PRELIMINARY ASSESSMENT OF THE VOLCANO HAZARDS OF PACAYA VOLCANO

GUATEMALA

Norman G. Banks - U.S. Geological Survey

in cooperation with

Instituto Nacional de Sismologia, Vulcanologia,
Meteorologia e Hidrologia

(INSIVUMEH)

***** CAUTION ***** ***** CAUTION ***** CAUTION ***** CAUTION *****

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INTRODUCTION

PURPOSE OF THIS REPORT

To provide a preliminary assessment of the volcanic hazards of Pacaya Volcano, Guatemala.

BACKGROUND OF THIS REPORT

Pacaya Volcano, Departmento Amatitlan, produced impressive eruptions 21 January and 25 January, 1987, prompting the evacuation of approximately 3,500 persons from the flanks of the Pacaya-Cerro Grande volcanic complex.

INSIVUMEH (Instituto Nacional de Sismologia, Vulcanologia, Meteorologia e Hidrologia) is the governmental agency responsible for assessing and providing early-warning of volcanic hazards in Guatemala. However, INSIVUMEH has few instruments for such duties, and thus issued an invitation to the U. S. Geological Survey for assistance in monitoring and assessing current activity at Pacaya. The invitation, issued through USAID, Guatemala, mobilized the Volcano Early-Warning and Disaster Assistance Program funded jointly through the U.S. Geological Survey and Office of Foreign Disaster Assistance of USAID, Washington.

The USGS team and INSIVUMEH evaluated the January activity of Pacaya and established a deformation monitor on the NW flank to increase INSIVUMEH's ability to assess the level of activity at Pacaya, and thereby improve hazard mitigation of future eruptions.

Because there were no hazards maps of Pacaya to assist INSIVUMEH and the other government agencies (principally, CONE (the Comite Nacional de Emergencia)) in estimating the future course of the January eruptions at Pacaya, the group also spent two days in reconnaissance study of the past eruptive products of Pacaya. This report is the product of this reconnaissance.

PRELIMINARY ASSESSMENT OF THE VOLCANO HAZARDS OF PACAYA VOLCANO

BACKGROUND AND QUALIFICATIONS TO THE DESIGNATED HAZARD AREAS

The necessary first element of a volcano emergency plan is a map showing the potential hazards around the volcano. Such maps require accurate and detailed knowledge of the depositional products associated with the past activity of the volcano. With these data, volcanologists can estimate the probable recurrence interval, type, and extent of the hazards presented by the volcano, as well as the impact that they may have on a given area in the future. Without this data, the hazards presented by the volcano are estimates at best and unknown at worst.

In the case of Pacaya, which is located about 40 km SSW of Guatemala City (Figure 1), very few detailed studies have been made of the deposits produced by the volcano. Egger's (1971) thesis provides a regional map and petrologic descriptions of the lava flows, but we know of no published studies detailing Pacaya's stratigraphy. Little time was available to us to add to the data in Egger's thesis; thus our hazard maps are based on Egger's work, 2 days of field work along the traverses indicated on Figure 2, and a few hours of photo-geologic work.

This is not sufficient time to fully evaluate the hazards of a volcanic complex as large as Pacaya. Therefore, this report should be regarded and used as a preliminary document that undoubtedly has errors and omissions. However, areas with definite and significant risks occur within the map area. These risks should be more fully evaluated as soon as possible by studies that provide more detailed data. Certainly, these risks should be seriously considered by the appropriate agencies, and by the people living around Pacaya.

PACAYA COMPLEX

Pacaya is part of a volcano complex located on the southern rim of Amatitlan Caldera (Figure 3). The caldera has produced more than 80 cubic kilometers (dense-rock equivalent) of pyroclastic deposits from 12 large eruptions that occurred between about 300,000 and 23,000 yr BP (Wunderman, 1982).

Pacaya is the youngest and southern-most volcano of a series of volcanoes and domes that have partially filled Amatitlan Caldera since the last caldera-forming event. The summit elevation of Pacaya is 2552 m, and the elevation of it's base is about 1500 m. Young Pacaya consists of three main eruptive centers: a now dormant cone, MacKenney cone, and Cerro Chino. These cones partially fill the remains of an larger, older edifice that coalesced in time and space with Cerro Grande to the north (Figure 4). At some unknown but relatively recent time, the older edifice failed by a sector collapse similar to that of Mount St. Helens in 1980. Debris avalanche deposits of this event occur in

the valley of Rio Metapa, still dam tributary streams, and are covered by less than 20 cm of soil. Possibly these deposits are less than 500 years old.

ERUPTIVE ACTIVITY AT PACAYA

Pacaya is one of the most active volcanoes in Latin America. Historic records extend back to 1565 and suggest that the eruptions cluster in groups that begin about mid century every 100 years (Figure 5), the last one of which began in 1961 (Figure 6). A summary of the historic activity of Pacaya occurs in Table 1.

TABLE 1.. Eruptive history of Pacaya Volcano (after Simkin and others, 1981; SEAN Bull.)

START			STOP			
YEAR	MO	DA	YEAR	MO	DA	CHARACTER
1565						
1651	2	18	1651	4	13	
1664			1664			Lighted sky at Antigua, 3 days
1668			1668			
1671	8		1671			
1674	7		1674			
?1677	7		1677			Several eruptions, every few years 1890-1900
1690	?		1699	?		
1775	7	11	1775	7		
?1846	2		1846	2		
1961	3	11	1961	4	15	
1965	7	4	1966	5		
1965	10	19				Strong eruption
1965	12	9				
1966	1					
1966	4					
1966	5					
1967	1		1967	4		
1967	9		1968	1	3	Continuous strombolian activity
1968	1	3				
1969	6		1970	1	7	
1970	1	7				
1972	2	2	1972	3		
1972	10	15	1973	12		
1975	10					
1975			1981	3	9	Gas emissions
1981	3	9	1987	1	21	Weak to strong strombolian bursts, occassional lava flows
1987	1	21	1987	1	25	Strong fire fountain events, explosive erosion of the vent conduit, impressive column, 1/21 and 1/25
1987	1	21	Continuing			Weak to strong strombolian bursts,

THE VOLCANIC HAZARDS OF PACAYA

This report deals only with the hazards specifically related to future eruptive events of Pacaya. This is not a particularly satisfactory division of the volcanic hazards in the area around Pacaya. Hazard zones of several volcanoes overlap the hazard zones Pacaya. In addition, Pacaya is an eruptive center of Amatitlan Caldera, and unrest at of Pacaya Volcano might accompany or perhaps intitate unrest at another now-dormant center in the caldera. This particularly applies to Cerro Grande, the main vent of which lies about 2 km northeast of the currently-active MacKenney cone of Pacaya.

Five maps accompany this report. They designate:

- Areas of High (A), Intermediate (B), and Lesser (C) Risk from Sector Collapse and Debris Avalanches from Pacaya Volcano
- Areas of High (A), Intermediate (B), and Lesser (C) Risk from Base Surge and other Pyroclastic Flows from Pacaya Volcano
- Areas of High (A), Intermediate (B), and Lesser (C) Risk from Lava Flows from Pacaya Volcano
- Areas of High (A), Intermediate (B), and Lesser (C) Risk from Mud Flows from Pacaya Volcano
- Area of High (A) Risk from Air-Fall and Ballistic Projectiles and Area of Intermediate (B) Risk from Air-Fall from Pacaya Volcano

The areas indicted as having high (A) risk from sector collapse, debris avalanches, base-surge events, and mudflows are areas where total devastation could occur with virtually no warning. Public agencies responsible for people and industry within this area definitely should be educated as to these risks, and these agencies should, in turn, pass on this information and their concerns to the people. The risks from heavy air-fall or ballistic projectiles from Pacaya (Area AF-A) are also high, and potentially fatal. Appendix I includes monthly wind-rose data that should be helpful in evaluating risk from air-fall deposits from future eruptions.

Note that a hazard zone describes an area where the indicated hazard may occur but does not necessarily have to occur during any one eruption. Moreover, the indicated hazard usually will not affect the entire area in the indicated zone during any given eruption. However, if the volcano continues to erupt in the manner indicated by earlier deposits, the areas labeled with

an A have high probability of eventually being affected by the indicated hazard; field relations indicate that the indicated hazard has occurred in areas labeled A at least once in the past. Areas labeled with B are areas where a given hazard has occurred less frequently or to a lesser degree than in the areas labeled as Area A. Areas labeled C are areas where field evidence was not found for the hazard, but where conditions can be visualized that could produce the hazard (e.g. a larger or longer-lived eruption than recorded before, a shift in the eruptive center, etc.).

RECOMMENDATIONS

- Communicate to the agencies responsible for the people and industry around Pacaya Volcano that potential risks definitely exist within the areas designated on the enclosed maps.

- Encourage low-population density use of all lands in Areas A of the Base Surge, Debris Avalanche, and Mudflow Risk Maps.

- Develop contingency plans for future volcano-generated emergencies at Pacaya, including but not restricted to:

    - Accurate census
    - Design of evacuation routes
    - Timing required to use evacuation routes
    - Rapid mobilization of transportation resources
    - Assembly points
    - Posters and bulletins describing evacuation routes, assembly points, survival techniques
    - Refugee support systems including shelter, water, food, protection

- Establish one or more means of rapid and effective communication between the population centers, INSIVUMEH, CONE, and other appropriate agencies. For example:

    - Telephone or radio links
    - Sirens with appropriate emergency codes in locations where concentrated and dispersed population centers can hear them
    - Public radio bulletins

- Establish a full-time observatory at Pacaya (Cerro Chino or San Vincent Pacaya) with receiver stations for the seismometer and tiltmeter and direct radio contact with INSIVUMEH

- Increase the level of monitoring of Pacaya, including:

    - Relocation or addition of a seismometer within a 1-2

kilometers of the vent (e.g. Cerro Chino)
- o Placement at INSIVUMEH of an automatic tremor alarm for the new seismic station
- o Placement of a telemetered tilt station at Cerro Chino with an automatic alarm at INSIVUMEH
- o Establish a procedure of reading, plotting, and interpreting the seismic and telemetered tilt data on an hourly (minimum 4-hourly) basis at INSIVUMEH
- o Establish a regular program of EDM, dry-tilt, and leveling monitoring of Pacaya

- o Improve the hazard maps and geologic studies of the entire Amatitlan area

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Simkin, Tom, and others, 1981, Active Volcanoes of the World: Smithsonian Press, ** pp.

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Williams, Howel, 1960, Volcanic history of the Guatemalan Highlands, Univ. California Pubs. in Geol. Sci., v.38, 81 pp.

APPENDIX I

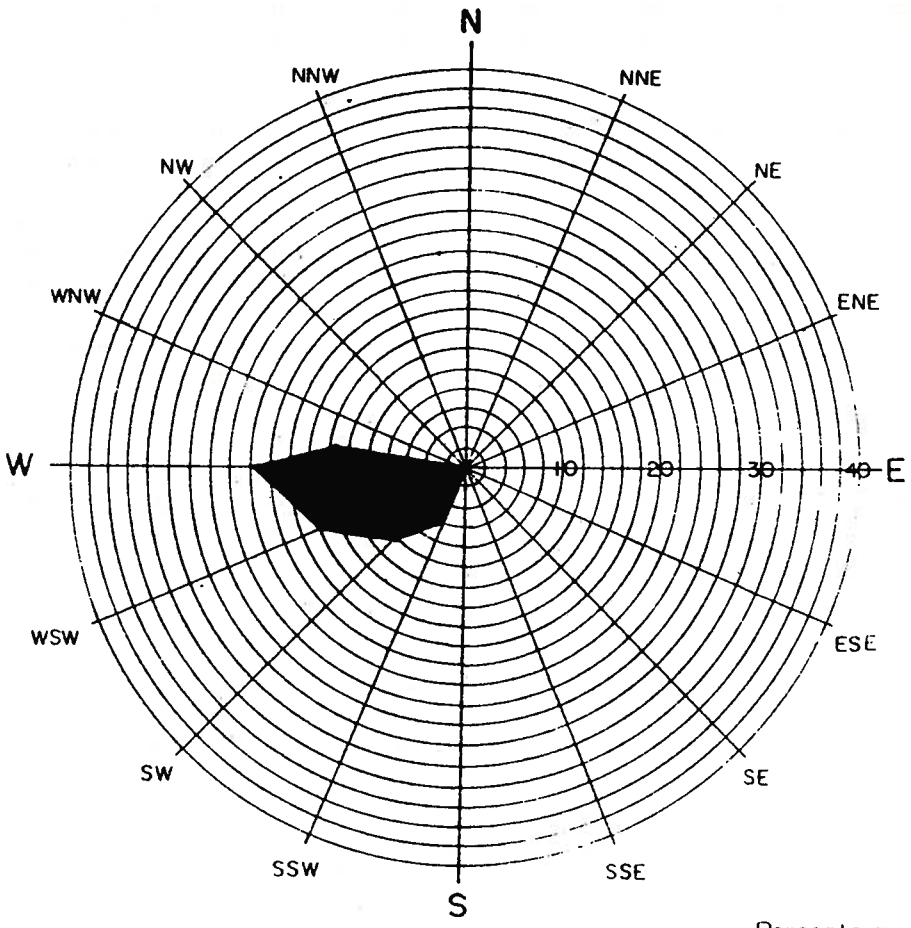
Table of wind directions 10,000-50,000 ft in altitude based on two years of radiosonde data at Guatemala City. The three most frequent wind directions (the direction from which the wind is blown) are listed for each month, with the percentage of the time that direction was applicable. The percentage of the time calm winds prevailed is also listed

Directions

Month	Most Freq.	2dn	3ro.	calm
January	W (23%)	WSW (17)	SW (14)	13
February	WSW (27)	SW (21)	W (21)	5
March	W (21)	WSW (19)	SW (13)	10
April	W (12)	NW (10)	WNW (10)	10
May	NE (12)	WSW (11)	W (11)	13
June	E (16)	ESE (10)	NE (8)	19
July	E (22)	NE (15)	ESE (11)	12
August	E (23)	ENE (18)	NE (10)	9
September	NE (17)	E (15)	ENE (12)	13
October	E (17)	NE (15)	ENE (13)	13
November	WSW (14)	SW (10)	W (10)	13
December	SW (15)	WSW(12)	W (7)	10

Source of Data: Sr. Leonel Najera
INSIVUMEH, Sección Meteorología Aeronaútica

ENERO

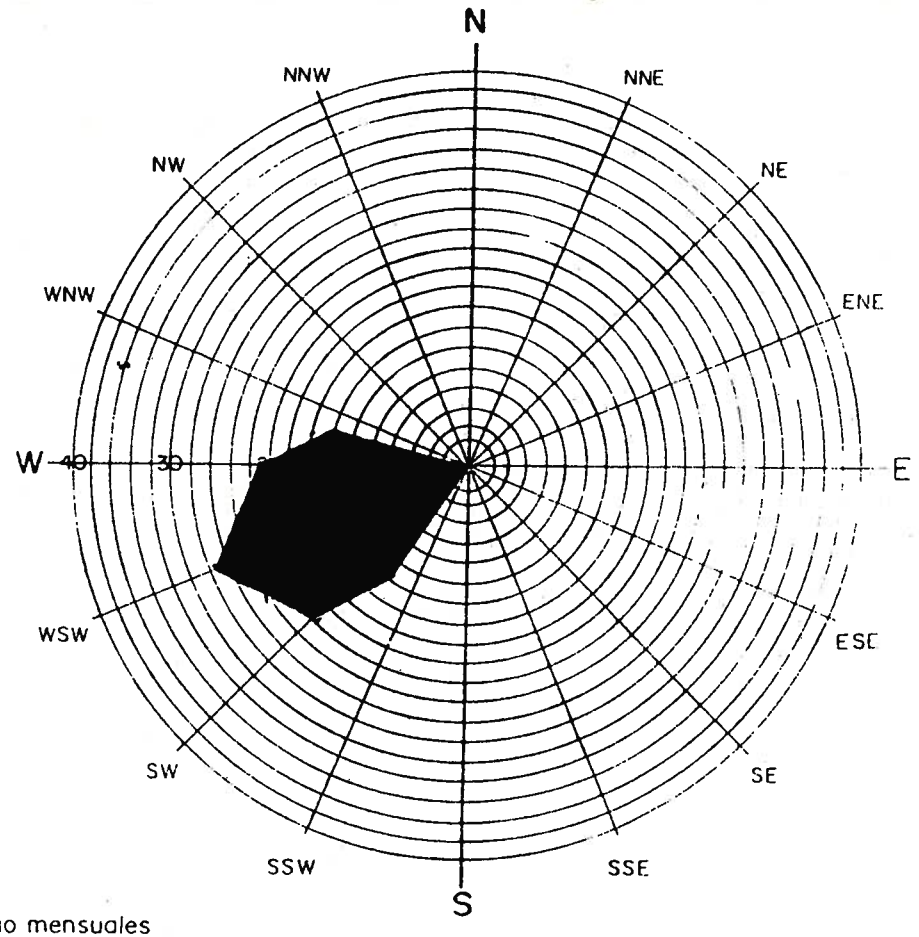


Porcentaje de vientos en calma

13 %

Porcentajes promedio mensuales de ocurrencia de las direcciones donde sopla el viento entre los 10,000 a 50,000 pies de elevación

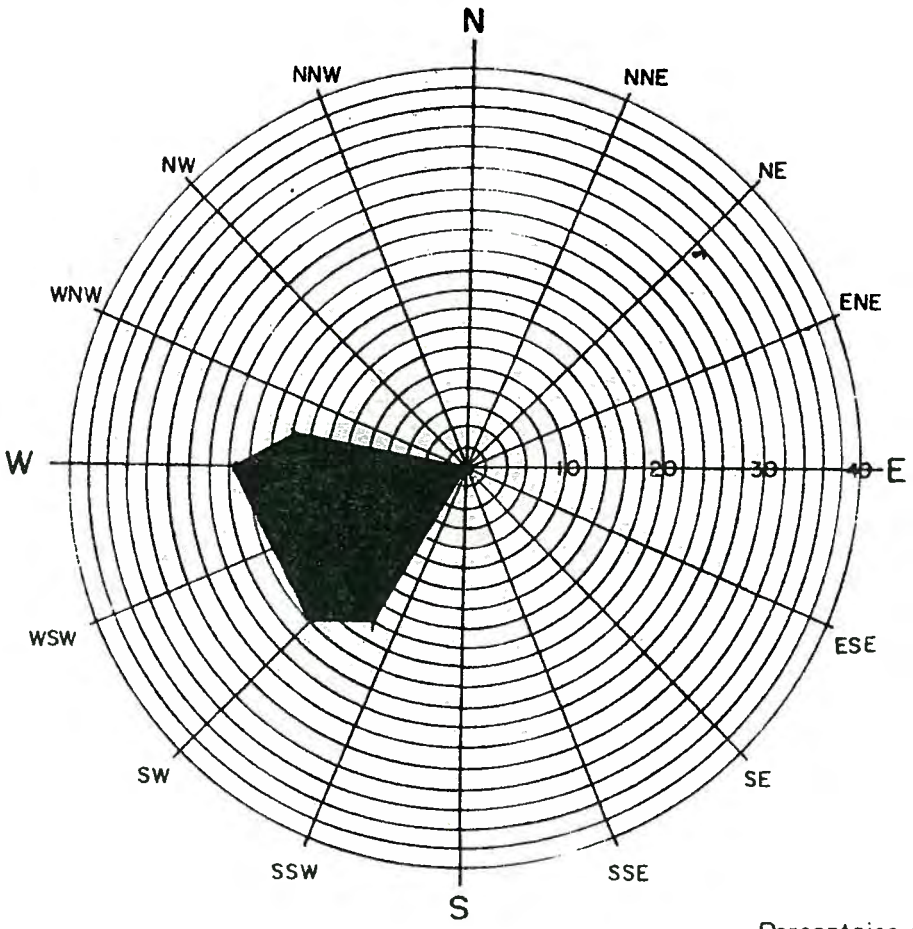
FEBRERO



Porcentaje de vientos en calma

5 %

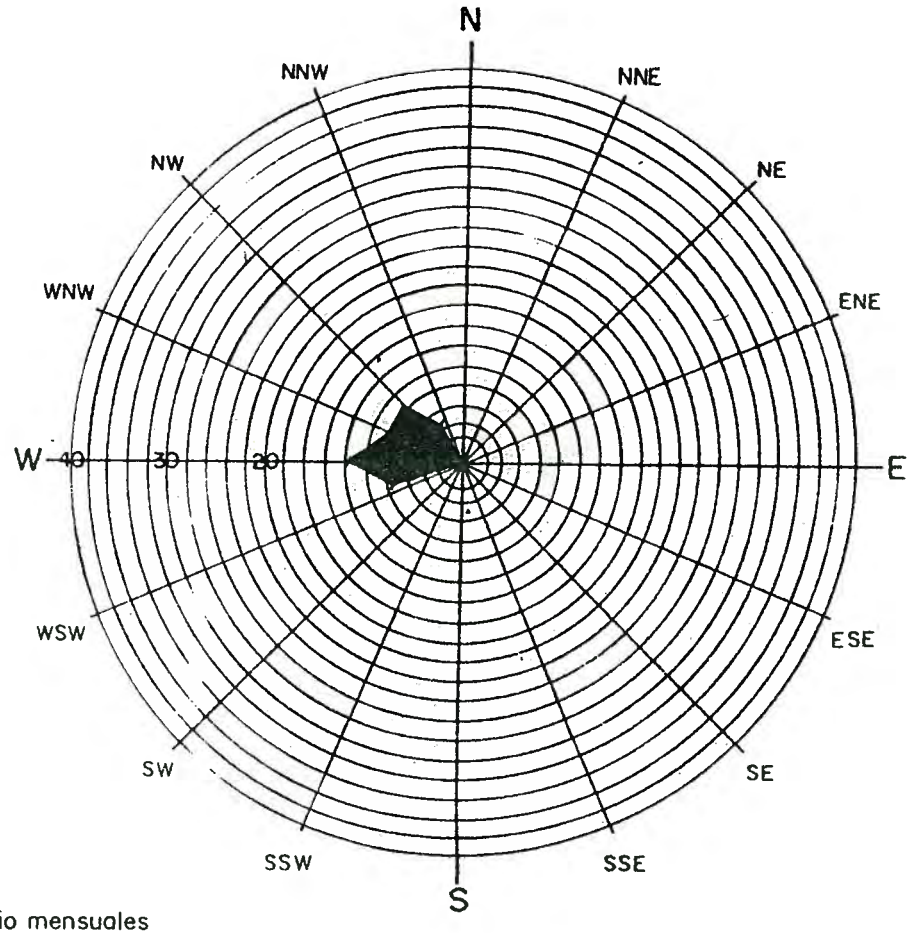
MARZO



Porcentaje de vientos en calma

10 %

ABRIL

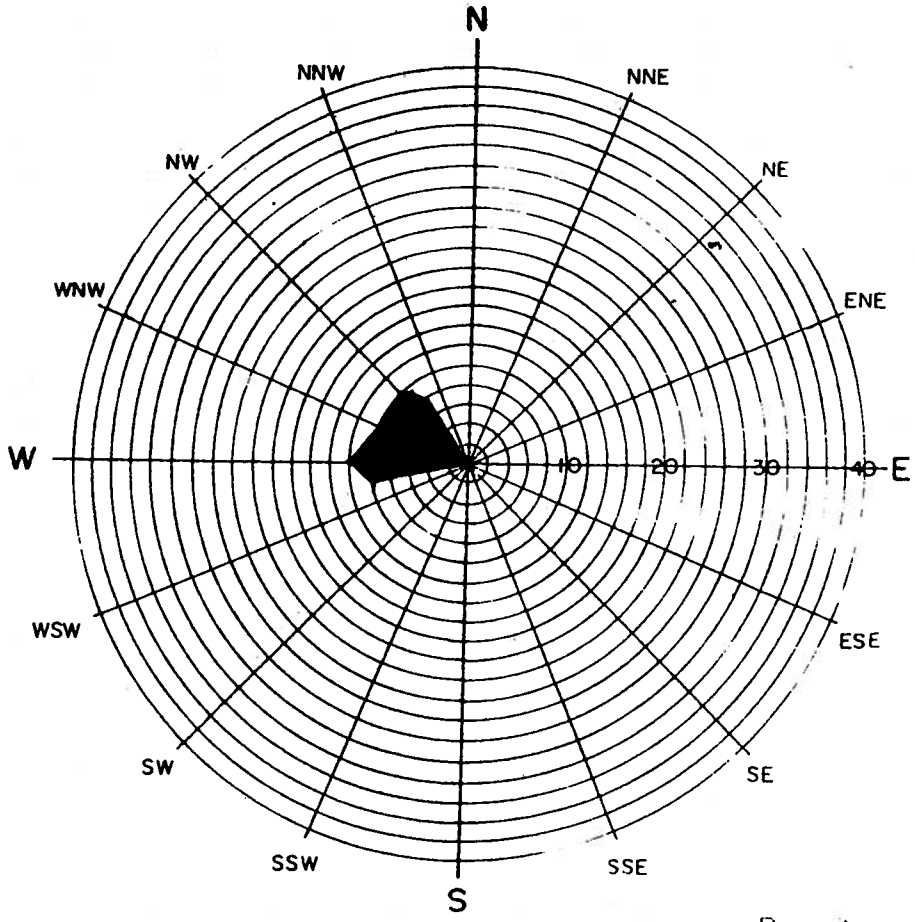


Porcentaje de vientos en calma

10 %

Porcentajes promedio mensuales de ocurrencia de las direcciones donde sopla el viento entre los 10,000 a 50,000 pies de elevación.

MAYO

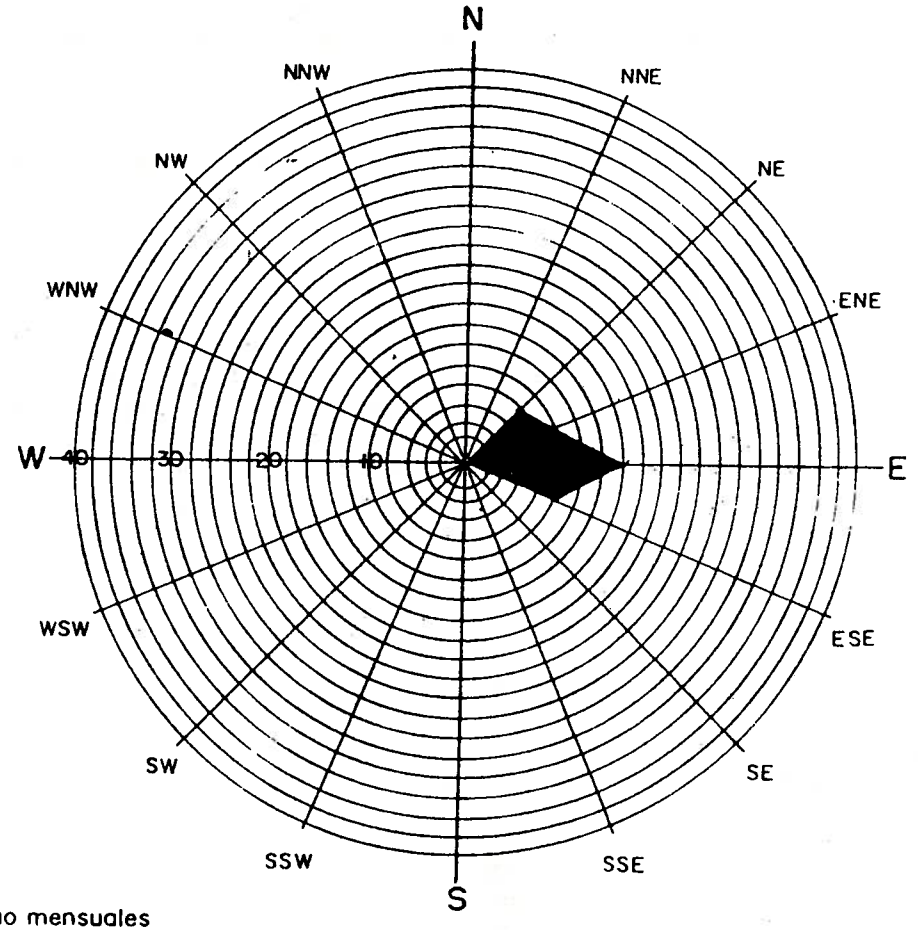


Porcentaje de vientos en calma

13 %

(%)

JUNIO

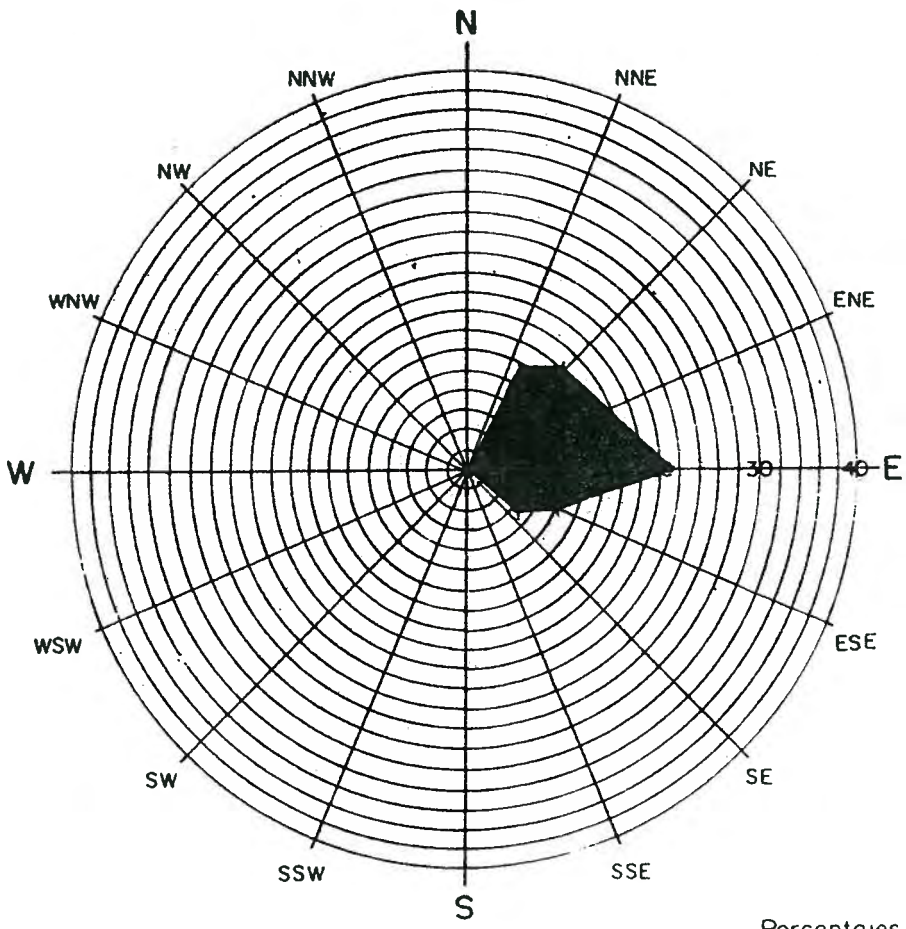


Porcentaje de vientos en calma

19 %

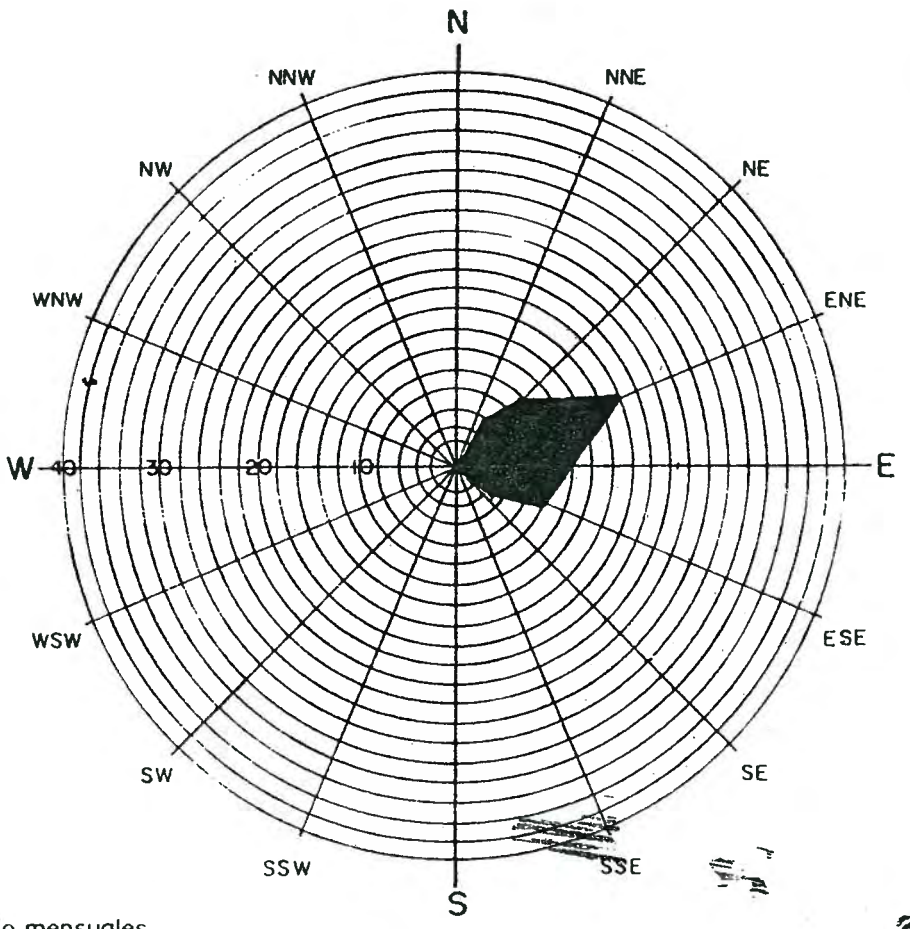
Porcentajes promedio mensuales de ocurrencia de las direcciones donde sopla el viento entre los 10,000 a 50,000 pies de elevación

JULIO



Porcentaje de vientos en calma
12 %

AGOSTO

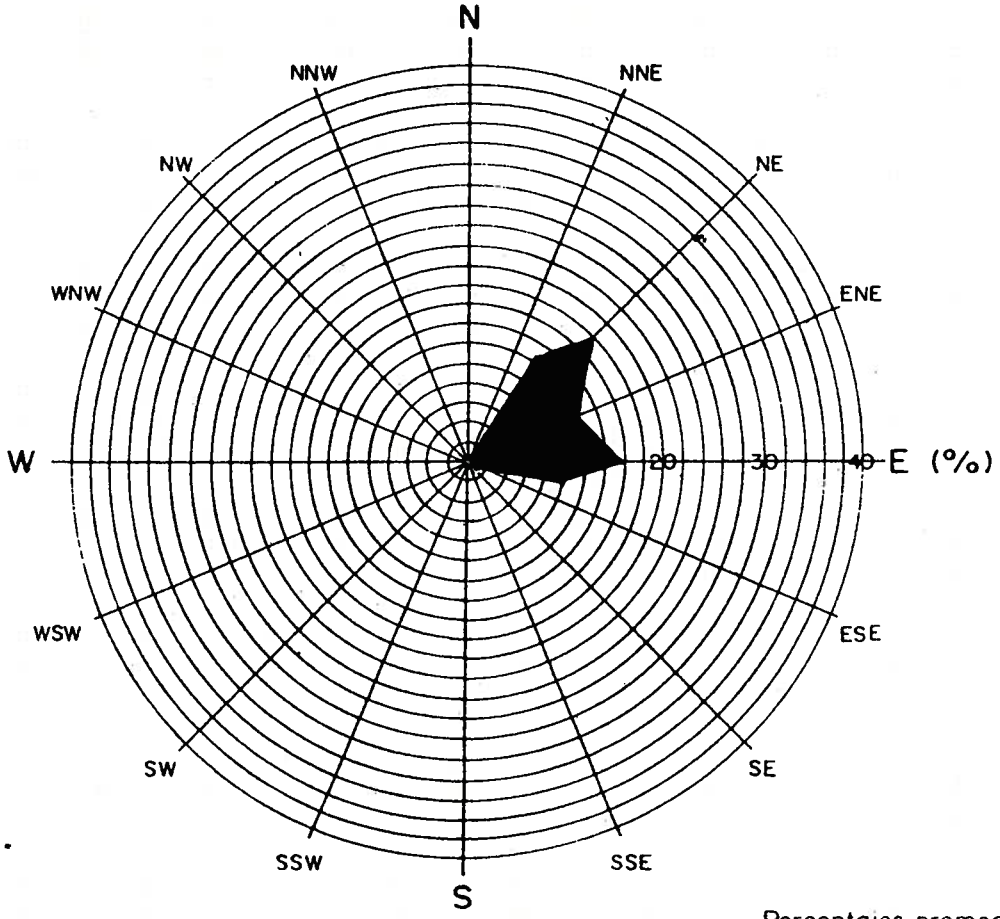


Porcentaje de vientos en calma
9 %

(%)

Porcentajes promedio mensuales de ocurrencia de las direcciones donde sopla el viento entre los 10,000 a 50,000 pies de elevación

SEPTIEMBRE

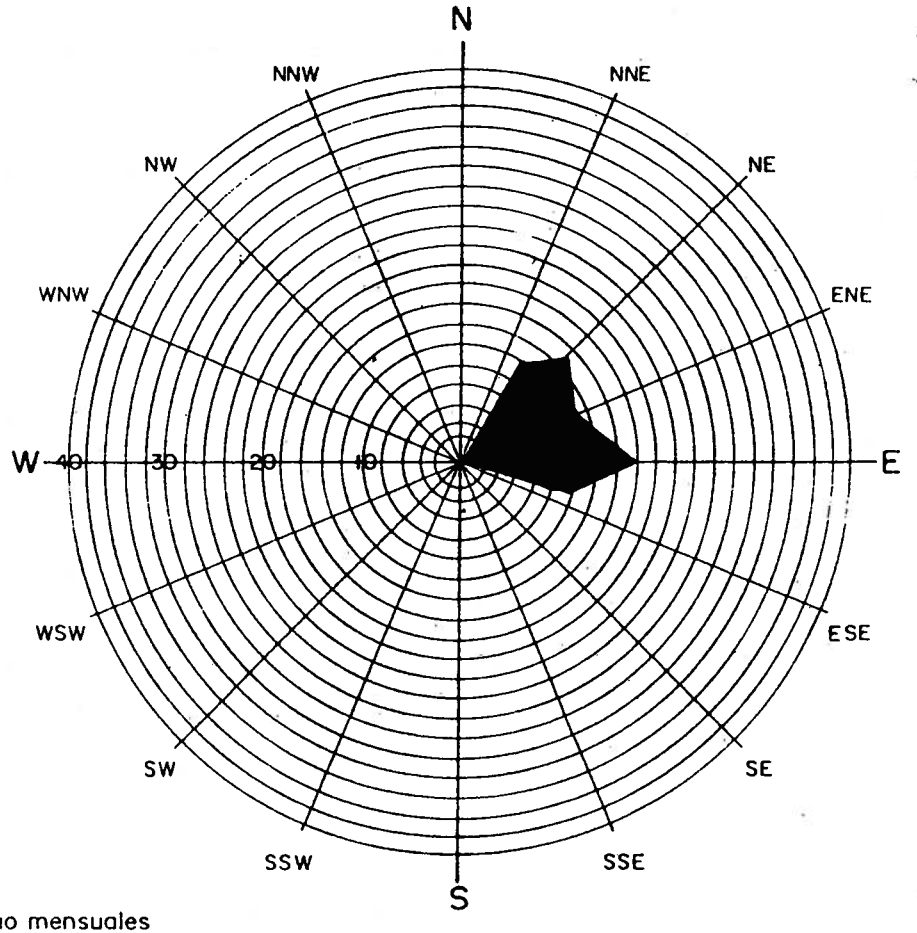


Porcentaje de vientos en calma

13 %

Porcentajes promedio mensuales de ocurrencia de las direcciones donde sopla el viento entre los 10,000 a 50,000 pies de elevación.

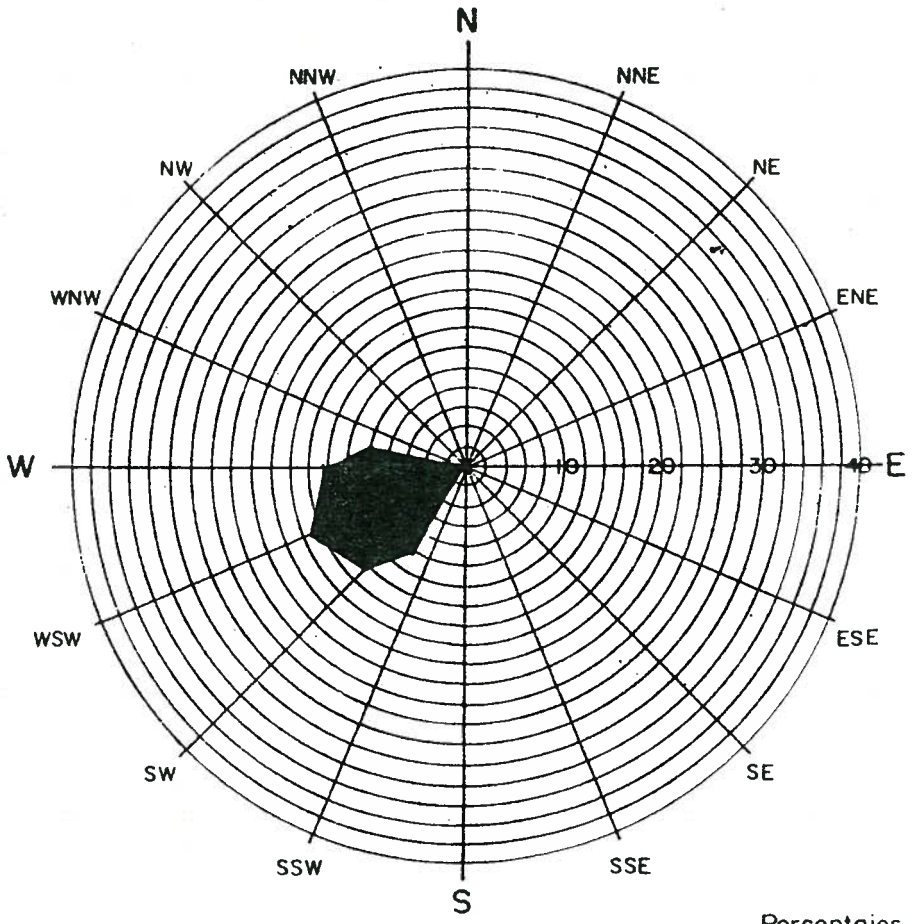
OCTUBRE



Porcentaje de vientos en calma

13 %

NOVIEMBRE

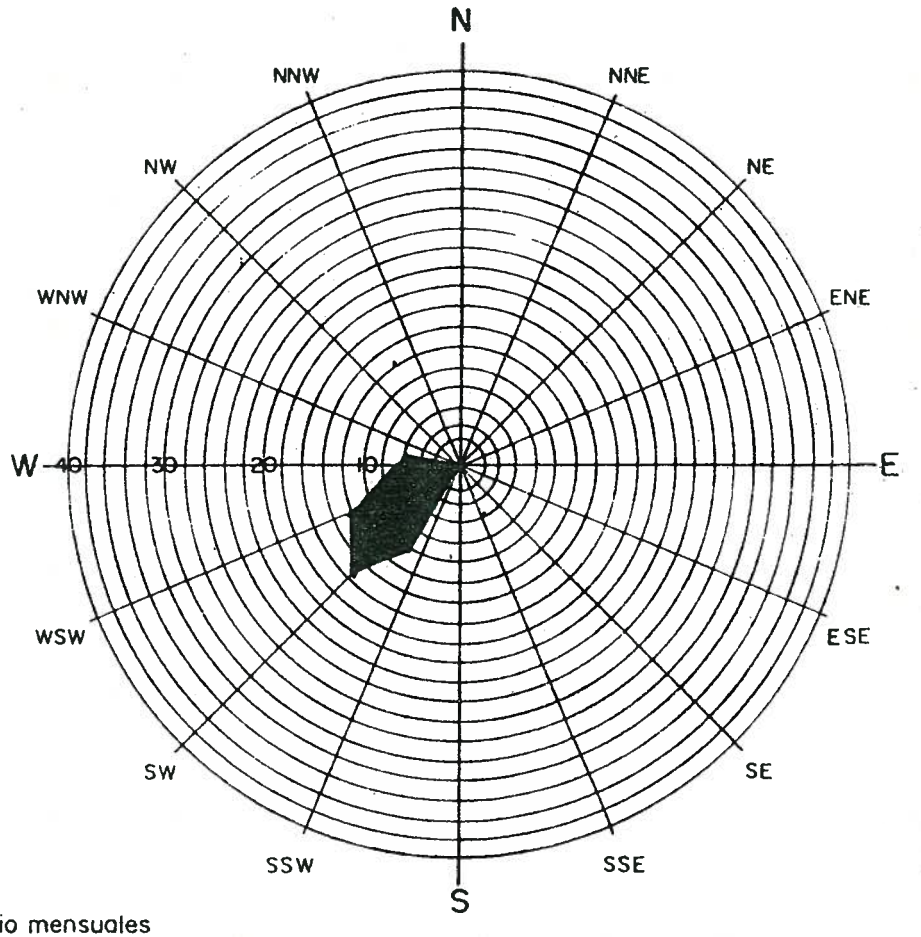


Porcentaje de vientos en calma

13 %

Porcentajes promedio mensuales de ocurrencia de las direcciones donde sopla el viento entre los 10,000 a 50,000 pies de elevación.

DICIEMBRE



Porcentaje de vientos en calma

10 %

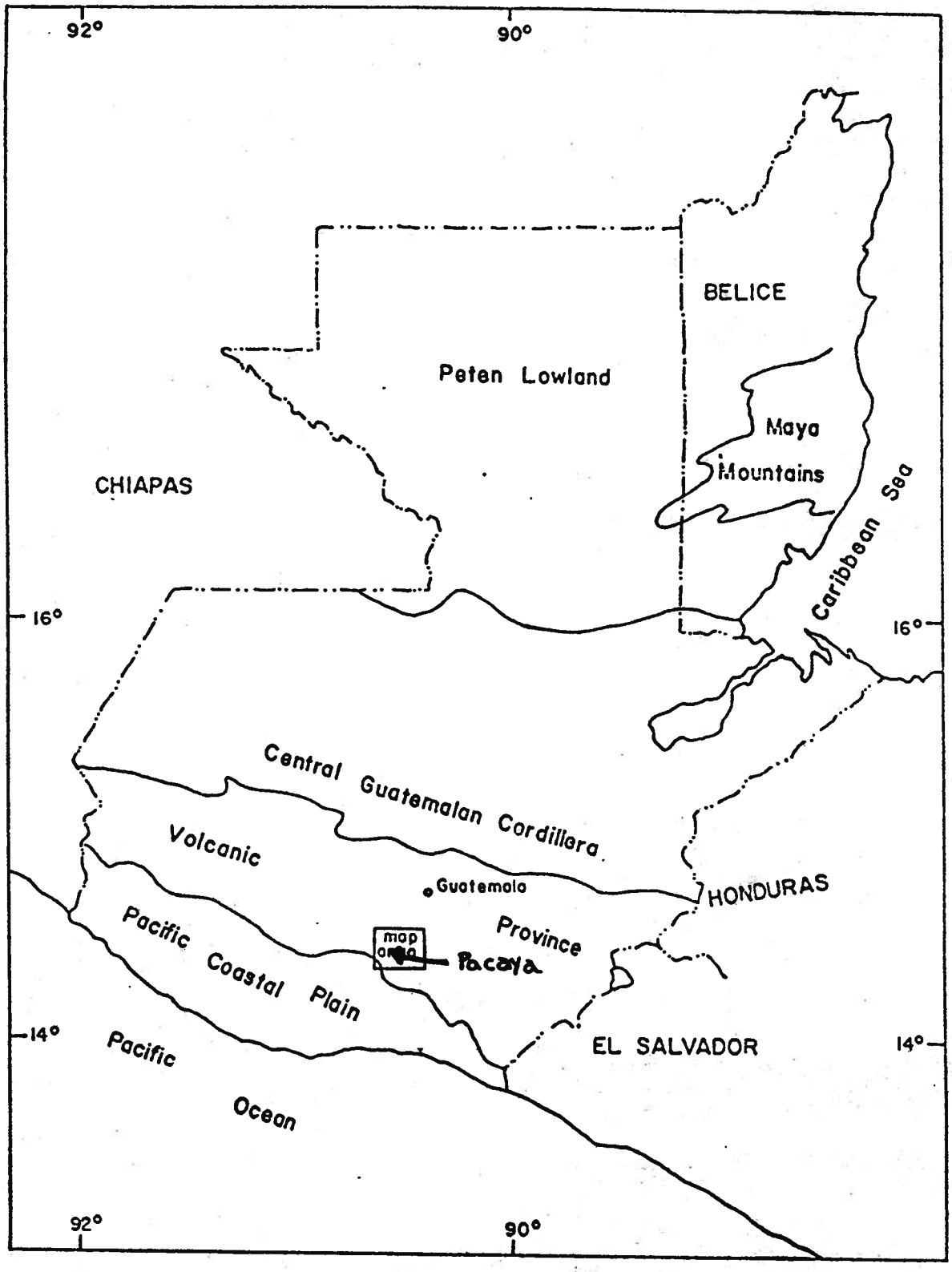


Figure 1 Physiographic provinces of Guatemala, from Bonis 1967, showing the location of Pacaya.

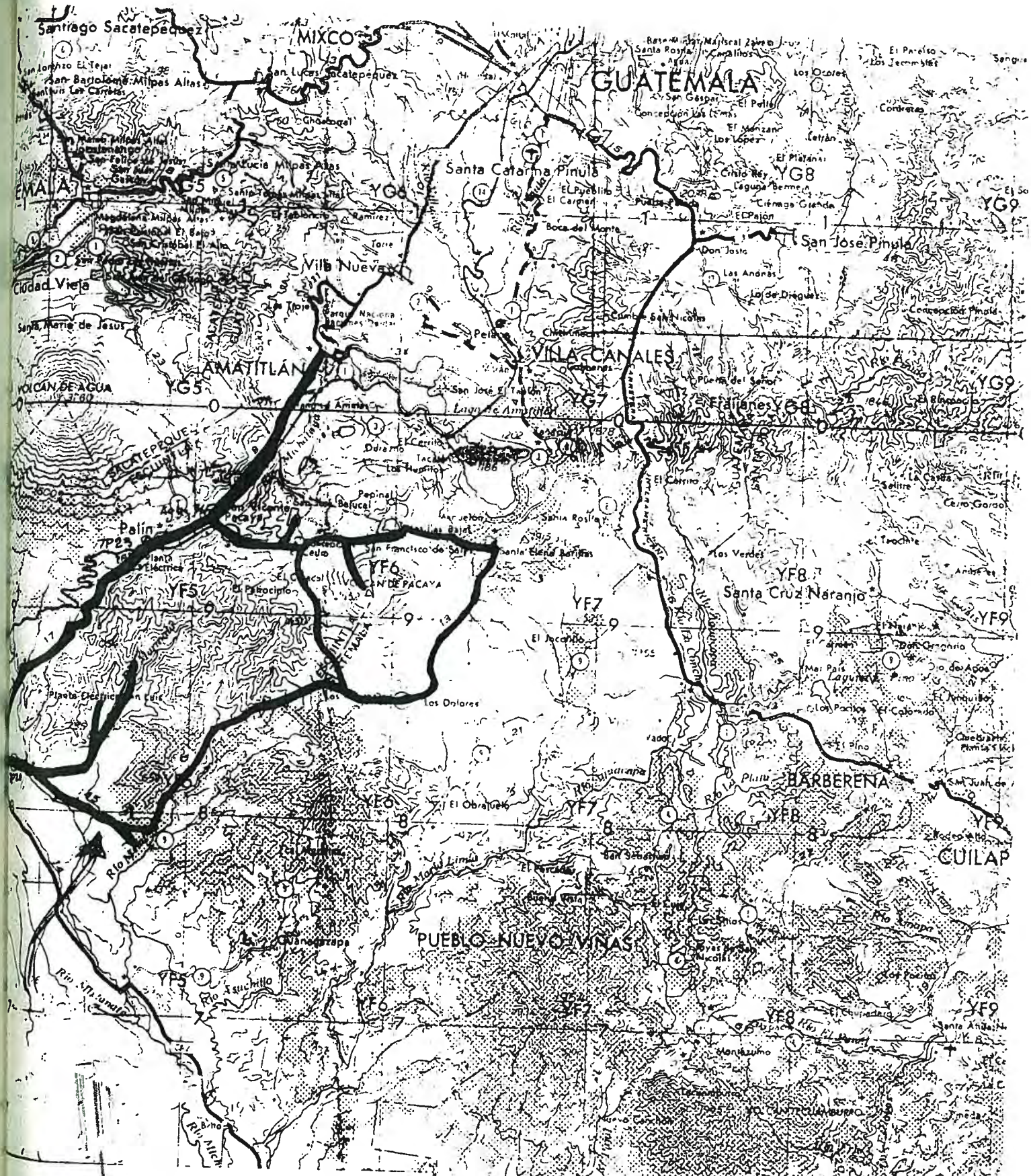


FIGURE 2

— = ROUTE USED FOR RECONNAISSANCE OF VOLCANO HAZARDS

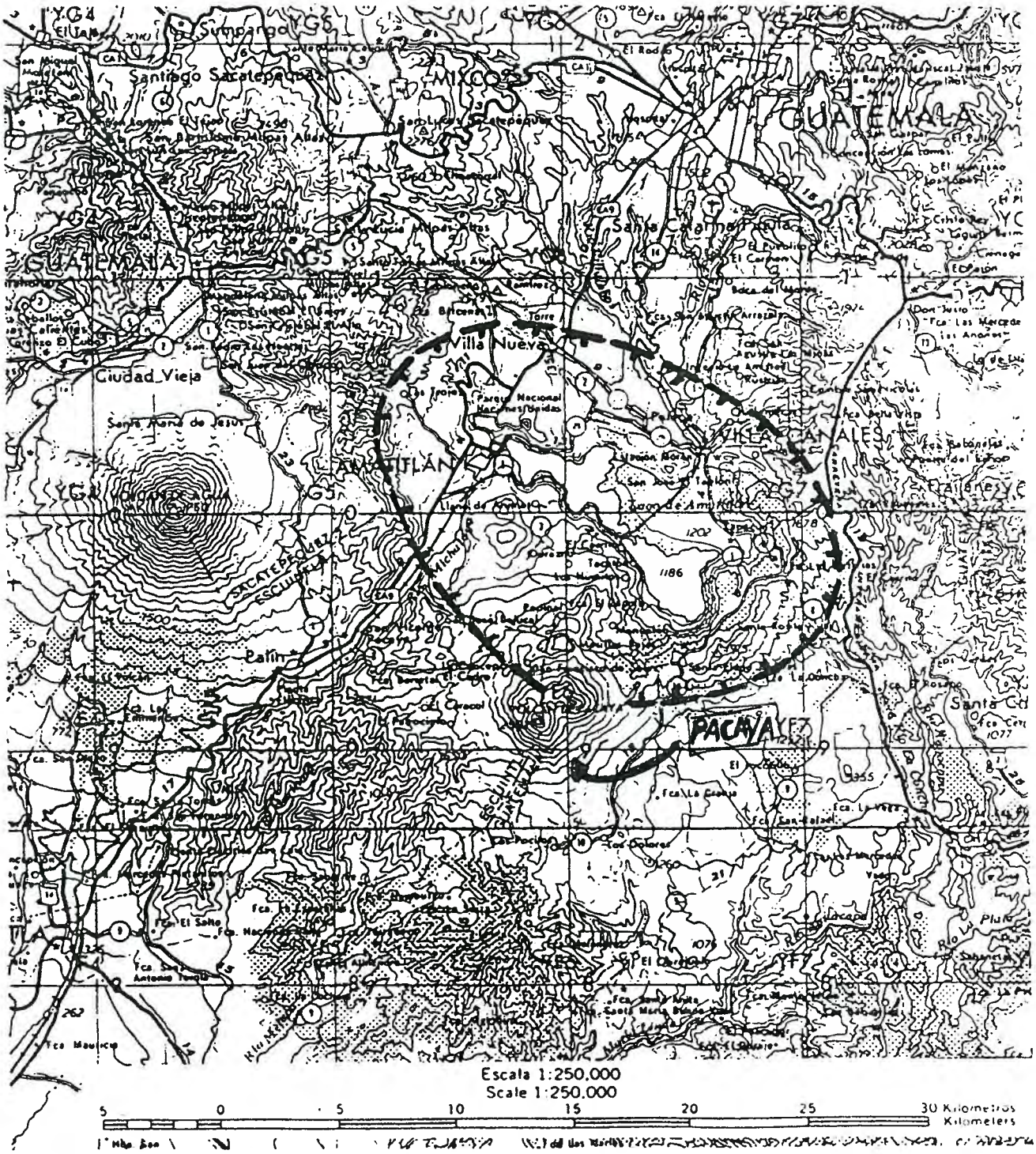


Figure No. 3
Approximate boundary of Amatitlan Caldera, as inferred by Wunderman (1982). Pacaya Volcano lies on the southern boundary of the caldera; Guatemala City is only a short distance north of the caldera.

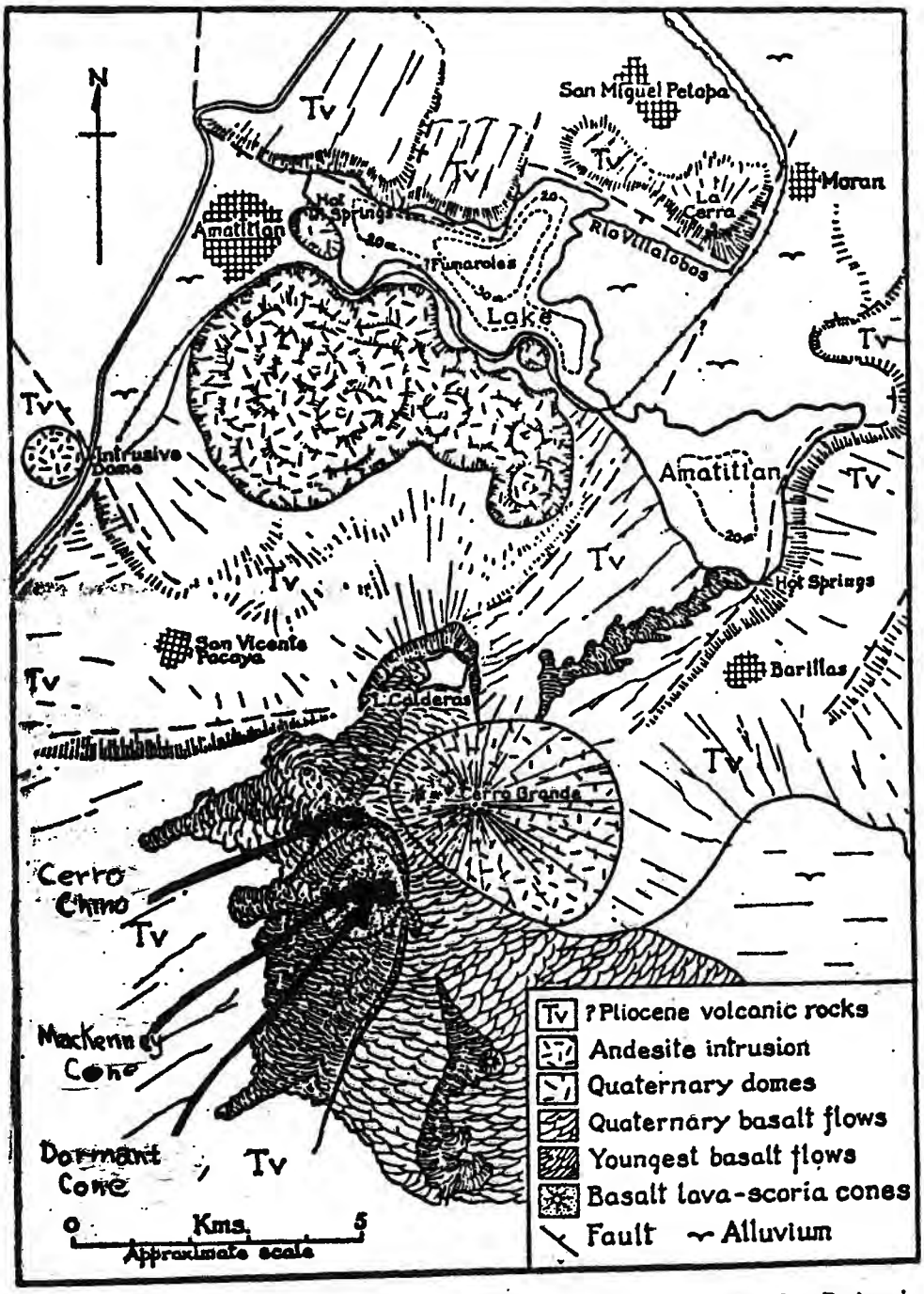


Fig.4 Pacaya volcano and vicinity. Depths of Lake Amatitlán in meters, after Borhegyi.
(from Williams, 1960)

Figure 5. Historic Eruptions of Volcan de Pacaya and/or Cerro Chino, all data from Meyer-Abich, 1956 (from Eggers, 1971)

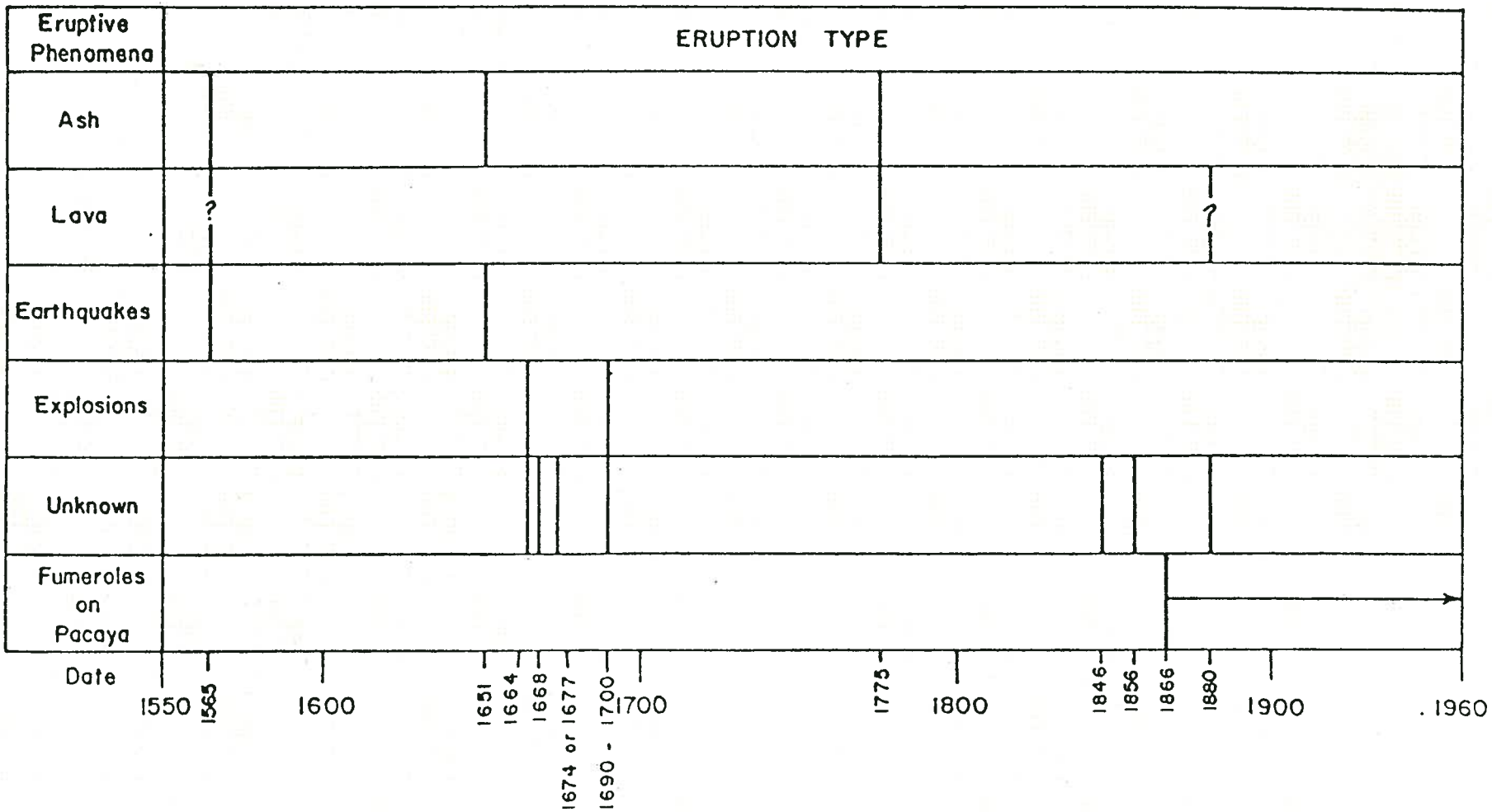


Figure 6 GENERALIZED MODERN (1961-1970) ERUPTIVE HISTORY OF VOLCÁN DE PACAYA (from Eggers, 1971)