculated pole position, the major discrepancy results from the fact that the angular rate of expansion is not uniform along the Indian Ocean ridges. The southeastern ridge appears to be spreading at a greater angular rate than the northwestern ridge.

The difference in observed spreading rates in the Indian Ocean is not without possible explanation. From Fig. 4 it can be seen that the northern sink counterparts facing the crustal sources of the ridge are of two types; in the west are the Himalayas, a folded mountain system, while in the east is the Java trench. Although there is little evidence to support this hypothesis it would seem that the unequal spreading rates possibly are as a result of less resistance offered by a trench system

*—It should be noted that these averages are quoted on the basis of the spreading rate of one side of the ridge away from the ridge; accordingly the rate at which the ocean floor is spreading would be twice the magnitude of these rates. It should also be noted that the spreading rates presented in Fig. 4 are relative to the ridge.

than by a mountain system. The only evidence in favor of this hypothesis is the very high, in the order of 5.0 cm/yr[42], spreading rate of the Pacific plate. In this case only trench systems are involved as sinks for crustal area.

Although the mismatch in angular spreading rates prohibits, at present, a simple and integrated description of the mechanics of the entire Indian-Australian crustal plate it does not prevent a local interpretation of the tectonics of the northwestern section. For this local consideration, the important result of Le Pichon et al is that ocean floor spreading along the Carlsberg ridge was established. In view of the strike of the Carlsberg ridge, this spreading will have the effects of rotating Africa away from Asia and the more important effect of thrusting the northwestern section of the Indian-Australian plate into continental Asia. The seismic zones associated with the Himalayas (schematically illustrated in Fig. 4) must be a manifestation of this thrusting. In particular the appearance of the triangular zone of shallow earthquakes with its base running concurrent with the Himalayas and being symmetrically arranged about a near-northeast direction imparts the impression that thrusting is indeed taking place. Although the primary result of this thrusting motion was to compress and fold the Himalayas and other nearby ranges, it appears now that owing to gravity considerations, the uplifting has reached the point where extensive overthrusting in the crust, well into the Asian continent (as far as Lake Baikal), is mechanically possible. The converging zone of the overthrusting in the shape of a triangle seems very appropriate from a mechanical viewpoint.

The average direction of the thrust of the northwestern section of the plate can be roughly established by either determining the direction of a perpendicular to the average strike of the Himalayas or by selecting a line which best bisects the triangular seismic zone. This has been done with the resulting direction of 30°E of north for the former and 35°E of north for the latter. Another method to determine the direction of thrust is to utilize the rotational hypothesis. In this case by sweeping a giant circle through the poles of rotation and through the Carlsberg ridge the thrust direction can be found by drawing a perpendicular to the circle. The results of this method yielded a direction of 31°E of north and this agrees surprisingly well with the above results.

The question of immediate interest is the local direction of thrust in the regions of Afghanistan which lie on the northwestern edge of the plate. For want of a better method it does seem reasonably correct to ascertain the direction of thrust as being parallel to the strike of the Owen fracture zone. This fracture zone demarcates the Arabian Peninsula plate* from the Indian-Australian plate. The world seismicity data (Fig. 3) and the research performed by C.W. Stover[49] on the seismicity of the Indian Ocean, indicates that the Owen fracture zone north of the Carlsberg ridge is seismically active over its length; this may be indicating that it is actually a fault system north of the ridge rather than a fracture zone. Regardless of this, the strike of the fracture

*--The Arabian Peninsula plate is also moving northeastward by sea floor spreading in the Red Sea. The Zagros mountains in Iran are a compressive mountain system analogous to the Himalayas.

appears to have a direction of 21°E of north which would imply that a similar thrusting direction would extend into the regions of Afghanistan. The strike of the Chaman fault, which has the shape of a gentle Z, has possible thrusting directions which vary from near due north to 35°E of north. For the moment little significance can be attached to this but it will be further discussed in Sec. 5.3. The important fact is that the direction of 21°E of north correlates very well with results obtained by A.R. Ritsema[50] who has performed extensive fault plane solutions for the earthquakes originating in the Hindu Kush center (36.5°N, 70.5°E). The salient conclusion reached in this study was that the principle direction of thrust for the intermediate-depth earthquakes was approximately 19°E of north. The agreement is excellent and it gives strong support to the fact that the earthquake activity in Afghanistan is very much related to the continental tectonics of the Indian-Australian crustal plate.

The existence of the Himalayas as a compressive zone created by the thrusting of the Indian-Australian plate and the opposing force produced by the Asian continent appears to be well established. The phenomenon of the occurrence of intermediate-depth earthquakes confined to the upper corners of the plate, as shown in Fig. 4, must be related with this general NNE thrusting but the mechanism requires a more sophisticated analysis in order to produce a plausible explanation. A number of investigations have been directed to this problem of deep earthquakes in the Hindu Kush with the most complete analysis being made by Ritsema[50]. Rather than discussing this interesting phenomena at this point it will be more appropriate to reserve further comment until Sec. 8.2 wherein a detailed seismicity analysis of the Hindu Kush intermediate-depth earthquake zone will be presented.

Before ending this discussion on recent continental tectonic patterns it seems appropriate to include a brief review of the envisaged continental movements in the southern hemisphere from lower Mesozoic times forward. The following description of the paths followed by the continents is according to the interpretations of Le Pichon et al[45] and Heirtzler et al[42] and is based primarily on magnetic anomaly data.

In lower Mesozoic possibly Permian (200 million years plus) the breakup of the super continent known as Gondwanaland was started. This massive continent, straddling the southern pole, included Africa, South America, India, Australia and Antartica. The first stage of the breakup was the separation of the Africa-South America block as a result of spreading about the southwest branch of the mid-Indian ridge. This spreading continued until lower Cretaceous and probably also included the initial separating phase of South America from Africa. From Cretaceous onwards it appears that very little or no further spreading has occurred in the southwest ridges of the Indian Ocean.

The second major phase of spreading involved the separation of India and New Zealand from Gondwana in upper Cretaceous (80 million years) and also further separation of South America from Africa. During this period India drifted northward by the effect of sea floor spreading about what are probably now subsided ridges of the Indian Ocean. The large fracture zones in the southwest floor of the Indian Ocean mark the locus of the west coast of India during this northward movement.

The third major phase of sea floor spreading was initiated during late Eocene (40 million years) and this marked the commencement of rapid spreading about the northwest and southeast branches of the mid-Indian ridge. This third phase completed the breakup of Gondwana with the separation of Australia from Antartica. During this period of rapid spreading the Indian continent came in contact with the Asian continent and the first large orogenic phase of the Himalayas occurred. In upper Oligocene or lower Miocene (30 million years) the spreading of the north-west rdige greatly slowed or ceased. This period marks the peak phase in the Himalayan and Hindu Kush orogeny. (This time scale agrees very well with the geological evidence presented in Sec. 4.2.) The slowing or cessation of spreading probably resulted from a temporary matching of the resistive forces in the Asian continent to the thrusting forces of the Indian block. It appears that this near static situation was overcome during very late Miocene (10-15 million years) when sea floor spreading about the northwestern ridge again resumed its former speed. This latest stage of spreading has continued at nearly constant rate to the present and it is of course one of the major sources promoting the seismic activity in the regions of Afghanistan today.

5.3 Regional Tectonics

The analysis of global and continental tectonics has set the stage for discussing the localized tectonic patterns in Afghanistan. It seems clear that the movement of the Indian-Australian crustal plate which is thrusting NNE along the eastern regions of Afghanistan, as demarcated by the Chaman fault, will be the dominant factor governing tectonic processes and promoting seismic activity in the eastern portions of the country. The rotation of the Arabian Peninsula away from the Red Sea, mentioned briefly in Sec. 5.2, will be the dominant factor affecting the tectonics of Iran proper and possibly the southwestern portions of Afghanistan. The coupling of these two continental movements and their interaction with the stable Asian mass in the north establishes the framework within which all localized tectonic mechanisms in the regions of Afghanistan must be set.

The approach to discussing the local tectonic patterns will be to present first the available information on the visible fault systems existing in the country. Mapped fault lines which appear on the surface of the earth along with data about their sense of movement are the keys which reveal the existence and nature of localized tectonic processes. Following the presentation of the known fault system in the country, the overall tectonic patterns of the region will be assessed.

5.3.1 Fault Systems

The fault systems which traverse Afghanistan have been identified through various geological and aerial photographic surveys. In the regions where extensive and detailed geological investigations have been performed[35,37], the faults have been mapped in great detail; this type of mapping of course does not exist for all the regions of the country. The present discussion however is not concerned with precision mapping of any one fault but rather only with the general location of a fault, its strike, its length, the sense of the motion about the fault and if the fault has been active in recent times. For this purpose two sources of information are relevant. The first is the recent 1969 geological map of Afghanistan (Fig. 2) and the second is the map of active faults prepared by H.W. Wellman[48]. The latter was compiled from data quite independent of the geological information used for the construction of the geological map. The following discussion is based on the information presented from these two sources.

The fault systems as depicted in the geological map have been reproduced in Fig. 5 for clarity purposes and for ease of comparison with the results provided by Wellman. The existence and location of the faults as shown in Fig. 5, have been established by on-the-ground geological surveys and aerial photo maps. It is clear from Fig. 5 that the fault systems extending through the country form a complex pattern. The predominant trend is in the SE to NW direction and aligns with the strike of the major mountain systems. In the central portion of the country, the second major trend is the narrowly confined Hari Rud system which extends to the western extremity of the country along a nearly EW strike. Between these two systems, in the central-western portions of the country, lesser fault lines having directions varying between the two major trends, are found. In the north-central sections a series of nearly EW faults, originating from the northern flanks of the Hindu Kush, are evident in the Sayghan and Ajar regions. Further west of these systems the fault patterns become erratic and sparse, disappearing altogether in the north near the basin areas of the Oxus River. Known fault patterns are also lacking in the southern regions of the country. The deep quaternary deposits in the north and south of the country of course prohibit the identification of faults if they should exist in these regions.

The major and most extensive fault shown is the Chaman fault which extends from the southern border to the southern flanks of the Hindu Kush. To the east of this fault there are almost no fault systems shown in the southern sectors. To the east and south of Kabul a number of NW striking fault lines, through the Nuristan mountains and the Kunar Valley, appear. The junction of four fault lines just west of Jalalabad is an unusual pattern and suggests a complex tectonic process.

Although the information provided by the geological map is valuable for the present study it does not provide any information about the nature of the faults; that is, whether they are strike-slip (transcurrent or also wrench), dextral or sinistral faults which involve primarily horizontal displacements or, of the dip-slip type, either normal or thrust (reverse), which involve primarily vertical displacements. Without this information, interpretation of the tectonic patterns is near impossible. For this reason the investigation and results produced by Wellman which include data on the displacements of some of the faults provides a very significant contribution to the subject.

Wellman's investigations[48] were performed during 1964 and were based almost exclusively on the use of air-photo-mosaics to identify the active transcurrent fault systems for the regions of Pakistan, Afghanistan and Iran. These photos, when magnified and viewed under stereo, provide exceptional detail which is not possible by inspecting ordinary aerial photos. Although this method of mapping fault lines is only effective for identifying faults which have primarily strike-slip components, it is on the other hand the most reliable method for this purpose. Dip-slip faulting is readily identifiable by vertical displacements of the topography which provide easily recognized reference surfaces but, it is extremely difficult if not impossible to detect and describe strike-slip faulting by field surveys. To establish horizontal displacements, geological reference lines are required and these are usually only recognizable from aerial photos covering broad regions. The reference lines which are sought in order to establish displacement and the sense of displacement are varied and depend on the amount of displacement involved or in other words on the length of time that the fault has been active. For movements of 5 mm to 10 meters, occurring during the last 100 years, man-made features such as the offsetting of railways, roads, walls and rows of trees are acceptable reference lines. Movements of 1 meter to 1 km which have taken place during the last 100,000 years, are most easily identified by trailing streams, ridges and terraces. Greater displacements of 2 km to as much as 700 km, dating from mid-Pleistocene to Jurassic, are established by geological matching of rocks and boundaries displaced along the opposite sides of the fault. Another identifying feature of strike-slip faults is that they are usually quite straight and are generally much longer than dip-slip faults which are primarily arc shaped. Topographical linear features on aerial photo maps are quite often active transcurrent fault lines.

With the techniques described above, Wellman identified and mapped the active transcurrent fault systems for the regions of Afghanistan. From the small map appearing in Wellman's paper the faults were carefully replotted and the results are presented in Fig. 6. The fault lines are represented according to size and quality of identification; the heavy lines correspond to the major active faults, the intermediate lines to lesser active faults, the light lines to minor active faults or lineations, and the dashed lines to uncertain faults. The overall appearance of the fault patterns agree reasonably well with the geological map as shown in Fig. 5; but there are some very notable differences. A comparative discussion will be given after the following detailed analysis of Wellman's data.

As illustrated in Fig. 6, Wellman identified three major fault lines; these are, the Chaman fault, the Herat fault and the Andarab fault. These will be discussed separately.

Chaman Fault:

Wellman traced this major fault of 800 km length, from the point where it first appears just west of Charikar to the point where it disappears in Pakistan about 300 km north of the Arabian Sea. An extension of the fault, from Charikar north to just west of Jabal-us-Siraj where it joins the Herat fault, has been inferred. In its NW traverse the fault passes between Kabul and Paghman and runs just east of Ghazni. As seen the fault is concave to the west in the north and concave to the east in the south with an inflection point (32.3°N, 67.5°E) occurring at about the mid point of the fault; this point coincides with the start of a spur fault which has special significance and will be discussed shortly. Wellman observed that north of the inflection point the Chaman fault and parallel branch faults are upthrown on the western side, which indicates that there are appreciable dip-slip components associated with the northern portion of the Chaman fault. In the south around the town of Chaman, from which the fault derives its name, the converse is true; that is, the eastern block is upthrown. According to Wellman[47] this is a common observation for most major transcurrent faults. These faults always take the shape of an S or Z and the regions on the concave sides of the ends of the faults are usually upthrown with respect to the blocks on the convex sides.

The sense of displacement for this fault was based primarily on trailing streams showing well defined S's. The offsets of these streams (south of the inflection point) varied from 20 meters to 1,000 meters along the fault with the displacement being such that the east block moved north relative to the west. This clearly establishes the fault as sinistral. By a comparison of displaced Tertiary rocks across the fault, Wellman has estimated a total displacement of roughly 500 km and this gives an estimated rate of movement of 1.5 cm/yr[47]. This is an important result because the rate of spreading of the Carlsberg ridge (Fig. 4) was found to be 1.5 cm/yr. This agreement greatly strengthens the hypothesis made in this report that the Chaman fault demarcates the northwestern edge of the Indian-Australian plate.

Herat Fault:

The fault has been traced for a total length of 1,100 km and is the longest in the country. It first appears just east of the Iran border and strikes nearly due east, passing about 10 km north of the city of Herat and hence the name. The fault passes through the lengths of the Hari Rud and Ghorband valleys, joining the Chaman fault at Jabal-us-Siraj and then turns more northward passing through the Panjshir valley. The fault has been identified to almost the village of Zebak at the start of the Wakhan. It may well extend beyond this point for another 400 km according to Wellman. The fault has the shape of an S, being concave to the north in the west and concave to the south in the east. The inflection point occurs at the upper end of the Panjshir valley at about 35.5°N and 70°E.

From trailing stream data near the inflection point, displacements of 60 to 100 meters in the dextral sense were clearly observed. Trailing streams were also identified on the section of the fault east of

Herat and dextral displacement established. Some dip-slip components were observed in the Panjshir region but the evidence compiled by Wellman establishes the Herat fault as a major transcurrent dextral fault. It is estimated that the displacement is at the rate of 1 cm/yr[47].

Andarab Fault:

This fault is shown in Fig. 3 as three distinct segments which are all nearly colinear and strike EW between the 36° and 35° north latitudes. Although Wellman does not show a connection with the Herat fault in the east, the geological map (Fig. 5) does and furthermore maps the fault as continuous. Wellman named the fault after the town of Talemazar (unfamiliar to authors) but since the fault clearly originates in and follows the Andarab valley, it has been renamed in this report as the Andarab fault. The length of the fault is nearly 300 km and based on trailing streams, the central portion of the fault shows dextral displacements of 25 meters.

Two other but less major faults were identified by Wellman, along which displacements and sense could be established with reasonable accuracy. Both have significance as related to the tectonics of the region and so will be discussed.

Uruzgan Fault:

This fault strikes primarily SW nearly bisecting the region between the Herat and Chaman faults. Wellman referred to this as the Darafshan fault (name unfamiliar to authors) but because the fault passes near to the town of Uruzgan it will be referred to as the Uruzgan fault in this report. The fault runs for a distance of 300 km and again by identifying trailing streams the fault was established as sinistral with displacements of about 150 meters.

Gardez Fault System (Chaman Spur Fault):

In Wellman's investigation he identified the existence of a spur fault bifurcating from the east side of the Chaman fault and striking nearly northeast. Although he identified it by trailing streams as being sinistral, he attached no further significance to it; however, this fault does have special significance for the present seismicity study. It will be seen in Sec. 9 that the recorded earthquake data when plotted follows this spur fault and its extension north, rather than the Chaman fault proper. From Fig. 6 it is quite possible to detect the extension of the spur fault as being composed of a series of segmented faults passing between Kabul and Jalalabad and all having the same NNE strike.

The last segment of the spur fault system, starting just north of the Kabul River, is particularly straight and joins the Herat fault at 36.2°N and 71.2°E. This observation also has important implication because the center of intermediate-depth earthquakes is found in this region. This result suggests that it is the Chaman Spur fault which acts as the major demarcation of the northwestern corner of the Indian-Australian plate from the Chaman fault inflection point north. In support of this hypothesis it should be noted that Wellman detected very little evidence of recent sinistral displacement along the Chaman fault north of Ghazni. Further evidence and discussion related to this hypothesis will be presented in Sec. 9.

In this report because the Chaman Spur fault and its extensions running north, align in such a way that the resulting strike passes very near to the city of Gardez, the entire system will be identified and referred to as the Gardez fault system.

In Fig. 6 several other significant faults are shown but displacement data is not available. For this report, these faults have been given names for ease of discussion. The assignment of names is based primarily on the location of the fault with respect to important cities or towns. In this category, as shown in Fig. 6, are the faults of Jurm, Urgun, Baghran, Farah and Pashtun Kot. Although not indicated as important according to the legend, the fault running up the Kunar valley has been named the Kunar fault in view of its importance as shown on the geological map and based on the established seismic activity to be presented. Any major fault lines lying outside of the country have not been named.

As previously mentioned, the fault systems represented in Figs. 5 and 6 have an overall agreement in appearance but, in detail they do differ. The fault trends as shown on the geological map are generally composed of disconnected segments as compared to Wellman's mapping. In this regard Wellman's survey is superior and understandably so. His procedure of identification was very broad and this allowed him to establish overall trends not recognizable in field surveys. Between the two maps there is excellent agreement on the location of the Chaman fault and its extent. For the Herat fault the geological result presents a far more complicated pattern than the single system shown by Wellman. Regardless the trends do agree. The most notable difference appears in the north and eastern portions of the country. In the Badakhshan region the geological map shows a complex fault pattern striking NNE whereas Wellman presents a simpler system with some EW striking faults. In the Kunduz, Mazar-i-Sharif and Maimana strip, Wellman has located many faults which do not appear on the geological map. This is also true for the eastern sector of the country. East of the Chaman fault virtually no faults are shown on the geological map but on Wellman's map this region is well covered by NE striking faults and in particular, the Urgun fault. Wellman also shows the faults in the center of the country as generally continuing further south than illustrated on the geological map. The geological map however does show a group of parallel en echelon faults just south of the Andarab fault which do not appear in Fig. 6.

The differences between the fault systems as presented by the two maps primarily results from the more thorough and directed study performed by Wellman. Certainly his method of mapping the faults had never before been applied and he was able to ascertain many faults which could not have been identified by other methods. The fault lines which appear only on the geological map are probably pure dip-slip faults and these of course are not detectable with Wellman's technique.

It is not the object of this report to ascertain the correctness of the fault systems as either determined by the geological surveys or by Wellman; certainly further field investigations are needed to achieve this. The first concern of the present report is only to compile all information available on the fault systems of the region and thereby perform the best possible seismo-tectonic analysis. For this purpose the approach will be to use Wellman's data and augment it with any major fault system shown on the gological map and not detected by Wellman. This will be presented in Sec. 9. The second objective is to determine if any overall regional tectonic pattern can be inferred from the fault line systems. With the present state of knowledge, that is, where the displacement sense of only a few fault lines are known, and in view of the complexities of the region, the development of an acceptable tectonic pattern will require much more research. Regardless, sufficient information does exist to allow the postulation of some preliminary models and this will be discussed in the following section.

5.3.2 Proposed Tectonic Patterns

The most comprehensive tectonic model proposed for the regions of Afghanistan was by Wellman in the same paper[48] in which he presented the fault systems. From the broad survey covering Pakistan, Afghanistan and Iran, Wellman established that the Dasht-i-Lut depression in eastern Iran, was behaving as a contraction center, towards which all regional crustal blocks west of the Chaman fault were moving. This was deduced by observing that the major transcurrent faults (Chaman excepted) had the appearance of spiralling outwards from the Lut center. By sketching a series of lines which effectively indicated the directions of maximum horizontal stress (at 45° to the strike of pure transcurrent faults) a spiralling pattern was obtained which converged at the Lut center (30.5°N, 59°E). In this demonstration it was seen that dextral faults spiral outwards clockwise and sinistral, counterclockwise; it was also observed that four sectors, centering on the Lut center, could be defined in which all faults within a sector were of the same sense. In this analysis the NE and SW sectors were dextral and the NW and SE sectors were sinistral. The eastern sectors were divided by a line passing just south of the Herat fault and if Wellman's hypothesis is valid it implies that all transcurrent faults north of the Herat fault are dextral in sense and all faults south sinistral (the Chaman, Uruzgan and Andarab faults fit this pattern).

Wellman's postulation about the existence of a contraction center as the hub of the regional tectonic patterns is an interesting model. The question which arises of course is, does this model fit into the global and continental tectonic patterns discussed in Secs. 5.1 and 5.2? Although based primarily on conjecture, the following continental pattern will be submitted as a possible tectonic mechanism to complement Wellman's regional model.

From Wellman's investigation it appears that it may be possible to define a sub-continent crustal block, containing the regions of Iran, Afghanistan and Pakistan and delineated by transcurrent fault lines. The block being postulated is demarcated by the Chaman and Gardez sinistral faults for the western edge, by the Herat dextral fault as the east section of the northern edge, by the Sharud sinistral fault running the strike of the Alborz mountain range and around the base of the Caspian Sea, as the west section of the northern edge, and by the Zagros dextral fault which runs southwest, parallel, but north of the Zagros mountain range. The latter fault forms the southwestern edge of the block. According to Wellman's regional map there are numerous secondary faults which strike west from the Chaman fault and may serve as suitable extensions to complete the boundaries of the block. The block thus envisaged has the shape approximating a thick irregular-shaped crescent, with the concave face north and the convex face south. A very similar sub-continental block has been used by W.J. Morgan[46] for the regions of Iran, Afghanistan and the extreme western section of Pakistan.

If the crescent shaped block described above is realistic, then the block is essentially acting as a buffer block between the stable Asian mass on the north and the two northward movements of the Indian-Australian crustal plate on the southeast, and the Arabian Peninsula block on the southwest. In such a position it is very clear that this sub-continent crustal plate will be in a state of compression and in this regard Wellman's postulation of a contraction center fits well.

The exact manner by which the surrounding continental crustal plates are compressing this, essentially, Iran-Afghan block, is of course not a simple problem. From the sense of displacement of the transcurrent fault lines defining the edge of the block it can be inferred that the compression is one of forcing the tips of the crescent inward towards each other. To support this point a possible physical mechanism will be proposed. For this purpose consider the crescent tip situated in Afghanistan and defined by the junction of the Herat and Gardez faults. To the east of the Gardez fault, crustal material is moving in roughly a NNE direction in sympathy with the spreading of the Carlsberg ridge. As this material is thrust into the corner formed by the Hindu Kush and Himalayan ranges a severe compression pocket is created. Because the Himalayan range is immensely more massive than the Hindu Kush the relief of this compression pocket will be one of movement parallel to the strike of the Himalayas or perpendicular to the Hindu Kush strike and hence the mechanism for forcing the crescent tip westward. It should also be stated that thrusting, perpendicular to the Hindu Kush will promote considerable buckling and uplifting and the transcurrent faults should exhibit considerable dip-slip components. It is interesting to note that in Ritsema's fault plane solutions for earthquakes in the Hindu Kush[50], he found that the direction of maximum stress for shallow earthquakes was indeed perpendicular to the strike of the Hindu Kush.

The postulation of the existence of an Iran-Afghan crustal block in the shape of a crescent and being compressed by the surrounding continental plates is a plausible tectonic model for the information available. The argument for the tips of the crescent being forced towards one another is also reasonable and is in keeping with Wellman's contraction-center hypothesis and Ritsema's calculations. The fact that the observed seismic activity as will be shown is very much confined to the edges of this block and particularly the regions surrounding the tips of the crescent adds further credence to the model. The lack of notable seismic activity in the center of the block around the Sistan and Dasht-i-Lut regions would seem to be an expected result. It may well be that the plate has some rotation and this would complicate the situation considerably. For the present, in view of the existing data, it is felt that the proposed tectonic mechanisms of an Iran-Afghan crustal block is a reasonable model.

The report to this point has developed in detail, the tectonic patterns from global to continental to regional and has attempted to bring together all information in order to establish the best possible concept of the regional tectonic processes. Although much remains to be done in this area the present tectonic analysis nevertheless is very significant and will greatly enhance the interpretation of the earthquake and seismicity data presented in the following sections.

6. EARTHQUAKE HISTORY - NON-INSTRUMENTAL (INTENSITY) DATA

6.1 Introductory Remarks

The investigation of the earthquake history of any region must be based on all available earthquake information. This information can be classified into two major categories; namely, instrumental and non-instrumental. Instrumental data is defined as that information produced by seismological instruments, that is, information recorded by seismological observatories. This type of data is quantitative in nature and gives the time, location and size of an earthquake; in seismological terms this is expressed as the origin time, the hypocenter and the magnitude of an earthquake. If such information is available for a given seismic event then the source or the cause of the earth's vibrations is reasonably well specified. The accumulation of earthquake instrumental information is essential to acquiring an understanding of the seismicity and earthquake risks of any region. All such instrumental data related to the regions of Afghanistan, has been compiled for the time period of 1893 to 1969 and this will be presented and discussed in Sec. 7.

The second category, non-instrumental data, is defined as that information which is concerned with the effects produced by an earthquake; these are based solely on human observations. The effects are primarily associated with (a) the sensations experienced by humans during an earthquake, (b) extent of damage to man-made structures, and (c) geological phenomena such as surface fracturing, landslides, etc. In seismological terms this type of information is referred to as intensity data or felt data. It should be noted that because this data derives from human observations it is only qualitative in nature, and furthermore, the quality or accuracy of the data is very much related to the observational capabilities of the individual and in most cases the reporting individuals do not possess scientific backgrounds. Regardless, intensity data whether recorded by trained observers or by laymen, provides valuable information which greatly augments the understanding of the seismic activity of a region.

The major importance of intensity data is twofold. In the first place intensity information can be used to identify the occurrence of an earthquake when instrumental data is not available. Before the existence of seismological observatories, that is, prior to the 20th century, intensity data was the only source of earthquake information. Actually for the greater part of the last 70 years, owing to the sparseness of active seismological observatories, intensity data continued to be the only type of information available for many regions of the world. Even today, when the number of operating world observatories has increased to over one thousand, the occurrence of some earthquakes is still only determined by human observations. The 1969 earthquake damage in Rustak, illustrated in the frontispiece of this report, is an example of the occurrence of a recent earthquake for which there was no instrumental epicentral determination. When earthquake events are established by intensity data the location of the energy release is not precisely known unless the effects are very localized or the earthquake is shallow and of such proportions that surface faulting occurred. Usually, documented historical earthquakes were of major proportions so that the region affected can be closely identified and hence the location of the earthquake center reasonably well defined.

The second and more important value of intensity data is that it establishes some understanding of the level of damage which can be expected to occur in a given region. Certainly such information is invaluable to the problem of assigning seismic risk zones for a country. Intensity data becomes particularly valuable when it can be related to known instrumental data. The correlation of cause and effect when possible provides a very complete interpretation of a seismic event. If such analyses are possible for a large number of events within a region it then becomes possible to establish very realistic seismic risk zones and well-tailored building codes can be devised. Unfortunately up to the present, this optimum condition does not exist for any earthquakes which have occurred within Afghanistan. It will be presented shortly that a significant number of the recorded earthquakes have been identified by both instrumental and non-instrumental data but the problem is that the effects are usually based on several or less observation points. Although this small number of intensity reports per earthquake has value the ultimate situation is to have intensity reports from a great number of locations uniformly distributed about the hypocenter. During the past two years the Seismological Center has initiated a project to collect intensity data on a country-wide basis but considerable time will be required before this produces a significant amount of data. For the present, the analysis of earthquake effects and seismic risks must be based, as best as possible, on the available scattered observations from past earthquakes.

As discussed, intensity or felt data in its raw form is a collection of human observations. In order to perform a quantitative analysis of the effects of an earthquake it is convenient and actually necessary to reduce the raw data to a more manageable form. For this purpose intensity scales have been established by which the effects experienced by man are categorized into well-defined levels ranging from minimal human sensations to catastrophic proportions. A number of intensity scales based on experience have been proposed and are in existence throughout the world. One of the most commonly used scales is the Modified Mercalli Scale devised in 1931 and it is this scale which will be adopted in this report. An abridged version, and actually somewhat rewritten by Richter[30] in 1956, is included in App. A of this report for reference purposes.

The Modified Mercalli Scale is divided into twelve grades of intensity and the grades are assigned Roman numerals from I to XII. (The adoption of Roman numerals has been incorporated to avoid confusion with the earthquake magnitude scale.) The first grade of intensity corresponds to effects detected only by seismic instruments. The second level is one where only people situated in favorable conditions, such as upper floors, would feel the disturbance. From this level the intensity ratings increase to the level VI, where the sensations are of frightening proportions and poor construction develops cracks. With higher grades the level of damage increases and at rating IX there is general panic, poor construction is totally destroyed, and well-built structures sustain considerable damage. The maximum intensity rating is reserved for the situation where destruction is total, that is, all types of structures regardless of the quality of construction are destroyed.

It should be noted that intensity is very much a function of ground acceleration but it is known that damage to structures is also a function of the amplitude of the ground motion and the length of time that the ground vibration continues. Despite the latter point, attempts have been made to convert the qualitative non-instrumental intensity data into quantitative acceleration terms. Several empirical relations have been proposed and the following equation, according to Richter[30], is a reasonable relation:

$$\log a = \frac{I}{3} - \frac{1}{2}$$

where I is the Modified Mercalli intensity expressed as a numerical number,

and a is the ground acceleration.

For $I = 1.5$ the above equation gives an acceleration of 1 cm/sec^2 which is about the threshold level of acceleration for human detection. With an intensity rating of 7.5 the corresponding acceleration is approximately 10 percent of gravity and this is recognized as the level which begins to produce significant damage in poor quality structures. The intensity-acceleration equation is certainly open to question but it does convey some quantitative feeling for the non-instrumental intensity scales.

The scope of this section of the report is to present all the known earthquake intensity data that could be found for the regions of Afghanistan. This history of non-instrumental earthquake data is summarized chronologically and where possible the raw data has been interpreted on the basis of the Modified Mercalli Intensity Scale. The assignment of intensity grades is necessary in order to standardize the data and thereby provide the opportunity for a regionalization of the country on the basis of intensity zones.

6.2 Sources of Intensity Data

The most obvious and direct approach to investigating past earthquake activity on a non-instrumental level in a given region is to perform a careful review of all issues of local newspapers. Newspaper files are usually maintained in the public libraries and these are the primary sources of information. In the present study the facilities of the Kabul Public Library were used extensively. Unfortunately, in Afghanistan, the publication of newspapers has existed for only a relatively short time in comparison to other countries. The first Afghan newspaper, Shams al-Nahar, appeared during the reign of Sher Ali-Khan but continued publication for only three years from 1866 to 1869. Following this no newspaper was published until 1905 when a lithographed paper, Siraj al-Akhbar, was started but this lasted for less than a year. In 1911 Siraj al-Akhbar was restarted using the first printing press in the country and continued publication until 1918. The next newspaper, during the reign of Amanullah, called Aman Afghan was printed from 1919 to 1925. In 1928 the Anis newspaper was started and this was followed in 1929 by the Islah newspaper; both these publications have continued since that time.

For the present investigation it was not possible to locate the 19th century Shams al-Nahar newspaper. Copies of this newspaper are extremely rare and probably exist only in the British Museum or in India. The first available newspaper which could be researched was the 1911 to 1918 Siraj al-Akhbar (designated Ref. 51) and several earthquake events were found. From the available copies of Aman Afghan no articles pertaining to local earthquakes were uncovered. Anis and Islah (designated as Refs. 52 and 53 respectively), although a number of issues were missing from the early years of publication, produced the bulk of the intensity information for this report from 1928 through 1969. In total, nearly 100 years of newspapers were gleaned for earthquake articles.

For the years of 1928 to 1944, the other major source of intensity data was Stenz's work[22]. Stenz resided in Afghanistan during 1939 to 1944 and made many personal observations during that time; but he also had access to earlier manuscript notices about earthquakes at Kabul. These were prepared by Dr. W. Iven and the Rev. E. Caspani for the years 1927 to 1932 and 1934 to 1936 respectively. It was not possible to locate these manuscripts and it has been necessary to accept Stenz's gleaning of these articles as being complete and accurate.

Following 1944 the only other source of intensity data is the intensity records maintained by the Seismological Center (designated as Ref. 54). These files were started in June of 1968 but regretably owing to vandalism, the records which included roughly 25 felt earthquakes, were lost. Consequently only some of the major important events for which some of the details could be reconstructed appear in this report.

Prior to 1928 the sources for earthquake information become more varied and less direct with the notable exception of the scientific paper by M.R. Furon[27] (1923 to 1924) and of course the Siraj al-Akhbar newspaper. For earthquake events dating from the 16th century to the first quarter of this century, the major information source was the British Residency Library in Kabul where an excellent collection of historical books pertaining to

Afghanistan have been assembled. As discussed in Sec. 2, the books written by the 19th century soldiers, political envoys and travellers, who had sojourned in Afghanistan at various periods of time, provided many excellent details of earthquake activity. Most notable of these are the accounts of Lady Sale[13], Lieut. Eyre[14] and others, who personally experienced the great earthquake of 1842. These personal narratives are exceptionally unique and singular; for this reason it has been deemed appropriate that some of the original descriptions of the 1842 earthquake should appear in this report. Appendix B, entitled, "Important Historical Earthquake Narratives", reproduces some of these classical 1842 accounts. In a similar category, but predating the English articles by more than three centuries, the narratives of Emperor Babur[6], who personally observed the catastrophic earthquake of 1505, has also been included in App. B.

Sources for seismic information preceding the 16th century are indeed rare and before this present research there was no known evidence of earthquakes in Afghanistan before Babur's time. This investigation, however, as already presented in Sec. 2, uncovered a scientific translation[7] of a 15th century Arabic manuscript written by Jelal-ed-din As-Soyuti in which he compiled a listing of ancient earthquakes in Southwest Asia. This document extended the earthquake history of the country to the year of 818 A.D. The oldest source of earthquake intensity data, however, is the archeological excavations of the ancient Greco-Bactrian city at Aikhanum. Through the evidence supplied by the Delegation Archeologique Francaise en Afghanistan, earthquake damage dating to the period of 50 B.C. to 50 A.D. has been identified with reasonable certainty. This has been discussed in Sec. 2 and will be treated further in Sec. 6.4.

From these various sources for earthquake intensity data an extensive catalogue of earthquake intensity reports has been compiled; this is presented in the next section.

6.3 Chronological Catalogue of Earthquake Intensity Data

One of the primary objectives of the present research was to perform as complete an investigation into the seismic nature of Afghanistan as possible. It was also considered paramount that the information uncovered should be documented in detail so that related investigations which follow would have a convenient and complete reference; also, so that if improved interpretations of the seismic risks are to be undertaken at a later date such analysis will not have to repeat the tremendous undertaking of surveying all the raw sources of earthquake information. In keeping with these objectives a detailed and thoroughly documented table of all earthquake intensity information has been included with this report. This non-instrumental earthquake history is compiled in Table C1 of App. C in the form of a chronological catalogue of earthquake intensity data.

A complete description of the format of Table C1 is presented under "Explanatory Remarks" in App. C. Some important aspects should however be emphasized. The terse accounts given under "Effect" are abridged versions of the original accounts; these have been composed by the authors with the intention of communicating the salient facts accurately, but briefly. The estimated Modified Mercalli ratings are based on the documented effects and are according to the description of the Modified Mercalli Intensity Scale presented in App. A. With the exception of those entries taken from Stenz[22] and Furon[27] the estimated intensity ratings are based exclusively on the judgment of the authors. An important feature of Table C1 is that the related instrumental data has been brought forward from App. D and included in the right-hand columns. This matching of intensity data with instrumental data has been done in order to provide a convenient correlation between cause and effect. It should be noted that the local times listed in the original intensity reports have been converted into Greenwich Mean Time (GMT). All times shown in Table C1 are GMT.

In the many references which have been used to support this report a common shortcoming is that names of places are presented with no identification given. If the location of a place is not known, then the intensity report has no value whatsoever. In order to avoid this situation, an extensive effort has been made in this report to identify all names of places which are mentioned. This has been accomplished by locating all major places on the map of the "Regions of Afghanistan" (Fig. 1), and by the inclusion of a Gazetteer at the end of App. C which lists and identifies all the minor or less significant places.

One final point with regard to the construction of Table C1 concerns the nature of the raw data. The assignment of correct dates and times from the newspaper articles is by no means a straightforward process. In many cases the events are reported well after the fact ranging from one, to seven days or even more. Careful analysis was required to determine the correct dates and times from the often loosely written newspaper articles. Furthermore it was also necessary to convert the Mohammedan calendar dates to the Gregorian calendar and this caused considerable trouble owing to an official change in the number of days of two months in 1958. Every effort was made to ensure the accuracy of Table C1, but there may well be some errors which have evaded the attention of the authors.

To anyone familiar with the subject and aware of previous investigation into the felt earthquakes in Afghanistan, it will be clear that the earthquake events listed in Table C1 greatly extends the known past earthquake activity in the country. In total, Table C1 lists nearly 500 earthquake events. The maximum recorded events prior to this research was 149 as compiled by Hosseini[34]. This latter research, however, only included events up to 1958 but in comparison, the present study for the same period of time has documented 334 earthquakes which is more than double. In comparison with Stenz's work[22], which to date was the only other investigation into the early earthquake history of the country, the present research has expanded the available information both in time and numbers. The earliest known event previously was the Paghman earthquake of 1505; however, if the Aikhanum event is accepted, then known earthquake activity in the country has been extended by 1500 years. Prior to the 20th century, Stenz listed only 6 earthquake events in the region whereas Table C1 documents 59 events. It is quite possible that Stenz elected not to list all the earthquake events recorded by Lady Sale in 1842, but even on this basis, Table C1 presents 25 events, 19 more than Stenz.

It is quite impossible to draw attention to all the interesting aspects of the intensity data presented in Table C1. In an effort to highlight some of the overall features, Table C2, which is a summation of Table C1, has been included in App. C. This table presents the temporal distribution on a monthly and yearly basis for all the reported felt and damaging earthquakes in the country. Owing to the sparsity of early data prior to 1922, many of the years have been lumped together. The detailed reports of Lady Sale in 1842 and Furon in 1923 and '24 are the reasons for the large number of events appearing in those years. Certainly 1842 was an active year but 1923 and 1924 were not unusual. After 1924 there appears to have been a lull in seismic activity up to 1928 but this probably is more a result of a lack of available reports. During the years between 1944 and 1947 there is a definite absence of major seismic activity in the region; this observation is also confirmed by the instrumental data presented in App. D. During 1947 to 1952, seismic activity increased somewhat but not greatly. This was followed by a very quiet period from 1952 through to the first half of 1956 when the country was jolted by the great Kahmard-Sayghan event which was obviously the most significant earthquake to occur within the country during this century. The 80 events documented during the second half of 1956 is without parallel. The gradual fall off in seismic activity in the subsequent years of 1957 to 1959 reflects the effects of 1956. Seismic activity again increased during 1962 to the first part of 1966 but the past four years have reflected a very low period in seismic activity.

It is interesting to note the monthly distribution of the intensity data in view of the fact that many people in the country firmly believe that earthquakes are a seasonal occurrence with the spring period being the earthquake season. Table C2 does not conform with this belief*. Earthquake activity appears to increase during the fall, reaching a maximum in the months of December and January and then falling off continually through the spring and reaching a minimum in the month of May. If Lady Sale's detailed observations had not been included, the spring months would appear as periods of below normal activity. In comparison to the world seismicity[5] which shows the fall of the year (November) as being the most active, it would appear that the regional activity in Afghanistan is shifted by two months. Temporal distribution studies of this type however are open to question because of the very short time periods involved. The only definite conclusion which can be made at this point is that spring time in Afghanistan, according to earthquake intensity data, is not an unusual seismic season.

Owing to the lack of time it has not been possible to perform a correlation study between earthquake effects as rated on the Modified Mercalli Scale and the related instrumental data. From the information presented in Table C1 such analyses can be readily performed and these will be pursued at a later date. One aspect which will be discussed briefly is the improvement in the amount of available instrumental data as 1970 is approached. Up to the 1960's only large earthquakes which occurred within the country could be detected and analysed by the existing world seismic stations. After 1960 the number of seismic stations increased greatly and many of the events in Table C1, where the intensity ratings are less than V,

*--The temporal distribution analysis given in Sec. 7.4 for the local instrumental data does, however, seem to conform.

show corresponding instrumental data. After June 1968 following the installation of the Kabul Seismological Observatory nearly all events shown in Table C1 have related instrumental data; the events which do not, actually have been recorded by the Observatory, but an epicentral analysis has not yet been made. Owing to the very high magnification at which the instruments operate at the Observatory it is very unlikely that any felt earthquake can occur within the country and not be recorded instrumentally.

6.4 Discussion of Major or Significant Earthquakes

From the catalogue of intensity data presented in Table C1 the following earthquake events have been selected for further discussion. The selection was made on the basis that the event was either of major proportions or of special significance with regard to the problem of establishing seismic risk zones for the country.

Event 50 B.C.-50 A.D. - Aikhanum:

The historical setting and significance of the ancient Greco-Bactrian city, known for the present as Aikhanum, was introduced in Sec. 2. In that discussion the possibility of earthquake damage to the Palace was ruled out but it was argued by eliminating pillage and natural decay, that the destruction of the nearby structure known as the Temple, was a result of earthquake activity. The evidence to support this claim is presented in Figs. 7, 8 and 9.

Figure 7 illustrates the general setting of the city, situated on the east bank of the Darya-i-Panj (Ab-i-Panj, Amu Darya or Oxus River, Fig. 1) and the north bank of the Darya-i-Kokca (Kokcha River, Fig. 1). The main portion of the city was built on the flat 2 km by 0.5 km plain (A in Fig. 7) with further structures on the hill or mound to the southeast (B and C in Fig. 7). The location of the Temple and the Palace have been identified on Fig. 7.

The details of the structure in question, the Temple, are presented in Figs. 8 and 9. Figure 8 illustrates the planform of the Temple which is very nearly a 19 meter square, measured to the outer faces of the walls. The building is oriented such that the front wall or entrance side, faces about 31° south of east. As illustrated, the walls were very massive being in the order of 2.75 meters thick and a terrace of 1.5 meter width having a height of 2 meters, ran around the entire building. The salient feature related to the present subject is the spatial distribution of the kilned cornice fragments which were uncovered; the positions of the fragments as shown in Fig. 8, are a careful reproduction of the actual site conditions. The claim of earthquake destruction is based on the location of these fragments.

From an inspection of Fig. 8 it is clear that the Temple was adorned with a double cornice which was affixed to the front and side walls. This fact is particularly clear from the double row of bricks which were found on the side of the right wall. This group is shown in Fig. 9 which presents two photographs taken along the right wall. Figure 9A is a view looking towards the rear of the building and Fig. 9B is the view looking

Event 818-819 - Balkh Earthquake:

This earthquake destroyed a quarter of Balkh according to As-Soyuti[7]. This event is significant because the 1948 Mazar-i-Sharif earthquake, to be discussed later, is in the same region. These two events taken together indicate that the Mazar-i-Sharif region has been and continues to be an active seismic region.

Event 848-849 - Herat Earthquake:

This very early event is the only known earthquake damage to the city of Herat*. It is difficult to state reliably but it would appear that the earthquake was a result of activity along the Herat fault line which runs just north of the city (Fig. 6). This is an important result because as it will be seen in Sec. 9, there has been no recorded seismic activity along the fault during the past 70 years. The absence of earthquake epicenters along the fault, however, may well be a result of lack of seismic stations in the area. This single event indicates that the regions of Herat are susceptible to damaging earthquakes but the frequency of occurrence is probably low.

Event 1052-1053 - Urgun Earthquake:

According to As-Soyuti[7], this earthquake was destructive but no further information was presented. The significance of this event is that it probably was associated with activity along the Urgun fault line (Fig. 6). The result is also important because it indicates that this fault has produced major activity and other activity is therefore probable.

Event 1505 - Paghman Earthquake:

Of all the major past seismic events, the Paghman earthquake is definitely the most significant result because it occurred near to the city of Kabul and the surrounding regions, where today, the greatest portion of the population of the country is concentrated. Clearly, if such an earthquake would occur again the destruction and loss of life would be immense. Even in Babur's time the toll was excessive despite the relative sparseness of the population in the 16th century.

According to Babur's description (App. B) extensive surface faulting accompanied the event and the strike of the fracture ran along the base of the Paghman mountain range and extended from Isterghach, which is a town just north of Istalif, for a distance of six or seven farsangs (50 to 60 km) to the "plain" which in the translation is footnoted as meaning Maidan. This seems to be correct because the distance from Isterghach to Maidan is about 60 km. From this observed fault length it is possible to calculate a surface magnitude for this earthquake. Tocher[55]

*--There is one report which claims that three of the Musalla minarets in Herat were destroyed by an earthquake in the 20th century. This is presented and discussed in Sec. 9.

has established that a reasonable relationship between fault length L (km) and surface wave magnitude M_S (see Sec. 7.1 for discussion of magnitude) is:

$$M_S = 5.65 + 0.98 \log L$$

By taking the fault length as 60 km, the above equation yields a magnitude M_S of 7.4 which is a major earthquake by modern standards and similar in size to the 1968 Iranian earthquake[3]. In view of the fact that the effects of the earthquake were recorded in Agra a distance of 800 km away it would seem that this magnitude evaluation is low. Furthermore, Babur's observations that 33 felt aftershocks occurred on the same day (this is considerably greater than the 1968 Iranian earthquake) also suggests a large earthquake and probably a magnitude in the order of 8 would be appropriate; if reasonable this indicates an energy release approaching the catastrophic Alaskan Earthquake of 1964.

If Babur's description of the location of the fault is accurate then according to Fig. 6 it is almost certain that the Paghman earthquake was a result of faulting along the northern section of the Chaman fault. The large vertical displacements noted by Babur clearly fits the observations made by Wellman that there are appreciable dip-slip components along the northern portions of this fault (Sec. 5.3.1). Because of the large gap in intensity information from 1505 to 1830 there is no way of knowing if the fault has been active during that period of time and thereby establishing a periodic pattern. During the last 70 years no earthquake has been recorded from this section of the fault but as will be discussed, it may be that the 1874 Jabal-us-Siraj earthquake was a result of further activity along the Chaman fault. If this were the case, it would suggest a periodic cycle of around 400 years provided there was no similar event between 1505 and 1874; owing to the sparseness of the data this is sheer conjecture. The important result from this discussion is that the northern section of the Chaman fault has been active in recent times and there is no argument to disclaim the possibility of future activity. The only conclusion that can be adopted is that the environs west of Kabul are in a high seismic risk zone.

Event 1832 - Badakhshan Earthquake:

The Badakhshan earthquake of 1832 appears to be the first documented earthquake known to have originated from the Hindu Kush source. According to Wood's[11] and Burnes'[12] descriptions, the event was one of the major earthquakes of the Hindu Kush variety. Because the destruction around the upper Kokcha valley areas was the greatest, the epicenter would seem to have been there. The loss of life must have been considerable and probably in the order of thousands.

Because the destruction seems to have been confined to the Badakhshan region it would seem that the depth of the earthquake must have been less than the usual 200 km values as determined for recent events. The widespread effects such as being recorded at Lahore, Bokhara and severely at Kabul (probable damage) would imply an earthquake of major or approaching, catastrophic proportions. In view of the recently recorded earthquakes from this region which approached magnitude values of 7 or more and by a comparison of the damages which occurred, it follows that the 1832 event could be assigned a magnitude of 8 or more.

Event #1, 1842 - Jalalabad-Tigri Earthquake:

Of all the major earthquakes to have occurred in Afghanistan, the event of 1842 is the most vividly described (App. B). It is not exactly clear as to precisely where the epicenter was located but from the evidence available some reasonable deductions can be made. According to the damage reports the maximum intensities were confined to the Alingar valley and the Jalalabad basin. Significant damage apparently did not extend to Kabul which would imply that the earthquake was not of deep Hindu Kush origin. The remaining most likely possibilities are that the earthquake was a result of shallow faulting either along the northern section of the Gardez fault system, north of Tigri, or along the Kunar fault between Tigri and Jalalabad (Fig. 6). The arguments supporting the Gardez system are based on the observations of Lady Sale. She states that, "When the earthquake first commenced in the hills in the upper part of the valley, its progress was clearly defined, coming down the valley, and throwing up dust like the action of an exploding mine." This statement combined with the very heavy damage all along the Alingar valley is strong evidence for the Gardez fault.

The evidence arguing for the Kunar fault is that the damage appeared to be heaviest in Tigri and Jalalabad regions. One particular report[15] stated that the waters of the Kabul River, near Jalalabad were twice thrown from their bed during the shock. If this report is accurate it would, according to the Modified Mercalli Scale (App. A) represent an intensity of X. This high intensity value would imply that the epicenter was close to the Kabul River and the Kunar fault fulfills this requirement. It should be pointed out however that the higher intensities near Tigri and Jalalabad may be a result of the geological environment. It is well known that deep alluvial plains with high water tables, such as exist at Tigri and Jalalabad, can greatly amplify the amplitudes of seismic waves[56]. Some researchers believe the amplitudes increase linearly with the depth of the alluvium. This dynamic amplification phenomenon would explain the higher intensities observed at Tigri and Jalalabad if the activity had resulted from the Gardez fault. Although the matter cannot be resolved to complete satisfaction, Lady Sale's observation would be difficult to explain if the Kunar fault had been active. Furthermore, if the Kunar fault was active it is strange that no reports of surface fracturing were given. The fault runs just north of Jalalabad.

From the description of the experiences it is evident that the earthquake was of major proportions. During the first 24 hours following the major event a total of nearly 60 aftershocks were felt and recorded by Lady Sale. In terms of present day earthquakes this number of aftershocks is extremely high and it would suggest that the major shock must have been a magnitude of 8 or more. If an earthquake of this size had occurred along the Kunar fault, the result would have been near total destruction in Jalalabad; but, this was not the case as the following very unique evidence will demonstrate.

At the time of the earthquake as discussed in Sec. 2, the town of Jalalabad was occupied by the British forces under General Sir Robert Sale. Prior to the earthquake, Sale had adopted a defensive strategy which involved the restoration of the town's defenses. The restoration had been completed before the earthquake but as a result of the shock all which had been built was torn down in the course of one minute. A number of the large bastions were totally destroyed, several large sections of the walls fell, the parapets along the four walls, nearly 2.2 kms in length, were nearly all thrown down and two-thirds of the houses within the town were destroyed[15]. By a concerted effort, Sale and his men were able to restore the defenses of the town and as a record of this achievement Sale submitted a report[17] to England. This report which was lithographed contained a complete set of accurate sketches indicating the extent of damage to the walls of the town. Through the courtesy of the British Embassy in Kabul this set of sketches has been photographed and is reproduced in this report as Figs. 10, 11, 12 and 13.

The entire length of the town's defenses are illustrated by a series of eleven separate pictures spreading over Figs. 10 to 13. The town walls consisted of four major sections each one nearly facing one of the four directions. In Figs. 10 to 13, the east wall which contained the Peshawar Gate is labelled as ABCD, the north wall which contained the River Gate, as DEFGHI, the west wall with the Kabul Gate, as IJKL and the south wall with the South Gate, as LMNA. In order to understand the significance of the sketches it should be understood that in Sale's original report he wanted to communicate three important phases of the defense of Jalalabad; these were, (a) the state of the defenses before the British occupation, (b) the restoration work, and (c) the extent of destruction caused by the earthquake. These three phases are illustrated in the sketches. The light colored portions of the walls represent the condition of the fort as found with the dark colored areas depicting the restored sections. The earthquake damage however, is illustrated by the portions of the wall located above the black line which has been sketched around the fort. Any portion of the wall above the line is to be interpreted as having been thrown down by the earthquake.

Based on the pictorial nomenclature discussed above, the extent of the earthquake damage can be readily identified in Figs. 10 to 13. The most notable overall effect is that nearly all the parapets were destroyed and from this observation it is clear that during the course of the earthquake the forces imparted were not singularly oriented. Such a result is usual in large earthquakes where significant ground motion continues over an extended period of time. As observed by Major-General Abbott[15], the duration of the shock was in the order of 1.5 minutes. In view of the size of the earthquake it is not surprising that the thin, essentially unsupported parapets, would have been thrown down. The result is similar to the decorative cornice work which was stripped from the Temple at Aikhanum.

From Figs. 10 to 13 it can be seen that the walls and bastions also received considerable damage but this was not uniformly distributed about the town. Close inspection shows that the north and south walls, or those walls with an EW orientation, sustained the greatest damage. In the north wall (a length of 550 meters), two bastions (one being the NE corner) were completely destroyed and three sections of the wall, having a total length of 80 meters, fell. On the south wall only one section of length 20 meters was thrown down but the wall does show several major cracks at other places. The only other face sustaining major damage was the north end of the west wall which contained the Kabul Gate. Here the bastions flanking the gate were destroyed and some small sections of the wall north of the gate were knocked down.

The observations made above have considerable significance. Clearly the distribution was not total but at the same time it should be noted that the walls of the town were massive in dimensions being in the order of 7 to 9 meters thick and the destruction which did occur could only have resulted from a major earthquake. The fact that the north and south facing walls sustained the greatest damage signifies that the strongest seismic pulses were in the NS direction and this would imply that the fault plane of the earthquake was primarily NS oriented. This evidence strongly suggests that it was not the Kunar fault but rather the NNE striking Gardez fault system from which the seismic energy was released. In view of all the evidence presented it seems reasonable to conclude that the Jalalabad-Tigri earthquake was a result of a NS fault plane and the major Gardez fault is a strong possibility.

Since the 1842 earthquake, the Jalalabad area has experienced numerous strong earthquakes, but nothing has equalled the 1842 catastrophy. The area is clearly one of great seismic activity and accordingly the seismic risks are high.

Event 1874 - Jabal-us-Siraj Earthquake:

The Jabal-us-Siraj earthquake was the third major seismic disturbance of the 19th century and although it was the most recent in time very little is known compared to the 1832 and 1842 events. Ballore[21] describes the earthquake damage as extending to Kandahar but no corroborating evidence has been found to support this. Stenz[22] was able to uncover the specific facts that Jabal-us-Siraj, Gulbahar and portions of Kohistan were completely destroyed and that ground cracks were observed. Although the details are sketchy, the intensity at Jabal-us-Siraj and Gulbahar would suggest possible faulting either along the Herat fault or the northern end of the Chaman fault. It is really difficult to make any further credible distinction than this, but it does follow that this singular region which contains the conjunction of the two major continental faults could well be the most dangerous seismic zone in the country.

Event 1892 - Chaman Earthquake:

The Chaman earthquake was the first seismic event in the regions for which some scientific information was recorded[30] and the identification of at least a portion of the Chaman fault was made. Sinistral horizontal offsetting of 2 to 3 feet was observed at the time. The earthquake rendered great damage to Chaman and although there are no corroborating reports it seems certain that Spin Baldak was strongly affected. The activity along this segment of the fault indicates that similar activity can occur at other points and all regions near to the fault should be considered as potential centers of seismic activity.

Event #9, 1924 - Hindu Kush Earthquake:

Little information is known about this event which was recorded by Furon in 1924. The significance to the present report is that the primary source of seismic disturbances affecting Kabul originate from the deep Hindu Kush center and this particular earthquake is the first major Hindu Kush event for which felt and instrumental data can be correlated. (Event #8, 1924 which preceded by one is actually the first event.) Furon estimated an MM of V-VI which appears to be conservative in view of the large magnitude of 7.3 shown in the instrumental data and by comparison to later similar events. It should be realized however that the determination of earthquake magnitudes and the estimation of MM ratings is not an exact science and the correlation of the two although valuable can produce wide discrepancies.

Event #2, 1931 - Pashghur Earthquake:

This relatively recent earthquake which took place in the Panjshir valley and heavily destroyed the town of Pashghur has not been listed by other researchers. The earthquake was not of major proportions but it was certainly large and was strongly felt in Kabul. The damage was localized to the regions of Pashghur and based on location of this town it seems reasonably certain that the earthquake resulted from shallow faulting along the Herat fault. The Panjshir valley is of course strongly influenced by the strong deep Hindu Kush earthquakes but the Pashghur event establishes that the valley can also expect violent activity from shallow seismic events.

Event #5, 1933 - Uruzgan Earthquake:

The Uruzgan earthquake is an important result because it establishes that seismic activity in the country can exist west of the Chaman fault and south of Kabul. It seems probable that this event was associated with the Uruzgan fault (Fig. 6) or some nearby en enchelon system. The earthquake, rated at a magnitude of 5.6, was not a large event but if the energy release was shallow it could have produced major damage (e.g.--the 1960 Agadir, Morocco earthquake was also only 5.6 and killed 12,000 people). The reports from Uruzgan and nearby Dai Chupan indicated that a number of buildings were destroyed, mountains collapsed and a series of aftershocks were felt. The event is very relevant to the present study by establishing that this region of the country is active.

Event #1, 1934 - Pashtun Kot Earthquake:

This earthquake was of destructive proportions and levelled most of the town of Pashtun Kot. The fact that little or no damage was reported[22] at Maimana, less than 10 km away, indicates a very localized effect. Although no instrumental data exists for this event it would seem reasonable to consider that this earthquake was a result of faulting along the Pashtun Kot fault (Fig. 6). Owing to the lack of nearby seismic stations in this region very few seismic events are known to originate from this source but it is clear from this 1934 event that the Pashtun Kot fault and associated systems are active and appropriate seismic risks should be ascribed to the region.

Event #3, 1937 - Hindu Kush Earthquake:

This 1937 Hindu Kush earthquake was one of the larger deep focus events with a magnitude of 7.3 and a depth of 240 km. The epicenter was the well-known 36.5°N and 70.5°E location, about 250 km away from Kabul. The unusual result of this earthquake was that damage was recorded as far away as Delhi. It is certain that Kabul also sustained some damage but nothing was reported. The widespread effects observed with this event are typical of deep earthquakes. In shallow shocks the high intensity regions are very localized and intensity falls off rapidly with distance. Deep earthquakes of equal energy release will not produce as large an intensity rating but significant damage can extend for very great distances.

An interesting feature of deep Hindu Kush earthquakes is the high intensity levels which are often recorded in northern India. The explanation for this is not clear but it seems reasonable to speculate that the phenomenon is related to the Himalayan mountain structure. This massive mountain range may be acting as a channel through which seismic energy transmits with little dissipation and accordingly the seismic disturbances would reach such places as Amritsar and Delhi with very little attenuation.

Event #1, 1943 - Hindu Kush Earthquake:

This earthquake was only somewhat small or in terms of energy release (magnitude of 7.0) and in effects produced, as compared to the event of 1937. Not much information was recorded, but Stenz[22] observed that building cracks were created by the earthquake in Kabul. The instrumental data shows that the source of energy was the deep Hindu Kush center.

Event #2, 1948 - Mazar-i-Sharif Earthquake:

The 1948 Mazar-i-Sharif earthquake is the largest earthquake to date which has been registered instrumentally in that region. The determined hypocenter was only 15 km NE from the city at a depth of 70 km. The magnitude was put at 6.3 which indicates a significant energy release. The effects were registered throughout the northern regions with damage occurring at Mazar-i-Sharif and Samangan where either tall or old structures suffered heavily. The maximum intensity levels for this event were put at VII but this may be conservative. As already mentioned, this event could well be similar in source to the ancient earthquake which destroyed much of Balkh in 818 to 819.

Event #2, 1949 - Hindu Kush Earthquake:

The March 4, 1949 Hindu Kush earthquake was one of the most severe earthquakes of the present century which originated from the deep-source center. The magnitude was put at 7.5 and as recorded in Table C1 the entire northeastern corner of the country suffered extensively. The loss of life was surprisingly low in view of the large number of homes and other buildings which were destroyed. Although the extent of damage is not known fully the information which appears in Table C1 gives considerable insight into the higher intensity levels which can be expected as a result of the deep Hindu Kush earthquake center.

Event #2, 1955 - Gulran Earthquake:

The Gulran series of earthquakes which took place during August of 1955 are among the most unique data uncovered during this century for the regions of Afghanistan. The earthquakes were not large but they were sufficient to cause the destruction of several houses. Of all the instrumental data which will be presented in Sec. 7 no recorded epicenter has been found in or even near to this region which is just NW of Herat. In all previous studies, this region like Herat, was considered aseismic. In light of this evidence the region must be evaluated as a seismically active zone.

Event #3, 1956 - Kahmard-Sayghan Earthquake:

Of the many earthquakes which have occurred in the regions of Afghanistan since the 1874 Jabal-us-Siraj earthquake, the 1956 Kahmard-Sayghan disturbance was probably the most destructive. The earthquake registered a magnitude of 7.4 with the instrumentally determined epicenter coinciding with the Kahmard and Sayghan district where the maximum intensities were observed. Prior to this event, major earthquake activity as westerly as this region was unknown. The tectonic mechanism which was responsible for the energy release is not certain. The epicenter was somewhat south of the major Andarab fault and may well be associated with one of the lesser fault lines which are identified on the geological fault map (Fig. 5).

The confusion created by this catastrophe prevented an assessment of the total loss of life at the time of the event. As shown in Table C1, according to the newspaper articles, only about 30 people were killed. As a result of a recent survey of the area by the Seismological Center, it has been found that the total number of deaths was somewhere between 300 and 400 people.

Extensive building damage was reported throughout the regions north of the Hindu Kush extending east to nearly the center of the country. Damage south of the Hindu Kush was minimal but intensities approaching VI were widespread. A total assessment of property damage has not been made but it is evident from the size of the earthquake and the region affected that a great many people must have been made homeless.

Although the earthquake occurred nearly 15 years ago some evidence of building destruction in the more remote regions still remains today. One such structure located to the west of Kahmard beyond the Darri Ajar gorge which, according to the local people killed 30 people when it collapsed, was recently inspected by the Seismological Center. Two pictures of this building are presented in Figs. 14 and 15. Figure 14 is a view of the building looking south. As seen, the upper portion of the building is completely destroyed and the entire west wall to the ground level has fallen outwards. Also evident from this photograph are the large shear or tension cracks which exist in the remaining portion of the north facing wall. Based on these two observations and the additional fact that the east wall (not shown in Fig. 14) was intact it follows that the principal motion of the earthquake was an eastward lurch. As further evidence to this conclusion Fig. 15 presents a view of an interior east-west wall which contained several large archways. It is obvious from this picture that the arches are tilted to the west. Also evident are that shear cracks which appear at the top of the arches and in the brickwork within the arch. It will be noted that these cracks are inclined to the vertical in the same sense as the crack in the north external wall.

From the above discussion and the evidence presented in Figs. 14 and 15 it follows that the regions of Kahmard, as a result of the 1956 earthquake, shifted to the east. This eastward shift implies that the fault plane of the earthquake had an east-west strike. This deduction is in keeping with the EW striking fault systems which are shown in Figs. 5 and 6 for this region. The question as to which fault was active can be partially approached, at least to the extent of eliminating the Andarab fault. According to Wellman (Fig. 6) the EW Andarab fault is dextral in sense which requires that the south block moves west relative to the north block. The structure shown in Fig. 14 lies south of the Andarab fault and accordingly the principal motion should be to the west if the Andarab fault was active; it is known however that the motion was opposite in sense and the Andarab fault is therefore eliminated. If Wellman's postulations are correct, that is, that all faults north of the Herat fault are dextral in sense then it can be further deduced that the earthquake was a result of faulting along an EW striking fault which runs south of the structure shown in Fig. 14.

In addition to structural and biological effects there were a number of impressive geological developments resulting from the 1956 earthquake. In particular, as recorded in Table C1, at Darri Ajar, a portion of the mountain fell down and blocked the river. This phenomenon can still be seen today and Fig. 16 confirms the observation which was made 15 years ago. The view shown is looking west into the gorge of the Darri Ajar on the downstream side of the collapsed material. Behind the debris which dammed the water flow is a small lake. Prior to the earthquake a motor road existed in this gorge but this has been eliminated by the collpase of the mountain. It should be noted that the building shown in Fig. 14 is located about 3 km west from the location shown in Fig. 16.

The most important feature of the June 1956 earthquake is that it upset the tectonic equilibrium of the entire region of Afghanistan and triggered a chain reaction of seismic events which lasted for nearly four years. This statement is well illustrated in Table C2 which shows only minimal activity up to 1955 and then the sudden jump from 3 events to 80 events in 1956. The years following 1956 show a gradual tapering of the events down to 8 shown in 1961 when seismic normalcy once again returned to the region. This result is an excellent example of the periodic pattern of earthquake activity. Although a region, which is known to be seismically active, remains quiet for a period of time, the tectonic processes are nevertheless continuing and seismic energy is accumulating. A major release of this energy at any particular point can initiate a series of events that extends outward both in time and space. The events of 1832, 1842 and 1874 all probably marked the beginning of intense periods of seismic activity as did the event of 1956.

Event #34, 1956 - Jaji Earthquake:

This earthquake of September 16, 1956 was one of the major events triggered by the Kahmard-Sayghan disturbance. The instrumental location of the epicenter indicates that the earthquake was associated with the Gardez fault system but along a section south of the Kabul River. No loss of life was reported but there was significant damage throughout the Jaji district. A major aftershock of magnitude 6.2, compared to the 6.4 principal event, was recorded on September 24 and other significant aftershocks followed extending into 1957.

Event #17, 1958 - Hindu Kush Earthquake:

This was again a typical large earthquake from the persistent deep center of the Hindu Kush which reached damaging proportions. The magnitude was rated at 7.0. It appears that when the energy release from this source attains this level, damage can be expected. This event was felt up to distances of 1,000 km from the epicenter.

Event #7, 1960 - Hindu Kush Earthquake:

According to the instrumentally determined magnitude, this Hindu Kush earthquake was not one of the larger events but the intensity levels in Kabul were high, approaching VII. The earthquake was felt in many parts of India and Russia.

Event #6, 1962 - Hindu Kush Earthquake:

Similar to Event #17 of 1958 this Hindu Kush earthquake registered a magnitude approaching 7 and was widely felt particularly at Dushanbe in Russia. Damage however was minimal throughout the regions of Afghanistan.

Event #3, 1964 - Hindu Kush Earthquake:

This earthquake was similar to the Event #7 of 1960 in that the magnitude was only in the order of 6 but the shock was sufficient to produce cracks in buildings in Kabul and was felt in Pakistan and parts of Russia. This wide variation between magnitude ratings and observed intensity levels prevents a straightforward development of a magnitude-intensity relationship for the deep Hindu Kush earthquakes. The difficulty may be either one of inconsistencies in the data or some physical phenomenon within the deep parts of the Hindu Kush. This can only be resolved by careful monitoring of future events.

Event #2, 1965 - Hindu Kush Earthquake:

This recent Hindu Kush earthquake is particularly significant because it is the last major event, up to the time of writing this report, which approached a magnitude rating of 7. The effects produced by this deep event were as usual quite widespread. The damage in Kabul was primarily limited to cracks in buildings but it is evident that if the shock had been any stronger considerable destruction would have occurred.

Owing to the seemingly persistent nature of the deep Hindu Kush source, it seems reasonable to pursue the possibility of establishing a periodic pattern, at least for the strong variety which produces, say, intensities approaching VII or greater. One difficulty in doing this is the incompleteness of older data and this prohibits a reliable periodic analysis over a broad time period which of course is desirable. Although it is relatively short, the data from 1937 onwards does seem to be reliable and reasonably complete and a preliminary periodic analysis could be made for the past 33 years. If this is done it reveals that damaging Hindu Kush earthquakes occur at the approximate rate of one every four years. This analysis however is really too crude to be of any direct value but it does illustrate that the Hindu Kush center represents a major seismic risk to the entire northeastern portion of the country.

Event #2, 1969 - Nurgal Earthquake:

In comparison to the preceding seismic events, the earthquake which affected the Nurgal region in the Kunar valley was very small registering only 5.6 on the magnitude scale. The earthquake however was shallow and therefore intensities approaching VII were recorded in the epicentral region. Based on the epicentral location, it appears that the earthquake resulted from movements along the Kunar fault system. The damage was confined to the immediate areas about the villages of Nurgal and Bila where the walls and roofs of a number of homes fell and one person was killed. The earthquake was felt in Kabul with an intensity sufficient to awake people from their sleep.

Shortly after the earthquake the Seismological Center conducted a field study of the damage and Figs. 17 and 18 illustrate some of the observed effects in the village of Nurgal. Figure 17 is a view looking to the west from Nurgal with the Jalalabad road running through the center.

The bastion of the qala in the center of the picture is partially destroyed and a number of sections of the mud wall along the roadside have fallen. Figure 18 is a view of the partially collapsed house wherein the single fatality of the earthquake occurred. It is quite evident from this picture that the building construction was acutely inferior.

This Nurgal event is very significant in that it demonstrates the potential seismic hazards which do exist in the country. The extensive catalogue of events, Table C1, thoroughly establishes that the country is susceptible to major seismic disturbances. The Nurgal event however was small on the seismic energy scale, but sufficient to cause damage because of inferior building construction. If the Nurgal area had been subjected to a somewhat larger earthquake, which is not unreasonable to assume, the entire village would have been destroyed. Throughout the country there are many places similar to Nurgal where the construction techniques are totally inadequate for the seismic risks which prevail. Without discussion, Fig. 19, which depicts earthquake damage in eastern Iran[3] in 1968, has been included to demonstrate the disastrous effects which can result when a major earthquake and inferior building methods coincide.

6.5 Intensity Zone Map - Summation of Intensity Data

The extensive data presented in Table C2 and the format which has been selected, provides an important base from which various future seismic analyses can proceed. Because one of the objects of the present report is to arrive at a preliminary seismic risk map for the country, an appropriate analysis of the data, beyond the discussion presented in Sec. 6.4, has been undertaken. This analysis involved the utilization of all intensity data in terms of the estimated Modified Mercalli Scale ratings, in order to construct an intensity zone map for the regions of Afghanistan. The final product of this analysis is presented in Fig. 20 and the following is a discussion of this result.

The procedure used to construct the intensity zone map was to first define suitable ranges of intensity ratings. The ratings which were adopted are shown in Fig. 20. The maximum intensity range selected was defined as $VIII < MM \leq X$. This range corresponds to the cases where major damage was recorded of the type which would involve, for example, the near total destruction of poor quality masonry as a minimum. The second level $VI < MM \leq VII$ denotes the range where moderate to severe damage of poor quality structures occurred. The third, $V < MM \leq VI$, covers the range from severely felt to levels where poor quality masonry begins to show cracks or some failures. The final two ranges spread over the effects which range from felt by all to where only marginal long period effects are noticed.

With the intensity ranges defined, the next step was to proceed through Table C1 and select all earthquake events which had produced intensity effects within the maximum range. The events falling into this category were the major earthquakes such as Paghman, Jalalabad-Tigri, Kahmard-Sayghan, etc. For each event, based on the places of observation, an appropriate intensity zone was sketched. The size and exact position of these zones involves a great deal of interpretation and judgment and it is by no means an exact science. The only approach available however is one of exercising the best possible interpretation and judgment on all the known facts. When all the maximum intensity zones were so established the next step was to apply the same procedure for the second category and thereby sketch the next range of intensity zones. In doing this second step it is necessary to return to the maximum intensity zones and sketch broader second level zones about each. This procedure, where possible, was continued down through the various intensity zone ratings. The final step in the construction of the map was to eliminate all internal lines within a particular zone so what appears in Fig. 20 are only the remaining outermost lines of each zone of different intensity range. In effect the final zones which appear in Fig. 20 are a summation of all the earthquake intensity data which is given in Table C1. It should be noted that in all cases the two highest intensity zones could be defined reasonably well and in some cases this was also possible for the third zone. However, in most cases, for the third level and lower, the associated broad regions at best could only be inferred based on previous experience of the variation of intensity effects with distances[3]. These inferred zones are identified on the map.

The intensity zone map displays several features. Clearly illustrated is the large second level intensity zone which occupies most of the NE corner of the country. The major seismic disturbances which have promoted this large intensity zone are the effects produced by the deep Hindu Kush earthquakes. This persistent center of large earthquakes is the dominant feature on the map and all intensity zones appear to radiate outwards from this center. The second important feature is the localized disconnected zones of the first and second levels which extend from Quetta to nearly the northern tip of Afghanistan. The overall trend of this zone is in a NNE direction and this is an expected result in view of the discussion on the regional tectonics presented in Sec. 5.3. The isolated events of Herat and Pashtun Kot are readily visible on the map. The large zone on the west side of the map results from the 1968 Iranian earthquake.

It is important to note that the intensity zone map as shown in Fig. 20 should not be misconstrued as being a facsimile of a seismic risk map. The zones depicted were established entirely and only on known documented felt data. As already discussed this information is far from complete. Many large earthquakes could have taken place in the past and were not documented. These unknown events may well be in regions of the low intensity zones as shown in Fig. 20. The purpose of the intensity zone map is to summarize all the information given in Table C1 and present it in such a form so that it can be easily combined with the tectonic information given in Sec. 5.3 and the instrumental data presented in the next section.

7. EARTHQUAKE HISTORY - INSTRUMENTAL DATA

7.1 Introductory Remarks

The instrumental detection and recording of earthquake disturbances on a reliable basis was not developed until the 1880's when a British scientist, John Milne, constructed the first equivalent of a modern seismograph. Simple instruments, however, capable of detecting earthquakes had long preceded Milne and date as early as the 2nd century. The importance of Milne's achievement, however, was that for the first time, ground motion resulting from a nearby earthquake could be recorded and studied. Shortly following this development, it was discovered in 1889 at Potsdam, Germany, that distant large earthquakes could also be recorded by the early seismographs. This discovery provided great impetus to the science of instrumental seismology and by the turn of the century, through the improvement of the seismograph and the development of theories for the interpretation of the seismographic records (seismograms), it became possible to record and identify the occurrence of distant earthquakes and to determine the approximate location of the earthquake source.

During the past 70 years instrumental seismology has continually progressed both in terms of the development of instruments with higher sensitivities, and the number of operating seismographic systems around the world. According to the latest information[57] from the National Earthquake Information Center in Rockville (USC&GS), the number of active seismographic systems or seismic stations throughout the world in 1969 was approaching a total of 1,100. Although the stations vary greatly in the type and quality of instruments operated and in the quality of operation, nevertheless, the accumulated instrumental seismic data during the past ten years exceeds the total data collected in all the years which preceded.

In the Near East South Asian region wherein Afghanistan is located the number of existing seismic stations, with the exception of Russia, remained very low up to the beginning of 1960. During the 1960's this situation improved considerably as a result of the project undertaken by the U.S. Coast and Geodetic Survey to install a network of 125 standard seismographic stations throughout the world. This network known as the Worldwide Standard Seismographic System (WWSSS) now involves nearly 60 countries and includes Iran, Afghanistan, Pakistan and India. As a result of the appearance of these high-quality stations in the region during the 1960's, the number of instrumentally recorded earthquakes has greatly increased and an improved understanding of the seismic behavior of the area is developing.

Figure 21 has been included in this report to illustrate the locations of presently active seismic stations near to Afghanistan and thereby establish an appreciation for the remoteness of some parts of the country with regard to the instrumental detection of earthquake activity. The map depicts the number of stations (the three letter symbols are the code names of the stations; e.g., KBL - KABUL) within distances of 500, 1,000 and 1,500 kms from the center of the country; this has been taken at 34°N and 67°E. Within the 500 km circle only four stations are located but there is a considerable increase for the 1,000 km circle with 18 being shown; most of the stations within this latter circle lie in the northern sector. A total of 29 stations exist within the 1,500 km circle but the positioning of the stations as shown in Fig. 21 is not in any way uniform. This seemingly strange distribution has resulted from the seismic nature of the region. A comparison of Fig. 21 with the world seismicity map (Fig. 3), shows that the greatest density of stations corresponds with the most seismically active sectors. (This will be more clearly demonstrated by the seismicity maps of the region presented in Sec. 8.) It is evident from Fig. 21 that the entire western portion of Afghanistan is well removed from any active station (MESHED is close but operates at a very low magnification) and this may be the explanation for the lack of recorded data in these regions as will be shown.

The single station which is located within Afghanistan is operated by the Seismological Center of Kabul University. The Station, or as referred to previously in this report as the Observatory, is part of the WWSSS and has been active since June of 1968. Owing to the low cultural noise level at the site, which is roughly 10 km west of Kabul, the Observatory operates at a short-period nominal magnification of 400,000 all year round which makes it one of the most sensitive stations in the world and probably the most sensitive in Asia. In addition to a three-component WWSSS short period system the Observatory also operates a complementing WWSSS three-component long period system and a three-component advanced system. For monitoring local earthquakes, a two-component intermediate 2,800 magnification system was installed in the summer of 1970 and for strong local earthquakes a standby strong motion recorder is available. This complete range of seismic instrumentation is a unique feature as compared to other seismic stations in Asia. A more detailed and technical description of the Observatory along with an introductory discussion on the principles of instrumental seismology can be found in Ref. 58.

Through the mutual interchange of instrumental seismic data between the seismic stations of the world, a systematic accumulation of earthquake information has resulted. A number of international seismological institutions have been formed for the sole purpose of handling the raw data produced by contributing world seismic stations and thereby performing reliable hypocentral determination of all the significant earthquakes throughout the world. The most notable of these organizations is the U.S. Coast and Geodetic National Earthquake Information Center. Through the use of computers, the USC&GS produces extensive monthly lists which include all earthquakes which were recorded by a sufficient number of stations to allow a reliable hypocentral determination to be made. It is through the availability of such extensive and complete information that the investigations of the earthquake history of a region in terms of instrumental data is possible.

There are many facets of instrumental data but for a general investigation of the earthquake history of a region the only essential data which is required is a knowledge of the origin time, the hypocentral location and the magnitude of the earthquake. The origin time is the time at which the earthquake originated and is a calculated result based on the arrival times of the first earthquake waves as recorded and reported by seismic stations. Although arrival times can be monitored to within 0.1 sec., the computed origin times are probably only accurate to $\pm$ 1.0 sec. at best. The hypocentral location of an earthquake is also a computed result based on arrival times. The hypocenter, also referred to as the source or focus, is specified in terms of the epicenter (that point in the earth's surface directly above the hypocenter) and the depth (the vertical distance between the epicenter and hypocenter). The accuracy of the epicenter and depth determinations depends very much on the number of stations recording the event and this depends on the density of the stations in the region of the earthquake and the size of the earthquake. (The larger the earthquake the greater will be the number of stations recording the event throughout the world.) With present day techniques it is possible, on the average, to determine[41] epicenters with a precision of $\pm$ 0.1° and depths to an accuracy of $\pm$ 25 km. Early instrumental data however is less accurate with the best accuracy[5] being $\pm$ 1° for the epicenter, $\pm$ 30 km for the depth and $\pm$ 5.0 sec. for the origin time.

The instrumental information classified as the magnitude of an earthquake requires a more elaborate discussion than the terms described above if some appreciation for magnitude is to be had. In 1935, C.F. Richter recognized the need to distinguish between the different size of earthquakes and he devised a scale based on instrumental measurements whereby a classification of earthquakes was possible. The scale has won wide acceptance and is now known as either the Richter Magnitude Scale or simply the Magnitude Scale. Although not intended in the original definition, the scale has since become related to the total energy released by an earthquake and even more recently it is recognized as possibly corresponding to the rate of energy release especially for large earthquakes.

It is not possible to include in this report a thorough treatment of the various mathematical definitions for the presently existing magnitude scales. An excellent introduction can be found in Richter's book[30]. For the present, it is necessary to present some of the important aspects. The magnitude of an earthquake is, by definition, primarily a function of the logarithm of the measured maximum trace amplitudes as recorded by a seismographic system, and also of the epicentral distance, that is, the distance of the epicenter from the seismic station. On this basis two types of magnitudes have been defined; one is based on the maximum trace amplitudes resulting from the body wave portion of an earthquake disturbance and most often on the first arriving compressional wave phases. This type of magnitude is referred to as the body wave magnitude, M_B. The second magnitude is based on the maximum trace amplitudes of the surface waves having a period in the range of 18 to 20 sec. and accordingly, this magnitude is called the surface wave magnitude, M_S. To clarify these definitions it should be mentioned that when an earthquake occurs, a portion of its energy spreads out through the body of the earth in the form of compressional and shear type waves and these are the body waves. A portion of the energy also spreads out along the surface of the earth by the formation of surface waves. The appearance of these two basic types of waves, which in part are each a manifestation of the energy released, is the reason why the two magnitude scales have resulted.

It has been found from repeated observations that for a given earthquake the body and surface wave magnitudes differ to some extent. This is demonstrated by the following relation established empirically by Richter[30].

$$M_b = 2.5 + 0.63\ M_s$$

This equation gives the result that the two magnitudes agree for the value of 6.75. Above this value $M_b < M_s$ and below, $M_b > M_s$. For example when $M_B = 8.0$, $M_S = 8.6$ and when $M_B = 4.0$, $M_S = 2.4$. There is no agreement on which type of magnitude is a more consistent indicator of the actual size of an earthquake. Both values are often determined for a large event and often the two values deviate considerably from Richter's equation.

The largest instrumentally recorded earthquakes to date registered an $M_S = 8.9$; these were the great Japanese earthquake of 1933 and the Colombia-Ecuador earthquake of 1906. Earthquakes with magnitude of 1 or less are only recorded by sensitive nearby seismographs. Those of magnitude 2 reach the level of human perceptibility if nearby. Damage rarely occurs in earthquakes of less than magnitude 4.0.

It should be understood that, the magnitude of an earthquake whether it be a function of the total energy release or of the rate of energy release, theoretically should not depend on the point of observation; this is inherent in the mathematical definitions. In this regard the magnitude scale is quite different from the intensity scale which is clearly a function of the distance of the observation point from the earthquake. Of course the other basic difference is that the magnitude scale is a quantitative instrumental scale by definition, whereas the intensity scale is qualitative, based on the observations of humans.

Although the magnitude scale is instrumental and rigorously defined it is nevertheless imperfect. For a given earthquake it has been found that the various seismic stations recording the event, report wide variations in determined magnitudes. The explanations for these inconsistencies are varied and are considered to involve such things as the location of the seismic station with respect to the fault plane of the earthquake, local geological conditions, instrumental idiosyncrasies and seismogram interpretation. One approach to resolve these variations is to devise some averaging technique for the data from a group of stations and this approach is used by the international seismological institutions in preparing their summaries of earthquakes. The method of averaging is still open to question and no one system has been uniformly adopted. As a result, reported magnitudes from different institutions when compared will show consistent differences[59,60] up to $\pm$ 0.5 units. Despite all these shortcomings the categorizing of earthquakes on the basis of magnitude ratings is extremely valuable and adds an important dimension to the study of the instrumental earthquake history of a region and to the assignment of seismic risks.

The objective of this section of the report is to present the known earthquake history of the regions of Afghanistan as established by instrumental data. This history of course is very limited in time owing to the relatively short period during which suitable instrumentation was available; similar to the non-instrumental history, the early phases are far from complete. In order to complement the intensity data given in App. C, the instrumental earthquake history, included in this report, will be presented in the form of a chronological listing, wherein the origin time, the epicentral location, depth and the magnitude are included.

7.2 Sources of Instrumental Data

Since the existence of the Kabul University Seismological Center in the summer of 1968, a complete record of all instrumentally recorded earthquakes in the region has been kept. Each month the Center prepares a seismological bulletin listing all data monitored by the Observatory and this is distributed to all the neighboring countries and to many of the international seismological institutions. In return the Center receives similar data which is used to augment and improve the locally produced data. Through such an interchange of seismic data a complete history of the earthquake activity in the country can and is being maintained. The continuation of this work will provide a valuable source of instrumental data in the future, but unfortunately, it cannot extend into the past beyond the summer of 1968. Clearly then, to perform an earthquake history investigation, other pre-existing sources must be used and these are not to be found within the country.

The major sources for pre-1968 instrumental data are the international seismological centers of the world where extensive catalogues of earthquakes on a worldwide basis are maintained. Prior to 1960 the most notable of these were the Bureau Central International De Seismologie (BCIS) in Strasburg, France, and the International Seismological Summary (ISS) in Edinborough, Scotland. In the 1960's the National Earthquake Information Center of the USC&GS was created. One of the important undertakings of this Center was to establish a computerized hypocentral data file, wherein all the information collected by the BCIS, ISS and USC&GS and also the world seismicity data compiled by Gutenberg and Richter[5], were stored. The computerized file was programmed such that the instrumental data for any region of the world could be selected and printed out upon request. Through the courtesy of the USC&GS, a printout of the data, related to the regions of Afghanistan up to 1970, was obtained, and this was the primary source of instrumental data for the present earthquake history study.

The second source of data for the investigation was the Atlas of Earthquakes in the U.S.S.R.[31]. This compendium of earthquake data is primarily related to the U.S.S.R. but does extend into Afghanistan to the 36°N latitude. It was found that the Atlas contained a number of significant earthquakes which were not listed in the USC&GS hypocentral data files. The disadvantage of the Atlas was that it did not cover the entire region of the country and was only current to 1957. Regardless the applicable information was extracted and added as part of the earthquake history of Afghanistan.

The third source of data was a list of significant earthquakes in and around Pakistan during the years of 1905 to 1967 compiled by the Geo-Physical Centre of Pakistan Meteorological Department in Quetta. This list also contained a number of significant events which did not appear elsewhere. Unfortunately the list did not include all of Afghanistan but only the eastern portions. As above, the approach was one of including the data if not available from other sources.

For the year of 1967 and onwards the USC&GS hypocentral data files were augmented through the use of the Preliminary Seismological Bulletin of Pakistan and the earthquake files of the Kabul University Seismological

Center. Even though the hypocentral data file is very complete, considering that it pertains to the entire world, many significant local earthquakes which occur in a given region are not included. This is not an omission on the part of the USC&GS, but simply a result of an insufficient number of stations reporting the events.

Through the careful comparison of all the earthquake data recorded in the above sources a list of earthquakes pertaining exclusively to the regions of Afghanistan was compiled. This list, in chronological order, comprises the instrumental earthquake history of the country.

7.3 Lists of Instrumentally Determined Earthquakes

To perform an earthquake history study of a region as irregular in shape as the political boundaries of Afghanistan, poses some difficulties. Certainly some earthquakes which appear outside the political boundary could be destructive to regions within the country. To cover this situation a possible approach would be to establish a fixed distance from the boundary within which all earthquakes would be included in the earthquake history. This of course leads to the difficulty of selecting the earthquakes from the data sources on the basis of a very irregular set of limiting coordinates. To avoid this problem it was decided to approach the study using a well-defined set of coordinates within which the entire country would be well contained. Based on this criterion, the region selected extends from 27° to 40°N in latitude and from 58° to 76°E in longitude. Although the NW and SE sectors of this enlarged area are well removed from the political boundaries of Afghanistan, it happens that these regions are low in seismic activity and hence have little effect on the analysis.

In keeping with the same objectives as discussed in Sec. 6.3 the lists of all recorded earthquakes within the region defined above, are included with this report as App. D. The lists have been separated, for ease of reference, into two tables; namely, Table D1 and Table D2. Table D1 is a chronological listing of all strong earthquakes, where strong is defined as earthquakes with a determined magnitude of $M \geqslant 5.8$. The second and more extensive listing, Table D2, is a chronological listing of all earthquakes which includes the strong earthquakes appearing in Table D1 and all other earthquakes of $M < 5.8$ but sufficient in size to be classified as significant events.

The details regarding the format of Tables D1 and D2 are presented in the "Explanatory Remarks" which precedes the tables in App. D. In addition, however, some discussion should be given regarding the procedure by which the entries in Tables D1 and D2 were made. In order to properly reduce the vast information which was available from the data sources, criteria had to be established. In the first place, a common occurring problem was the listing of an earthquake event in two or more data sources with small variations in the instrumental data appearing. The criterion adopted to handle this situation was to record the event from one source, based on the following priority: (1) USC&GS, (2) USSR Atlas, and (3) Pakistan. In the case where the USC&GS source listed several values for the same event, the criterion used was to accept the result which best represented the average of the instrumental data or provided the most complete set of data; that is, a magnitude and depth were reported. In utilizing the priority list above, it often developed that the second or third sources included additional information on depth and magnitude. In these cases the additional information was added to the entry with due recognition being given to the authority.

Another major difficulty encountered in compiling the lists of significant earthquakes was the very large number of earthquakes listed in the U.S.S.R. Atlas with a rating of $M < 4.25$, during the years of 1940 to 1957. All these earthquakes were considered to be below a significant level and were not included in the lists. Also, for the years preceding 1960, all the events listed by the USC&GS for which no magnitude appeared, were evaluated as being significant by comparing the events with the U.S.S.R. Atlas. The criterion used was that if the event was listed in the Atlas and rated as $M < 4.25$, it was considered insignificant. If no matching entry could be found in the Atlas and if Moscow with its nearby stations was not listed as an authority, it was felt that this was a significant event in that it was documented only by authorities well removed from the country.

From 1960 onwards all recorded earthquakes were included in Table D2. Although some of the events listed are small in magnitude it was felt that the number of seismic stations in the region by that time had increased to a sufficient level so that the instrumental determinations were reasonably accurate and would thereby contribute to the understanding of the seismicity of the region.

One final point related to the data presentation in Tables D1 and D2 concerns the magnitude values shown. In nearly all cases the listed magnitude values are body wave magnitudes; however, the data which has Gutenberg and Richter as the authority, the listed magnitudes are based on surface waves. In some earthquakes where both body and surface wave magnitudes were determined, the criterion was to accept the larger value of the two. Surface wave magnitudes selected on this basis are identified in Tables D1 and D2 with an asterisk as a superscript. The surface wave magnitudes could have been converted to body wave magnitudes by the relation presented in Sec. 6.1, but it was felt that, owing to the uncertainties of the magnitude values in the first place and the questionable accuracy of the conversion equation, such a manoeuver would have little value. Accordingly, the seismicity analysis presented in the next section will not differentiate between the two types of magnitude.

One feature of Tables D1 and D2 which will be pointed out in this section is the inclusion of the intensity data column. This has been done in order to provide a convenient cross reference between Tables D1 and D2, and Table C1 for future cause and effect correlation studies.

The extensive listings of the instrumental earthquake history as given in Tables D1 and D2 are the first such listings ever to be compiled for the regions of Afghanistan. The originality of the information in this form provides the opportunity to perform a number of interesting analyses from which valuable information related to the region can be determined. Two such analyses will be performed in this report. The first will be a straightforward analysis regarding the temporal distribution of the events; this is presented and discussed in the following subsection. The second analysis known as a seismicity study involves more elaborate treatment of the data and this forms the subject of Sec. 8.

7.4 Temporal Distribution of Instrumental Data

Owing to the extensiveness of the instrumental data presented in Tables D1 and D2 it is difficult to draw attention to the highlights without regrouping the data into a more manageable format. One such approach is to summarize the information on a temporal basis, similar to the form used in Table C2 of App. C. This temporal distribution analysis has been performed and the results are given in Table D3 of App. D. The information included in this table is a summary of all the data included in Tables D1 and D2 which is for the region 27°-40°N and 58°-76°E. For the all earthquake list, Table D3 displays the monthly and yearly frequencies; for strong earthquakes only yearly frequencies are presented.

As a result of the scant instrumental data available up to 1924 the first entries in Table D3 are grouped on the basis of five year intervals starting with all earthquakes up to 1899. Of interest are the early earthquakes which are included in the, to 1899, entry. From Table D1 it is seen that the first recorded earthquake is an event in 1893 and was obtained from the U.S.S.R. Atlas. The event is somewhat removed from Afghanistan being NW of Meshed by 100 km. It is questionable whether or not this is an instrumentally recorded event but it is possible because seismographs were in existence at that time. The entire group of earthquakes up to 1904 were all obtained from the U.S.S.R. Atlas. The first event listed by the USC&GS files is the Kangra, India earthquake of 1905. As seen in Table D1, the first recorded earthquake to be located within Afghanistan is the April 13, 1907 deep Hindu Kush event of 7.0 magnitude.

Table D3 shows that a total of nearly 2,000 significant earthquakes have been included into the instrumental earthquake history of the region during the years of 1893 to 1969. Of this total nearly 200 earthquakes are grouped in the strong category ($M \geq 5.8$). It is quite evident from Table D3 that no seismic stations existed in the region up to 1928. This conclusion is based on the result that nearly all recorded earthquakes up to that time were of the strong variety, that is, the earthquakes were sufficiently large to be recorded by the existing distant European seismic stations. After 1928 the number of recorded earthquakes increases significantly compared to the number of strong earthquakes. This increase probably resulted from the installation of some Russian seismic stations within or near to the region. The large number of earthquakes shown for 1935 is attributed to the destructive Quetta earthquake and its aftershocks.

The very low number of earthquakes shown for the years of 1945 and 1946 agrees very well with the intensity data shown in Table C2 and it must be concluded that 1945 and 1946 were years of very low seismic activity in the region. The year of 1949 shows a very large increase in the number of recorded events and by reference to Table C1 it is seen that this corresponds to the large March 4, 1949 Hindu Kush earthquake. The intense seismic activity which followed the Kahmard-Sayghan earthquake of 1956 is well illustrated by the large number of strong earthquakes listed for the years of 1956 to 1960. The increase in the number of recorded earthquakes during the 1960's is primarily a result of the installation of seismic stations in the region during that time. This is particularly well demonstrated by the 172 earthquakes listed for 1969 which was not in any way a year of unusual seismic activity.

The temporal distribution of the recorded earthquakes on a monthly basis reveals that the most active month in terms of all earthquakes during the period 1893 to 1969 was September with the minimum activity appearing in February. In terms of strong earthquakes, which is possibly a more representative measure, September is again the most active month but February is replaced by December as the month of minimum activity. These months of maximum and minimum activity do not agree very well with the intensity data given in Table C2 which showed January as most active and May as minimum. This lack of correlation is not surprising in view of the incompleteness of the data and the different time periods and regions concerned. The only conclusion possible from this rather chaotic monthly distribution is to state that there appears to be no discernible relationship between earthquake activity and the seasons of the year within the time period and region analysed.

A further analysis which can be pursued, is to perform a temporal distribution study for the recorded earthquakes which were determined as having occurred within the political boundaries of Afghanistan. Such an analysis was performed and the compiled results are shown in Table D4 which has the same format as Table D3. The salient result shown by this analysis is that the total number of all earthquakes has been reduced by 50 percent in comparison to the broad region covered in Table D3. In terms of strong earthquakes it is seen that of the 199 shown in Table D3 nearly 60 percent, of 116, have occurred within Afghanistan. In view of the fact that the land area of Afghanistan accounts for roughly 30 percent of this broad region, it follows that the seismic activity within Afghanistan is well above the average activity for the broad region.

Another interesting feature depicted in Table D4 concerns the monthly distribution of the events. The statistics for all earthquakes show that December was the most active month and February the least. Although the month of February agrees with Table D3, December represents a definite shift (from September) in the maximum activity. The more notable feature however appears in the monthly totals of strong earthquakes. The total of 18 earthquakes in the month of March and 13 in April clearly stand out compared to the other months. The fact that these were strong earthquakes and therefore probably in the felt category, supports the often-made claim that the spring season in Afghanistan is one of increased seismic activity. The time interval for the present temporal analysis is really too brief to permit any definite conclusion, but it could be stated that within Afghanistan during the past 60 years, the occurrence of strong earthquakes have been more prevalent during the spring months of March and April.

As will be convincingly demonstrated in the seismicity analysis of Sec. 8, the major source of seismic activity in the country results from the zone of deep* earthquakes in the NE regions of the country. (This zone is depicted in Fig. 35.) Although somewhat out of order, it seemed appropriate at this point to include a temporal analysis of the earthquakes originating from this zone. From Tables D1 and D2, all earthquakes having epicenters within the deep zone, defined as shown in Fig. 35, were compiled and a temporal distribution table was constructed; the result appears in Table D5. The most striking aspect of this analysis is the 810 total earthquakes which have occurred within this relatively small zone. Of the total number of all earthquakes (1,933) listed for the broad region, 40 percent are therefore confined to this small zone of approximately 4 degrees quadrangle area. In terms of the broad region which encompasses 234 degree quadrangles, this zone represents less than 2 percent of the area. These statistics vividly demonstrate the intense seismic activity which occurs within this pocket of deep earthquakes.

Table D5 also demonstrates that the seismic nature of Afghanistan is predominantly related to the activity in the deep earthquake zone. Although the deep zone extends outside the Afghan boundaries it is still evident from Tables D4 and D5 that roughly 75 percent of the strong earthquake activity in the country originates from the Hindu Kush zone of deep earthquakes.

The monthly distribution of strong earthquakes in Table D5 shows a similar but less pronounced distribution trend to that given in Table D4. Based on the monthly statistics, it seems that the probability of strong earthquakes occurring in the Hindu Kush becomes greater during the spring months.

The temporal analysis of the instrumental earthquake history of the region, has shown that earthquake activity has been reasonably continuous through the period for which data was available. There were, however, some well-defined intervals when the seismic activity greatly increased and also some intervals of very low activity. The distribution of events on a monthly basis gave no definite trends with the exception of a notable increase in the number of strong earthquakes occurring within Afghanistan, and also in the deep earthquake zone of the Hindu Kush, during the spring months.

The investigation into the frequency of recorded earthquakes is really one phase of a seismicity analysis. The second and more important phase however is the analysis of the earthquake events in terms of spatial distribution. The results produced by a spatial analysis form an integral part of the information necessary for establishing seismic risk zones.

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*--In the accepted terminology of world seismicity data (Fig. 3) the term "deep", here, is incorrectly used; the correct terminology should be "intermediate-depth" and this is used in Fig. 35. However, for this regional study the terminology of intermediate-depth is awkward and "deep" will be used occasionally to denote those earthquakes which originate below the crust of the earth.

8. SEISMICITY ANALYSIS

The term, seismicity, has been used extensively throughout this report without a clear definition being given previously. In general, if the seismicity of a region is know, it implies that the nature of the earthquake activity is known and can be expressed in terms of, the spatial distribution of the epicenters throughout the region, the size or magnitude of the earthquakes, the frequency of occurrence and the depth of the foci. The seismicity of a region includes non-instrumental as well as instrumental information. The most common method of illustrating seismicity is by plotting all known earthquake epicenters on a map and using a notation whereby the different magnitudes and depths are distinguishable. The frequency of occurrence is conveyed by limiting the map to a certain time interval. A map conveying this type of information, presented in this manner, is known as a seismicity map. Correctly, Fig. 3 in this report is called a seismicity map with the region being the entire world for the time period 1961-1969. Figure 20, the intensity zone map, in part is also a seismicity map in that the epicentral regions of the major earthquakes are represented.

The scope of this section of the report is to present a seismicity analysis for the regions of Afghanistan utilizing the instrumental data compiled in Tables D1 and D2. As already mentioned, the temporal distribution analyses given in Tables D3, D4 and D5 can be considered partly as a seismicity study. The present analysis, however, will be in the form of presenting and discussing the seismicity maps of the region, constructed in the manner described above. The analysis will be based entirely on the instrumental data.

8.1 Regional Seismicity Maps and Discussion

Four regional seismicity maps have been produced for this report and are included as Figs. 22, 23, 24 and 25. Figure 22 is a seismicity map based on all strong earthquake data as presented in Table D1 and therefore covers the time period of 1893 to 1969. Figures 23 to 25 are seismicity maps which were plotted for all earthquakes from Table D2. The time period of 1893 to 1959 is shown in Fig. 23, from 1960 to 1969 in Fig. 24 and Fig. 25 is a composite plot of all earthquakes during the time period of 1893 to 1969.

Before discussing these regional seismicity maps in particular, several comments should be made regarding the criteria used in constructing the maps. Owing to the difficulty of establishing a suitable nomenclature which could differentiate simultaneously between depths and magnitude, it was decided to omit the depth parameter in the regional plots. This is not a serious shortcoming because the entire region analysed is primarily subjected to shallow earthquakes with the exception of the NE sector. An additional argument for this choice is that many of the earthquakes listed in Tables D1 and D2 before 1959, are without determined depths.

The criterion used for the magnitude nomenclature has several facets. Firstly, suitable ranges of magnitude had to be selected and this posed some problems owing to the incompatibility of the data in the U.S.S.R.

Atlas, which listed many earthquake magnitudes as a range of values, with the magnitude values listed in the other sources. Because the ranges selected by the U.S.S.R. Atlas were too broad for the present analysis, more appropriate ranges were established and the Russian data was fitted in as best as possible. The magnitude ranges are shown in Figs. 22 to 25 and this system was retained throughout the seismicity analysis. As seen, six ranges are given; three for the strong earthquakes and three for the smaller earthquakes of less than 5.8 magnitude. The star symbol corresponds to earthquakes equal to or greater than 7.3 and the Russian magnitudes listed as 7.5+ are included in this range. The second magnitude range, $6.5 \leqslant M < 7.3$, is denoted by the hexagon and the Russian magnitudes listed as 6.5+ have been plotted with this symbol. The third range, $5.8 \leqslant M < 6.5$ is represented by a square and the 5.3+ Russian magnitudes fall into this category. For the smaller earthquakes, the first range of magnitudes, $5.0 \leqslant M < 5.8$, is assigned the large circle symbol. The second range, $4.5 \leqslant M < 5.0$, is designated by the intermediate circle with the Russian magnitude values of 4.3+ included in this range. The final range which includes all earthquakes of $M < 4.5$, is represented by the small circles.

Owing to the listing of many earthquakes without determined magnitudes it was necessary to adopt a system whereby these events could be plotted consistently. It was decided that all earthquakes up to 1959, without a magnitude, would be assigned a magnitude rating of $4.5 \leqslant M < 5.0$, and all earthquakes from 1960 onwards would be put in the range of $M < 4.5$. This difference in magnitude assignments between the 60's and pre-60's was considered justifiable, based on the increase in the number of seismic stations during the 1960's. Because there were fewer seismic stations in the region before 1960 it was felt that for an earthquake to have been located instrumentally, on the average, it must have been greater than a 4.5 magnitude. After 1960, for an event without magnitude, it seemed appropriate to place it in the lowest magnitude range in view of the increased number of stations.

The first seismicity map to be discussed is Fig. 22 which pertains only to strong earthquakes from 1893 to 1969. Inspection of this map reveals the intense Hindu Kush pocket of strong earthquakes, as the most striking feature. This "persistent source" of earthquake activity as expressed by Gutenberg and Richter[5], is well demarcated with the center at 36.5°N and 70.5°E. In Fig. 22 this center has been depicted by a large star owing to the fact that a total of 51 strong earthquakes were listed with these coordinates as their epicenter. The insert in Fig. 22 gives a breakdown of the number of events in the three ranges. The reason that so many epicenters have this precise set of coordinates is that most of these earthquakes occurred before 1960 and owing to fewer seismic stations, epicenters could not be determined with the present day accuracies of $\pm 0.1°$; accordingly most epicenters were quoted to the nearest half degree. This explanation also accounts for the pocket of earthquakes around 36.0°N and 70.5°E and the other one-half degree intersections in this region.

The second most active region illustrated in Fig. 22 is the extreme northeastern sector of the map which lies in Russia. The greatest activity is centered just above the most northerly point of Afghanistan and reference to Fig. 1 shows that this activity lies just to the east of Garm. It will also be noticed that the general trend of the epicenters follows the course of the Vakhsh River valley in Russia. The fact that these strong earthquakes are all shallow in depth, makes it clear that the regions bordering the Vakhsh River are high-risk seismic zones. It is also evident from Fig. 22 that the Pamir regions are susceptible to strong earthquakes.

The other notable region, where strong earthquakes occur, is the Quetta area in Pakistan. The epicenter denoted by the star SSW of Quetta, represents the 1935 earthquake which destroyed Quetta. It will be seen that the region of strong earthquake epicenters extends eastward from Quetta and is very much associated with physiographic features of the Indus basin. Inspection of Fig. 1 shows that the edge of the plateau regions demarcates the limits of earthquake activity.

Within Afghanistan the 1956 Kahmard-Sayghan earthquake is clearly the most distinguishable feature outside the Hindu Kush pocket. Also evident, is the 1948 Mazar-i-Sharif earthquake just to the NE of the city. Besides the large second-class earthquake south of Kunduz the only other region in the country where strong earthquake epicenters appear is the group of third-class events south of Kabul. These events as will be shown in Sec. 9 are related to the Gardez fault system. The lone third-class epicenter in the center of the country appears to be an isolated event.

Figure 22 also reveals strong earthquake activity in regions to the west of Afghanistan. The first-class event shown at 34°N is the disastrous Dasht-e-Bayaz earthquake of 1968. The pocket of strong earthquakes in the NW sector of the map relates in part to the 1948 Ashkhabad earthquake which occurred on the borders of Iran and Russia. The only other zone of strong earthquakes is to the extreme east of the map and the first-class event shown here is the great Kangra earthquake of 1905.

The seismicity map of strong earthquakes has given a clear representation of the strong earthquake zones in the region, but it does not convey the extent of the seismically active zones. To do this the strong earthquake data must be augmented with the smaller earthquake activity; this has been done and the results appear in Figs. 23 to 25. These seismicity maps have been constructed in order to demonstrate the earthquake activity up to 1959, the activity during the past decade, and the total activity during the time period for which instrumental data exists. This particular split in time has been selected in accordance with the increase in the number of seismic stations from the pre-60's to post-60's. Owing to the improved quality of the instrumental data during the 1960's it was felt that a more detailed and reliable seismicity study could be performed by placing special emphasis on only the past ten years.

Figure 23 demonstrates very well the improved interpretation possible, by including more earthquake epicenters into a seismicity map. The dense pocket of epicenters south of Faizabad is clearly the most distinguishable aspect of the regional seismicity. It was not possible to include and display all epicenters which were located in this zone; the presentation procedure was to plot first the larger earthquakes and then proceed progressively to the small magnitude ranges. The extent of this intense seismic zone is approximately confined to the one degree quadrangle demarcated by the 36° and 37° latitudes and the 70° and 71° longitudes; there is some spreading however, to the east and north. Interestingly, this pocket has the appearance of being detached from the seismic activity surrounding it. It will be seen later that part of the reason for this result is that within the pocket the earthquakes are of intermediate-depth whereas outside, the earthquakes are primarily shallow.

Another notable observation in Fig. 23 is the high density of epicenters in the Garm region, around the Vakhsh River. By comparing the location of these epicenters with the geography shown in Fig. 1 it becomes quite evident that the Vakhsh valley must coincide with a major tectonic system. The Pamir region adjacent to the Vakhsh seismic zone also displays considerable seismic activity throughout its extent.

Within Afghanistan it is seen that up to 1959 the region directly south of Kunduz showed considerable activity; there was also some activity to the west of Mazar-i-Sharif and one lone fourth-class event SE of Maimana. The region along the Gardez fault system showed significant activity and this extended westward well beyond Ghazni. The other notable region where activity can be observed is along the Amu Darya and Ab-i-Panj River basins with some concentrations occurring near Khorog and north of Rustak.

A comparison between the seismicity of 1893 to 1959, as shown in Fig. 23, with the 1960-1969 seismicity presented in Fig. 24, reveals some interesting features. Most noticeable is the absence of any first-class events throughout the entire region with the one exception being the 1968 Iran earthquake in the west. In view of the difference in time period, roughly 70 years to 10, this is not a surprising result, but it does indicate that if the periodic pattern of the first 70 years is maintained, the occurrence of some major disturbances is quite probable within the next ten years.

The second important difference between Figs. 23 and 24 is the appearance of the epicentral distribution in the Hindu Kush region. Very definitely, the location and shape of the intense activity zone in the 1960-1969 seismicity map has changed. The locus formed by the epicenters has moved south away from the 37° latitude and east to about the 71.5° longitude and shows a very definite bulge in the NE direction. This definite NE trending was not at all visible in the 1893-1959 seismicity map. Also different in the 1960-1969 map is the lack of a definite separation between the very dense grouping of epicenters in the Hindu Kush region and the surrounding epicenters; this is particularly evident on the west side, south of Kunduz. One possible explanation for these observed differences is that the earthquake activity during the two intervals of time was not equivalent. This explanation, although probably quite correct, accounts for only part of the difference. The more plausible explanation is that the earthquake data of the past ten years is considerably more reliable and accordingly the intense seismic zone can be delineated more accurately; this fact was well demonstrated by the world seismicity data shown in Fig. 3.

The belt of activity which strikes to the NE is one of the salient results which was not evident in the 1893-1959 seismicity map. It is interesting to note that this NE belt appears to join the Vakhsh belt of earthquakes in the extreme NE corner of the region. Enclosed between these two belts is a well-defined region of relatively minor seismic activity, the center of which appears to be the Safed Khir mountains (see Fig. 1). Actually the entire NE corner of the broad region has taken on a somewhat different appearance in the 1960-1969 result but without the additional information related to the depths of the events it is not profitable to point out further features; this will be reserved for Sec. 8.2 which is a detailed analysis of the NE region.

In addition to a general increase in the number of events which appear in going from Fig. 23 to Fig. 24, there are two other noteworthy differences. The first is the seismic activity which is seen around Jalalabad and extends up into the Kunar valley; this did not appear in the 1893-1959 seismicity map. The second is the definite belt of seismic activity which stretches in the SE direction along the foothills of the Himalayas and this was, at best, only poorly visible in the older seismic data. The reason for the observed seismic activity in these two regions during the 60's is obviously a result of the appearance of regional seismic stations. During the 1970's when more high-quality data becomes available, these zones will become even more clearly identified.

By superimposing the 1960-1969 data on the 1893-1959 map the regional seismicity map for the combined time period of 1893 to 1969 was produced; this is Fig. 25. In essence, it is a pictorial representation of the instrumental earthquake history of the region. The entire 1,933 earthquakes listed in Table D2 appear on this map.

All features which were presented in the preceding discussion are clearly amplified and accentuated in this 1893-1969 seismicity map. The seismically active regions are very distinguishable from the aseismic regions. The broad earthquake belt stretching from well north of Jalalabad, past Ghazni, and down to Quetta, is very evident. Also clear is the belt which strikes west from Kunduz, through Mazar-i-Sharif and then SW to near Maimana. The almost complete aseismic character of the SW block of the country is very obvious. Some sparsely distributed seismic activity is seen along the south and west extremities of the map but these do not extend to the south and southwest borders of Afghanistan. The closest major activity on the west is the 1968 Iranian earthquake with its concomitant cluster of aftershocks.

The major importance of the 1893-1969 seismicity map in the form presented in Fig. 25 is that it can be combined with both the intensity data as summarized in Fig. 20 and the tectonic data as presented in Fig. 6. The combination of seismicity, intensity and tectonic data as will be presented in Secs. 9 and 10 is the culmination of this report.

8.2 Detailed Seismicity Analysis of the NE Region

The salient aspect of the regional seismicity map of 1893-1969 is clearly the northeast region which contains the extremely dense distribution of epicenters about the Hindu Kush mountain range. Although the limits of this intensely active seismic zone were well defined in Fig. 25, owing to the great number of epicenters located there, it was impossible to distinguish any further features. From the temporal analysis presented in Sec. 7.4 and according to Table D5, it was shown that more than 800 epicenters were distributed in this small zone. If an inspection of Table D2 is made, it would be found that these earthquakes vary anywhere from very shallow foci to depths of nearly 300 km. This broad variation in depth of foci is the most unique feature of this pocket of earthquake epicenters, and as already presented in Sec. 5.2, and illustrated in Fig. 4, there is strong evidence to suggest that the deep earthquakes in this group are directly related to the movement of the Indian-Australian crustal plate.

In order to acquire a deeper insight into this very special zone of earthquake activity, a seismicity analysis, giving attention to the variation in earthquake depths is essential. Such an analysis has been performed and the presentation and discussion of the results is the scope of this section.

A seismicity study of a region where there is a considerable variation in depth of foci presents an additional dimension to the investigation and accordingly an additional degree of complexity. The main problem is to adopt an appropriate format for displaying the distribution of the foci so that the principal features of the phenomenon are exhibited. Throughout the seismological literature a number of different techniques have been used and after due consideration, it was decided to present the variation in depth, by a series of seismicity maps each displaying the epicentral distributions for a given range of foci depths. The selection of the depth ranges was open to speculation and a number of different ranges and groupings were attempted. Partly governing this selection was the knowledge that the crustal thickness in the regions of the Hindu Kush was in the order of 70 kms[50]. With this as a base and with knowledge that the deepest earthquakes in the region do not exceed 250 kms (a few isolated events in Table D2 show depths slightly greater than 250 km) appropriate depth ranges were established. As an alternate base, a crustal depth of 50 kms was also considered.

Figures 26 through 33 present the results of this detailed seismicity analysis of the NE region defined by the 33° to 40°N latitudes and the 67° to 76°E longitudes. This particular region was selected because it is only within this area where earthquakes below the crust predominantly occur; all other regions shown in Fig. 25 contain crustal earthquakes with the exception of a few below the crust events near Quetta. Before discussing the results it should also be mentioned that this seismicity study was restricted to the 1960 to 1969 period because of the greater reliability of this data. Furthermore, all earthquakes appearing in Table D2 without depth determinations were discarded from the analysis.

Figures 26 and 27 present the results of separating the 1960-1969 seismicity data, given in Fig. 24, into two broad depth ranges; namely, those earthquakes occurring within the crust (0-70 km) which is Fig. 26 and those earthquakes occurring below the crust ($>$70 km), Fig. 27. A comparison of these two seismicity maps reveals a number of important observations. The shallow earthquakes of Fig. 26 are distributed somewhat uniformly throughout the region whereas the deeper earthquakes in Fig. 27, are very much confined to the pocket zone south of Faizabad, with effectively, a tail which strikes to the NE. Throughout Fig. 27, there is a sparse and chaotic scattering of events about the zone of high-density epicenters; however, there is a visible trend which strikes SE from the pocket and this is along the foothills of the Himalayas (see Fig. 1). Most evident is the near absence of any deep events in the Vakhsh valley and throughout the Zaalayskiy Khrebet regions and it follows that the tectonic processes in these regions are primarily crustal in nature. This conclusion is also valid for the regions around Jalalabad and Peshawar. In contrast to this however, there is almost a near absence of shallow events (Fig. 26) within the intense zone of deep earthquakes (Fig. 27) and it can be concluded that the tectonic processes in this region are primarily sub-crustal in nature.

Another important observation from the comparison of Figs. 26 and 27 is the difference in the size of the earthquakes. In Fig. 26 there is only one second-class event and two third-class events whereas in Fig. 27 a total of 5 second-class events and 16 third-class events appear. From this observation it is evident that the stronger earthquakes in the region predominantly occur below the crust. This implies that considerably more energy is being accumulated as a result of sub-crustal tectonic processes than those processes affecting the crustal layers.

The absence of shallow earthquakes in the epicentral zone of deep events, depicted in Fig. 27, is even more clearly demonstrated in Fig. 28, which is a seismicity map for all earthquakes in the depth range of 0-50 km. This seismicity map also conveys more clearly the fact that the surface events in the NE region separate into two broad zones; namely, the region on the northern side of the Hindu Kush and the regions on the southern side. This observation is in keeping with the tectonic analysis given in Secs. 5.2 and 5.3 and this will be discussed further when the results of these seismicity maps are summarized.

Figures 29 and 30 present the seismicity plots of the epicenters associated with the earthquakes in the depth ranges of 51-100 km and 71-100 km, respectively. These two particular depth ranges have been selected in order to link the deep earthquake seismicity maps which follow with either of the shallow seismicity maps given by Figs. 26 and 28. In either of these maps it can be seen that with the increase in the depth of the earthquakes, there is an appreciable increase in the number of epicenters which fall in the zone of deep earthquake epicenters, as defined by Fig. 27. Although not clearly visible the NE trending of the epicentral distribution can be seen; this will however become very evident in the deeper seismicity plots which follow.

The final three seismicity maps produced for this detailed seismicity analysis appear as Figs. 31, 32 and 33 wherein the depth ranges of 101-150 km, 151-20 km and depths >200 km are presented respectively. A comparison of Fig. 31 (101-150 km) with either Fig. 29 or Fig. 30, illustrates very definitely the converging effect of the epicentral locations with increasing depth. With the exception of a few small scattered events along the Himalayan range, the entire seismic activity is confined to the small region in the NE corner of the country and the narrow belt which extends NE into the Pamir Knot. The greatest density of epicenters coincides with the throat of the Wakhan corridor, situated just south of the village of Zebak.

Figure 32 (151-200 km) has a somewhat similar appearance to Fig. 31 but there are some notable differences. Firstly, it can be observed that the dense region of epicentral distributions for this deeper range of earthquakes has spread outward to some extent in comparison to the distribution shown in Fig. 31. Also evident is the first appearance of a number of strong earthquakes of the second and third-class variety; these did not occur in the shallower layer above. The scattered isolated events which are located in the extreme north of the map do not follow the converging pattern which has been observed with increasing depths. The explanation for this apparent discrepancy is not clear but it is suspected that the data may be unreliable. If reference is made to Table D2, it will be observed that these earthquakes were obtained from the preliminary seismological bulletins of Pakistan and it may be that when the final analysis of these events is published, they will be relocated.

The most dramatic result of this series of seismicity maps appears in Fig. 33 which presents the epicentral distribution for all earthquakes with depths below 200 km. As clearly seen, the highly well-defined dense pocket of strong earthquake epicenters is the salient feature. Obviously, this very confined grouping of earthquake foci, in just over a one-half degree quadrangle and at depths of 200 to 250 km, is the "remarkable persistent source of earthquakes" which was observed by Gutenberg and Richter[5] in 1949. This source of strong, deep earthquakes, has never been more clearly highlighted than as shown in Fig. 33. In comparison to the seismic characteristics of the other regions in the world, this source must be rated as one of the most unique seismic phenomenon known. Although a seismic energy investigation has not been performed in this report, it may well be found that when the appropriate calculations are made, the average energy release per unit time per unit volume from this source exceeds any other seismic region in the world.

Some particular observations related to Fig. 33 should be made. Although the locus generated by the dense distribution of epicenters is well defined, there are clearly a number of scattered events throughout the intermediate region. The significance of these scattered epicenters, if they have been reliably determined, is not clear. It may well be that the data supporting these events is in error, but this cannot be established at present. As more reliable data is compiled through the 1970's the validity of these isolated events will be either proven or discredited. If the events should be valid, it would greatly alter the tectonic interpretations presented in this report.

By way of summarizing and highlighting the results presented in the series of seismicity maps, from Figs. 26 through 33, a seismic regionalization map based on depth of foci, has been constructed and is included as Fig. 34. This map is a schematic representation of the epicentral distribution for the different ranges of earthquake depths. Four depth zones are shown; namely, 0-70, 71-150, 151-200 and >200 km. The zones were drawn by successively overlaying the appropriate seismicity maps and including within each zone all significant epicenters; scattered events of magnitude <4.5 were disregarded. Before discussing Fig. 34 it should be stated that this type of data presentation suffers from the fact that a great number of earthquakes in Table D2, displayed depths with values bordering the limits of two zones. In view of the accuracy of depth determinations ($\pm$ 25 km) it follows that a number of events could in reality fall into a zone other than shown, and some modification to Fig. 34 would occur. Regardless of this drawback, the overall features displayed in Fig. 34 should be valid.

The discussion of Fig. 34 will first be directed to the shallow earthquake zones. As seen, two detached zones wherein earthquakes of 0-70 depth occur, are shown. These zones occupy the northeastern and southeastern sectors of the region; the unshaded area which separates them, represents the regions where very little or no earthquake epicenters appeared during 1960-1969. By comparing this unshaded area with the physiographic features illustrated in Fig. 1, it is evident that the separation zone is coincident with the locations and strikes of the Hindu Kush, Karakoram and Himalayan mountains. The existence of these two shallow earthquake zones is a result which agrees very well with the continental and regional tectonic analyses presented in Secs. 5.2 and 5.3. The southern zone demarcates the northwest corner of the Indian-Australian crustal plate with the western edge running approximately along the Gardez fault system. The northern zone on the other side lies within the Asian continental system. The Hindu Kush and the other mountain ranges are the interaction or transition zones between these two continental plates.

The second phase of discussion pertaining to Fig. 34, concerns the zones of deep earthquakes or sub-crustal seismic events. Most evident is the fact that the shallowest layer (71-150 km) has the broadest extent and almost entirely contains the other two depth zones. The overlap of the 151-200 km zone on the south side is not considered significant and as already discussed it may be just a result of the particular limits which were used in the seismicity analysis. The deep zone ($>$200 km) however, is well contained within both the shallower zones. The obvious conclusion from this spatial distribution of the three zones, is that within the Hindu Kush region, the extent of earthquake activity continually converges with increasing depths. Although not illustrated in Fig. 34, the previous seismicity maps also clearly demonstrated the increase in the magnitudes of the earthquakes with increasing depths and this provides the additional conclusion that, within the Hindu Kush, the occurrence of strong earthquakes becomes more probable and prevalent with increasing depths.

It is interesting and also challenging to postulate on the possible nature of the tectonic processes which might be promoting the hypocentral distribution in the sub-crustal regions of the Hindu Kush, as shown in Fig. 34. Certainly the behavior is not of the trench-type tectonic patterns as observed in the major oceanic trench systems. It will be recalled from the discussion on global tectonics, and on the world seismicity data (Sec. 5.1), that owing to the down thrusting of one crustal plate beneath the other, a plunging fault plane was observed and the earthquake foci were distributed along this plane in the depth pattern of shallow, intermediate and deep. Disregarding the crustal earthquakes in Fig. 34, it is evident that this is not the case below the Hindu Kush. By approaching and passing through the zone by any direction the pattern is one of shallow to deep and back to shallow. In essence, what appears in the Hindu Kush is, in part, a double trench effect, but, in addition, the entire volume within the limits of the v-shaped or elongated conical pocket is seismically active.

A yet unpublished theory, proposed by R.S. Dietz and J.C. Holden of the U.S. Environmental Science Services Administration, relates to the physical phenomenon which resulted when the Indian sub-continent made contact with the Asian continent (recall discussion in Sec. 5.2). They postulate that as the Indian continent approached the Asian continent, a trench was formed between them by the mutual downturning of their edges. As a result, crustal material was downthrusted from both sides into the upper mantle. This situation, if valid, contrasts to the case of the ocean trench systems where an oceanic crustal plate slides under a continental plate. If the Dietz and Holden postulation is valid it would imply that the upper mantle phenomenon in the Hindu Kush is one of the very active remanents which has remained from the original interaction of the Asian and Indian continents.

The unsatisfying aspect of the above postulation is the lack of similar activity along the entire strike of the Himalayan range. There is one notable exception of intermediate-depth earthquakes, however, in the Burma region; this was schematically illustrated in Fig. 4. In a recent paper by T. Santo[61], a seismicity study of the Burma region was made and it was established that the Burma zone was not similar to the Hindu Kush phenomenon but had the characteristics of a trench system. Santo also analysed the Hindu Kush center using 1961-1967 USC&GS hypocentral data and his observations and conclusions are similar to those presented in this report. Santo established that the Burma phenomenon is a continuation of the Java trench tectonic system and accordingly it follows that the creation of crustal material in the Indian Ocean is being eliminated by underthrusting along this NS edge of the Indian-Australian crustal plate.

With the Burma phenomenon reasonably well established, it still leaves a required explanation for the Hindu Kush-Himalayan edge of the plate. A possible explanation which could be submitted, is that the original underthrusting of crustal material along the Himalayan arc, has now been replaced by overthrusting into the Asian continent and the triangular seismic zone (see Fig. 4 and discussion in Sec. 5.2) is a manifestation of this effect. In the Hindu Kush center, the apparent remanent downthrusting could well be a result of the interaction of two convection cells within the mantle; one cell promoting and being associated with the movement of the NW corner of the Indian-Australian plate and a similar but somewhat oppositely faced convection cell under the Asian continent. The interaction of these two cells could be producing the trough-like pocket of seismic activity in the upper mantle below the Hindu Kush. Furthermore, as a result of these two convection cells the crustal blocks above are being pushed together with upthrusting about the Hindu Kush resulting. The north and south crustal flanks of the Hindu Kush which correspond to the zones of shallow earthquakes, as illustrated in Fig. 34, are therefore a crustal manifestation of the material movements in the upper mantle.

The Hindu Kush center of deep earthquakes has attracted the attention of many seismologists, and many investigations, based solely on the seismograms written by distant seismic stations, have been performed in order to ascertain the nature of the focal plane mechanism and the direction of thrusting associated with this unique center. It is beyond the scope of this report to review these papers or the techniques applied in the investigations. For later studies directed at improving the current understanding of the tectonic processes at work under the Hindu Kush, an excellent base can be developed by reviewing the work of A.R. Ritsema[50,62], J.H. Hodgson[63], A.E. Scheidegger[64], E.I. Shirokova[65], I. Lehman[66], R. Chander et al[67], and A. Hedayati et al[68].

Before ending this discussion on the seismicity results for the NE region it is profitable to relate the findings of Ritsema, in his latest paper[50], to the observations and conclusions presented in this seismicity study. By averaging many of the fault plane solutions produced in the references quoted above, Ritsema was able to establish some important overall trends and, in particular, he observed that the maximum stress axis associated with the deep earthquakes was about 19°E of north (discussed in Sec. 5.2), whereas for the shallow seismic events, the maximum stress was directed about perpendicular to the structural trend of the Hindu Kush. Furthermore, from fault plane solutions, he established that at shallow depths the fault plane in general is a true thrust plane striking about SW-NE and dipping at 45° with primarily strike-slip components. At deep levels the fault plane strikes ESE-WNW with a probable dip of 25°N. Based on the differences in direction of thrust and on the differences in the nature of the fault planes, Ritsema concluded that the crustal and sub-crustal tectonic processes in the Hindu Kush region are not directly coupled. Furthermore, Ritsema's findings are well supported by the results of the present study as shown in Fig. 34. In Fig. 34 it can be seen that the zone of shallow earthquakes on the northern flank of the Hindu Kush cuts through the zones of deep earthquakes and it is difficult to explain this result other than by the explanation that the shallow tectonic processes are not directly associated with the deep tectonic processes.

Ritsema's possible explanation that the deep earthquakes are a result of a NNE flow in the upper mantle and the shallow earthquakes are determined mainly by the configuration of the surrounding crustal blocks is in complete agreement with the continental and regional tectonic models which have been developed and proposed in this report.

8.3 Seismicity of the Kabul Region

One of the interesting and also very important results demonstrated in the 1893-1969 seismicity map (Fig. 25), was the lack of any recorded seismic data near to the city of Kabul. The closest event shown was a sixth-class event about 30 km east of the city. The closest strong earthquakes are those associated with the Gardez fault system; these are about 60 km in distance. Furthermore, the entire regions to the south, west and north are depicted as being devoid of seismic activity. The closest activity on the north side is well beyond Jabal-us-Siraj. Therefore from the seismicity maps alone, it would be concluded that the upper Kabul valley and the Koh Damon valley represent regions of very low seismic activity. This conclusion, however, runs counter to the intensity data which has thoroughly documented the occurrence of the great 1505 and 1874 earthquakes within the region; consequently, the observed low seismicity characteristics of the region are put into doubt.

Without the existence of the Kabul Seismological Observatory, the issue of whether or not the Kabul regions are seismically active could not be ascertained in this report; however, reference to the instrumental data file which has been produced for the last two years clearly settles the issue. During the year of 1969 when a low magnification vertical channel at the Observatory was in operation, a total of more than 40 significant earthquakes were determined as having originated within the Kabul region. Many of these events were small on the magnitude scale but several reached levels for human detection in Kabul. Unfortunately, owing to vandalism, the felt data for these events has been lost. Two very significant events close to Kabul did occur in November of 1968 and these are listed with the instrumental data given in Table D2. These epicenters were not plotted on the seismicity maps because the locations were based on the data from a single-component seismographic system; such data provides reliable estimates of distance to be made, but the azimuth cannot be ascertained. Also not appearing in Table D2 are a number of felt earthquakes which strongly jolted Kabul in the summer of 1970. These were analysed by the new two-component, low-magnification Wood-Anderson system at the Observatory and the epicenters were fixed at just 10 km north of Kabul.

The recent instrumental data produced by the Kabul Observatory and presented above, substantiates that the Kabul region is not seismically inactive, as suggested by the seismicity analysis. This statement however should not be misinterpreted as implying that the seismicity analysis in this report is in error. The discrepancy is simply explained by the lack of any seismic station in the region before the existence of the Kabul Observatory. Prior to 1968 the closest station to Kabul (see Fig. 21) was the Warsak Station in Pakistan, a distance of 200 km to the east. The next closest stations were in Russia, more than 400 km away. Even if Warsak recorded an event originating from Kabul, the records from a single station would be insufficient to perform an epicentral determination*. It is quite possible that many of the felt earthquakes in Kabul, as listed in Table C1 of App. C., originated in the Kabul regions but the lack of correlating instrumental data prevented identification of the source. From the seismicity data, however, it can be stated, with reasonable certainty, that within the past ten years, no strong earthquakes have taken place within the Kabul regions.

A detailed analysis of the seismicity of the Kabul region cannot be performed in this report; the instrumental data compiled during the past two years simply represents too short an interval of time. Through the continued monitoring, however, of these nearby events as recorded by the new low-magnification system at the Observatory, valuable regional data will be forthcoming and this will provide the basis for a future study.

The observations and explanations presented above, do not pertain just to the Kabul region, but have much broader implications. It seems certain that if significant seismic events have gone unrecorded in the Kabul area, there must be many other regions in Afghanistan where similar situations prevail. For example, the lack of recorded activity along the major Herat fault which is actually even more remote in terms of nearby seismic stations, is a strong possibility. Many other fault systems in the country may well be producing activity which is below the detectable level of the remote seismic stations of the region. Whether or not the

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*--In the USC&GS computerized programs, a minimum of five reporting stations is considered necessary to calculate, reliably, the location of an earthquake. A single station, however, can make a reasonable epicentral determination of a nearby event if suitable instrumentation is available. The low-magnification, two-component Wood-Anderson system at the Kabul Observatory was installed for this precise purpose.

various fault systems of the region have an appreciable level of activity and whether or not the aseismic regions shown in Fig. 25 are really devoid of seismic activity, can only be resolved by future seismicity studies based on more complete and reliable data. The Kabul Observatory with its high-magnification systems will contribute greatly to resolving these uncertainties.

9. SEISMO-TECTONIC ANALYSIS

The inseparable relationship between tectonic processes and earthquake phenomena, discussed in Sec. 5, provides the opportunity to extend the information of one based on the information of the other. Consequently, the optimum approach to acquiring the best understanding of the seismic or tectonic nature of a region is through a combination of this information. Because the seismic nature of a region is well described by a seismicity map and the tectonic nature by a map of the regional fault systems, the most straightforward way of coupling the data is by superimposing the results of a seismicity map on a fault systems map. A map which imparts this type of information is referred to as a seismo-tectonic map and in itself, produces one form of a seismo-tectonic analysis.

For the present study it was deemed essential that a seismo-tectonic analysis in the form of a map should be presented. An analysis of this type, in addition to complementing the information presented in the tectonics section of this report, would represent in one map a summary of most of the regional tectonic systems, as presently known for Afghanistan, and the earthquake history, as known on an instrumental basis. The existence of such a seismo-tectonic map would definitely be an excellent reference and guide for many different aspects in the country's development. One application in particular, is that it would form the basis for the assignment of seismic risk zones and this is one of the objects of this report.

By overlaying the 1893-1969 regional seismicity map (Fig. 25) on the regional fault systems map (Fig. 6), a seismo-tectonic map for the regions of Afghanistan was constructed. This map is included in the report as Fig. 35 and because of its importance, a larger reproduction is included in the pocket attached to the back cover. Before discussing some of the features, several comments regarding the construction are necessary. In the first place, the map does not cover as broad a region as the 1893-1969 seismicity map. Because the fault systems were not known for the extremities of the broad region, and because the purpose of the map is primarily directed towards the needs of Afghanistan, the smaller zone was chosen. Secondly, as shown in Fig. 35, the intense pocket of earthquake epicenters associated with the deep earthquake zone (more correctly referred to as intermediate zone in Fig. 35) have been removed and replaced with simply a boundary denoting the region wherein deep earthquakes occur. This was accomplished by first eliminating all epicenters in the zone and then, by proceeding through Table D2, all shallow earthquakes (< 70 km) with coordinates in the zone were determined and plotted. All earthquake epicenters which appear in Fig. 35 are shallow events; there may however be several earthquakes outside the deep zone which are sub-crustal but could not be removed with certainty because the depth was not given. The reason for only considering shallow earthquakes in the seismo-tectonic analysis is that the fault lines which appear on the surface are very unlikely to be associated with the deep earthquake events. The result shown in Fig. 34 and the findings of Ritsema[50] support this very well. Finally, it should be mentioned that a number of significant fault lines which appeared on the geological map and were not mapped by Wellman[48], were included in Fig. 35; the additions however were primarily confined to the Kahmard-Sayghan region.

The information presented in Fig. 35 is extensive and many important features are depicted. Certainly one of the most interesting developments, in view of the discussion relating to the movement of the Indian-Australian crustal plate, is the seismic activity along the Chaman fault. Although the activity is shifted to the east in the Quetta region, it is evident that the Chaman fault is active within Afghanistan as far north as Ghazni. Related to this observation is the obvious seismic activity which is coincident with the Gardez fault system throughout its entire length. The lack of any significant events to the immediate west of the system, gives strong support to the statement which was made in Secs. 5.3.1 and 5.3.2 that the Gardez fault system forms part of the transcurrent fault which demarcates the northwestern edge of the Indian-Australian crustal plate. The further observation that the northern end of the Gardez fault system intersects the Herat fault at nearly the precise location of the >200 km depth, earthquake zone (see Fig. 33 or 34), is indeed further evidence to support the statement. If there are convection cells within the mantle which are dragging the Indian-Australian crustal plate NNE, and if the material in these cells is downthrusting in the Hindu Kush center, then the Gardez fault system along with its observed seismic activity and its observed intersection with the Herat fault above the point of deep earthquakes, is an acceptable physical manifestation of this postulated driving mechanism. Furthermore, the possible existence of an Iran-Afghan crustal block which was hypothesized in Sec. 5.3.2, gains more credence in light of this seismo-tectonic evidence.

The second notable feature, is the lack of any epicenters near to the major trans-country Herat fault throughout most of its length. Along the northeast section, some epicenters are located near to the fault; but, it is not clear whether these are related to the Herat fault or some nearby lesser faults. In view of the significance attached to this fault, as presented in the discussion of the regional tectonics (Sec. 5.3), the lack of associated seismic activity is surprising. The discussion thus centers on the question of whether or not the instrumental seismic evidence is realistic. In previous analysis, it has been noted that owing to the sparsity of regional seismic stations, many sectors in the country could be producing seismic activity which is not instrumentally detectable. The discussion of the Kabul region (Sec. 8.3) is an excellent example, and the fact that the Herat fault is even more removed from the regional seismic stations (see Fig. 21), the possibility of unrecorded earthquakes is even greater. The evidence that Herat City was heavily damaged by an earthquake in 848 A.D. (Table C1) provides some testimony that the fault is active. On the other hand, it is unlikely that any strong earthquake has originated from this tectonic system in the last thirty years; this particular estimate is based on the knowledge that the Pashtun Kot earthquake of 1934 (see Sec. 6.4), which took place 150 km north, was not instrumentally recorded.

Of interest and of value to the above issue is the existence of the very remote Jam minaret[69] situated on the Hari Rud at 34.4°N and 64.6°E; this 60 meter high and 8 meter, in base diameter, minaret is situated directly on the Herat fault. Although the construction methods were excellent for the period, the fact that the minaret has existed for nearly 700 years would indicate, at least, that no major disturbance along that portion of the fault has occurred for quite some time. The existence of the six slender Musalla minarets in Herat City, of 15th century vintage, can also be cited as evidence supporting small activity along the fault; however, there is an unsubstantiated report[70] that, of the original complex, two of the minarets fell in 1931 and one in 1951 as a result of earthquakes. At the time of writing this report it has not been possible to acquire corroborating testimony to support this earthquake damage.

The discussion presented above does not in any way resolve the question of whether or not the Herat fault is active. It seems certain that the fault does not possess the same level of activity as the Chaman fault, but beyond this, the matter remains in doubt. Hopefully, the careful monitoring of seismic events by the Kabul University Seismological Center will provide the needed information in the near future. Until such time, the Herat fault and its immediate area must be treated as potential sources of seismic disturbances.

Some of the other fault lines which show recent seismic activity near to their strikes, should be mentioned. From Fig. 35, the major Kahmard-Sayghan earthquake is very evident lying just south of the Andarab fault which is in accordance with the discussion presented in Sec. 6.4. Interestingly, the aftershock sequence following the major earthquake appears to be more related with the Andarab fault. Because of the uncertainty of the epicentral location when analysed in terms of these small distances, it is difficult to say with certainty, whether or not a seismic event and a fault line correspond; however, in the case of the Kahmard-Sayghan earthquake and in view of the evidence given in Sec. 6.4, it seems reasonable to conclude that the initial event must have been associated with either one of the lesser EW faults shown in Fig. 35 or an unmapped fault. Other sections of the Andarab fault do not show any related seismic events with the exception of the extreme end of the eastern section.

The Kunar fault running north of Jalalabad and into the Kunar valley shows a considerable number of related events and it seems clear that this system is quite active. The Urgun fault south of Jalalabad, which runs a NS course, also exhibits some nearby seismic activity; this observation coupled with the intensity data in Table C1, testifying to the occurrence of a destructive earthquake in 1052 A.D., establishes the fault and its regions as being an active tectonic system. The region west of the Chaman fault, extending to and beyond the Uruzgan fault, contains a number of seismic events and it is evident that this sector of the country, with its system of NE striking faults, is undergoing tectonic processes. Although no strong earthquake epicenters appear, it is known (Uruzgan earthquake, 1933, Sec. 6.4) that the level of seismic activity can reach damaging proportion in this region. Further west, in the remote center of the country, little earthquake activity can be seen with the exception of the lone, strong event associated with one of the spur faults which bifurcates from the northeast end of the Baghran fault.

Correlation between fault lines and earthquake activity is also evident in the regions north of the Herat fault. In the west, southeast of Maimana, three earthquake epicenters can be seen; these appear to be associated with minor and as yet unnamed faults. Although no event is located near to the Pashtun Kot fault, the intensity data relating to the Pashtun Kot earthquake of 1934 does substantiate that significant tectonic processes are at work.

The Mazar-i-Sharif region is particularly revealing in Fig. 35. Although Wellman[48] was not able to map any fault with certainty in this region, owing to the thick Quaternary deposits, it seems evident from the seismo-tectonic map that there is a significant EW striking fault which passes just to the north of Mazar-i-Sharif. This fault must have been the source of the 1948 Mazar-i-Sharif earthquake and probably the ancient 848 A.D. Balkh earthquake. It seems reasonable, based on the strong identifying evidence, that the segments of the fault, as shown in Figs. 6 and 35, should in reality be joined, and the resulting continuous fault could appropriately be referred to as the Mazar-i-Sharif fault.

Within the extreme northern sectors of the country there appears to be a strong correlation between earthquake activity and the short EW striking fault lines which have been mapped. Also of particular interest, is the one near NS fault line which passes just to the west of Rustak (see Fig. 1) and breaks to the west on approaching the Ab-i-Panj River where a dense cluster of epicenters is located. Activity along this fault could well have been the cause of the 1969 damage in Rustak illustrated in the frontispiece.

It is not possible to highlight all the features which are demonstrated by the seismo-tectonic map. The discussion given has been primarily confined to the significant results which either relate directly to previous observations and discussions, or to the development of the seismic risk map in the following section. The analysis has clearly strengthened a number of the hypotheses made in this report; but, at the same time it has demonstrated a number of uncertainties. The most serious handicap in the construction of the map was the lack of complete and reliable seismic data beyond the past ten years; this of course cannot be remedied. Reliable data in the future, however, will be forthcoming, and if the map is updated periodically, an improved insight into the tectonic and seismic nature of the country will result.

10. SEISMIC RISK REGIONALIZATION

Throughout this report, much of the discussion related to the information presented has been directed toward the assessment of the potential seismic hazards which prevail throughout the various regions of the country. The purpose of this final section in the report is to synthesize all the various types of information which can contribute to the establishment of seismic risks and thereby construct a seismic risk regionalization map. This type of map reveals the various zones in which a certain range of earthquake effects are probable or can be expected, and accordingly, it forms the basis for the establishment of earthquake-resistant, building-code provisions.

The procedure for performing a seismic risk regionalization analysis is not in any way standardized throughout the world. The reason in part for this is the lack of a true quantitative understanding of the effects produced by an earthquake with varying distances from the hypocenter, and also the great uncertainties about the occurrence or reoccurrence of earthquakes in a region. Owing to the present state of the art, seismic regionalizations are primarily based on judgment and experience; the latter unfortunately do not often appear in open literature. Despite the different approaches to the problem, it is well accepted by all, that the essential prerequisite is a compilation of all available related earthquake information. For Afghanistan the prerequisite has been accomplished in this report.

In addition to the varied ways of approaching a seismic risk analysis, the final product, which is the risk zone map, has no standard format. The various zones defined on such a map have been expressed in terms of such variables as, probable maximum intensity scale levels, expected intensity ratings versus average return period, maximum probable horizontal accelerations, rate of strain energy release, and etc. Many of these approaches involve a statistical analysis of the raw data and the results in many cases require considerable interpretation in order to be incorporated into earthquake building codes. A simple format, which has been adopted in such countries as the U.S.A., Canada and India[71,72], involves the regionalization of the country into zones which reflect directly, the type of damage that can be expected*. The number of zones selected to represent the seismic risks varies, but the coverage in all cases spans the range from major damage to no damage. In this system, each zone is assigned a weighted factor and these are directly incorporated into building-code formulas from which the lateral earthquake forces on structures can be calculated. Although this presentation is by no means perfect, the simplicity of the system is a great advantage, and hence it is a reasonable compromise.

*—Pakistan has also developed a seismic-risk regionalization map which presents the probable maximum ground accelerations for the various regions of the country. It is not known if this map has been published in the open literature, but a copy is available at the Seismological Center.

In view of the immediate needs of Afghanistan it was considered paramount that a preliminary regionalization of the country should be undertaken and presented in this report. It was also decided that the regionalization should follow the simple format used by the U.S.A. and other countries so that the earthquake building code provisions[71,74] already adopted and established in these countries*, could be easily used as a guide for the creation of a similar set of codes tailored to the environmental conditions of Afghanistan. In keeping with this objective, a seismic risk zone map has been constructed and this is included in the report as Fig. 36; the following discussion centers on the methods used in constructing the map and some of the important related aspects.

As seen from Fig. 36, the country has been divided into four zones of probable seismic risks. The first zone (0), represents those regions of the country wherein the possibility of earthquake damage is remote. The second zone (1), corresponds to regions where minor earthquake damage could be expected and the third zone (2), represents the case where moderate damage is probable. The fourth zone (3), demarcates the regions of the country wherein the seismic hazards are the greatest and major damage could occur. The numerals identifying the various zones are according to the seismic risk map of the U.S.A.

The manner in which the four zones were established in Fig. 36, requires some explanation. The fundamental criterion used was that the regionalization should be a synthesis of all data; that is, the intensity data as given in Table C1 and summarized in the intensity zone map (Fig. 20), the instrumental data as given in Tables D1 and D2 and presented in the 1893-1969 seismicity map (Fig. 25), and the data on tectonics as given by the maps of the regional fault systems (Figs. 5 and 6). The coupling of this extensive and diversified data was accomplished by superimposing the intensity zone map (Fig. 20) on the seismo-tectonic map (Fig. 35). In this way, all information was displayed simultaneously and by overlaying a third map of the region, the seismic risk zones were drawn according to the evidence beneath and the judgment of the authors.

The phrase "judgment of the authors" should be further explained. The judgment exercised was uniformly applied according to preset guidelines or criteria. Firstly, it was accepted that, any region wherein a major earthquake had been know to occur, it must be assumed that such an event could occur again within the same region and to the same extent. Secondly, if the major earthquake or any lesser damaging earthquake appeared to be associated with a mapped fault line, it must be assumed that a similar event could occur at any point along the same fault line. Thirdly, for any mapped fault line which did not exhibit any related seismic data but the lack of recorded activity may be a result of the absence of local seismic stations, it must be assumed, for the present, that the fault could represent a seismic risk.

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*--Iran has established an antiseismic construction code[73] which was compiled in 1966. The code was written based on a future regionalization map of three seismic risk zones. The map was to be compiled at a later date and at the time of writing this report it is not known whether or not such a map exists.

With the above criteria presented, a discussion of the seismic risk zone map is now possible. The most important aspect is the probable major damage zone. As seen, this occupies the greater part of the north-east sector. The northern part of this zone was drawn according to the 1832 earthquake and the fact that the region lies directly above the intense zone of intermediate-depth earthquakes. The western bulge of this zone, just south of Kunduz, is in sympathy with the second-class ($6.5 \leq M < 7.3$) earthquake epicenter which was located in this region. The very prominent westerly extension of the zone reflects the 1956 Kahmard-Sayghan earthquake and the Andarab fault system. This extension reaches nearly to the 66°E longitude which represents the most westerly point of the Andarab fault (Fig. 35), and is in accordance with the second criterion stated above.

The second criterion was also applied in drawing the long narrow belt which stretches from north of Kabul to the southeastern corner of the country. This belt straddles the Chaman fault and owing to the great 1505 Paghman earthquake and the 1892 Chaman earthquake, it follows that all regions near to the fault are susceptible to probable major damage. The width of the zone shown was, in general, set at approximately 10 km to either side of the fault; this distance was based in part on the observed intensity-epicentral distance relationship observed in the 1968 Iranian earthquake[3] and on the fact that the epicenter need not coincide with the mapped fault line. The difference in the width of the zone results from the influence of known earthquake damage zones.

The branch which bifurcates from the Chaman fault belt, just south of Ghazni, and strikes NNE to the west of Jalalabad, represents the possible risks associated with the Gardez fault system. This zone is somewhat wider owing to distribution of epicenters and the discontinuous nature of the faults which compose this system. From this branch the high-risk zone was drawn to the south of Jalalabad and thereby also includes the Kunar valley. The great 1842 earthquake which heavily damaged Jalalabad and the known seismic activity along the Kunar fault, promoted this configuration.

The zone of moderate damage probable, in most cases, encloses the high-risk zone and this in part results from the intensity-epicentral distance effect; but, in many regions the limits are according to known intensity, instrumental or tectonic data. Most notable in this category are the regions around Mazar-i-Sharif and south of Maimana. The known damaging earthquakes which affected Mazar-i-Sharif in 1948 and Pashtun Kot in 1934 have dictated the western extremities of this zone. The bulge to the southwest of Maimana is according to the extent of the mapped Pashtun Kot fault. Also highly prominent in this level of zoning, is the narrow belt which extends to the western boundary of the country and includes Herat. This belt straddles the Herat fault and has been drawn according to the third criterion listed under "judgment of the authors". The branch which bifurcates from the Herat fault zone to the NW, results from the 1955 Gulran series of earthquakes and the NW striking fault lines which are mapped in this region (Fig. 35).

As seen, the moderate damage zone occupies a large part of the north-central region of the country and this results from the widespread effects associated with the strong, deep Hindu Kush earthquakes. If the activity along the northern section of the Chaman fault could be disregarded, Kabul would be included in this zone. The broad region of this zone, which extends southward, west of the Chaman fault, results from the known earthquake activity and numerous fault lines in this region and in particular the 1933 Uruzgan earthquake. The bulge in this zone which takes in Kandahar is based on intensity data (Event #3, 1933, Table C1) and the extension of mapped fault lines into the region. Actually the inclusion of Kandahar into this moderate damage zone may be somewhat of an overestimation of the existing seismic risks.

The zone representing probable minor damage is primarily drawn according to the intensity-epicentral distance effects for earthquake activity within the country; two exceptions however exist. The broad zone on the western border has resulted from the known earthquake activity in Iran at those particular latitudes; the 1968 Iranian earthquake is the primary example. The zone in the center of the country, in the configuration of a split tongue, follows the northeastern ends of the Farah and Baghran faults; this has been drawn based on the third criterion but because of the lack of any instrumental or intensity data whatsoever throughout the entire southwestern corner, the zones were truncated short of the entire lengths of the faults.

The seismic risk zone map as presented in Fig. 36 is the first such map to be compiled for Afghanistan. Although the map has been established by using all the information collected in this report, it must nevertheless be considered as a preliminary model. The zones were drawn according to the present state of knowledge and as pointed out, there is definitely a lack of high-quality seismic data for many of the regions in the country. As improved data becomes available during the 1970's, it will be possible to reevaluate many of the zones and in particular, those which were drawn on the basis of insufficient information (e.g., the zone related to the Herat fault). The appearance of new geological information, especially the identification of additional fault lines, should also be incorporated into later versions of the seismic risk map.

Future modifications to the risk zone map in the form of improved and refined interpretations of the data, are also possible. Certainly, investigations into the intensity-epicentral distance relations for the shallow and deep earthquakes occurring in Afghanistan should be pursued. The format of Tables C1, D1 and D2, which jointly display the intensity data and the instrumental data, has been adopted for this precise purpose. Of particular importance to such an investigation will be the future collection of intensity data from the country-wide network of 125 earthquake reporting centers which was established by the Seismological Center in 1969. A starting point for the analysis and interpretation of such data can be found in the work done by K. Ergin[75] wherein empirical intensity-epicentral distance relations were established. If similar realistic relations can be devised for Afghanistan, an improved version of the seismic risk map can be produced.

Refinements to the seismic risk zone map can also be done on the basis of performing more specific regionalization studies, that is, localized seismic risk evaluations. The map as presented in Fig. 36 is an overall assessment of the country and it is evident that within the various zones, localized geology such as nearby active faults and deep alluvium, and such other things as high water tables and soil bearing pressures, could produce at a given site, a greater seismic risk than assigned by the broad zone. Some excellent work, related to seismic risk analysis on a small scale, has been performed by A. Cornell[76]; reference to this work would provide a base for similar studies related to particularly critical locations in Afghanistan.

One final aspect related to the seismic risk zone map concerns the format. In establishing the zones, no consideration was given to time; that is, if a large event occurred in a given region, the region was assigned the appropriate seismic risk based on the known intensity data regardless of how often an event of this size might occur. For example, on the evidence of the great Paghman earthquake of 1505, Kabul was placed in the high-risk seismic zone. If an earthquake of this size has not reoccurred since that time, then as a conservative estimate it might be assumed that such a level of intensity has a return period of 500 years. From an economic point of view, it could well be argued that such a long period risk does not justify the resulting increases in construction costs to accommodate this maximum level of intensity; accordingly, a smaller maximum intensity might be selected for the design criterion. Such an approach is reasonable if the maximum intensity versus average return period is known to within an acceptable probability limit; however, the incompleteness of the seismic data for the regions of Afghanistan makes the statistical approach difficult to apply with any certainty. For the present, it is believed that the format used in exhibiting the seismic risk zones, as given in Fig. 36, complies with the state of the art and the current needs of Afghanistan.

11. CONCLUSIONS

An extensive and documented research into the earthquake history of Afghanistan has been accomplished. The history has been presented by a chronological catalogue of non-instrumental intensity reports, and by a chronological listing of recorded instrumental data.

Known earthquake activity in Afghanistan has been greatly expanded both in time and extent. Identification of earthquake damage to the Greco-Bactrian city near Aikhanum, in the north of the country, has extended the earthquake history by 1,500 years. The inclusion of the documented earthquake destruction to the cities of Balkh and Herat and the town of Urgun, has provided written testimony to the occurrence of earthquakes in the country, 700 years earlier than recognized in previous studies. A consierable amount of new evidence related to earthquake phenomenon in the 19th century, has been uncovered; namely, the exact dating of the 1832 Badakhshan earthquake; pictorial evidence of the level of destruction in Jalalabad in the 1842 earthquake, and the inclusion of many additional 19th century earthquakes which were not listed in previous studies. New evidence of damaging earthquakes in the 20th century has also been found; this includes the 1931 Pashghur earthquake in the Panjshir valley, the 1948 Mazar-i-Sharif earthquake and the 1955 Gulran earthquake northwest of Herat. In total, nearly 500 earthquakes of non-instrumental origin have been compiled.

The first list of instrumentally recorded earthquakes for the regions of Afghanistan has been assembled and published. The list includes nearly 2,000 earthquakes of which 199 have been categorized in a strong earthquake list. Temporal analysis of the instrumental data for the past 60 years has revealed a tendency for strong earthquakes to occur during the spring months within the country.

A comprehensive review of the latest global tectonic concepts has been presented. It has been postulated, based on the evidence of ocean floor spreading about the Indian Ocean ridge and the world seismicity data, that Afghanistan is straddling the northwestern corner of a continental-oceanic crustal plate which has been termed the Indian-Australian crustal plate in this report. The north-northeastward movement of this plate, as a result of spreading about the Carlsberg ridge in the Indian Ocean, is considered as being the primary source of tectonic processes and seismic activity in the eastern sectors of Afghanistan. The Chaman fault and, as named in this report, the Gardez fault system, have been identified as possibly demarcating the northwestern edge of the Indian-Australian crustal plate.

Information on the tectonics of the region has been compiled and the mapped fault systems as known for the regions of Afghanistan have been presented and discussed. The existence of an Iran-Afghan crustal block, which acts as a buffer block, compressed between the Asian continental mass on the north, the northward movements of the Indian-Australian crustal plate on the southeast and the Arabian Peninsula block on the southwest, has been postulated.

The first series of seismicity maps for the broad region between 27° and 40°N and 58° and 76°E, for the time period of 1893 to 1969, have been produced. It has been demonstrated that the northeastern sector of Afghanistan is a region of intense seismic activity whereas the southwestern corner appears to be totally aseismic.

A detailed seismicity analysis for the time period of 1960 to 1969 has been presented for the northeastern portion of the country. The well-known source of intermediate-depth Hindu Kush earthquakes has been revealed with exceptional clarity by means of a series of depth-restricted seismicity maps. It has been observed that with increasing depths, the epicentral spatial distributions converge and the number of strong earthquakes increase. It has been concluded that the upper mantle tectonic processes in the Hindu Kush region are not similar in pattern to the oceanic trench systems. The unique Hindu Kush phenomenon may be an active remanent of the original interaction of the Indian and Asian continents which, as postulated, produced a mutual downthrusting of crustal material. The evidence produced by the seismicity maps is in accordance with Ritsema's deductions that the crustal tectonic processes in the Hindu Kush regions are not coupled with the upper mantle tectonic processes; also, the evidence demonstrates that the Hindu Kush mountain range appears to be an interaction zone between a portion of the Asian crustal block and the northwestern corner of the Indian-Australian crustal block.

A seismo-tectonic map for Afghanistan has been produced. Strong correlations between earthquake activity and the regional fault systems were observed. From the activity along the Gardez fault system and its intersection point with the Herat fault in the zone of intermediate-depth earthquakes, the postulation that the Gardez fault system forms part of the Indian-Australian crustal plate edge, was strengthened. The lack of seismic activity along the major Herat fault was observed and it was concluded that the lack of activity, if such exists, could be explained by the remoteness of regional seismic stations.

The first seismic risk zone map for Afghanistan has been constructed by a synthesis of all earthquake related data. The map in its present form should be considered as a "preliminary" model until further information in the form of high-quality seismic data can be compiled. It is hoped that the preliminary map will provide the base for the development of later improved versions, and also provide the basis for the establishment and adoption of earthquake-resistant building codes for Afghanistan.

This report has attempted to bring together, under one cover, all information related to the seismic and tectonic nature of the regions of Afghanistan. In view of the present development in the country, the fact that the region straddles one of the more active seismic zones in the world and the fact that the regional seismic activity was not well understood, the need for a detailed seismic investigation was evident. The primary purpose of this report, therefore, was to fulfill this need and thereby contribute to the development of the country.

In unfolding the seismic history of Afghanistan, the report has raised many unanswered questions and has presented a number of postulated models to explain observed physical phenomena. In going beyond its primary objective, the report has endeavored to provide a stimulus for continued research. If, as a result of this study, future investigations follow to resolve the unanswered questions and to prove or disprove the postulations, the report will have served another useful purpose.

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APPENDIX A

MODIFIED MERCALLI INTENSITY SCALE

It should be noted that the following intensity scale is an abridged and rewritten version of the original 1931 Modified Mercalli Scale and was introduced by C.F. Richter[30] in 1956.

I. Not felt. Marginal and long-period effects of large earthquakes.

II. Felt by persons at rest, on upper floors, or favorably placed.

III. Felt indoors. Hanging objects swing. Vibration like passing of light trucks. Duration estimated. May not be recognized as an earthquake.

IV. Hanging objects swing. Vibration like passing of heavy trucks; or sensation of a jolt like a heavy ball striking the walls. Standing motor cars rock. Windows, dishes, doors rattle. Glasses clink. Crockery clashes. In the upper range of IV wooden walls and frame creak.

V. Felt outdoors; direction estimated. Sleepers wakened. Liquids disturbed, some spilled. Small unstable objects displaced or upset. Doors swing, close, open. Shutters, pictures move. Pendulum clocks stop, start, change rate.

VI. Felt by all. Many frightened and run outdoors. Persons walk unsteadily. Windows, dishes, glassware broken. Knickknacks, books, etc., off shelves. Pictures off walls. Furniture moved or overturned. Weak plaster and masonry D cracked. Small bells ring (church, school). Trees, bushes shaken (visibly, or heard to rustle--CFR).

VII. Difficult to stand. Noticed by drivers of motor cars. Hanging objects quiver. Furniture broken. Damage to masonry D, including cracks. Weak chimneys broken at roof line. Fall of plaster, loose bricks, stones, tiles, cornices (also unbraced parapets and architectural ornaments--CFR). Some cracks in masonry C. Waves on ponds; water turbid with mud. Small slides and caving in along sand or gravel banks. Large bells ring. Concrete irrigation ditches damaged.

VIII. Steering of motor cars affected. Damage to masonry C; partial collapse. Some damage to masonry B; none to masonry A. Fall of stucco and some masonry walls. Twisting, fall of chimneys, factory stacks, monuments, towers, elevated tanks. Frame houses moved on foundations if not bolted down; loose panel walls thrown out. Decayed piling broken off. Branches broken from trees. Changes in flow or temperature of springs and wells. Cracks in wet ground and on steep slopes.

IX. General panic. Masonry D destroyed; masonry C heavily damaged, sometimes with complete collapse; masonry B seriously damaged. (General damage to foundations--CFR.) Frame structures, if not bolted, shifted off foundations. Frames racked. Serioud damage to reservoirs. Underground pipes broken. Conspicuous cracks in ground. In alluviated areas sand and mud ejected, earthquake fountains, sand craters.

X. Most masonry and frame structures destroyed with their foundations. Some well-built wooden structures and bridges destroyed. Serious damage to dams, dikes, embankments. Large landslides. Water thrown on banks of canals, rivers, lakes, etc. Sand and mud shifted horizontally on beaches and flat land. Rails bent slightly.

XI. Rails bent greatly. Underground pipelines completely out of service.

XII. Damage nearly total. Large rock masses displaced. Lines of sight and level distorted. Objects thrown into the air.

In the above intensity scale the four grades of masonry, A, B, C and D are defined as follows:

Masonry A. Good workmanship, mortar, and design; reinforced, especially laterally, and bound together by using steel, concrete, etc.; designed to resist lateral forces.

Masonry B. Good workmanship and mortar; reinforced, but not designed in detail to resist lateral forces.

Masonry C. Ordinary workmanship and mortar; no extreme weaknesses like failing to tie in at corners, but neither reinforced nor designed against horizontal forces.

Masonry D. Weak materials, such as adobe; poor mortar; low standards of workmanship; weak horizontally.

APPENDIX B

IMPORTANT HISTORICAL EARTHQUAKE NARRATIVES

(i) The Great Earthquake of July 5, 1505

(ii) The Great Earthquake of February 19, 1842

FOREWORD

Throughout historical times it seems certain that Afghanistan has been subjected periodically to earthquakes of major proportions. Historical accounts of these tragedies are indeed sparse and only a few documents are available today to testify to the havoc which has been inflicted on the region from time to time. Much of the information which is available is of the heresay or after-the-fact variety and this usually does not communicate the actual degree of severity. Two notable exceptions, however, do exist. These are the great earthquake of July 5, 1505 which was witnessed by Emperor Babur while he was camped near Kabul, and the great earthquake of February 19, 1842 which rendered great damage to the regions of Jalalabad and was thoroughly documented by Lady Sale, Lieut. Eyre and Major-General Abbott. The personal accounts of these observers are vivid testimonies to the calamities endured. Because of their significance to the present report, excerpts from the original articles have been reproduced and are included in this Appendix.

The Great Earthquake of July 5, 1505

Emperor Babur's Narrative

From: "Memoirs of Zehir-Ed-Din Muhammed Babur" (Reference 6)

"We had marched[a] as far as the auleng (or meadow) of Kush-Nadir where we had halted, when I was seized with a fever.

"At this period there was such an earthquake that many ramparts of fortresses, the summits of some hills, and many houses, both in the towns and villages, were violently shaken and levelled with the ground. Numbers of persons lost their lives by their houses and terraces falling on them. The whole houses of the village of Pamghan (Paghman) fell down, and seventy or eighty respectable householders were buried under the ruins. Between Pamghan and Bektut[b], a piece of ground, about a stone's throw in breadth, separated itself, and descended for the length of a bowshot; and springs burst out and formed a well in the place that it had occupied. From Isterghach to the plain[c], being a distance of about six or seven farsangs[d], the whole space was so rent and fractured, that in some places the ground was elevated to the height of an elephant above its old level, and in other places as much depressed; and in many places it was so split, that a person might have hid himself in the gaps. During the time of the earthquake, a great cloud of dust rose from the tops of the mountains. Nur-allah, the lutanist, happened to be playing before me on the mandolin, and had also another instrument with him; he instantly caught up both the instruments in his hands, but had so little command of himself, that they knocked against each other. Jehangir Mirza was at Tibah[e], in the upper veranda of a palace built by Ulugh Beg Mirza. The moment the earth began to quake, he threw himself down, and escaped without injury. One of his domestics was in the same story, when the terrace of this upper floor fell on him. God preserved him, and he did not sustain the slightest harm. Many rising-grounds[f] were

a - on the way to Kandahar
b - valley just north of Paghman
c - Maidan
d - 1 farsang equals 8 kilometers approx.
e - village about 20 km northwest of Kabul
f - houses in Tibah

levelled. That same day there were thirty-three shocks; and for the space of a month, the earth shook two or three times every day and night. The Begs and soldiers had orders to repair the rents and breaches in the walls and fortifications of the fortress. By great diligence and exertions, in twenty days or a month, all the parts of the walls that had been damaged or thrown down were repaired and rebuilt."

The Great Earthquake of February 19, 1842

A) Lady Sale's Narrative

From: "Journal of the Disasters in Afghanistan 1841-2" (Reference 13)

At Buddeeabad, 12 km northeast of Tigri, in the Alingar Valley

February 19:
"At noon I was on the top of the house; when an awful earthquake took place. I had gone upstairs to see after my clothes; . . . and in our present situation we must learn to do everything that is useful. But to return to the earthquake. For some time I balanced myself as well as I could; till I felt the roof was giving way. I fortunately succeeded in removing from my position before the roof of our room fell in with a dreadful crash. The roof of the stairs fell in as I descended them; but did me no injury. All my anxiety was for Mrs. Sturt (daughter); but I could only see a heap of rubbish. I was nearly bewildered, when I heard the joyful sound, "Lady Sale, come here, all are safe;" and I found the whole party uninjured in the courtyard. When the earthquake first commenced in the hills in the upper part of the valley, its progress was clearly defined, coming down the valley, and throwing up dust, like the action of exploding a mine.--I hope a soldier's wife may use a soldier's simile, for I know of nothing else to liken it to. Our walls, and gateways, and corner towers, are all much shaken, or actually thrown down. We had at least twenty-five shocks before dark; and about fifteen more during the night, which we spent in the courtyard. The end wall of the room Lady Macnaughten and party were in has sunk about two feet, and all the beams have started."

February 20:
"I wrote to Sale, to tell him we were all safe. At 3 in the morning we had a pretty smart shock, and constant ones, some severe, and many very slight, on an average every half hour all day, and five or six slight ones at night. The gentlemen gave up their largest room to my party, who were utterly roofless. Nearly all the others slept outside: but we had only one crack in the roof of our room, caused by part of the wall falling on it. The cold outside was intense; and the dew completely saturated the bed clothes last night: added to which, should the buildings come down, we were safer above, for the yard was so crammed that, in case of accident, half the people below must be crushed."

February 21:
"At 1 in the morning a sharp shock made us run to the door. We had numerous slight, and three or four pretty good shocks: they became more frequent in the evening. Part of our party made awnings in the courtyard to sleep under; but Mrs. Sturt and myself still preferred the house as safest.

"Dost Mahommed Khan brought workmen to clear away the debris. He tells us our fort is the best of forty that have suffered in this valley; and that many are entirely thrown down. In one, a tower fell, and crushed five women and a man: others have not a wall remaining.

"We have various reports regarding Jellalabad;--that it has been taken, that the walls and all the defences are thrown down, etc."

February 22:
"We had earthquakes day and night; less severe, but equally frequent. A prop was put up in our room to support the broken roof. We experienced a curious shock in the evening like a heavy ball rolled over our heads. Some large pieces of hills have fallen, and immense masses of stone. I miss some large upright stones on the hills that divide us from Kaffiristan, and that looked in the distance like large obelisks."

February 23:
"This has been a very close and gloomy day; earthquakes frequent, and some very sharp ones."

February 24:
"Very few shocks, and those gentle ones: but all last night, and great part of to-day, particularly late in the evening, there was a tremulous motion as of a ship that has been heavily struck by a sea, generally feeling as if on the larboard quarter, and accompanied by a sound of water breaking against a vessel. At other times we have just the undulatory motion of a snake in the water: but the most uncommon sensation we have experienced has been that of a heavy ball rolling over our heads, as if on the roof of our individual room, accompanied by the sound of distant thunder."

February 25:
"The earth is still unquiet, constantly trembling, with reports like explosions of gunpowder, but no severe shocks."

February 27:
"Earthquakes very frequent, but not severe, though worse than yesterday."

February 28:
"A smart shock of an earthquake about 9 o'clock in the evening; and during the night several slight ones."

March 1:
"A smart double shock in the morning, with slight tremulous motion."

March 3 & 4:
"Earthquakes as usual."

March 5:
"At 3 A.M. turned out of bed by a smart shock of an earthquake. Three continuous ones at breakfast-time."

March 9:
"Several slight shocks at night."

March 13:
"Earthquakes as usual."

March 14:
"Earthquakes in plenty."

March 18:
"We had two slight shakes, with reports like distant guns or thunder in the morning; and another during prayers at night."

March 20:
"During prayers (it being Sunday) about one o'clock we felt three distinct shocks."

March 23:
"An earthquake early in the morning, and many slight ones at night."

March 26:
"Earthquakes in the usual number."

March 27:
"Four earthquakes before breakfast, and more at night."

April 11:
"As we marched* through the valley, we saw the effects of the late earthquake: not a fort was entire; very few habitable, and most of them masses of ruins."

*—left Buddeeabad and heading towards Tigri.

B) Lieut. Vincent Eyre's Narrative

From: "The Military Operations at Cabul" (Reference 14)

At Buddeeabad, 12 km northeast of Tigri, in the Alingar Valley

February 19:
"On the 6th, we had a heavy fall of rain, since which the weather had become exceedingly close. This morning it was remarked that an unusual degree of heat and stillness pervaded the air. Whether these were premonitory symptoms of what was shortly to happen it is impossible to determine; but at 11 A.M. we were suddenly alarmed by a violent rocking of the earth, which momentarily increased to such a degree that we could with difficulty maintain our balance. Large masses of the lofty walls that encompassed us fell in on all sides with a thundering crash; a loud subterraneous rumbling was heard, as of a boiling sea of liquid lava and wave after wave seemed to lift up the ground on which we stood, causing every building to rock to and fro like a floating vessel. After the scenes of horror we had recently witnessed, it seemed as if the hour of retribution had arrived and that Heaven designed to destroy the bloodstained earth at one fell swoop. The dwelling in which we lodged was terribly shaken, and the room inhabited by Lady Sale fell in,—her ladyship, who happened to be standing on the roof just above it, having barely time to escape. Most providentially, all the ladies with their children, made a timely rush into the open air at the commencement of the earthquake, and entirely escaped injury. Gen. Elphinstone, being bedridden, was for several moments in a precarious position,

from which he was rescued by the intrepidity of his servant Moore, a private of H.M. 44th, who rushed into his room and carried him forth in his arms. The quaking continued for several minutes with unabated violence, and a slight tremor in the earth was perceptible throughout the remainder of the day. The Affghans were, for the time being, overwhelmed with terror; for, though slight shocks of earthquake are of common occurrence every year during the cold season, none so fearful as this had visited the country within the memory of the present generation. We shortly learned that our fort had been singularly favoured, almost every other fort in the valley having been laid low, and many inhabitants destroyed in the ruins. The town of Turghuree (Tigri) especially seems to have suffered severely, scarcely a house being left standing, and several hundreds of people having been killed in the fall.

"We all passed the night in open air, being afraid to trust the tottering walls of our habitation, especially as shocks of earthquake continued to occur almost every hour, some of which were rather severe."

March 3:
"Severe shocks of earthquake every day."

C) <u>Major-General Augustus Abbott's Narrative</u>

From: "The Afghan War, 1838-1842" (Reference 15)

At Jalalabad

February 19:
"The last week has been an eventful one. We have been gratified by intelligence of strong reinforcements marching to our aid, but the very day which brought us the news, witnessed a most extraordinary calamity. I was walking round the place yesterday, about noon, when the ground trembled under my feet, and I was sensible of the shock of an earthquake. The oscillation increased, and as the ground actually undulated, I sat down to avoid falling. Before me was a lofty bastion three stories high, on which stood a Sepoy sentry. This high building began nodding in a strange manner, and I fully expected it to fall at full length outwards, but only the thin parapet was shaken off, and the sentry remained unhurt at his post. All the parapets along the face commenced falling in like manner, and several large breaches were made in the bastions and the curtains. Within the works a confusion of cries arose, and a dense cloud of dust denoted that great injury had been sustained. The whole of the town was more or less injured, and two-thirds of the houses were totally destroyed. Our house had not escaped; my room is the only one now habitable, and that has its walls and roof in such a state, that last night I was more than once about to desert it, for we had eight or ten shocks between nine a.m. and daylight this morning. The aspect of the town is now most wretched, but fortunately few lives were lost. The working parties were all out, and only four men were killed of all our force. Colonel Monteith, of the 35th Native Infantry, was burried in the debris of a curtain, which fell under him, but the men speedily dug him out, and he is doing well. The whole country has suffered dreadfully. The bastions and curtains of many forts have been thrown down, and the clouds of dust that arose from every fort and village denoted that we were by no means the only sufferers. The market people tell us that women and children have been

killed by dozens, the waters of the river were twice thrown from their bed during the shock, and I had no idea that such mischief could be done in a minute and a half. To see the solid bastions of this fort, on which my guns looked like toys, split and thrown down by invisible agency, to see a mile and a half of parapet, the work of all hands during three months, in the same short time shaken down in their whole circuit, was equally awful and vexatious. The first great shock lasted only a minute and a half, but at short intervals we have ever since had slight shocks, which invariably sends all hands scampering into the open air."

March 20:
"Ever since the catastrophe of the 19th of February, slight shocks of earthquake continued almost daily, and on the 20th of March, there was so severe a shock that the left centre battery, on the river face, was cracked, and the parapets were damaged."

APPENDIX C

NON-INSTRUMENTAL (INTENSITY) DATA

(i) Explanatory Remarks

(ii) Table C1 - Chronological Catalogue of Earthquake Intensity Data

(iii) Table C2 - Summary and Temporal Distribution of Felt and Damaging Earthquakes

(iv) Gazetteer - Places of Observation

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EXPLANATORY REMARKS

The following remarks are presented in order to clarify the format of Table C1 and to draw attention to some important points.

1) The earthquake intensity reports, in addition to being identified by year, date and time in the first three columns, are also identified simply by year and event number as given in the first column. If only one event is known for a given year the event number does not appear. If more than one event is known for a given year, each event is then assigned a number from one onwards in the chronological order. The times shown have all been converted to GMT in order to allow ready comparison with the instrumental data given in Appendix D.

2) The places of observation appearing in the fourth column can be in the form of a city, a town, a district, a province or a country. All major observation places can be found on the map of the "Regions of Afghanistan" (Fig. 1). Less important and unfamiliar places have been identified in the Gazetteer which follows Table C1. In each case the places are geographically identified by reference to the major places found on Fig. 1.

   The spelling of place names for the regions of Afghanistan has yet to be standardized and for that matter many places are known by several names (e.g., Aibak and Samangan). It was not the object of this report to resolve the spellings or to perform a toponymical study. The approach has been to adopt a certain spelling or name and then to remain consistent throughout the report.

3) It should be clearly understood that the effects of the earthquake as recorded in column five are the effects which were reported at the place of observation. Although these effects are an abridged version of the original reports, care has been taken to include all salient facts.

4) Column six presents the references from which the intensity data was extracted. The reference numbers quoted correspond to the reference numbers in the general bibliography of the report.

5) The estimated Modified Mercalli Scale ratings (EST MM) are given in column seven. These estimates were made according to the data shown in the "Effect" column and are based on the levels of the MM intensity ratings defined in Appendix A. In many cases considerable interpretation was required in order to make a realistic assessment of the intensity reports. The EST MM values shown are exclusively based on the judgment of the authors with the exception of the entries taken from Stenz (Ref. 22) and Furon (Ref. 27).

   It should be clearly noted that the use of Arabic numerals to represent the MM Scale is not standard practice. The correct Roman numeral representation has been replaced in Table C1 for the purpose of conserving space.

6) The right-hand set of columns grouped under "Instrumental Data" have been included to allow convenient correlation between intensity data and instrumental data. The information in these columns has been brought forward from the chronological listings of instrumental data presented in Appendix D. This data includes the calculated origin time of the earthquake (GMT), the latitude and longitude of the epicenter, the magnitude and the depth.

For many events it will be noted that the instrumental origin times differ considerably from the times given by the intensity reports. These differences result primarily from the fact that for most intensity reports the times are known only approximately and can be in error by as much as hours. The matching of the intensity and instrumental data was made on the basis of dates, times and locations. Although for most events this could be done with complete certainty there were a number of cases where the judgment of the authors was exercised.

7) In Table C1 it will be noted that a number of entries are accompanied by a question mark. This notation has been used to signify that there was some uncertainty about the accuracy of the data.

8) Table C2, following Table C1, is a summary of the data given in C1. The format selected illustrates the temporal distribution of earthquake reports for the regions of Afghanistan. A similar format has been adopted for the instrumentally recorded earthquakes and these tables appear in Appendix D.

TABLE C1

CHRONOLOGICAL CATALOGUE OF EARTHQUAKE INTENSITY DATA

YEAR EVENT #	DATE	TIME Hr Mn	PLACE OF OBSERVATION	EFFECT	REF	EST MM	INSTRUMENTAL DATA TIME Hr Mn Sc	LAT N	LONG E	MAG	DPTH km
50BC -	50AD	--	Aikhanum	Building destruction. (See Sec.6.4)	54	8-9					
818 819	Jul 09 Jun 27	203 AH	Balkh	Mosque and one-quarter of the houses destroyed; earthquakes lasted for 70 days. (See Sec.6.4)	7	7-9					
848 849	Aug 05 Jul 26	234 AH	Herat	Many houses destroyed. (See Sec.6.4)	7	7-9					
1052 1053	May 03 Apr 22	444 AH	Urgun	Destructive earthquake. (See Sec.6.4)	7	7-9					
1505	Jul 05	--	Paghman	All houses fell down; 70-80 people buried. (See Sec.6.4)	6	9-10					
			Isterghach	Extensive surface fracturing, extending for 30 miles, possibly to Maidan.	6	8-9					
			Kabul	Fortress damaged.	6	7-8					
			Akserai	Severe building damage.	6	7-8					
			Koh Damon & Kabul Valleys	33 aftershocks felt on July 5; for one month following, 2 to 3 shocks every day and night; surface fracturing.	6						
			Agra (India)	Earthquake felt.	6	?					
1519	Jan 03	--	Jandol Valley	Very strongly felt; continual shocks for nearly 1/2 hour. (Lower Jandol Valley - 34.8°N, 71.8°E)	6	6					

YEAR EVENT #	DATE	TIME Hr Mn	PLACE OF OBSERVATION	EFFECT	REF	EST MM	INSTRUMENTAL DATA TIME Hr Mn Sc	LAT N	LONG E	MAG	DPTH km
1831	Spring	---	Daraban (Pakistan)	Severe damage occurred; surface fractures and ponds created; difficult to maintain balance.	9	8-9					
			Peshawar	Felt.	9	?					
1832	Jan 22	07:30	Badakhshan Province	Most of the villages overthrown; thousands of people buried. (See Sec.6.4)	12	7-9					
			Kalifgan	All forts and houses destroyed; many lives lost.	11	8-9					
			Jurm	Houses destroyed; 12 of 25 people killed.	11	8-9					
			Kokcha Valley	156 people killed of total 310 population.	11	8-9					
			Sargolan Valley	72 killed of 155 population.	11	8-9					
			Wardodj Valley	Buildings destroyed; mountain collapse.	11	8-9					
			Kabul	Severely felt.	10	?					
			Lahore	Strongly felt; houses shaken violently; duration about 10 secs.	11, 12	5-6					
			Bokhara (U.S.S.R.)	Felt.	31	?					
1833 1	Apr 17	---	Kabul	Slight earthquake; mildly felt.	8	4					
2	Apr 19	---	Kabul	Strongly felt; rafters rattled.	8	5					
1836	Summer	---	Kabul	Weak earthquake felt.	9	3-4					
1837	Dec 14	---	Kabul	Three earthquakes felt; many earthquakes felt before and after Dec 14.	10	4-5					

TABLE C1

YEAR EVENT #	DATE	TIME Hr Mn	PLACE OF OBSERVATION	EFFECT	REF	EST MM	INSTRUMENTAL DATA TIME Hr Mn Sc	LAT N	LONG E	MAG	DPTH km
1838											
1	Jan 07	11:35	Jurm	Strongly felt.	10	5					
2	Jan 08	19:30	Jurm	Very strongly felt.	10	6					
1842											
1	Feb 19	6:30 to 7:30	Buddeeabad	Violent earthquake felt; building damage; dust thrown up by seismic waves; loud rumbling noises; 30 to 40 aftershocks felt on Feb 19. (See Sec.6.4)	13 14	7-8					
			Alingar Valley	Every fort levelled; many inhabitants killed.	13 14	8-9					
			Tigri	Almost all houses destroyed; several hundred people killed.	14	8-9					
			Jalalabad	Extensive damage; two-thirds of the houses of the town were destroyed; all the parapets of the town's wall were knocked down; several bastions destroyed; dozens of people killed in region; difficult if not impossible to stand; duration of shock nearly 1-1/2 minutes; waters of the river twice thrown from their bed.	15 16 17 18	8-9					
			Tezeen	Parts of the forts destroyed.	13 14	6-7					
2	Feb 20	---	Buddeeabad	Severe and slight shocks felt all day, every half hour.	13	4-6					
3	Feb 21	---	Buddeeabad	Strong and weak shocks felt; frequency increased in evening.	13	4-6					
4	Feb 22	---	Buddeeabad	Earthquakes felt continually all day; boulders shaken loose from mountains; landslides; loud noises.	13	4-6					

TABLE C1

TABLE C1

YEAR EVENT #	DATE	TIME Hr Mn	PLACE OF OBSERVATION	EFFECT	REF	EST MM	INSTRUMENTAL DATA TIME Hr Mn Sc	LAT N	LONG E	MAG	DPTH km
1842 5	Feb 23	----	Buddeeabad	Continual earthquakes felt, some strong.	13	4-6					
6	Feb 24	----	Buddeeabad	Few shocks felt; loud noises heard in distance.	13	4-5					
7	Feb 25	----	Buddeeabad	Continual tremors felt; noises heard.	13	4-5					
8	Feb 26	----	Buddeeabad	Earthquakes felt.	13	4-5					
9	Feb 27	----	Buddeeabad	Frequent earthquakes felt.	13	4-5					
10	Feb 28	16:30	Buddeeabad	Sharp shock felt, followed by slight tremors.	13	4-5					
11	Mar 01	----	Buddeeabad	Two strong shocks felt.	13	4-5					
12	Mar 03	----	Buddeeabad	Continual earthquakes felt.	13	4					
13	Mar 04	22:30	Buddeeabad	Strong earthquake felt; smaller shocks all day.	13	4-5					
14	Mar 05	----	Buddeeabad	Earthquakes felt.	13	4					
15	Mar 09	----	Buddeeabad	Slight earthquakes felt.	13	4					
16	Mar 13	----	Buddeeabad	Continual shocks felt.	13	4					
17	Mar 14	----	Buddeeabad	Continual earthquakes felt.	13	4					
18	Mar 18	----	Buddeeabad	Three slight earthquakes felt; distant noises heard.	13	3-4					
19	Mar 20	08:30	Buddeeabad	Three distinct shocks felt.	13	4					
			Jalalabad	Severe shock felt; damage to town's walls and parapets.	15	6					
20	Mar 23	----	Buddeeabad	Earthquakes felt in the morning and at night.	13	3-4					
21	Mar 26	----	Buddeeabad	Continual earthquakes felt.	13	3-4					
22	Mar 27	----	Buddeeabad	Earthquakes felt in morning and evening.	13	3-4					

YEAR EVENT #	DATE	TIME Hr Mn	PLACE OF OBSERVATION	E F F E C T	REF	EST MM	INSTRUMENTAL DATA				
							TIME Hr Mn Sc	LAT N	LONG E	MAG	DPTH km
1842											
23	Mar 29	---	Buddeeabad	Slight earthquake felt.	13	3					
24	Mar 30	---	Buddeeabad	Slight shocks felt.	13	3					
25	Apr 20	---	Tezeen	Severe earthquake felt; fort wall damaged; several other shocks felt.	13 14	5-6					
26	Jun 04	---	Shewakee	Earthquake felt.	14	3-4					
27	Jun 10	---	Shewakee	Slight earthquake in the morning; four shocks at night.	13 14	3-4					
28	Jun 28	06:30	Shewakee	Earthquake felt; creaking rafters.	13	4					
29	Jun 28	16:30	Shewakee	Earthquake felt; creaking rafters.	13	4					
30	Jul 11	---	Shewakee	Earthquake felt at night.	13	3-4					
31	Jul 14	---	Shewakee	Two earthquakes felt.	13	3-4					
32	Jul 23	---	Shewakee	Earthquake felt at night.	13	3-4					
33	Aug 02	10:30	Shewakee	Earthquake felt; loud rumbling noises.	14	4					
34	Aug 03	---	Shewakee	Shock felt.	13	3-4					
35	Aug 19	18:00	Shewakee	Earthquake felt.	13	3-4					
1857											
1	Mar 27	---	Kurram Valley	Sharp shock felt (upper part of valley).	19	4-5					
2	Jul 13	12:30	Kandahar	Sharp shock felt; duration several seconds.	19	4-5					
1874	Aug	---	Jabal-us-Siraj	Violent earthquake; all houses destroyed; many casualties.(Sec.6.4)	21 22 27	9					
			Gulbahar	All houses destroyed; many casualties.	22	9					
			Kohistan	Many houses destroyed; ground fracturing; strong aftershock.	22	8-9					
1879	Jul 31	---	Kabul	Violent earthquake in evening.	20	5-6					

TABLE C1

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TABLE C1

YEAR EVENT #	DATE	TIME Hr Mn	PLACE OF OBSERVATION	E F F E C T	REF	EST MM	INSTRUMENTAL DATA				
							TIME Hr Mn Sc	LAT N	LONG E	MAG	DPTH km
1889 1	Apr	---	Kabul	Strong earthquake felt; lasted nearly four minutes; doors swung open; chairs heaved; noises heard.	23	5-6					
2	Oct	13:00	Mazar-i-Sharif	Felt strongly; doors and windows rattled.	23	5					
1890	Sep	21:00	Kabul	Strongly felt; lasted several minutes; floor heaved; windows and doors rattled.	23	5-6					
1891	Jun	---	Paghman	Felt; windows rattled.	23	4					
1892	Dec 20	---	Chaman (Pakistan)	Major earthquake; sinistral strike-slip fault traced for a few miles; horizontal offset of 2 to 3 feet. (Probable damage at Spin Baldak; probably felt strongly at Kandahar.) (See Sec.6.4)	21 30	8-9					
1898	- 1899	---	Khorog	Many strong earthquakes felt; houses shaken.	24	4-5					
			Karategin	Mosque collapsed.	24	6-7					
			Darvas	Old castle collapsed.	24	6-7					
1905	Apr 04	---	Kangra (India)	Highly destructive; 19,000 people killed; extensive surface fracturing. (probably felt in Afghanistan)	30	9-10	00 50 00	33.0	76.0	8.0	50-
1913	May 14	00:30	Kabul	Felt severely; no significant damage.	51	5-6					
1914	Jun 22 (?)	---	Ghori	Strongly felt; no significant damage.	51	5-6					
1918 (?)	Feb(?)	---	Jabal-us-Siraj	Strong earthquake; some mud walls thrown down.	25	5-6					

TABLE C1

YEAR EVENT #	DATE	TIME Hr Mn	PLACE OF OBSERVATION	E F F E C T	REF	EST MM	INSTRUMENTAL DATA TIME Hr Mn Sc	LAT N	LONG E	MAG	DPTH km
1923											
1	Apr 24	00:30	Kabul	Slight earthquake.	27	3					
2	Apr 24	18:30	Kabul	Slight shock.	27	3					
3	Apr 27	18:30	Kabul	Slight shock.	27	3					
4	May 11	18:30	Kabul	Slight shock.	27	3					
5	Aug	---	Kabul	Strong earthquake; rumbling noises; dishes slide off table; swinging chandeliers.	26	5-6					
6	Nov 20	21:50	Kabul	Felt; duration of shock 6 secs.	27	4-5					
7	Nov 22	13:50	Kabul	Slight shock.	27	3					
8	Nov 22	18:15	Kabul	Light shock.	27	3					
9	Nov 25	22:10	Kabul	Slight shock.	27	3					
10	Nov 26	06:00	Kabul	Lightly felt.	27	3					
11	Nov 26	16:45	Kabul	Lightly felt.	27	3					
12	Nov 28	16:30	Kabul	Strong shock; duration 10 secs.	27	4-5					
13	Dec 01	10:55	Kabul	Lightly felt.	27	3					
14	Dec 01	11:45	Kabul	Lightly felt.	27	3					
15	Dec 01	12:25	Kabul	Very strongly felt; duration 10 secs; walls cracked; small after-shocks felt.	27	6					
16	Dec 01	13:30	Kabul	Slightly felt.	27	3					
17	Dec 02	05:45	Kabul	Strongly felt.	27	4-5					
18	Dec 02	16:05	Kabul	Slightly felt.	27	3					
19	Dec 04	18:30	Kabul	Strongly felt.	27	4-5					
20	Dec 05	15:00	Kabul	Strongly felt.	27	4-5					
21	Dec 08	03:45	Kabul	Moderately felt.	27	4					
22	Dec 17	12:15	Kabul	Slightly felt.	27	3					

TABLE C1

YEAR EVENT #	DATE	TIME Hr Mn	PLACE OF OBSERVATION	EFFECT	REF	EST MM	INSTRUMENTAL DATA TIME Hr Mn Sc	LAT N	LONG E	MAG	DPTH km
1924											
1	Jan 16	16:35	Kabul	Slightly felt.	27	3					
2	Jan 16	17:20	Kabul	Slightly felt.	27	3					
3	Feb 09	16:55	Kabul	Moderately felt.	27	4					
4	Mar 18	---	Jalalabad	Very strong earthquake; loud noises preceded; windows strongly rattled; plaster falls from walls; Bagh-i-Shah Palace damaged slightly.	29	6-7					
			Peshawar	Felt.	29	?					
			Delhi	Felt.	29	?					
5	Jul 09	23:30	Kabul	Slightly felt.	27	3					
6	Jul 15	17:30	Kabul	Slightly felt.	27	3					
7	Aug 02	---	Kabul	Very strong earthquake; many houses damaged.	27	6-7					
			Jalalabad	Bagh-i-Shah Palace seriously cracked; duration of shock 15 secs.	27	6-7					
8	Sep 17	10:40	Kabul	Generally felt; duration 15 secs.	27	4	10 20 51	36.8	70.7	5.3+	100
9	Oct 13	16:40	Kabul	Strongly felt; all run from houses; (See Sec.6.4)	27	5-6	16 17 45	36.0	70.5	7.3	220
10	Oct 17	18:30	Kabul	Slightly felt.	27	3					
11	Oct 19	18:30	Kabul	Slightly felt.	27	3					
1928											
1	Feb 23	17:00	Kabul	Felt, relatively severe; duration 20 secs.	52	5-6					
2	Aug 10	15:34	Kabul	Felt; no further information.	22	5-6	15 33 48	36.5	70.5	6.8	230
1929	Mar 13	11:01	Kabul	Felt; no further information.	22	5	11 01 37	36.5	70.0	5.8	200
1931											
1	Jan 20	09:27	Kabul	Felt; no further information.	22	5	09 27 22	36.5	71.5	6.5	220
2	Jun 02	17:50	Kabul	Felt by all, stronger than usual; earth trembled for several minutes.	53	6					

YEAR EVENT #	DATE	TIME Hr Mn	PLACE OF OBSERVATION	EFFECT	REF	EST MM	INSTRUMENTAL DATA TIME Hr Mn Sc	LAT N	LONG E	MAG	DPTH km
1931											
2	Jun 02	17:50	Pashghur	Felt very severely; 18 persons killed or injurred; 50 houses destroyed and many damaged; boulders fell down from the mountains. (See Sec.6.4)	53	7-8					
3	Jun 09	02:00	Panjshir	Felt moderately; no significant damage.	53	5					
4	Aug 24	---	Quetta	Three major shocks felt, preceded by a loud noise; many buildings destroyed or damaged; a few people injurred; a railway bridge damaged.	53	7-8	21 35 22	30.3	67.8	7.0	50-
5	Oct 05	22:31	Kabul	Felt; no further information.	22	5(?)	22 31 27	36.5	70.5	6.8	220
1933											
1	Jan 08	---	Khanabad	Felt severely; strong and continuous shaking; no significant damage.	53	6					
		20:30	Kabul	Felt moderately.	53	4-5					
2	Jan 09	02:20	Kabul	A strong shock felt; duration 3 min.; two to three shops damaged.	53	6	02 01 43	36.5	70.5	6.5	230
3	Feb 17	09:30	Kandahar	Earthquake felt; frightening noises heard; no significant damage.	53	5-6					
4	Feb 23	03:30	Kabul	Two minor shocks felt.	53	4-5					
		05:30	Kabul	Earthquake felt; duration 20 secs.; no significant damage.	53	5-6					
5	Oct 16	04:00	Uruzgan	Three major shocks felt; duration of each 2 min.; destroyed three qalas; boulders fell down from the mountains; a portion of the mountain collapsed. (See Sec.6.4)	53	7	04 34 44	33.0	67.0	5.6	---
6	Oct 16	---	Dai Chupan	17 shocks felt one after another; a portion of the mountain collapsed; many frightened.	53	7					

TABLE C1

TABLE C1

YEAR EVENT #	DATE	TIME Hr Mn	PLACE OF OBSERVATION	EFFECT	REF	EST MM	INSTRUMENTAL DATA TIME Hr Mn Sc	LAT N	LONG E	MAG	DPTH km
1934											
1	Mar 30 (Ref 22)	---	Pashtun Kot	150 houses and a number of gardens sank; no fatalities; frightening noises heard; many people fainted. (See Sec.6.4)	52 22	8					
2	Jul 05	05:50	Mazar-i-Sharif	Felt; no further information.	22	6-7					
3	Jul 13	20:30	Ghazni	Felt; no further information.	22	5					
4	Jul 22	19:57	Kabul	Felt; no further information.	22	6	19 56 57	36.5	70.5	6.8	240
5	Aug 05	---	Doshi	Frightening noises followed by a major shock; stones fell down from the mountains; no significant damage.	53	6					
6	Oct 01	11:10	Kabul	Felt moderately; duration 4 secs.	53	5					
7	Nov 18	03:30	Peshawar	Felt severely; duration 50 secs.; people were frightened, but no significant damage.	53	6	03 21 24	36.5	70.5	6.5	220
			Lahore	Felt.	53	4-5					
1935											
1	Feb 03	01:50	Kabul	Earthquake felt; duration 50 secs.; no significant damage.	53	5	02 10 47	36.5	70.5	6.0	230
2	Apr 03	11:12	Kabul	Felt; no further information.	22	5	11 11 59	36.5	70.5	6.3	250
3	May 19	03:50	Kabul	Felt; no further information.	22	6					
4	May 30	21:30	Quetta	A disastrous earthquake occurred; city totally destroyed; railroad destroyed; about 20,000 people killed.	53	10	21 32 46	29.5	66.8	7.5	50-
			Mustung	Destroyed totally.	53	9					
			Kalat	Destroyed totally; all the villages between Kalat and Quetta destroyed.	53	9					
			Chaman	Felt strongly; no damage.	53	6					

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TABLE C1

YEAR EVENT #	DATE	TIME Hr Mn	PLACE OF OBSERVATION	EFFECT	REF	EST MM	INSTRUMENTAL DATA				
							TIME Hr Mn Sc	LAT N	LONG E	MAG	DPTH km
1935 5	Jul 05	17:45	Mazar-i-Sharif	A major earthquake felt; duration over 3 min.; no significant damage.	53	6	17 53 01	38.0	67.5	6.0	50-
			Aibak Tashkurghan Balkh Akcha Sheberghan Sari Pul	Felt; no significant damage.	53	5-6					
6	Oct 11	04:20	Kabul	Felt; no further information.	22	5	04 20 18	36.5	70.5	5.8	230
1936	Jun 29	14:30	Kabul	Felt; no further information.	22	5-6	14 30 10	36.5	71.0	6.8	230
1937 1	Oct 29	07:26	Kabul	Felt; no further information.	22	5	07 26 30	36.5	70.5	6.3	230
2	Nov 02	---	Chitral	A major earthquake felt; a few people killed; some damage.	53	8					
3	Nov 14	11:30	Kabul	Felt severely; possible damage to older buildings. (See Sec.6.4)	53	6	10 58 12	36.5	70.5	7.2	240
			Amritsar Jullundur Kangra Delhi (India) Shekhupura Rawalpindi Bahawalpur (Pakistan)	A major earthquake felt; many buildings were damaged; no fatalities.	53	5-6					
1938	Aug 08	---	Arghestan	Earthquake shocks felt; no significant damage.	53	5-6					
1939 1	Nov 21	11:02	Kabul	Felt; no further information.	22	5-6	11 01 50	36.5	70.5	6.9	220
2	Dec 19	00:02	Kabul	Felt; no further information.	22	5-6	00 02 31	36.5	70.5	5.5	220

YEAR EVENT #	DATE	TIME Hr Mn	PLACE OF OBSERVATION	EFFECT	REF	EST MM	INSTRUMENTAL DATA TIME Hr Mn Sc	LAT N	LONG E	MAG	DPTH km
1940											
1	Feb 12	16:37	Kabul Area	Felt; no further information.	22	5					
2	Mar 19	04:37	Kabul	Earthquake shocks felt moderately; duration 10 secs.; no significant damage.	53	5-6	04 35 50	35.8	70.0	6.0	50
3	Jun 12	17:39	Ghazni	Earthquake shocks felt; duration 18 secs.; no significant damage.	53	5					
4	Sep 21	13:49	Kabul	Felt; no further information.	22	5	13 48 58	36.5	70.5	6.3	230
5	Nov 20	18:00	Kabul	Felt; no further information.	22	5	17 59 59	36.0	70.5	5.8	200
1941											
1	Mar 11	21:49	Kabul	Felt; no further information.	22	5	21 48 55	36.5	71.0	6.0	210
2	Sep 29	02:32	Spin Baldak	Felt; no further information.	22	5	-- -- --	30.7	67.2	5.8	50-
3	Nov 28	12:23	Kabul	Felt; no further information.	22	5	12 23 23	36.5	70.5	5.8	220
4	Dec 28	11:30	Hazrat-i-Imam	Earthquake shocks felt; no significant damage.	53	5					
5	Dec 29	00:30	Hazrat-i-Imam	Earthquake shocks felt; no significant damage.	53	5					
6	Dec 30	09:30	Hazrat-i-Imam	Earthquake shocks felt; no significant damage.	53	5					
1942											
1	Jan 02	19:30	Hazrat-i-Imam	Earthquake shocks felt; no significant damage.	53	5					
2	Mar 22	02:08	Kabul	Felt; no further information.	22	5	02 08 33	36.5	70.3	6.0	210
3	Nov 16	21:33	Kabul	Felt; no further information.	22	6	21 26 17	36.5	70.5	5.5	230
1943											
1	Feb 28	12:55	Kabul	Felt; no further information.	22	6	12 54 33	36.5	70.5	7.0	210
2	Apr 20	15:21	Kabul	Felt; no further information.	22	5-6					
3	May 19	11:17	Kabul	Felt; no further information.	22	5-6					
4	Jun 21	08:15	Jalalabad	Felt; no further information.	22	5					

TABLE C1

YEAR EVENT #	DATE	TIME Hr Mn	PLACE OF OBSERVATION	EFFECT	REF	EST MM	INSTRUMENTAL DATA				
							TIME Hr Mn Sc	LAT N	LONG E	MAG	DPTH km
1943 5	Dec 12	15:58	Kabul	Felt; no further information.	22	5	15 54 21	36.0	70.5	5.5	230
6	Dec 28	14:59	Kabul	Felt; no further information.	22	5	14 56 30	37.8	71.2	4.3+	--
1944 1	Apr 15	20:11	Kabul	Felt; no further information.	22	5					
2	May 21	07:06	Kabul	Felt; no further information.	22	5					
3	Jul 24	08:25	Kabul	Felt; no further information.	22	5					
1947	Nov 08	18:10	Baghlan	A major shock of earthquake felt; no significant damage.	53	5-6	16 26 01	36.9	68.0	5.0	--
1948 1	Jan 09	14:50	Kabul	Felt moderately.	53	4-5	14 52 30	36.6	70.5	4.3+	240
2	Jan 28	15:46	Kabul	Felt moderately. (See Sec.6.4)	53	5	15 51 20	36.8	67.2	6.3	70
			Mazar-i-Sharif	Earthquake felt severely; upper part of the shrine building and tops of the towers fell down; some old shops and buildings destroyed.	53	6-7					
			Samangan	Two domes and sugar storage building destroyed.	53	6-7					
			Maimana	Felt, relatively severe; no significant damage.	53	5					
			Shah Anjir	Felt very severely; killed two persons and a number of sheep and goats.	53	7					
3	Sep 07	08:25	Kabul	Several shocks felt one after another.	52	5-6	08 15 22	36.9	70.6	5.3+	220
1949 1	Feb 15	08:30	Kabul	Felt moderately.	52	4-5					

TABLE C1

YEAR EVENT #	DATE	TIME Hr Mn	PLACE OF OBSERVATION	EFFECT	REF	EST MM	INSTRUMENTAL DATA TIME Hr Mn Sc	LAT N	LONG E	MAG	DPTH km
1949 2	Mar 04	10:15	Kabul Area	Major shocks of earthquake felt; duration more than a minute; some walls fell down. (See Sec.6.4)	53	6-7	10 19 25	36.0	70.5	7.5	230
			Doabi-Mikhe-Zarin	Boulders fell down from the mountains and damaged telephone poles.	53	7-8					
			Charikar	Walls and old houses destroyed; a woman and a child killed; three children injured.	53	7					
			Farkhar	Several houses and shops destroyed.	53	7					
			Rustak	70 houses destroyed.	53	7-8					
			Khwaja-i-Ghar	The government office building destroyed.	53	7					
			Khanabad	A fort destroyed.	53	7					
			Samangan	79 houses destroyed; one killed, two injured.	52	7-8					
			Darri Peech District	70 houses destroyed.	52	7-8					
			Brikot	4 houses, 8 balconies and the Jandormary building destroyed.	52	7-8					
			Chouki	10 houses destroyed.	52	7					
			Kuz Kunar	Earthquake felt very severely; 23 houses, 11 walls, a military base on the border and three mosques destroyed.	52	7-8					
			Asmar	4 houses destroyed and a fort damaged.	52	7					
			Shewa	A house destroyed; 4 cows killed.	52	7					
			Shagi Village	A house destroyed; one killed and three injured.	52	7					
			Hadda	A house destroyed.	52	6-7					

TABLE C1

YEAR EVENT #	DATE	TIME Hr Mn	PLACE OF OBSERVATION	EFFECT	REF	EST MM	INSTRUMENTAL DATA TIME Hr Mn Sc	LAT N	LONG E	MAG	DPTH km
1949 3	Jul 10	04:00	Kabul Area	A minor shock of earthquake felt; no significant damage.	53	5	03 53 36	39.0	70.5	7.6	50-
1950 1	Jul 09	16:25	Kabul	A relatively major shock felt; no significant damage.	52	5-6	16 10 20	36.5	71.0	6.5+	220
2	Sep 19	18:55	Kabul	Minor shocks of earthquake felt.	52	4-5					
3	Oct 10	00:30	Kabul	Felt moderately; no damage.	52	4-5	00 02 52	36.7	70.5	4.3+	223
4	Oct 27	19:10	Kabul	Felt moderately; no damage.	53	4-5					
5	Dec 27	05:05	Kabul	A minor shock felt; no damage.	52	4-5					
6	Dec 30	06:50	Kabul	A major earthquake felt; duration 20 secs.; no significant damage.	52	5-6					
7	Dec 31	---	Kabul Shamali Ghorband Charikar Sarobi Tagab Kohistan Doshi Puli Alam	Earthquake shocks felt; no significant damage.	52	5-6					
1951 1	Jan 04	13:10	Kabul	Felt moderately.	52	4-5					
2	Jan 06	05:25	Kabul Parwan Qatghan Mazar-i-Sharif Southern & Eastern Prov.	A relatively major earthquake felt; no significant damage.	53	5-6	05 17 19	36.5	70.5	6.8	250
			Peshawar	Felt; no significant damage.	53	4-5					
3	Mar 17	00:25	Kabul	Felt, relatively severe; no significant damage.	53	5-6					

TABLE C1

YEAR EVENT #	DATE	TIME Hr Mn	PLACE OF OBSERVATION	EFFECT	REF	EST MM	INSTRUMENTAL DATA				
							TIME Hr Mn Sc	LAT N	LONG E	MAG	DPTH km
1951 4	Jun 12	22:45	Kabul	Earthquake felt; no significant damage.	53	5	22 40 36	36.5	71.3	6.5+	220
5	Dec 30	15:52 16:06	Kabul	Two major shocks felt one after another; no significant damage.	52	5-6					
1952 1	Jan 18	21:30	Kabul	Minor shocks of earthquake felt.	52	4-5					
2	Feb 06	---	Badakhshan	Felt moderately.	52	4-5					
3	Jul 05	17:25	Kabul	An earthquake felt; duration several seconds; no significant damage.	52	5-6	17 19 51	36.7	70.5	5.3+	223
4	Nov 27	07:44	Kabul Mazar-i-Sharif Qatghan Jalalabad Gardez Parwan	Felt severely; duration 35 secs.; no significant damage.	52	6	07 20 31	36.6	70.1	5.3+	160
1953	Nov 20	20:40	Baghlan Qatghan	Minor shocks felt; duration 30 secs.	53	5					
1954 1	Jul 10	23:00	Kabul	A minor earthquake felt; duration more than 30 secs.; no significant damage.	53	5	22 56 54	36.6	71.1	5.3+	223
2	Oct 02	11:55	Jalalabad	Earthquake shocks felt; no significant damage.	53	5-6					
1955 1	Feb 18	---	Quetta	An earthquake felt severely, similar to 1935 quake; several foreshocks felt; 9 killed, 50 injured; heavy damage; a number of aftershocks felt.	53	7-8	22 48 35	30.3	67.0	6.1	5
			Chaman	Felt; no significant damage.	53	5					

TABLE C1

YEAR EVENT #	DATE	TIME Hr Mn	PLACE OF OBSERVATION	EFFECT	REF	EST MM	INSTRUMENTAL DATA TIME Hr Mn Sc	LAT N	LONG E	MAG	DPTH km
1955 2	Aug	---	Gulran	Successive shocks felt for more than a month; a few houses destroyed; frightening noises heard. (Sec.6.4)	53	6					
3	Sep 11	16:00	Jalalabad Region	Earthquake shocks felt; no significant damage.	53	5					
1956 1	Apr 06	07:14	Kabul Ghazni Parwan Jalalabad	Felt strongly; no significant damage.	52	5	07 11 31	36.5	71.0	6.8	150
2	Jun 08	03:50	Kabul	Felt moderately.	52	4-5	04 07 29	35.0	67.5	5.8	--
3	Jun 09	23:15	Bamiyan District	Major earthquake felt; in several villages, houses destroyed or damaged; about 20 people killed and a few injured; a number of animals killed. (See Sec.6.4)	52	8-9	23 13 52	35.3	67.5	7.4	50-
			Sayghan & Kahmard	The center of the quake seemed to be Sayghan, Kahmard and Bamiyan; the number of dead estimated at 60 to 70.	52	8-9					
			Darri Ajar	A portion of mountain fell down and blocked the water flow to Kahmard, raising the water level and sinking villages and farms.	52	8-9					
			Darri Shakari	Rocks fell down from the mountains, blocked the roads and damaged the communication lines.	53	7					
			Yakawolang	A number of houses destroyed; 9 killed and one injurred; a number of animals killed; rocks fell down from the mountains, blocked the roads and knocked down telephone poles; shocks felt one after another for two days.	52	7-8					

TABLE C1

YEAR EVENT #	DATE	TIME Hr Mn	PLACE OF OBSERVATION	EFFECT	REF	EST MM	INSTRUMENTAL DATA				
							TIME Hr Mn Sc	LAT N	LONG E	MAG	DPTH km
1956 3	Jun 09	23:15	Daizangi Behsud Parwan	Felt severely.	52	5-6					
			Darri Suf	Rocks fell down from the mountains and killed two.	52	6					
			Kabul	Felt strongly; no significant damage.	53	5-6					
			Pul-i-Khumri Qatghan Mazar-i-Sharif	Felt moderately.	53	4-5					
4	Jun 12	20:30	Bulola & Bamiyan	A minor quake felt.	52	5					
5	Jun 13	00:30	Bulola & Bamiyan	Felt moderately.	52	4-5					
6	Jun 13	03:30	Bulola & Bamiyan	A minor quake felt.	52	4-5					
7	Jun 13	07:30	Bulola & Bamiyan	Felt lightly.	52	4-5					
8	Jun 13	09:30	Bulola & Bamiyan	Felt moderately.	52	4-5					
9	Jun 13	12:30	Bamiyan & Kahmard	Beginning at 12:30, seven shocks of earthquake felt within 24 hrs.; one person injurred.	52	6					
10	Jun 14	19:30	Tala & Barfak	Two successive shocks felt; a portion of the mountain fell down and blocked the road.	53	6					
11	Jun 21 to Jun 22	19:30 to 07:30	Kahmard	Three minor shocks felt within 12 hours.	52	5					

TABLE C1

YEAR EVENT #	DATE	TIME Hr Mn	PLACE OF OBSERVATION	E F F E C T	REF	EST MM	INSTRUMENTAL DATA TIME Hr Mn Sc	LAT N	LONG E	MAG	DPTH km
1956 12	Jun 22	19:30	Darri Ajar	A major earthquake felt; a portion of the mountain fell down and blocked the Kahmard River.	52	6					
13	Jun 25	20:30	Kahmard	Felt strongly.	52	5-6					
14	Jun 28	20:30	Kahmard & Doab	A major shock felt.	52	5-6					
15	Jun 29	02:30	Kahmard & Doab	Felt moderately.	52	4-5					
16	Jun 30 to Jul 01	15:30 to 02:30	Bamiyan	During the 11 hours three shocks felt moderately.	52	4-5					
17	Jul 01	03:45	Faizabad	A minor quake felt.	52	4-5					
18	Jul 01	22:30	Kahmard	Felt moderately.	52	4-5					
19	Jul 03	23:28	Kabul	A relatively major quake felt; no significant damage.	52	5-6	23 26 19	36.5	70.5	6.1	220
20	Jul 08	15:50	Charikar	A minor shock felt.	53	4-5					
21	Jul 13	03:30	Kahmard	Felt moderately.	52	4-5					
22	Jul 14	00:15	Jalalabad Kabul	A minor quake felt.	52	4-5	00 14 30	36.0	71.0	4.3+	--
23	Jul 26	11:30	Faizabad	Felt moderately.	53	4-5					
24	Jul 27	03:30	Kahmard	Felt strongly.	53	5-6					
25	Jul 31	21:00	Gardez	A minor quake felt.	53	4-5					
26	Aug 04	01:30	Kahmard	Felt moderately.	53	4-5					
27	Aug 12 (?)	---	Peshawar	Felt, relatively strong; 16 houses destroyed; no fatalities.	53	6					
28	Aug 19	00:57	Farkhar	A minor quake felt.	52	4-5					
29	Sep 03	07:30	Kahmard	Felt moderately.	52	4-5					
30	Sep 03	08:30	Faizabad	A minor shock felt.	52	4-5	09 24 45	36.8	71.4	4.3+	120

TABLE C1

YEAR EVENT #	DATE	TIME Hr Mn	PLACE OF OBSERVATION	EFFECT	REF	EST MM	INSTRUMENTAL DATA TIME Hr Mn Sc	LAT N	LONG E	MAG	DPTH km
1956											
31	Sep 06	03:00	Panjshir	Felt moderately.	52	4-5					
32	Sep 07	03:30	Faizabad	Minor earthquake shocks felt.	52	4-5					
33	Sep 14	18:30	Kahmard	Felt moderately.	52	4-5					
34	Sep 16	08:36	Jaji District	Felt severely; 10 houses destroyed in the villages; 4 cows killed; rocks fell down from Jaji Mountains. (See Sec.6.4)	52	6-7	08 37 22	34.0	69.5	6.4	50-
			Sayd Karam	A mosque and a house destroyed; two injured.	52	6-7					
			Parwan, Logar, Behsud, Hazarajat, Ghazni, Mukur	Felt strongly.	52	5-6					
35	Sep 16	14:30	Jalalabad	Felt moderately.	52	5	14 23 22	34.0	69.5	-	60
			Kabul	A minor shock felt.	52	4-5					
36	Sep 16	19:00	Kabul	Felt lightly.	52	4-5					
37	Sep 17	08:36	Kabul Region	Felt severely; no significant damage.	52	5-6					
38	Sep 17	08:48	Kabul	Felt moderately.	52	4-5					
39	Sep 24	09:00	Kahmard, Bamiyan, Doab, Gardez & Jalalabad Regions	Felt moderately.	52	4-5					
40	Sep 24	10:20	Kabul, Logar & Jalalabad Regions	Felt moderately.	52	4-5	10 20 38	34.3	69.8	6.2	--
41	Sep 24	17:00	Kahmard	A major shock of earthquake felt; rocks fell down from the mountains.	52	6					

TABLE C1

YEAR EVENT #	DATE	TIME Hr Mn	PLACE OF OBSERVATION	EFFECT	REF	EST MM	INSTRUMENTAL DATA TIME Hr Mn Sc	LAT N	LONG E	MAG	DPTH km
1956											
42	Sep 24	21:30	Farkhar & Faizabad	Felt moderately.	52	4-5					
43	Sep 25	16:28	Kabul	Felt strongly.	52	5-6	16 25 14	34.3	69.8	-	--
			Paktia	A minor shock felt.	52	4-5					
44	Sep 26	00:00	Kabul	Felt moderately.	52	4-5					
45	Sep 26	21:00	Kahmard	A relatively major shock felt; no damage reported.	53	5					
46	Sep 27	01:00	Gardez	A minor quake felt.	53	4-5					
47	Sep 27	16:30	Kahmard	A small shock felt.	52	4-5					
48	Oct 01	18:00	Kahmard	A strong earthquake felt; rocks fell down from the mountains.	53	5-6					
49	Oct 01	18:30	Kahmard	A strong shock of earthquake felt causing rocks to fall down from the mountains.	53	5-6					
50	Oct 02	08:23	Kabul	The earthquake felt moderately.	53	4-5					
			Gardez	The quake felt moderately..	52	4-5					
51	Oct 02	17:30	Faizabad	Earthquake felt moderately.	52	4-5					
52	Oct 02	18:50	Faizabad	Felt moderately.	52	4-5					
53	Oct 03	23:30	Faizabad	Felt moderately.	52	4-5					
54	Oct 13	08:30	Farkhar	Felt severely; duration two min.; no significant damage.	53	5-6	08 21 25	36.0	70.5	6.1	150
55	Oct 13	17:00	Faizabad	Felt, relatively severe.	53	5-6					
56	Oct 14	00:30	Faizabad	Felt moderately.	53	4-5					
57	Oct 14	07:55	Faizabad	Felt, relatively severe.	53	5-6					
58	Oct 17	01:16	Kabul Parwan Ghorband Surkh-o-Parsa	Felt moderately.	52	4-5	01 14 51	36.8	70.5	4.3+	200

TABLE C1

YEAR EVENT #	DATE	TIME Hr Mn	PLACE OF OBSERVATION	E F F E C T	REF	EST MM	INSTRUMENTAL DATA				
							TIME Hr Mn Sc	LAT N	LONG E	MAG	DPTH km
1956											
59	Oct 18	01:30	Farkhar	A minor shock followed by a major one; duration 3 min.; no significant damage.	52	5-6					
60	Oct 18	10:50	Kahmard	Felt moderately.	52	4-5	10 25 03	37.3	69.0	4.3	--
61	Oct 24	07:30	Kahmard	Felt, relatively severe.	52	5					
62	Oct 24	17:30	Kahmard	Felt moderately.	52	4-5					
63	Oct 25	20:30	Kahmard & Doab	A relatively major shock felt; rocks fell down from the mountains, knocking down some telephone poles in Darri Shakari.	52	6					
64	Oct 26	00:30	Kahmard & Doab	A relatively major shock felt; rocks fell down from the mountains, knocking down some telephone poles in Darri Shakari.	52	6					
65	Nov 01	15:30	Kahmard	A relatively major shock felt; no significant damage.	52	5-6					
66	Nov 07	14:15	Kahmard	A major shock felt; no significant damage.	52	5-6					
67	Nov 12	18:30	Kahmard	A relatively strong shock felt.	52	5					
68	Nov 14	00:53	Kabul	A weak foreshock followed by a stronger shock; no significant damage.	52	5-6	00 51 30	37.0	71.0	5.5	--
69	Nov 14	23:36	Charikar Gulbahar Panjshir Tagab Nejrab	The earthquake felt everywhere and by all.	52	5-6					
70	Nov 15	00:50	Gardez Khust Sayd Karam Jaji Chamkani Azru	The earthquake felt all over Paktia Province.	52	5-6					

TABLE C1

YEAR EVENT #	DATE	TIME Hr Mn	PLACE OF OBSERVATION	E F F E C T	REF	EST MM	INSTRUMENTAL DATA				
							TIME Hr Mn Sc	LAT N	LONG E	MAG	DPTH km
1956											
70	Nov 15	00:50	Jalalabad & Mazar-i-Sharif	Felt.	52	5-6					
			Qatghan & Badakhshan	The earthquake felt severely; one person killed in the New Jurm area and some houses damaged.	52	6					
71	Nov 27	20:30	Panjshir	Shocks were felt moderately.	52	4-5	18 48 33	36.5	70.0	4.3+	200
72	Dec 04	07:00	Panjshir	Earthquake felt, relatively strong.	52	5-6					
73	Dec 04	13:30	Panjshir	The earthquake was felt severely.	52	5-6					
74	Dec 13	12:00	Doab & Kahmard	A relatively strong quake felt.	52	5					
75	Dec 14	12:30	Bulola	A relatively severe quake felt.	52	5					
76	Dec 21	18:30	Kahmard	Earthquake felt moderately.	52	4-5					
77	Dec 23	06:30	Kabul	A relatively strong earthquake felt.	52	5-6					
			Panjshir	Earthquake was preceded by three minor shocks.	52	5-6					
78	Dec 23	20:30	Charikar	Two minor shocks and a relatively major shock felt.	52	5					
79	Dec 26	00:30	Mazar-i-Sharif	A relatively strong earthquake felt.	52	5					
80	Dec 29	16:30	Doab & Kahmard	A relatively major shock felt.	52	5					
1957											
1	Jan 04	19:30	Kahmard	A relatively major shock felt.	52	5					
2	Jan 08 (?)	---	Warsaj Region	Several minor shocks felt in the last few days.	52	4-5					
3	Jan 08	19:30	Kahmard	A minor shock felt.	53	4-5					
4	Jan 10	15:30	Farkhar	Minor shocks of earthquake felt.	52	4-5					
5	Jan 10	16:55	Faizabad	An earthquake felt moderately.	52	4-5					

TABLE C1

YEAR EVENT #	DATE	TIME Hr Mn	PLACE OF OBSERVATION	E F F E C T	REF	EST MM	INSTRUMENTAL DATA				
							TIME Hr Mn Sc	LAT N	LONG E	MAG	DPTH km
1957											
6	Jan 11	16:45	Faizabad	A minor earthquake felt.	52	4-5					
7	Jan 16	15:30	Doab & Kahmard	An earthquake felt moderately.	53	4-5					
8	Jan 17	19:06	Kabul	A minor quake felt.	53	4-5					
9	Jan 17	21:30	Faizabad	Minor shocks felt.	52	4-5					
10	Jan 20	18:15	Kabul	A minor shock of earthquake felt.	52	4-5	18 12 47	36.5	71.5	4.3+	150
			Mazar-i-Sharif & Baghlan	Minor shocks felt.	52	4-5					
			Quramqol	Two shocks, felt moderately.	52	4-5					
			Faizabad	Relatively major shocks felt.	52	5					
11	Jan 20	19:15	Surkh-o-Parsa	A relatively major shock felt.	52	5					
12	Jan 20	20:30	Charikar Gulbahar Kohistan Kapisa Panjshir	A relatively major shock felt all over the region.	52	5					
13	Jan 22	18:30	Kahmard	An earthquake felt moderately.	52	4-5					
14	Jan 24	22:05	Faizabad	Two shocks felt moderately.	52	4-5					
15	Jan 25	10:35	Parwan	A relatively major shock felt.	52	5					
16	Feb 07	16:30	Panjshir	A shock felt moderately.	52	4-5					
17	Mar 09	03:50	Kabul Region	A relatively major shock followed by a minor shock felt; no significant damage.	52	5-6					
			Doab Kahmard Charikar Ghorband	The earthquake felt severely.	52	5-6					

YEAR EVENT #	DATE	TIME Hr Mn	PLACE OF OBSERVATION	EFFECT	REF	EST MM	INSTRUMENTAL DATA				
							TIME Hr Mn Sc	LAT N	LONG E	MAG	DPTH km
1957 17	Mar 09	03:50	Darri Shakari	Rocks fell down from the mountains knocking down two telephone poles.	52	6					
			Baghlan	The earthquake felt moderately.	52	4-5					
18	Mar 24	12:08	Faizabad	The earthquake felt severely; some walls fell down; no fatalities.	52	6-7	12 05 16	36.6	70.9	4.3+	194
			Baghlan Kunduz & Other Parts of Qatghan	The earthquake felt moderately all over Qatghan Province.	52	4-5					
			Jalalabad Kabul Parwan	The earthquake felt moderately.	52	4-5					
19	Apr 04	11:30	Sayghan Kahmard Charikar Gulbahar Panjshir Jabal-us-Siraj Ghorband Bamiyan Doab	The earthquake felt severely;	52	5-6	11 36 16	35.5	70.5	5.3	—
			Kabul	The earthquake felt moderately.	52	4-5					
20	Apr 13	06:30	Khawak	Destroyed 35 houses; no fatalities; 21 injured; 46 sheep and goats killed; frightening noises heard for 3 days preceding the quake; claims of observed mountain movements.	52	7					
21	Apr 26	02:30	Faizabad	The shock felt was relatively major.	52	5	02 11 52	37.0	70.5	4.3+	200
			Farkhar	Felt moderately.	52	4-5					
22	Apr 26	03:30	Jaji Azru Chamkani	Felt moderately.	52	4-5					

TABLE C1

YEAR EVENT #	DATE	TIME Hr Mn	PLACE OF OBSERVATION	EFFECT	REF	EST MM	INSTRUMENTAL DATA				
							TIME Hr Mn Sc	LAT N	LONG E	MAG	DPTH km
1957											
23	Apr 27	01:13	Kabul	Felt, relatively severe; no significant damage.	53	5					
24	May 15	01:15	Kabul	Relatively severe; no significant damage.	52	4-5	01 19 59	35.0	70.0	-	--
25	May 23	10:30	Panjshir	Two shocks felt moderately.	52	4-5					
26	May 27	---	Kabul	Felt twice moderately.	52	4-5					
27	Aug 09	15:00	Faizabad	Shocks felt moderately.	52	4-5					
28	Aug 12	05:48	Faizabad	Minor shocks of earthquake felt.	52	4-5					
29	Oct 17	15:40	Faizabad Region	Earthquake felt, relatively strong; no significant damage.	52	5					
30	Nov 15	23:30	Faizabad	Earthquake felt moderately.	52	4-5					
31	Nov 16	19:30	Faizabad	A minor quake felt.	52	4-5					
32	Nov 18	21:30	Doab	Felt severely; no significant damage.	53	5-6					
33	Nov 19	07:30	Farkhar	Felt moderately.	53	4-5					
34	Nov 25	15:30	Farkhar	Felt moderately.	53	4-5					
35	Nov 26	00:46	Wakhan	Three major shocks felt; duration 5 min.	53	5-6	00 41 35	37.3	72.5	-	--
36	Nov 26	22:30	Kabul	A relatively major shock felt; no damage reported.	53	5					
37	Dec 11	03:30	Farkhar Region	Felt, relatively severe; no damage reported.	52	5-6					
38	Dec 13	09:45	Faizabad	Two relatively major shocks felt.	53	5	09 07 57	36.8	70.0	-	--
39	Dec 13	11:30	Farkhar Region	Two relatively major shocks felt; no damage reported.	53	5-6					
40	Dec 21	07:30	Farkhar Region	Felt, relatively severe; no damage reported.	53	5-6					
41	Dec 23	13:30	Kahmard Region	Felt moderately; rocks fell down from mountains;no damage reported.	52	5					

TABLE C1

YEAR EVENT #	DATE	TIME Hr Mn	PLACE OF OBSERVATION	E F F E C T	REF	EST MM	INSTRUMENTAL DATA TIME Hr Mn Sc	LAT N	LONG E	MAG	DPTH km
1957											
42	Dec 24	20:45	Faizabad	Felt severely; no damage reported.	53	5-6					
1958											
1	Jan 05	01:00	Faizabad	Earthquake felt moderately.	53	4-5					
2	Jan 06	01:30	Faizabad	Felt, relatively severe; no significant damage.	53	5-6	01 54 39	38.0	71.5	5.8	--
			Jurm	Felt, relatively severe.	53	5-6					
3	Jan 10	17:30	Farkhar	Felt, relatively severe; accompanied by frightening noises.	53	5-6					
4	Jan 11	18:30	Farkhar	A relatively major shock felt; frightening noises heard.	53	5-6					
5	Jan 22	20:30	Farkhar	Felt severely.	52	5-6					
6	Jan 23	17:30	Farkhar	Felt severely.	52	5-6					
7	Jan 25	04:00	Farkhar	A major shock felt.	52	5-6					
8	Jan 25	22:20	Qarabagh & Jaghori	Felt, relatively severe; no damage reported.	52	5-6					
9	Feb 16	05:22	Kabul	Felt severely; no damage reported.	53	5-6					
10	Feb 17	05:25	Khust Urgun Jaji Gardez Qatghan Mazar-i-Sharif	Felt, relatively severe.	53	5-6	05 18 38	36.0	71.0	6.6	200
11	Mar 07	20:30	Farkhar Region	A relatively major shock felt; no significant damage.	52	5-6					
12	Mar 08	06:58	Charikar Kabul Jalalabad	Felt moderately.	52	4-5					
13	Mar 16	09:55	Faizabad	Felt moderately.	52	4-5					
14	Mar 20	20:00	Faizabad	Minor shocks felt.	52	4-5	22 23 16	36.8	71.0	-	100

TABLE C1

TABLE C1

YEAR EVENT #	DATE	TIME Hr Mn	PLACE OF OBSERVATION	EFFECT	REF	EST MM	INSTRUMENTAL DATA TIME Hr Mn Sc	LAT N	LONG E	MAG	DPTH km
1958											
15	Mar 28	04:55	Kabul	Felt moderately; no damage reported.	52	5	04 09 40	37.0	71.0	5.8	200
16	Mar 28	08:38	Kabul	Felt moderately.	53	5					
17	Mar 28	12:10	Kabul & Qatghan	Felt severely; walls fell down; one person killed, two children seriously injured. (See Sec.6.4)	53	6-7	12 06 26	37.0	71.0	7.0	200
			Parwan Jalalabad Gardez Jaghori Jaghatu Andar Qarabagh Mazar-i-Sharif	Felt very severely.	53	6					
			Peshawar Quetta Rawalpindi Lahore Kashmir	Felt relatively severe.	52	5-6					
			India Turkistan (U.S.S.R.)	Felt in some parts.	53	4-5					
18	Mar 28	12:35	Kabul	Felt moderately.	53	4-5					
19	Apr 08	10:06	Kabul	Felt, relatively severe; no damage reported.	52	5-6	09 59 15	33.0	67.5	5.8	50-
20	Apr 09	20:40	Keshm	A house destroyed in the village of Charkh; no fatalities.	52	6					
21	Apr 15	06:30	Faizabad	Felt moderately.	52	4-5					

TABLE C1

YEAR EVENT #	DATE	TIME Hr Mn	PLACE OF OBSERVATION	EFFECT	REF	EST MM	INSTRUMENTAL DATA TIME Hr Mn Sc	LAT N	LONG E	MAG	DPTH km
1958											
22	May 08	22:00	Faizabad Region	Relatively major shocks felt; no damage reported.	52	5-6					
			Farkhar	Felt moderately.	52	4-5					
23	Jul 12	20:30	Baghlan	Felt, relatively severe; no damage reported.	52	5-6					
24	Aug 04	20:50	Kabul	Felt moderately; no damage reported.	53	4-5	20 47 55	37.0	72.0	-	--
25	Aug 12	10:30	Faizabad	Felt moderately; no damage reported.	52	4-5					
26	Aug 16	---	Khost-o-Fring	Earthquake felt severely; frightening underground noises heard twice; some walls fell down; no fatalities reported.	53	6					
27	Sep 18	20:45	Baghlan	Felt moderately.	53	4-5	20 53 03	36.8	70.5	6.1	170
28	Sep 18	23:30	Faizabad	Felt, relatively severe; no significant damage.	53	5					
29	Sep 19	16:40	Parwan	Felt moderately; no damage reported.	52	4-5					
30	Sep 19	20:55	Parwan	Felt moderately; no damage caused.	52	4-5					
			Jalalabad	Minor shocks felt; no damage reported.	52	4-5					
31	Nov 09	---	Ishkamish Region	Severe shocks felt at different times.	53	5-6					
			Bangi Region	Major shocks felt; frightening noises heard.	53	5-6					
32	Nov 16	16:00	Charikar	Relatively major shocks felt.	52	5					
33	Nov 16	19:30	Khost-o-Fring	Felt severely; frightening underground noises heard.	52	5-6					
34	Nov 17	18:40	Khost-o-Fring	Felt, relatively severe; no damage reported.	52	5-6					
35	Dec 12	03:45	Kabul	Felt moderately.	52	4-5					

TABLE C1

YEAR EVENT #	DATE	TIME Hr Mn	PLACE OF OBSERVATION	EFFECT	REF	EST MM	INSTRUMENTAL DATA TIME Hr Mn Sc	LAT N	LONG E	MAG	DPTH km
1959											
1	Jan 01	22:40	Baghlan Region	Felt, relatively severe; no damage reported.	52	5-6					
2	Jan 01	---	Khost-o-Fring	A relatively major shock felt; frightening noises heard on Jan 03; no damage reported.	53	5-6					
3	Feb 01	03:15	Kabul	Felt moderately.	53	4-5	03 13 38	36.0	71.5	5.5	250
4	Feb 11	22:00	Kabul	Felt, relatively severe.	53	5					
5	Feb 12	00:50	Kabul	Felt, relatively severe.	53	5					
6	Mar 30	04:25	Qarabagh	Felt moderately.	52	4-5					
7	Mar 31	06:57	Gardez	Felt moderately.	52	4-5					
8	Apr 03	23:40	Parwan	Felt moderately.	53	4-5					
9	Apr 20	21:30	Qarabagh	Felt, relatively severe; no damage reported.	53	5-6					
10	Apr 21	03:40	Kabul	Felt, relatively severe.	53	5					
11	May 17	20:50	Kabul	Felt moderately.	52	4-5					
12	May 19	15:20 to 20:50	Qarabagh	Several shocks felt severely; many houses destroyed; no fatalities.	52	6-7	15 17 44	33.0	68.5	5.8	35
13	May 20 to May 25	---	Qarabagh	Several shocks felt severely; people were frightened and camped outside; some kariz fell down; no fatalities.	52	6-7					
14	May 26	---	Rustak	Felt severely; destroyed 60 roofs in Aspak Village; killed 20 cows and sheep; destroyed 12 roofs in Tut Village; killed 180 cows and sheep; no fatalities.	52	7-8	06 36 00	37.5	70.0	5.4	--
15	Jun 07	01:30	Qarabagh	Felt, relatively severe; no damage reported.	52	5-6					
16	Jun 20	19:00	Qarabagh District	Felt, relatively severe; no damage reported.	52	5-6					

YEAR EVENT #	DATE	TIME Hr Mn	PLACE OF OBSERVATION	EFFECT	REF	EST MM	INSTRUMENTAL DATA				
							TIME Hr Mn Sc	LAT N	LONG E	MAG	DPTH km
1959											
17	Jul 29	10:40	Ghazni	Felt by all; no damage reported.	52	5-6	09 53 56	33.5	67.5	-	--
18	Jul 29	22:55	Qarabagh & Jaghatu	Two shocks felt, relatively severe; no damage reported.	52	5-6					
19	Sep 02	15:15	Qarabagh	Felt, relatively severe; no damage reported.	52	5-6					
20	Nov 26	15:30	Ghazni	Felt severely; no damage reported.	52	5-6					
21	Dec 05	13:25	Qarabagh	Felt, relatively severe; no damage reported.	52	5-6					
22	Dec 16	22:44	Qarabagh Region	Felt, relatively severe; no damage reported.	52	5-6					
23	Dec 18	11:00	Faizabad Region	Relatively major shocks felt; no significant damage.	52	5-6					
24	Dec 22	06:50	Faizabad	Felt; no damage reported.	52	5					
25	Dec 23	20:30	Jaghatu & Qarabagh	A shock felt; no damage reported.	52	5					
26	Dec 23	22:30	Jaghatu & Qarabagh	A shock felt; no damage reported.	52	5					
27	Dec 30	06:35	Faizabad	Earthquake shocks felt; no damage reported.	52	5					
28	Dec 31	15:00	Azru	Felt, relatively severe; no damage reported.	52	5-6					
1960											
1	Jan 01	15:50	Jaghori & Qarabagh	A relatively major shock felt; no damage reported.	52	5-6					
2	Jan 09	07:26	Kabul & Parwan	Felt, relatively severe.	52	5-6	07 24 04	36.5	70.0	6.7	200
			Baghlan & Most of Qatghan Faizabad	Felt moderately.	52	4-5					

TABLE C1

YEAR EVENT #	DATE	TIME Hr Mn	PLACE OF OBSERVATION	EFFECT	REF	EST MM	INSTRUMENTAL DATA TIME Hr Mn Sc	LAT N	LONG E	MAG	DPTH km
1960											
3	Jan 17	21:48	Kabul	Felt moderately.	52	4-5					
			Parwan	Felt, relatively severe; no damage reported.	52	5-6					
			Andarab	Felt severely; no damage reported.	52	5-6					
4	Jan 24	05:05	Kabul	Felt moderately.	52	4					
5	Feb 17	07:55	Faizabad	Felt moderately; no damage.	52	4-5	08 05 30	37.0	71.5	-	250
6	Feb 18	02:05	Kabul	Felt moderately; no damage reported.	52	4-5	01 59 23	35.5	73.0	-	150
7	Feb 19	10:40	Kabul Region	Felt severely; 6 shops destroyed; some walls fell down; one injured. (See Sec.6.4)	52	6-7	10 36 52	36.5	70.5	6.4	220
			Parwan Paktia Nangarhar Ghazni Qatghan Badakhshan	Felt, relatively severe; no significant damage.	52	5-6					
			Pakistan India U.S.S.R.	Felt in some parts.	52	4-5					
8	Feb 20	05:20	Charikar Panjshir Gulbahar Kohistan Kapisa Bulola Bamiyan Doab	Felt moderately.	52	4-5					
9	Feb 23	02:12	Kabul	Felt moderately.	52	4-5	02 09 42	36.0	70.0	-	200
10	Mar 13	11:30	Qarabagh	Felt, relatively severe; no damage reported.	52	5-6					
11	Jul 14	22:13	Kabul & Baghlan	Felt, relatively severe; no information about the damage.	52	5-6	22 11 06	36.0	70.0	4.5	100
			Badakhshan	Felt severely; no damage reported.	52	6					

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TABLE C1

YEAR EVENT #	DATE	TIME Hr Mn	PLACE OF OBSERVATION	EFFECT	REF	EST MM	INSTRUMENTAL DATA TIME Hr Mn Sc	LAT N	LONG E	MAG	DPTH km
1960 12	Jul 17	05:45	Faizabad Region	Major shocks of earthquake felt; no damage reported.	52	6	05 14 56	36.0	69.0	5.9	200
13	Jul 29	14:30	Kandahar	Felt, relatively severe; no damage reported.	52	5-6	14 33 50	32.0	67.0	5.3	--
			Maruf Kalat Shinkai	Felt.	52	4-5					
14	Aug 02	23:15	Faizabad	Felt, relatively severe; no damage reported.	52	5-6					
15	Aug 07	04:45	Qarabagh	Felt severely; no damage reported.	52	6					
16	Sep 09	02:04	Qarabagh	Felt, relatively severe; no damage reported.	52	5					
17	Sep 09	10:07	Kabul	Felt moderately.	52	4-5	10 05 22	36.6	71.6	-	236
18	Sep 19	03:40	Faizabad	Felt, relatively severe; no damage reported.	52	5-6					
19	Sep 20	06:20	Jabal-us-Siraj	Felt moderately.	52	4-5					
20	Dec 05	06:20	Kabul	Felt moderately.	52	4-5					
1961 1	Jan 15	21:30	Faizabad	Earthquake felt, relatively severe; no damage reported.	52	5-6					
2	Jan 16	12:45	Faizabad	A relatively major shock felt; no damage reported.	52	5-6					
3	Jan 28	04:15	Baghlan	Felt, relatively severe; no damage reported.	52	5-6					
4	Feb 18	06:30	Parwan	Felt moderately.	52	4-5					
5	Jun 19	16:05	Kabul Region	Two major shocks felt; one person injured; no significant damage.	52	6	17 04 36	36.5	70.5	6.7	220
6	Aug 03	12:20	Faizabad	Felt, relatively severe; no damage reported.	53	5-6					

YEAR EVENT #	DATE	TIME Hr Mn	PLACE OF OBSERVATION	EFFECT	REF	EST MM	INSTRUMENTAL DATA				
							TIME Hr Mn Sc	LAT N	LONG E	MAG	DPTH km
1961											
7	Aug 05	20:35	Kabul	Felt, relatively severe; no damage reported.	53	5-6					
8	Sep 04	23:50	Ali Shing	Felt severely; no damage reported.	53	5-6					
1962											
1	Jan 08	22:25	Kabul	Relatively major shocks felt; no significant damage.	53	5-6	22 15 13	36.7	70.5	5.7	200
2	Feb 24	18:10	Kabul	Felt moderately.	52	4-5	18 06 45	34.3	70.1	-	25
3	Mar 12	02:10	Kabul	Felt moderately.	52	4-5	02 11 12	34.0	71.0	5.0	--
4	Mar 28	00:50	Faizabad	Felt, relatively severe; no damage reported.	52	5-6	00 51 55	36.6	71.6	-	108
5	Apr 01	---	Birjand (E. Iran)	A major quake felt; caused a number of deaths and injuries.	53	7-8	00 45 10	33.2	58.6	5.8	--
6	Jul 06	23:08	Kabul	Relatively major shocks felt; duration 30 secs.; no significant damage; one person injured. (Sec.6.4)	52	5-6	23 05 32	36.6	70.4	6.8	203
			Mazar-i-Sharif & Qatghan	Felt severely; no significant damage.	52	5-6					
			Paktia	Felt.	52	4-5					
			Dushanbe & Other Parts Tajikistan (U.S.S.R.)	Felt.	52	5					
7	Jul 25	17:57	Kabul Region	Felt, relatively severe; duration 1 sec.; no significant damage.	52	5-6					
8	Aug 11	21:30	Mukur Region	Felt severely; a house destroyed in the village of Musa Khil; two persons killed.	52	6-7					
9	Sep 03	23:24	Kabul Region	Felt moderately; no damage reported.	52	4-5	23 23 00	34.7	69.5	3.8	--

TABLE C1

YEAR EVENT #	DATE	TIME Hr Mn	PLACE OF OBSERVATION	EFFECT	REF	EST MM	INSTRUMENTAL DATA TIME Hr Mn Sc	LAT N	LONG E	MAG	DPTH km
1962 10	Sep 10	20:57	Regions of: Kabul, Mazar-i-Sharif, Jalalabad, Baghlan & Other Parts of Qatghan	Felt, relatively severe; no significant damage.	53	5-6					
11	Sep 13	09:05	Jalalabad	Felt moderately.	52	4-5					
12	Sep 14	01:00	Baghlan	A relatively major shock felt.	53	5-6					
13	Sep 19	15:00	Faizabad Region	Felt, relatively severe; no damage reported.	52	5-6					
14	Sep 22	08:00	Kabul & Charikar	Earthquake shocks felt; no damage reported.	53	5	08 06 28	36.5	68.7	5.0	33
			Baghlan & Other Parts of Qatghan	Felt severely.	53	5-6					
			Panjshir	Earthquake felt; no damage reported.	53	5					
15	Oct 09	16:00	Kabul & Baghlan	Felt moderately; no damage reported.	52	4-5	15 59 14	36.4	71.3	-	209
16	Oct 29	03:49	Jalalabad	Felt moderately; no damage.	52	4-5					
17	Nov 03 to Nov 04	----	Khwahan	Relatively major shocks felt; rocks fell down from the mountains; no damage reported.	53	6					
			Faizabad	Felt moderately on Nov 03.	53	4-5					
18	Nov 26	01:42	Faizabad Region	Felt, relatively severe; caused no damage.	52	5-6	01 41 10	35.8	70.3	5.5	150
			Kabul	Felt moderately; no damage.	52	4-5					
1963 1	Jan 12	06:20	Baghlan	Felt moderately.	52	4-5	06 20 16	36.1	69.9	-	129

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TABLE C1

YEAR EVENT #	DATE	TIME Hr Mn	PLACE OF OBSERVATION	EFFECT	REF	EST MM	INSTRUMENTAL DATA TIME Hr Mn Sc	LAT N	LONG E	MAG	DPTH km
1963											
2	Feb 16	11:30	Faizabad	Felt, relatively severe.	53	5-6	12 19 30	36.5	70.4	5.4	208
3	Feb 18	14:27	Kabul	Felt moderately.	53	4-5	14 25 19	36.6	70.5	4.9	200
4	Mar 02	18:45	Faizabad	Relatively major shocks felt; no damage reported.	52	5-6					
5	Mar 03	17:05	Faizabad Region	Felt, relatively severe; no damage reported.	53	5-6	17 04 58	36.8	71.0	4.3	100
6	Mar 26	06:37	Bamiyan	A relatively major shock felt; no reported damage.	52	5-6					
7	Apr 01	09:15	Kabul Region	Felt severely; no damage or fatalities reported.	52	6	09 22 55	35.8	69.7	4.8	--
			Nangarhar & Parwan	Major shocks felt.	52	5-6					
8	Apr 17	10:45	Baghlan Region	Minor shocks felt; caused no damage.	52	4-5	10 45 19	36.4	70.5	-	79
9	Apr 28	19:50	Faizabad Region	Relatively major shocks felt; no significant damage.	52	5-6	19 50 09	36.3	71.3	4.9	133
10	Apr 29	02:07	Kabul	Felt moderately; no damage.	52	4-5					
11	May 15	13:55	Faizabad	Felt moderately.	52	4-5					
12	Jun 10	03:45	Faizabad	Minor shocks felt.	52	4-5					
13	Jun 11	08:30	Faizabad	Relatively major shocks felt; no significant damage.	52	5-6					
14	Jul 14	10:50	Regions of: Kabul Jalalabad Parwan	Felt moderately; caused no damage.	52	4-5	10 51 43	36.1	70.6	5.1	120
15	Sep 22	04:30	Faizabad Region	Relatively major shocks felt; no significant damage.	52	5-6	03 28 47	36.6	71.1	3.5	--
16	Oct 01	15:50	Faizabad	Minor shocks felt; caused no damage.	52	4-5					
17	Nov 09	23:55	Baghlan	Felt, relatively strong; no damage.	52	5-6					
18	Dec 26	20:53	Kabul	Felt moderately; no damage.	53	4-5	20 50 21	36.4	71.3	4.9	140

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YEAR EVENT #	DATE	TIME Hr Mn	PLACE OF OBSERVATION	E F F E C T	REF	EST MM	INSTRUMENTAL DATA TIME Hr Mn Sc	LAT N	LONG E	MAG	DPTH km
1964 1	Jan 17	01:58	Gardez & Sayd Karam	Felt, relatively severe; no significant damage.	52	5					
2	Jan 17	03:28	Kabul	Felt moderately.	52	4-5	03 25 01	36.8	71.4	5.2	94
3	Jan 28	14:10	All Afghanistan (except the western parts)	Felt. (See Sec.6.4)	52		14 09 17	36.5	70.9	6.1	207
			Kabul	Felt severely; electrical blackout for 5 min.; walls cracked; articles thrown off shelves.	54	6					
			Faizabad	Felt, very strongly; no significant damage.	53	6					
			Sarobi	Shocks felt were strongest for the last few years; duration one min.	52	6					
			Peshawar Rawalpindi Lahore	Felt, relatively severe; duration more than 30 secs.; no damage is reported.	52	5					
			Ozbekistan Tajikistan (U.S.S.R.)	Felt moderately.	52	4-5					
4	Feb 16	18:43	Kabul Region	A relatively major shock felt; no significant damage.	52	5-6					
5	Mar 05	20:48	Kabul Region	Felt moderately; no significant damage.	52	4-5					
6	Mar 05	21:10	Kabul	A minor shock felt; no damage.	52	4-5					
7	May 16	08:40	Nangarhar & Kunar	Felt moderately; caused no damage.	52	4-5	08 38 54	36.3	71.5	5.3	122
8	May 18	11:45	Baghlan Region	Felt, relatively strong; caused no damage.	52	5-6					

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YEAR EVENT #	DATE	TIME Hr Mn	PLACE OF OBSERVATION	E F F E C T	REF	EST MM	INSTRUMENTAL DATA				
							TIME Hr Mn Sc	LAT N	LONG E	MAG	DPTH km
1964 9	Jul 08	12:10	Faizabad	Felt severely; caused cracks in some buildings; no fatalities.	52	6-7					
10	Oct 12	23:05	Kabul	Felt moderately; no damage.	53	4-5					
11	Nov 15	17:25	Faizabad	Felt, relatively strong; no damage.	53	5-6	17 12 44	36.5	70.9	5.0	220
12	Nov 16	04:30	Faizabad Region	Felt, relatively severe; no damage reported.	53	5-6	04 47 28	36.3	70.4	5.5	225
13	Dec 24	01:13	Kabul	Felt moderately; caused no damage.	53	4-5	01 08 38	36.2	70.9	5.6	158
1965 1	Feb 16	20:58	Kabul Region	Felt moderately; no significant damage.	52	4-5	20 46 37	36.3	70.8	5.3	190
2	Mar 14	15:54	Kabul	The earthquake felt was very strong; several walls fell down; a number of houses and buildings cracked; two and three story buildings in the University, and similarly the buildings of Rahman Baba and Habibia High School suffered light damage; the gasoline storage tanks in Shirshah Mina and Beni-Naizar were also damaged; a few people injured, some fainted, no fatalities; reported power blackout from Sarobi Power Plant. (See Sec.6.4)	54	6-7	15 53 07	36.3	70.7	6.6	219
			Bakakhshan	Felt very severely; several walls fell down.	52	6-7					
			Northern Part of the Country	The earthquake felt was very severe.	52	6-7					
			Ashpushta	The mountain slid for a length of 200 meters; no damage caused.	52	6-7					
			Pakistan & N. India	Felt; no significant damage.	52	5					

TABLE C1

TABLE C1

YEAR EVENT #	DATE	TIME Hr Mn	PLACE OF OBSERVATION	EFFECT	REF	EST MM	INSTRUMENTAL DATA TIME Hr Mn Sc	LAT N	LONG E	MAG	DPTH km
1965											
3	Apr 02	22:27	Balk Samangan Jozjan	Relatively major shocks felt; duration one min.; no significant damage.	52	5-6	22 26 47	36.8	66.6	5.5	38
4	Apr 25	02:30	Kabul	Felt moderately; caused no damage.	52	5	02 27 46	36.3	70.5	4.7	231
			Baghlan	Felt; caused no damage.	52	5					
5	Aug 22	19:20	Kabul Region	Felt, relatively strong; caused no damage.	52	5-6					
6	Nov 01	10:55	Jalalabad	Felt moderately; caused no damage.	53	5					
7	Nov 16	01:07	Kabul Region	Relatively major shocks felt; no significant damage.	53	5-6	01 03 56	36.4	71.1	5.5	244
1966											
1	Jan 27 to Jan 28	18:30 to 03:15	Shahjui District	Relatively major shocks felt; a mosque destroyed; some walls fell down and some cracked; no fatalities.	52	6					
2	Jan 30	07:15	Shahjui	Felt, relatively severe; frightening noises heard from a kariz in Jamal Khil Village; some kariz blocked; a few houses damaged; no fatalities reported.	52	6-7					
3	Mar 01	05:10	Baghlan Region	Relatively major shocks felt; no significant damage.	53	5-6	04 59 50	36.7	69.0	4.6	44
4	Mar 12	21:45	Kapisa	Three relatively major shocks felt; caused no damage.	52	5-6					
5	Apr 18	19:30	Kabul Region	Felt, relatively severe; no significant damage.	52	5-6	19 29 41	34.5	69.8	4.2	55
6	Apr 18	19:57	Kabul	Felt moderately.	52	4-5					
7	Apr 26	19:35	Ghazni	Felt severely; caused no damage.	52	6					
8	May 21	21:25	Kabul Region	Two relatively minor shocks felt; no damage occurred.	52	4-5					
9	Jun 05	04:15	Charikar Region	Felt, relatively strong; caused no damage.	53	5-6					

TABLE C1

YEAR EVENT #	DATE	TIME Hr Mn	PLACE OF OBSERVATION	EFFECT	REF	EST MM	INSTRUMENTAL DATA TIME Hr Mn Sc	LAT N	LONG E	MAG	DPTH km
1966 10	Jun 06	07:48	Faizabad	Strong shocks felt one after another for two min.; some walls cracked.	53	6-7	07 46 16	36.4	71.1	6.2	221
			Kabul Nangarhar Kunar Laghman Kapisa Baghlan Takhar Dushanbe Tashkent Samarkand (U.S.S.R.)	Felt.	53	5-6					
			Parwan Paktia Peshawar	Felt.	53	5					
11	Jun 24	15:29	Baghlan	Felt moderately; caused no damage.	53	4-5					
12	Aug 01	06:00	Bamiyan	Felt, relatively severe; caused no damage.	52	5-6					
13	Aug 01	----	Quetta	Felt severely.	52	6-7	21 03 00	30.1	68.6	6.0	33
			Loralai (Pakistan)	Felt stronger here than anywhere else; one killed; many buildings in several villages destroyed or damaged severely.	52	7-8					
			Barkal (Pakistan)	Felt severely.	52	6-7					
14	Aug 16	02:20	Kabul Region	Relatively major shocks felt; no significant damage.	52	5-6	02 16 20	36.5	70.8	5.5	199
15	Aug 28	10:56	Nangarhar, Kunar & Laghman	Felt, relatively severe; no significant damage.	52	5-6	10 43 02	36.4	70.9	4.8	180
16	Nov 21	03:00	Parwan & Kapisa	Felt, relatively strong; no significant damage.	52	5-6					

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YEAR EVENT #	DATE	TIME Hr Mn	PLACE OF OBSERVATION	EFFECT	REF	EST MM	INSTRUMENTAL DATA TIME Hr Mn Sc	LAT N	LONG E	MAG	DPTH km
1966 17	Dec 06	12:11	Kabul	Relatively major shocks felt; no significant damage.	52	5-6					
18	Dec 10	20:30	Nangarhar & Laghman	Felt moderately; caused no damage.	53	4-5					
1967 1	Jan 25	01:50 to 02:00	Kabul, Baghlan, Kunduz, Takhar, Badakhshan, Balkh, Jozjan, Samangan	Felt severely; the shocks occurred two to three times.	53	5-6	01 50 19	36.6	71.6	5.7	281
			Logar, Ghazni, Nangarhar, Kunar, Laghman	Felt strongly.	53	5-6					
			Zabul & Herat	Felt very lightly.	53	4					
2	Mar 11	06:30	Kabul	Felt moderately; no damage.	52	4-5	06 31 09	36.4	70.7	5.0	220
3	Aug 06	10:47	Kabul Region	An earthquake shock felt; no damage reported.	53	4-5	10 31 06	38.0	74.5	4.8	215
4	Aug 15	07:36	Faizabad	Felt moderately; caused no damage.	53	4-5	07 40 29	36.3	70.2	4.7	189
1968 1	Aug 31	10:47	Dasht-e-Bayaz, Buzkabad, Meinhaj, Karish, Miam (towns in Iran, 300 km west of Herat)	Catastrophic earthquake, near total destruction; all houses and buildings of mud and dome construction completely levelled; nearly 12,000 people killed in region; extensive surface faulting, extending for more than 25 km.	3 54	10	10 47 37	34.0	59.0	7.3	13

TABLE C1

TABLE C1

YEAR EVENT #	DATE	TIME Hr Mn	PLACE OF OBSERVATION	EFFECT	REF	EST MM	INSTRUMENTAL DATA TIME Hr Mn Sc	LAT N	LONG E	MAG	DPTH km
1968 1	Aug 31	10:47	Kakh & Khezri (Iran,as above)	Most of the buildings destroyed; great loss of life.	3 54	9					
			Herat	Felt severely; no damage reported; water splashes out of pools.	53 54	5-6					
			Farah	Felt severely; no damage.	53	5					
			Badghis	Felt severely; no damage.	53	5					
			Bust	Water in Bust Hotel swimming pool set into oscillation; seismic seiche.	54						
2	Sep 03	18:50	Kabul & Northern Parts of Country	Felt moderately; no damage is reported.	52	4-5	18 48 16	36.2	69.2	5.3	75
3	Sep 28	00:55	Kabul Region	Felt moderately; no damage reported.	53	4-5					
			Paktia Parwan Kunar	Earthquake felt.	53	4-5					
4	Dec 19	04 35	Taliqan Faizabad Takhar Kunduz Charikar Kapisa	Felt severely; duration one min., no damage reported.	53	6	05 17 52	36.1	70.1	5.4	151
		05:25	Kabul Region	Felt severely; duration 25 secs.; some people frightened and run from buildings.	54	5-6					
1969 1	Mar 05	19:35	Kabul Region	Felt moderately; no damage reported.	52	4-5	19 33 23	36.4	70.7	5.9	208

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YEAR EVENT #	DATE	TIME Hr Mn	PLACE OF OBSERVATION	EFFECT	REF	EST MM	INSTRUMENTAL DATA				
							TIME Hr Mn Sc	LAT N	LONG E	MAG	DPTH km
1969 2	May 15	20:40	Nurgal & Bila	Felt severely; walls and some roofs fell down; one person killed, two injured; a few houses partially collapsed; rumbling noises heard; some claimed flashes in sky seen. (See Sec.6.4)	54	6-7	20 39 46	34.6	70.9	5.6	22
			Nangarhar & Kunar	Strongly felt; walls cracked.	54	5-6					
			Laghman	Felt strongly.	54	5					
			Kabul Region	Felt moderately; some people awoke from sleep; rattling of doors.	54	4-5					
3	Jun 10	23:30	Kunduz & Baghlan	A major shock felt; no damage reported.	53	5-6	23 30 54	36.3	70.4	5.2	213
			Kabul	Felt moderately.	53	4-5					
4	Aug 08	06:32	Kabul Region	Two relatively major shocks felt; no damage reported.	52	5	06 30 57	36.4	70.9	5.8	198
5	Sep 04	02:58	Kabul	Felt lightly.	54	3	02 57 19	36.5	70.9	4.8	221
6	Sep 12	05:09	Kabul	Felt moderately.	54	4	05 08 02	36.4	70.9	5.1	198
7	Sep 14	23:25	Kabul	Felt moderately.	54	3-4	23 45 40	37.7	72.5	-	33
8	Oct 02	09:11	Kabul	Felt moderately.	54	3-4					
9	Nov 12	12:00	Mahmud Raqi & Kohistan	Two major shocks felt; no damage	53	5-6					

TABLE C1

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TABLE C2

SUMMARY & TEMPORAL DISTRIBUTION OF FELT & DAMAGING EARTHQUAKES

YEAR	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	TOT
To 1500													4
1505							1						1
To 1831	1		1										2
1832	1												1
To 1841	2			2				1				1	6
1842		10	14	1		4	3	3					35
To 1873			1				1						2
1874								1					1
To 1922		2		2	1	2	1		1	1		1	11
1923				3	1			1			7	10	22
1924	2	1	1				2	1	1	3			11
1928		1						1					2
1929			1										1
1931	1					2		1		1			5
1933	2	2								2			6
1934			1				3	1		1	1		7
1935		1		1	2		1			1			6
1936						1							1
1937										1	2		3
1938								1					1
1939											1	1	2
1940		1	1			1			1	1			5
1941			1						1		1	3	6
1942	1		1								1		3
1943		1		1	1	1						2	6

YEAR	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	TOT
1944				1	1		1						3
1947											1		1
1948	2								1				3
1949		1	1				1						3
1950							1		1	2		3	7
1951	2		1			1						1	5
1952	1	1					1				1		4
1953											1		1
1954							1			1			2
1955		1						1	1				3
1956				1		15	9	3	19	17	7	9	80
1957	15	1	2	5	3			2		1	7	6	42
1958	8	2	8	3	1		1	3	4		4	1	35
1959	2	3	2	3	4	2	2		1		1	8	28
1960	4	5	1				3	2	4			1	20
1961	3	1				1		2	1				8
1962	1	1	2	1			2	1	6	2	2		18
1963	1	2	3	4	1	2	1		1	1	1	1	18
1964	3	1	2		2		1			1	2	1	13
1965		1	1	2				1			2		7
1966	2		2	3	1	3		4			1	2	18
1967	1		1					2					4
1968								1	2			1	4
1969			1		1	1		1	3	1	1		9
TOT'S	55	39	49	33	19	36	36	34	48	37	44	52	486

G A Z E T T E E R

PLACES OF OBSERVATION

AIBAK, provincial capital of Samangan Province; shown as Samangan on Fig. 1.
AKCHA, a town about 50 km NE of Sheberghan.
AKSERAI, a village about 20 km NNW of Kabul.
ALI SHING, a valley running almost NS to the W of the Alingar Valley.
ANDAR, a district about 30 km S of Ghazni.
ARGHESTAN, a town and district 80 km E of Kandahar.
ASHPUSHTA, a village in Kahmard district.
ASMAR, a district about 70 km NE of Nurgal.
ASPAK, a village close to Rustak.
AZRU, a district about 60 km SE of Kabul.

BANGI, a town about 25 km W of Taliqan.
BARFAK, a village about 45 km E of Kahmard.
BEHSUD, a village about 50 km S of Bamiyan.
BILA, a village on the east side of the Kunar River across from Nurgal.
BRIKOT, a village in the Kunar Valley about 100 km NE of Nurgal.
BUDDEEABAD, a village about 12 km NE of Tigri.
BULOLA, a village about 15 km ENE of Bamiyan.

CHAMKANI, a town about 55 km NE of Gardez.
CHARK, a village very near to Keshm.
CHITRAL, a region and also a town about 180 km N of Peshawar.
CHOUKI, a village about 18 km NE of Nurgal.

DAI CHUPAN, a village about 55 km N of Kalat (Afghanistan).
DAIZANGI, previous name for a large district consisting of Behsud, Daikundi, Lal, Sar Jangal, Yakawolang and Shahrestan regions.
DARRI AJAR, a small village 10 km E of Kahmard; also a river, see Fig. 1.
DARRI PEECH, a district in Kunar Province, about 80 km NNE of Jalalabad.
DARRI SHAKARI, north of Shibar Pass.
DARRI SUF, a town about 65 km SE of Samangan (Aibak).
DARVAS, a district and also a town about 130 km N of Faizabad.
DOABI-MIKHE-ZARIN, a village about 30 km ESE of Kahmard.

GHORI, a town about 15 km WSW of Pul-i-Khumri in the upper Kunduz River Valley.
GULBAHAR, a town about 10 km NE of Jabal-us-Siraj.
GULRAN, a district NW of Herat, the centre of which is about 85 km NW of Herat.

HADDA, a village about 10 km SE of Jalalabad.
HAZARAJAT, a region in central Afghanistan located to the W of Kabul Province and to the E of Ghor Province.
HAZRAT-I-IMAM, a town about 50 km N of Kunduz.

ISHKAMISH, a district about 35 km S of Khanabad.
ISTERGHACH, a village about 15 km SW of Charikar.

JABAL-US-SIRAJ, shown on the map of Afghanistan in abbreviated form as Jabal Siraj.
JAGHATU, a village about 25 km N of Ghazni.
JAGHORI, a district about 90 km SW of Ghazni.
JAJI, a district about 55 km NE of Gardez.
JAMAL KHIL, a village 6.5 km SE of Shahjui.
JANDOL, a valley in NW Pakistan (34.8°N and 71.8°E).
JOZJAN, a province in northern Afghanistan with Sheberghan being the provincial center.

KALAT, a city in Pakistan about 150 km SE of Quetta; also a town in Afghanistan, see Fig. 1.
KALIFGAN, a district about 20 km NNW of Farkhar between Taliqan and Faizabad.
KAPISA, a province immediately NE of Kabul Province.
KARATEGIN, a province in the U.S.S.R. just north of Afghanistan containing the town of Garm.
KESHM, a district and also a town about 35 km NE of Farkhar.
KHOST-O-FRING, a village about 70 km S of Taliqan.
KHAWAK, a village in the northern end of the Panjshir Valley.
KHWAHAN, a town about 80 km NNW of Faizabad.
KHWAJA-I-GHAR, a town about 35 km almost due W of Rustak.
KOH DAMON, a large valley N of Kabul and S of Charikar.
KOHISTAN, a region of Kapisa Province about 50 km NE of Kabul.
KURRAM, a valley about 100 km NE of Gardez.
KUZ KUNAR, the lower part of the Kunar Valley.

LAGHMAN, a province in eastern Afghanistan with Tigri (now Mehtarlam) as the provincial center.

MAHMUD RAQI, a town in Kapisa Province about 16 km E of Charikar.
MAIDAN, a town or plain 45 km WSW of Kabul.
MARUF, a town in Zabul Province about 55 km SSE of Kalat (Afghanistan).
MUSA KHIL, a small village near to Mukur.
MUSTUNG, a town in Pakistan, about 60 km S of Quetta.

NANGARHAR, a province in eastern Afghanistan with Jalalabad as the provincial center.
NEJRAB, a district and also a town about 30 km E of Charikar.

PAKTIA, a large province in eastern Afghanistan including the towns of Gardez and Urgun.
PARWAN, a province N of Kabul including the Ghorband and Panjshir Valleys.
PASHGHUR, a town in the Panjshir Valley, 40 km NE of Charikar.
PULI ALAM, a village in Logar Province, about 35 km NNW of Gardez.

QARABAGH, a town about 50 km SW of Ghazni.
QARAMQOL, a village about 10 km SW of Andkhoy.
QATGHAN, previous name of a province which included Baghlan, Kunduz and Takhar Provinces.

SARGOLAN, a valley running NW to SE about 40 km E of Jurm.
SARI PUL, a town about 50 km SSE of Sheberghan.
SAROBI, a town about 50 km E of Kabul.
SAYD KARAM, a district and a town about 18 km NE of Gardez.

SHAGI, a village about 45 km SE of Kabul.
SHAH ANJIR, a village about 38 km S of Mazar-i-Sharif.
SHAHJUI, a district and a town about 60 km NW of Kalat (Afghanistan).
SHAMALI, the regions immediately N of Kabul.
SHEWA, a village about 15 km W of Nurgal.
SHEWAKEE, a village about 10 km S of Kabul.
SHINKAI, a village about 38 km SE of Kalat (Afghanistan).
SURKH-O-PARSA, a village about 45 km WSW of Charikar.

TAGAB, a village in Kapisa Province about 50 km NE of Kabul.
TAKHAR, a province in northeastern Afghanistan with Taliqan as the provincial center.
TALA, a village about 45 km SW of Doshi.
TASHKURGHAN (Khulm), a town about 50 km E of Mazar-i-Sharif.
TEZEEN, a village about 35 km SE of Kabul.
TUT, a small village close to Rustak.

WARDODJ, a valley running nearly NW, about 20 km E of Jurm.
WARSAJ, a town about 35 km SSE of Farkhar.

YAKAWOLANG, a district and also a town about 72 km W of Bamiyan.

* * *

APPENDIX D

INSTRUMENTAL EARTHQUAKE DATA

(i) Explanatory Remarks

(ii) Table D1 - List of Strong Earthquakes ($M \geq 5.8$)

(iii) Table D2 - List of All Earthquakes

(iv) Table D3 - Temporal Distribution of Recorded Earthquakes in the Region 27°-40°N and 58°-76°E

(v) Table D4 - Temporal Distribution of Recorded Earthquakes Within Afghanistan

(vi) Table D5 - Temporal Distribution of Recorded Earthquakes in the Deep Earthquake Zone (See Fig. 35)

(vii) Identification of Data Sources and Authorities

EXPLANATORY REMARKS

In order to clarify the data format used in Tables D1 and D2, the following explanatory remarks are given:

1) The date of the earthquake in terms of year (Yr), month (Mo) and day (Dy) appears in the first column. (See Item 8)

2) The GMT origin time of the earthquake is given in column two in the form of hours (Hr), minutes (Mn) and seconds (Sc). In all cases the time in seconds as obtained from the original sources has been rounded off to the nearest second. Events for which the time in seconds or minutes was not available, dashes have been inserted.

   All entries extracted from the Pakistan list of significant earthquakes (Source G') are without times; these were not given in the Pakistan listing.

3) The latitude (LAT) and longitude (LONG) of the earthquake epicenter are given in columns three and four; these have been rounded off to the nearest tenth of a degree.

4) The determined magnitude (MAG) for each earthquake is presented in column five. For the cases where no magnitude determination was made a dash has been inserted. All magnitudes have been rounded off to the nearest tenth of a unit.

   Particular attention must be drawn to the magnitude values taken from the Atlas of Earthquakes in the U.S.S.R. (Source E or Ref. 31). In many cases the magnitudes listed in this source were quoted by stating a range of magnitude values. In order to reflect this situation, the method adopted has been to record the lowest magnitude of the stated range and insert a + sign behind the listed value. For all magnitudes taken from Source E, a + sign behind the value indicates the following:

   $4.3+ - 4.3 \leq MAG < 5.3$
   $5.3+ - 5.3 \leq MAG < 6.5$
   $6.5+ - 6.5 \leq MAG < 7.5$
   $7.5+ - 7.5 \leq MAG$

   All magnitudes listed in Tables D1 and D2 are considered to be body waves (M_b) magnitudes with two exceptions. These are:

   (i) Those magnitudes which were determined by the Seismological Laboratory at Pasadena, California (Authority f) are all surface wave magnitudes. These all appear with an "f" superscript.

   (ii) Those magnitudes which are listed with an asterisk (*) as a superscript are surface wave magnitudes.

5) Earthquake depths in km are given in column six. Where no depth has been determined, dashes are inserted.

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6) Columns seven and eight give the source (SRCE) and authority (AUTH). The source here denotes the data source and the authority denotes the organization which computed the instrumental values.

For the cases where some portion of the instrumental data was computed by an authority other than the one listed in column seven, a superscript denoting the correct authority has been inserted.

The letter codes used for the authorities and data sources are identified at the end of this appendix under the section "Identification of Data Sources and Authorities".

7) The ninth and last column of the tables presents the known intensity data which correlates with the instrumental data. This information has been included to provide a convenient cross reference with Table C1 of Appendix C.

In nearly all cases the intensity data appearing in the "Intensity" column relates to Table C1, but there are some exceptions. From the original instrumental data source a number of events appeared with felt data either in the form of "felt" or with estimated Modified Mercalli Scale ratings. When no local information as listed in Table C1 could be found to replace this data, the intensity data was recorded as reported by the data source.

8) Owing to an inadvertent oversight, six earthquakes were omitted in Table D2. These have been included as an Addendum on the last page of Table D2. To draw attention to these omitted entries, a + sign has been inserted between the year and month in column one of Table D2.

9) Tables D3, D4 and D5, following Table D2, are a summary of the information presented in Tables D1 and D2. These tables present a temporal distribution of the instrumental data similar in format to Table C2 of Appendix C. For a discussion of these tables, see Sec. 7.4.

TABLE D1

LIST OF STRONG EARTHQUAKES (M ≥5.8), 1893 - 1969

LAT: 27°N - 40°N LONG: 58°E - 76°E

DATE Yr Mo Dy	TIME Hr Mn Sc	LAT N	LONG E	MAG	DEPTH km	AUTH	SRCE	INTENSITY DATA
1893 Nov 17	07 -- --	37.1	58.4	6.5+	0-80	e	E	
1895 Jan 17	11 -- --	37.1	58.5	6.5+	0-80	e	E	
Aug 04	08 -- --	37.8	75.1	6.5+	0-80	e	E	
1897 Sep 17	08 -- --	39.7	69.0	6.5+	0-80	e	E	
1902 Aug 22	08 00 --	39.8	76.0	7.5+	0-80	e	E	
1905 Apr 04	00 50 00	33.0	76.0	8.0[f]	0-50[g]	b	A	Event,1905,APP.C
1907 Apr 13	17 57 18	36.5	70.5	7.0[f]	260	b	A	
Oct 21	04 23 36	38.0	69.0	8.0[f]	0-50[g]	b	A	
Oct 21	08 -- --	38.6	68.0	7.5+	--	e	E	
Dec 25	22 36 00	36.5	70.5	6.8[f]	240	b	A	
1908 Mar 12	19 26 24	36.5	70.5	6.5[f]	200	b	A	
Apr 16	17 38 48	36.5	70.5	6.8[f]	220	b	A	
Oct 23	20 14 06	36.5	70.5	7.0[f]	220	b	A	
Oct 24	21 16 36	36.5	70.5	7.0[f]	220	b	A	
1909 Jul 07	21 37 50	36.5	70.5	7.8[f]	230	b	A	
Oct 20	-- -- --	30.0	68.0	7.2	0-50	g	G'	
1910 Jul 12	07 36 12	37.0	76.0	6.8[f]	120	b	A	
1911 Feb 18	18 41 03	40.0	73.0	7.8[f]	0-50[g]	b	A	
Jul 04	13 33 26	36.0	70.5	7.6[f]	190	b	A	
1912 Apr 25	10 27 48	36.5	70.5	6.8[f]	220	b	A	
May 22	23 08 18	36.5	70.5	6.3[f]	220	b	A	
Jun 01	00 31 18	36.5	70.5	6.0[f]	200	b	A	
Aug 23	21 14 30	36.5	70.5	6.8[f]	200	b	A	
Nov 28	20 55 00	36.5	70.5	6.5[f]	230	b	A	
1914 Feb 06	11 42 18	29.5	65.0	7.0[f]	100	b	A	
1915 Jun 03	08 08 36	36.5	70.5	5.8[f]	200	b	A	
1916 Apr 21	13 56 22	36.5	70.5	6.3[f]	220	b	A	

TABLE D1

DATE Yr Mo Dy	TIME Hr Mn Sc	LAT N	LONG E	MAG	DEPTH km	AUTH	SRCE	INTENSITY DATA
1917 Apr 21	00 49 49	37.0	70.5	7.0[f]	220	b	A	
1921 May 20	00 43 20	36.0	70.5	6.8[f]	220	b	A	
Nov 15	20 36 38	36.5	70.5	7.8[f]	215	b	A	
1922 Dec 06	13 55 36	36.5	70.5	7.5[f]	230	b	A	
Dec 17	00 51 20	36.5	70.5	6.3[f]	210	b	A	
1923 Dec 28	22 24 52	39.5	68.0	6.0[f]	0-50[g]	b	A	
1924 Sep 16	02 36 00	39.0	70.5	6.3[f]	0-50[g]	b	A	
Oct 13	16 17 45	36.0	70.5	7.3[f]	220	b	A	Event #9,1924,APP.C
1925 Mar 08	11 27 47	34.0	67.0	5.8[f]	200	b	A	
Jun 20	13 04 15	36.5	71.5	6.5[f]	230	b	A	
Dec 18	18 10 25	36.5	71.0	6.0[f]	230	b	A	
1927 Apr 18	15 02 00	37.0	71.0	6.0[f]	200	b	A	
Jul 07	20 06 30	27.0	62.0	6.5[f]	100	b	A	
Jul 15	03 46 43	36.5	70.5	5.8[f]	250	b	A	
1928 Apr 25	01 16 58	38.5	73.5	5.8[f]	150	b	A	
Jun 24	04 34 38	36.0	70.5	6.5[f]	120	b	A	
Aug 10	15 33 48	36.5	70.5	6.8[f]	230	b	A	Event #2,1928,APP.C
Sep 01	06 09 00	29.0	68.5	6.3[f]	0-50[g]	b	A	
Oct 15	14 19 41	28.5	67.5	6.8[f]	0-50[g]	b	A	
Nov 14	04 33 09	35.0	72.5	6.0[f]	110	b	A	
1929 Feb 01	17 14 26	36.5	70.5	7.1[f]	220	b	A	
Mar 03	03 11 02	36.5	71.0	6.3[f]	250	b	A	
Mar 13	11 01 37	36.5	70.0	5.8[f]	200	b	A	Event, 1929,APP.C
May 01	15 37 30	38.0	58.0	7.1[f]	0-80[e]	b	A	
1930 Sep 11	17 20 16	36.5	70.5	5.8[f]	250	b	A	
Sep 22	16 26 40	38.6	69.4	5.8	0-80	e	E	
1931 Jan 20	09 27 22	36.5	71.5	6.5[f]	220	b	A	Event #1,1931,APP.C
Aug 15	04 01 08	36.5	70.5	6.0[f]	240	b	A	
Aug 24	21 35 22	30.3	67.8	7.0[f]	0-50[g]	b	A	Event #4,1931,APP.C
Aug 27	15 27 17	29.8	67.3	7.4[f]	0-50[g]	b	A	
Sep 14	03 32 16	36.5	70.5	5.8[f]	220	b	A	
Oct 05	22 31 27	36.5	70.5	6.8[f]	220	b	A	Event #5,1931,APP.C
1932 Apr 03	10 52 41	36.8	70.5	6.0[f]	250	b	A	
Apr 30	10 52 36	36.6	70.6	6.0	140	e	E	
Oct 29	11 08 49	39.5	72.0	6.0[f]	0-50[g]	b	A	
1933 Jan 09	02 01 43	36.5	70.5	6.5[f]	230	b	A	Event #2,1933,APP.C
May 27	22 41 58	37.0	70.5	5.8[f]	230	b	A	

TABLE D1

DATE Yr Mo Dy	TIME Hr Mn Sc	LAT N	LONG E	MAG	DEPTH km	AUTH	SRCE	INTENSITY DATA
1934 Jun 13	22 10 28	27.5	62.5	7.0^f	80	b	A	
Jul 22	19 56 57	36.5	70.5	6.8^f	240	b	A	Event #4, 1934, APP.C
Aug 31	14 57 41	38.8	71.0	6.5^f	0-50^g	b	A	
Nov 18	03 21 24	36.5	70.5	6.5^f	220	b	A	Event #7, 1934, APP.C
1935 Feb 03	02 10 47	36.5	70.5	6.0^f	230	b	A	Event #1, 1935, APP.C
Apr 03	11 11 59	36.5	70.5	6.3^f	250	b	A	Event #2, 1935, APP.C
May 15	02 01 24	28.0	68.0	6.0^f	0-50^g	b	A	
May 30	21 32 46	29.5	66.8	7.5^f	0-50^g	b	A	Event #4, 1935, APP.C
Jun 02	09 16 25	30.0	66.8	6.0^f	0-50^g	b	A	
Jul 05	17 53 01	38.0	67.5	6.0^f	0-50^g	b	A	Event #5, 1935, APP.C
Jul 28	05 23 58	36.0	71.0	6.0^f	150	b	A	
Jul 29	23 16 36	39.5	73.5	5.8	--	e	E	
Oct 08	09 19 06	38.8	70.8	6.0	--	e	E	
Oct 11	04 20 18	36.5	70.5	5.8^f	230	b	A	Event #6, 1935, APP.C
1936 Jun 29	14 30 10	36.5	71.0	6.8^f	230	b	A	Event, 1936, APP.C
Jun 30	19 26 06	33.0	60.0	6.3^f	0-50^g	b	A	
1937 Oct 29	07 26 30	36.5	70.5	6.3^f	230	b	A	Event #1, 1937, APP.C
Nov 07	19 07 40	35.0	73.0	5.8^f	100	b	A	
Nov 14	10 58 12	36.5	70.5	7.2^f	240	b	A	Event #3, 1937, APP.C
1938 Jan 18	09 29 02	36.5	70.5	5.8^f	250	b	A	
1939 May 30	10 07 06	38.9	70.4	5.8	--	e	E	
Nov 21	11 01 50	36.5	70.5	6.9^f	220	b	A	Event #1, 1939, APP.C
1940 Jan 26	15 20 45	36.5	72.0	5.8^f	200	b	A	
Feb 08	15 15 20	36.5	70.5	5.8^f	220	b	A	
Mar 19	04 35 50	35.8	70.0	6.0^f	50	b	A	Event #2, 1940, APP.C
May 04	21 01 54	35.3	58.3	6.3^f	--	b	A	
May 27	04 10 38	37.0	71.0	6.3^f	240	b	A	
Sep 21	13 48 58	36.5	70.5	6.3	230	e	E	Event #4, 1940, APP.C
Nov 04	08 30 12	36.5	70.8	5.8^f	210	b	A	
Nov 20	17 59 59	36.0	70.5	5.8^f	200	b	A	Event #5, 1940, APP.C
1941 Feb 16	16 39 03	33.8	59.0	6.3^f	--	b	A	
Mar 11	21 48 55	36.5	71.0	6.0^f	210	b	A	Event #1, 1941, APP.C
Apr 20	17 38 30	39.0	70.5	6.5^f	0-50^g	b	A	
May 06	16 55 36	39.0	70.5	6.0^f	60	b	A	
May 15	15 19 52	36.5	70.0	6.0^f	230	b	A	
May 17	21 29 34	36.5	70.5	5.8^f	250	b	A	
Sep 29	-- -- --	30.7	67.2	5.8	0-50	g	G'	Event #2, 1941, APP.C
Nov 28	12 23 23	36.5	70.5	5.8^f	220	b	A	Event #3, 1941, APP.C
1942 Mar 22	02 08 33	36.5	70.3	6.0^f	210	b	A	Event #2, 1942, APP.C
1943 Jan 11	19 50 18	38.7	69.3	6.0	--	e	E	
Feb 28	12 54 33	36.5	70.5	7.0^f	210	b	A	Event #1, 1943, APP.C
Apr 05	01 56 14	39.0	72.5	6.5^f	100	b	A	

DATE Yr Mo Dy	TIME Hr Mn Sc	LAT N	LONG E	MAG	DEPTH km	AUTH	SRCE	INTENSITY DATA
1943 Sep 09	04 06 10	36.5	70.5	6.3[f]	200	b	A	
Sep 24	11 31 37	36.5	74.0	6.8[f]	120	b	A	
1944 Mar 15	05 03 53	39.7	73.1	5.8	--	e	E	
Sep 27	16 25 02	39.0	73.5	7.0[f]	40	b	A	
1945 Jun 22	18 00 57	32.5	76.0	6.5[f]	60	b	A	
1947 Jan 30	12 32 42	36.5	70.5	5.8[f]	200	b	A	
Sep 23	12 28 09	33.0	59.0	6.8[f]	--	b	A	
Oct 03	06 13 51	27.5	58.0	6.3[f]	--	b	A	
1948 Jan 28	15 51 20	36.8	67.2	6.3	70	e	E	Event #2, 1948, APP.C
Oct 05	20 12 05	37.5	58.0	7.3[f]	--	b	A	
Oct 06	01 24 44	37.4	58.8	5.8	--	e	E	
1949 Mar 04	10 19 25	36.0	70.5	7.5[f]	230	b	A	Event #2, 1949, APP.C
Jul 10	03 53 36	39.0	70.5	7.6[f]	0-50[g]	b	A	Event #3, 1949, APP.C
Jul 10	15 49 17	39.2	71.0	6.0	--	e	E	
Jul 10	16 24 00	39.1	71.0	6.5	--	e	E	
Jul 13	10 13 59	39.2	71.0	5.8	--	e	E	
1950 May 09	11 16 57	38.5	58.8	6.3[h]	--	c	A	
Jul 09	16 10 20	36.5	71.0	6.5+[e]	220	a	A	Event #1, 1950, APP.C
1951 Jan 06	05 17 19	36.5	70.5	6.8[f]	250	c	A	Event #2, 1951, APP.C
Apr 14	04 10 04	39.3	72.0	5.8[i]	--	c	A	
Jun 12	22 40 36	36.5	71.3	6.5+[e]	220	c	A	Event #4, 1951, APP.C
1952 Oct 10	18 47 32	30.2	70.0	6.1[h]	--	d	A	Felt
Dec 25	22 22 43	29.4	70.0	5.8[k]	--	d	A	
1955 Feb 18	22 48 35	30.3	67.0	6.1[ij]	5	c	A	Event #1, 1955, APP.C
Apr 15	03 40 52	40.0	74.5	6.9[f]	--	a	A	Felt
Apr 15	04 13 26	40.0	74.5	7.0	0-50[g]	e	E	
May 14	13 35 43	36.6	71.3	5.9[k]	223	d	A	Felt
Aug 23	14 09 21	31.0	71.5	6.5[l]	64	d	A	
1956 Mar 05	07 12 02	37.0	74.0	5.9[n]	--	c	A	
Apr 06	07 11 31	36.5	71.0	6.8[k]	150	c	A	Event #1, 1956, APP.C
Apr 11	01 45 10	38.8	70.3	5.8[n]	--	d	A	
May 13	07 50 33	29.9	70.0	6.1[k]	--	c	A	Felt VIII MM
Jun 08	04 07 29	35.0	67.5	5.8[k]	--	c	A	Event #2, 1956, APP.C
Jun 09	23 13 52	35.3	67.5	7.4[f]	0-50[g]	c	A	Event #3, 1956, APP.C
Jul 03	23 26 19	36.5	70.5	6.1[n]	220	c	A	Event #19,1956, APP.C
Sep 16	08 37 22	34.0	69.5	6.4[f]	0-50[g]	a	A	Event #34,1956, APP.C
Sep 22	15 54 27	39.0	69.0	5.8[n]	--	c	A	
Sep 24	10 20 38	34.3	69.8	6.2[n]	--	c	A	Event #40,1956, APP.C
Oct 13	08 21 25	36.0	70.5	6.1[n]	150	c	A	Event #54,1956, APP.C

DATE Yr Mo Dy	TIME Hr Mn Sc	LAT N	LONG E	MAG	DEPTH km	AUTH	SRCE	INTENSITY DATA
1957 Jun 11	04 57 28	36.5	70.5	5.8[n]	220	c	A	
Jul 15	23 08 08	29.0	70.0	5.8[g]	0-50[g]	a	A	
Aug 20	01 50 06	37.5	72.5	5.9[g]	200[g]	c	A	
Aug 20	15 21 09	36.7	71.2	5.9[g]	227	d	A	
Sep 02	21 27 35	37.0	71.0	6.1[g]	200	c	A	
Sep 04	08 07 20	28.0	65.3	6.0[k]	0-50[g]	c	A	
1958 Jan 06	01 54 39	38.0	71.5	5.8[e]	--	c	A	Event #2, 1958, APP.C
Feb 17	05 18 38	36.0	71.0	6.6[n]	200	c	A	Event #10,1958, APP.C
Mar 22	11 07 50	35.5	67.5	5.9[e]	--	c	A	
Mar 23	00 25 38	35.5	67.5	6.2	0-50[g]	c	A'	
Mar 27	-- -- --	37.0	71.0	7.3	200	g	G'	
Mar 28	04 09 40	37.0	71.0	5.8[n]	200	c	A	Event #15,1958, APP.C
Mar 28	12 06 26	37.0	71.0	7.0[n]	200	c	A'	Event #17,1958, APP.C
Apr 03	-- -- --	36.5	71.0	6.0	100	g	G'	
Apr 08	09 59 15	33.0	67.5	5.8[g]	0-50[g]	a	A	Event #19,1958, APP.C
Apr 30	08 16 51	36.5	70.5	6.0[g]	220	c	A	
Sep 18	20 53 03	36.8	70.5	6.1[n]	170	c	A	Event #27,1958, APP.C
Dec 10	03 43 50	37.0	71.0	6.4[n]	180	c	A	
1959 Mar 02	15 51 40	36.5	70.5	6.1[r]	220	c	A	Felt
May 19	15 17 44	33.0	68.5	5.8[n]	35	d	A	Event #12,1959, APP.C
Jul 31	19 53 10	38.5	70.0	5.9[n]	0-50[g]	c	A	
Sep 12	21 19 57	36.0	71.0	6.4[g]	200	a	A	Felt
Nov 15	10 25 18	39.0	75.0	6.3[r]	--	c	A	
1960 Jan 09	07 24 04	36.5	70.0	6.7[n]	200	c	A	Event #2, 1960, APP.C
Jan 29	07 33 43	36.5	70.5	6.1[g]	220	c	A	
Feb 19	10 36 52	36.5	70.5	6.4[o]	220	c	A	Event #7, 1960, APP.C
May 19	02 07 00	36.0	71.0	6.0[r]	200[r]	c	A	Felt
Jul 06	05 16 46	36.5	70.5	6.6[g]	220	c	A	
Jul 17	05 14 56	36.0	69.0	5.9[o]	200	c	A	Event #12,1960, APP.C
1961 Mar 20	-- -- --	35.6	71.1	6.0	121	g	G'	
Jun 19	17 04 36	36.5	70.5	6.7[n]	220	c	A	Event #5, 1961, APP.C
Sep 05	06 12 59	38.5	73.0	6.0[n]	100	c	A	
Sep 28	05 00 45	36.5	70.5	6.1[g]	220	c	A	
1962 Apr 01	00 45 10	33.2	58.6	5.8[e]	--	c	A	Event #5, 1962, APP.C
Jul 06	23 05 32	36.6	70.4	6.8[f]	203	c	A	Event #6, 1962, APP.C
Sep 12	20 57 00	36.4	68.8	6.6[f]	50	c	A'	
Sep 15	-- -- --	32.3	75.7	6.0	0-50	g	G'	
1963 Feb 17	05 38 18	36.5	70.5	6.2	200	a	A	
Oct 16	15 43 01	38.6	73.4	5.9	33	a	A	
1964 Jan 28	14 09 17	36.5	70.9	6.1	207	a	A	Event #3, 1964, APP.C
Jul 06	10 13 45	37.1	71.4	5.9	100	a	A	
Oct 13	23 02 26	35.8	71.1	5.8	120	a	A	

TABLE D1

DATE Yr Mo Dy	TIME Hr Mn Sc	LAT N	LONG E	MAG	DEPTH km	AUTH	SRCE	INTENSITY DATA
1965 Feb 02	15 56 51	37.5	73.4	5.8	33	a	A	
Mar 14	15 53 07	36.3	70.7	6.6	219	a	A	Event #2, 1965, APP.C
Jun 10	05 48 57	36.1	70.5	5.8	92	a	A	
1966 Feb 07	04 26 11	29.9	69.7	6.0	10	a	A	
Feb 07	23 06 35	30.3	69.9	5.8	11	a	A	
Jun 06	07 46 16	36.4	71.1	6.2	221	a	A	Event #10,1966, APP.C
Aug 01	21 03 00	30.1	68.6	6.0	33	a	A	Event #13,1966, APP.C
1968 Aug 31	10 47 37	34.0	59.0	7.3*	13	a	A	Event #1, 1968, APP.C
Sep 01	07 27 30	34.0	58.2	6.3*	--	a	A	
1969 Mar 05	19 33 23	36.4	70.7	5.9	208	a	A	Event #1, 1969, APP.C
Aug 08	06 30 57	36.4	70.9	5.8	198	a	A	Event #4, 1969, APP.C
Nov 07	18 34 00	27.9	60.1	6.7*	35	a	A	Felt

TABLE D2

LIST OF ALL EARTHQUAKES 1893 - 1969

LAT: 27°N - 40°N LONG: 58°E - 76°E

DATE Yr Mo Dy	TIME Hr Mn Sc	LAT N	LONG E	MAG	DEPTH km	AUTH	SRCE	INTENSITY DATA
1893 Nov 17	07 -- --	37.1	58.4	6.5+	0-80	e	E	
1895 Jan 17	11 -- --	37.1	58.5	6.5+	0-80	e	E	
Aug 04	08 -- --	37.8	75.1	6.5+	0-80	e	E	
Nov 13	-- -- --	38.9	70.4	5.3+	0-80	e	E	
1896 Sep 27	21 27 --	39.6	73.6	5.3+	0-80	e	E	
Nov 01	09 10 --	39.7	75.9	5.3+	0-80	e	E	
1897 Sep 17	08 -- --	39.7	69.0	6.5+	0-80	e	E	
1902 Aug 22	08 00 --	39.8	76.0	7.5+	0-80	e	E	
1905 Apr 04	00 50 00	33.0	76.0	8.0[f]	0-50[g]	b	A	Event, 1905, APP.C
1907 Apr 13	17 57 18	36.5	70.5	7.0[f]	260	b	A	
Oct 21	04 23 36	38.0	69.0	8.0[f]	0-50[g]	b	A	
Oct 21	08 -- --	38.6	68.0	7.5+	---	e	E	
Dec 25	22 36 00	36.5	70.5	6.8[f]	240	b	A	
1908 Mar 12	19 26 24	36.5	70.5	6.5[f]	200	b	A	
Apr 16	17 38 48	36.5	70.5	6.8[f]	220	b	A	
Oct 23	20 14 06	36.5	70.5	7.0[f]	220	b	A	
Oct 24	21 16 36	36.5	70.5	7.0[f]	220	b	A	
1909 Jul 07	21 37 50	36.5	70.5	7.8[f]	230	b	A	
Oct 20	-- -- --	30.0	68.0	7.2	0-50	g	G'	
1910 Jul 12	07 36 12	37.0	76.0	6.8[f]	120	b	A	
1911 Feb 18	18 41 03	40.0	73.0	7.8[f]	0-50[g]	b	A	
Jul 04	13 33 26	36.0	70.5	7.6[f]	190	b	A	
1912 Apr 25	10 27 48	36.5	70.5	6.8[f]	220	b	A	
May 22	23 08 18	36.5	70.5	6.3[f]	220	b	A	
Jun 01	00 31 18	36.5	70.5	6.0[f]	200	b	A	
Aug 23	21 14 30	36.5	70.5	6.8[f]	200	b	A	
Nov 28	20 55 00	36.5	70.5	6.5[f]	230	b	A	
1914 Feb 06	11 42 18	29.5	65.0	7.0[f]	100	b	A	

DATE Yr Mo Dy	TIME Hr Mn Sc	LAT N	LONG E	MAG	DEPTH km	AUTH	SRCE	INTENSITY DATA
1915 Jun 03	08 08 36	36.5	70.5	5.8^f	200	b	A	
1916 Apr 21	13 56 22	36.5	70.5	6.3^f	220	b	A	
1917 Apr 21	00 49 49	37.0	70.5	7.0^f	220	b	A	
Nov 28	14 42 24	36.5	59.1	5.3	0-80	e	E	
1921 May 20	00 43 20	36.0	70.5	6.8^f	220	b	A	
Nov 15	20 36 38	36.5	70.5	7.8^f	215	b	A	
1922 Dec 06	13 55 36	36.5	70.5	7.5^f	230	b	A	
Dec 17	00 51 20	36.5	70.5	6.3^f	210	b	A	
1923 Dec 28	22 24 52	39.5	68.0	6.0^f	$0\text{-}50^g$	b	A	
1924 Sep 16	02 36 00	39.0	70.5	6.3^f	$0\text{-}50^g$	b	A	
Sep 17	10 20 51	36.8	70.7	5.3+	100	e	E	Event #8, 1924, APP.C
Oct 13	16 17 45	36.0	70.5	7.3^f	220	b	A	Event #9, 1924, APP.C
1925 Mar 08	11 27 47	34.0	67.0	5.8^f	200	b	A	
Jun 20	13 04 15	36.5	71.5	6.5^f	230	b	A	
Dec 07	08 34 28	37.0	76.0	5.5	0-80	e	E	
Dec 18	18 10 25	36.5	71.0	6.0^f	230	b	A	
1926 Mar 22	16 24 10	36.0	70.0	5.6	$0\text{-}50^g$	b	A	
Apr 11	06 26 24	39.0	71.0	5.0	--	e	E	
Jul 06	16 28 14	39.2	74.2	4.5	--	e	E	
1927 Apr 18	15 02 00	37.0	71.0	6.0^f	200	b	A	
Apr 24	11 20 20	36.4	70.5	5.0	--	e	E	
+ Jul 07	20 06 30	27.0	62.0	6.5^f	100	b	A	
1928 Feb 25	17 23 58	37.5	67.0	5.6^f	--	b	A	
Apr 25	01 16 58	38.5	73.5	5.8^f	150	b	A	
Jun 24	04 34 38	36.0	70.5	6.5^f	120	b	A	
Jul 10	21 33 47	36.9	71.1	4.25+	200	e	E	
Aug 10	15 33 48	36.5	70.5	6.8^f	230	b	A	Event #2, 1928, APP.C
Sep 01	06 09 00	29.0	68.5	6.3^f	$0\text{-}50^g$	b	A	
Oct 15	14 19 41	28.5	67.5	6.8^f	$0\text{-}50^g$	b	A	
Nov 14	04 33 09	35.0	72.5	6.0^f	110	b	A	
1929 Feb 01	17 14 26	36.5	70.5	7.1^f	220	b	A	
Mar 03	03 11 02	36.5	71.0	6.3^f	250	b	A	
Mar 13	11 01 37	36.5	70.0	5.8^f	200	b	A	Event, 1929, APP.C
Mar 27	02 36 00	39.1	71.7	4.25+	--	e	E	
Mar 27	03 37 11	39.2	71.8	4.25+	--	e	E	
May 01	15 37 30	38.0	58.0	7.1^f	$0\text{-}80^e$	b	A	
May 04	06 31 13	37.5	58.2	4.3	--	e	E	
Jul 13	07 36 30	37.0	58.5	5.5	0-80	e	E	
Sep 24	24 52 17	36.7	70.7	5.25+	200	e	E	
Dec 10	17 55 00	36.6	70.6	4.25+	120	e	E	

DATE Yr Mo Dy	TIME Hr Mn Sc	LAT N	LONG E	MAG	DEPTH km	AUTH	SRCE	INTENSITY DATA
1930 Jan 07	17 27 36	39.2	72.1	5.0	---	e	E	
Feb 08	06 28 58	39.4	74.9	5.3	---	e	E	
Mar 01	05 35 23	40.0	75.3	5.0	---	e	E	
Mar 06	15 44 20	39.0	72.0	5.0	---	e	E	
Jul 14	20 41 53	38.6	68.8	4.5	---	e	E	
Jul 31	00 07 41	39.2	73.8	4.5	---	e	E	
Aug 09	22 41 01	39.2	73.8	5.0	---	e	E	
Sep 05	10 14 01	37.7	72.6	4.3+	120	e	E	
Sep 11	17 20 16	36.5	70.5	5.8[f]	250	b	A	
Sep 22	16 26 40	38.6	69.4	5.8	0-80	e	E	
Sep 23	10 15 20	37.6	71.6	4.3+	120	e	E	
Sep 29	13 29 00	27.5	68.5	5.6[f]	---	b	A	
Oct 30	16 15 42	38.6	75.0	4.3+	---	e	E	
Dec 16	08 19 33	36.6	70.5	4.3+	200	e	E	
1931 Jan 07	03 49 42	36.5	71.0	5.5[f]	200	b	A	
Jan 20	09 27 22	36.5	71.5	6.5[f]	220	b	A	Event #1, 1931, APP.C
Apr 26	00 13 48	39.0	73.6	4.5	---	e	E	
Aug 08	08 54 16	37.0	58.5	5.6[f]	---	b	A	
Aug 15	04 01 08	36.5	70.5	6.0[f]	240	b	A	
Aug 24	21 35 12	27.0	60.0	-	---	a	A	
Aug 24	21 35 22	30.3	67.8	7.0[f]	0-50[g]	b	A	Event #4, 1931, APP.C
Aug 26	19 29 20	28.0	69.0	5.6[f]	---	b	A	
Aug 27	15 27 17	29.8	67.3	7.4[f]	0-50[g]	b	A	
Sep 14	03 32 16	36.5	70.5	5.8[f]	220	b	A	
Sep 30	11 14 45	28.5	69.0	5.6[f]	---	b	A	
Oct 05	22 31 27	36.5	70.5	6.8[f]	220	b	A	Event #5, 1931, APP.C
Nov 04	15 21 30	37.0	69.5	4.8	---	e	E	
Nov 16	06 15 10	39.7	69.6	4.5	---	e	E	
1932 Feb 09	02 19 44	36.5	70.5	5.3[f]	220	b	A	
Feb 14	20 30 22	37.3	71.1	4.3+	---	e	E	
Mar 09	01 11 52	36.8	70.8	4.3+	100	e	E	
Apr 03	10 52 41	36.8	70.5	6.0[f]	250	b	A	
Apr 30	10 52 36	36.6	70.6	6.0	140	e	E	
Aug 16	21 53 34	39.1	72.9	4.5	---	e	E	
Sep 08	07 25 32	31.0	58.5	5.6[f]	---	b	A	
Sep 23	22 31 24	40.0	75.2	4.5	---	e	E	
Oct 29	10 59 16	39.3	72.3	4.8	---	e	E	
Oct 29	11 08 49	39.5	72.0	6.0[f]	0-50[g]	b	A	
1933 Jan 02	17 41 02	39.0	70.7	4.3+	---	e	E	
Jan 09	02 01 43	36.5	70.5	6.5[f]	230	b	A	Event #2, 1933, APP.C
Jan 20	12 12 12	36.5	70.5	5.5[f]	230	b	A	
May 21	17 53 43	36.5	70.5	5.5[f]	220	b	A	
May 27	22 41 58	37.0	70.5	5.8[f]	230	b	A	
Jun 12	09 17 19	38.9	69.8	4.3+	---	e	E	
Jun 19	22 34 03	37.6	73.0	4.3+	---	e	E	
Jun 23	20 50 45	36.7	67.1	4.3+	---	e	E	
Jul 25	13 38 23	39.0	72.0	5.5[f]	250	b	A	

DATE Yr	Mo	Dy	TIME Hr	Mn	Sc	LAT N	LONG E	MAG	DEPTH km	AUTH	SRCE	INTENSITY DATA
1933	Oct	16	04	34	44	33.0	67.0	5.6[f]	--	b	A	Event #5, 1933, APP.C
	Dec	02	02	15	16	36.5	69.5	5.6[f]	--	b	A	
	Dec	09	07	52	10	36.5	69.5	5.6[f]	--	b	A	
1934	Jan	18	15	47	22	38.9	70.6	4.3+	--	e	E	
	Feb	20	20	08	38	39.2	71.3	4.3+	--	e	E	
	Apr	03	11	26	37	35.5	65.0	5.6[f]	--	b	A	
	Apr	30	12	25	39	36.5	70.5	4.3+	200	e	E	
	May	01	03	40	40	27.0	69.0	5.6[f]	--	b	A	
	Jun	04	05	55	49	38.4	72.8	5.3+	160	e	E	
	Jun	13	22	10	28	27.5	62.5	7.0[f]	80	b	A	
	Jun	18	03	26	32	36.6	70.8	4.3+	200	e	E	
	Jul	05	07	30	30	37.6	69.5	4.3+	--	e	E	
	Jul	22	19	56	57	36.5	70.5	6.8[f]	240	b	A	Event #4, 1934, APP.C
	Aug	31	14	57	41	38.8	71.0	6.5[f]	0-50[g]	b	A	
	Sep	01	06	50	28	38.5	70.3	4.3+	--	e	E	
	Sep	01	09	02	50	38.5	70.4	4.3+	--	e	E	
	Sep	01	12	31	13	38.5	70.4	4.5	--	e	E	
	Sep	03	02	48	57	38.5	70.4	4.3+	--	e	E	
	Sep	03	10	19	18	39.2	70.9	4.8	--	e	E	
	Sep	04	09	33	39	38.9	70.8	4.3+	--	e	E	
	Sep	05	10	19	50	38.9	70.8	4.3+	--	e	E	
	Sep	08	06	44	56	38.5	71.0	5.6[f]	--	b	A	
	Sep	11	14	07	05	38.9	70.5	4.5	--	e	E	
	Sep	18	07	07	56	39.0	71.2	4.5	--	e	E	
	Sep	23	01	24	31	39.3	71.1	4.5	--	e	E	
	Nov	15	23	14	42	36.5	71.0	5.6[f]	--	b	A	
	Nov	18	03	21	24	36.5	70.5	6.5[f]	220	b	A	Event #7, 1934, APP.C
	Dec	12	03	16	28	39.4	70.4	4.5	--	e	E	
	Dec	27	13	37	35	36.4	70.6	4.5	--	e	E	
1935	Jan	04	10	22	16	38.9	70.9	5.0	--	e	E	
	Jan	04	21	43	28	38.9	70.9	4.3+	--	e	E	
	Jan	16	06	12	13	39.0	71.0	4.3+	--	e	E	
	Jan	16	23	19	53	39.3	70.5	4.3+	--	e	E	
	Feb	03	02	10	47	36.5	70.5	6.0[f]	230	b	A	Event #1, 1935, APP.C
	Apr	03	11	11	59	36.5	70.5	6.3[f]	250	b	A	Event #2, 1935, APP.C
	Apr	20	07	47	17	37.6	71.0	4.3+	--	e	E	
	Apr	22	13	15	27	39.8	67.5	5.0	--	e	E	
	May	04	00	23	10	37.5	69.7	4.3+	--	e	E	
	May	12	05	20	13	37.5	72.0	5.0	--	e	E	
	May	15	02	01	24	28.0	68.0	6.0[f]	0-50[g]	b	A	
	May	16	17	24	16	37.2	69.0	5.5	--	e	E	
	May	30	21	32	46	29.5	66.8	7.5[f]	0-50[g]	b	A	Event #4, 1935, APP.C
	Jun	02	04	16	22	37.9	70.2	4.3+	--	e	E	
	Jun	02	09	16	25	30.0	66.8	6.0[f]	0-50[g]	b	A	
	Jun	25	23	52	43	36.6	70.8	4.3+	100	e	E	
	Jun	29	09	47	39	38.1	71.7	4.5	--	e	E	
	Jul	05	17	53	01	38.0	67.5	6.0[f]	0-50[g]	b	A	Event #5, 1935, APP.C
	Jul	13	18	58	18	37.6	70.4	4.3+	--	e	E	

DATE Yr	Mo	Dy	TIME Hr	Mn	Sc	LAT N	LONG E	MAG	DEPTH km	AUTH	SRCE	INTENSITY DATA
1935	Jul	22	06	55	18	38.9	72.6	4.5	--	e	E	
	Jul	28	05	23	58	36.0	71.0	6.0^f	150	b	A	
	Jul	29	23	16	36	39.5	73.5	5.8	--	e	E	
	Jul	31	09	47	39	39.5	73.5	5.0	--	e	E	
	Aug	22	06	43	21	39.4	71.4	4.5	--	e	E	
	Sep	28	08	19	30	39.2	71.0	4.3+	--	e	E	
	Oct	08	09	19	06	38.8	70.8	6.0	--	e	E	
	Oct	10	04	37	44	39.0	70.7	4.5	--	e	E	
	Oct	11	04	20	18	36.5	70.5	5.8^f	230	b	A	Event #6, 1935, APP.C
	Oct	14	20	20	12	38.9	70.8	5.0	--	e	E	
	Dec	19	23	10	45	36.5	70.5	5.5^f	230	b	A	
1936	Jan	07	11	53	02	36.6	71.0	4.3+	200	e	E	
	Jan	30	22	37	03	38.2	70.3	4.3+	--	e	E	
	Feb	02	05	13	40	36.4	68.0	4.5	--	e	E	
	Apr	09	00	53	00	39.0	73.0	5.0	--	e	E	
	Apr	30	16	05	55	39.4	69.5	4.5	--	e	E	
	May	07	01	53	13	36.5	69.3	5.0	--	e	E	
	Jun	10	03	29	12	27.5	63.5	-	--	a	A	
	Jun	22	22	42	03	38.9	73.7	5.0	--	e	E	
	Jun	24	04	04	34	36.4	69.4	4.3+	100	e	E	
	Jun	29	14	30	10	36.5	71.0	6.8^f	230	b	A	Event, 1936, APP.C
	Jun	30	19	26	06	33.0	60.0	6.3^f	$0\text{-}50^g$	b	A	
	Jul	15	14	47	18	38.1	69.9	4.3+	--	e	E	
	Aug	20	02	33	23	36.5	71.0	5.6^f	--	b	A	
	Aug	20	23	32	42	36.7	71.2	4.3+	200	e	E	
	Aug	26	16	08	00	40.0	70.3	-	--	e	E	
	Aug	29	12	41	50	38.2	72.0	5.0	--	e	E	
	Sep	17	12	57	06	39.9	74.4	4.3+	--	e	E	
	Sep	25	01	08	28	38.9	69.2	4.5	--	e	E	
	Oct	20	22	10	11	38.7	73.9	4.3+	100	e	E	
	Nov	11	00	03	10	37.9	70.7	4.3+	--	e	E	
	Nov	11	17	11	24	39.5	74.2	5.0	--	e	E	
	Nov	29	04	10	59	38.9	70.8	4.5	--	e	E	
	Dec	02	18	30	23	39.3	70.5	4.3+	--	e	E	
1937	Apr	15	08	33	02	39.4	70.6	4.3+	--	e	E	
	Apr	25	03	58	16	36.8	70.2	4.3+	--	e	E	
	Apr	27	15	39	01	39.7	71.5	4.5	--	e	E	
	May	15	09	17	53	38.5	69.7	4.3+	--	e	E	
	Jul	23	20	44	17	38.7	74.0	4.3+	100	e	E	
	Sep	09	17	35	30	36.3	71.8	4.3+	--	e	E	
	Sep	19	16	10	34	38.8	72.0	4.5	--	e	E	
	Oct	29	07	26	30	36.5	70.5	6.3^f	230	b	A	Event #1, 1937, APP.C
	Nov	07	19	07	40	35.0	73.0	5.8^f	100	b	A	
	Nov	14	10	58	12	36.5	70.5	7.2^f	240	b	A	Event #3, 1937, APP.C
	Dec	06	19	17	17	38.1	69.7	4.3+	--	e	E	

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DATE Yr	Mo	Dy	TIME Hr Mn Sc	LAT N	LONG E	MAG	DEPTH km	AUTH	SRCE	INTENSITY DATA
1938	Jan	12	01 08 21	38.8	70.5	5.0	--	e	E	
	Jan	18	09 29 02	36.5	70.5	5.8^{f}	250	b	A	
	Jan	26	10 48 12	36.5	70.5	5.3^{f}	250	b	A	
	Feb	14	19 15 00	37.2	70.0	4.3+	--	e	E	
	Apr	06	01 14 30	36.5	70.5	5.3^{f}	240	b	A	
	May	24	09 37 26	36.7	73.8	5.0	--	e	E	
	Aug	05	14 17 40	36.8	71.0	5.5	--	e	E	
	Oct	31	05 27 15	37.0	71.3	4.3+	--	e	E	
	Nov	01	00 47 12	37.0	71.0	4.3+	--	e	E	
	Dec	19	18 56 42	38.0	58.0	-	--	a	A	
1939	Feb	06	21 10 16	36.5	71.0	5.5^{f}	250	b	A	
	Apr	02	14 11 54	38.0	70.4	4.3+	--	e	E	
	Apr	04	18 17 48	38.4	70.0	4.3+	--	e	E	
	May	12	09 46 11	37.6	71.0	4.3+	--	e	E	
	May	30	10 07 06	38.9	70.4	5.8	--	e	E	
	Jun	19	00 42 40	36.5	71.0	5.6^{f}	--	b	A	
	Jun	22	17 02 42	39.2	69.2	4.5	--	e	E	
	Jul	18	21 36 44	38.4	70.1	4.3+	--	e	E	
	Jul	19	06 30 46	38.2	69.8	4.5	--	e	E	
	Jul	26	07 52 12	39.1	71.6	4.3+	--	e	E	
	Aug	01	23 56 35	39.3	72.3	4.5	--	e	E	
	Aug	28	21 35 36	36.4	58.0	5.0	--	e	E	
	Sep	06	11 27 32	36.6	66.5	5.0	--	e	E	
	Oct	03	09 24 05	38.8	70.3	4.5	--	e	E	
	Oct	10	20 42 30	36.3	69.0	5.0	--	e	E	
	Oct	12	23 12 13	38.2	70.4	4.3+	--	e	E	
	Nov	08	17 21 00	35.3	58.8	5.3	--	e	E	
	Nov	21	11 01 50	36.5	70.5	6.9^{f}	220	b	A	Event #1, 1939, APP.C
	Dec	19	00 02 31	36.5	70.5	5.5^{f}	220	b	A	Event #2, 1939, APP.C
1940	Jan	26	15 20 45	36.5	72.0	5.8^{f}	200	b	A	
	Feb	02	19 54 10	38.9	70.5	4.3+	--	e	E	
	Feb	08	15 15 20	36.5	70.5	5.8^{f}	220	b	A	
	Mar	19	04 35 36	29.0	67.0	-	--	a	A	
	Mar	19	04 35 50	35.8	70.0	6.0^{f}	50	b	A	Event #2, 1940, APP.C
	Mar	22	10 03 02	36.7	72.0	4.5	--	e	E	
	Apr	14	09 19 30	39.8	75.2	4.3+	--	e	E	
	May	04	21 01 54	35.3	58.3	6.3	--	b	A	
	May	06	12 54 06	39.6	69.3	4.5	--	e	E	
	May	27	04 10 38	37.0	71.0	6.3^{f}	240	b	A	
	Jun	01	21 35 12	38.9	75.7	4.3+	--	e	E	
	Jun	17	22 43 09	37.0	70.9	4.3+	--	e	E	
	Jul	17	06 36 22	36.8	71.0	5.5	--	e	E	
	Jul	17	11 44 44	36.7	70.0	5.3	--	e	E	
	Aug	01	19 45 06	38.0	72.5	5.5	--	e	E	
	Sep	01	18 46 29	36.5	68.7	5.0	--	e	E	
	Sep	01	18 50 39	36.5	68.7	4.3+	--	e	E	
	Sep	21	13 48 58	36.5	70.5	6.3	230	e	E	Event #4, 1940, APP.C
	Oct	05	14 44 33	37.2	69.0	5.3	--	e	E	

TABLE D2

DATE Yr	Mo	Dy	TIME Hr	Mn	Sc	LAT N	LONG E	MAG	DEPTH km	AUTH	SRCE	INTENSITY DATA
1940	Nov	04	08	30	12	36.5	70.8	5.8[f]	210	b	A	
	Nov	20	17	59	59	36.0	70.5	5.8[f]	200	b	A	**Event #5, 1940, APP.C**
	Dec	25	23	07	33	36.5	70.5	5.5[f]	250	b	A	
	Dec	27	16	57	34	39.5	73.2	4.5	—	e	E	
1941	Feb	16	16	39	03	33.8	59.0	6.3[f]	—	b	A	
	Feb	18	19	45	20	38.9	71.7	4.3+	—	e	E	
	Mar	11	21	48	55	36.5	71.0	6.0[f]	210	b	A	**Event #1, 1941, APP.C**
	Apr	05	09	58	38	39.3	72.1	5.0	—	e	E	
	Apr	09	10	54	46	39.9	74.0	4.3+	—	e	E	
	Apr	14	19	32	45	36.0	71.0	5.5[f]	240	b	A	
	Apr	20	17	38	30	39.0	70.5	6.5[f]	—	b	A	
	Apr	26	02	54	37	36.6	70.2	4.3+	180	e	E	
	Apr	26	07	08	03	36.8	70.2	4.3+	180	e	E	
	Apr	26	23	11	01	39.0	70.5	5.6[f]	0-50[g]	b	A	
	May	06	16	55	36	39.0	70.5	6.0[f]	60	b	A	
	May	15	15	19	52	36.5	70.0	6.0[f]	230	b	A	
	May	17	21	29	34	36.5	70.5	5.8[f]	250	b	A	
	Jun	17	10	52	10	36.7	71.0	4.3+	—	e	E	
	Jul	15	16	52	20	39.4	70.5	4.3+	—	e	E	
	Aug	12	14	22	11	37.7	71.6	4.3+	—	e	E	
	Sep	05	17	10	30	40.0	74.8	4.5	—	e	E	
	Sep	11	01	37	29	37.1	71.9	4.3+	—	e	E	
	+Oct	23	07	47	32	38.3	71.7	4.5	—	e	E	
	Nov	28	12	23	23	36.5	70.5	5.8[f]	220	b	A	**Event #3, 1941, APP.C**
1942	Jan	08	13	31	20	39.4	72.9	5.0	—	e	E	
	Feb	28	04	54	55	39.2	70.9	5.3	—	e	E	
	Mar	22	02	08	33	36.5	70.3	6.0[f]	210	b	A	**Event #2, 1942, APP.C**
	May	15	16	55	30	36.5	70.5	5.5[f]	250	b	A	
	May	28	15	20	03	38.8	70.9	5.0	—	e	E	
	Jul	19	05	52	47	39.2	72.9	4.3+	—	e	E	
	Aug	14	20	53	23	39.0	70.4	4.5	—	e	E	
	Nov	02	04	35	54	37.6	75.4	4.5	—	e	E	
	Nov	16	21	26	17	36.5	70.5	5.5[f]	230	b	A	**Event #3, 1942, APP.C**
1943	Jan	11	19	50	18	38.7	69.3	6.0	—	e	E	
	Jan	12	09	05	09	38.7	69.3	5.5	—	e	E	
	Jan	12	10	41	42	38.7	69.3	5.0	—	e	E	
	Feb	06	09	36	37	36.5	70.3	4.3+	240	e	E	
	Feb	14	19	17	24	39.0	69.4	4.5	—	e	E	
	Feb	28	12	54	33	36.5	70.5	7.0[f]	210	b	A	**Event #1, 1943, APP.C**
	Apr	05	01	56	14	39.0	72.5	6.5[f]	100	b	A	
	Jun	02	02	55	24	39.2	71.8	5.5	—	e	E	
	Aug	23	01	58	59	39.2	70.3	4.3+	—	e	E	
	Sep	09	04	06	10	36.5	70.5	6.3[f]	200	b	A	
	Sep	24	11	31	37	36.5	74.0	6.8[f]	120	b	A	
	Oct	02	14	37	38	39.7	71.8	4.3+	—	e	E	
	Oct	20	02	44	26	37.5	71.2	4.5	—	e	E	
	Nov	02	03	39	17	38.7	70.1	4.8	—	e	E	

DATE Yr	Mo	Dy	TIME Hr	Mn	Sc	LAT N	LONG E	MAG	DEPTH km	AUTH	SRCE	INTENSITY DATA
1943	Nov	07	07	05	53	39.6	73.8	4.3+	--	e	E	
	Dec	05	03	16	17	36.5	70.6	4.3+	150	e	E	
	Dec	12	15	54	21	36.0	70.5	5.5f	230	b	A	Event #5, 1943, APP.C
	Dec	28	14	56	30	37.8	71.2	4.3+	--	e	E	Event #6, 1943, APP.C
1944	Mar	15	05	03	53	39.7	73.1	5.8	--	e	E	
	Mar	15	05	50	00	39.6	73.0	4.3+	--	e	E	
	Mar	15	06	17	21	39.6	73.0	5.5	--	e	E	
	Apr	29	21	41	26	36.5	71.0	5.5f	200	b	A	
	May	10	17	44	12	39.1	73.5	4.5	--	e	E	
	Aug	31	00	34	05	38.9	70.9	4.5	--	e	E	
	Sep	02	02	30	21	39.3	72.0	5.0	--	e	E	
	Sep	27	16	25	02	39.0	73.5	7.0f	40	b	A	
	Sep	30	05	09	08	39.3	74.8	5.0	--	e	E	
	Sep	30	07	41	07	39.2	74.8	5.5	--	e	E	
	Oct	17	19	39	31	39.2	71.8	4.3+	--	e	E	
	Oct	17	21	17	40	39.2	71.8	5.0	--	e	E	
	Nov	12	13	39	41	39.8	74.3	4.5	--	e	E	
	Nov	14	23	18	10	36.5	70.5	5.5f	200	b	A	
	Dec	08	06	44	18	36.7	70.6	4.3+	200	e	E	
1945	Feb	01	19	53	23	36.0	59.3	5.0	--	e	E	
	Feb	16	11	07	47	36.6	70.6	4.3+	200	e	E	
	May	28	06	39	50	38.9	71.9	4.5	--	e	E	
	Jun	22	18	00	57	32.5	76.0	6.5f	60	b	A	
	Oct	01	05	16	40	29.0	67.0	-	--	a	A	
	Oct	18	23	39	10	36.7	70.5	4.3+	210	e	E	
1946	Jan	20	23	34	27	36.6	71.2	4.3+	100	e	E	
	Jan	31	13	47	25	36.3	71.0	4.3+	100	e	E	
	Feb	07	02	22	51	36.6	71.0	4.3+	100	e	E	
	Mar	09	09	08	05	38.0	73.6	4.3+	100	e	E	
	Apr	29	16	30	43	36.9	69.4	4.3+	100	e	E	
	Jun	26	15	21	37	36.5	71.0	5.3	210	b	A	
	Dec	04	21	40	24	36.5	68.6	5.0	--	e	E	
1947	Jan	30	12	32	42	36.5	70.5	5.8	200	b	A	
	Feb	04	05	27	42	36.7	70.5	4.3+	200	e	E	
	Apr	06	01	08	21	38.0	73.1	4.3+	100	e	E	
	Apr	09	00	20	13	36.8	70.6	4.3+	--	e	E	
	Apr	30	03	36	40	35.5	59.0	4.3	--	e	E	
	Jun	23	21	33	26	37.0	69.5	4.3+	--	e	E	
	Jul	16	21	15	55	36.9	70.7	4.3+	200	e	E	
	Aug	13	13	23	17	38.5	73.5	4.3+	180	e	E	
	Aug	13	19	05	14	37.3	70.8	4.3+	100	e	E	
	Aug	23	04	17	44	36.8	70.6	4.3+	200	e	E	
	Sep	20	18	56	35	36.2	69.2	5.0	--	e	E	
	Sep	23	12	28	09	33.0	59.0	6.8f	--	b	A	
	Oct	03	06	13	51	27.5	58.0	6.3f	--	b	A	
	Oct	11	09	03	02	36.6	68.8	4.3+	--	e	E	

DATE Yr Mo Dy	TIME Hr Mn Sc	LAT N	LONG E	MAG	DEPTH km	AUTH	SRCE	INTENSITY DATA
1947 Oct 14	22 29 31	38.6	72.7	5.0	--	e	E	
Nov 08	16 26 01	36.9	68.0	5.0	--	e	E	Event, 1947, APP.C
Nov 27	04 33 42	36.6	70.8	4.3+	--	e	E	
Nov 30	11 18 00	39.3	72.6	4.3+	--	e	E	
Dec 07	01 44 18	36.7	70.5	4.3+	200	e	E	
1948 Jan 09	14 52 30	36.6	70.5	4.3+	240	e	E	Event #1, 1948, APP.C
Jan 28	15 51 20	36.8	67.2	6.3	70	e	E	Event #2, 1948, APP.C
Jun 08	17 17 40	36.8	71.2	4.3+	150	e	E	
Jun 27	15 46 18	36.8	71.0	4.3+	140	e	E	
Jul 18	05 22 11	38.2	72.5	4.3+	100	e	E	
Jul 19	05 08 12	36.8	70.8	4.3+	200	e	E	
Jul 25	21 47 38	36.7	70.9	4.3+	140	e	E	
Sep 07	08 15 22	36.9	70.6	5.3+	220	e	E	Event #3, 1948, APP.C
Oct 05	20 12 05	37.5	58.0	7.3[f]	0-80[e]	b	A	
Oct 06	01 24 44	37.4	58.8	5.8	0-80	e	E	
Oct 17	06 16 25	37.3	59.0	4.8	--	e	E	
Nov 02	15 24 31	38.4	59.2	4.8	--	e	E	
Nov 22	16 06 04	39.3	68.6	4.3+	--	e	E	
Dec 02	23 42 14	36.9	71.4	4.3+	100	e	E	
Dec 19	04 58 10	37.6	58.6	4.5	--	e	E	
1949 Feb 13	08 21 28	39.1	71.3	4.3+	--	e	E	
Feb 24	23 02 18	30.0	69.0	-	--	a	A	
Mar 04	10 19 25	36.0	70.5	7.5	230	b	A	Event #2, 1949, APP.C
Mar 11	19 22 25	36.6	70.6	4.3+	200	e	E	
Apr 04	07 48 10	38.5	70.1	4.5	--	e	E	
Apr 15	14 52 06	37.7	71.5	4.3+	180	e	E	
Apr 17	06 41 25	36.8	69.9	4.3+	160	e	E	
May 10	09 13 25	36.9	69.9	4.3+	180	e	E	
Jul 08	07 50 40	39.2	70.8	5.0	--	e	E	
Jul 08	08 02 16	39.2	70.8	5.5	--	e	E	
Jul 10	03 53 36	39.0	70.5	7.6[f]	0-50[g]	b	A	Event #3, 1949, APP.C
Jul 10	07 18 51	39.2	70.6	4.8	--	e	E	
Jul 10	10 43 55	39.2	70.8	4.8	--	e	E	
Jul 10	10 57 28	39.2	70.8	4.3+	--	e	E	
Jul 10	11 57 50	39.0	71.0	5.0[e]	--	b	A	
Jul 10	14 13 24	39.2	71.1	5.3	--	e	E	
Jul 10	15 07 49	39.1	70.9	4.8	--	e	E	
Jul 10	15 18 58	39.5	71.0	5.5[e]	--	a	A	
Jul 10	15 49 17	39.2	71.0	6.0	--	e	E	
Jul 10	16 24 00	39.1	71.0	6.5	--	e	E	
Jul 10	17 40 49	39.2	71.0	4.3+	--	e	E	
Jul 10	18 03 07	39.2	70.9	4.3+	--	e	E	
Jul 10	18 45 15	39.3	70.6	4.3+	--	e	E	
Jul 10	18 51 12	37.9	70.5	4.3+	--	e	E	
Jul 10	18 54 46	39.3	70.8	4.3+	--	e	E	
Jul 11	01 12 24	39.3	70.9	4.3+	--	e	E	
Jul 11	03 55 26	39.2	70.9	4.3+	--	e	E	
Jul 11	09 43 08	39.1	71.0	4.3+	--	e	E	

DATE Yr	Mo	Dy	TIME Hr	Mn	Sc	LAT N	LONG E	MAG	DEPTH km	AUTH	SRCE	INTENSITY DATA
1949	Jul	11	23	38	10	39.2	71.1	4.5	—	e	E	
	Jul	12	02	30	54	39.2	70.9	4.3+	—	e	E	
	Jul	12	03	51	59	39.2	71.2	4.5	—	e	E	
	Jul	13	08	50	36	38.9	70.4	4.5	—	e	E	
	Jul	13	10	13	59	39.2	71.0	5.8	—	e	E	
	Jul	13	18	28	25	39.2	70.8	4.3+	—	e	E	
	Jul	14	00	18	40	39.3	70.3	4.3+	—	e	E	
	Jul	14	13	49	18	39.1	70.6	4.3+	—	e	E	
	Jul	17	17	32	23	39.2	71.0	4.3+	—	e	E	
	Jul	17	23	03	47	39.1	71.1	4.3+	—	e	E	
	Jul	18	02	24	40	39.2	70.4	4.3+	—	e	E	
	Jul	18	16	35	52	39.2	70.9	4.3+	—	e	E	
	Jul	18	17	41	07	36.6	70.6	4.3+	200	e	E	
	Jul	18	22	11	13	39.1	71.0	4.3+	—	e	E	
	Jul	19	13	28	55	39.0	71.1	4.5	—	e	E	
	Jul	19	14	42	10	39.5	71.0	5.5[e]	—	a	A	
	Jul	21	12	52	15	36.8	70.4	4.3+	210	e	E	
	Jul	22	15	06	46	39.0	70.7	4.3+	—	e	E	
	Jul	23	17	41	33	39.2	70.9	4.5	—	e	E	
	Jul	25	09	32	37	38.9	71.0	4.5	—	e	E	
	Jul	31	22	13	14	39.1	71.1	4.5	—	e	E	
	Aug	01	07	39	45	35.5	74.5	–	—	a	A	
	Aug	06	14	34	14	38.9	70.7	4.5	—	e	E	
	Aug	06	15	30	11	38.9	70.8	4.3+	—	e	E	
	Aug	09	21	32	03	39.3	71.1	4.5	—	e	E	
	Aug	10	05	17	00	39.2	70.9	4.3+	—	e	E	
	Aug	23	22	03	50	39.0	71.0	5.0[e]	—	a	A	
	Aug	23	23	37	25	39.2	71.1	4.3+	—	e	E	
	Aug	29	14	32	23	38.9	71.0	5.0	—	e	E	
	Sep	20	07	43	52	39.2	70.7	4.5	—	e	E	
	Sep	25	03	26	52	39.3	71.0	4.5	—	e	E	
	Nov	17	05	08	20	39.2	70.7	4.3+	—	e	E	
	Dec	14	03	43	53	35.9	58.9	4.8	—	e	E	
	Dec	18	19	13	16	36.6	69.4	4.5	—	e	E	
1950	Jan	12	21	07	41	39.2	70.7	4.3+	—	e	E	
	Feb	19	03	52	00	30.1	68.8	–	—	d	A	
	Mar	05	00	32	40	39.2	70.7	4.8[e]	—	d	A	
	Mar	12	02	05	58	29.5	70.7	–	—	d	A	
	Mar	23	00	24	41	30.1	68.8	–	—	d	A	
	Mar	30	22	37	33	36.7	70.5	4.3+[e]	—	d	A	
	Mar	31	13	37	51	36.7	70.5	–	223	d	A	
	Apr	06	02	43	28	38.1	58.2	5.3	0–80	e	E	
	Apr	19	13	47	37	39.2	71.2	4.3+	—	e	E	
	May	02	16	42	59	36.5	58.5	4.5	—	e	E	
	May	09	11	16	57	38.5	58.8	6.3[h]	0–80[e]	c	A	
	May	17	19	30	37	36.5	71.0	4.3+[e]	223	d	A	
	May	20	18	53	54	37.1	71.2	5.3+	128	d	A	
	May	21	10	06	22	39.6	73.2	4.3+	—	e	E	
	Jun	23	05	39	16	39.6	73.8	4.3+	—	e	E	

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TABLE D2

DATE Yr	Mo	Dy	TIME Hr	Mn	Sc	LAT N	LONG E	MAG	DEPTH km	AUTH	SRCE	INTENSITY DATA
1950	Jun	23	06	17	02	39.6	73.8	4.5	—	e	E	
	Jun	26	12	10	51	38.3	74.0	4.5[e]	128	d	A	
	Jul	06	07	03	28	39.3	73.3	4.5[e]	—	d	A	
	Jul	09	16	10	20	36.5	71.0	6.5+[e]	220	a	A	Event #1, 1950, APP.C
	Jul	11	09	30	29	39.3	73.3	4.5	—	e	E	
	Aug	08	05	29	16	38.2	58.5	4.5	—	e	E	
	Aug	08	09	36	57	38.6	70.5	4.5[e]	—	d	A	
	Aug	12	03	59	06	32.6	75.9	-	—	d	A	
	Sep	06	07	37	08	30.2	70.0	-	—	d	A	
	Sep	12	06	16	12	36.2	73.0	4.3+[e]	—	d	A	
	Sep	13	19	03	44	36.8	70.8	4.3	80	e	E	
	Sep	19	22	42	56	36.5	75.5	-	—	d	A	
	Sep	24	18	49	04	39.0	71.0	4.5	—	e	E	
	Sep	24	22	56	26	34.0	62.0	-	—	c	A	
	Sep	25	17	58	02	32.6	75.9	-	—	d	A	
	Oct	10	00	02	52	36.7	70.5	4.3+[e]	223	d	A	Event #3, 1950, APP.C
	Nov	12	16	37	36	33.3	58.0	-	—	d	A	
	Nov	17	22	01	04	38.6	70.5	5.0	—	e	E	
	Nov	19	21	34	56	38.4	72.2	4.8[e]	—	d	A	
	Nov	21	20	53	56	38.6	70.5	5.0[e]	—	d	A	
	Dec	03	18	26	03	36.5	71.0	4.3+[e]	—	d	A	
	Dec	24	04	35	37	36.7	70.5	4.3+[e]	223	d	A	
1951	Jan	01	07	16	06	39.3	73.6	4.5	—	e	E	
	Jan	04	03	38	18	38.4	73.6	5.3+	140	e	E	
	Jan	04	10	19	53	38.8	70.0	4.3+	—	e	E	
	Jan	06	05	17	19	36.5	70.5	6.8[f]	250	c	A	Event #2, 1951, APP.C
	Jan	10	21	39	49	39.7	75.0	4.5	—	e	E	
	Jan	16	08	08	42	36.7	70.5	4.3+[e]	223	d	A	
	Jan	28	10	20	08	36.7	71.1	4.3+[e]	96	d	A	
	Mar	09	18	57	44	39.1	71.7	4.3+	—	e	E	
	Mar	30	02	37	00	37.1	71.2	4.3+[e]	128	d	A	
	Apr	02	17	56	52	38.6	70.5	4.5[e]	—	d	A	
	Apr	03	19	26	15	39.2	70.7	4.3+[e]	—	d	A	
	Apr	07	19	43	50	36.8	68.5	4.5	—	e	E	
	Apr	14	04	10	04	39.3	72.0	5.8[i]	—	c	A	
	Apr	14	04	52	19	39.0	71.8	5.0[e]	—	d	A	
	Apr	14	12	45	06	39.0	71.8	4.5[e]	—	d	A	
	May	12	22	07	53	39.6	71.3	5.5[e]	—	d	A	
	May	14	04	07	32	30.2	70.0	-	—	d	A	
	May	19	11	54	49	39.0	71.3	-	—	d	A	
	May	24	15	31	00	37.6	71.6	4.3+[e]	96	d	A	
	Jun	12	22	40	36	36.5	71.3	6.5+[e]	220	c	A	Event #4, 1951, APP.C
	Jul	12	16	33	11	39.6	73.8	4.3+[e]	—	d	A	
	Jul	21	04	06	34	36.7	70.5	4.3+[e]	160	d	A	
	Jul	25	12	48	22	36.7	70.8	4.5	190	e	E	
	Aug	03	23	35	30	39.2	71.5	4.8[e]	—	d	A	
	Aug	04	00	16	06	39.0	71.8	4.8[e]	—	d	A	
	Aug	19	15	38	46	36.9	70.8	4.3+[e]	223	d	A	Felt
	Aug	26	18	23	58	36.9	70.8	4.3+[e]	223	d	A	

DATE Yr	Mo	Dy	TIME Hr	Mn	Sc	LAT N	LONG E	MAG	DEPTH km	AUTH	SRCE	INTENSITY DATA
1951	Sep	20	23	19	33	32.6	75.9	-	---	d	A	
	Oct	04	05	43	08	36.7	70.5	$4.3+^e$	223	d	A	
	Oct	15	14	48	54	36.5	70.4	4.3+	200	e	E	
	Oct	29	21	16	35	30.3	68.3	-	96	d	A	
	Nov	01	18	49	34	37.2	69.3	$4.3+^e$	---	d	A	
	Nov	01	20	19	06	37.2	69.3	4.5^e	---	d	A	
	Dec	11	21	00	23	37.1	71.2	$4.3+^e$	---	d	A	
	Dec	12	14	17	33	39.0	71.8	$4.3+^e$	---	d	A	
	Dec	30	18	21	05	28.5	58.3	-	---	c	A	
1952	Feb	27	04	05	48	38.6	68.8	4.5^e	---	d	A	
	Mar	06	03	13	42	40.0	73.0	-	---	c	A	
	Mar	06	09	11	24	40.0	73.0	-	---	c	A	
	Mar	30	01	29	56	29.4	67.1	-	---	d	A	
	May	26	05	07	48	37.4	58.8	4.3+	---	e	E	
	May	28	07	47	42	36.9	70.8	$4.3+^e$	223	d	A	
	Jun	02	19	01	13	37.6	71.6	$4.3+^e$	160	d	A	
	Jun	03	11	21	26	36.7	70.5	$4.3+^e$	192	d	A	
	Jun	03	23	24	32	36.7	70.5	4.3+	192	d	A	
	Jun	07	16	01	23	36.7	70.5	$4.3+^e$	223	d	A	
	Jun	08	12	42	20	36.3	69.1	4.5^e	---	d	A	
	Jun	13	21	52	01	38.9	67.5	$4.3+^e$	---	d	A	
	Jun	21	08	46	27	36.3	69.1	4.5^e	---	d	A	
	Jun	22	05	44	11	39.5	74.7	4.3+	---	e	E	
	Jun	22	14	48	52	38.8	69.7	4.3+	---	e	E	
	Jul	05	17	19	51	36.7	70.5	5.3+	223	d	A	Event #3, 1952, APP.C
	Jul	07	01	38	01	37.1	68.4	4.3^e	---	d	A	
	Aug	13	03	14	21	37.3	69.8	4.8^e	---	d	A	
	Aug	24	18	32	29	39.1	70.6	4.3+	---	e	E	
	Aug	30	06	58	52	39.5	73.0	-	---	d	A	
	Sep	15	04	31	32	37.9	58.0	5.0	---	e	E	
	Sep	15	11	28	06	30.8	72.0	-	---	c	A	
	Sep	20	18	41	09	27.0	63.0	-	---	c	A	
	Oct	08	08	42	12	36.5	71.0	$4.3+^e$	128	d	A	
	Oct	09	07	37	06	39.2	70.7	4.5^e	---	d	A	
	Oct	10	18	47	32	30.2	70.0	6.1^h	---	d	A	Felt
	Oct	12	02	27	49	37.2	71.1	4.0	---	e	E	
	Oct	18	21	26	17	36.6	70.4	4.3+	200	e	E	
	Oct	22	21	30	31	37.5	69.7	4.5	---	e	E	
	Oct	22	22	22	52	37.4	69.8	4.5	---	e	E	
	Oct	26	08	23	19	29.4	67.9	-	---	d	A	Felt (i)
	Nov	02	15	29	03	36.9	70.8	$4.3+^e$	128	d	A	
	Nov	03	05	17	10	39.2	70.7	4.5^e	---	d	A	
	Nov	27	07	20	31	36.6	70.1	$5.3+^e$	160	d	A	Event #4, 1952, APP.C
	Dec	05	17	48	35	37.1	71.2	4.5^e	---	d	A	
	Dec	10	07	37	46	36.1	68.2	-	---	d	A	
	Dec	14	16	54	44	39.3	74.7	4.5^e	---	d	A	
	Dec	21	08	10	18	36.8	71.4	$4.3+^e$	128	d	A	
	Dec	25	22	22	43	29.4	70.0	5.8^k	---	d	A	
	Dec	27	18	45	37	31.2	74.8	-	---	d	A	Felt (d)
	Dec	29	17	36	50	37.9	58.2	5.0	---	e	E	

TABLE D2

DATE Yr	Mo	Dy	TIME Hr	Mn	Sc	LAT N	LONG E	MAG	DEPTH km	AUTH	SRCE	INTENSITY DATA
1953	May	01	21	18	19	33.7	72.5	-	64	d	A	
	May	13	05	10	04	38.5	73.9	4.3+	160	e	E	
	May	17	18	26	51	36.2	69.3	4.5	—	e	E	
	May	21	18	44	06	36.5	68.8	4.5	—	e	E	
	May	27	12	53	57	37.0	71.0	4.5	50	e	E	
	May	28	21	06	38	38.0	75.0	4.5	—	e	E	
	Jun	06	00	02	24	35.6	59.0	4.5	—	e	E	
	Jun	16	08	59	36	36.8	70.9	4.3+	160	e	E	
	Jul	07	01	21	33	38.5	69.0	4.5	—	e	E	
	Jul	09	07	19	09	37.9	69.1	4.5	—	e	E	
	Jul	10	21	42	46	39.3	72.7	4.3	—	e	E	
	Jul	12	00	53	10	36.5	71.0	5.3+	96	d	A	
	Jul	13	18	04	01	38.5	75.1	4.3+	160	e	E	
	Jul	14	17	21	37	36.8	69.4	4.3+	160	e	E	
	Aug	11	10	07	22	38.9	67.0	4.5	—	e	E	
	Sep	05	22	52	53	39.8	71.3	4.5[e]	—	c	A	
	Nov	01	17	24	40	36.5	70.0	4.3+	200	c	A	Felt
	Nov	05	08	21	39	36.7	70.5	5.3+	223	d	A	Felt
	Dec	02	13	39	48	36.6	70.6	4.3+	140	e	E	
	Dec	10	21	27	35	36.5	70.5	4.3+[e]	220	c	A	Felt
	Dec	21	01	41	56	38.5	75.0	4.3+[e]	—	c	A	
1954	Jan	10	13	38	48	40.0	75.3	4.5	—	e	E	
	Jan	23	16	06	30	37.3	72.5	5.5[e]	—	d	A	
	Jan	23	17	11	56	37.3	72.5	5.0[e]	—	d	A	
	Jan	23	22	03	33	37.4	72.5	4.3	—	e	E	
	Jan	25	17	09	21	37.4	72.5	4.3	—	e	E	
	Feb	09	19	29	00	37.4	72.5	4.5	—	e	E	
	Feb	11	18	14	13	37.2	71.3	4.3+	100	e	E	
	Feb	16	02	23	32	34.0	74.8	4.5	—	c	A	
	Feb	22	01	16	57	36.8	70.7	4.3+	180	e	E	
	Feb	26	18	46	27	36.5	70.5	5.3+[e]	220	c	A	
	Mar	05	15	07	09	36.5	69.2	5.0	—	e	E	
	Mar	12	00	50	38	39.1	70.5	4.3	—	e	E	
	Mar	13	00	59	02	28.1	65.6	-	—	c	A	
	Mar	24	18	06	26	37.0	71.0	4.3	—	e	E	
	Apr	02	01	53	26	39.5	67.2	4.3	—	e	E	
	Apr	11	10	53	32	36.4	70.8	5.3+[e]	192	d	A	
	Apr	13	17	02	48	38.6	72.9	4.3+	—	e	E	
	Apr	19	16	53	19	39.1	75.0	5.0[e]	—	d	A	
	May	16	20	10	42	36.5	70.5	4.3+[e]	200	a	A	
	May	24	22	31	50	38.7	75.6	4.8	—	e	E	
	Jun	17	05	59	56	36.8	70.2	4.3+	220	e	E	
	Jul	10	22	56	54	36.6	71.1	5.3+	223	d	A	Event #1, 1954, APP.C
	Jul	23	14	45	14	34.0	69.6	-	—	d	A	
	Jul	31	22	15	14	39.6	71.2	4.5	—	e	E	
	Aug	05	03	13	25	37.6	71.8	4.3+	140	e	E	
	Aug	06	02	54	22	36.9	71.3	4.3+	170	e	E	
	Aug	07	15	13	44	36.4	70.7	4.3+[e]	192	d	A	

DATE Yr	Mo	Dy	TIME Hr Mn Sc	LAT N	LONG E	MAG	DEPTH km	AUTH	SRCE	INTENSITY DATA
1954	Aug	18	23 32 10	39.0	70.6	4.5[e]	--	d	A	
	Sep	09	18 54 49	36.7	70.5	4.3+	200	e	E	
	Oct	13	22 11 44	37.5	69.3	5.0[e]	--	d	A	
1955	Jan	10	04 25 48	37.0	71.0	4.3+	150	a	A	
	Feb	18	22 48 35	30.3	67.0	6.1[j]	5	c	A	Event #1, 1955, APP.C
	Mar	05	10 23 02	36.8	71.3	4.3+	100	e	E	
	Mar	06	20 55 27	38.1	72.9	4.3+[e]	128	d	A	
	Mar	12	16 42 18	34.6	73.2	-	--	d	A	
	Mar	16	20 39 39	36.7	70.3	4.3+[e]	223	d	A	
	Mar	19	08 05 06	38.8	69.8	4.3	--	e	E	
	Apr	15	03 40 52	40.0	74.5	6.9[f]	--	a	A	Felt
	Apr	15	04 13 23	40.0	75.0	7.0[e]	--	a	A	Felt
	Apr	17	01 28 03	40.0	74.6	4.3	--	e	E	
	Apr	27	11 49 55	39.8	72.5	4.5[e]	--	c	A	
	Apr	29	11 53 07	38.4	71.8	4.5	--	e	E	
	May	14	13 35 43	37.0	72.5	5.9[k]	--	c	A	Felt
	Jun	05	15 43 09	38.8	75.5	5.5	--	d	A	
	Jun	15	01 03 55	39.0	71.4	5.0[e]	--	d	A	
	Jul	03	14 01 55	38.8	71.0	5.3+[e]	96	d	A	
	Jul	19	08 47 37	39.7	68.0	5.3[e]	--	d	A	
	Jul	26	22 10 23	39.7	74.7	4.5	--	e	E	
	Jul	28	03 06 10	36.7	66.7	4.8	--	e	E	
	Aug	21	00 42 52	38.6	69.6	5.0	--	e	E	
	Aug	23	14 09 21	31.0	71.5	6.5	64	d	A	Felt (a)
	Aug	26	17 05 05	37.5	69.4	4.3	--	e	E	
	Oct	14	06 01 34	36.4	70.3	4.3+	140	e	E	
	Dec	11	05 42 35	37.5	71.5	4.3+[e]	100	c	A	
1956	Jan	11	22 16 17	31.0	69.5	-	--	c	A	
	Mar	05	07 12 02	37.0	74.0	5.9[n]	--	c	A	
	Apr	06	07 11 31	36.5	71.0	6.8[n]	150	c	A	Event #1, 1956, APP.C
	Apr	11	01 45 10	38.8	70.3	5.8[n]	--	d	A	
	Apr	15	12 46 04	39.3	72.0	4.8[e]	--	c	A	
	May	08	19 50 02	38.8	74.7	5.0[e]	--	d	A	
	May	13	07 50 33	29.9	70.0	6.1[k]	--	d	A	Felt VIII MM
	Jun	04	23 47 49	39.0	71.0	4.5[e]	--	c	A	
	Jun	08	04 07 29	35.0	67.5	5.8[k]	--	c	A	Event #2, 1956, APP.C
	Jun	09	23 13 52	35.3	67.5	7.4[f]	0-50[g]	c	A	Event #3, 1956, APP.C
	Jun	09	23 53 41	35.0	68.0	-	--	a	A	
	Jun	10	01 01 35	35.0	68.0	-	--	a	A	
	Jun	10	03 32 58	35.0	67.5	5.0[e]	--	c	A	
	Jun	10	23 43 38	35.0	67.5	-	--	c	A	
	Jun	11	02 57 15	35.0	67.5	-	--	a	A	
	Jun	16	01 29 22	38.9	70.4	4.3	--	e	E	
	Jun	20	10 39 43	27.3	60.0	-	--	c	A	
	Jun	25	12 51 54	30.5	60.0	5.0[e]	--	c	A	
	Jun	30	03 08 18	39.5	70.0	4.3+[e]	--	a	A	
	Jul	03	23 26 19	36.5	70.5	6.1[n]	220	c	A	Event #19,1956, APP.C
	Jul	10	22 08 29	36.0	71.5	5.5[g]	100	c	A	
	Jul	14	00 14 30	36.0	71.0	4.3+[e]	--	c	A	Event #22,1956, APP.C

DATE Yr Mo Dy	TIME Hr Mn Sc	LAT N	LONG E	MAG	DEPTH km	AUTH	SRCE	INTENSITY DATA
1956 Jul 16	23 50 51	36.3	69.2	4.5	--	e	E	
Jul 17	06 37 45	36.1	70.7	4.5	--	e	E	
Jul 22	03 32 55	39.2	70.9	4.3+	--	e	E	
Aug 08	23 02 10	32.0	67.0	-	--	a	A	
Sep 03	09 24 45	36.8	71.4	4.3+	120	e	E	Event #30,1956, APP.C
Sep 10	14 15 30	36.9	71.4	4.3+	160	e	E	
Sep 16	08 37 22	34.0	69.5	6.4[f]	0-50[g]	a	A	Event #34,1956, APP.C
Sep 16	14 23 22	34.0	69.5	-	60[c]	a	A	Event #35,1956, APP.C
Sep 22	15 54 27	39.0	69.0	5.8[n]	--	c	A	
Sep 24	10 20 38	34.3	69.8	6.2[n]	--	c	A	Event #40,1956, APP.C
Sep 25	16 25 14	34.3	69.8	-	--	c	A	Event #43,1956, APP.C
Oct 13	08 21 25	36.0	70.5	6.1[n]	150	c	A	Event #54,1956, APP.C
Oct 15	23 07 20	37.5	68.5	4.8[e]	--	a	A	
Oct 17	01 14 51	36.8	70.5	4.3+[e]	200	c	A	Event #58,1956, APP.C
Oct 18	10 25 03	37.3	69.0	4.3	--	e	E	Event #60,1956, APP.C
Nov 11	12 56 36	39.0	71.5	4.8[e]	5-20[e]	c	A	
Nov 11	13 02 15	39.0	71.5	4.8[e]	5-20[e]	c	A	
Nov 14	00 51 30	37.0	71.0	5.5[e]	--	c	A	Event #68,1956, APP.C
Nov 27	18 48 33	36.5	70.0	4.3+	200	e	E	Event #71,1956, APP.C
Dec 06	20 30 21	36.3	71.0	4.3+[e]	200	c	A	
1957 Jan 13	11 38 16	38.5	70.5	5.0[e]	10[e]	c	A	
Jan 14	13 43 14	37.3	71.5	4.3+	100	e	E	
Jan 20	18 12 47	36.5	71.5	4.3+[e]	150	a	A	Event #10,1957, APP.C
Jan 28	21 01 42	38.5	69.5	-	--	a	A	
Mar 16	12 22 34	36.8	71.5	4.3+[e]	100[e]	c	A	
Mar 24	12 05 16	36.6	70.9	4.3+[e]	194	d	A	Event #18,1957, APP.C
Apr 04	11 36 16	35.5	70.5	5.3[e]	--	c	A	Event #19,1957, APP.C
Apr 26	02 11 52	37.0	70.5	4.3+[e]	200	a	A	Event #21,1957, APP.C
May 01	20 01 34	37.4	71.5	4.3+	110	e	E	
May 09	08 44 18	39.0	70.5	4.8[e]	--	c	A	
May 15	01 19 59	35.0	70.0	-	--	a	A	Event #24,1957, APP.C
May 25	01 14 30	39.0	71.5	-	--	c	A	
Jun 10	04 46 12	30.0	68.0	-	--	a	A	
Jun 11	04 57 28	36.5	70.5	5.8[n]	220	c	A	
Jun 14	11 37 00	32.0	67.0	4.5[e]	--	c	A	
Jul 01	11 42 06	38.0	69.0	4.8[e]	--	c	A	
Jul 11	17 14 27	37.0	71.5	-	--	a	A	
Jul 15	23 08 08	29.0	70.0	-	--	a	A	
Jul 19	03 24 24	36.0	71.0	5.5[g]	--	a	A	
Jul 26	17 45 36	36.0	71.0	-	--	c	A	
Aug 01	10 59 38	36.5	71.0	5.4[g]	200	c	A	
Aug 07	15 28 26	36.0	70.8	-	200	c	A	
Aug 12	21 42 00	34.0	70.0	-	--	c	A	
Aug 13	-- -- --	36.5	66.5	5.7	--	g	G'	
Aug 20	01 50 06	37.5	72.5	5.9[g]	200[g]	c	A	
Aug 20	15 21 09	36.7	71.2	5.9	227	d	A	
Aug 30	16 18 01	39.5	72.5	5.5[e]	--	c	A	
Aug 31	01 47 12	39.0	73.0	4.3[e]	--	c	A	
Sep 01	12 49 53	39.0	75.0	5.4[n]	--	c	A	
Sep 02	21 27 35	37.0	71.0	6.1[g]	--	c	A	Felt

DATE Yr	Mo Dy	TIME Hr Mn Sc	LAT N	LONG E	MAG	DEPTH km	AUTH	SRCE	INTENSITY DATA
1957	Sep 04	08 07 20	28.0	65.3	6.0^k	$0\text{-}50^g$	c	A	
	Sep 12	17 26 05	40.0	73.5	-	--	a	A	
	Sep 13	22 32 40	36.5	69.5	-	--	c	A	
	Sep 18	18 51 00	37.0	71.0	-	150	c	A	
	Sep 20	10 01 58	36.5	71.0	5.0^g	200	a	A	
	Sep 23	04 10 30	27.0	58.0	-	--	c	A	
	Oct 01	08 08 50	35.0	73.0	-	--	c	A	
	Oct 05	22 40 44	38.0	69.5	4.8^e	--	a	A	
	Oct 10	18 08 42	37.0	70.0	4.8^e	--	c	A	
	Nov 01	14 21 46	37.0	72.5	-	--	c	A	
	Nov 03	19 11 24	29.0	69.5	-	--	c	A	
	Nov 15	01 20 41	36.0	70.5	-	200	c	A	
	Nov 20	22 18 56	37.0	72.0	-	150	c	A	
	Nov 22	20 59 31	39.5	71.0	-	--	c	A	
	Nov 26	00 41 35	37.3	72.5	-	--	c	A	Event #35,1957, APP.C
	Nov 28	17 04 55	36.5	71.5	-	150	c	A	
	Dec 13	09 07 57	36.8	70.0	-	--	c	A	Event #38,1957, APP.C
	Dec 18	09 50 55	36.5	71.0	-	--	c	A	
1958	Jan 06	01 54 39	38.0	71.5	5.8^e	--	c	A	Event #2, 1958, APP.C
	Jan 07	06 05 10	39.0	70.0	5.4^e	5^e	c	A	
	Jan 13	20 28 45	39.5	72.0	-	--	c	A	
	Jan 28	17 15 00	36.0	58.5	-	--	a	A	
	Jan 29	17 13 25	27.3	66.5	-	--	c	A	
	Feb 17	05 18 38	36.0	71.0	6.6^n	200	c	A	Event #10,1958, APP.C
	Feb 17	08 18 42	36.5	70.7	-	210	d	A	
	Feb 19	03 39 57	39.5	75.0	-	--	a	A	
	Feb 19	10 33 03	39.1	74.9	-	--	d	A	
	Feb 27	03 55 12	35.0	58.0	-	--	c	A	
	Mar 03	13 47 53	34.0	58.5	-	--	c	A	
	Mar 03	16 55 38	35.5	70.0	-	--	a	A	
	Mar 07	06 55 30	37.0	71.0	-	200	a	A	
	Mar 18	08 34 06	33.8	67.5	-	--	c	A	
	Mar 20	12 59 32	37.5	73.0	-	100	c	A	
	Mar 20	22 23 16	36.8	71.0	-	100	c	A	Event #14,1958, APP.C
	Mar 22	11 07 50	35.5	67.5	5.9^e	--	c	A	
	Mar 23	00 25 38	35.5	67.5	6.2	$0\text{-}50^g$	c	A	
	+Mar 28	04 09 40	37.0	71.0	5.8^n	200	c	A	Event #15,1958, APP.C
	Mar 28	12 06 26	37.0	71.0	7.0^n	200	c	A	Event #17,1958, APP.C
	+Apr 08	09 59 22	33.0	68.0	5.6^r	--	c	A	Event #19,1958, APP.C
	Apr 12	16 10 40	30.3	71.0	-	--	c	A	
	Apr 25	18 32 15	36.5	71.5	-	150	c	A	
	Apr 30	08 16 51	36.5	70.5	6.0^g	220	c	A	
	May 03	18 27 15	37.5	72.5	-	100	c	A	
	May 07	13 28 57	32.0	68.5	-	--	c	A	
	May 07	14 47 49	36.0	72.5	4.8^e	--	c	A	
	May 29	03 15 50	38.0	72.5	-	121^d	a	A	
	May 30	01 10 20	36.5	71.0	5.7^g	150	c	A	
	Jun 03	08 49 18	29.5	70.8	-	--	c	A	
	Aug 04	20 47 55	37.0	72.0	-	--	c	A	Event #24,1958, APP.C
	Aug 08	12 52 06	37.0	72.0	-	200	a	A	

TABLE D2

DATE Yr Mo Dy	TIME Hr Mn Sc	LAT N	LONG E	MAG	DEPTH km	AUTH	SRCE	INTENSITY DATA
1958 Aug 13	07 33 33	36.5	66.5	5.7^{n}	--	c	A	
Aug 13	17 32 26	29.0	69.0	-	--	c	A	
Aug 14	23 26 48	28.3	64.0	-	100	c	A	
Aug 31	09 18 15	28.5	62.0	-	--	a	A	
Sep 01	08 37 15	27.8	63.8	-	--	c	A	
Sep 16	14 22 30	34.5	59.5	-	--	a	A	
Sep 18	20 53 03	36.8	70.5	6.1^{n}	170	c	A	Event #27,1958, APP.C
Sep 25	06 54 00	36.5	70.0	-	200	a	A	
Oct 13	10 11 54	38.0	70.0	-	--	c	A	
Oct 14	10 06 42	28.5	58.5	-	--	c	A	
Nov 05	22 56 33	36.8	72.0	-	100	c	A	
Nov 08	17 09 43	36.5	70.5	-	220	c	A	
Nov 15	18 22 40	30.0	70.5	-	--	c	A	
Nov 15	18 36 47	29.8	70.8	-	--	c	A	
Nov 21	05 00 04	36.0	70.5	-	--	c	A	
Nov 21	23 32 48	30.0	70.0	-	--	c	A	
Dec 03	10 16 11	33.5	69.0	-	--	c	A	Felt
Dec 03	21 34 24	36.3	70.5	-	220	c	A	
Dec 07	02 46 48	36.0	71.5	-	150	c	A	
Dec 08	14 05 30	29.0	70.0	-	--	c	A	
Dec 08	14 34 27	29.5	70.0	-	--	c	A	
Dec 10	03 43 50	37.0	71.0	6.4^{n}	180	c	A	
Dec 24	05 07 12	37.0	71.5	-	--	c	A	
1959 Jan 12	12 08 11	36.0	71.0	-	200	c	A	
Jan 30	13 44 49	37.5	73.3	-	150	c	A	
Jan 31	21 42 46	36.5	70.5	-	220	c	A	
Feb 01	03 13 38	36.0	71.5	5.5^{g}	250	c	A	Event #3, 1959, APP.C
Feb 22	08 53 30	31.5	69.0	-	--	c	A	
Mar 02	15 51 40	36.5	70.5	6.1^{r}	220	c	A	Felt
Mar 17	19 07 48	32.0	70.0	-	--	c	A	
Mar 25	06 03 48	30.0	70.0	-	100	a	A	
Mar 25	16 25 36	39.0	70.0	-	--	c	A	
Mar 26	11 04 35	39.0	71.5	-	--	a	A	
Mar 28	18 42 45	35.5	71.0	-	200	a	A	
Apr 22	03 36 49	35.5	69.7	-	116	d	A	
May 05	11 40 08	34.5	71.5	-	--	a	A	
May 19	15 17 44	33.0	68.5	5.8^{n}	35	d	A	Event #12,1959, APP.C
May 26	06 36 00	37.5	70.0	5.4^{e}	--	c	A	Event #14,1959, APP.C
Jun 07	16 12 02	31.0	70.0	-	--	c	A	
Jun 11	08 23 48	38.5	71.5	-	--	c	A	
Jun 20	14 16 52	38.7	70.8	-	62	d	A	
Jun 25	03 12 48	36.0	71.5	-	200	c	A	
Jul 15	16 42 18	36.0	71.0	-	--	c	A	
Jul 26	00 02 35	36.0	71.0	-	150	c	A	
Jul 29	09 53 56	33.5	67.5	-	--	c	A	Event #17,1959, APP.C
Jul 30	16 45 55	36.0	70.5	-	200	a	A	
Jul 31	19 53 10	38.5	70.0	5.9^{n}	$0\text{-}50^{g}$	c	A	
Aug 08	13 44 15	39.0	75.0	-	--	c	A	
Aug 20	21 11 24	36.5	70.5	-	--	c	A	

DATE Yr	Mo	Dy	TIME Hr	Mn	Sc	LAT N	LONG E	MAG	DEPTH km	AUTH	SRCE	INTENSITY DATA
1959	Aug	22	23	48	14	27.3	63.3	-	---	c	A	
	Aug	23	03	18	59	28.8	69.0	-	---	c	A	
	Aug	23	05	39	36	28.8	70.0	-	---	c	A	
	Aug	29	05	31	40	39.0	74.5	-	---	c	A	
	Aug	30	22	57	00	37.0	68.5	-	---	a	A	
	Sep	09	05	44	40	36.5	70.5	-	220	c	A	
	Sep	12	21	19	57	36.0	71.0	6.4^g	200	a	A	Felt
	Sep	13	19	15	52	39.5	74.5	-	---	a	A	
	Sep	21	12	19	30	40.0	74.5	-	---	a	A	
	Oct	12	01	38	52	36.8	73.3	-	---	c	A	
	Oct	23	16	54	23	33.5	59.0	-	---	a	A	
	Nov	02	12	02	45	40.0	73.0	-	---	c	A	
	Nov	04	09	54	48	32.5	66.0	-	---	c	A	
	Nov	15	10	25	18	39.0	75.0	6.3^r	---	c	A	
	Dec	07	19	03	24	29.5	67.5	-	---	c	A	
	Dec	08	12	20	55	37.5	72.5	-	---	a	A	
	Dec	15	10	47	42	37.0	70.0	-	---	a	A	
	Dec	28	02	12	18	37.0	70.5	-	200	a	A	
1960	Jan	09	07	24	04	36.5	70.0	6.7^n	200	c	A	Event #2, 1960, APP.C
	Jan	18	22	00	53	29.5	67.5	-	---	c	A	
	Jan	29	07	33	43	36.5	70.5	6.1^g	220	c	A	
	Feb	08	18	54	23	36.5	70.5	-	150	a	A	
	Feb	17	08	05	30	37.0	71.5	-	250	a	A	Event #5, 1960, APP.C
	Feb	18	01	59	23	35.5	73.0	-	150	a	A	Event #6, 1960, APP.C
	Feb	19	10	36	52	36.5	70.5	6.4^o	220	c	A	Event #7, 1960, APP.C
	Feb	20	23	30	31	36.0	71.0	-	200	c	A	
	Feb	23	02	09	42	36.0	70.0	-	200	a	A	Event #9, 1960, APP.C
	Feb	25	14	07	29	36.5	71.3	-	200	c	A	
	Mar	18	14	46	23	37.3	71.0	-	---	c	A	
	Apr	02	10	29	55	36.5	70.5	-	220	c	A	
	Apr	20	19	23	11	36.3	70.0	5.5^q	200	c	A	Felt
	May	02	02	43	45	37.0	69.0	-	---	a	A	
	May	08	12	23	57	37.0	71.0	-	200	a	A	
	May	15	03	00	48	28.5	59.0	-	---	c	A	
	May	19	02	07	00	36.0	71.0	6.0^r	200^r	c	A	Felt
	May	23	02	25	48	37.5	73.5	-	---	c	A	
	May	23	03	00	00	37.5	73.5	-	---	c	A	
	Jun	02	07	22	30	33.5	60.0	5.3^e	---	c	A	
	Jun	16	16	09	18	39.0	73.5	-	---	c	A	
	Jul	06	05	16	46	36.5	70.5	6.6^g	220	c	A	
	Jul	06	23	14	19	39.5	71.5	-	---	a	A	
	Jul	07	22	37	42	37.5	68.0	-	---	c	A	
	Jul	14	22	11	06	36.0	70.0	4.5^e	100	c	A	Event #11,1960, APP.C
	Jul	17	05	14	56	36.0	69.0	5.9^o	200	c	A	Event #12,1960, APP.C
	Jul	18	01	48	36	39.0	65.0	-	---	a	A	
	Jul	18	16	51	41	37.5	70.5	-	---	a	A	

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DATE Yr Mo Dy	TIME Hr Mn Sc	LAT N	LONG E	MAG	DEPTH km	AUTH	SRCE	INTENSITY DATA
1960 Jul 20	15 20 35	36.8	69.5	-	100	c	A	
Jul 29	14 33 50	32.0	67.0	5.3	--	c	A	Event #13,1960, APP.C
Aug 03	07 02 26	27.3	66.5	-	32	a	A	
Aug 14	22 37 12	36.5	69.5	5.0	--	c	A	
Aug 23	08 58 11	29.1	59.8	-	64	a	A	
Aug 26	07 09 47	29.3	67.6	-	64	a	A	
Aug 16	09 45 33	34.7	70.8	-	43	a	A	
Aug 29	16 23 11	36.3	71.2	-	103	a	A	
Sep 05	04 36 30	36.4	70.3	-	220	a	A	
Sep 09	10 05 22	36.6	71.6	-	236	a	A	Event #17,1960, APP.C
Sep 16	01 38 59	38.6	68.6	5.5^{e}	45	c	A	
Oct 03	00 49 03	29.0	69.5	5.0^{e}	--	c	A	Felt
Oct 24	05 47 01	36.6	71.1	-	246	a	A	
Nov 02	19 44 46	39.1	71.9	-	54	a	A	
Nov 05	21 28 23	29.5	68.0	-	--	c	A	
Nov 10	01 54 57	36.2	70.8	-	193	a	A	
Nov 19	13 12 50	30.0	69.5	-	--	c	A	
Dec 19	00 01 31	36.6	71.6	-	25	a	A	
Dec 26	20 43 02	39.0	70.8	-	--	c	A	
Dec 30	21 33 24	36.3	71.0	-	200	a	A	
1961 Jan 28	11 20 30	37.0	71.0	-	--	c	A	
Feb 17	13 08 27	36.5	70.6	-	195	a	A	
Feb 27	17 53 47	38.2	74.4	-	180	a	A	
Mar 20	-- -- --	35.6	71.1	6.0	121	g	G'	
Mar 21	09 28 55	38.5	74.0	4.3^{e}	--	c	A	
Apr 07	04 40 36	36.4	71.0	-	29	a	A	
Apr 07	04 52 40	36.3	70.7	-	60	a	A	
Apr 07	21 17 44	39.3	73.0	5.3^{r}	44	c	A	Felt
Apr 19	06 57 28	30.5	70.0	4.5^{e}	33^{a}	c	A	
Apr 26	05 23 24	36.5	70.5	4.5^{e}	235^{a}	c	A	
May 01	01 37 42	34.8	59.0	4.5^{e}	33^{a}	c	A	
May 19	21 30 17	38.5	72.6	-	37	a	A	
May 27	05 14 54	36.5	70.5	4.8^{e}	220	c	A	
May 27	10 37 40	35.4	70.0	-	32	a	A	
Jun 04	11 18 33	37.1	71.9	-	190	a	A	
Jun 04	23 35 27	33.5	75.4	-	25	a	A	
Jun 08	03 59 21	36.4	71.0	-	264	a	A	
Jun 09	03 55 51	34.7	73.8	-	110	a	A	
Jun 14	17 31 28	36.6	68.1	4.5^{e}	220^{a}	c	A	
Jun 15	20 49 42	39.1	70.0	-	45	a	A	
Jun 19	17 04 36	36.5	70.5	6.7^{n}	220	c	A	Event #5, 1961, APP.C
Jul 16	09 04 40	36.4	70.7	5.7^{g}	206	a	A	
Jul 17	14 53 14	39.5	73.0	4.5^{e}	--	c	A	

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TABLE D2

DATE Yr Mo Dy	TIME Hr Mn Sc	LAT N	LONG E	MAG	DEPTH km	AUTH	SRCE	INTENSITY DATA
1961 Jul 20	00 48 54	38.5	71.0	-	--	c	A	
Jul 22	13 54 21	36.0	70.0	4.3[e]	200[a]	c	A	
Jul 22	20 53 18	40.0	70.5	4.7	--	c	A	
Aug 08	18 53 16	34.3	74.6	-	23	a	A	
Aug 16	12 23 13	36.5	71.2	-	220	a	A	
Aug 17	03 35 42	35.7	69.7	-	205	a	A	
Aug 21	07 00 20	36.4	71.7	-	120	a	A	
Aug 23	04 12 35	38.0	68.8	5.3[e]	25[a]	c	A	Felt
Sep 05	06 12 59	38.5	73.0	6.0[n]	100	c	A	Felt
Sep 06	13 35 42	36.5	70.6	-	197	a	A	
Sep 23	11 40 44	37.0	72.3	-	--	c	A	
Sep 28	05 00 45	36.5	70.5	6.1[g]	220	c	A	
Oct 01	14 17 41	37.6	71.8	-	122	a	A	
Oct 07	04 21 53	31.4	70.2	4.5[e]	59	c	A	
Nov 02	06 59 43	33.9	69.6	4.5[e]	38[a]	c	A	
Nov 06	12 29 00	38.0	73.5	4.5[e]	191[a]	c	A	
Nov 10	08 16 27	38.5	71.0	4.5[e]	--	c	A	
Nov 13	09 12 12	35.9	70.4	-	123	a	A	
Nov 18	01 43 08	32.7	73.6	-	48	a	A	
Nov 21	05 00 04	40.0	71.0	4.0[e]	--	c	A	
Nov 28	10 14 45	35.7	73.6	-	31	a	A	
Dec 08	13 06 40	36.0	71.0	-	200	c	A	
Dec 23	18 09 05	36.3	71.3	-	183	a	A	
1962 Jan 05	04 27 04	36.3	71.4	-	125	a	A	
Jan 08	22 25 13	36.7	70.5	5.7[k]	200	c	A	Event #1, 1962, APP.C
Jan 15	12 22 16	39.1	70.9	4.0[e]	--	c	A	
Jan 16	16 51 25	36.3	70.5	-	221	a	A	
Jan 31	00 05 53	38.5	70.0	4.9[e]	--	c	A	
Feb 24	18 06 45	34.3	70.1	-	25	a	A	Event #2, 1962, APP.C
Feb 27	05 40 54	36.3	71.3	-	111	a	A	
Feb 27	09 20 36	35.7	70.5	-	122	a	A	
Mar 07	19 20 01	36.4	71.6	-	100	a	A	
Mar 12	02 11 12	34.0	71.0	5.0[e]	--	c	A	Event #3, 1962, APP.C
Mar 22	10 33 12	36.3	69.3	-	144	a	A	
Mar 28	00 51 55	36.6	71.6	-	108	a	A	Event #4, 1962, APP.C
Mar 30	10 01 25	36.8	70.5	-	180	c	A	
Apr 01	00 45 10	33.2	58.6	5.8[e]	--	c	A	Event #5, 1962, APP.C
Apr 07	18 20 12	36.7	68.0	4.5[e]	--	c	A	
Apr 07	22 14 47	36.6	71.4	-	105	a	A	
Apr 08	14 35 33	36.7	70.5	-	200	c	A	
Apr 11	09 33 36	36.5	71.6	-	97	a	A	
Apr 11	20 43 18	35.9	71.1	-	158	a	A	
Apr 17	06 48 02	39.9	74.4	3.5[e]	--	c	A	
Apr 17	08 09 23	36.5	70.3	-	160	c	A	
Apr 20	07 52 20	36.9	70.9	-	200	c	A	

DATE Yr Mo Dy	TIME Hr Mn Sc	LAT N	LONG E	MAG	DEPTH km	AUTH	SRCE	INTENSITY DATA
1962 Apr 20	20 23 25	36.9	70.1	-	220	c	A	
Apr 21	01 07 53	36.5	69.2	4.5^e	--	c	A	
Apr 21	06 48 32	36.6	71.1	-	200	c	A	
Apr 23	15 18 26	36.5	70.3	5.0^e	120	c	A	
Apr 24	14 20 11	36.6	70.3	-	200	c	A	
Apr 25	07 03 04	36.7	70.7	-	200	c	A	
Apr 25	12 21 32	37.0	71.1	-	190	c	A	
Apr 26	01 54 11	39.4	71.0	3.5^e	--	c	A	
Apr 29	12 26 09	39.4	72.6	3.8^e	--	c	A	
May 06	07 09 58	36.8	70.5	-	200	c	A	
May 06	22 54 36	36.8	70.4	-	200	c	A	
May 08	19 38 21	32.9	73.1	4.5^e	--	c	A	
May 09	12 12 24	36.6	68.4	5.0^e	96^a	c	A	
May 12	17 36 50	36.5	70.6	-	193	a	A	
May 15	12 54 40	36.8	70.8	-	200	c	A	
May 15	15 37 10	37.5	69.8	-	--	c	A	
May 19	20 50 07	39.6	73.6	4.5^e	--	c	A	
May 29	08 09 22	36.6	70.8	-	200	c	A	
Jun 01	09 29 07	36.7	71.1	-	191	a	A	
Jun 03	07 07 07	36.6	69.7	-	182	a	A	
Jun 03	23 32 20	39.1	71.2	3.3^e	--	c	A	
Jun 04	00 56 44	39.1	71.2	3.3^e	--	c	A	
Jun 04	15 21 55	29.8	70.3	4.3^e	33^a	c	A	
Jun 05	10 51 14	39.7	74.7	4.0^e	--	c	A	
Jun 09	00 28 25	36.8	70.8	-	200	c	A	
Jun 09	10 44 05	36.7	70.8	-	200	c	A	
Jun 10	12 01 47	38.5	73.9	-	150	c	A	
Jun 15	12 21 51	36.5	71.0	-	100	c	A	
Jun 15	17 58 34	37.3	73.1	3.8^e	--	c	A	
Jun 16	11 26 41	39.4	73.2	4.3^e	--	c	A	
Jun 17	04 39 30	33.2	75.9	5.3^e	--	c	A	
Jun 19	08 13 47	38.3	69.0	4.3^e	--	c	A	
Jun 22	20 45 34	39.4	70.8	3.8^e	--	c	A	
Jun 23	23 26 57	37.5	72.4	3.8^e	--	c	A	
Jun 27	08 51 09	36.5	70.8	-	100	c	A	
Jun 27	21 31 41	36.5	69.2	-	140	c	A	
Jul 01	21 23 45	40.0	75.0	5.0^e	--	c	A	
Jul 03	03 16 56	36.7	70.9	-	200	a	A	
Jul 06	23 05 32	36.6	70.4	6.8^f	203	c	A	Event #6, 1962, APP.C
Jul 11	01 03 59	31.8	66.9	5.1^r	25	c	A	
Jul 16	21 06 02	36.3	70.0	4.0^e	--	c	A	
Jul 21	06 04 05	33.0	67.0	4.0^e	--	c	A	
Jul 21	17 28 43	36.7	71.6	-	107	a	A	
Jul 25	07 47 00	39.9	75.5	3.8^e	--	c	A	
Jul 30	09 12 50	38.4	69.1	3.5^e	--	c	A	
Jul 30	23 10 08	36.7	70.2	-	220	c	A	
Jul 31	18 43 35	33.5	76.0	-	--	c	A	

DATE Yr Mo Dy	TIME Hr Mn Sc	LAT N	LONG E	MAG	DEPTH km	AUTH	SRCE	INTENSITY DATA
1962 Aug 02	15 32 15	33.0	73.5	4.5[e]	33[a]	c	A	
Aug 03	18 02 46	36.6	71.1	-	209	a	A	
Aug 06	10 50 38	37.0	71.0	-	120	c	A	
Aug 09	08 13 01	36.8	69.7	-	200	c	A	
Aug 10	23 42 22	33.3	67.5	4.5[e]	--	c	A	
Aug 14	01 06 26	36.9	70.2	-	160	c	A	
Aug 18	21 54 50	38.5	73.5	3.5[e]	--	c	A	
Aug 19	-- -- --	36.4	70.7	4.3	200	g	G'	
Aug 19	-- -- --	36.5	70.8	4.3	230	g	G'	
Aug 24	09 22 26	31.0	68.5	3.5[g]	--	c	A	
Aug 24	14 55 59	31.0	68.5	3.5[g]	--	c	A	
Aug 27	19 12 50	36.5	70.2	-	221	a	A	
Sep 03	23 23 00	34.7	69.5	3.8[e]	--	c	A	Event #9, 1962, APP.C
Sep 04	06 14 47	37.8	71.3	4.0[e]	--	c	A	
Sep 07	-- -- --	36.3	70.7	4.8	250	g	G'	
Sep 10	14 16 03	38.0	68.0	-	--	c	A	
Sep 12	20 57 00	36.4	68.8	6.6[f]	50	c	A	
Sep 13	12 45 58	36.4	69.0	-	50	c	A	
+Sep 17	10 11 48	36.8	70.8	-	220	c	A	
Sep 18	05 23 05	36.5	69.0	-	50	c	A	
Sep 20	13 10 12	35.0	58.5	4.5[e]	--	c	A	
Sep 21	16 28 25	36.5	69.8	-	120	c	A	
Sep 22	08 06 28	36.5	68.7	5.0[e]	33[g]	c	A	Event #14,1962, APP.C
Sep 24	15 15 04	36.4	70.9	-	216	a	A	
Sep 27	08 13 05	39.0	70.3	-	--	c	A	
Sep 28	16 17 05	36.3	71.0	-	100	c	A	
Sep 30	06 04 55	38.4	73.1	4.6[g]	33	a	A	
Oct 01	00 06 44	36.8	70.1	-	220	c	A	
Oct 05	20 02 22	35.1	58.6	5.0[e]	33[a]	c	A	
Oct 05	22 17 44	36.9	71.2	-	120	c	A	
Oct 07	01 11 00	36.8	71.2	-	170	c	A	
Oct 09	15 59 14	36.4	71.3	-	209	a	A	Event #15,1962, APP.C
Oct 14	09 07 17	36.3	70.4	-	217	a	A	
Oct 16	04 58 45	39.4	73.3	4.0[e]	--	c	A	
Oct 16	11 59 36	34.0	60.5	4.5[e]	--	c	A	
Oct 18	21 26 03	39.3	73.1	-	53	a	A	
Oct 19	11 47 24	30.8	70.8	-	41	a	A	
Oct 23	20 10 58	36.7	71.1	-	216	a	A	
Oct 27	16 01 52	38.9	70.4	4.5[e]	--	c	A	
Oct 29	01 57 28	36.5	70.5	-	--	c	A	
Oct 30	02 21 31	37.5	71.0	-	140	c	A	
Oct 30	03 50 35	36.6	70.8	4.0[e]	--	c	A	
Nov 01	13 46 32	37.7	70.7	5.0[e]	132[g]	c	A	
Nov 01	15 26 44	37.7	70.0	4.9[e]	124[g]	c	A	
Nov 02	13 23 08	36.7	70.6	4.0[e]	--	c	A	
Nov 04	18 26 27	38.5	70.6	3.5[e]	--	c	A	
Nov 07	09 45 18	39.0	71.5	3.8[e]	--	c	A	
Nov 13	02 23 28	39.4	73.8	3.5[e]	--	c	A	

DATE Yr	Mo	Dy	TIME Hr	Mn	Sc	LAT N	LONG E	MAG	DEPTH km	AUTH	SRCE	INTENSITY DATA
1962	Nov	17	15	12	30	37.3	70.8	-	--	c	A	
	Nov	21	08	08	08	36.8	70.8	-	200	c	A	
	Nov	22	22	46	10	36.8	70.8	-	200	c	A	
	Nov	26	01	41	10	35.8	70.3	5.5[g]	150	c	A	Event #18,1962, APP.C
	Nov	29	22	51	55	39.0	70.3	4.0[e]	--	c	A	
	Dec	02	18	19	56	36.5	70.8	-	201	a	A	
	Dec	10	12	33	54	36.5	70.5	-	220	c	A	
	Dec	10	18	46	22	39.8	74.3	3.5[e]	--	c	A	
	Dec	12	--	--	--	36.4	70.8	4.9	180	g	G'	
	Dec	16	06	34	16	36.2	71.3	4.3[g]	145	a	A	
	Dec	18	02	06	03	40.0	71.4	4.3[e]	77[a]	c	A	
	Dec	18	14	50	26	36.9	71.2	-	160	c	A	
	Dec	21	10	11	32	38.0	68.0	3.5[e]	--	c	A	
	Dec	23	06	28	01	38.4	73.3	-	118	a	A	
	Dec	26	14	58	56	38.6	72.8	-	188	a	A	
	Dec	30	15	25	25	37.5	72.9	-	35	a	A	
	Dec	31	06	34	58	37.5	72.0	-	200	c	A	
1963	Jan	01	19	27	32	35.4	58.8	4.5[e]	--	c	A	
	Jan	06	07	00	18	39.7	73.7	3.5[e]	--	c	A	
	Jan	10	06	47	05	36.6	70.8	-	209	a	A	
	Jan	10	18	13	50	39.0	75.0	3.5[e]	--	c	A	
	Jan	11	11	41	38	35.8	70.6	-	107	a	A	
	Jan	12	06	20	16	36.1	69.9	-	129	a	A	Event #1, 1963, APP.C
	Jan	14	06	26	13	36.7	71.2	-	190	c	A	
	Jan	15	19	11	02	38.7	75.7	-	87	a	A	
	Jan	16	15	30	07	36.4	70.3	4.3[g]	215	a	A	
	Jan	16	20	31	30	36.7	70.8	-	200	c	A	
	Jan	19	02	35	05	39.0	75.0	4.5[e]	51[a]	c	A	
	Jan	21	16	19	54	37.2	69.2	3.5[e]	--	c	A	
	Jan	21	21	02	36	37.0	70.8	4.3[g]	98	a	A	
	Jan	26	16	43	36	39.5	63.3	-	--	c	A	
	Jan	26	19	17	37	36.5	68.5	3.8	--	c	A	
	Jan	28	09	42	01	36.8	70.3	4.7[g]	200	c	A	
	Jan	29	14	56	30	38.0	70.0	-	--	c	A	
	Feb	04	00	35	21	39.8	69.8	-	33	a	A	
	Feb	04	23	20	31	37.0	71.3	4.8[g]	200	c	A	
	Feb	07	12	12	31	36.5	70.7	3.7[g]	208	a	A	
	Feb	10	17	47	07	36.3	71.2	-	108	a	A	
	Feb	15	21	41	47	38.2	72.4	-	33	a	A	
	Feb	16	12	19	30	36.5	70.4	5.4	208	a	A	Event #2, 1963, APP.C
	Feb	17	05	38	18	36.5	70.5	6.2	200	a	A	
	Feb	17	09	09	07	37.5	74.4	4.4	54	a	A	
	Feb	18	14	25	19	36.6	70.5	4.9[u]	200	c	A	Event #3, 1963, APP.C
	Feb	23	02	41	31	37.1	70.7	3.5[e]	--	c	A	
	Feb	27	10	41	31	38.7	71.0	3.8[e]	157[g]	c	A	
	Feb	27	17	27	53	38.6	69.6	4.3	61	a	A	

TABLE D2

DATE Yr Mo Dy	TIME Hr Mn Sc	LAT N	LONG E	MAG	DEPTH km	AUTH	SRCE	INTENSITY DATA
1963 Mar 01	03 20 02	35.8	59.9	4.8	33	a	A	
Mar 03	01 48 11	36.6	71.4	4.4	229	a	A	
Mar 03	17 04 58	36.8	71.0	4.3u	100	c	A	Event #5, 1963, APP.C
Mar 06	08 35 01	34.0	72.5	4.3u	36g	c	A	
Mar 07	21 49 26	36.7	71.2	5.3g	104	c	A	
Mar 11	10 27 47	36.4	71.1	5.0u	250	c	A	
Mar 11	-- -- --	36.7	71.1	4.7	189	g	G'	
Mar 13	17 27 20	36.6	70.4	4.0	160	c	A	
Mar 16	19 16 42	36.5	70.9	-	160	a	A	
Mar 16	22 28 51	39.0	71.8	4.9	73g	c	A	
Mar 17	15 33 28	36.9	71.0	4.7g	120	c	A	
Mar 18	00 45 08	38.2	72.9	4.3g	111	a	A	
Mar 24	10 58 55	36.6	70.5	5.5w	200	c	A	
Mar 24	21 59 31	39.5	75.0	3.8e	---	c	A	
Mar 27	03 39 02	37.3	71.9	-	148	a	A	
Mar 28	17 12 26	31.2	70.1	4.5e	---	c	A	
Mar 29	20 04 52	36.5	70.4	4.2	204	a	A	
Mar 30	17 30 04	38.6	75.8	4.3	33	a	A	
Mar 31	00 49 12	37.4	70.0	3.5e	---	c	A	
Apr 01	09 22 55	35.8	69.7	4.8u	---	c	A	Event #7, 1963, APP.C
Apr 01	18 36 30	37.1	70.9	4.9g	150	c	A	
Apr 07	08 44 35	36.0	70.6	-	244	a	A	
Apr 13	14 49 38	35.8	70.9	-	142	a	A	
Apr 17	02 54 00	36.8	70.5	-	200	c	A	
Apr 17	10 45 19	36.4	70.5	-	79	a	A	Event #8, 1963, APP.C
Apr 20	22 44 17	37.2	71.2	-	104	a	A	
Apr 22	00 51 09	31.5	74.0	-	37	a	A	
Apr 24	20 31 08	36.4	71.3	3.9	116	a	A	
Apr 25	12 13 48	36.7	68.3	-	50	a	A	
Apr 28	04 32 59	37.5	73.1	3.8e	---	c	A	
Apr 28	19 50 09	36.3	71.3	4.9	133	a	A	Event #9, 1963, APP.C
Apr 30	06 49 53	37.0	73.2	4.5e	---	c	A	
May 01	08 09 14	36.4	71.2	-	222	a	A	
May 01	19 52 15	38.8	75.4	4.5	54	a	A	
May 07	03 16 40	36.7	71.1	5.7x	---	c	A	
May 07	04 50 33	36.5	70.7	4.4g	140	c	A	
May 15	05 02 02	39.4	72.2	4.0	---	c	A	
May 15	06 35 25	38.5	75.5	5.0	33	a	A	
May 15	06 57 20	38.7	75.4	3.8	---	c	A	
May 16	06 33 00	30.0	70.0	-	---	c	A	
May 16	21 38 31	36.7	70.5	-	200	c	A	
May 17	16 21 14	36.7	71.0	-	80	c	A	
May 18	23 58 55	37.6	72.8	4.3	91	a	A	
May 19	13 25 41	38.8	67.9	4.0e	---	c	A	
May 23	17 13 12	32.8	76.0	4.5	---	c	A	
May 24	02 54 19	37.2	73.5	4.0	---	c	A	
May 25	20 49 39	36.6	70.9	-	200	a	A	
May 29	08 35 04	27.0	59.4	5.2v	52	a	A	
May 31	00 37 51	36.5	70.0	-	200	c	A	
May 31	08 18 22	39.2	73.0	-	---	c	A	

DATE Yr Mo Dy	TIME Hr Mn Sc	LAT N	LONG E	MAG	DEPTH km	AUTH	SRCE	INTENSITY DATA
1963 Jun 01	10 49 57	36.1	71.2	5.1	100	a	A	
Jun 02	09 13 46	37.5	73.1	3.8	--	c	A	
Jun 03	12 34 20	39.4	70.7	4.5^e	33^g	c	A	
Jun 04	03 51 10	37.5	73.1	3.8	--	c	A	
Jun 09	03 50 22	36.7	72.0	3.9^g	250	c	A	
Jun 10	18 50 55	36.3	70.7	4.2^g	250	c	A	
Jun 11	03 25 42	37.1	70.1	5.4	44	a	A	
Jun 11	18 34 11	38.4	69.5	4.3	32	a	A	
Jun 17	11 02 42	30.7	69.6	3.5	33	c	A	
Jun 18	08 37 57	36.5	70.6	4.0	206	a	A	
Jun 27	-- -- --	36.7	70.2	4.0	200	g	G'	
Jun 29	09 28 20	37.5	73.0	3.5	--	c	A	
Jun 30	03 59 16	36.5	70.5	4.4	205	a	A	
Jul 05	13 11 38	37.2	73.0	5.0	111	a	A	
Jul 05	16 27 28	36.7	73.0	4.3	193	a	A	
Jul 06	13 34 05	28.0	58.0	--	100	c	A	
Jul 08	15 29 34	35.8	69.7	--	131	a	A	
Jul 09	-- -- --	36.2	70.3	3.9	200	g	G'	
Jul 10	02 11 58	36.5	71.8	4.9	33	a	A	
Jul 14	10 51 43	36.1	70.6	5.1	120	a	A	Event #14,1963, APP.C
Jul 21	07 14 33	32.8	72.9	-	--	c	A	
Jul 21	18 48 30	36.5	69.9	4.0	112	a	A	
Jul 21	20 29 24	39.9	71.2	3.5^e	--	c	A	
Jul 22	07 45 31	30.0	68.0	4.5^e	--	c	A	
Jul 22	11 31 44	37.3	71.6	4.3^g	--	c	A	
Jul 29	07 38 23	38.4	71.9	4.0	--	c	A	
Aug 01	18 15 16	36.7	70.6	-	220	c	A	
Aug 03	19 31 36	37.4	73.3	3.5	--	c	A	
Aug 11	19 40 52	36.2	71.2	-	148	a	A	
Aug 13	07 03 50	36.6	70.9	4.7	244	a	A	
Aug 14	17 33 31	37.3	71.2	4.1^g	100	c	A	
Aug 17	21 58 54	36.7	59.7	4.8	33	a	A	
Aug 18	02 50 06	37.0	71.1	-	80	c	A	
Aug 18	23 09 01	36.9	71.3	-	80	c	A	
Aug 20	23 17 04	38.9	75.1	4.5^e	04	c	A	
Aug 26	05 42 43	36.3	68.3	4.0^e	--	c	A	
Aug 28	03 18 57	36.0	70.0	-	80	c	A	
Aug 29	08 53 48	39.6	74.2	5.5	31	a	A	
Aug 31	08 34 34	39.4	72.3	4.5^e	--	c	A	
Sep 01	01 34 34	33.9	74.7	5.1	44	a	A	
Sep 01	03 58 39	36.8	70.6	4.4^g	--	c	A	
Sep 02	04 34 32	33.9	74.7	5.1	44	a	A	
Sep 05	10 27 23	36.7	70.4	-	200	c	A	
Sep 06	13 30 39	36.8	70.0	4.6^g	200	c	A	
Sep 09	21 41 44	31.3	72.1	4.7	33	a	A	
Sep 11	04 49 23	37.9	73.2	4.0	--	c	A	
Sep 17	11 51 16	39.9	73.0	4.0	--	c	A	
Sep 19	16 31 15	31.0	66.8	4.2	37	a	A	

DATE Yr	Mo	Dy	TIME Hr	Mn	Sc	LAT N	LONG E	MAG	DEPTH km	AUTH	SRCE	INTENSITY DATA
1963	Sep	21	04	38	40	36.7	71.0	-	100	c	A	
	Sep	22	03	28	47	36.6	71.1	3.5[e]	--	c	A	Event #15,1963, APP.C
	Sep	27	17	09	33	27.9	66.1	4.7	88	a	A	
	Sep	28	20	03	06	32.7	71.8	4.8[g]	--	c	A	
	Sep	29	10	39	58	36.4	70.4	4.8	214	a	A	
	Sep	29	15	31	31	36.1	72.0	4.9	150	a	A	
	Oct	05	01	03	47	36.8	71.2	-	200	c	A	
	Oct	06	05	48	46	37.5	72.0	-	200	c	A	
	Oct	06	22	31	05	37.8	69.4	3.5[e]	--	c	A	
	Oct	07	11	04	45	39.0	70.9	4.0[e]	10	c	A	
	Oct	14	12	35	24	36.6	70.3	-	200	c	A	
	Oct	14	21	12	43	36.8	71.9	5.4[g]	160	c	A	
	Oct	14	23	05	12	39.0	74.3	4.0[e]	--	c	A	
	Oct	15	13	39	44	39.7	74.2	-	--	c	A	
	Oct	16	15	43	01	38.6	73.4	5.9	33	a	A	
	Oct	16	16	20	43	38.8	73.2	4.5[e]	--	c	A	
	Oct	16	18	22	39	38.8	73.2	4.0[e]	--	c	A	
	Oct	16	18	27	39	38.8	73.2	-	--	c	A	
	Oct	16	19	02	25	28.8	58.0	4.8	32	a	A	
	Oct	16	19	14	35	38.8	73.2	4.0	--	c	A	
	Oct	16	20	31	06	38.8	73.2	4.8[e]	70[a]	c	A	
	Oct	17	00	12	09	38.8	73.2	4.0	--	c	A	
	Oct	17	09	33	24	38.8	73.4	4.4	40[g]	a	A	
	Oct	17	23	05	50	38.8	73.2	4.0	--	c	A	
	Oct	18	12	31	41	38.3	68.6	3.5	--	c	A	
	Oct	21	14	49	15	38.4	73.3	4.8	84	a	A	
	Oct	24	19	03	14	39.0	70.7	4.5[e]	10	c	A	
	Oct	30	12	29	41	36.9	71.0	-	200	c	A	
	Oct	31	20	10	54	37.2	70.0	4.5	105	a	A	
	Nov	04	21	12	12	36.3	71.3	4.7	148	a	A	
	Nov	22	17	22	31	36.6	70.7	4.6[g]	--	c	A	
	Nov	28	08	52	10	36.8	70.9	-	220	c	A	
	Nov	29	20	24	58	36.5	70.5	-	--	c	A	
	Dec	05	--	--	--	36.8	71.1	4.3	100	g	G'	
	Dec	08	11	08	05	39.9	58.7	4.5	33	a	A	
	Dec	08	15	18	10	36.5	70.8	-	212	a	A	
	Dec	09	18	01	55	36.1	71.2	5.0	157	a	A	
	Dec	17	10	58	12	36.7	71.2	4.2	203	a	A	
	Dec	18	--	--	--	36.3	70.6	5.3	200	g	G'	
	Dec	26	20	50	21	36.4	71.3	4.9	140	a	A	Event #18,1963, APP.C
	Dec	28	01	44	05	36.6	70.2	5.0	205	a	A	
1964	Jan	02	17	28	36	36.4	71.1	4.8	233	a	A	
	Jan	03	16	37	19	36.0	71.3	4.5	123	a	A	
	Jan	04	--	--	--	36.3	71.3	4.3	200	g	G'	
	Jan	07	20	04	36	39.3	73.8	4.5	33	a	A	
	Jan	15	--	--	--	36.8	71.4	5.1	200	g	G'	
	Jan	17	03	25	01	36.8	71.4	5.2	94	a	A	Event #2, 1964, APP.C

DATE Yr Mo Dy	TIME Hr Mn Sc	LAT N	LONG E	MAG	DEPTH km	AUTH	SRCE	INTENSITY DATA
1964 Jan 23	15 19 32	36.9	71.2	4.4	28	a	A	
Jan 24	10 00 47	35.6	74.4	-	215	a	A	
Jan 28	14 09 17	36.5	70.9	6.1	207	a	A	Event #3, 1964, APP.C
Jan 29	05 45 48	36.7	73.2	3.8	187	a	A	
Jan 31	00 14 58	36.3	71.4	4.2	127	a	A	
Feb 07	-- -- --	36.4	70.8	4.3	214	g	G'	
Feb 10	03 48 06	36.4	71.0	4.1	249	a	A	
Feb 10	22 12 21	39.7	68.3	4.8	46	a	A	
Feb 13	05 10 48	34.9	72.7	4.6	70	a	A	
Feb 13	13 53 31	34.9	72.7	-	144	a	A	
Feb 17	-- -- --	36.9	71.3	4.6	174	g	G'	
Feb 18	11 11 17	36.2	71.0	-	226	a	A	
Feb 18	17 08 10	36.3	70.7	5.0	223	a	A	
Feb 21	01 04 01	34.4	58.1	5.0	33	a	A	
Feb 27	-- -- --	38.1	69.6	4.0	157	g	G'	
Mar 01	-- -- --	35.7	59.9	5.0	33	g	G'	
Mar 03	-- -- --	36.4	71.3	4.6	156	g	G'	
Mar 06	-- -- --	33.8	72.6	4.5	33	g	G'	
Mar 09	10 27 33	36.2	71.5	4.8	132	a	A	
Mar 09	19 41 01	36.5	70.9	-	181	a	A	
Mar 16	03 28 12	38.0	72.9	5.2	132	a	A	
Mar 23	07 36 24	37.2	72.3	4.4	143	a	A	
Mar 23	13 40 26	38.3	73.7	5.4	126	a	A	
Mar 27	19 12 51	36.8	71.2	5.6	206	a	A	
Apr 28	18 27 03	37.1	71.7	-	146	a	A	
May 07	17 41 40	36.0	70.7	4.7	108	a	A	
May 16	08 38 54	36.3	71.5	5.3	122	a	A	Event #7, 1964, APP.C
May 19	-- -- --	36.3	70.6	4.6	160	g	G'	
May 24	16 36 05	35.8	70.8	5.0	164	a	A	
Jun 03	-- -- --	36.4	71.2	4.6	25	g	G'	
Jun 04	02 57 08	36.4	69.3	4.9	33	a	A	
Jun 06	08 05 56	37.1	72.1	5.0	166	a	A	
Jul 03	14 10 33	33.9	74.5	4.9	94	a	A	
Jul 06	10 13 45	37.1	71.4	5.9	100	a	A	
Jul 07	21 12 34	35.8	73.4	5.2	19	a	A	
Jul 13	-- -- --	36.9	71.7	4.3	200	g	G'	
Aug 01	00 47 09	36.7	70.3	-	149	a	A	
Sep 07	15 52 12	37.1	71.8	4.3	168	a	A	
Sep 19	00 39 11	36.5	70.0	4.7	212	a	A	
Sep 28	06 51 05	36.3	71.6	5.5	118	a	A	
Oct 04	07 00 57	27.9	69.2	4.8	14	a	A	
Oct 13	23 02 26	35.8	71.1	5.8	120	a	A	
Oct 21	17 23 34	35.9	71.3	4.4	181	a	A	
Oct 22	06 41 33	38.9	75.8	4.4	120	a	A	
Oct 24	06 51 02	38.8	71.0	5.1	57	a	A	

DATE Yr Mo Dy	TIME Hr Mn Sc	LAT N	LONG E	MAG	DEPTH km	AUTH	SRCE	INTENSITY DATA
1964 Oct 25	22 56 08	38.7	70.8	5.0	33	a	A	
Oct 28	19 35 16	36.1	71.3	5.5	130	a	A	
Nov 03	06 05 33	31.6	66.4	5.1	38	a	A	
Nov 03	06 14 31	32.4	59.1	-	33	a	A	
Nov 04	19 46 06	36.4	70.8	4.6	210	a	A	
Nov 07	22 03 19	36.5	70.8	-	215	a	A	
Nov 15	17 12 44	36.5	70.9	5.0	220	a	A	Event #11,1964, APP.C
Nov 16	04 47 28	36.3	70.4	5.5	225	a	A	Event #12,1964, APP.C
Nov 25	11 45 54	38.9	71.0	4.8	85	a	A	
Nov 27	11 03 48	36.3	70.7	5.2	219	a	A	
Dec 02	12 31 45	38.9	70.6	4.7	33	a	A	
Dec 24	01 08 38	36.2	70.9	5.6	158	a	A	Event #13,1964, APP.C
Dec 30	23 37 41	36.4	69.9	5.3	123	a	A	
1965 Jan 15	00 34 15	36.5	71.0	5.4	245	a	A	
Jan 18	03 28 26	37.9	72.1	4.9	33	a	A	
Jan 23	22 03 09	35.3	72.8	4.9	200	a	A	
Jan 29	20 06 02	35.6	73.6	5.7	33	a	A	
Feb 02	15 56 51	37.5	73.4	5.8	33	a	A	
Feb 08	14 03 53	36.4	73.0	5.1	220	a	A	
Feb 16	20 46 37	36.3	70.8	5.3	190	a	A	Event #1, 1965, APP.C
Mar 14	05 11 22	36.8	73.1	4.3	163	a	A	
Mar 14	11 41 53	36.5	68.4	4.9	86	a	A	
Mar 14	15 53 07	36.3	70.7	6.6	219	a	A	Event #2, 1965, APP.C
Mar 18	16 31 02	36.9	70.7	4.7	200	a	A	
Apr 02	22 26 47	36.8	66.6	5.5	38	a	A	Event #3, 1965, APP.C
Apr 03	03 54 52	37.7	73.1	5.3	33	a	A	
Apr 09	01 15 15	38.0	72.9	4.8	150	a	A	
Apr 10	14 11 22	37.6	73.4	5.5	33	a	A	
Apr 10	21 21 27	37.3	71.9	4.9	136	a	A	
Apr 24	20 01 56	35.9	65.3	5.0	33	a	A	
Apr 25	02 27 46	36.3	70.5	4.7	231	a	A	Event #4, 1965, APP.C
Apr 26	03 24 34	36.3	70.2	4.6	239	a	A	
Apr 27	00 53 41	36.0	73.1	-	140	a	A	
May 13	04 30 41	37.0	71.4	-	90	a	A	
May 26	03 47 22	36.3	70.5	4.6	229	a	A	
May 28	09 31 19	36.7	70.1	5.0	236	a	A	
May 30	11 38 41	36.5	70.1	4.9	220	a	A	
Jun 06	20 29 57	36.0	70.3	4.6	121	a	A	
Jun 07	19 55 34	36.3	71.1	-	122	a	A	
Jun 09	20 57 47	36.6	70.1	-	241	a	A	
Jun 10	05 48 57	36.1	70.5	5.8	92	a	A	
Jun 10	14 04 53	36.4	70.5	4.6	207	a	A	
Jun 13	04 21 28	33.6	69.4	4.9	50	a	A	
Jun 14	04 59 17	38.0	68.3	-	33	a	A	
Jun 20	13 28 12	36.7	71.6	-	150	a	A	

DATE Yr Mo Dy	TIME Hr Mn Sc	LAT N	LONG E	MAG	DEPTH km	AUTH	SRCE	INTENSITY DATA
1965 Jun 20	18 11 13	36.6	71.0	4.9	173	a	A	
Jun 28	12 14 51	27.3	66.9	5.3	41	a	A	
Jul 06	13 21 07	36.6	73.0	4.6	163	a	A	
Jul 07	04 51 14	38.6	74.8	5.3	33	a	A	
Jul 12	13 52 39	36.4	70.7	5.0	212	a	A	
Jul 13	23 09 53	36.5	70.7	5.0	200	a	A	
Jul 14	14 30 44	37.3	71.8	-	171	a	A	
Jul 20	07 43 28	36.7	71.4	5.1	194	a	A	
Jul 21	22 40 27	36.5	71.4	4.6	105	a	A	
Jul 24	17 57 42	36.5	71.2	4.9	225	a	A	
Jul 28	08 03 11	36.0	70.4	-	150	a	A	
Aug 03	07 02 35	36.2	69.4	4.9	37	a	A	
Aug 04	19 43 19	37.3	72.0	-	162	a	A	
Aug 07	11 32 43	37.4	72.1	-	219	a	A	
Aug 08	16 16 53	28.9	69.2	4.3g	33	a	A	
Aug 12	17 19 03	36.5	70.2	4.4	227	a	A	
Aug 14	17 14 48	37.5	72.3	4.7	198	a	A	
Aug 15	05 59 47	36.5	71.1	4.8	201	a	A	
Aug 18	00 48 47	36.5	70.3	-	222	a	A	
Aug 26	20 54 02	37.4	71.5	-	116	a	A	
Sep 09	12 10 34	37.4	72.0	-	222	a	A	
Sep 09	23 31 22	36.4	70.7	4.6	212	a	A	
Sep 11	06 16 27	36.6	70.6	-	234	a	A	
Sep 11	11 12 59	37.4	72.0	4.6	173	a	A	
Sep 13	07 14 28	36.4	71.1	4.2	116	a	A	
Sep 14	18 57 28	36.5	70.1	4.8	223	a	A	
Sep 16	23 57 55	36.1	70.2	4.4	113	a	A	
Sep 19	18 00 37	36.0	71.2	4.3	103	a	A	
Sep 27	16 04 25	36.5	70.2	4.4	221	a	A	
Sep 28	-- -- --	36.1	71.2	4.5	190	g	G'	
Sep 30	02 24 48	36.3	71.0	4.8g	96	a	A	
Oct 03	21 57 52	36.4	70.7	4.6	209	a	A	
Oct 06	15 35 05	36.5	70.2	5.3	218	a	A	
Oct 06	16 43 47	36.5	71.0	4.6	208	a	A	
Oct 06	22 41 22	36.4	71.2	4.9	135	a	A	
Oct 09	03 06 12	36.5	70.7	4.9	212	a	A	
Oct 09	04 34 22	32.3	74.0	4.5	79	a	A	
Oct 09	07 43 14	36.0	70.5	4.6	116	a	A	
Oct 11	17 17 47	35.4	70.2	-	150	a	A	
Oct 18	14 47 38	38.9	71.4	-	42	a	A	
Oct 21	02 45 53	36.4	69.7	4.8	161	a	A	
Oct 26	09 03 00	34.1	70.4	5.0	57	a	A	
Oct 29	13 45 36	39.2	71.6	4.3	53	a	A	
Oct 31	20 25 31	37.8	68.0	4.6	37	a	A	
Oct 31	23 12 31	38.0	72.5	5.2	109	a	A	
Nov 06	14 56 34	37.6	72.3	-	182	a	A	
Nov 06	15 56 39	37.6	72.3	4.7	159	a	A	

DATE Yr Mo Dy	TIME Hr Mn Sc	LAT N	LONG E	MAG	DEPTH km	AUTH	SRCE	INTENSITY DATA
1965 Nov 08	21 23 09	34.6	73.3	4.6	65	a	A	
Nov 10	-- -- --	37.1	71.2	4.6	107	g	G'	
Nov 16	01 03 56	36.4	71.1	5.5	244	a	A	Event #7, 1965, APP.C
Nov 16	15 12 49	39.4	73.0	4.4	33	a	A	
Dec 03	21 17 41	36.3	69.4	5.4	74	a	A	
Dec 07	00 29 33	36.7	71.5	4.6	279	a	A	
Dec 07	14 50 45	39.2	73.4	4.8	31	a	A	
Dec 11	19 10 09	36.6	70.9	4.5	221	a	A	
Dec 12	10 26 56	36.3	70.4	4.8	69	a	A	
Dec 17	12 58 37	36.7	68.9	-	71	a	A	
Dec 19	14 28 52	36.3	69.2	4.6	60	a	A	
Dec 26	17 43 28	36.9	71.6	5.0	156	a	A	
Dec 29	04 07 55	31.9	69.8	4.9	75	a	A	
1966 Jan 05	10 26 32	36.7	71.2	4.7	188	a	A	
Jan 05	20 45 52	38.2	69.1	4.9	18	a	A	
Jan 06	16 07 15	39.2	72.4	4.8	41	a	A	
Jan 11	09 13 00	34.0	72.0	5.3	54	a	A	
Jan 11	16 16 44	38.5	69.7	4.4	63	a	A	
Jan 13	19 48 44	39.2	68.7	-	17	a	A	
Jan 18	12 14 52	36.5	70.9	4.7	189	a	A	
Jan 19	08 04 58	39.5	71.5	-	54	a	A	
Jan 24	02 15 29	32.6	67.6	5.1	52	a	A	
Jan 24	07 23 10	29.9	69.7	5.6	26	a	A	
Jan 24	09 42 15	30.3	69.8	4.7	69	a	A	
Jan 24	15 32 52	29.9	69.7	5.1	26	a	A	
Jan 28	08 52 05	39.3	73.1	5.3	43	a	A	
Jan 30	21 38 52	37.9	72.6	4.1	132	a	A	
Feb 02	09 20 09	33.8	73.1	5.1	46	a	A	
Feb 07	04 26 11	29.9	69.7	6.0	10	a	A	
Feb 07	05 21 45	30.0	69.9	5.4	13	a	A	
Feb 07	05 30 16	30.0	69.8	5.4	23	a	A	
Feb 07	06 57 01	30.1	70.2	4.8	24	a	A	
Feb 07	07 28 19	30.3	70.0	4.7	43	a	A	
Feb 07	08 38 11	30.1	70.0	4.7	9	a	A	
Feb 07	23 06 35	30.3	69.9	5.8	11	a	A	
Feb 08	00 03 21	30.2	69.9	5.0	34	a	A	
Feb 08	00 11 32	30.0	69.9	4.1	36	a	A	
Feb 08	00 25 57	29.9	69.9	-	19	a	A	
Feb 08	05 53 06	30.2	70.1	5.1	6	a	A	
Feb 09	08 22 18	29.9	69.8	5.2	28	a	A	
Feb 09	22 26 10	30.1	69.9	4.5	31	a	A	
Feb 10	14 58 00	39.2	71.5	-	93	a	A	
Feb 11	22 43 07	36.5	70.4	-	225	a	A	
Feb 12	08 04 55	39.2	71.6	4.7	42	a	A	
Feb 12	16 34 11	36.7	71.5	4.9	175	a	A	
Feb 13	13 47 44	37.6	73.3	4.2	65	a	A	
Feb 13	19 09 45	30.0	69.7	5.1	9	a	A	
Feb 14	05 41 06	29.9	69.7	4.8	16	a	A	

DATE Yr Mo Dy	TIME Hr Mn Sc	LAT N	LONG E	MAG	DEPTH km	AUTH	SRCE	INTENSITY DATA
1966 Feb 16	09 44 22	29.9	69.7	4.8	34	a	A	
Feb 17	18 26 20	30.1	69.9	4.3	41	a	A	
Feb 19	09 42 59	37.3	70.5	4.8	27	a	A	
Feb 19	12 50 43	35.1	70.8	5.1	68	a	A	
Feb 28	00 03 00	36.2	71.1	4.6	88	a	A	
Mar 01	04 59 50	36.7	69.0	4.6	44	a	A	Event #3, 1966, APP.C
Mar 02	04 02 46	36.2	70.5	4.4	147	a	A	
Mar 04	06 01 01	30.1	70.0	5.0	3	a	A	
Mar 08	07 21 38	36.3	70.7	-	110	a	A	
Mar 11	04 20 20	30.1	69.9	4.4	29	a	A	
Mar 11	15 46 26	36.4	71.1	-	248	a	A	
Mar 15	09 14 29	30.0	69.8	4.7	35	a	A	
Mar 16	00 08 18	33.3	76.0	5.0	36	a	A	
Mar 16	17 40 28	29.9	69.8	4.9	13	a	A	
Mar 18	10 44 11	30.0	69.9	4.8	38	a	A	
Mar 26	18 51 10	29.9	69.7	4.0	36	a	A	
Mar 31	01 25 40	36.7	71.3	-	188	a	A	
Mar 31	23 38 01	36.4	70.8	5.4	207	a	A	
Apr 05	05 18 45	36.9	71.0	4.7	114	a	A	
Apr 06	01 51 53	34.9	73.0	5.0	58	a	A	
Apr 08	22 15 03	36.4	70.8	4.7	200	a	A	
Apr 11	16 42 52	38.9	70.6	4.8	13	a	A	
Apr 13	03 00 21	36.4	70.8	4.6	201	a	A	
Apr 14	13 55 12	39.0	70.5	4.6	4	a	A	
Apr 14	21 06 14	38.9	70.6	5.1	12	a	A	
Apr 15	20 31 01	31.9	68.9	-	40	a	A	
Apr 16	15 50 55	38.9	70.6	-	1	a	A	
Apr 18	19 29 41	34.5	69.8	4.2	55	a	A	Event #5, 1966, APP.C
Apr 22	10 06 00	36.6	71.0	4.6	225	a	A	
Apr 25	07 32 26	38.9	70.4	-	9	a	A	
Apr 25	18 11 57	30.1	70.0	4.7	33	a	A	
Apr 30	10 21 16	36.5	71.4	-	106	a	A	
May 07	18 28 19	34.6	70.7	4.4	19	a	A	
May 10	21 57 45	37.2	71.2	4.6	97	a	A	
May 11	01 53 59	34.5	69.8	5.1	48	a	A	
May 13	23 12 35	30.0	70.0	4.0	26	a	A	
May 13	23 54 05	32.9	68.6	4.5	55	a	A	
May 15	02 13 04	39.7	74.4	4.8	62	a	A	
May 15	17 16 17	36.6	70.9	4.6	226	a	A	
May 17	17 50 31	36.5	70.7	-	240	a	A	
May 19	12 51 03	38.0	73.0	4.8	153	a	A	
May 22	12 23 26	32.2	68.8	-	36	a	A	
May 23	07 11 08	36.0	70.3	3.4	155	a	A	
May 24	04 35 25	30.1	70.0	3.9	26	a	A	
May 30	12 51 58	36.0	68.8	4.6	220	a	A	
Jun 04	05 11 55	36.4	70.7	5.4	213	a	A	
Jun 06	07 46 16	36.4	71.1	6.2	221	a	A	Event #10,1966, APP.C
Jun 09	02 16 00	37.6	72.3	4.5	171	a	A	

TABLE D2

DATE Yr Mo Dy	TIME Hr Mn Sc	LAT N	LONG E	MAG	DEPTH km	AUTH	SRCE	INTENSITY DATA
1966 Jun 11	06 08 49	35.8	72.0	4.8	98	a	A	
Jun 11	22 29 37	36.5	70.5	4.5	201	a	A	
Jun 13	11 27 24	37.4	72.3	4.9	195	a	A	
Jun 17	11 46 01	36.4	70.8	-	179	a	A	
Jun 20	12 16 45	37.7	73.8	4.8	231	a	A	
Jun 21	19 46 45	36.5	70.7	4.7	182	a	A	
Jun 23	07 03 53	36.2	66.7	-	22	a	A	
Jun 23	17 42 04	36.4	71.3	4.3	105	a	A	
Jun 24	07 05 19	36.6	71.5	4.3	193	a	A	
Jul 03	12 47 07	36.4	71.2	4.4	215	a	A	
Jul 04	08 45 46	36.8	71.1	4.6	78	a	A	
Jul 06	11 57 25	38.9	71.2	4.7	30	a	A	
Jul 07	19 00 29	36.5	71.3	4.1	73	a	A	
Jul 11	02 58 03	38.9	70.4	-	11	a	A	
Jul 12	14 04 25	36.9	71.4	-	107	a	A	
Jul 19	03 28 52	36.3	71.5	4.6	140	a	A	
Jul 22	06 32 49	36.2	71.2	-	77	a	A	
Jul 23	17 44 58	36.5	70.7	4.5	203	a	A	
Jul 24	05 07 39	30.0	69.9	4.3	6	a	A	
Jul 26	15 15 33	36.7	71.5	5.1	125	a	A	
Aug 01	04 27 59	39.4	72.0	-	19	a	A	
Aug 01	06 29 42	39.1	70.3	5.1	34	a	A	
Aug 01	19 09 55	29.9	68.7	4.5	22	a	A	
Aug 01	20 30 55	30.0	68.5	5.6	17	a	A	
Aug 01	21 03 00	30.1	68.6	6.0	33	a	A	Event #13,1966, APP.C
Aug 01	21 35 41	29.7	69.2	5.0	33	a	A	
Aug 01	22 30 53	29.9	68.8	5.1	20	a	A	
Aug 02	05 41 38	30.1	68.7	5.0	33	a	A	
Aug 02	09 18 58	29.9	69.2	5.0	21	a	A	
Aug 03	22 13 26	37.2	71.3	4.7	86	a	A	
Aug 04	17 32 45	36.7	71.3	-	206	a	A	
Aug 04	22 29 25	29.9	68.6	4.9	33	a	A	
Aug 10	22 05 35	38.4	69.6	5.3	5	a	A	
Aug 11	06 37 39	38.4	69.4	-	10	a	A	
Aug 14	05 08 34	38.3	73.7	4.6	144	a	A	
Aug 15	12 10 49	29.7	68.6	4.8	33	a	A	
Aug 16	02 16 20	36.5	70.8	5.5	199	a	A	Event #14,1966, APP.C
Aug 21	11 43 11	36.5	71.0	-	167	a	A	
Aug 24	02 46 58	37.4	73.0	4.7	38	a	A	
Aug 24	04 32 40	36.9	73.5	4.9	182	a	A	
Aug 24	06 51 16	30.0	68.6	5.0	33	a	A	Event #15,1966, APP.C
Aug 28	10 43 02	36.4	70.9	4.8	180	a	A	
Aug 31	01 19 00	36.5	71.3	4.7	73	a	A	
Sep 01	19 03 46	29.7	68.8	4.8	33	a	A	
Sep 05	04 06 06	37.1	71.5	4.8	140	a	A	
Sep 08	12 18 15	36.5	70.4	4.8	225	a	A	
Sep 13	11 18 20	39.2	72.9	-	44	a	A	
Sep 17	08 40 59	36.4	70.7	4.8	204	a	A	
Sep 22	04 51 13	37.4	71.7	4.7	140	a	A	

DATE Yr Mo Dy	TIME Hr Mn Sc	LAT N	LONG E	MAG	DEPTH km	AUTH	SRCE	INTENSITY DATA
1966 Sep 25	14 02 46	39.3	72.2	4.6	45	a	A	
Sep 26	11 29 21	36.5	70.2	-	238	a	A	
Sep 29	-- -- --	37.3	72.1	4.6	160	g	G'	
Sep 30	05 59 53	38.8	64.5	5.1	33	a	A	
Oct 01	-- -- --	38.0	72.9	4.8	96	g	G'	
Oct 01	07 38 29	34.8	71.0	5.3	25	a	A	
Oct 07	-- -- --	37.7	71.7	5.4	33	g	G'	
Oct 16	09 26 37	30.0	68.6	4.9	33	a	A	
Oct 16	23 32 05	36.5	72.0	-	228	a	A	
Oct 23	00 00 02	29.9	68.2	4.8	25	a	A	
Oct 24	14 31 21	37.7	59.0	5.0	33	a	A	
Oct 25	10 06 58	29.9	68.9	5.3	6	a	A	
Oct 29	14 46 57	36.7	69.8	4.9	73	a	A	
Oct 29	-- -- --	27.5	66.5	4.7	33	g	G'	
Nov 02	-- -- --	37.3	72.3	4.5	200	g	G'	
Nov 04	22 17 32	34.0	72.5	-	35	a	A	
Nov 09	10 11 57	38.9	71.5	4.5	85	a	A	
Nov 19	19 05 38	37.0	71.4	4.9	130	a	A	
Nov 19	20 29 47	35.8	70.8	4.6	140	a	A	
Nov 20	23 35 46	27.6	67.7	4.8	36	a	A	
Nov 26	13 49 30	37.7	58.6	4.9	29	a	A	
Nov 29	10 11 02	36.4	70.2	4.5	228	a	A	
Dec 01	16 51 51	37.0	73.4	4.3	218	a	A	
Dec 05	-- -- --	36.6	70.0	4.4	160	g	G'	
Dec 06	02 30 53	36.2	70.0	4.9	58	a	A	
Dec 06	23 29 51	36.3	70.5	4.5	233	a	A	
Dec 07	-- -- --	36.2	70.1	4.3	223	g	G'	
Dec 08	02 07 07	29.3	69.9	5.1	37	a	A	
Dec 13	12 21 02	37.3	71.9	5.3	126	a	A	
Dec 21	-- -- --	36.2	70.7	4.4	287	g	G'	
Dec 25	17 07 01	37.2	70.1	4.6	91	a	A	
Dec 26	01 28 04	35.9	69.9	5.0	180	a	A	
Dec 29	21 35 20	29.9	68.3	4.6	14	a	A	
1967 Jan 02	10 31 21	29.8	69.1	-	16	a	A	
Jan 05	-- -- --	35.6	72.1	4.0	223	g	G'	
Jan 05	10 07 58	39.4	72.9	5.3	11	a	A	
Jan 08	-- -- --	36.5	70.8	4.2	223	g	G'	
Jan 14	10 59 25	39.1	70.6	4.9	25	a	A	
Jan 15	-- -- --	30.0	74.9	4.8	220	g	G'	
Jan 20	05 09 19	32.3	69.9	-	66	a	A	
Jan 20	-- -- --	36.5	71.3	4.3	280	g	G'	
Jan 20	05 16 40	32.3	69.8	5.1	70	a	A	
Jan 22	16 11 57	36.7	71.3	4.5	154	a	A	
Jan 25	01 50 19	36.6	71.6	5.7	281	a	A	Event #1, 1967, APP.C
Jan 26	11 02 54	30.0	68.7	4.9	33	a	A	
Jan 28	02 58 34	30.2	69.5	4.5	39	a	A	

TABLE D2

DATE Yr Mo Dy	TIME Hr Mn Sc	LAT N	LONG E	MAG	DEPTH km	AUTH	SRCE	INTENSITY DATA
1967 Feb 02	07 37 55	39.7	75.5	5.3	39	a	A	
Feb 10	-- -- --	36.5	71.3	4.0	280	g	G'	
Feb 10	05 46 28	33.0	75.5	4.9	27	a	A	
Feb 11	08 05 08	36.7	71.1	4.6	58	a	A	
Feb 12	16 06 48	35.8	71.0	5.2	100	a	A	
Feb 20	14 23 48	33.7	75.7	4.8	33	a	A	
Feb 20	15 18 40	33.7	75.3	5.7	24	a	A	
Feb 20	-- -- --	33.7	75.4	4.7	33	g	G'	
Feb 21	12 37 45	33.6	75.3	5.1	31	a	A	
Feb 21	-- -- --	33.8	75.3	4.5	33	g	G'	
Feb 21	-- -- --	33.6	75.2	4.6	33	g	G'	
Feb 21	-- -- --	33.6	75.6	5.5	33	g	G'	
Mar 11	06 31 09	36.4	70.7	5.0	220	a	A	Event #2, 1967, APP.C
Mar 14	14 35 12	36.5	70.6	4.8	193	a	A	
Mar 15	-- -- --	30.1	66.9	4.0	15	g	G'	
Mar 24	11 11 43	34.6	70.0	4.2	61	a	A	
Mar 25	22 26 29	28.8	60.3	4.9	41	a	A	
Mar 26	03 08 27	27.2	67.5	4.5	21	a	A	
Mar 30	13 09 51	36.2	70.9	4.4	172	a	A	
Apr 08	-- -- --	36.5	71.7	4.6	200	g	G'	
Apr 08	-- -- --	35.8	71.2	4.4	160	g	G'	
Apr 23	-- -- --	34.8	71.2	4.5	33	g	G'	
Apr 24	08 51 11	37.4	72.7	5.6	31	a	A	
Apr 26	04 59 43	36.6	71.0	4.4	119	a	A	
Apr 28	-- -- --	36.2	71.3	4.4	220	g	G'	
Apr 29	04 57 00	39.5	74.9	5.0g	33	a	A	
Apr 29	-- -- --	36.3	71.2	4.2	220	g	G'	
Apr 29	-- -- --	36.6	71.0	4.3	220	g	G'	
May 02	01 09 30	36.5	71.0	4.9	226	a	A	
May 05	03 11 24	36.1	68.8	4.8	18	a	A	
May 08	13 48 05	36.4	70.2	4.8	215	a	A	
May 08	20 36 01	36.2	71.1	4.4	111	a	A	
May 11	14 50 59	39.4	73.8	5.6	21	a	A	
May 12	05 21 05	39.5	73.8	4.9	5	a	A	
May 14	09 00 55	39.2	73.9	5.0	33	a	A	
May 20	08 47 20	39.2	72.8	5.1	33	a	A	
May 21	18 34 46	35.6	64.7	4.7	138	a	A	
May 22	17 41 21	37.0	68.0	4.8	37	a	A	
May 22	19 19 25	37.1	68.3	4.7	48	a	A	
May 27	12 42 54	36.2	71.5	4.9	109	a	A	
May 28	12 03 02	37.7	73.4	4.9	33	a	A	
May 30	18 56 29	31.7	70.1	4.6	36	a	A	
May 31	16 12 44	36.7	70.3	4.5	274	a	A	
Jun 18	16 39 12	36.4	71.9	5.0	83	a	A	
Jun 23	18 50 17	36.6	71.1	4.2	205	a	A	
Jun 24	-- -- --	36.5	70.3	4.5	160	g	G'	
Jul 02	08 32 30	33.2	75.6	4.8	33	a	A	
Jul 14	-- -- --	35.5	70.6	4.3	160	g	G'	

DATE Yr	Mo	Dy	TIME Hr	Mn	Sc	LAT N	LONG E	MAG	DEPTH km	AUTH	SRCE	INTENSITY DATA
1967	Jul	19	17	28	32	36.5	70.3	4.7	223	a	A	
	Jul	23	01	16	43	36.9	71.4	4.6	180	a	A	
	Jul	26	--	--	--	36.0	70.8	4.1	250	g	G'	
	Jul	29	14	12	19	35.5	70.8	4.6	194	a	A	
	Aug	04	08	06	59	34.8	70.1	4.8	33	a	A	
	Aug	06	10	31	06	38.0	74.5	4.8	215	a	A	Event #3, 1967, APP.C
	Aug	07	05	49	58	36.5	71.2	5.0	229	a	A	
	Aug	12	22	54	39	37.0	71.4	5.1	121	a	A	
	Aug	15	07	40	29	36.3	70.2	4.7	189	a	A	Event #4, 1967, APP.C
	Aug	19	01	34	44	36.9	71.5	4.9	127	a	A	
	Aug	27	04	50	00	36.3	71.1	4.5	225	a	A	
	Sep	08	00	26	03	36.9	71.5	5.0	111	a	A	
	Sep	08	05	23	41	38.4	70.5	4.9	14	a	A	
	Sep	11	06	12	01	27.5	66.4	4.6	36	a	A	
	Sep	18	08	26	37	35.9	70.4	4.8	140	a	A	
	Sep	22	22	11	48	36.2	71.4	4.7	127	a	A	
	Oct	02	17	49	51	37.6	72.1	4.3	105	a	A	
	Oct	13	03	24	47	39.7	74.4	5.2	33	a	A	
	Nov	07	19	57	26	37.0	71.7	5.3	136	a	A	
	Nov	12	10	40	36	36.3	71.4	5.1	98	a	A	
	Nov	16	00	41	25	37.6	69.7	4.7	33	a	A	
	Nov	29	05	19	01	36.4	70.8	4.8	228	a	A	
	Dec	04	15	35	34	36.1	71.2	4.9	143	a	A	
	Dec	09	04	56	14	36.3	70.8	4.8	225	a	A	
	Dec	17	00	25	15	36.5	71.4	5.2	82	a	A	
	Dec	19	03	23	56	37.5	72.0	5.5	89	a	A	
	Dec	19	--	--	--	36.4	70.0	4.4	223	g	G'	
	Dec	28	20	15	49	37.2	71.8	4.7	156	a	A	
	Dec	29	06	24	50	36.3	70.2	4.7	230	a	A	
1968	Jan	13	00	21	04	36.3	71.4	-	223	g	G	
	Jan	22	10	35	37	38.2	75.6	5.3	108	a	A	
	Jan	25	14	28	14	36.3	73.1	-	223	g	G	
	Jan	29	05	00	10	36.3	70.4	5.5	225	a	A	Felt at Pesh.,Lah.
	Jan	30	08	17	32	36.4	70.7	5.2	205	a	A	
	Feb	02	16	42	13	37.9	74.1	-	287	g	G	
	Feb	07	12	23	03	36.2	70.7	4.9	155	a	A	
	Feb	08	17	41	35	33.8	75.3	-	96	g	G	
	Feb	09	14	39	47	29.8	68.7	4.6	33	a	A	
	Feb	28	09	54	56	30.3	67.6	4.8	25	a	A	
	Mar	03	09	31	20	34.7	72.3	5.2	33	a	A	
	Mar	03	15	09	20	34.5	71.4	-	100	g	G	
	Mar	21	02	45	56	37.8	72.5	4.8	131	a	A	
	Mar	23	20	04	38	36.4	71.3	-	160	g	G	
	Mar	26	15	03	06	36.1	70.1	4.7	157	a	A	
	Mar	29	19	00	35	36.6	70.4	4.7	209	a	A	

DATE Yr Mo Dy	TIME Hr Mn Sc	LAT N	LONG E	MAG	DEPTH km	AUTH	SRCE	INTENSITY DATA
1968 Apr 05	06 17 45	35.8	70.2	-	160	g	G	
Apr 05	20 29 45	36.1	71.1	-	33	g	A	
Apr 05	21 54 30	36.4	71.0	-	223	g	A	
Apr 09	01 14 53	35.5	73.3	4.4	14	a	A	
Apr 09	01 26 47	36.2	71.1	4.1	160	g	G	
Apr 12	10 33 58	36.7	69.1	-	67	a	A	
Apr 16	07 34 17	32.7	69.5	-	33	g	G	
Apr 17	09 50 39	36.3	71.4	4.8	94	a	A	
Apr 17	13 11 37	36.4	71.5	5.2	113	a	A	
Apr 23	06 45 12	36.3	71.2	5.2	114	a	A	
Apr 26	15 03 07	35.9	70.2	-	160	g	G	
Apr 26	20 02 15	36.5	70.9	4.9	223	g	G	
May 06	20 49 46	36.5	70.8	5.0	231	a	A	
May 07	08 33 18	35.9	70.6	4.3	160	g	G	
May 08	22 45 08	37.1	71.9	5.1	160	a	A	
May 11	00 16 14	38.4	72.7	4.8	160	g	G	
May 12	05 22 50	36.5	71.3	-	160	g	G	
May 14	02 41 16	36.1	70.9	4.7	128	a	A	
May 15	15 50 16	36.4	71.2	4.9	223	g	G	
May 15	18 05 45	37.1	70.7	3.9	160	g	G	
May 19	16 56 51	36.2	70.7	-	160	g	G	
May 21	03 59 12	38.9	65.2	5.4	13	a	A	
Jun 05	00 09 41	36.1	66.2	4.8	33	a	A	
Jun 07	20 31 13	30.4	69.3	3.8	---	g	G	
Jun 09	19 17 25	35.8	70.2	4.0	160	g	G	
Jun 10	17 36 30	39.0	75.1	4.8	51	a	A	
Jun 11	01 31 24	36.3	71.1	3.9	160	g	G	
Jun 13	22 38 01	36.6	71.5	4.8	213	a	A	
Jun 14	04 02 22	31.2	70.2	4.9	25	a	A	
Jun 14	12 27 25	30.9	70.4	3.6	33	g	G	
Jun 17	01 19 00	36.8	71.2	-	160	g	G	
Jun 17	06 26 55	37.4	72.3	4.8	195	a	A	
Jun 28	01 04 02	30.9	68.9	4.1	---	g	G	
Jun 28	19 39 50	34.6	70.8	-	25	a	A	
Jul 03	19 46 54	34.7	75.1	4.5	113	a	A	
Jul 08	13 14 30	38.0	67.6	5.2	28	a	A	Felt Widely
Jul 12	12 26 59	36.0	70.6	4.1	223	g	G	
Jul 15	01 25 36	36.3	68.4	4.1	35	a	A	
Jul 16	11 13 40	36.0	71.2	4.0^{g}	137	a	A	
Jul 17	15 52 50	36.6	69.9	3.9	223	g	G	
Jul 17	06 22 19	37.0	71.4	-	160	g	G	
Jul 20	08 22 09	39.4	73.8	4.8	61	a	A	
Jul 26	20 48 03	32.1	70.1	4.8	35	a	A	
Aug 02	13 30 23	27.5	60.9	5.7	62	a	A	
Aug 04	00 23 53	36.2	70.4	-	223	g	G	
Aug 04	11 19 36	33.9	59.1	5.1	25	a	A	
Aug 04	19 03 58	38.1	72.0	4.5	160	g	G	
Aug 05	02 41 12	35.7	70.2	3.6	145	a	A	

DATE Yr Mo Dy	TIME Hr Mn Sc	LAT N	LONG E	MAG	DEPTH km	AUTH	SRCE	INTENSITY DATA
1968 Aug 08	18 40 25	37.8	72.0	4.9	160	g	G	
Aug 22	00 37 48	36.3	70.4	4.0	223	g	G	
Aug 26	18 23 41	36.4	70.7	5.0	203	a	A	
Aug 27	17 29 05	36.2	70.6	4.8	160	g	G	
Aug 30	21 11 20	34.9	59.5	-	33	a	A	
Aug 31	10 47 37	34.0	59.0	7.3*	13	a	A	Event #1, 1968, APP.C
Aug 31	11 34 33	33.9	59.2	5.5	24	a	A	
Aug 31	13 23 00	34.1	59.4	4.8	33	a	A	
Aug 31	14 06 16	34.1	59.4	5.0	18	a	A	
Sep 01	07 27 30	34.0	58.2	6.3*	15	a	A	
Sep 01	08 23 10	33.7	58.2	-	16	a	A	
Sep 01	11 04 02	34.0	59.6	4.8	33	a	A	
Sep 01	19 16 37	34.2	58.3	5.0	23	a	A	
Sep 01	21 16 45	34.4	58.0	4.8	44	a	A	
Sep 03	09 53 47	33.8	59.2	5.0	16	a	A	
Sep 03	18 48 16	36.2	69.2	5.3	75	a	A	Event #2, 1968, APP.C
Sep 04	05 54 08	35.1	58.5	4.7	33	a	A	
Sep 04	08 08 44	33.9	59.2	5.0	24	a	A	
Sep 04	11 19 36	33.4	54.1	5.1	25	a	A	
Sep 04	23 24 47	34.0	58.2	5.4	15	a	A	
Sep 06	02 27 37	34.0	59.3	4.9	27	a	A	
Sep 09	02 46 30	28.0	68.0	4.1	33	g	G	
Sep 10	17 18 09	36.3	70.8	5.0	223	a	A	
Sep 10	20 31 59	34.0	59.4	4.7	18	a	A	
Sep 11	08 27 01	36.2	71.4	-	160	g	G	
Sep 11	19 17 13	33.9	59.4	5.4*	33	a	A	
Sep 14	10 18 32	36.3	70.2	4.2	223	g	G	
Sep 14	20 30 42	36.3	69.8	-	193	a	A	
Sep 15	09 42 15	34.0	59.4	4.9	20	a	A	
Sep 15	14 16 56	37.2	72.7	5.2	33	a	A	
Sep 17	19 15 09	34.0	58.3	-	34	a	A	
Sep 18	07 37 22	37.2	71.9	5.0	123	a	A	
Sep 19	05 15 16	34.4	58.0	4.6	48	a	A	
Sep 26	00 46 14	33.7	69.9	5.2	45	a	A	
Sep 27	02 20 37	37.7	72.0	5.1	160	g	G	
Sep 27	10 37 56	37.8	72.3	5.2	119	a	A	
+Sep 29	14 29 47	33.7	72.1	4.3	33	g	G	
Oct 06	07 57 53	33.9	72.7	4.1	--	g	G	
Oct 07	21 22 29	34.0	72.6	-	33	g	G	
Oct 10	22 49 02	37.2	70.0	4.9	33	a	A	
Oct 11	03 16 50	36.0	69.5	4.7	185	a	A	
Oct 11	12 40 43	34.1	72.4	-	96	g	G	
Oct 11	22 48 56	38.2	70.2	-	160	g	G	
Oct 12	23 20 19	36.4	70.8	5.3	203	a	A	
Oct 13	01 34 54	34.0	58.7	-	47	a	A	
Oct 19	02 33 31	37.3	73.1	4.9	76	a	A	
Oct 19	07 01 33	37.3	73.2	5.2	51	a	A	
Oct 19	09 52 03	37.5	73.3	5.4	33	a	A	
Oct 30	04 07 21	37.4	73.2	5.5	12	a	A	

DATE Yr	Mo	Dy	TIME Hr	Mn	Sc	LAT N	LONG E	MAG	DEPTH km	AUTH	SRCE	INTENSITY DATA
1968	Nov	01	20	49	17	37.6	72.2	4.7	41	a	A	
	Nov	05	02	02	44	32.4	76.4	4.9	---	a	A	
	Nov	11	02	35	51	36.3	70.4	-	223	g	G	
	Nov	11	09	10	20	34.5?	70.2?	-	---	p	P	
	Nov	14	17	38	36	36.2	70.4	-	160	g	G	
	Nov	18	05	05	04	33.1	71.1	5.3	41	a	A	
	Nov	19	14	01	30	34.5?	70.2?	-	---	p	P	
	Nov	21	03	04	39	36.4	70.6	5.0	204	a	A	
	Nov	21	14	54	08	36.5	70.0	-	---	g	G	
	Nov	21	21	45	09	36.2	70.5	-	223	g	G	
	Dec	01	01	11	16	36.7	71.3	4.8	144	a	A	
	Dec	04	17	32	16	36.4	71.0	-	223	g	G	
	Dec	05	00	29	50	36.6	71.0	-	223	g	G	
	Dec	05	01	03	43	36.9	70.7	-	223	g	G	
	Dec	06	09	20	12	36.4	70.1	-	223	g	G	
	Dec	08	18	36	43	36.5	71.0	4.8	187	a	A	
	Dec	10	23	33	30	36.2	70.2	-	223	g	G	
	Dec	16	00	29	30	36.0	71.0	5.0	103	a	A	
	Dec	16	17	08	45	35.6	70.3	4.3	160	g	G	
	Dec	17	06	39	43	36.2	70.5	4.0	223	g	G	
	Dec	19	05	17	52	36.1	70.1	5.4	151	a	A	Event #4, 1968, APP.C
	Dec	20	23	37	56	36.4	71.0	4.7	197	a	A	
	Dec	23	23	20	00	36.4	70.6	4.7	225	a	A	
1969	Jan	03	03	16	38	37.1	57.9	5.6	11	a	A	
	Jan	04	01	32	20	36.4	71.1	-	160	g	G	
	Jan	05	02	38	52	39.9	75.8	4.8	---	a	A	
	Jan	06	17	29	40	36.3	71.2	-	223	g	G	
	Jan	06	19	37	07	36.2	70.9	-	223	g	G	
	Jan	09	07	45	03	38.2	74.0	5.0	137	a	A	
	Jan	12	22	21	42	35.6	70.1	-	160	g	G	
	Jan	21	14	37	15	38.3	69.7	5.1	52	a	A	
	Jan	22	04	16	12	35.7	70.0	4.3	141	a	A	
	Jan	22	19	42	22	32.2	70.0	4.7	41	a	A	
	Jan	23	20	01	20	32.2	76.0	4.0	---	a	A	
	Jan	23	23	46	26	32.2	76.0	-	---	a	A	
	Jan	26	09	59	12	38.2	73.8	5.1	138	a	A	
	Jan	27	10	59	27	37.3	71.5	5.2	49	a	A	
	Feb	16	15	03	38	38.2	73.1	-	160	g	G	
	Feb	17	05	27	42	36.2	70.8	-	160	g	G	
	Feb	18	19	51	28	29.7	68.4	4.6	51	a	A	
	Feb	19	15	20	11	37.4	71.8	-	160	g	G	
	Mar	03	06	20	26	30.1	79.8	-	33	g	G	
	Mar	03	14	03	01	31.0	71.8	4.5	33	a	A	
	Mar	05	19	33	23	36.4	70.7	5.9	208	a	A	Event #1, 1969, APP.C
	Mar	07	09	27	36	36.4	71.0	-	195	a	A	
	Mar	09	10	16	40	36.7	70.1	3.9	223	g	G	
	Mar	09	16	31	48	36.6	71.1	-	223	g	G	

DATE Yr Mo Dy	TIME Hr Mn Sc	LAT N	LONG E	MAG	DEPTH km	AUTH	SRCE	INTENSITY DATA
1969 Mar 10	08 27 21	36.4	69.6	-	223	g	G	
Mar 10	18 50 53	37.1	71.5	4.4	142	a	A	
Mar 10	19 04 03	36.4	71.0	5.1	201	a	A	Felt Slightly Warsak(g)
Mar 22	01 55 07	36.1	70.7	-	223	g	G	
Mar 22	04 52 33	38.9	70.6	5.3	8	a	A	
Mar 24	00 10 10	34.3	74.9	-	33	g	G	
Mar 27	11 19 29	39.0	71.9	4.9	37	a	A	
Mar 27	19 37 44	39.0	71.8	5.2	33	a	A	
Apr 01	05 49 08	36.3	70.8	4.6	212	a	A	
Apr 01	16 36 23	30.0	67.4	4.9	20	a	A	
Apr 03	00 03 21	37.1	71.8	-	155	a	A	
Apr 04	11 23 16	36.0	70.9	-	160	g	G	
Apr 10	15 58 40	36.3	70.1	-	223	g	G	
Apr 12	22 18 10	36.2	69.7	4.0	119	a	A	
Apr 14	18 07 11	36.1	71.0	4.5	147	a	A	
Apr 14	19 43 19	37.5	71.7	-	160	g	G	
Apr 17	03 21 16	30.1	69.9	4.5	7	a	A	
Apr 19	14 46 00	37.2	72.0	-	223	g	G	
Apr 21	04 16 30	37.6	71.0	-	223	g	G	
Apr 25	07 36 36	30.8	70.3	4.9	23	a	A	
Apr 27	04 59 41	36.9	71.2	4.8	96	g	G	
Apr 29	09 35 25	35.7	70.2	4.7	189	a	A	
Apr 30	03 37 06	38.2	73.9	4.7	223	g	G	
May 01	08 08 13	37.0	71.6	-	160	g	G	
May 04	03 22 04	36.4	71.5	4.6	126	a	A	
May 07	15 38 10	37.8	71.5	4.7	160	g	G	
May 08	17 49 52	38.1	72.3	-	33	a	A	
May 10	13 07 30	36.2	71.4	-	161	a	A	
May 11	08 56 24	35.7	71.4	-	160	g	G	
May 11	13 16 33	36.2	71.3	4.5	110	a	A	
May 13	10 04 37	39.9	70.9	4.8	33	a	A	
May 13	12 27 52	38.0	73.4	4.6	211	a	A	
May 14	17 03 19	36.8	71.5	-	160	g	G	
May 15	20 39 46	34.6	70.9	5.6	22	a	A	Event #2, 1969, APP.C
May 18	04 49 50	35.9	70.0	-	160	g	G	
May 19	10 01 48	36.1	71.3	4.6	141	a	A	
May 21	15 32 00	36.4	70.2	5.0	229	a	A	
May 31	03 36 28	33.1	72.5	-	160	g	G	
May 31	21 59 42	36.3	70.9	4.7	134	a	A	
Jun 02	17 53 05	36.3	71.2	4.8	228	a	A	
Jun 03	13 13 25	37.0	71.4	5.0	160	g	G	
Jun 05	06 00 29	36.7	71.2	4.6	232	a	A	
Jun 05	14 04 53	36.5	71.0	-	223	g	G	
Jun 06	10 56 14	36.1	70.8	-	160	g	G	
Jun 08	14 23 53	36.0	70.8	-	160	g	G	
Jun 10	22 52 12	36.4	70.7	5.4	203	a	A	Felt at Warsak, Pesh.
Jun 10	23 30 54	36.3	70.4	5.2	213	a	A	Event #3, 1969, APP.C
Jun 19	18 19 00	38.5	71.0	4.8	117	a	A	

DATE Yr Mo Dy	TIME Hr Mn Sc	LAT N	LONG E	MAG	DEPTH km	AUTH	SRCE	INTENSITY DATA
1969 Jun 24	06 23 20	37.3	69.8	-	223	g	G	
Jun 25	08 12 34	36.4	71.1	-	223	g	G	
Jun 29	12 44 05	36.3	70.6	4.8	223	a	A	
Jun 30	16 26 06	35.8	70.4	-	223	g	G	
Jul 08	19 34 57	37.5	72.1	-	223	g	G	
Jul 08	21 12 39	30.1	67.8	-	33	g	G	
Jul 09	19 54 40	36.2	70.5	-	223	g	G	
Jul 18	04 46 23	37.4	69.6	-	216	g	G	
Jul 19	08 47 25	36.4	70.2	-	216	g	G	
Jul 20	07 07 52	36.5	71.1	4.9	220	a	A	
Jul 25	17 38 32	36.2	69.9	-	33	g	G	
Jul 29	11 37 42	37.0	71.4	-	160	g	G	
Aug 04	07 56 06	36.9	69.2	-	96	g	G	
Aug 08	06 30 57	36.4	70.9	5.8	198	a	A	Event #4, 1969, APP.C
Aug 12	05 08 02	36.4	70.9	5.1	198	a	A	
Aug 16	06 23 16	39.3	74.7	-	160	g	G	
Aug 18	14 57 57	29.9	67.5	5.0	15	a	A	
Aug 20	11 51 23	37.2	75.4	-	223	g	G	
Aug 20	18 03 24	34.9	70.1	-	223	g	G	
Aug 20	20 27 00	34.6	70.7	-	160	g	G	
Aug 23	19 16 18	33.9	58.9	5.1	32	a	A	
Aug 24	20 31 18	36.3	70.5	-	223	g	G	
Aug 26	03 23 19	37.1	72.7	4.7	65	a	A	
Aug 27	22 35 54	35.4	71.4	5.2	55	a	A	
Aug 27	23 53 14	35.4	71.4	-	33	a	A	
Aug 28	03 58 35	39.1	73.6	5.1	20	a	A	
Aug 28	04 06 22	39.2	73.9	5.1	26	a	A	
Sep 03	23 39 03	34.3	58.3	4.8	33	a	A	
Sep 04	02 57 19	36.5	70.9	4.8	221	a	A	Event #5, 1969, APP.C
Sep 05	09 13 13	37.5	72.9	-	160	g	G	
Sep 05	21 12 54	39.3	73.6	-	223	g	G	
Sep 12	05 08 02	36.4	70.9	5.1	198	a	A	Event #6, 1969, APP.C
Sep 14	14 46 21	39.6	74.9	5.1	33	a	A	
Sep 14	16 15 25	39.7	74.9	5.6*	33	a	A	
Sep 14	23 45 40	37.7	72.5	-	33	g	G	Event #7, 1969, APP.C
Sep 16	21 19 27	39.8	75.1	4.9	19	a	A	
Sep 19	00 55 40	37.2	70.2	-	160	g	G	
Sep 19	18 31 55	36.3	70.3	-	160	g	G	
Sep 19	19 36 08	39.9	71.5	-	96	g	G	
Sep 20	04 48 46	29.7	68.6	5.2	40	a	A	
Sep 20	14 07 58	38.4	69.8	5.1	52	a	A	
Sep 21	19 09 54	36.0	69.3	4.7	72	a	A	
Sep 23	12 31 55	30.3	69.7	4.5	30	a	A	
Sep 24	04 42 15	37.7	72.2	-	160	g	G	
Sep 27	15 37 25	39.8	70.4	-	160	g	G	
Sep 27	16 56 20	39.4	74.9	-	160	g	G	
Sep 28	16 27 05	37.7	70.6	-	160	g	G	
Sep 28	18 53 29	39.3	73.6	5.0	62	a	A	
Sep 29	07 03 17	38.3	70.2	-	160	g	G	

DATE Yr Mo Dy	TIME Hr Mn Sc	LAT N	LONG E	MAG	DEPTH km	AUTH	SRCE	INTENSITY DATA
1969 Oct 01	10 19 28	29.1	68.7	-	33	g	G	
Oct 01	22 48 13	36.5	70.9	4.9	230	a	A	
Oct 04	15 55 49	35.0	70.5	4.7	195	a	A	
Oct 14	23 02 35	39.7	72.5	-	160	g	G	
Oct 15	16 32 20	35.9	70.9	-	223	g	G	
Oct 17	12 27 54	36.3	70.6	-	223	g	G	
Oct 18	06 50 07	36.6	70.7	-	223	g	G	
Oct 19	18 05 46	35.1	72.3	-	160	g	G	
Oct 20	10 25 30	35.2	72.3	4.5	160	g	G	
Oct 23	06 53 07	37.7	71.0	-	223	g	G	
Oct 27	18 29 59	36.1	70.4	4.7	192	a	A	
Oct 28	18 45 11	36.5	70.9	5.0	229	a	A	
Oct 28	21 28 41	36.3	71.1	-	223	g	G	
Nov 05	02 16 30	37.5	70.3	-	160	g	G	Felt
Nov 07	00 00 34	36.7	70.4	-	160	g	G	
Nov 07	18 34 00	27.9	60.1	6.7	35	a	A	
Nov 09	14 25 05	36.1	68.8	-	223	g	G	
Nov 11	00 25 00	36.3	71.6	-	223	g	G	
Nov 15	04 37 18	36.1	70.7	-	223	g	G	
Nov 24	17 23 20	37.2	71.7	5.6	123	a	A	
Nov 24	22 14 36	36.5	70.6	4.9	223	g	G	
Nov 25	15 46 56	36.2	70.9	-	223	g	G	
Nov 25	21 01 39	36.2	70.4	-	160	g	G	
Dec 02	10 17 40	34.5	73.9	-	96	g	G	
Dec 02	18 17 01	36.5	70.6	5.1	206	a	A	
Dec 02	22 46 16	33.9	58.6	5.1	33	a	A	
Dec 03	16 44 20	36.4	71.1	4.7	211	a	A	
Dec 05	15 22 29	37.5	72.0	-	160	g	G	
Dec 06	04 33 15	37.9	73.0	4.9	131	a	A	
Dec 08	03 13 05	37.4	71.9	-	160	g	G	
Dec 08	17 36 06	35.6	70.1	-	160	g	G	
Dec 12	22 34 27	36.6	69.9	-	160	g	G	
Dec 14	17 31 38	37.0	70.1	-	160	g	G	
Dec 15	03 46 18	36.3	68.5	-	39	a	A	
Dec 15	21 03 35	37.2	71.6	-	160	g	G	
Dec 16	11 01 59	36.6	70.7	-	160	g	G	
Dec 17	06 36 06	36.5	71.3	4.5	63	a	A	
Dec 20	04 23 28	36.0	70.5	-	160	g	G	
Dec 20	21 27 53	36.3	71.1	-	160	g	G	
Dec 21	19 13 42	36.5	70.2	-	160	g	G	
Dec 22	04 53 33	35.9	69.9	-	223	g	G	
Dec 22	12 48 36	37.7	72.4	-	160	g	G	
Dec 24	14 58 42	36.6	70.6	-	223	g	G	
Dec 25	18 07 45	36.6	71.5	-	223	g	G	
Dec 28	16 50 00	36.4	71.2	4.8	202	a	A	
Dec 29	18 08 56	37.0	71.8	4.7	42	a	A	
Dec 31	09 10 56	36.1	70.7	-	96	g	G	

DATE Yr Mo Dy	TIME Hr Mn Sc	LAT N	LONG E	MAG	DEPTH km	AUTH	SRCE	INTENSITY DATA
ADDENDUM+:								
1927 Jul 15	03 46 43	36.5	70.5	5.8f	250	b	A	
1941 Sep 29	-- -- --	30.7	67.2	5.8	0-50	g	G'	Event #2, 1941, APP.C
1958 Mar 27	-- -- --	37.0	71.0	7.3	200	g	G'	
Apr 03	-- -- --	36.5	71.0	6.0	100	g	G'	
1962 Sep 15	-- -- --	32.3	75.7	6.0	0-50	g	G'	
1968 Sep 28	09 25 37	27.6	66.9	5.2	33	a	A	

TABLE D3

TEMPORAL DISTRIBUTION OF RECORDED EARTHQUAKES IN THE REGION 27°-40°N AND 58°-76°E

YEAR	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC	TOTALS ALL	TOTALS STRONG
to 1899	1	-	-	-	-	-	-	1	2	-	3	-	7	4
to 1904	-	-	-	-	-	-	-	1	-	-	-	-	1	1
to 1909	-	-	1	3	-	-	1	1	-	5	-	1	12	11
to 1914	-	2	-	1	1	1	2	1	-	-	1	-	9	9
to 1919	-	-	-	2	-	1	-	-	-	-	1	-	4	3
to 1924	-	-	-	-	1	-	-	-	2	1	1	3	8	7
1925	-	-	1	-	-	1	-	-	-	-	-	2	4	3
1926	-	-	1	1	-	-	1	-	-	-	-	-	3	-
1927	-	-	-	2	-	-	2	-	-	-	-	-	4	3
1928	-	1	-	1	-	1	1	1	1	1	1	-	8	6
1929	-	1	4	-	2	-	1	-	1	-	-	1	10	4
1930	1	1	2	-	-	-	2	1	5	1	-	1	14	2
1931	2	-	-	1	-	-	-	6	2	1	2	-	14	6
1932	-	2	1	2	-	-	-	1	2	2	-	-	10	3
1933	3	-	-	-	2	3	1	-	-	1	-	2	12	2
1934	1	1	-	2	1	3	2	1	11	-	2	2	26	4
1935	4	1	-	3	5	4	6	1	1	4	-	1	30	10
1936	2	1	-	2	1	5	1	4	2	1	3	1	23	2
1937	-	-	-	3	1	-	1	-	2	1	2	1	11	3
1938	3	1	-	1	1	-	-	1	-	1	1	1	10	1
1939	-	1	-	2	2	2	3	2	1	3	2	1	19	2
1940	1	2	3	1	3	2	2	1	3	1	2	2	23	8
1941	-	2	1	7	3	1	1	1	3	1	1	-	21	8
1942	1	1	1	-	2	-	1	1	-	-	2	-	9	1
1943	3	3	-	1	-	1	-	1	2	2	2	3	18	5
1944	-	-	3	1	1	-	-	1	4	2	2	1	15	2
1945	-	2	-	-	1	1	-	-	-	2	-	-	6	1

TABLE D3

YEAR	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC	TOTALS ALL	TOTALS STRONG
1946	2	1	1	1	-	1	-	-	-	-	-	1	7	-
1947	1	1	-	3	-	1	1	3	2	3	3	1	19	3
1948	2	-	-	-	-	2	3	-	1	3	2	2	15	3
1949	-	2	2	3	1	-	41	8	2	-	1	2	62	5
1950	1	1	5	2	5	3	3	3	7	1	4	2	37	2
1951	7	-	2	6	4	1	3	4	1	3	2	3	36	3
1952	-	1	3	-	2	9	2	3	3	8	3	7	41	2
1953	-	-	-	-	6	2	6	1	1	-	2	3	21	-
1954	5	5	4	4	2	1	3	4	1	1	-	-	30	-
1955	1	1	5	5	1	2	4	3	-	1	-	1	24	5
1956	1	-	1	3	2	12	6	1	7	4	4	1	42	11
1957	4	-	2	2	4	3	5	8	8	3	7	2	48	6
1958	5	5	11	5	5	1	-	6	4	2	6	7	57	12
1959	3	2	6	1	3	4	5	7	4	2	3	4	44	5
1960	3	7	1	2	6	2	9	6	3	2	4	3	48	6
1961	1	2	2	5	4	7	5	5	4	2	7	2	46	4
1962	5	3	5	18	9	18	11	12	16	15	11	12	135	4
1963	17	12	19	13	18	13	13	13	16	23	4	8	169	2
1964	11	10	9	1	4	3	4	1	3	7	8	3	64	3
1965	4	3	4	9	4	10	9	9	11	14	6	9	92	3
1966	14	26	13	14	13	12	11	23	10	10	8	12	166	4
1967	13	12	7	9	15	3	6	7	5	2	4	7	90	-
1968	5	5	6	12	12	10	9	14	30	12	10	13	138	2
1969	14	4	14	15	16	13	8	15	22	14	12	25	172	3
TOTALS:														
ALL	141	125	140	169	163	159	195	182	205	162	139	153	1933	
STRONG	13	14	19	22	17	16	21	14	24	19	13	7		199

TABLE D4

TEMPORAL DISTRIBUTION OF RECORDED EARTHQUAKES WITHIN AFGHANISTAN

YEAR	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC	TOTALS ALL	TOTALS STRONG
to 1904	-	-	-	-	-	-	-	-	-	-	-	-	-	-
to 1909	-	-	1	2	-	-	1	-	-	2	-	1	7	7
to 1914	-	1	-	1	1	1	1	1	-	-	1	-	7	6
to 1919	-	-	-	2	-	1	-	-	-	-	-	-	3	3
to 1924	-	-	-	-	1	-	-	-	1	1	1	2	6	5
1925	-	-	1	-	-	1	-	-	-	-	-	1	3	3
1926	-	-	1	-	-	-	-	-	-	-	-	-	1	-
1927	-	-	-	2	-	-	-	-	-	-	-	-	2	2
1928	-	-	-	-	-	1	1	1	-	-	-	-	3	2
1929	-	1	2	-	-	-	-	-	1	-	-	1	5	3
1930	-	-	-	-	-	-	-	-	2	-	-	1	3	1
1931	2	-	-	-	-	-	-	1	1	1	1	-	6	4
1932	-	2	1	2	-	-	-	-	-	-	-	-	5	2
1933	2	-	-	-	2	1	-	-	-	1	-	2	8	2
1934	-	-	-	2	-	1	2	-	1	-	2	1	9	2
1935	-	1	-	2	3	2	2	-	-	1	-	1	12	4
1936	1	1	-	-	1	2	-	2	-	-	1	-	8	1
1937	-	-	-	1	-	-	-	-	1	1	1	-	4	2
1938	2	1	-	1	-	-	-	1	-	1	1	-	7	1
1939	-	1	-	1	1	1	-	-	1	2	1	1	9	1
1940	1	1	2	-	1	1	2	-	3	1	2	1	15	6
1941	-	-	1	3	2	1	-	1	-	-	1	-	9	4
1942	-	-	1	-	1	-	-	-	-	-	1	-	3	1
1943	-	2	-	-	-	-	-	-	1	1	-	3	7	2
1944	-	-	-	1	-	-	-	-	-	-	1	1	3	-
1945	-	1	-	-	-	-	-	-	-	1	-	-	2	-
1946	2	1	-	1	-	1	-	-	-	-	-	-	5	-
1947	1	1	-	1	-	1	1	2	1	1	2	1	12	1

TABLE D4

YEAR	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC	TOTALS ALL	TOTALS STRONG
1948	2	-	-	-	-	2	2	-	1	-	-	1	8	1
1949	-	-	2	2	1	-	3	-	-	-	-	1	9	1
1950	-	-	2	-	2	-	1	-	2	1	-	2	10	1
1951	3	-	1	1	1	1	2	2	-	2	2	1	16	2
1952	-	-	-	-	1	6	2	1	-	5	2	3	20	-
1953	-	-	-	-	3	1	3	-	-	-	2	2	11	-
1954	-	3	2	1	1	1	2	2	1	1	-	-	14	-
1955	1	-	2	-	1	-	1	1	-	1	-	1	8	1
1956	-	-	1	1	-	7	4	1	6	3	2	1	26	8
1957	2	-	1	2	2	2	2	5	4	1	4	2	27	3
1958	1	2	8	3	2	-	-	1	2	-	3	5	27	11
1959	3	2	2	1	2	1	4	2	2	1	1	3	24	3
1960	2	6	1	2	5	-	6	3	2	1	1	2	31	6
1961	1	1	1	3	2	3	2	3	3	-	3	2	24	3
1962	3	3	5	14	7	9	7	8	11	10	7	5	89	2
1963	10	8	12	11	8	9	7	9	7	5	4	7	97	1
1964	8	4	4	1	4	3	2	1	3	3	6	2	41	3
1965	1	2	4	5	4	8	7	4	9	9	2	7	62	2
1966	3	5	6	7	9	8	8	7	5	4	3	9	74	1
1967	4	3	4	7	9	3	5	6	3	1	3	6	54	-
1968	3	1	3	11	8	6	5	5	7	7	6	13	75	-
1969	6	2	8	10	12	13	6	9	6	9	9	18	108	2
TOTALS:														
ALL	64	56	79	104	97	98	91	79	87	78	76	110	1019	
STRONG	9	7	18	13	9	12	11	5	11	8	8	5		116

TABLE D5

TEMPORAL DISTRIBUTION OF RECORDED EARTHQUAKES IN THE DEEP EARTHQUAKE ZONE (SEE FIG. 35)

YEAR	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC	TOTALS ALL	TOTALS STRONG
to 1904	-	-	-	-	-	-	-	-	-	-	-	-	-	-
to 1909	-	-	1	2	-	-	1	-	-	2	-	1	7	7
to 1914	-	1	-	1	1	1	1	1	-	-	1	-	7	6
to 1919	-	-	-	2	-	1	-	-	-	-	-	-	3	2
to 1924	-	-	-	-	1	-	-	-	1	1	1	2	6	5
1925	-	-	-	-	-	1	-	-	-	-	-	1	2	2
1926	-	-	1	-	-	-	-	-	-	-	-	-	1	-
1927	-	-	-	2	-	-	-	-	-	-	-	-	2	2
1928	-	-	-	-	-	1	1	1	-	-	-	-	3	2
1929	-	1	2	-	-	-	-	-	-	-	-	-	3	3
1930	-	-	-	-	-	-	-	-	3	-	-	1	4	1
1931	2	-	-	-	-	-	-	1	1	1	-	-	5	4
1932	-	2	1	2	-	-	-	-	-	-	-	-	5	2
1933	2	-	-	-	2	-	-	-	-	-	-	-	4	1
1934	-	-	-	1	-	1	1	-	-	-	2	1	6	2
1935	-	1	-	1	1	1	-	-	-	1	-	1	6	4
1936	1	-	-	-	-	1	-	2	-	-	-	-	4	1
1937	-	-	-	1	-	-	-	-	1	1	1	-	4	2
1938	2	-	-	1	-	-	-	1	-	1	1	-	6	1
1939	-	1	-	-	-	1	-	-	-	-	1	1	4	1
1940	-	1	-	-	1	1	2	-	1	-	2	1	9	6
1941	-	-	1	3	2	1	-	-	1	-	1	-	9	4
1942	-	-	1	-	1	-	-	-	-	-	1	-	3	1
1943	-	2	-	-	-	-	-	-	1	-	-	2	5	2
1944	-	-	-	1	-	-	-	-	-	-	1	1	3	-
1945	-	1	-	-	-	-	-	-	-	1	-	-	2	-
1946	2	1	-	-	-	1	-	-	-	-	-	-	4	-

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TABLE D5

YEAR	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC	TOTALS ALL	TOTALS STRONG
1947	1	1	-	1	-	-	-	1	-	-	1	1	6	1
1948	1	-	-	-	-	2	2	-	1	-	-	1	7	-
1949	-	-	2	1	1	-	2	-	-	-	-	-	6	1
1950	-	-	2	-	2	-	1	-	1	1	-	2	9	1
1951	3	-	1	-	1	1	2	2	-	2	-	1	13	2
1952	-	-	-	-	1	4	1	-	-	3	2	2	13	-
1953	-	-	-	-	1	1	1	-	-	-	2	2	7	-
1954	4	4	1	1	1	2	1	3	1	-	-	-	18	-
1955	1	-	2	-	-	-	-	-	-	1	-	1	5	1
1956	-	-	-	1	-	-	3	-	2	2	2	1	11	3
1957	2	-	2	1	-	1	3	4	3	1	2	2	21	4
1958	-	2	4	2	2	-	-	2	1	-	3	4	20	8
1959	2	1	1	-	-	1	3	1	2	-	-	3	14	2
1960	2	6	1	2	2	-	2	1	2	1	1	2	22	5
1961	1	1	1	3	1	3	2	2	3	1	1	2	21	2
1962	3	1	3	12	5	7	5	6	5	8	4	7	66	1
1963	7	7	11	8	8	5	5	7	6	5	4	6	79	1
1964	8	5	5	1	4	2	2	1	3	3	5	2	41	2
1965	2	1	2	3	4	7	7	7	11	8	4	4	60	2
1966	2	4	5	4	4	9	8	6	6	1	4	7	60	1
1967	4	3	3	7	5	2	3	5	3	1	3	7	46	-
1968	3	1	4	8	8	4	4	6	7	1	5	12	63	-
1969	4	2	7	8	8	11	6	3	5	7	7	17	85	2
TOTALS:														
ALL	59	50	64	80	67	73	69	63	71	54	62	98	810	
STRONG	8	7	13	11	7	10	10	6	8	7	8	5		100

IDENTIFICATION OF DATA SOURCES AND AUTHORITIES

The Data Source and Authority codes used in Tables D1 and D2 are identified as follows:

DATA SOURCES:

CODE	DATA SOURCE
A	United States Coast & Geodetic Hypocentral Data File
E	Atlas of Earthquakes in the U.S.S.R. (Ref. 31)
G	Preliminary Seismological Bulletin of Pakistan Geophysical Centre
G'	List of Significant Earthquakes In and Around Pakistan During 1905 and 1967, Pakistan Meteorological Department, Geophysical Centre, Quetta, 1969
P	Kabul University Seismological Center Earthquake Files

AUTHORITIES:

CODE	AUTHORITY
a	United States Coast & Geodetic Survey, Rockville, Maryland, U.S.A.
b	Seismicity of the Earth, Gutenberg & Richter (Ref. 5)
c	Bureau Central International De Seismologie, Strasbourg, France
d	International Seismological Summary, Kew Observatory, England
e	U.S.S.R. Institute of Physics, Moscow, U.S.S.R. (MOS)
f	Seismological Laboratory, California Institute of Technology, Pasadena, California, U.S.A. (PAS)
g	Geophysical Centre, Pakistan Meteorological Department, Quetta, Pakistan (QUE)
h	Charles University, Geophysical Institute, Prague (PRAH), Czechoslovakia (PRA)
i	Strasbourg, France (STR)
j	Institute Nazionale Di Geo Fisica, Rome, Italy (ROM)
k	Seismological Institute, University of Uppsala, Uppsala, Sweden (KIR)

Authorities: (cont'd.)

CODE	AUTHORITY
l	India Meteorological Department, Central Seismological Observatory, Shillong, India (SHL)
m	Karachi, Pakistan (KAR)
n	Seismological Institute, University of Uppsala, Uppsala, Sweden (UPP)
o	Japan Meteorological Agency, Tokyo, Japan (MAT)
p	Kabul University Seismological Center, Kabul, Afghanistan (KBL)
r	United Kingdom Meteorological Office, Kew Observatory, Richmond, England (KEW)
s	Pakistan Geophysical Institute (WRS)
t	Khorog, Tadzhik, U.S.S.R. (KHO)
u	College Observatory, Coast & Geodetic Survey, College, Alaska, U.S.A. (COL)
v	Landeserdbebendienst, Stuttgart, Germany (STU)
w	Tulsa, Oklahoma, U.S.A. (TUL)
x	University of Helsinki, Institute of Seismology, Helsinki, Finland (NUR)

NOTE: In the above listing of authorities, the three letter codes are the station code letters for the seismic station operated by the authority.

F I G U R E S

FIGS. 1 to 36

NOTE: Enlarged copies of Fig. 1 and Fig. 35 can be found in the pocket on the back cover of this report.

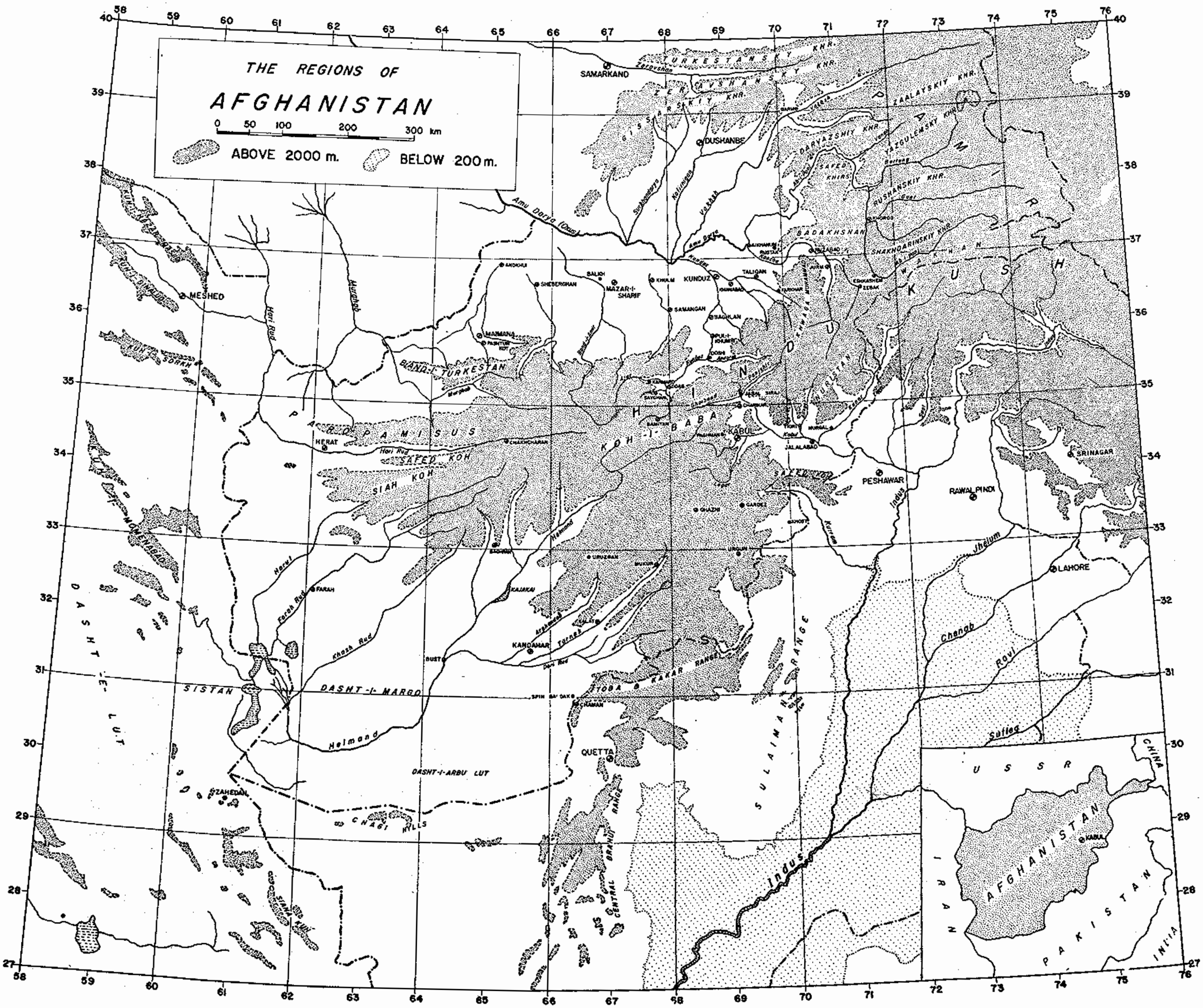

FIG. 1 MAP OF THE REGIONS OF AFGHANISTAN

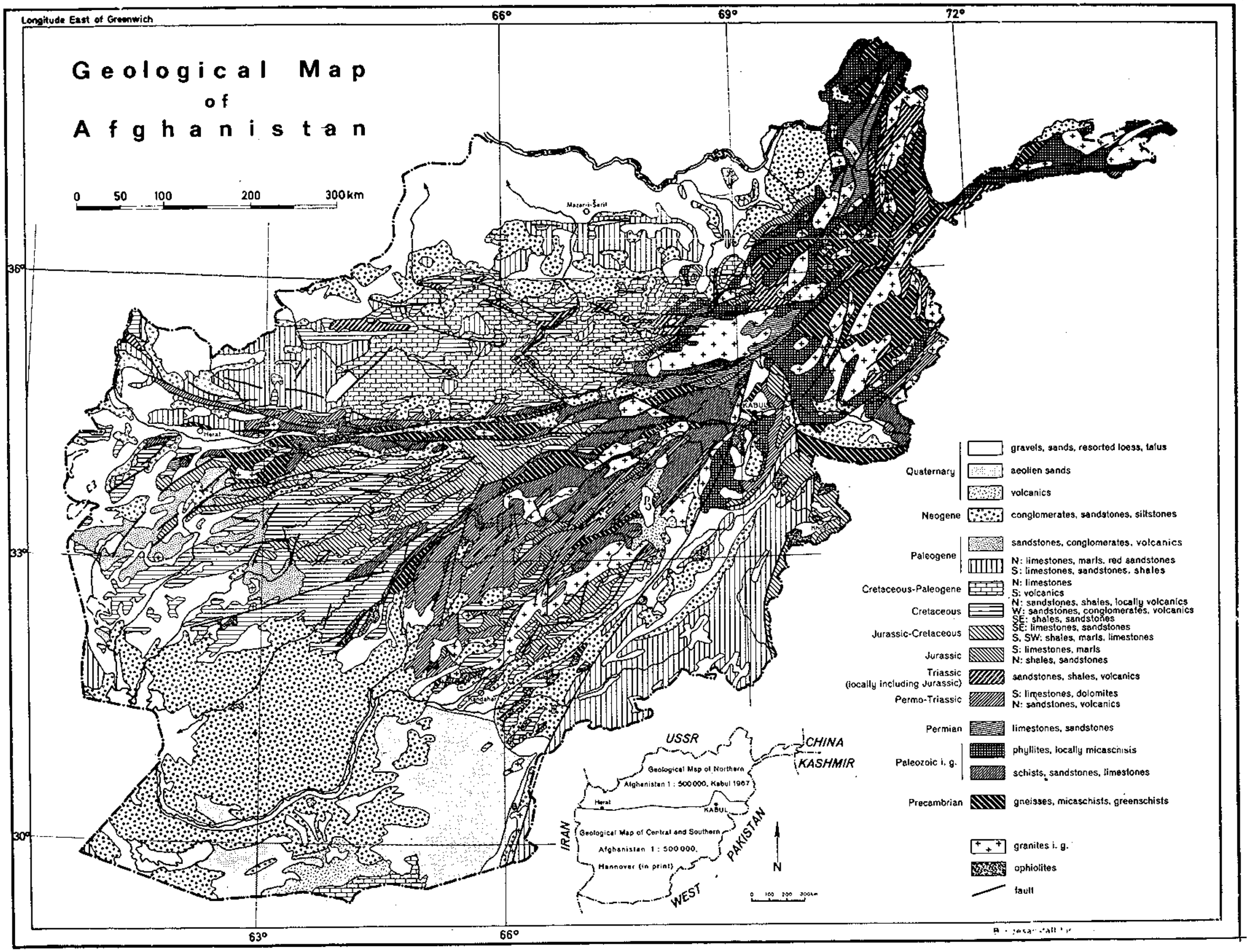

FIG. 2 GEOLOGICAL MAP OF AFGHANISTAN

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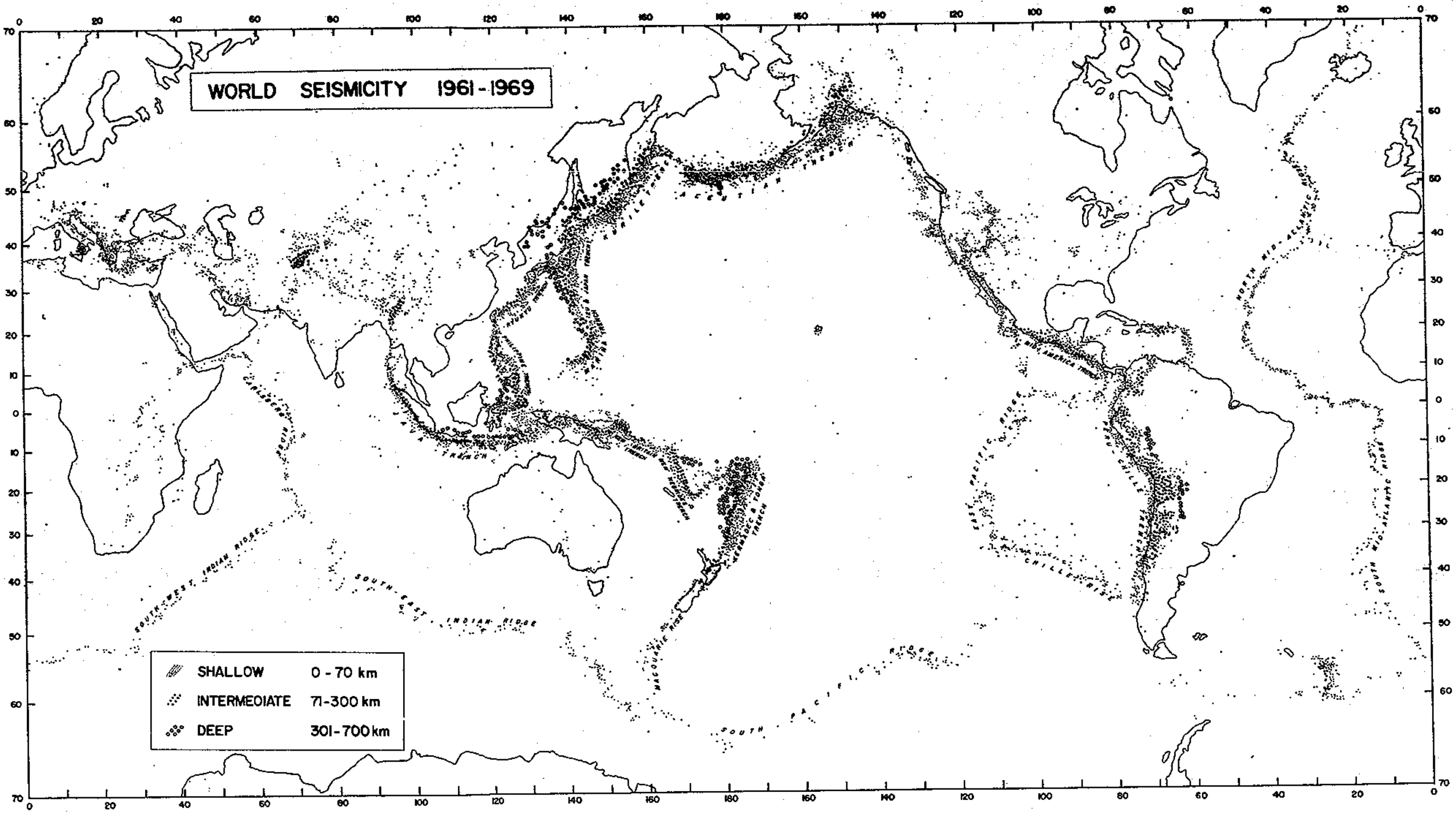


FIG. 3 WORLD SEISMICITY MAP 1961-1969
Depth of Foci, Shallow, Intermediate and Deep

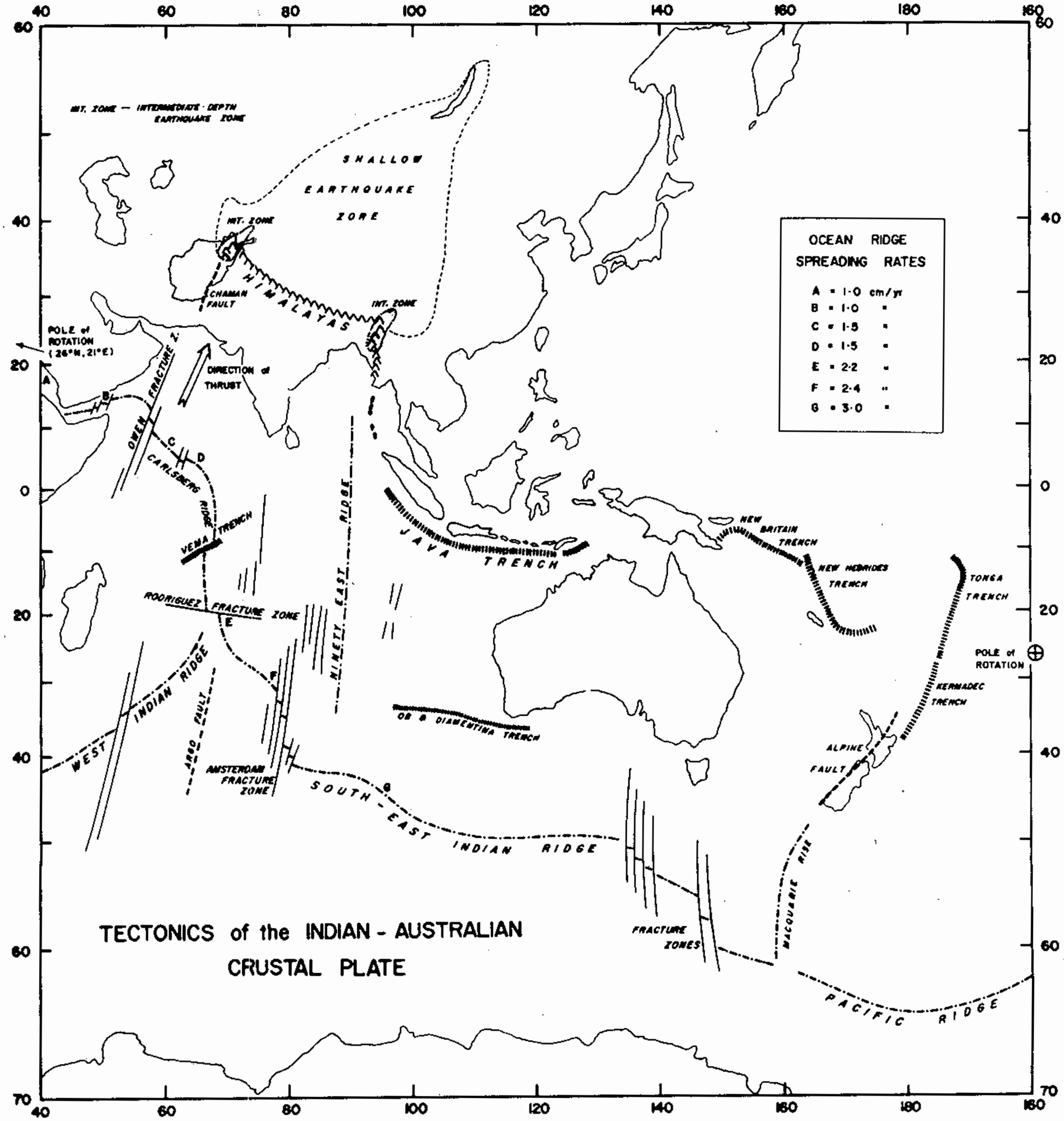


FIG. 4 TECTONIC AND PHYSIOGRAPHIC MAP OF THE INDIAN-AUSTRALIAN CONTINENTAL CRUSTAL PLATE

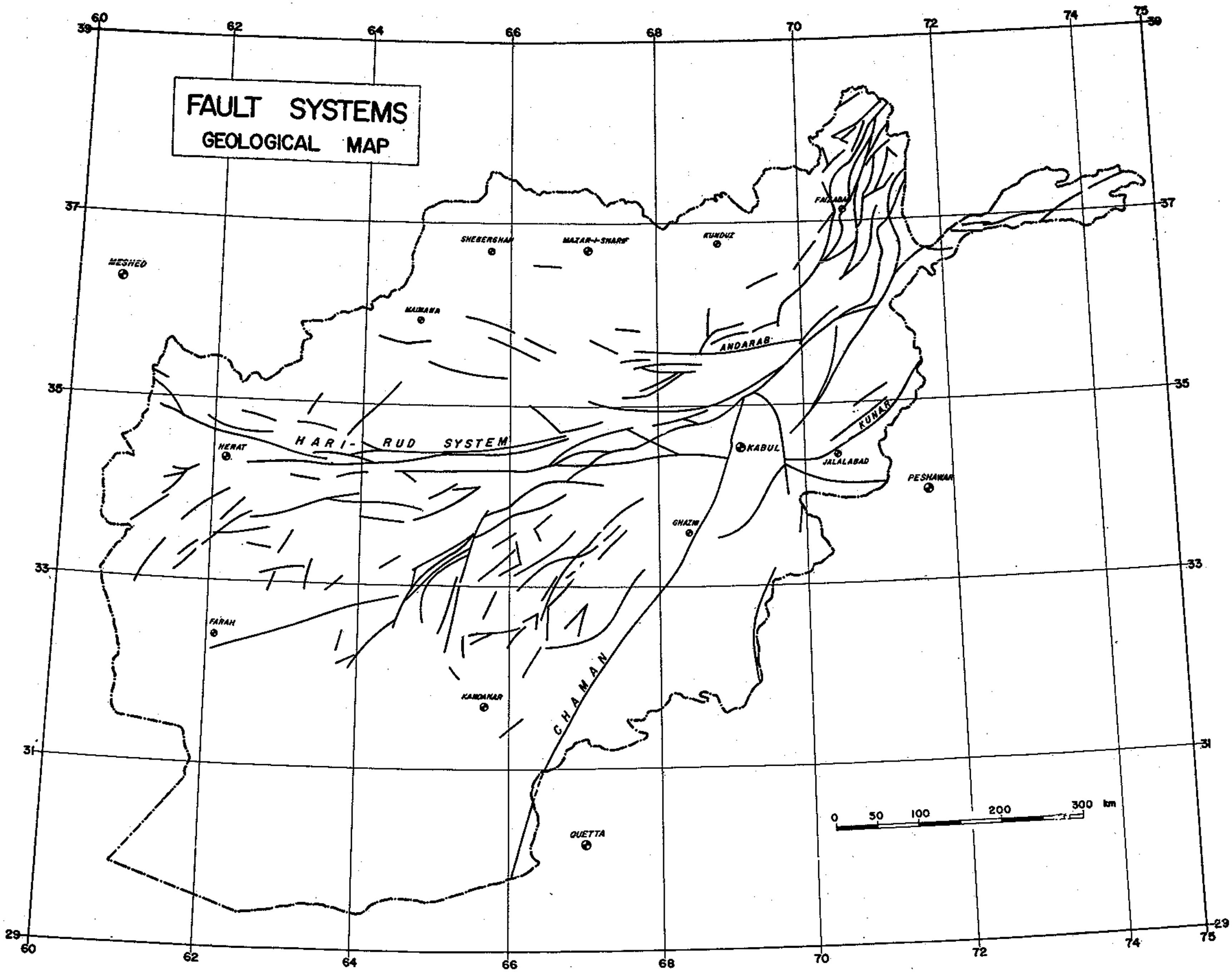


FIG. 5 FAULT SYSTEMS IN AFGHANISTAN FROM THE GEOLOGICAL MAP (Fig. 2)

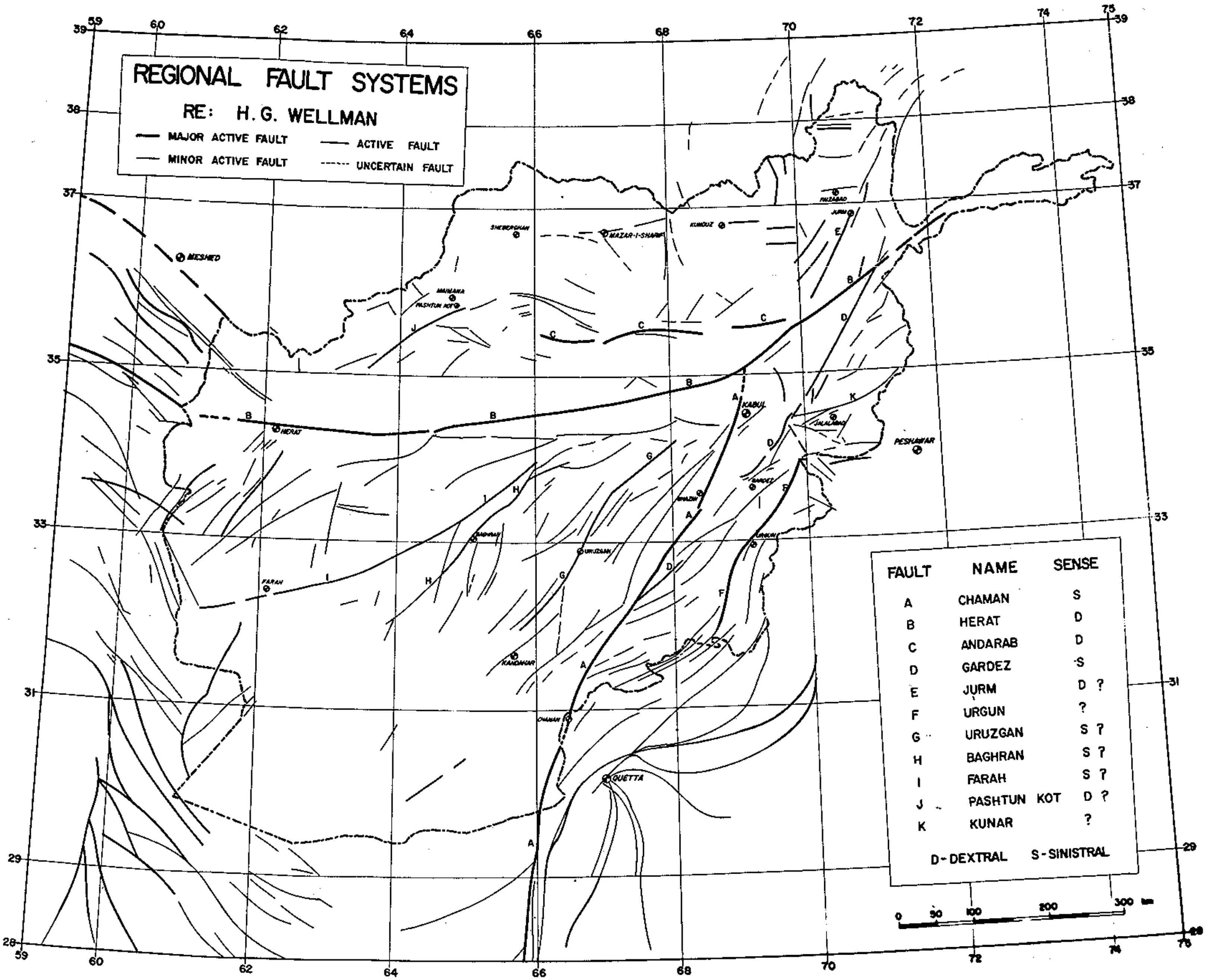


FIG. 6 REGIONAL FAULT SYSTEMS MAPPED BY H.W. WELLMAN (Ref. 48)

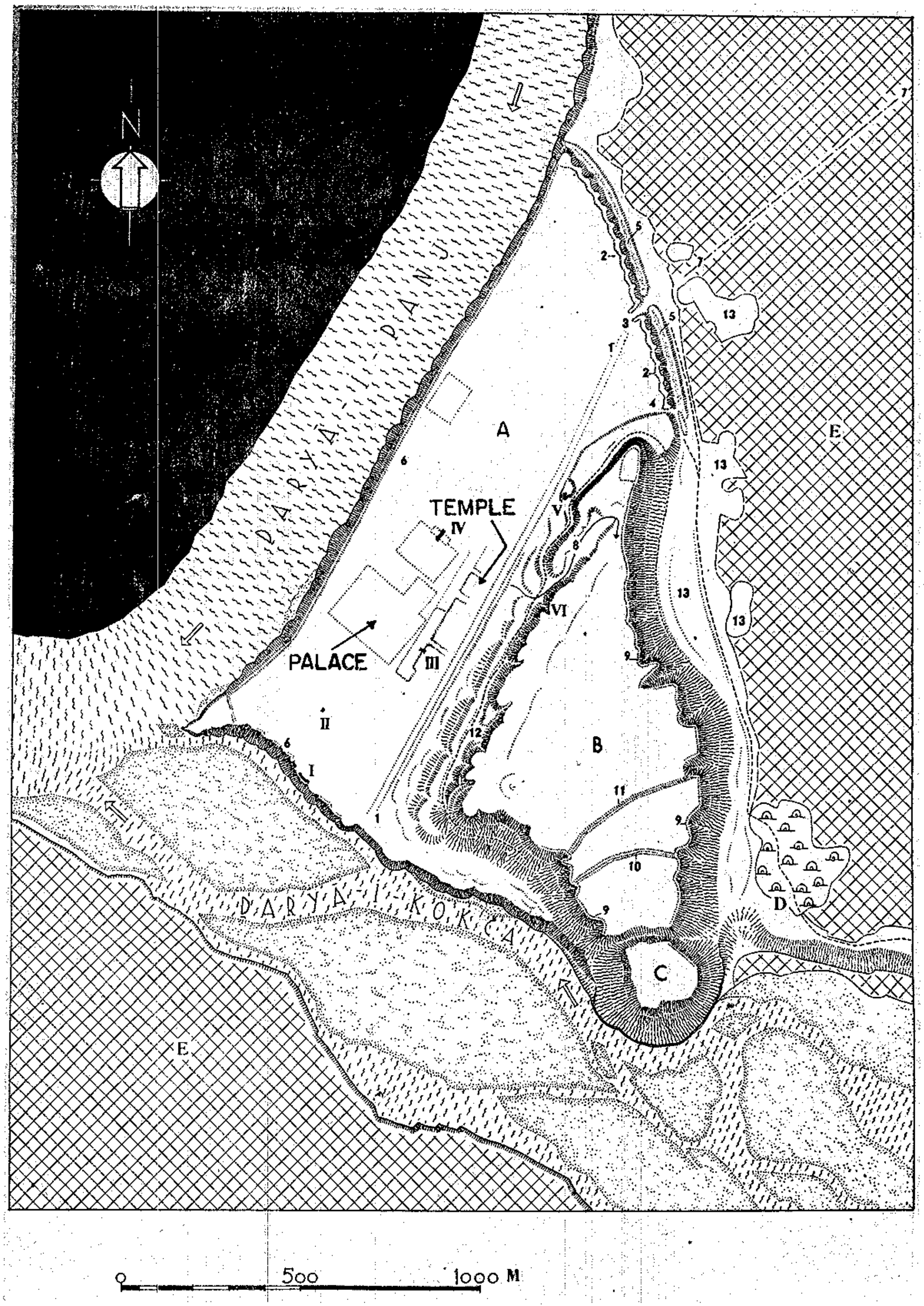


FIG. 7 PLAN MAP OF AIKHANUM SITE
(Courtesy of Délégation Archéologique en Afghanistan)

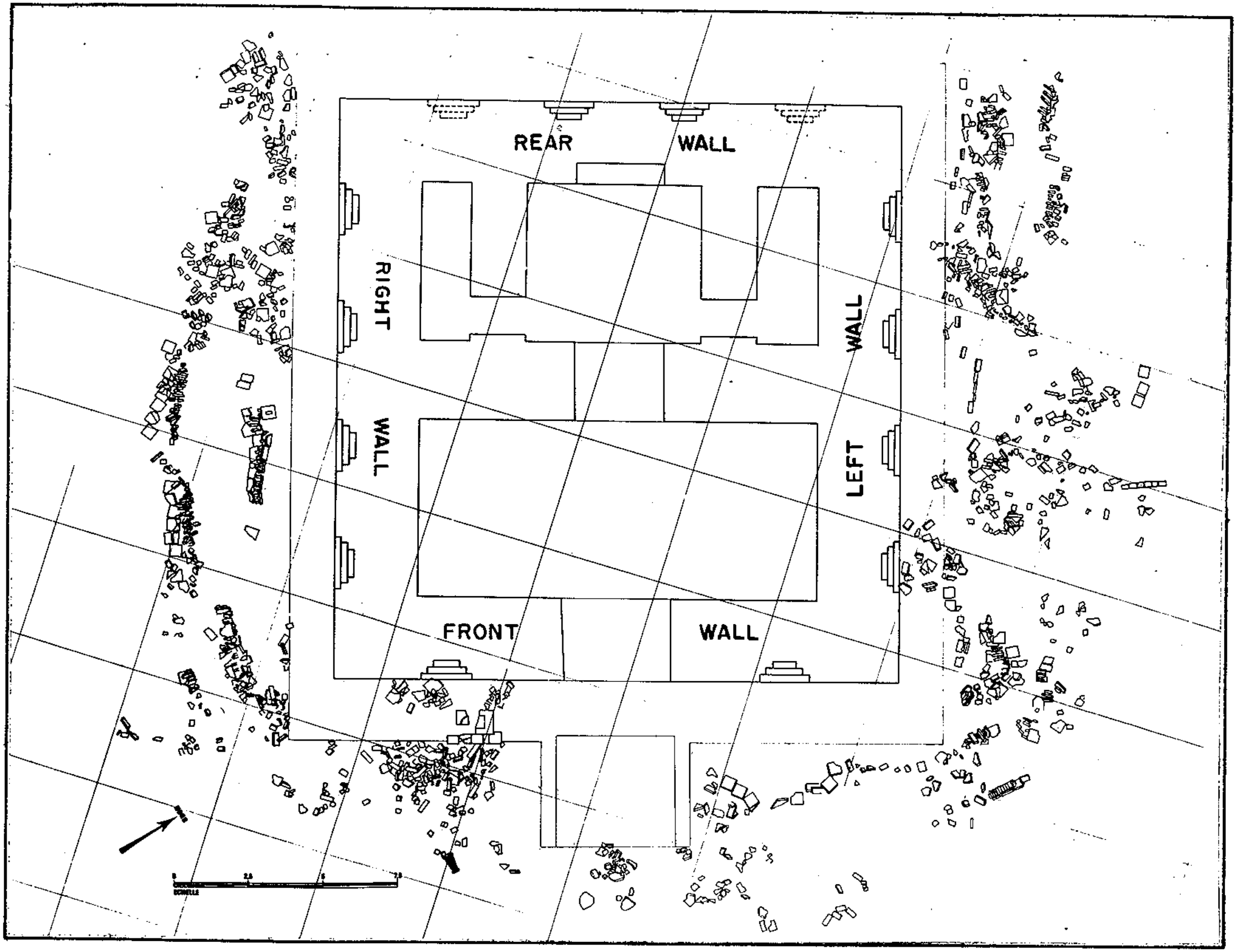


FIG. 8 PLANFORM OF THE TEMPLE AT AIKHANUM ILLUSTRATING DISTRIBUTION OF CORNICE FRAGMENTS
(Courtesy of Délégation Archéologique Francaise en Afghanistan)

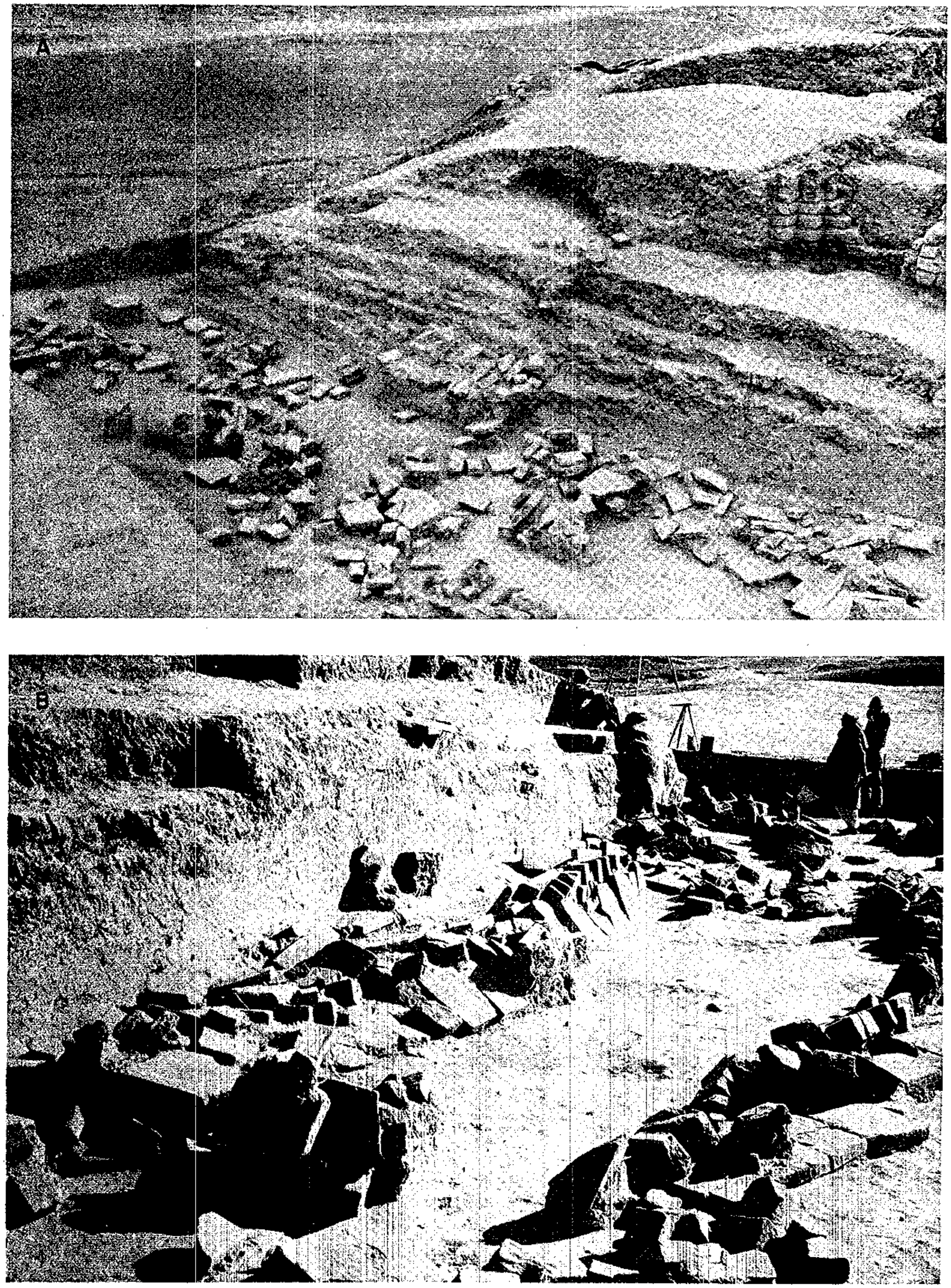
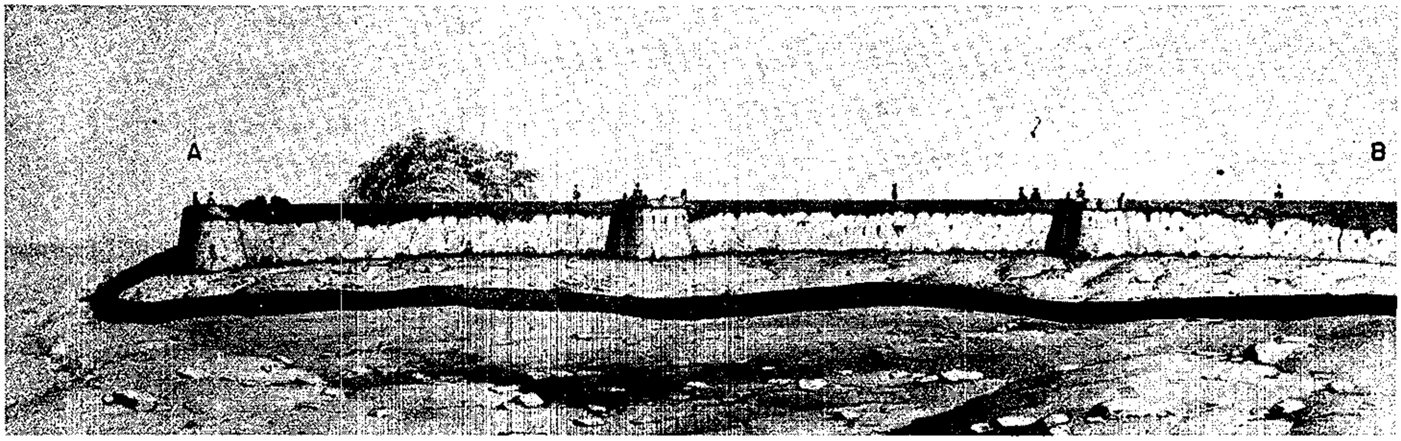


FIG. 9 CORNICE FRAGMENTS ALONG RIGHT WALL OF TEMPLE
A) VIEW LOOKING TOWARDS REAR OF TEMPLE
B) VIEW LOOKING TOWARDS FRONT OF TEMPLE
(Courtesy of Délégation Archéologique Francaise en Afghanistan)



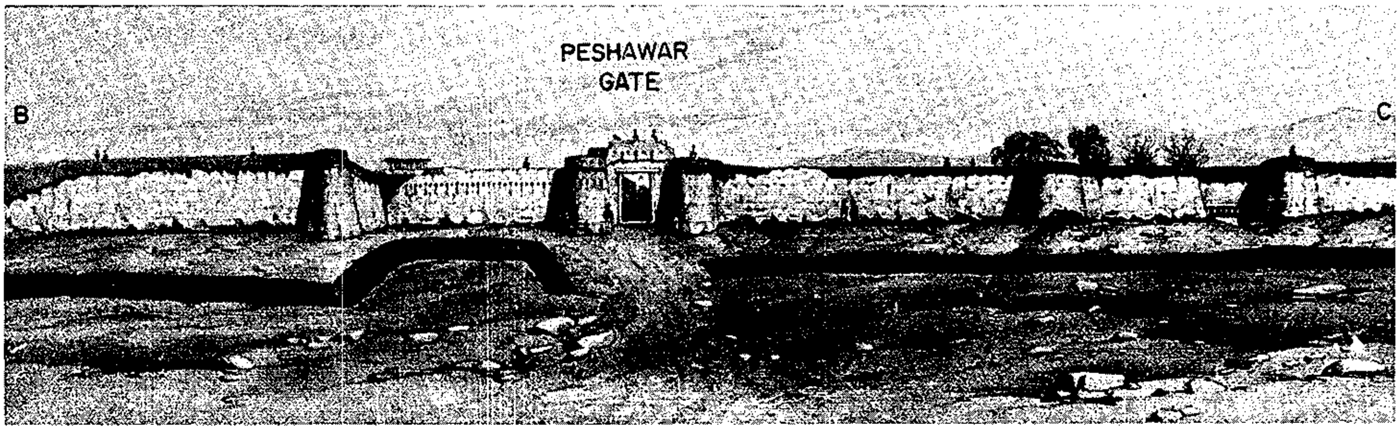


FIG. 10 EARTHQUAKE DAMAGE TO THE DEFENSES OF JALALABAD - 1842
(Courtesy of the British Embassy, Afghanistan)

In Figs. 10, 11, 12 and 13:

All Portions Above Black Line Were Destroyed by the February 19, 1842 Earthquake.

ABCD - East Wall With Peshawar Gate
DEFGHI - North Wall With River Gate
IJKL - West Wall With Kabul Gate
LMNA - South Wall With South Gate

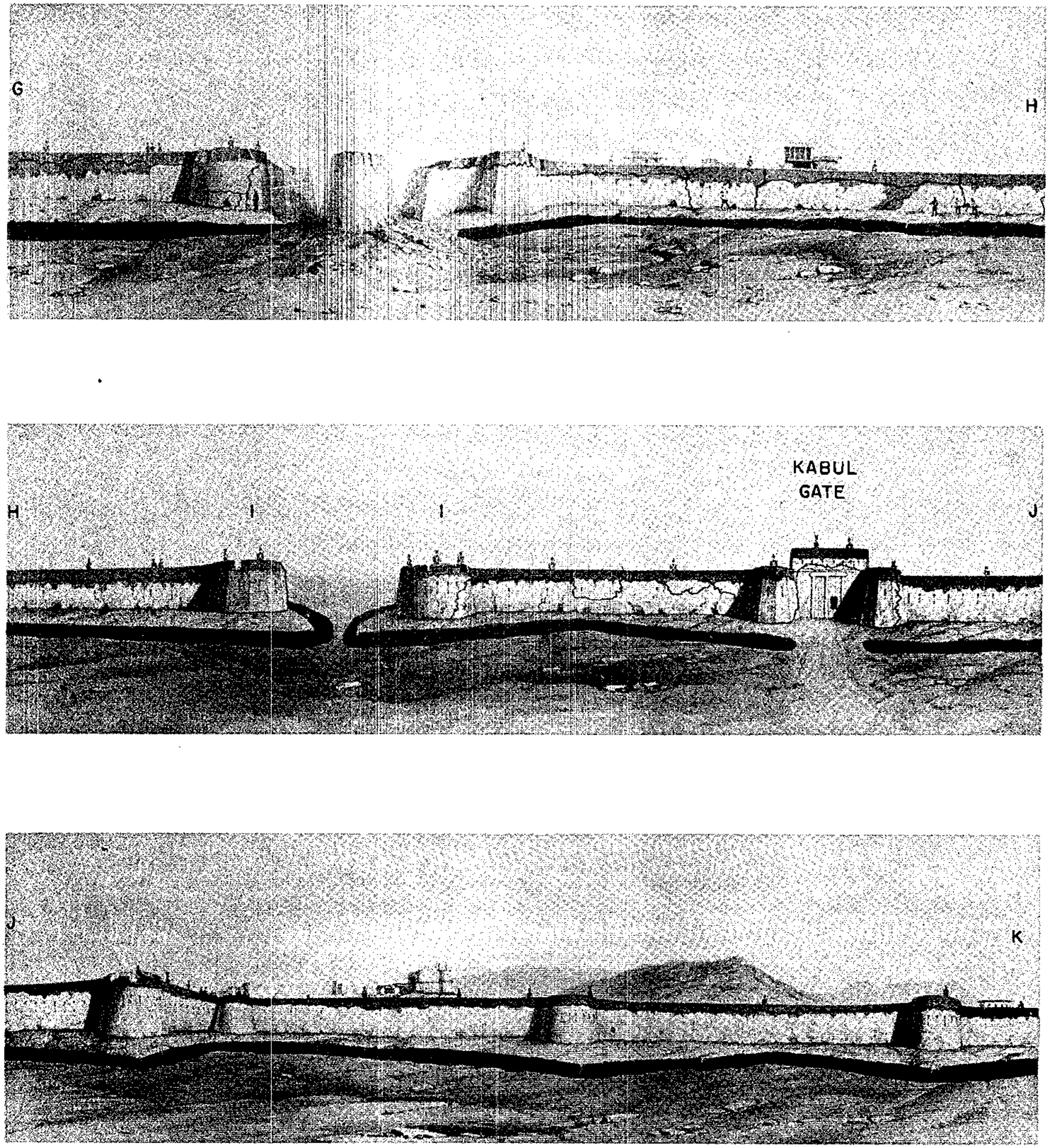


FIG. 12 EARTHQUAKE DAMAGE TO THE DEFENSES OF JALALABAD - 1842
(Courtesy of the British Embassy, Afghanistan)

See Fig. 10 for Explanatory Notes

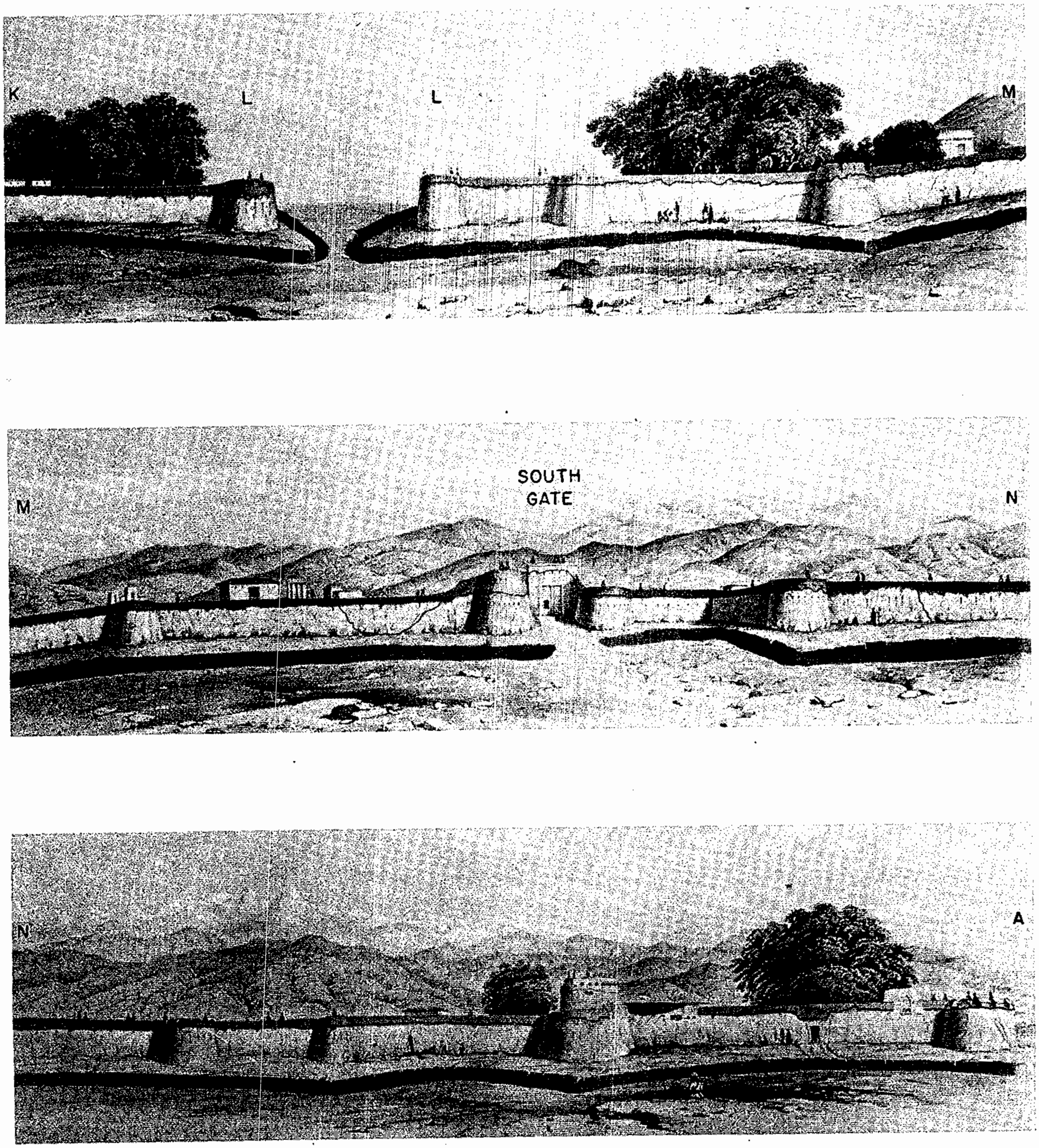


FIG. 13 EARTHQUAKE DAMAGE TO THE DEFENSES OF JALALABAD - 1842
(Courtesy of the British Embassy, Afghanistan)

See Fig. 10 for Explanatory Notes

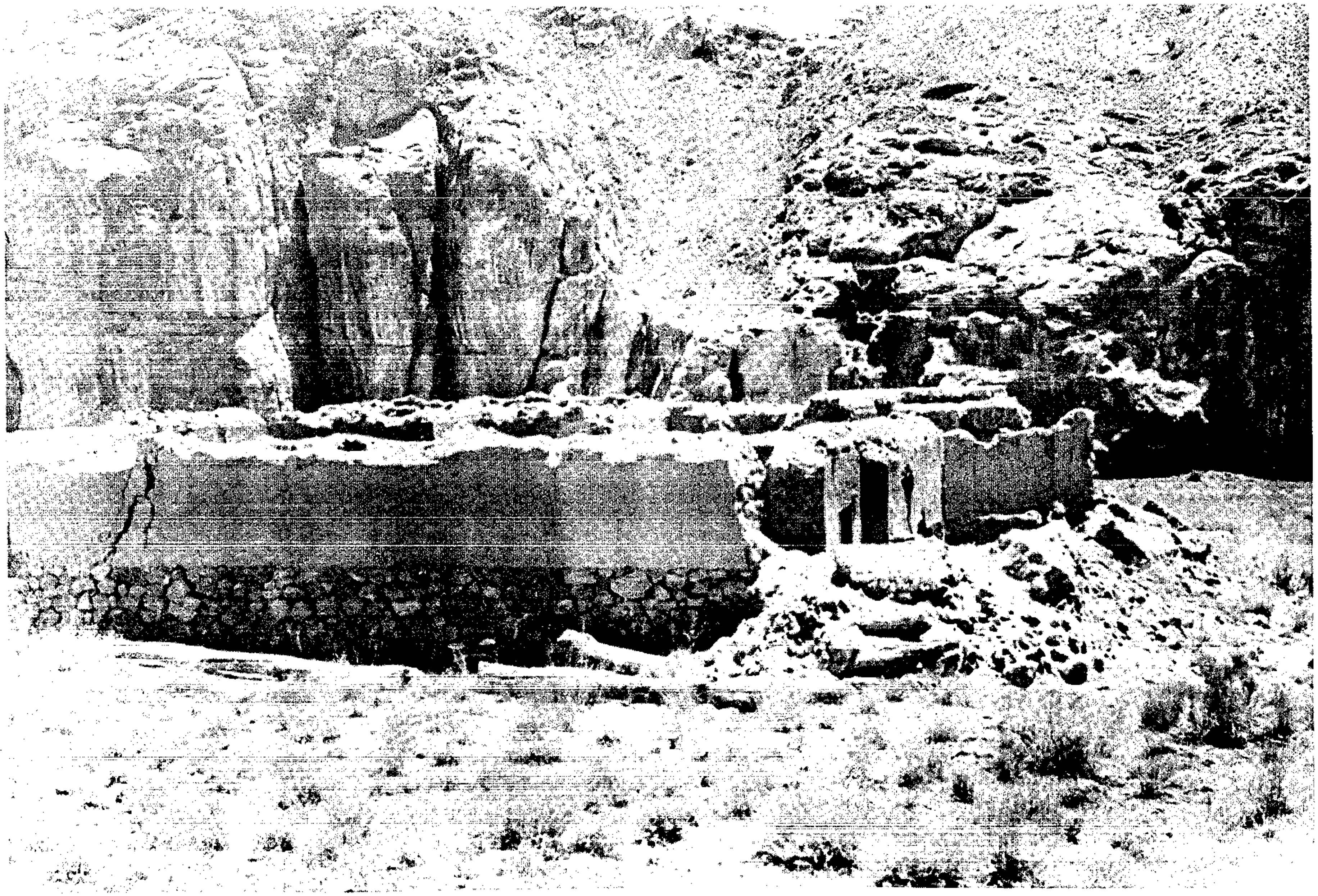


FIG. 14 OVERALL VIEW OF DESTROYED BUILDING AT DARRI AJAR - JUNE 9, 1956 EARTHQUAKE
(Total Destruction of West Wall)

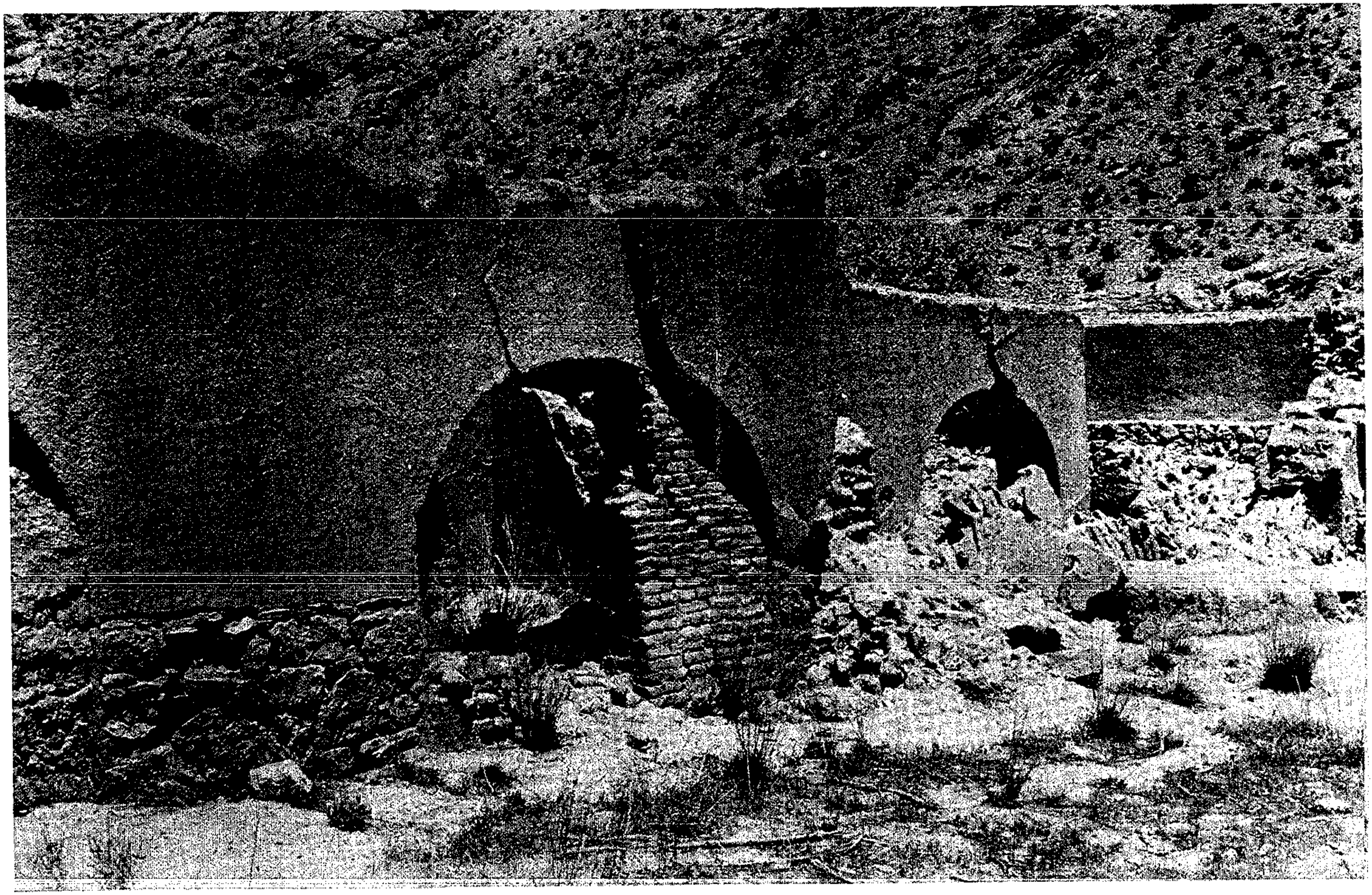


FIG. 15 VIEW OF AN EW INTERNAL WALL OF BUILDING AT DARRI AJAR
(The West Direction is to the Left, See Fig. 14)

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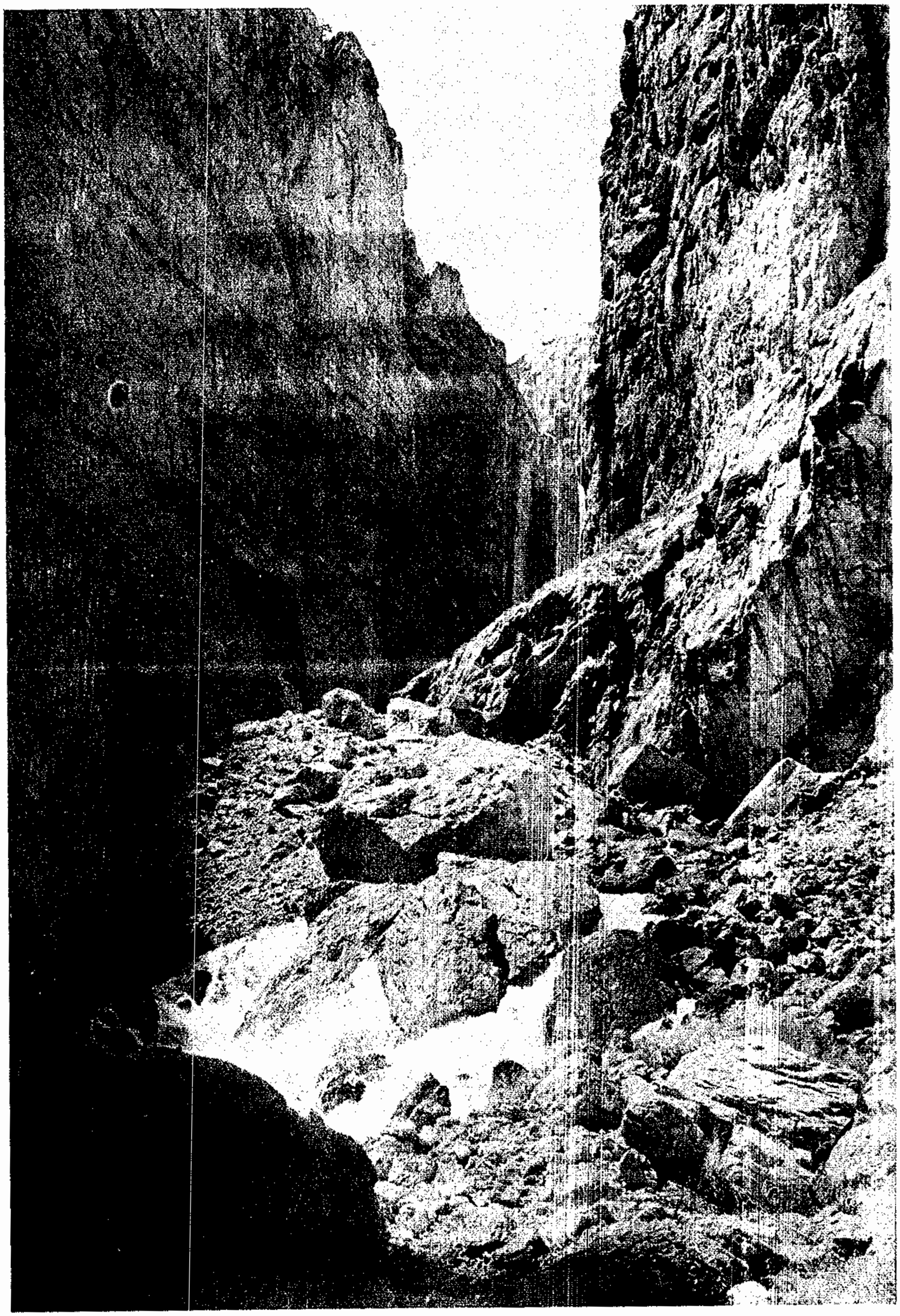

FIG. 16 VIEW OF PARTIAL COLLAPSE OF GORGE WALL AT DARRI AJAR
JUNE 9, 1956 EARTHQUAKE

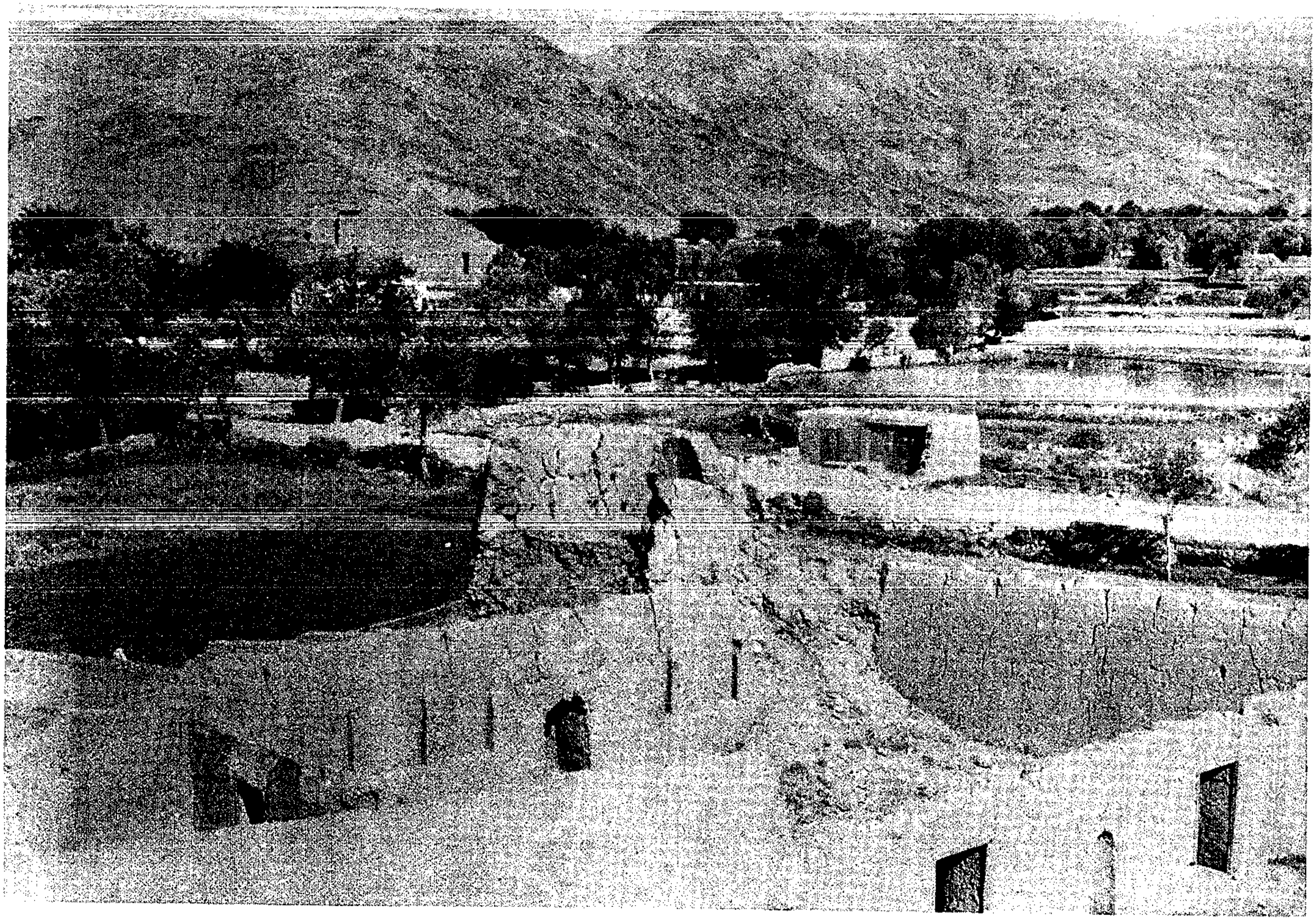

FIG. 17 EARTHQUAKE DAMAGE AT NURGAL - MAY 15, 1969
(Note Destruction to Bastion and Mud Walls Along Road)

FIG. 18 VIEW OF A DESTROYED HOUSE IN NURGAL - MAY 15, 1969 EARTHQUAKE

FIG. 19 BUILDING DESTRUCTION IN IRAN - AUGUST 31, 1968 EARTHQUAKE

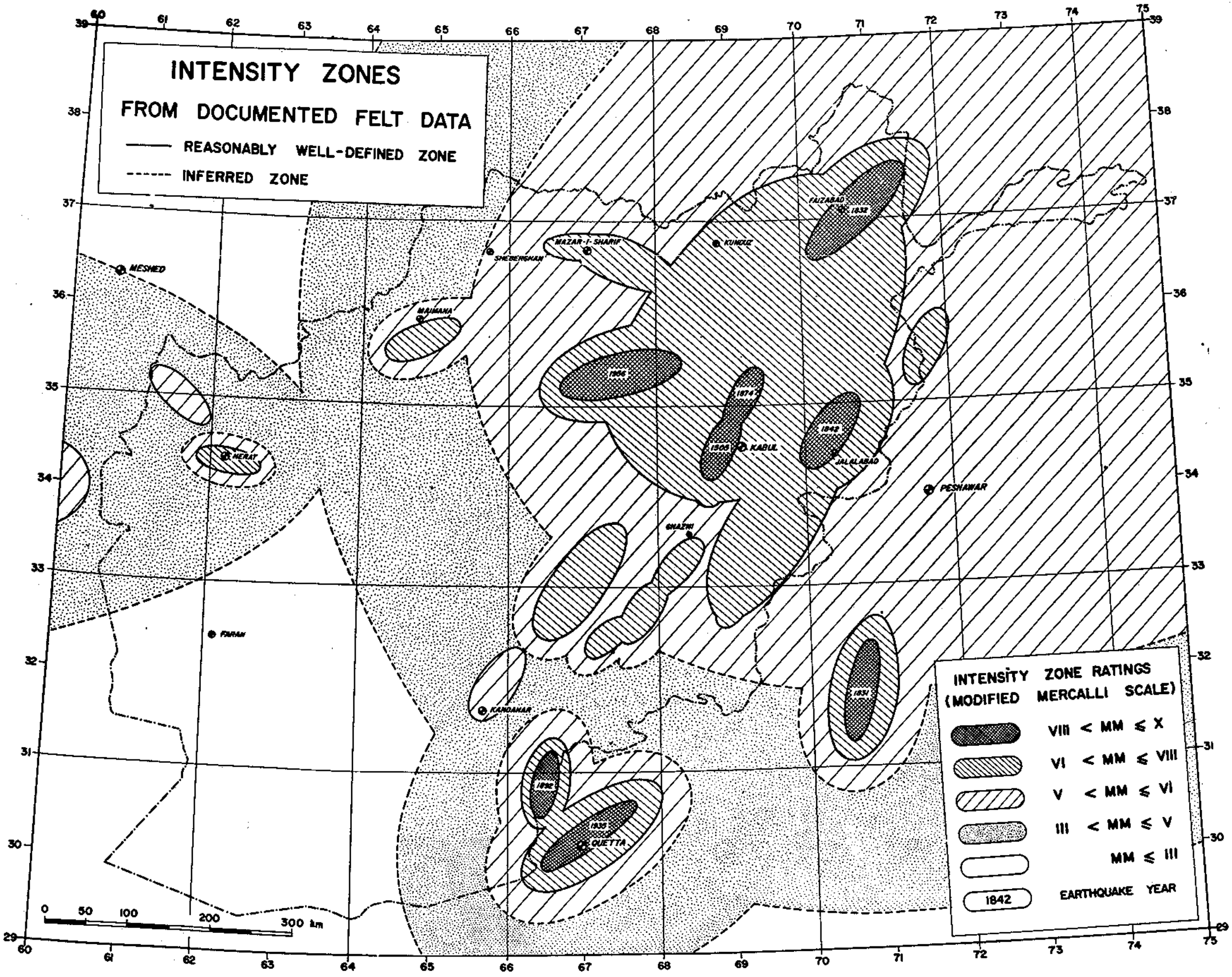

FIG. 20 INTENSITY ZONE MAP BASED ON DOCUMENTED FELT DATA

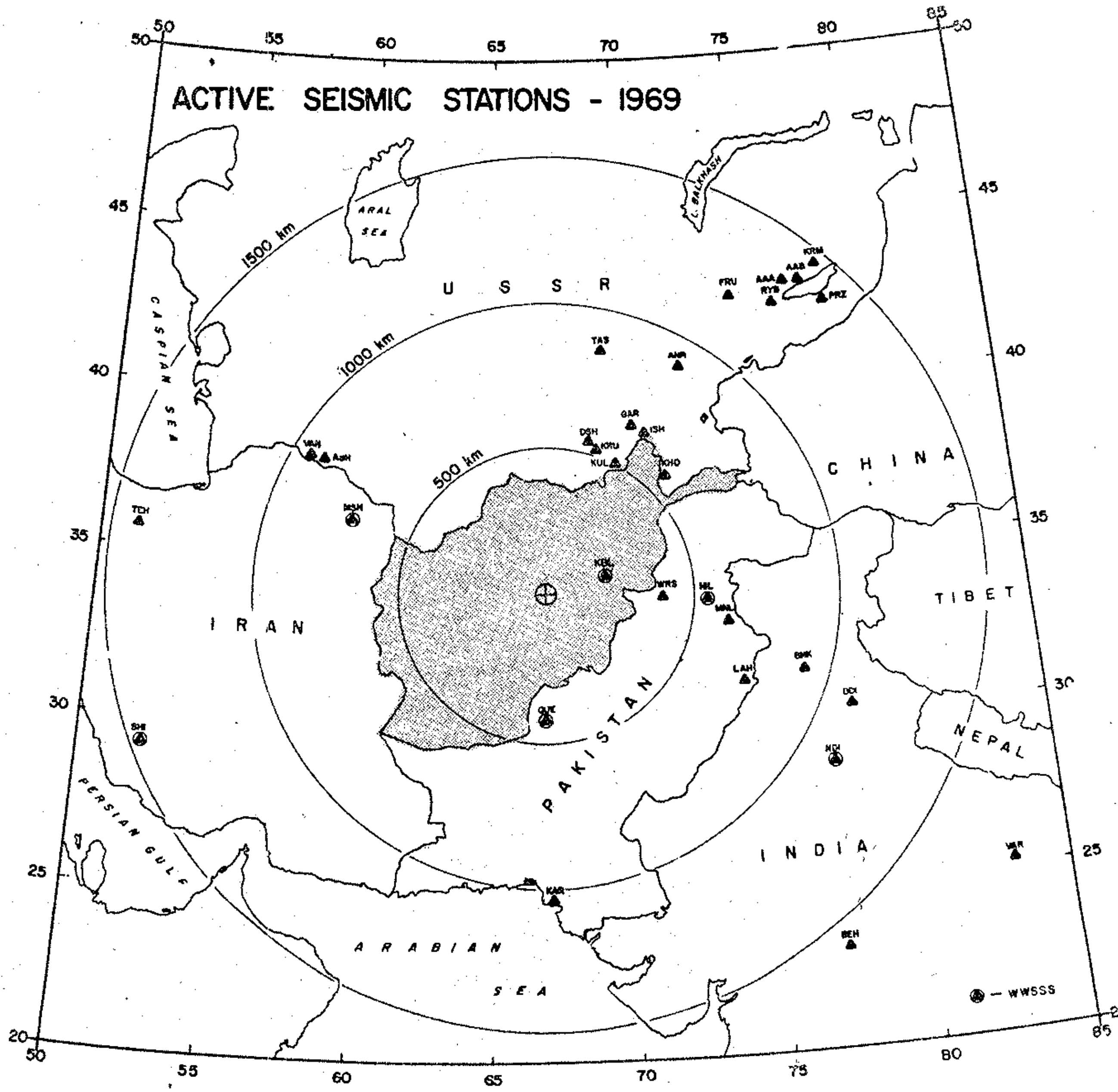

FIG. 21 LOCATIONS OF ACTIVE SEISMIC STATIONS NEAR TO AFGHANISTAN - 1969 (WWSSS - Worldwide Standard Seismographic System)

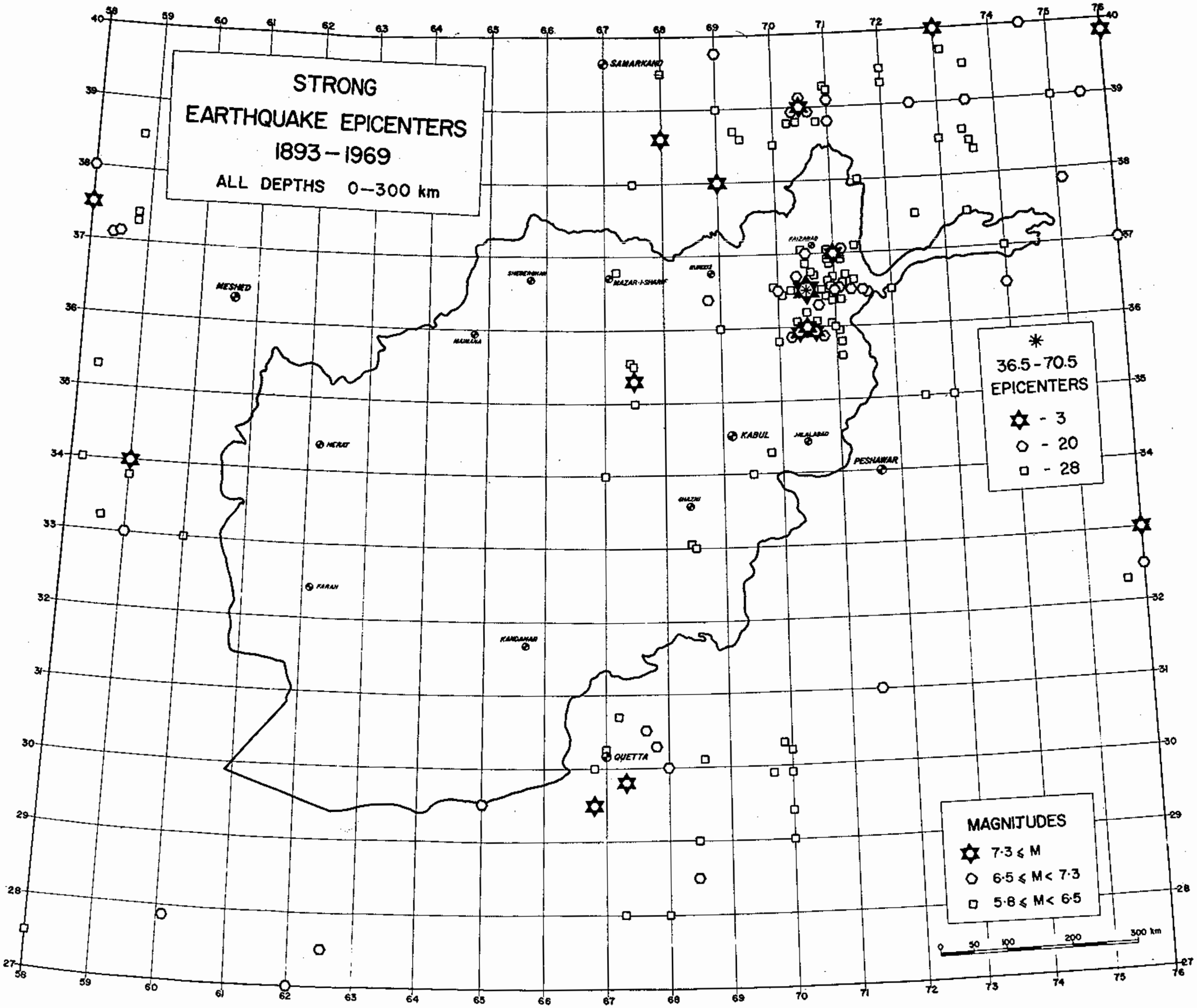

FIG. 22 SEISMICITY MAP - STRONG EARTHQUAKES (M ≥ 5.8) DURING 1893-1969

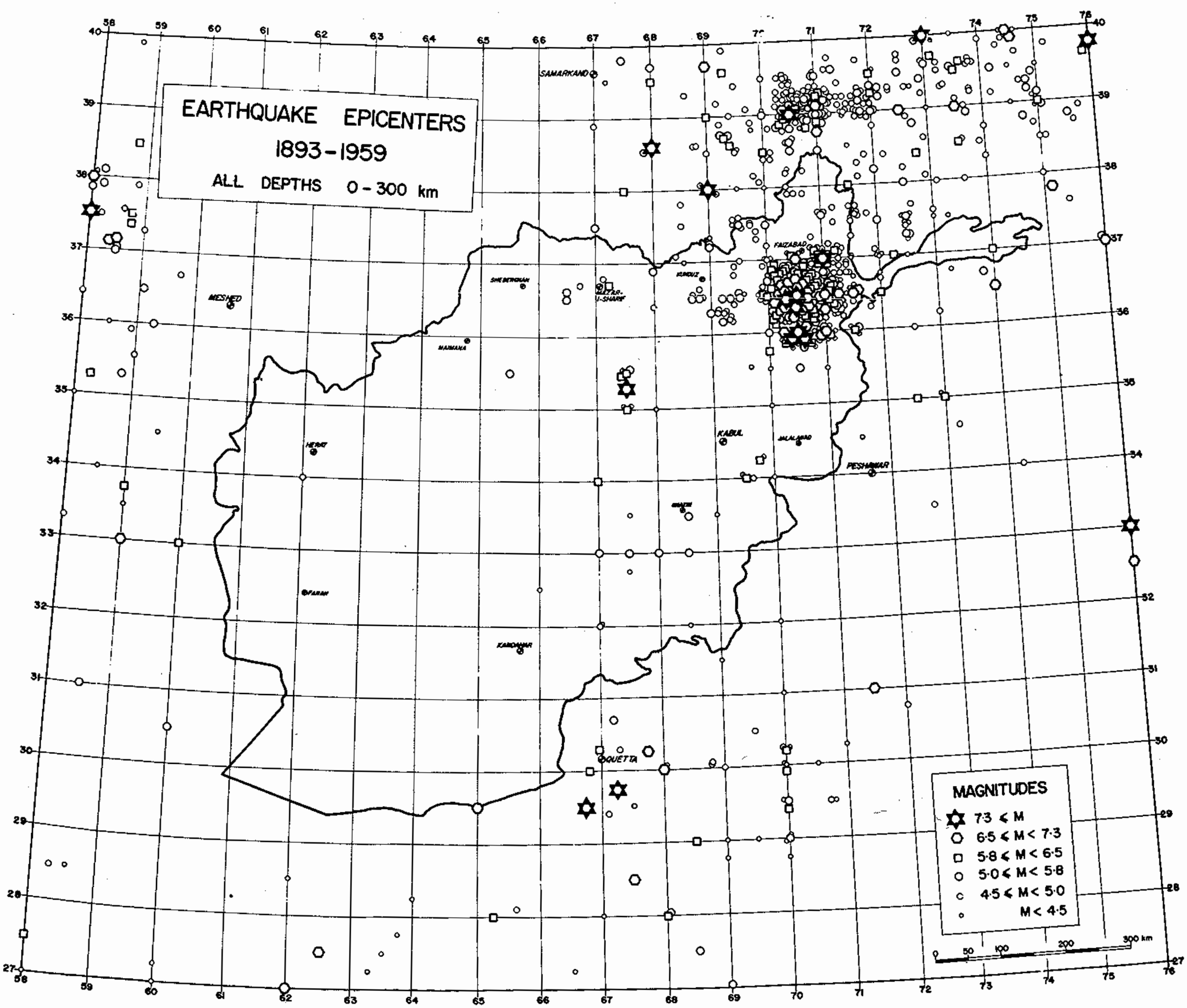

FIG. 23 SEISMICITY MAP - ALL EARTHQUAKES DURING 1893-1959

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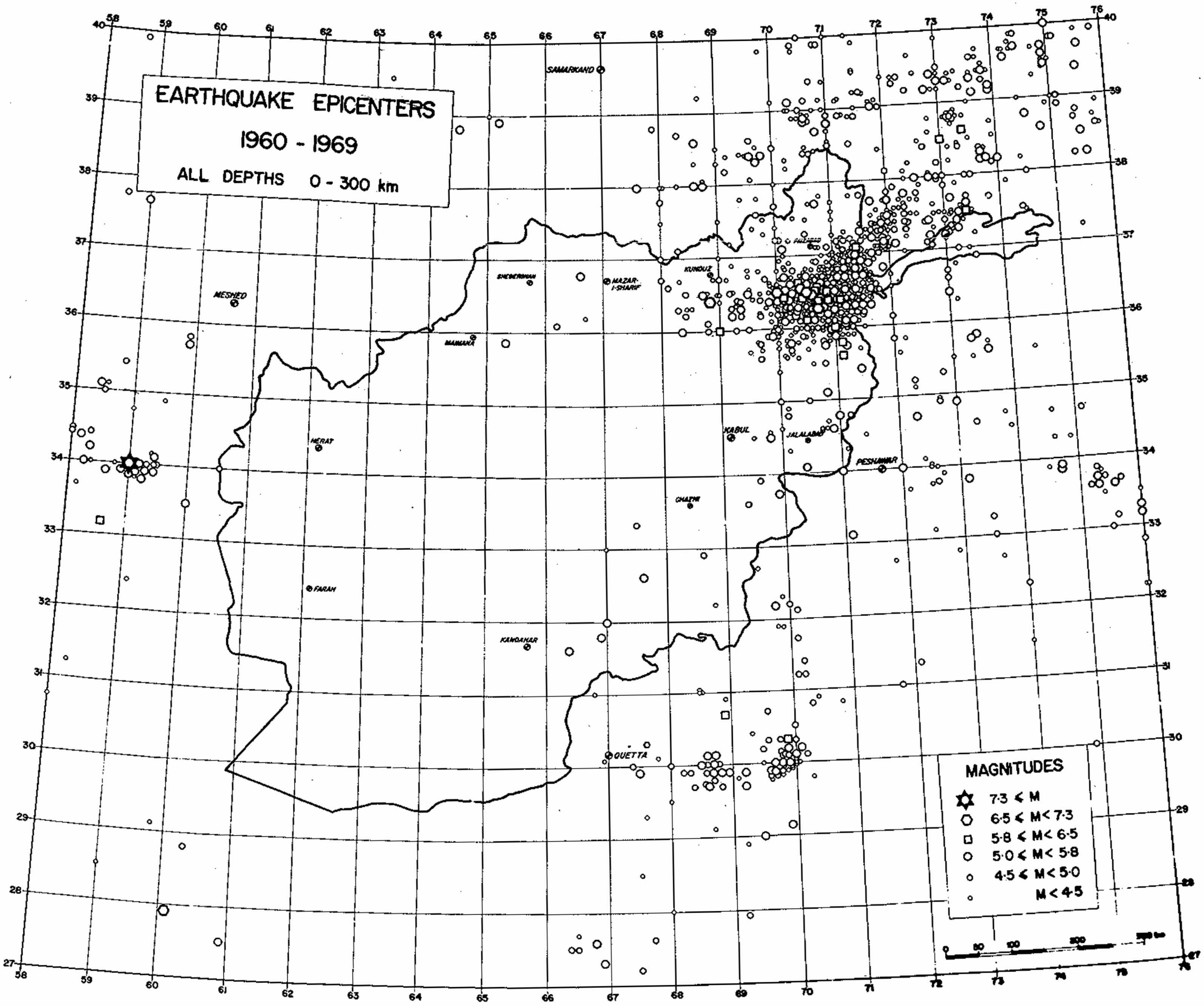

FIG. 24 SEISMICITY MAP - ALL EARTHQUAKES DURING 1960-1969

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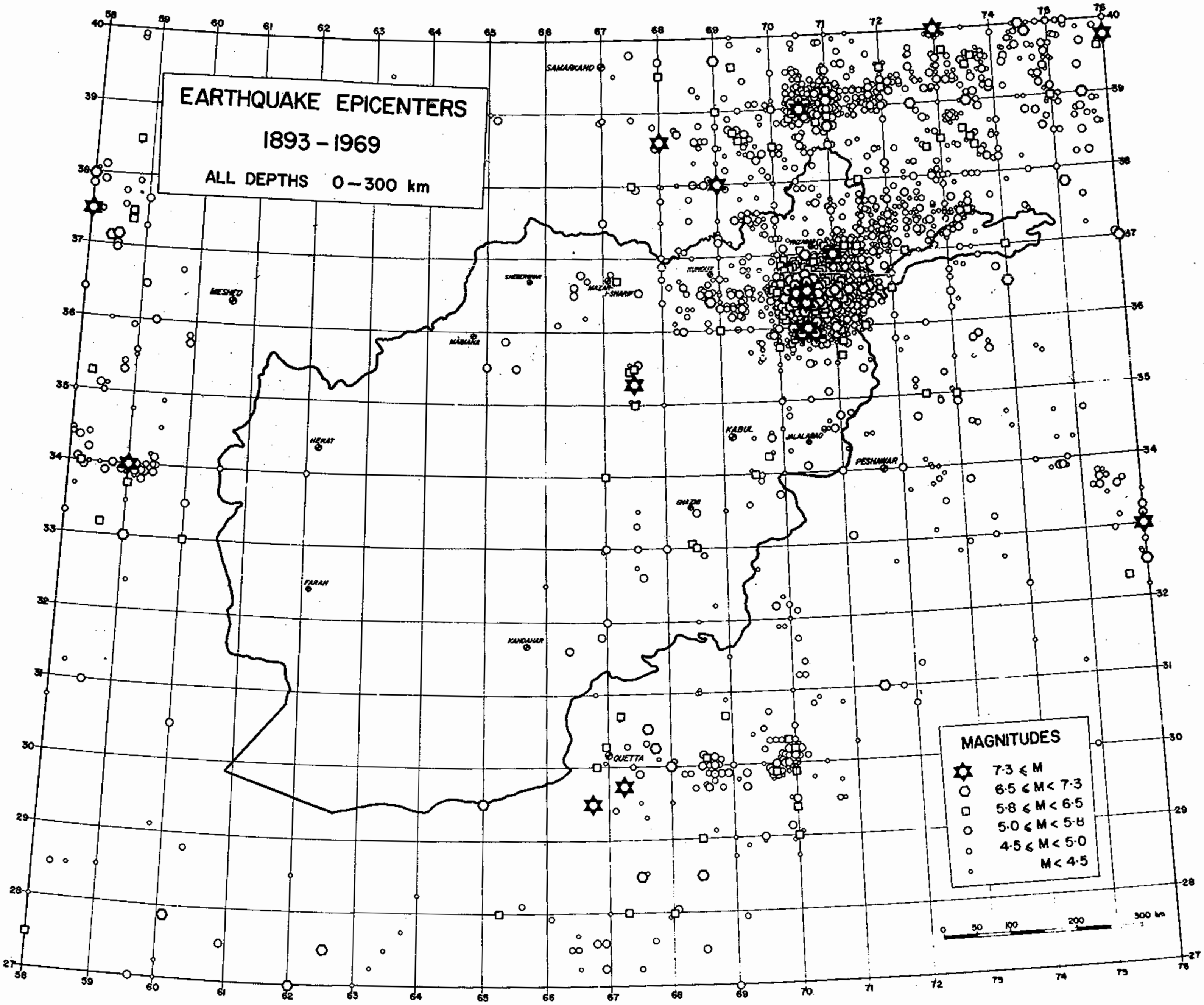

FIG. 25 SEISMICITY MAP - ALL EARTHQUAKES DURING 1893-1969

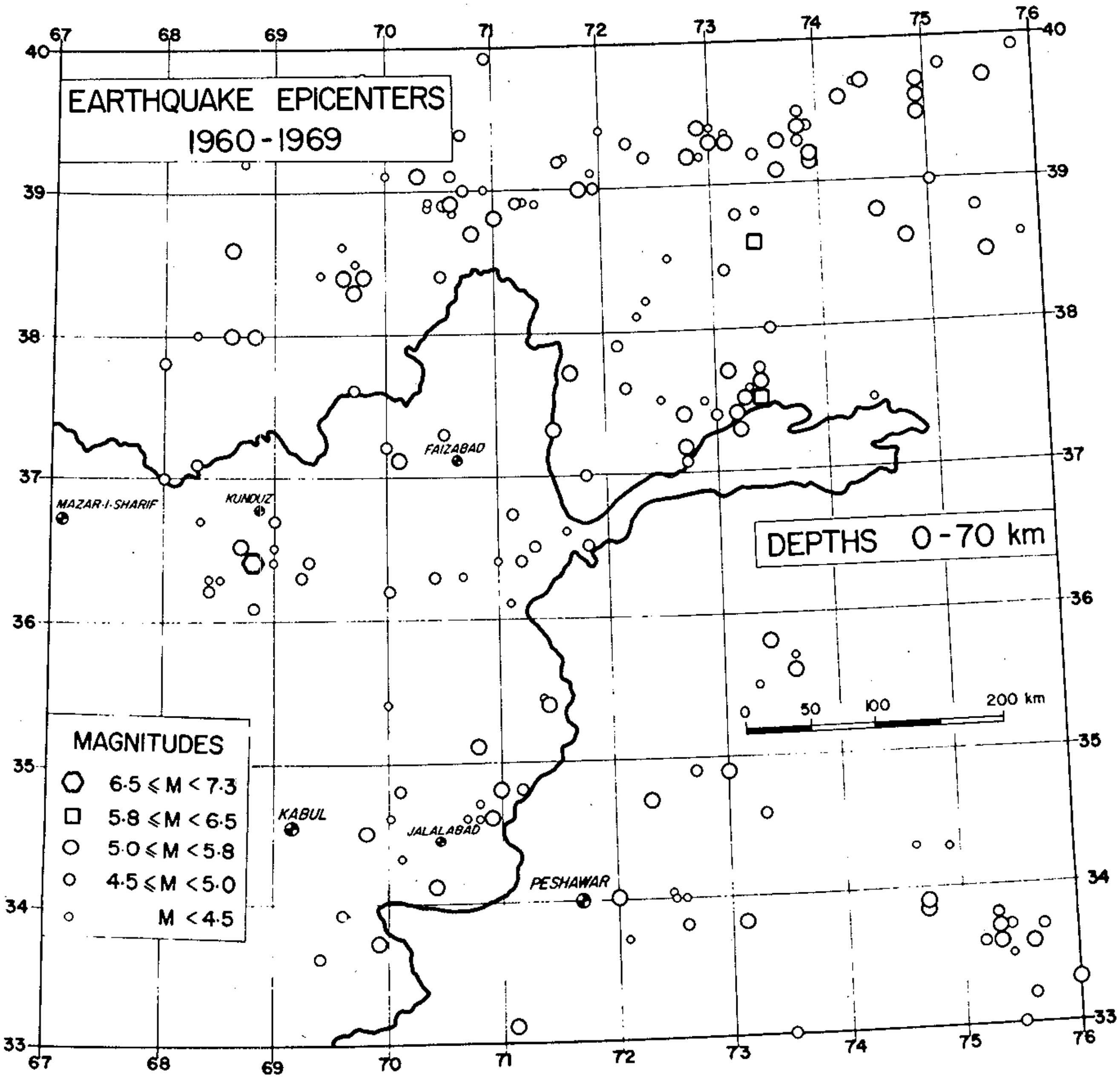

FIG. 26 SEISMICITY MAP OF NE REGIONS OF AFGHANISTAN
DEPTHS 0–70 KM 1960–1969

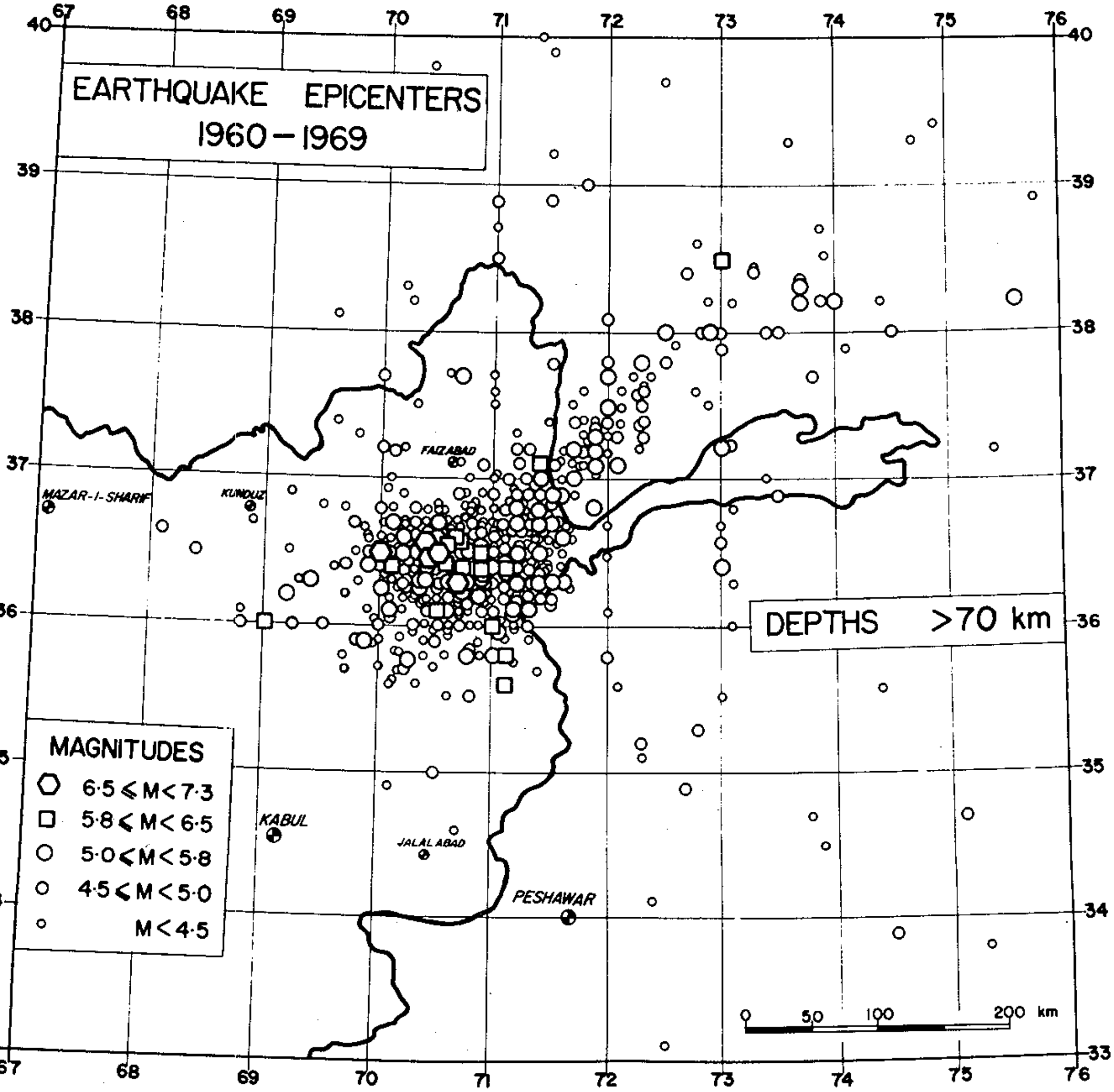

FIG. 27 SEISMICITY MAP OF NE REGIONS OF AFGHANISTAN
DEPTHS >70 KM 1960-1969

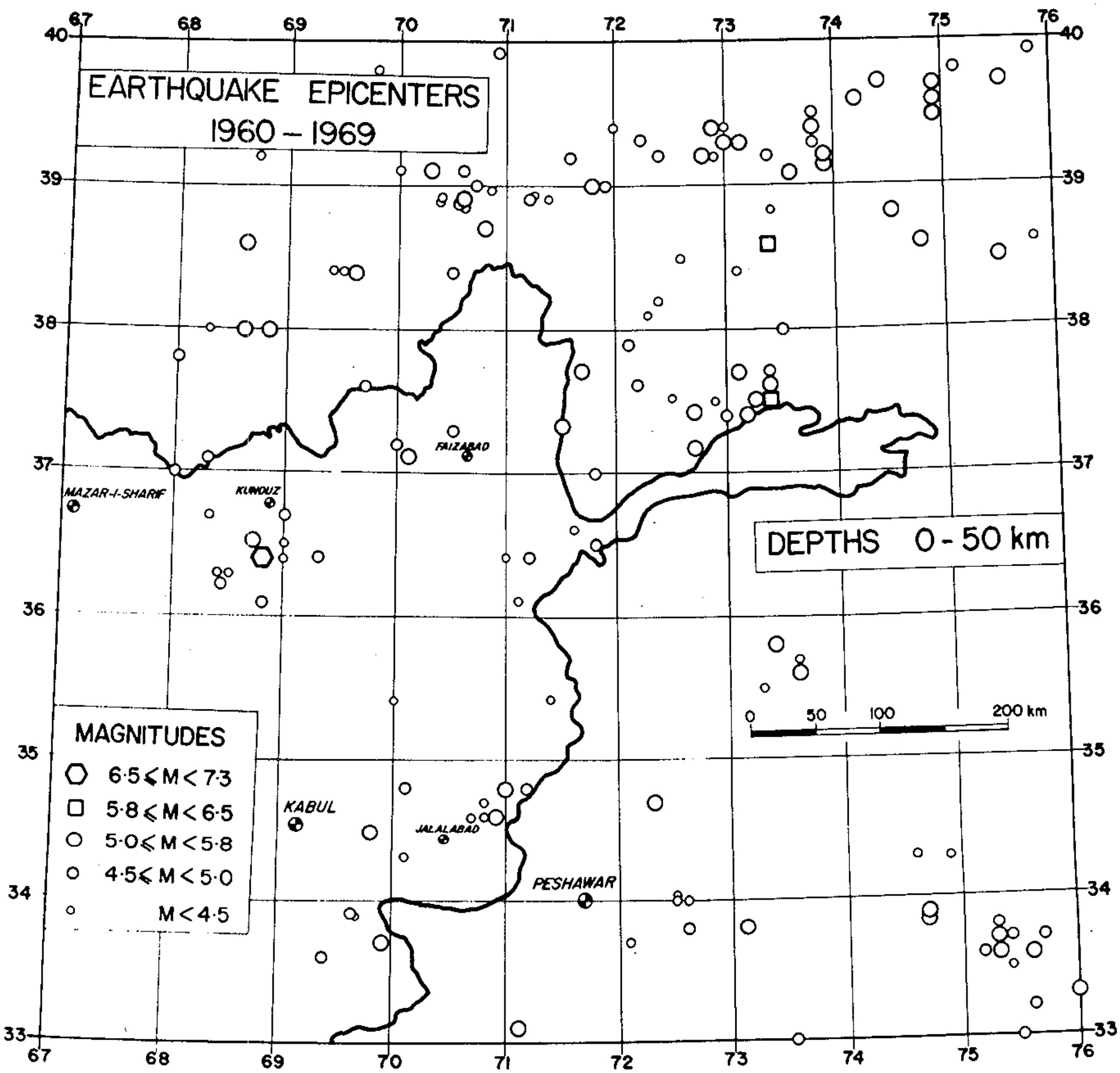

FIG. 28 SEISMICITY MAP OF NE REGIONS OF AFGHANISTAN
DEPTHS 0–50 KM 1960–1969

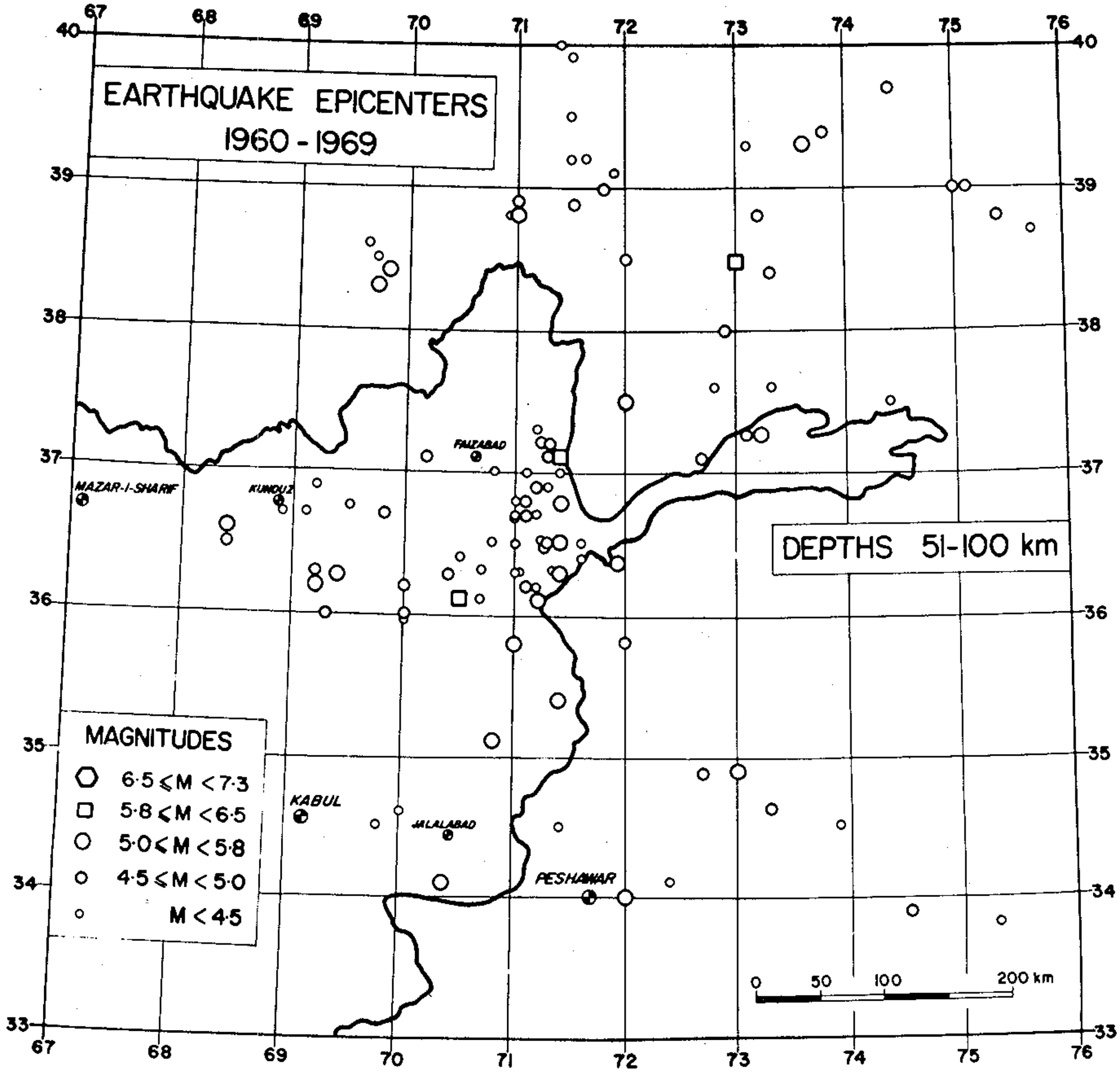

FIG. 29 SEISMICITY MAP OF NE REGIONS OF AFGHANISTAN
DEPTHS 51-100 KM 1960-1969

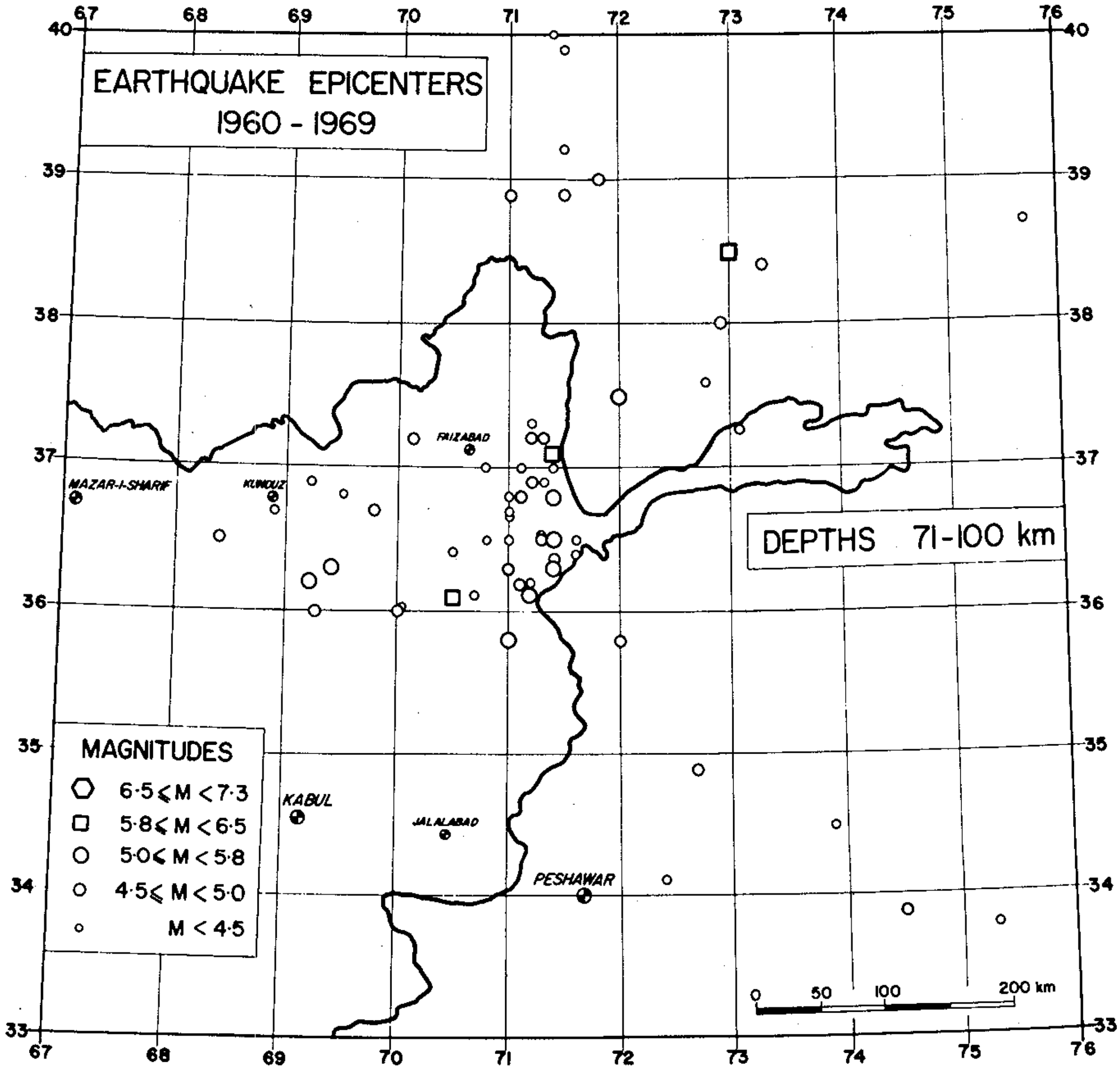

FIG. 30 SEISMICITY MAP OF NE REGIONS OF AFGHANISTAN
DEPTHS 71-100 KM 1960-1969

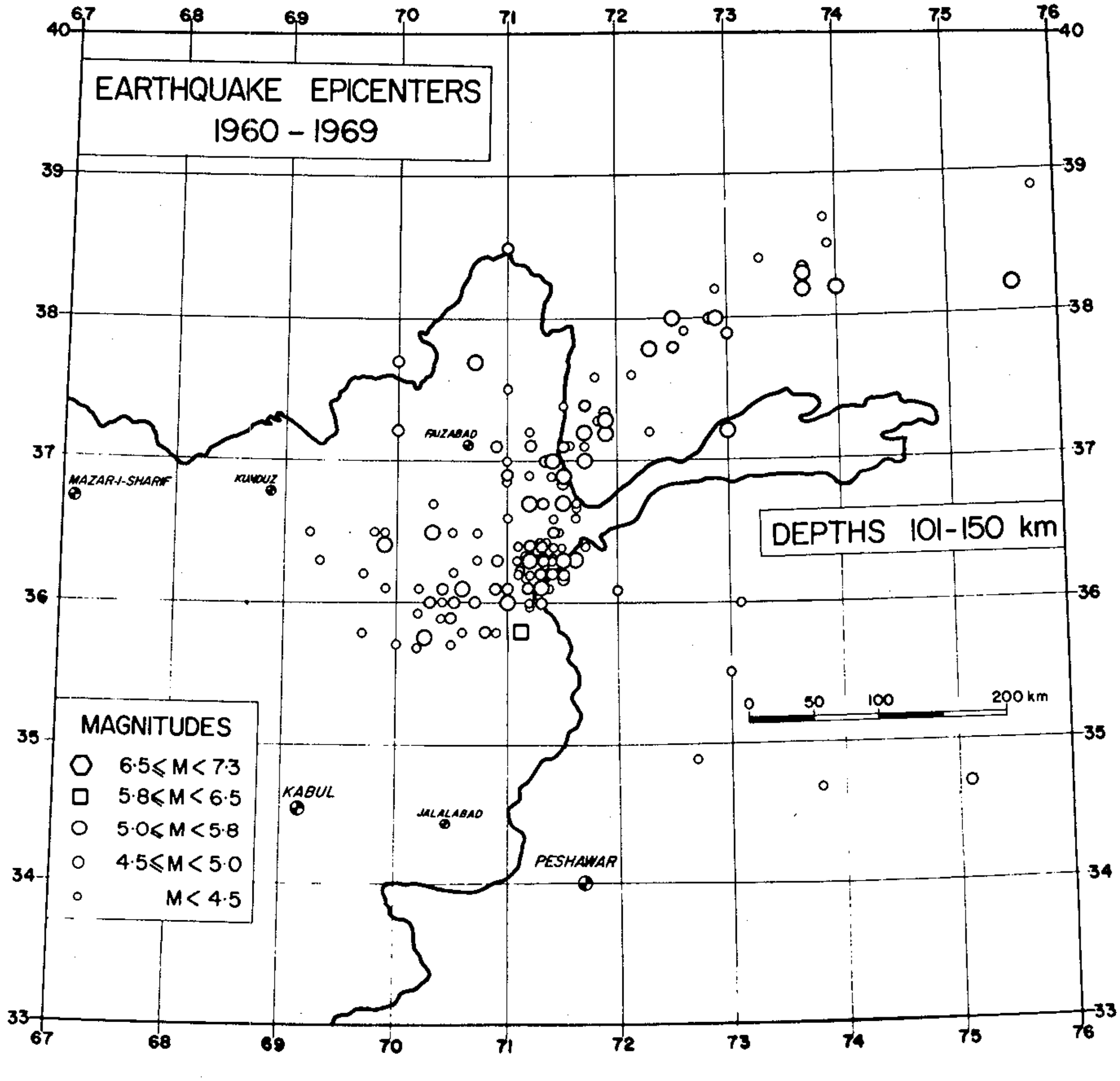

FIG. 31 SEISMICITY MAP OF NE REGIONS OF AFGHANISTAN
DEPTHS 101-150 KM 1960-1969

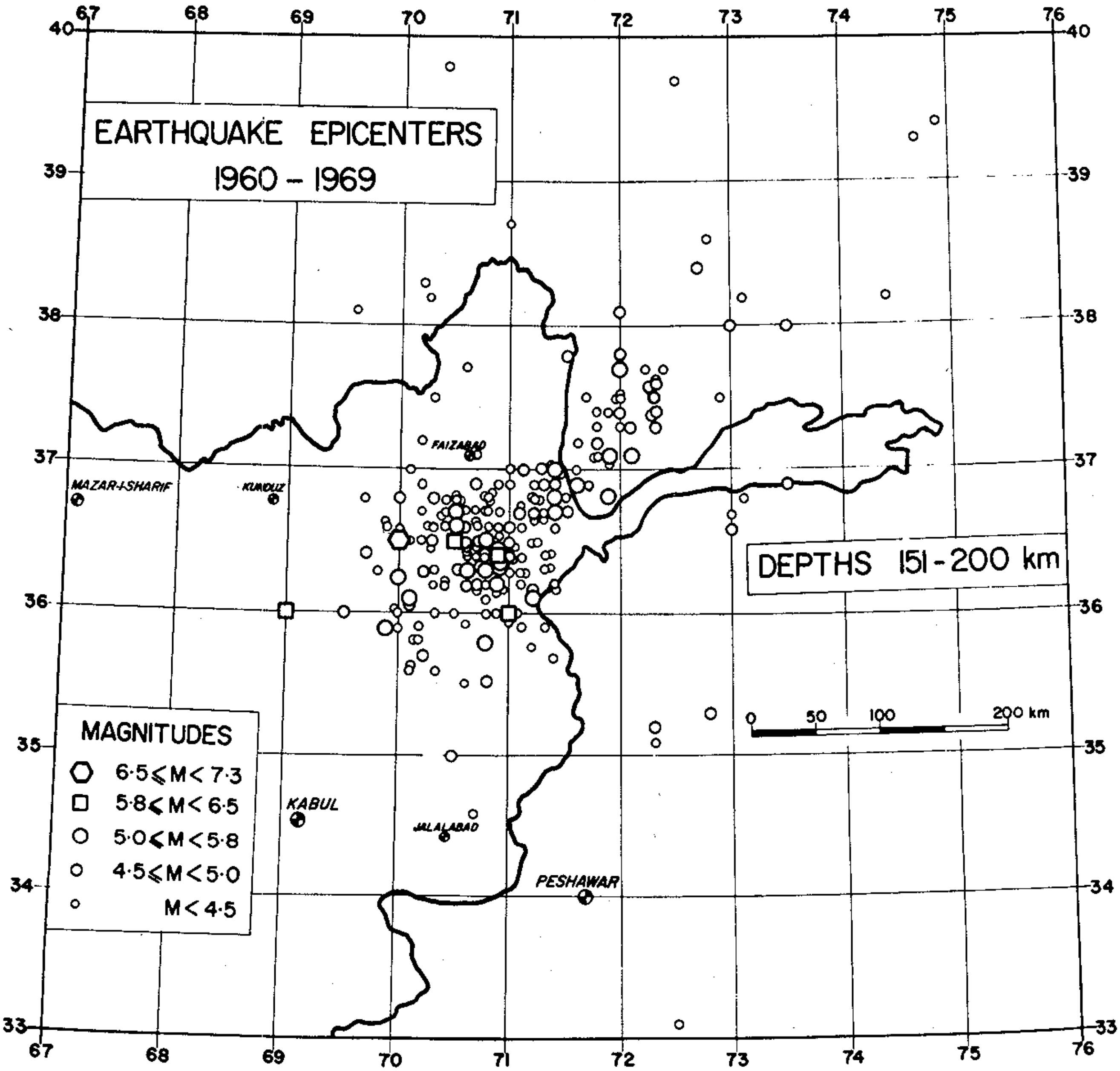

FIG. 32 SEISMICITY MAP OF NE REGIONS OF AFGHANISTAN
DEPTHS 151-200 KM 1960-1969

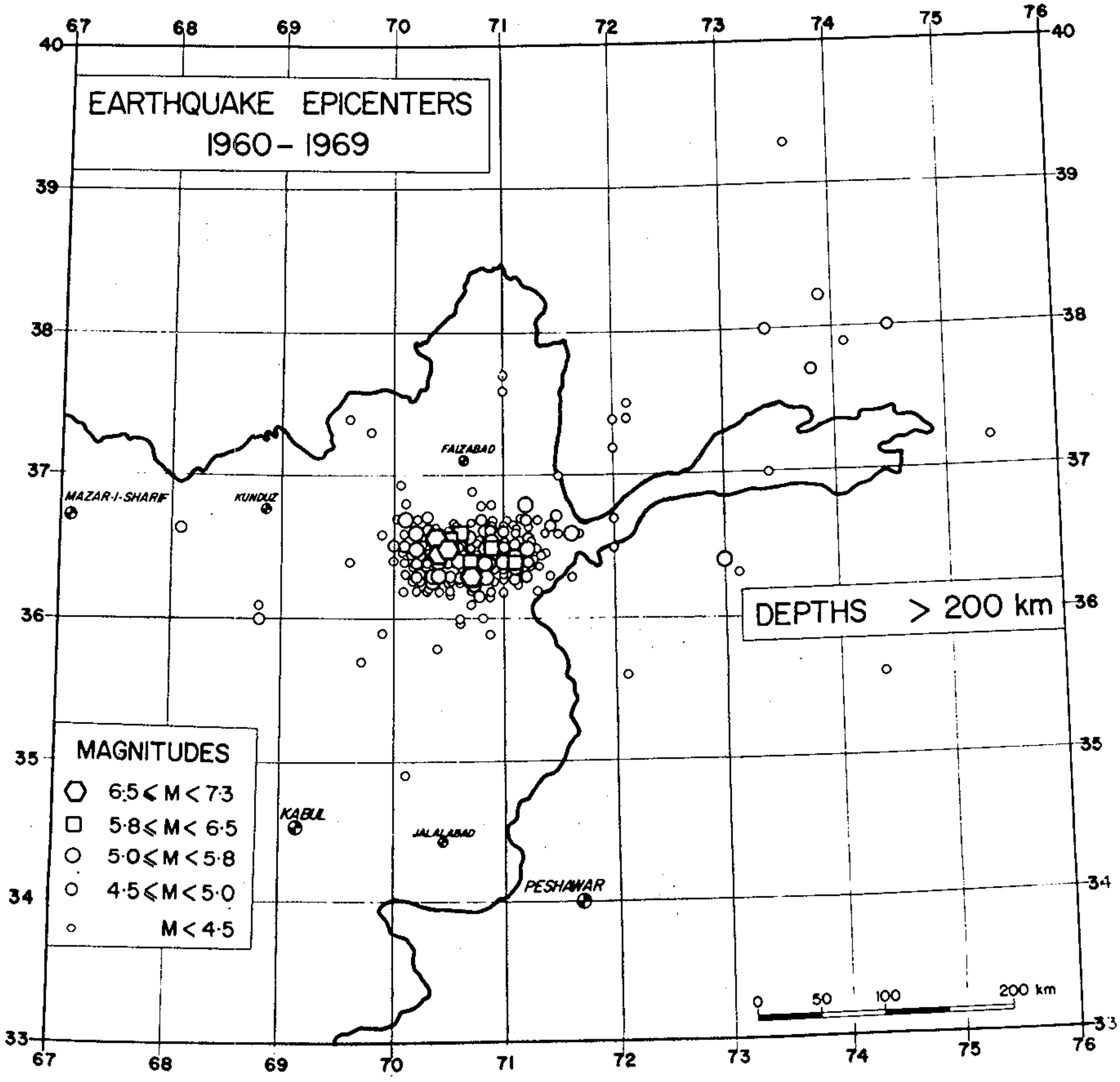

FIG. 33 SEISMICITY MAP OF NE REGIONS OF AFGHANISTAN
DEPTHS >200 KM 1960-1969

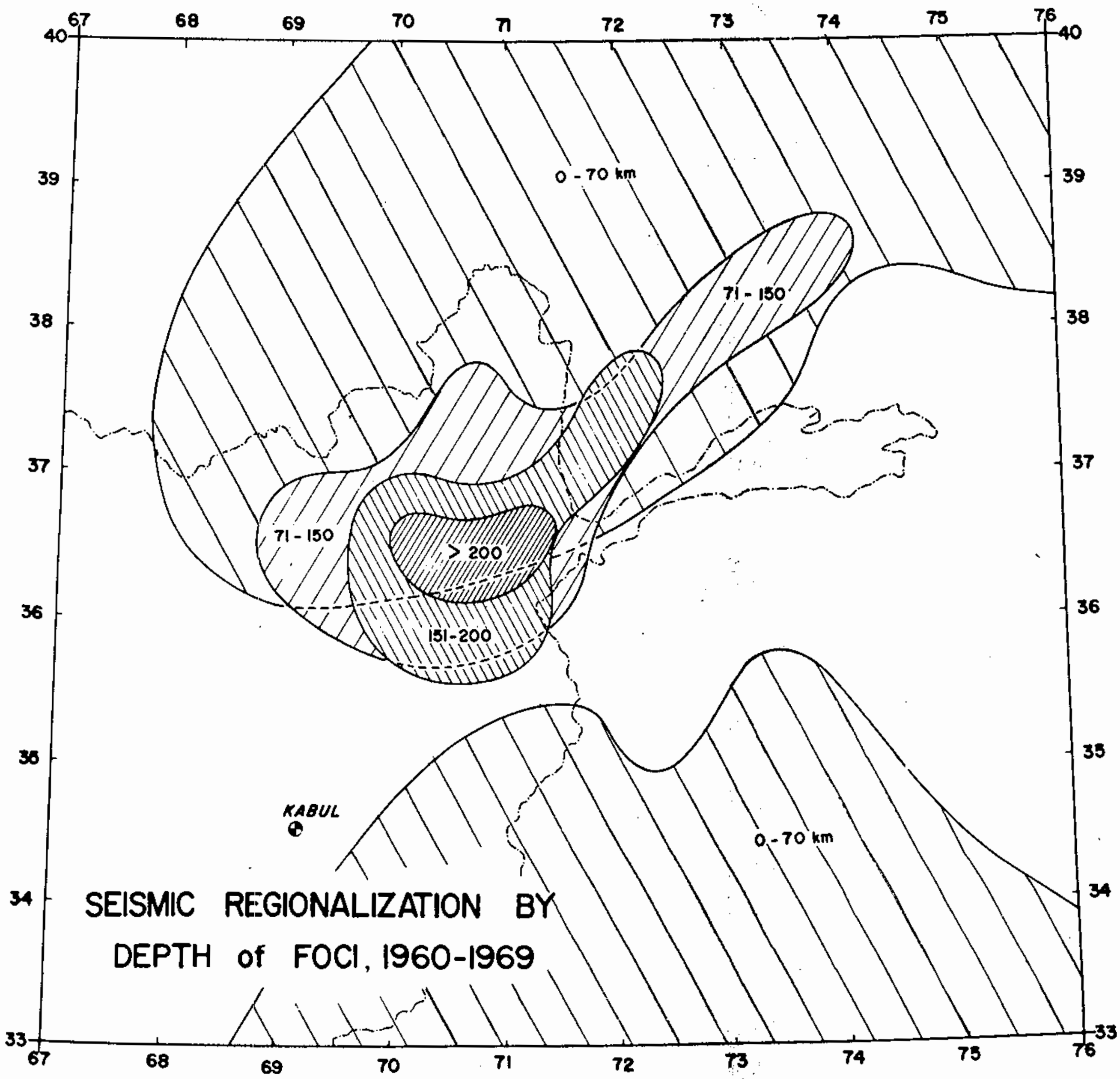

FIG. 34 SEISMIC REGIONALIZATION OF THE NE REGIONS OF AFGHANISTAN BY DEPTH OF EARTHQUAKE FOCI 1960-1969

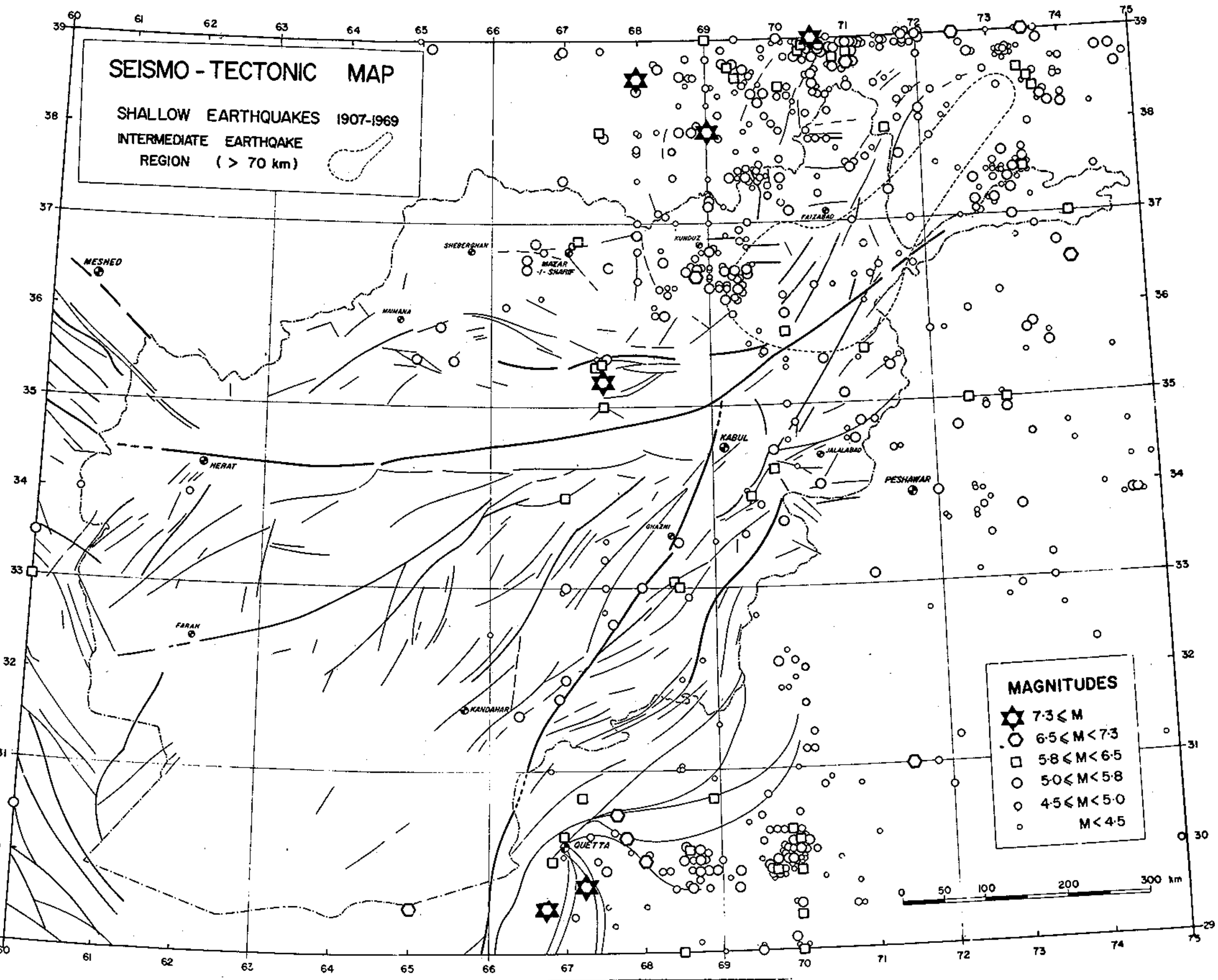

FIG. 35 SEISMO-TECTONIC MAP OF AFGHANISTAN

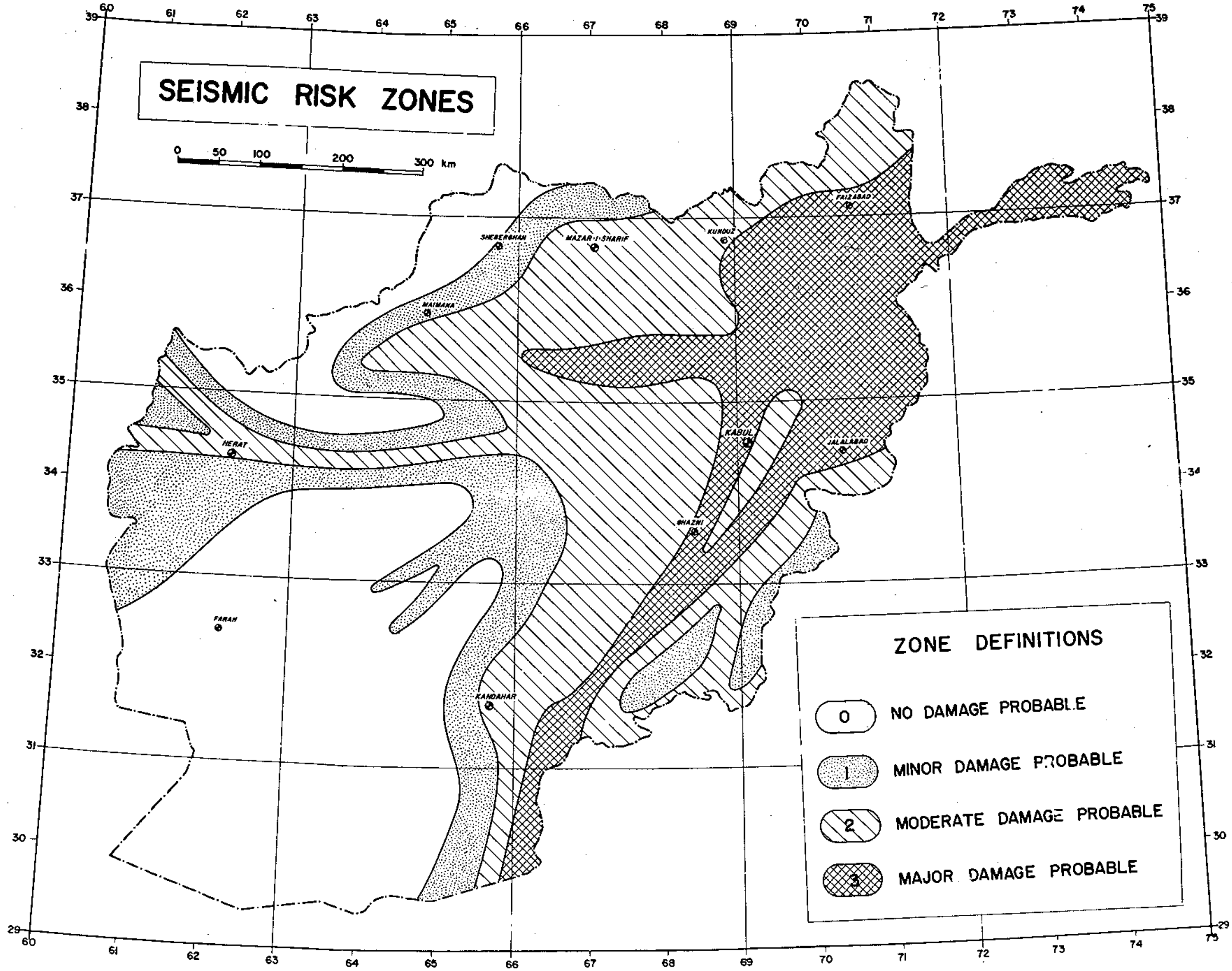

FIG. 36 MAP OF SEISMIC RISK ZONES FOR AFGHANISTAN