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# Investor Information Package- Chitral

Institutional Support to Khyber Pakhtunkhwa Mineral Development Department

June, 2014

This publication was produced for review by the USAID. It was prepared by Mr. Fuzail Siddiqi and Mr. Muhammad Nawaz for an assignment commissioned by Chemonics International under the USAID Firms Project.





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# Abstract:

The landscape of Khyber Pakhtunkhwa with an area of 74,521 km<sup>2</sup> is dominated by mountainous terrains. The province has almost all varieties of mineral resources and other natural endowments. Most of the potential areas of minerals have abundant resources of water bodies in the form of rivers and streams providing suitable sites for hydel power generation to meet the need of mining industry. The people of the region being talented in nature are a source of man power for development of natural endowments including minerals.

The Minerals Development Department, Khyber Pakhtunkhwa deals with the management of mineral resources of the province in terms of exploration promotion and grant of mining concessions to potential investors. The Department has developed this document with a purpose to attract investment by identifying various highly potential exploration-targets in District Chitral and incentives from the Provincial and Federal Governments. The main concept is to provide comprehensive information to the prospective investors in establishing exploration and mining ventures in the Khyber Pakhtunkhwa. The Khyber Pakhtunkhwa province welcomes the world to become its partners in benefitting from its multiple mineral resources and trigger mutually beneficial economic growth.

Commencing January 21st, 2014, the consultant was contracted to provide institutional support to the Government of KPK to create a business friendly environment in order to increase the contribution of minerals to the economy of KPK, while enforcing maximum local value addition and responsible environmental stewardship and SOPs for the purpose.

The Government of Khyber Pakhtunkhwa through its Minerals Development Department is willing to undertake all endeavors to offer its virtually untapped mineral sector to the investors. It is hoped that the present document will find a wide range of investors, both national and international.



# Acronyms

DGMM	Directorate General Mines & Minerals, Khyber Pakhtunkhwa
EL	Exploration License
EPD	Exploration Promotion Division
KPK	Khyber Pakhtunkhwa
MDD	Minerals Development Department
MIFA	Mineral Investment Facilitation Authority
ML	Mining Lease
MTL	Mineral Testing Laboratory
Pan. Con.	Panned heavy mineral concentrate
RL	Reconnaissance License
SDA	Sarhad Development Authority
SOW	Scope of Work



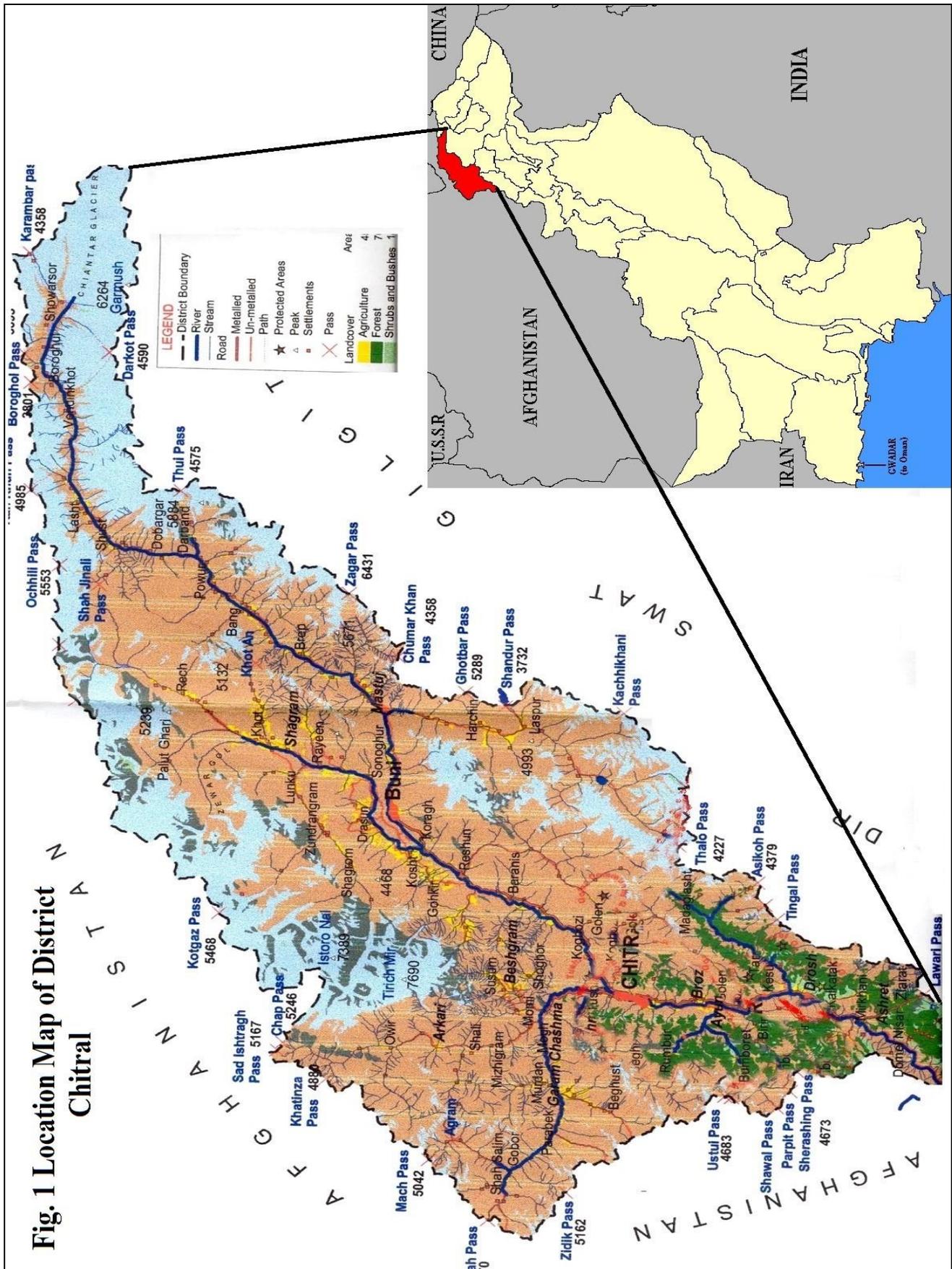


Figure 1: Location Map of District Chitral



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# Executive Summary

The province Khyber Pakhtunkhwa (KPK) in Pakistan is host to vast mineral resources that hold considerable potential to generate revenue. Development of these minerals can ensure not only that revenue is generated but that economic growth and social improvements directly result from this development. Mining operations are generally privately operated although the State does hold shares and participate in some mining activities. KPK but has yet to generate the truly beneficial employment, economic or social gains for which it holds potential.

Part of the consultancy was Support the department in delineating mineral blocks for allocation to investors through open bidding each block with data packages comprising geology and known mineral occurrences and available exploration data in GIS format particularly for metallic minerals.

This document includes information on geology, known metallic minerals and gemstones together with information on past exploration coverage in Chitral region. An eight page comprehensive bibliography is included to facilitate Investors' own due diligence. This information is provided in conjunction with planned business friendly facilitation to attract the investors in follow-up exploration of identified targets in District Chitral through exploration licenses. The Department is also working to compile similar information about other exploration targets of metallic minerals & gemstones in other districts of KPK.



# 1. An Overview of Chitral Region

## 1.1 Geographic description

The geographic location of District Chitral may be seen from Figure-1. As shown in Figure-2, it is a high altitude and high relief mountainous region, representing eastern most terrains of Hindukush ranges with highest altitude of 7,690 meter at the famous Tirich Mir peak, in the northwest of Khyber Pakhtunkhwa. The Chitral valley is the uppermost reaches of Kunar–Chitral drainage system, a tributary of Kabul River draining the Chitral (Khyber Pakhtunkhwa, Pakistan) in the east and flowing towards Kunar–Nuristan (Afghanistan) in the west. The high altitude gullies of the valley, covered with glaciers and the peaks with ice caps, serve as perennial source of water for fertile low-land along the main valley.

Area–Wise, the Chitral region of around 14,800 Km<sup>2</sup> is the largest District of the Province, housing about 400,000 people. The southern part of the District is densely populated wherein; the Chitral town is the District Headquarter. The dwellers are friendly and hospitable and encourage economic activities in the region. Unskilled manpower is frequently available; however skilled persons are not readily available.

## 1.2 Infrastructure and accessibility

In terms of infrastructure including communication and accessibility, the region is rated as reasonable. Road access from down country to Chitral is through Lowari Pass with an altitude of 3,200 meter which remains closed due to snow fall in the winter season (December to April). While work on Lowari Tunnel has almost been completed to make an access to Chitral round the year, the tunnel is nevertheless opened for traffic on certain days of the week in winter months. An all-weather access to Chitral is also via Arandu Pass through Kunar (Afghanistan). Domestic airline operates between Chitral and Peshawar/Islamabad excepting bad weather.

## 1.3 Climate

Climatically, the region is typical of Central–Asian Alpine in type, dry and warm summers and cold winters with little to heavy snow fall. As a result, the mountains are barren of forest. However, the southern part seldom gets moon–soon rains in summers and has forests of pines and conifers.

## 1.4 Exploration and mining history

The documented history indicates that geological exploration of Chitral region was initiated from study of fossils collected by travelers in diplomatic, military and surveying expeditions who crossed the rugged terrains of the Hindukush long before the days of motor vehicles in the 19th century. In the past four decades the northern Pakistan, owing to its interesting geology, has attracted significant geological research, which is providing a base for mineral exploration. The references given in this report indicates the pace of geological work in the region.

In the field of mineral exploration, the first exploration work was by a German group DEMAG in 1953. The work comprised geophysical survey and geological mapping of Dommel Nisar iron ore occurrence. Another report on the same prospect was by GSP in 1958. The GSP Mineral Directory of Pakistan by Zaki Ahmad (1968) also includes description of a few mineral occurrences from Chitral. Calkins et al in 1981 published the joint work of US Geological Survey

and Geological Survey of Pakistan, on the geology and mineral resources of Chitral. This was an integrated investigation, which covered geology and mapping as well as brief studies of known mineral occurrences.

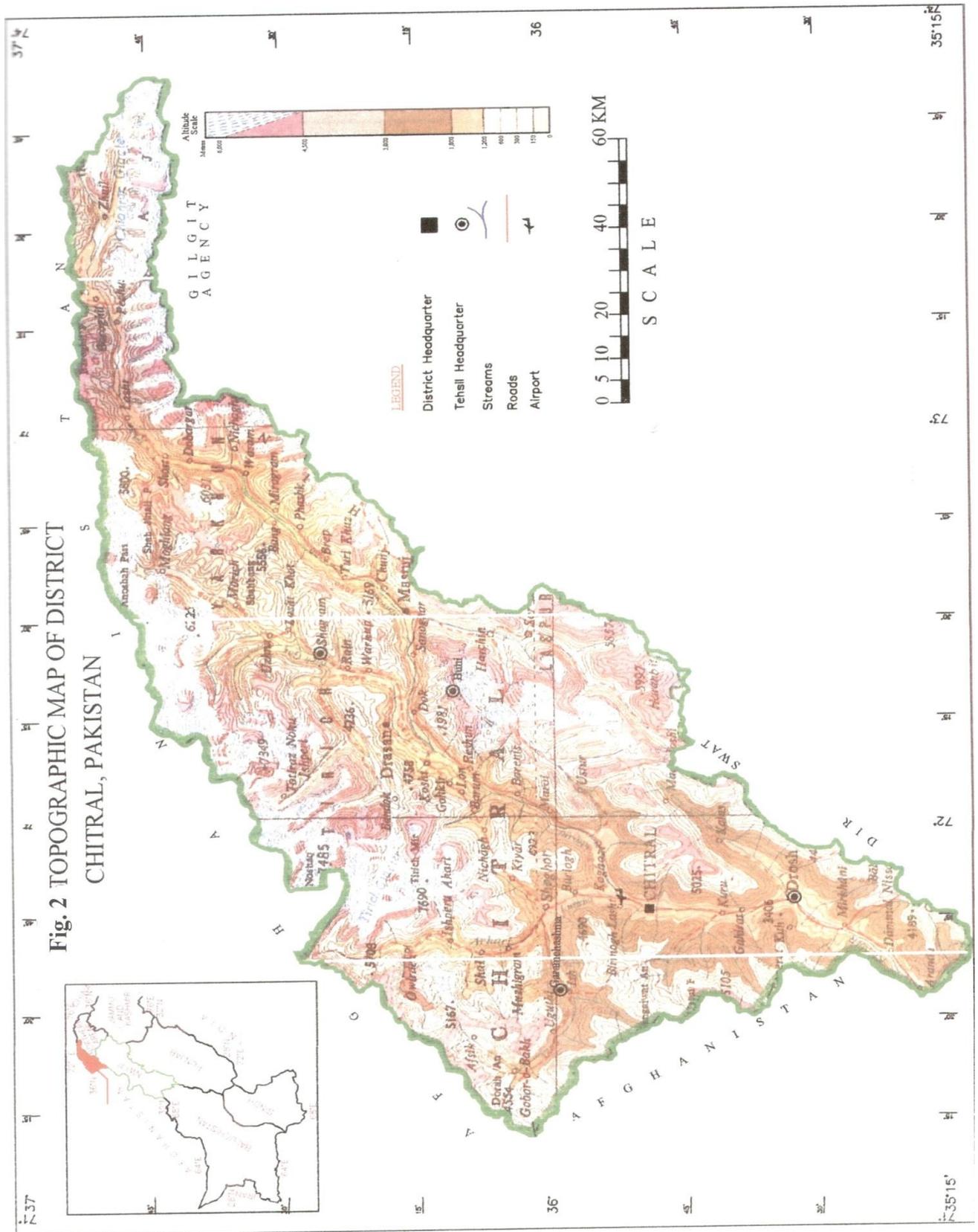


Figure 2: Topographic Map of District Chitral, Pakistan

They have also given references of the unpublished reports file on the Krinj antimony by Sondhi (1942), Nath (1944) and Crookshank (1951) and Mineral Occurrence of Chitral State by S.T. Ali (1949), S.I. Ali (1951) and M.G. White (1975) available with GSP. Another report by Jankovic (1984) on the preliminary assessment of metallogeny and mineral potential of northern Pakistan and particularly work on Chitral was also a joint project between GSP and UNDP.

A systematic geological mapping and mining exploration in Chitral was conducted during 1974-78. The exploration work was sponsored under a Austrominerals (Austrian Consultant Company). The work resulted in regional geological mapping of the entire Chitral and mapping as well as surface and subsurface exploration of selected prospects of Awireth gold-silver, Dommel Nisar copper-iron, Buni Zome iron, Pakhturi copper-lead-zinc, Shah Jinali molybdenum, Krinj antimony, and Shishi valley talc- magnesite.

The formally Mineral Directorate of Sarhad Development Authority (SDA) "now Exploration Promotion Division" of the Directorate General Mines and Minerals (DGMM), KPK being a provincial development agency has been involved in the mining exploration and development of mineral resources of the province. Systematic geochemical-exploration coverage of the region was initiated through the Australia- Pakistan Gold Exploration and Mineral Analysis Project (GEMAP) of AusAID technical-assistance program in 1992-95. The exploration studies on localized occurrences of tungsten, gold-silver, copper-silver and antimony, during the period 1981-92, are in addition to these.

Presently, a few small-scale mining operations are in progress mainly on marble. However, the region has abundant potential of other minerals, particularly metallic minerals and gemstones.

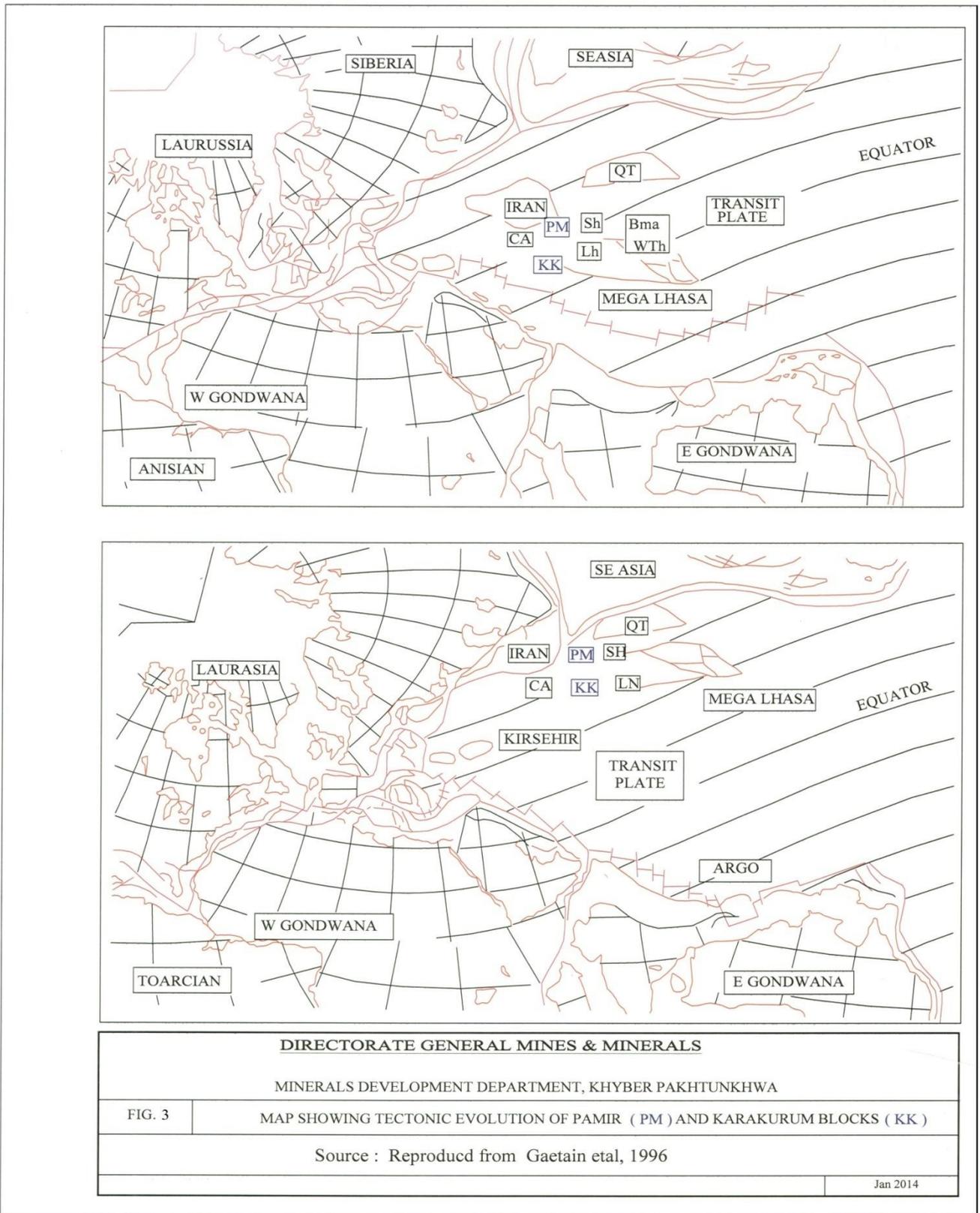
## 2. Geological Environments

### 2.1 Geo-tectonics

The Chitral region encompasses southern part of Pamir Block in the north, western Karakorum Block in its central part and northern margin of Kohistan Island Arc in the south. These micro continental plates of the peri-Gondwana land drifted apart toward north under the realm of Permo-Triassic rifting along the southern border of Palaeo-Tethys. The northward drifting of the Karakorum Block along with other micro continental blocks from southern Hemisphere, consuming the Palaeo-Tethys oceanic crust and its suturing with the southern margin of Asian continental plate was completed around early Jurassic. The Kohistan Island Arc, developed as an intra-oceanic arc of the Neo-Tethys, was sandwiched between Asian plate in the north and Indian plate in the south. The accretion of Indian plate to Asian continent is dated around 50 Ma.

The collision zone between Kohistan Island Arc and Hindukush-Karakorum plate in Chitral passes along the Arandu-Mir Khani valley following Chitral River and Shishi valley, entering Gilgit Agency in a NEE direction, north of Shandur pass. Syn to post- collision events, mainly under thrusting of one underneath another plate during the prevailing compressional regime has resulted into emplacement of subduction as well as crustal-melt related batholiths (igneous plutonic rocks), crustal shortening and uplifting and the associated deformation and metamorphism of rock belts. The evidence of the intermittent extensional phases is also indicated by the occurrence of intraplate tectonic scars and volcanic to subvolcanic activities along the rift zones. Based on metamorphic isograds, it is interpreted that the geomorphologic denudation, accompanying as well as the ensuing crustal shortening and uplifting in northern Pakistan, have removed rock overburden of more than 30 Km vertical thicknesses. This resulted into exposure of deep-seated profile of the plutons.

Figure-3 & 4 reproduced from the relevant literature summarize the above-mentioned geotectonic evolution and palaeogeographic position of Karakorum Block and Kohistan Island Arc. The position of the present day boundaries of the Kohistan Island Arc and Karakorum Block and generalised geology (rock types) with respect to Chitral and adjoining areas of Hindukush-Karakorum and Pamirs is indicated by Figure-5 reproduced from Gaetani (1996).



**Figure 3: Map showing Tectonic Evolution of Pamir and Karakorum Blocks**

## 2.2 Geological Setting

Geology of Chitral region is characterized by the occurrence of thick sedimentary succession comprising terrigenous to carbonate sediments of Palaeozoic to Mesozoic age. The stratigraphic succession represents Palaeo and Neo-Tethys sedimentation of continental shelf and flysh type deposition of Pamir and Karakorum Block in the north and the adjoining Kohistan Magmatic Block in the south of Chitral.

The tectonic blocks i.e. Pamir Block, Karakorum and Kohistan Block extending from eastern Karakorum, are separated by two major tectonostratigraphic lineaments, the Tirich Mir Suture Zone (TSZ) and Syok Suture Zone (or Northern Suture Zone – NSZ). An intraplate structural lineament, Reshun Fault Zone (RFZ) of the Karakorum Block in Chitral is marked by the occurrence of shallow marine to fluvial sedimentation comprising carbonates, arkose sandstones and conglomerates of Mid-Cretaceous to Tertiary age.

The Paleozoic-Mesozoic sequences of the tectonic blocks were strongly compressed, folded and faulted mainly during Cretaceous – Tertiary suturing of blocks along N.S.Z followed by collision of Indian mass along Main Mantle Thrust (MMT), another tectonic boundary forming southern limits of Kohistan Magmatic Block . The Kohistan Magmatic Block represent intra-oceanic arc of the Neo-Tethys developed during late Jurassic and sandwiched in between Asia plate in the north and Indian Mass in the south during Cretaceous-Tertiary period.

Subsequent to Permo-Triassic break-up of the Peri-Gondwana fringe, and northward drifting of the continental fragments, the accretion of the block to Asia plate was accompanied by emplacement of subduction to crustal melt-related granitoids. These syn to post collisional granitoids in Chitral, are referred to Tirich Mir pluton, Karakorum Axial Batholith (KAB) and Kohistan Batholith. The former is dominated by crustal melt – related intrusives while the later two are dominated by subduction related calc-alkaline phases. The Mirkani pluton and Drosh volcanics represent post–suturing calc-alkaline volcano–plutonic activities along the sites of N.S.Z and earlier arc volcanics. Younger leucogranite intrusions (24 Ma) are represented by Garam Chashma pluton.

The alternating phases of compressional and extensional regimes of the Cretaceous–Tertiary orogeny has resulted into crustal shortening accompanied by geomorphologic as well as tectonic denudation and has also led to strong deformation and development of rock fabrics. However, regional metamorphism in general, is low to medium and seldom exceeds green schist facies.

Figure-6 is a regional scale geological map of Chitral, originally compiled on a scale of 1:250,000, basing the unpublished geological map prepared by Austrominerals, for SDA Mineral Directorate in the year 1978. Other sources include unpublished maps of SDA mineral projects in Chitral, and the published work of Calkins et al, 1981, Pudsey et al, 1985, Buchroithner & Gamerith, 1986, Gaetani&Leven, 1993, Gaetani et al, 1996, Talent et al, 1999, GSP, 2001 and other related literature on sedimentary succession and magmatic development of northern Pakistan including the Chitral region. This layer of the data together with known mineral occurrences will be used to provide a base for exploration of gold and base metals anomalies in terms of geological environments.

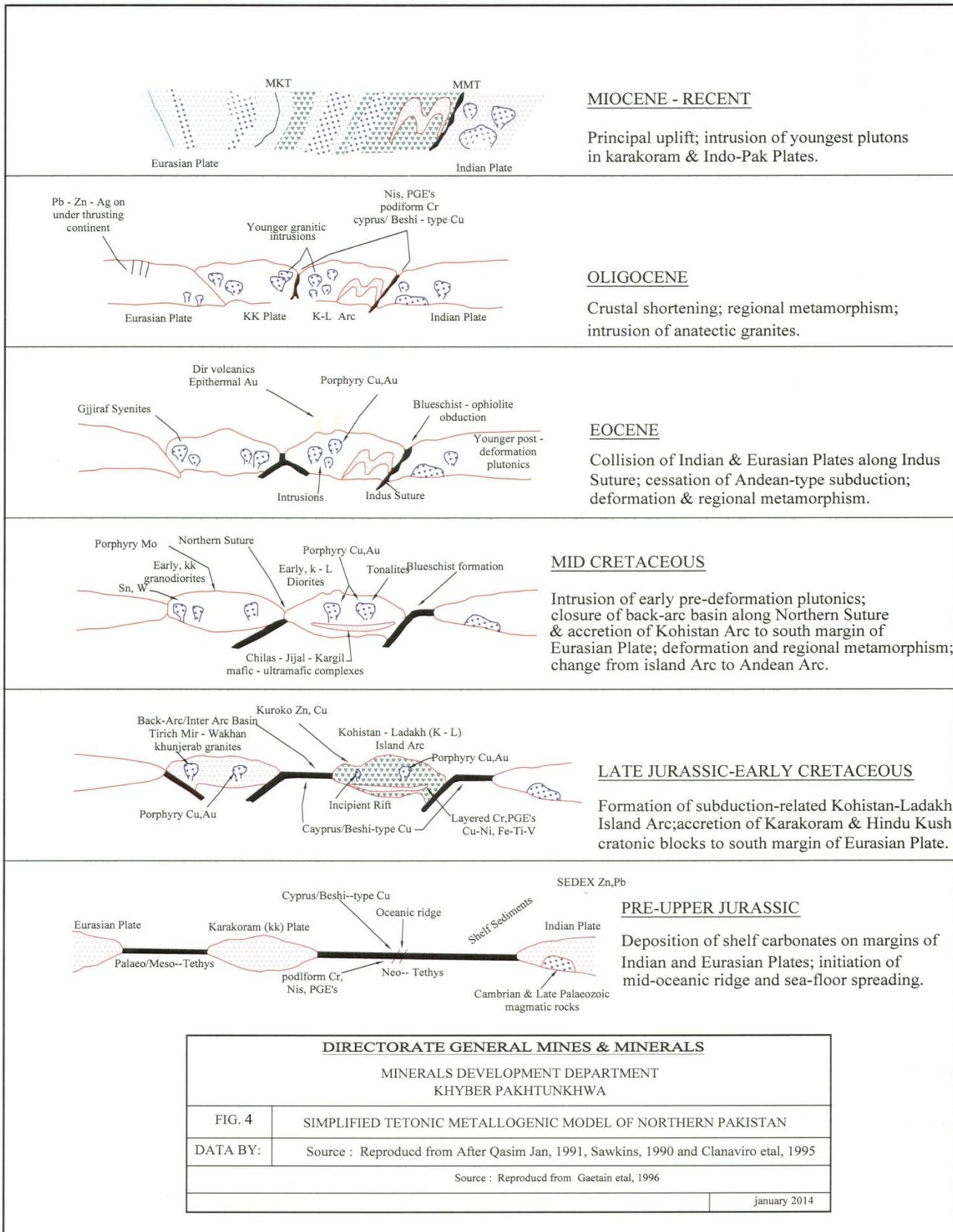


Figure 4: Simplified Tectonic Metallogenic Model of Northern Pakistan

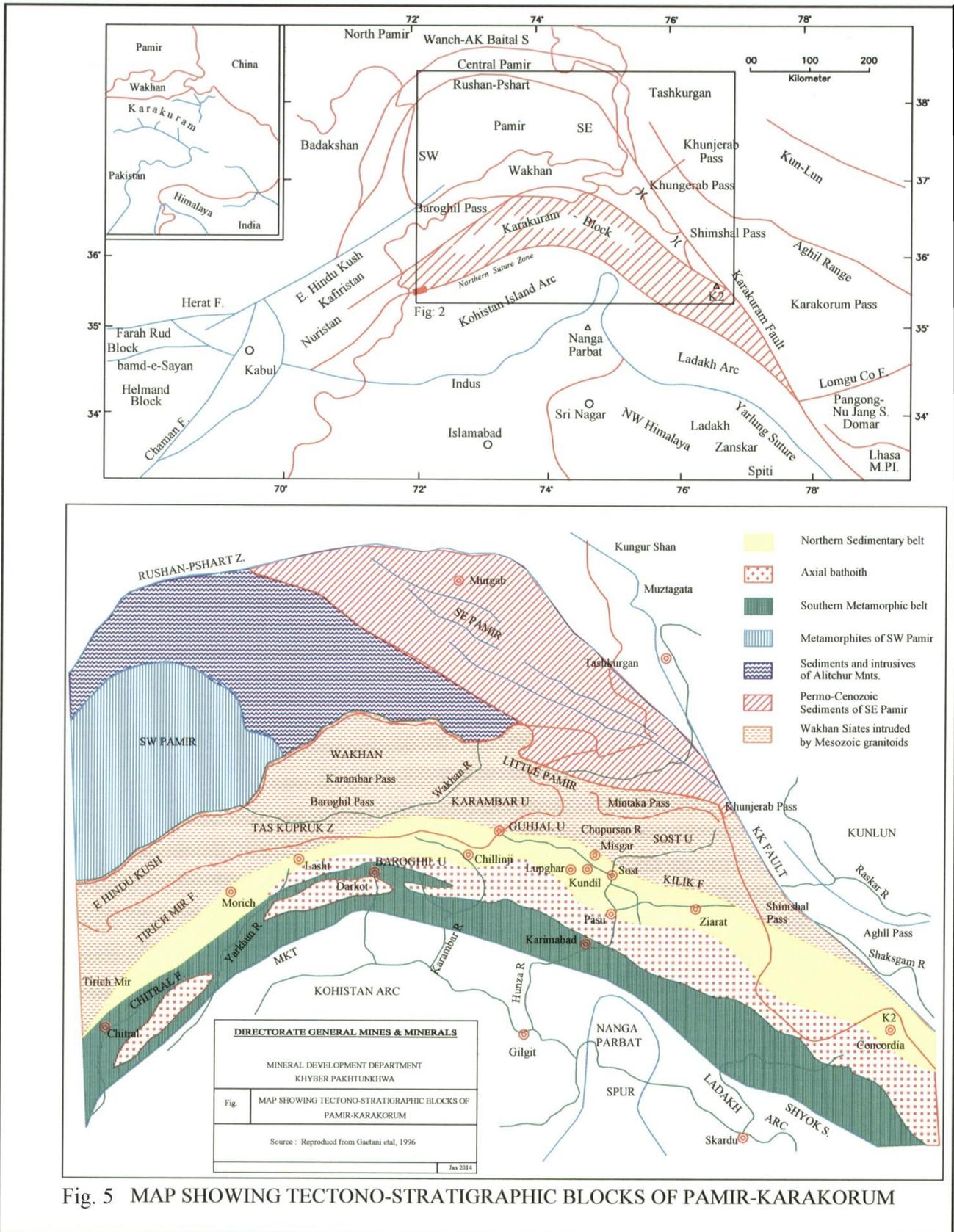


Fig. 5 MAP SHOWING TECTONO-STRATIGRAPHIC BLOCKS OF PAMIR-KARAKORUM

Figure 5: Map showing Tectono-stratigraphic Blocks of Pamir-Karakorum

Geological subdivision of Chitral region is mainly controlled by the occurrences of NE trending tectonic lineaments. From north towards south the region is divisible into seven tectonostratigraphic units, as adopted in this report (see Table-1).

### 2.3 Regional Structure

The structural elements of Chitral region represent a strong deformation in response to Cretaceous-Tertiary orogenic activities. At least two major episodes of deformation may have taken place. The one probably dominant brittle deformation during the collision along Northern suture zone, which may have resulted into regional longitudinal faults, macrofolds and weak foliation and cleavage surfaces. The other ductile deformations during the collision along Indus suture zone (MMT) lead to crustal shortening, thickening and uplift of the terrains and developed a complex superimposition of structures.

The regional longitudinal faults of the terrains, particularly along rock inhomogeneities, may have occurred during earlier oblique convergence and sinistral strike-slip relative motion of Kohistan Arc with respect to Asia (Pudsey et al, 1985 and Searl, 1991). Later phases of NW-SE perpendicular convergence may have resulted in overthrust along these faults i.e. Reshun Fault and Naz Bar Fault. Transform faults are not pronounced, however local fault intersection with the major faults at places, form a conjugate fault system.

The individual rock series/Formations in between regional faults exhibit macrofolds and have been further subjected to later phases of deformations and strong compression which has resulted into a complex superimposition of meso to micro scale isoclinal folding on the limbs of macro and mesofolds. Foliation and cleavage surfaces parallel to the axial planes of these folding are, although well developed, represent a very complicated structure. At places the folding is so tight that it is easily mistaken for cleavage planes. In general, axial planes and cleavages are steep upright with a distinct verge of south to southeast.

At least two or three cleavage planes (S1, S2, S3) can be observed, but in most cases the original bedding (S0) is not identifiable. In general, trend of the terrains are parallel to the trend of convergent zone, as indicated by the NNE-SSW and NW attitude in the north west and south east Chitral respectively, which change to NEE-SWW trend in the eastern part of Chitral region.

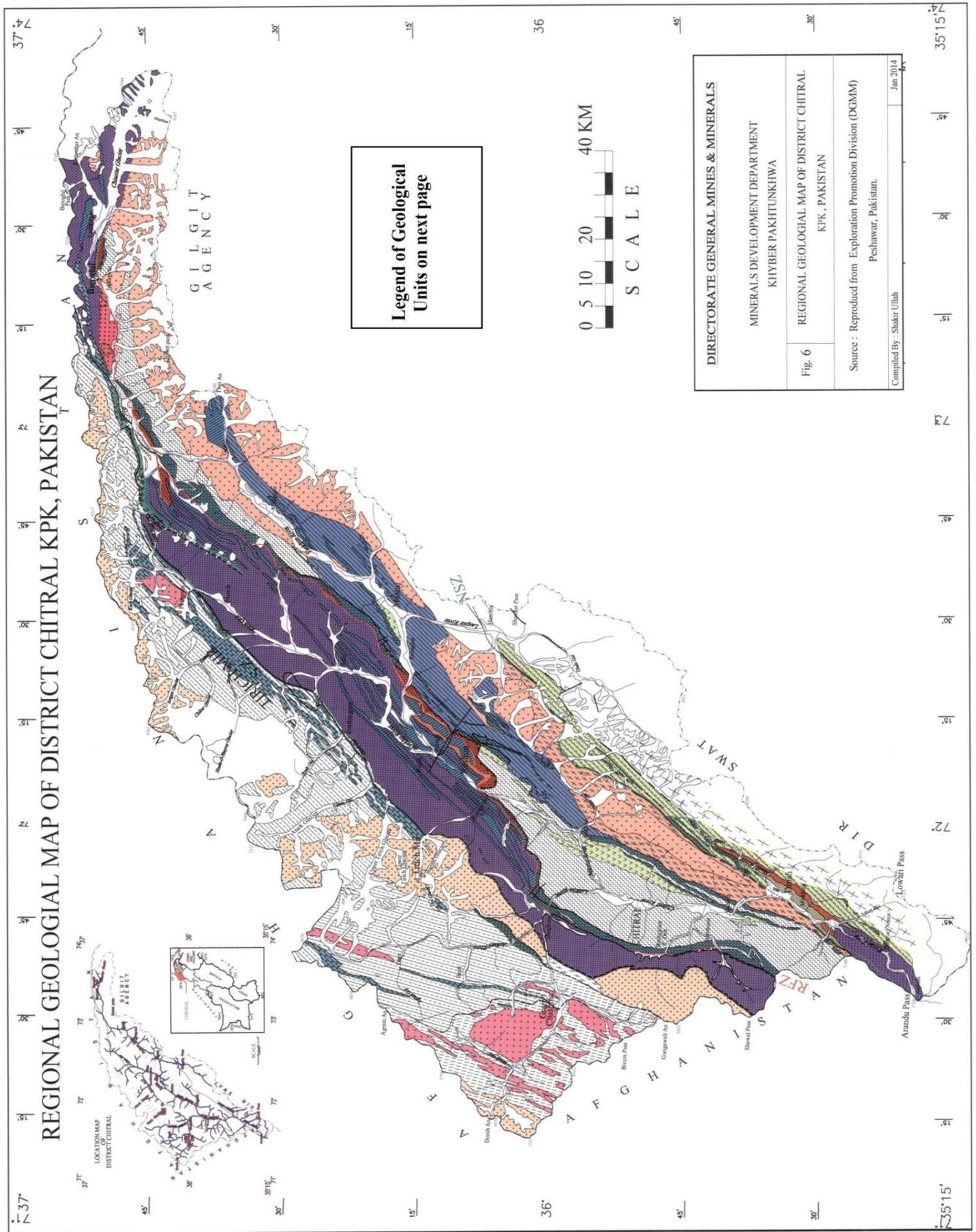
### 2.4 Metamorphism

In contrast to structural deformation, the regional metamorphism is low and seldom exceeds green schist facies. In general, metamorphism has resulted in the formation of slate, phyllite, quartzite, calcareous schist, crystalline limestone and marble and green schist (metavolcanics). However, where the sediments and volcanics come in close proximity with the intrusive bodies, an abrupt increase in grade of metamorphism is observed. In Herchine area of Laspur valley, the volcanics at contact with the Kohistan Batholith represent amphibolite-facies metamorphism. In Buni Zome, the slates at the contact next to intrusive, have the growth of andesite and cordierite (Gamerith and Kolmer, 1973) in Buchroithner and Gamerith (1986).

In north-western Chitral along Lutkho valley, a gradual increase in grade of metamorphism from green phyllite to muscovite and biotite schist to garnet- mica-tourmaline rock to gneisses and migmatites to anatectic granite is seen. Near Garam Chashma garnet-staurolite- mica schist to quartz- mica schist are observed.

**Table 1: Regional Geological Setting of Chitral Region**

<b>Tectono-stratigraphic Belt</b>	<b>Age</b>	<b>Related granitoids</b>	<b>Tectonic Block</b>
Wakhan Sedimentary Belt	Late Permian to Triassic to Early Jurassic	Tirich Mir Pluton Garam Chashma Leucogranites	Pamir Block
Tirich Mir Suture Zone	Early Carboniferous to Cretaceous beds	Intruded by Tirich Mir Pluton	
Northern Sedimentary Belt	Pre-Ordovician basement transgressed over by Ordovician to Late Devonian & Permian succession	In between Karakorum Batholith & Tirich Mir Pluton	Karakorum Block
Reshun Fault Zone	Mid Cretaceous to Tertiary?	—	
Southern Metamorphic Belt	Devonian to Permian + Mesozoic ?	Karakorum Axial Batholith (Karakorum Block Pluton)	
Shyok Suture Zone	85 - 100 Ma Late Jurassic to Cretaceous?	Intruded by Karakorum Axial Batholith & Mirkhani Pluton	Kohistan Block
Kohistan Island Arc	Late Jurassic to Cretaceous	Kohistan Batholith & Mirkhani Pluton	



**Figure 6: Regional Geological Map of District Chitral**

# LEGEND

 HOLOCENE, PLEISTOCENE UNDIFFERENTIATED

## PAMIR BLOCK

### WAKHAN SEDIMENTARY BELT

-  GARAM CHASHMA PLUTON – 24Ma  
Two mica ( $\pm$ garnet  $\pm$ tourmaline) leucogranite, foliated & unfoliated
-  TIRICHMIR PLUTON – 115  $\pm$ 4 Ma  
Porphyritic to very coarse grained granite gneisses & augenites. Few aligned plagioclase megacryst texture at places
-  ATARK MARBLE – TRIASSIC TO JURASSIC (?)  
Limestone & marble partly or wholly recrystallized to granular marble
-  WAKHAN SLATES – PERMIAN TO TRIASSIC, AND CRETACEOUS  
Homogenous dark grey slate to siltstone with intercalations of calcareous schist & sandstones to quartzites.
-  LUTKHO METAMORPHICS – METAMORPHOSE EXTENSION OF WAKHAN SEDIMENTARY BELT  
Sillimanite grade schist & magmatites with pegmatites and leucogranit dikes

## KARAKORUM BLOCK

### NORTHERN SEDIMENTARY BELT

-  TIRICH MIR SUTURE ZONE – PERMIAN TO EARLY CARBONIFEROUS  
Includes banded gabbro – amphibolites (partly tectonized / serpentinized) & diorites and Taskupruk Alkali Basalts
-  SHOGRAM FORMATION – MIDDLE TO LATE DEVONIAN  
Lime stone to dolostone partly silty, shales to slates & quartzites & coarse sand stone
-  CHARUN QUARTZITES – EQUIVALENT OF CHILIMERABAD FORMATION – EARLY DEVONIAN  
Mainly arenites to quartzite
-  LUN SHALE – SILURIAN ? TO EARLY DEVONIAN  
Mainly dark grey shales to slates with subordinate quartzite & limestone and other terrigenous sediments of Late Devonian age.
-  ISHKARWAZ GRANITOIDS – INTRUDING PRE-ORDOVICIAN CRYSTALLINE BASEMENT  
Melanocratic granitoids of calcalkaline affinity (adamellite)
-  ISHKARWAZ CRYSTALLINE BASEMENT – PRE ORDOVICIAN  
Dark grey siltstone, low grade quartzites and magmatites and other meta-terrigenous sediments

### SOUTHERN METAMORPHIC BELT

-  RESHUN RED FORMATION – MID CRETACEOUS  
Polymictic pebble & cobble conglomerate, arkose sandstones and shale and slates, often red.
-  KESU-BUNI ZONE PLUTON OF KARAKORUM AXIAL BATHOLITH – 85 TO 115 Ma  
Granodiorite to diorite with later phases of granite, aplite and pegmatites.
-  ZAIT LIME STONE / SHOGHOR LIME STONE & GAHIRET MARBLE – TRIASSIC TO PERMIAN (?) CRETACEOUS  
Fusulinid lime stone and dolostone, often massive and partly marbled. May include Shoghor lime stone and Gahiret Marble
-  CHITRAL SALATES – LOWER PERMIAN (?) JURASSIC (?) CRETACEOUS (?)  
Mainly slates with subordinate sand stone, quartzites, calcareous slates with occasional lime stone lenses.
-  KOGHAZI GREEN SCHIST / METAVOLCANICS – LOWER CARBONIFEROUS (?) PERMIAN TO TRIASSIC (?) CRETACEOUS (?)  
Fine grained banded thinly laminated quartz – chlorite – epidote – plagioclase schist – metavolcanics / tuffs
-  MUSTUJ SERIES EQUIVALENT TO DARKOT GROUP – PERMIAN TO CARBONIFEROUS, PARTLY MESOZOIC  
Fine grained banded mud stone, sand stone to quartzite and intercalation of calcareous schist and carbonate beds.

## KOHISTAN ISLAND ARC

-  DROSH VOLCANICS – EQUIVALENT TO SHAMRAN VOLCANICS – 58 Ma  
Calc-alkaline subaerial volcanics – basaltic andesite, desites and pyroclastics & volcanic breccia
-  MIRKHANI PLUTON OF KOHISTAN BATHOLITH  
Weakly foliated to porphyritic quartz – diorite to granodiorite with later porphyries & diabase dikes
-  NORTHERN SUTURE ZONE / SHYOK SUTURE ZONE / MKT – 85 TO 100 Ma  
Melange zone – Cretaceous lime stone and mafic – ultra mafic blocks in a shaly to slaty matrix.
-  PURIT FORMATION – EQUIVALENT TO RESHUN FORMATION – MID CRETACEOUS  
Clastic conglomerates, sand stone, Quartzites, shales, slates, and phyllites, often red
-  ORBITOLINA LIME STONE OF GAWUCH FORMATION – EARLY CRETACEOUS  
**Lime stone of Yasin Gorup (tuffs, shales, slates, phyllites & carbonates)**
-  GAWUCH FORMATION / CHALT VOLCANICS & YASIN GROUP – LATE JURASSIC TO EARLY CRETACEOUS  
Green metabasalts – tholeiites / bonninites (Chalt Volcanics) interbedded with younger Yasin Group
-  ZIARAT AMPHIBOLITES – LATE JURASSIC TO EARLY CRETACEOUS  
Mainly amphibolitized / granitized sequence of Gawuch Formation
-  MAFIC – ULTRA MAFIC BLOCKS OF NORTHERN SUTURE ZONE



# 3. Metallic- Mineral Occurrences

## 3.1 Base metals

In Chitral, occurrences and showings of a diversity of metallic minerals (Figure 7) in the form of veins and disseminations, are cropping out at various localities. The major localities of base metal (other than gold and PGE's) showings and occurrences include:

**Lutkho Copper-lead:** Copper-lead sulphide (galena and chalcopyrite) bearing quartz veins hosted in metasedimentary units of Karakorum sedimentary belt have been reported from Imirdin and Parabeck localities of the Lutkho valley. These appear to be epigenetic and metamorphogenic type and therefore may depict small-scale occurrences. However the same may also represent remobilised veining from deep-seated, sediment hosted massive sulphide, system.

**Lutkho Tungsten:** A rock belt of granular marble and quartzitic rocks in Arkari and Garam Chashma are found to contain calcium tungstate (Scheelite) in the form of veins and dissemination. The occurrence is one called syngenetic stratabound type mineralisation and at places, is also associated by copper-lead-zinc sulphide veining in granular marble. The mineralisation, although stratiform, covering a rock belt of several kilometres from Garam Chashma to Arkari, appears to be erratic and patchy. However occurrence of a discrete mineable zone, if located, may be a workable prospect.

**Agram Gol Lead:** Lead mineralization associated with sheared quartz vein of about 2 meter thick & more than 200 m long is reported in Agram gol (Owir) area of Arkari valley. Pb-Zn and Au pan con geochemical anomalies are also identified in Agram gol area. The area appears significant for Au, Pb & Zn mineralization.

**Moghlang Copper-Molybdenum:** Showings of these metals in the form of veinlets and dissemination in a granitoid body and associated skarns are found in Moghlang locality of Rich valley. The same being sporadic in occurrence and limited showings are apparently insignificant.

**Tirich Arsenic:** Carbonate hosted arsenic sulphide (orpiment and realgar) is found in Mirghash, Uchu gol and Alikote and Lun gol localities of the Tirich valley. The occurrence is one called epigenetic & metamorphogenic type and is also associated by small lenses of fluorite mineralisation. The occurrence is being exploited on a small scale through unsystematic mining operations as observed in Mirghash and Alikote localities. Arsenic is a gold indicator element (pathfinder element) in which regard this is an important metallic mineral occurrence warranting detail investigations.

**Pakhturi Copper-Lead-Zinc:** Calcareous sandstone-hosted sulphides of these metals as quartz veining are found in Pakhturi locality of Kushum, Mulkho. This is also an epigenetic & metamorphogenic type mineralisation along the axial planes of a macrofold structure. Further occurrence of similar type may be looked for in the adjoining localities, which may or may not be economically significant but the same may represent remobilised veining from a sediment-hosted massive sulphide zone, deep in the system.

**Shoghore Polymetallic Veins:** Sulphosalt of lead-Antimony-copper (Boulangerite) rich in gold and silver, in the form of small lenticular bodies and veins have been explored in the Awireth and Sewakht localities of Shoghore, Lutkho valley. The structurally controlled, fault related,

metamorphogenic type, polymetallic-mineralization is also rich in gold and silver mentioned under gold occurrences

**Krinj Antimony:** This is the famous antimony-lead sulphide occurrence of Krinj-Kamal gol locality in Chitral being exploited on a small scale since 1939. This is also a structurally controlled, fault related, metamorphogenic type mineralization. The occurrence has an 'exploration information' status of about 100,000 tonne.

**Yarkhun Copper-Iron:** Occurrence of small iron ore bodies are reported from Bang gol and Paur gol localities of Yarkhun valley. Some copper showings are also reported from the adjoining localities, which together with the skarn iron bodies may indicate a porphyry copper (gold, molybdenum) system. These occurrences warrant further assessment through follow-up exploration in light of integrated granite geochemical anomalies of gold and base metals identified in the area.

**Melph Lead-Zinc:** A polymetallic veining of metamorphogenic type is being mined by a private party in Melph locality of Turkho area. The mineralization dominated by lead-zinc, within a zone of shearing of 200m length and 2 meters wide, occurs as dilational pods and lenticular bodies upto 30cm thickness. The resource justifies small-scale mining of the rich part of the sheared zone.

**Buni Zom Ironstone:** Two isolated occurrences of laterite type iron stones are reported from Chakoli Bukht (Golen gol) and Reshun area of the Buni Zom mountain. Both occurrences being at higher altitude of difficult accessibility do not appear amenable to economic exploitation at this stage.

**Birir Lead Ore:** A number of small occurrences of lead mineralization of good quality upto 38% Pb are found in the upper reach of Birir Valley. The area needs geological investigation.

**Koghazi Green Schist Iron-Copper:** The meta-basalt unit is found to contain magnetite, pyrite and copper-staining, at places. The occurrence is a significant target for follow-up exploration. The geochemical anomalies also include Pt over the Koghazi Green Schist unit.

**Drosh Copper-Lead-Antimony:** Granitoid hosted sulphides of these metals are found in various localities of Drosh area. The host rocks are located for several kilometres from Drosh gol to Langer locality of Shishi valley. At places the occurrence are associated by iron skarn bodies i.e in Kaldam gol. Owing to patchy and erratic nature with sparse dissemination of sulphide minerals the overall grade of the occurrence is apparently low. However the same in a discrete mineable zone, if located, may be a workable prospect.

**Dommel Nisar Copper-Iron:** Dissemination of copper sulphides is common in a belt of 4 Km and 0.4 Km in Dommel Nisar locality of southern Chitral. Iron skarn bodies occurring as isolated small irregular-bodies are associated at places. At present this is a top priority target of metallic minerals in Chitral. The mineralization has been interpreted tentatively as porphyry style copper (gold, molybdenum) system and therefore should have distal and proximal products of gold rich system in the adjoining localities. Accordingly, the iron skarn bodies are found to contain copper. In-situ source of gold mineralization up to 80 gram/tonne gold-values in chip channel samples has also been identified in Ashret near Lowari Pass.

### 3.2 In-Situe Gold

Although potential of in-situe gold in Chitral, is evident from the occurrence of placer gold along the main rivers. But the same is debatable with a view that most of the bedrocks hosted economic concentration of gold, either have been eroded completely or have left behind the outcrops with uneconomic values of gold concentration. Few showings identified in Chitral include:

**Shoghor Red Carbonates:** Chip-channel sampling from red carbonate rocks along Chitral Fault in Shoghore locality indicate very low grade values of gold upto 0.15 ppm. The grade is insignificant however further systematic sampling, mapping and laboratory work may indicate fault-related and sediment-hosted gold-silver mineralization.

**Shoghore Polymetallic Veins:** Sulphosalt of lead-antimony-copper veins along Chitral Fault in Shoghore locality are rich in gold-silver values. The average gold values reach upto 50 ppm while that of silver upto 200 ppm but the same are of low tonnage (about 20,000 to 30,000 tonnes).

**Ashiret Dioritic Rocks:** Gold values in the range of 0.6 ppm to 18 ppm in few samples from quartz porphyry dioritic rocks of Ashiret locality, Drosh area, near Lowari Pass were identified. The locality appears to be a proximal or distal product of Dommel Nissar porphyry copper (gold, molybdenum) system. Further work has identified the occurrence of volcanic breccia-hosted gold values upto 80 ppm. Systematic chip channel sampling, mapping and laboratory work may indicate breccia related and/or epithermal gold (copper, silver) prospect as part of a porphyry system.



## 4. Metallogeny

Northern Pakistan, including the Chitral region, has a complex history of geotectonic evolution. The development of the intra oceanic Kohistan Island Arc, followed by the events of its collision and subduction of the oceanic crust along the plate boundaries of Karakorum Block in the north and India in the south, resulted into rich diversity of geological environments. Earlier intra-plate rifting like Tirich Mir Suture Zone and associated sedimentary processes are in addition to these. The geological environments of northern Pakistan are therefore, attributable to a range of geotectonic settings which compared favorably with geologically identical mineral-producing regions elsewhere in the world.

### 4.1 Conceptual Modeling

Conceptually, the geological environments of Chitral region are inferred from evidence of a diversity of mineralizations. These include:

- Fault-related, structurally-controlled, metamorphogenic-type polymetallic veinings/lodes and associated gold-silver values along major fault zones e.g Reshun Fault Zone.
- Fault-related, structurally-controlled and/or sediment hosted (metamorphogenic and/or disseminated) gold-silver along major fault zones/suture zones i.e Tirich Suture Zone, Keshor Fault Zone and Northern Suture Zone.
- Juxtaposed anomalies of gold-platinum along a belt of metabasalt volcanoclastics i.e Koghazi green schist.
- Granitoid and/or sediment hosted, metamorphogenic type polymetallic veining and associated gold values e.g Northern Sedimentary Belt and granitoids of Kohistan Island Arc.
- Porphyry copper (gold, molybdenum) system in association with calcalkaline porphyries and volcanic breccia e.g Mirkhani Pluton.

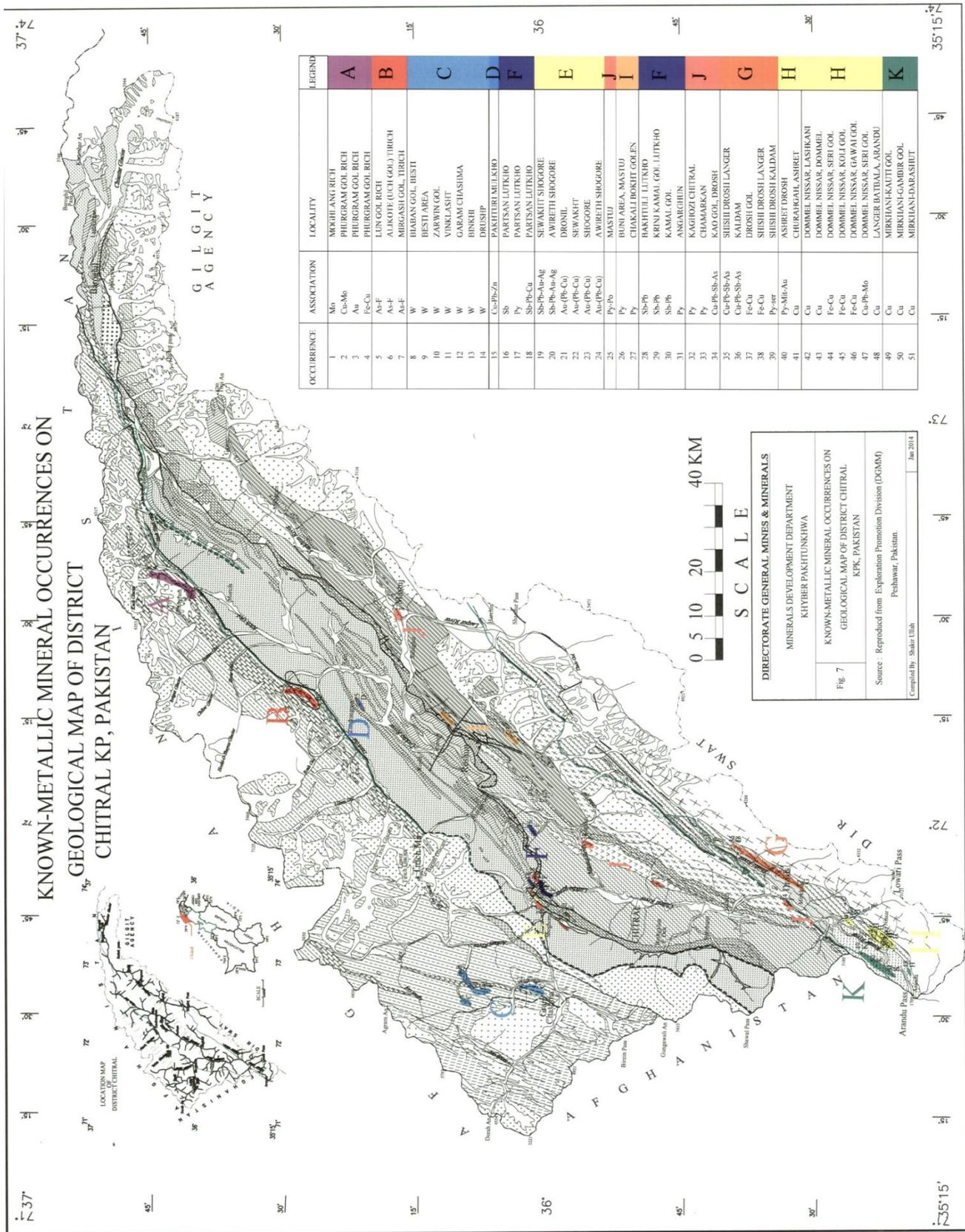


Figure 7: Known Metallic Mineral Occurrences on the Geological Map of District Chitral

## 4.2 Some comments on geology and metallogeny of Chitral region

Interpretation of the above mentioned regional-scale targets, mainly based on stream-sediment geochemistry, metallic-mineral occurrences and geology are quite exciting for follow-up exploration. However, a different picture arises when these are assessed in the perspective of 50Ma collision i.e. crustal shortening and uplifting in response to 50 Ma collision and the ensuing geo morphological denudation of the Hindukush-Karakorum terrains.

Accordingly, it is considered that most of the intrusive-related primary mineralization like porphyry Cu (Au, Mo) system and related gold-silver subsystems that were emplaced at shallow level (1 Km to 5 Km) during magmatic development of Kohistan Island Arc and continental margin of Karakorum-Block either has been eroded completely or only root zones are existing as remnant of the primary mineralization.

And the drainage geochemical anomalies of gold and base metals, interpreted as porphyry and massive sulphide systems, along the magmatic sites of tectonic boundaries represent product of regional metamorphism rather than primary mineralization. Similarly the drainage geochemical anomalies along major faults, interpreted as fault related and structurally controlled mesothermal to epithermal type sediment hosted gold-silver and polymetallic mineralization, are indicative of the known metamorphogenic type metallic mineral occurrence along Tirich Mir Suture Zone and Reshun Fault Zone. (Halfpenny and Mazzuchelli,1999). This may lead to the conclusion that chances of world-class ore bodies in the region are minimum except the less significant metamorphogenic type occurrences.

Most of the drainage-gold anomalies are scattered and are not supported by pathfinder elements. These, in turn, may be representing placer gold values derived from terrace sources common in the region or may indicate dispersed sources rather than discrete mineable primary gold lodes.

Although the above factors of crustal deformation and deep erosion in northern Pakistan are quite convincing to give a least priority to the exploration of metallic minerals in the region but despite these the prospects of occurrence of economic ore bodies in the form of primary deposits and/or metamorphogenic type gold lodes may not be precluded. However, these are assumptions till further investigations.



# 5. Stream-Sediment Geochemical Exploration Coverage

## 5.1 Australia-Pakistan GEMAP Exploration Work

A systematic stream-sediments geochemical exploration coverage of northern Pakistan including the Chitral region, Khyber Pakhtunkhwa, was initiated in January, 1992, in collaboration with the Australia–Pakistan Gold Exploration & Mineral Analysis Project (GEMAP) sponsored by Australian International Development Assistance Bureau (AIDAB now AusAID). Under the GEMAP, (January 1992 to June, 1995), the Pakistani geoscientists including the consultant were provided with specialized on–site training in the gold fields of Australia and in northern Pakistan. This was to initiate a systematic and comprehensive exploration coverage of northern Pakistan, appropriate to local condition of the terrains for gold and related metallic minerals, in particular and other minerals, in general.

In view of encouraging results, the GEMAP–designed exploration strategy, comprised mainly stream-sediment sampling, was also extended to cover Malakand and Hazara regions to the south of Chitral. As such the government of Khyber Pakhtunkhwa, Pakistan has completed first pass stream sediments sampling of northern part of KPK over an area of 40,000 Km<sup>2</sup> besides similar work in Northern Areas, east of KPK.

## 5.2 GEMAP-designed exploration methodology

The major component of the exploration methodology adopted under the studies, remained the stream sediments sampling to systematically cover the region. The strategy was based on the premise that any significant outcropping mineral–deposits, through natural physical and chemical weathering and erosion processes, contribute components (in the form of rocks, mineral grains and geochemical values) to the sediments of the drainage system in which the deposits are located. Sampling from each site comprises collection of panned heavy mineral concentrates and fine fraction of sediments in addition to collection and study of mineralized rock float.

The methodology is based on the strategy of covering the reconnaissance scale geological belts, targeting economic ore bodies through stages of regional to prospect and deposit scale exploration and assessment for any detailed–exploration including drilling the ore bodies.

The results of the stream–sediments data in integration with geology, known mineral occurrence and other exploration data including remote sensing on aerial photographs and satellite imageries, is representing a multi-component system encompassing aspects of geology and mineralization. The techniques have been found appropriate to demonstrate the mineral potential of the region and locating the ore bodies. However, the component of remotely sensed-data remained on poor side and needs to be generated in coincidence with the drainage geochemical anomalies and metallic mineral occurrences to ascertain the identified target-areas. The barren mountains of Chitral offer exposures well suited for exploration by remote sensing techniques.

### 5.3 Laboratory analysis:

Chemical analysis of stream-sediment samples were carried out for eight metallic elements in Mineral Testing Laboratory of the Exploration Promotion Division, Directorate General Mines & Minerals, KPK, Peshawar. The analytical techniques involved the AAS using aqua regia acid digest and DIBK gold extraction after the samples are prepared and pulverized to -200#. The Pan. Conc. are dissolved as a whole and analysed in multiple aliquots of 30 grams while the – 80# samples were analysed in a single batch of 30 grams. The laboratory is equipped with GBC & Philips Atomic Absorption Spectrometer and has the capability of determining the eight elements (Au, Cu, Pb, Zn, Ag, Co, Ni and Bi), with detection limit in g/t.

It is worth mentioning here that a uniform size of 20 litres sediments is panned from each sample site for comparison of geochemical values from different sites. For further comparison of values, the original weight of pan. con. is recorded before the analytical treatment in the Lab. This is required to standardize the analytical values of the varied weight of pan conc samples to a standard weight of 100 grams pan. con.

### 5.4 MINORCO Involvement

The MINORCO was a subsidiary company of Anglo–American & Debeers who owned exploration and mining operations in South Africa and South America and was seeking metallic-minerals properties in Pakistan and Central Asian and Mongolia. Keeping in view the availability of the duplicate stream sediments samples (Pan Con as well as fine fraction), as source of exploration, the MINORCO signed one-year MOU with Government of Khyber Pakhtunkhwa, Pakistan in June, 1997, for exploration of Chitral, Malakand & Hazara regions. Under the joint venture, the MINORCO re-analyzed the duplicates of stream sediment samples for and expanded suite of elements (32 elements) mostly at mg/t level in the Ultra Trace laboratory, Perth. WA. The pan. conc. samples were analyzed only for Au, Pt and Pd using fire assay/ICP-Oes method on 50 gram samples. The fine fraction stream-sediments (–80# samples) were analyzed for all the 32 elements using the analytical method of mixed acid digest/ICP-OES method 30 gram sample with the exception of Au and Ag for which the technique of aqua regia digest/ICP-MS was adopted. Amongst others, the MINORCO experts who visited the area included Dr. Richard Sillitoe of UK and Richard Mazzucchelli of WA. The stream sediments geochemical data as such, was upgraded by virtue of involvement of MINORCO. This led to generation of an expanded database of long lasting value for follow-up exploration of selected targets of gold and related metallic minerals over an area of 40,000 Km<sup>2</sup> of northern part of Khyber Pakhtunkhwa.

### 5.5 MINORCO's Statistical treatment of data and Interpretation of 1: 2,000,000 Plots

Dr. Mazzucchelli, the MINORCO exploration geochemist, merged the field data of the stream-sediments with the Ultra Trace analytical report and carried out statistical analyses for interpretation of drainage geochemical anomalies. The interpretations were presented on scale 1:2000,000 plots which show the distribution of geochemical values of all the elements analyzed over the entire concentration range, using spectral color scheme distinguishing anomalous values from background dispersion pattern. The plots prepared both for single elements, and 10 factors of multi elements distribution, reflect aspects of regional geology as well as areas of potential mineralization. The histograms of the geochemical data and 1:2,000,000 plots are available with MDD. The salient features of the interpretation based on 1: 2000,000 plots are:

**Plots of regional geological aspects:** The distribution of various suites of elements, characteristic of specified geological environment, significantly correspond to the regional

geology of the region, distinguishing Kohistan Island Arc from Eurasian and Indian plates and suture zones (MMT and NSZ) in addition to Tirich Mir Fault Zone (an inferred intraplate suture zone). Factor-1 (Fe-Mn-V-Zn-Ti) and Factor-2 (Ni-Cr-Mg/Ca-Co-V) summarize the single element distribution in conformity with the major geological domains of the region.

**Plots representing areas of potential mineralization:** Interpreting the data for target areas of potential mineralization, the prominent anomalies in Chitral region are summarized as under:

- A prominent Molybdenum anomaly in Yarkhun area, indicative of Cu(Au, Mo) system and related Cu-Fe-Skarn, base metals replacement and epithermal Au (Cu, Ag) style mineralization.
- Mercury-Arsenic- Antimony anomaly in Tirich valley along Tirich Mir Failed Rift Zone leading to interpretation of structurally controlled, fault related gold-silver mineralization.
- Copper-Gold anomaly in Dommel Nissar Ashret area along northern margin of Kohistan Island Arc corresponding with the known porphyry style mineralization in the Mir Khani area of geological significance.
- Scattered Gold anomalies within the Eurasian plate, which are not supported by path finders, have been interpreted as placer values rather than primary sources..
- Zinc anomaly in Moghlang-Rich area in coincidence with Ni-Cr-Mg/Ca-Co-V along Tirich Mir Failed Rift Zone.
- A prominent fine Gold anomaly in Mustuj over a green stone lithology rich in pyrite and pyrrohotite should have some significance.
- Another weak anomaly of fine Gold in coincidence with Koghazi green schist unit, rich in pyrite magnetite at places in Yarkhun valley, need necessary investigation.
- Similarly fine Gold anomalies along north of Tirich Mir Fault Zone and South west of Chitral and Antimony anomaly in Yarkhun valley need necessary investigation.

## 5.6 EPD interpretation work

The Exploration Promotion Division (EPD) of Khyber Pakhtunkhwa Directorate General Mines & Minerals has digitized the geochem data in ESRI's ArcGIS as part of systematic documentation and storage of available exploration-data of the Province. The geochem data of Chitral has been interpreted into 14 suits of anomalies of metals in coincidence with known metallic-mineral occurrences along geological belts of the accreted tectonic-blocks. The geochem map of Chitral showing distribution of metal anomalies, reproduced from open file of EPD is placed at table 2 and Fig. 8–11. Some of the nomenclatures used for geological belts are not corresponding with those used in the published work. The interpretation of the follow-up exploration targets is based on integration of the following data:

- Topographic maps – Survey of Pakistan toposheets.
- Geological map - Austromineral's geological map (1978) of District Chitral on scale 1:250,000 as base map for superimposition of data from published papers including maps on geology of Chitral region and field observations during the geochem survey.
- Metallic minerals map – Published data as well as involvement as part of exploration activities in Chitral.
- Geochem map – Geochem data of Regional Mineral Exploration Project Chitral initiated under GEMAP of AUSaid and upgraded during MINORCO involvement.

- Geostatistical analysis – MINORCO's statistical analysis for global threshold values of gold and base metals (32 elements) over northern part of Pakistan worked out by Dr. Mazzuchilli, consultant exploration geochemist, Perth WA. (see Appendix B).

## 5.7 Discussion on Results of the Stream Sediment Sampling

Dr. Mazzuchilli in the MINORCO report has given the following comments while evaluating the techniques and results of the stream sediment sampling initiated under the Australian technical assistance program.

- The stream sediment sampling methodology adopted under Ausaid-GEMAP program, represent patterns of concentration rather than dispersion of elements which is against the trend of a geochemical vector pointing toward source mineralization as normally revealed by a systematic fine fraction low energy stream-sediment sampling.
- Most of the drainage-gold anomalies are scattered and are not supported by pathfinder elements. These in turn, may be representing placer gold values derived from terrace sources common in the region or may indicate dispersed sources rather than discrete mineable primary gold lodes.

Keeping in view on-ground experience of the local geologists, the above comments are discussed as under:

- Although the GEMAP sampling techniques, particularly Pan.con. sampling represent concentration rather than normal dispersion pattern but the same was adopted to indemnify reconnaissance scale drainage anomalies (i.e to catch the opposite end of a geochemical vector) during the first pass exploration coverage of the region with limited exploration and geological data. Moreover, the results of samples closely match the regional geology and indicate all known mineral occurrences, which reveal the effectiveness of the sampling methodology. Despite these, it is felt advisable that –200# sampling through collection of fine fraction from low energy stream sediments and 2mm and –200# sampling from talus along the outcrops, as demonstrated by Dr. Mazzuchilli during his field visit in Chitral, may be made a part of in-fill/ follow-up sampling.
- Presence of terrace deposits along the main valleys and even upstream in the first and second order tributaries is typical of the geomorphological features of northern Pakistan. These normally contain reworked visible gold particles and even pieces. Necessary efforts are made to avoid the terraces along mouth of drainage while selecting sampling site but sediments from upstream terraces are unavoidable, if present.
- Therefore, analytical gold values not supported by pathfinders may represent the placer sources. In general the provision of –80# stream sediment sampling in GEMAP methodology is exclusively to obtain analytical results for fine gold and base metal values and that of Pan. con. for coarse gold. One of the objectives of Pan.Con. sampling is the optical study of visible gold to have an idea of upstream distance and possible nature of source using colour, shape, form and angularity of visible gold. This is also an attempt to distinguish between primary source from placer gold. The data of Pan.Con. mineralogy including visible gold studies, have been documented(hard copy data) as part of the drainage geochemical data and can be compared with analytical values of gold in Pan. con and in –80# samples

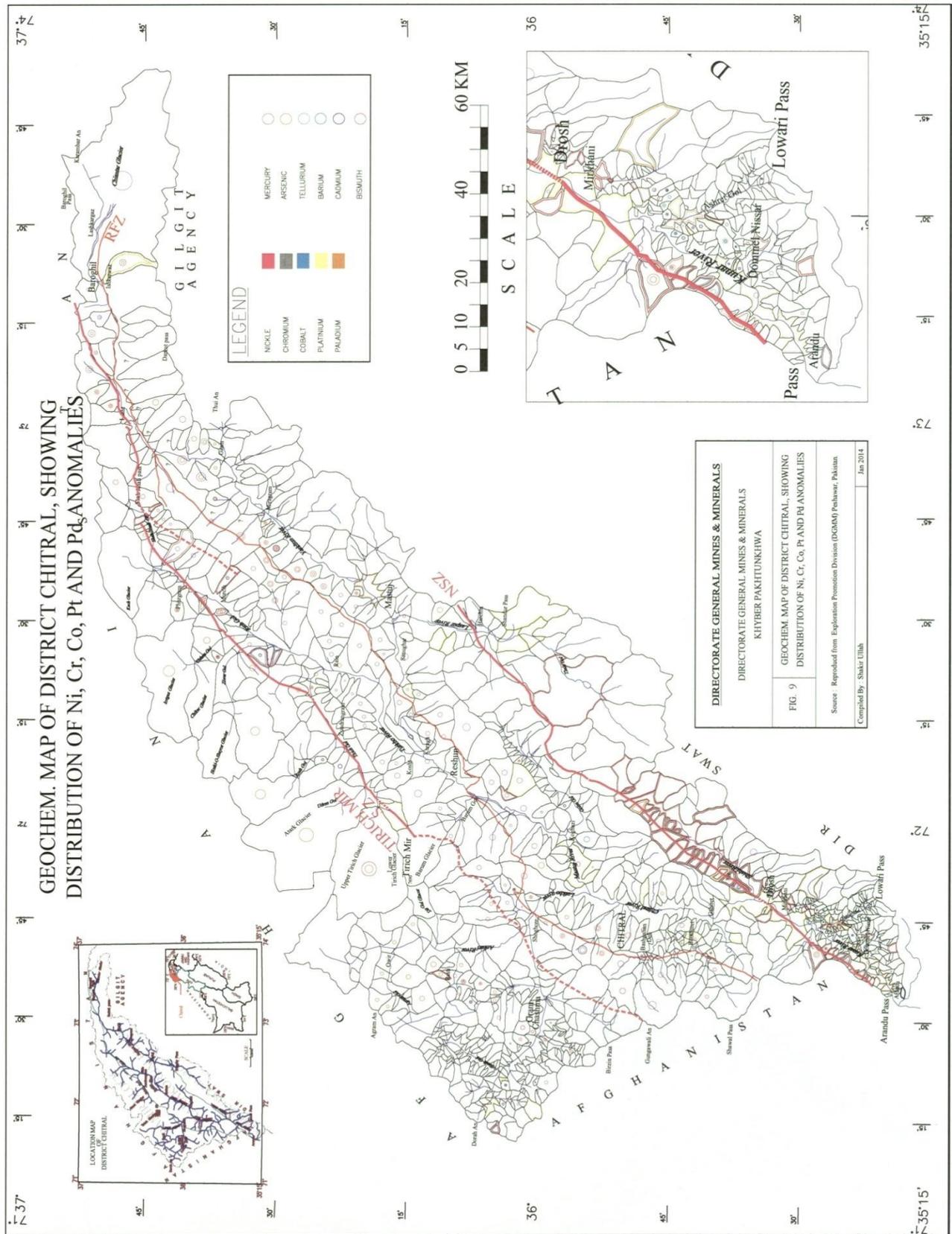


Figure 8: Geochem Map of District Chitral

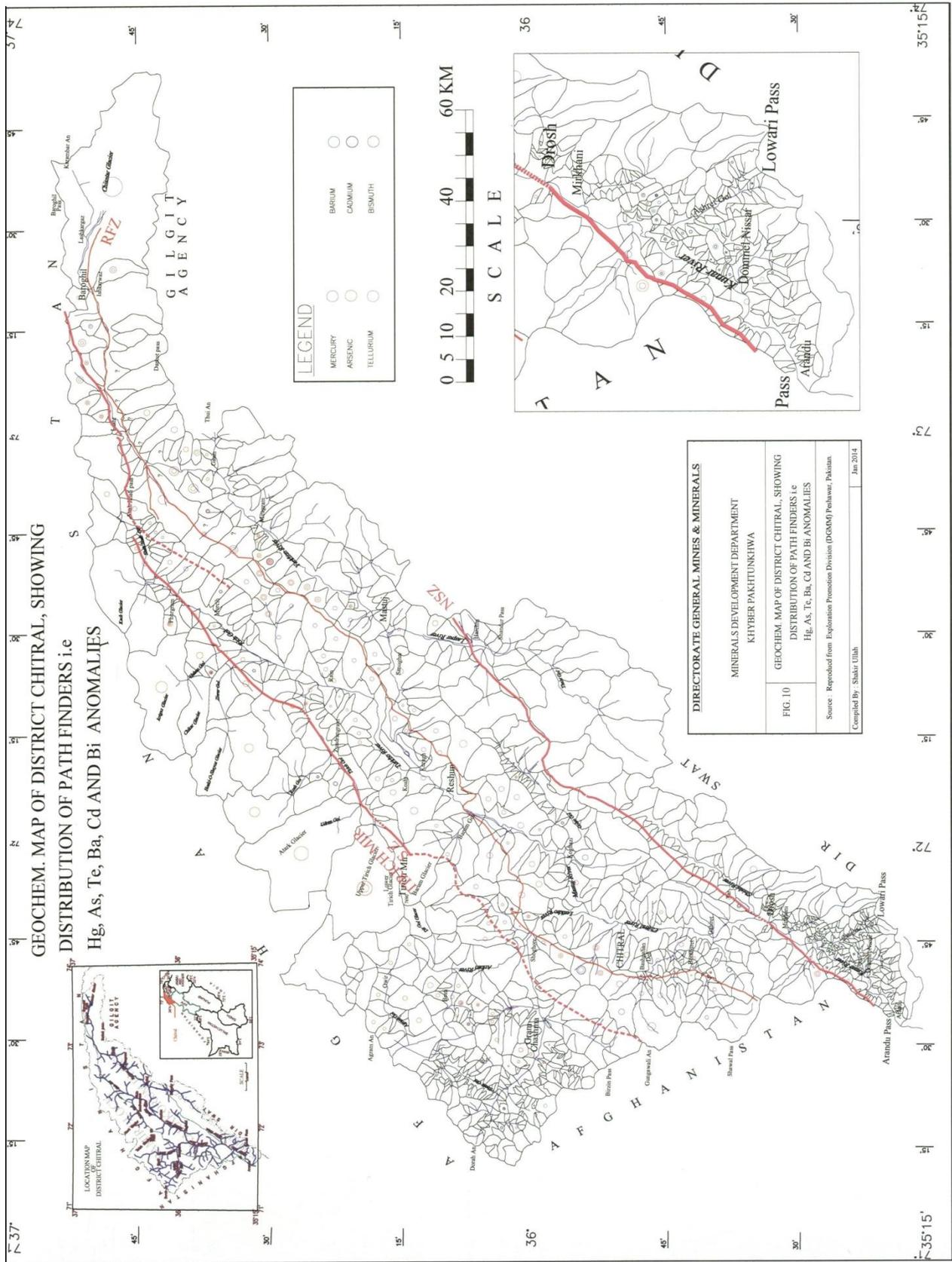


Figure 9: Geochem Map of District Chitral, showing distribution of Pathfinders

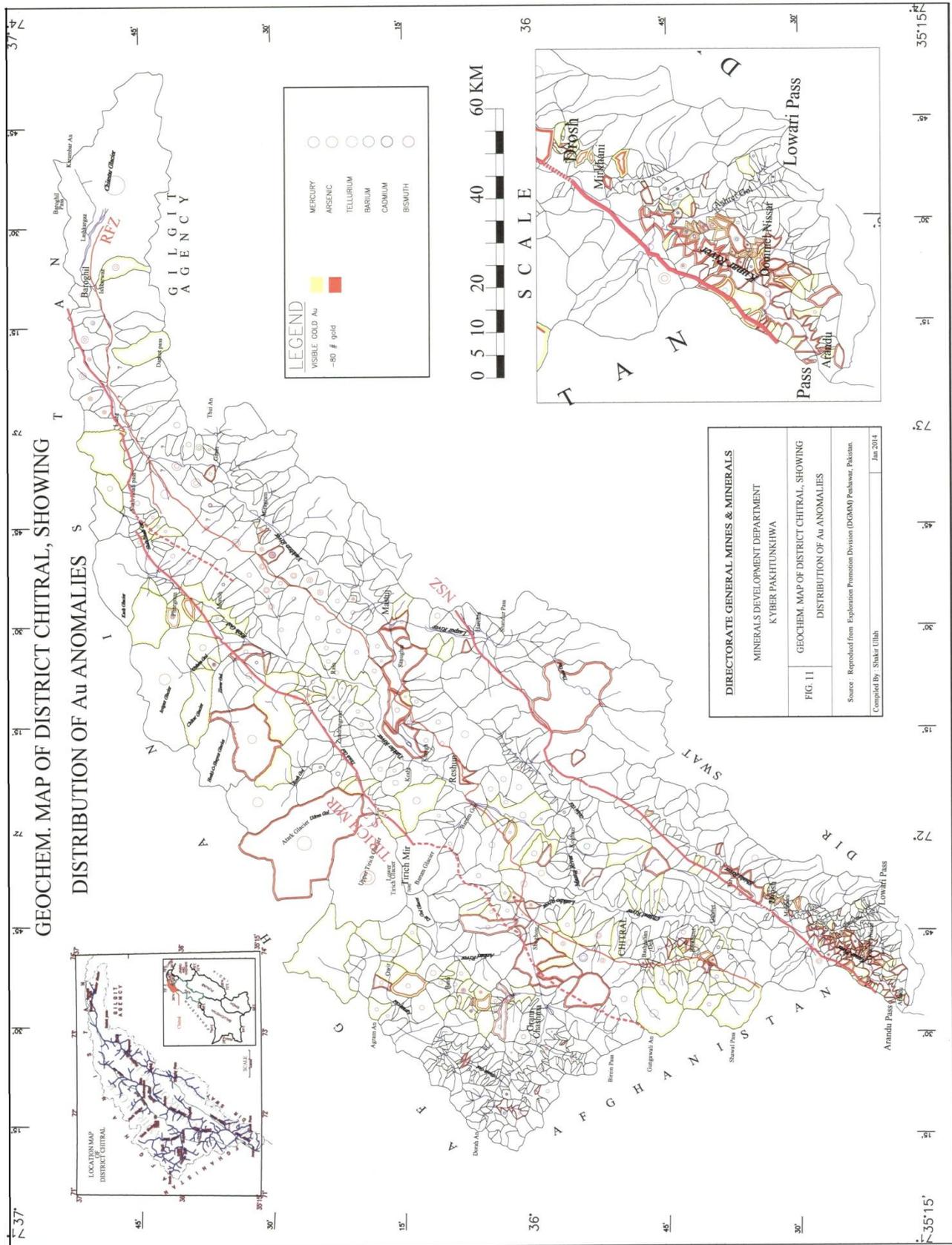


Figure 10: Geochem Map of District Chitral, showing distribution of Au Anomalies

**Table 2: Summary of the Interpretation of First Pass Exploration Coverage for Gold & Base Metals in District Chitral**

T.Block	Geological Belt	Anomalous Metals/Path Finders	Known Mineralization	Possible Exploration Targets
Pamir Block	Wakhan Sedimentary Belt intruded by granitoids of Tirich Mir Pluton & Garam Chashma Pluton/leucogranites.	*W- Au-As±Bi  *Pb-Zn/Bi±Te	*Low-grade Au bearing metamorphic quartz veins in Rich valley.  *Stratabound W± Pb-Zn-Cu in Garam Chasma & Rich valley.  *Leucogranite & associated scattered lead veining in upper Lutko valley.	*Fault related/sediment hosted Au-Ag mineralization.  *Stratabound tungston ± Cu-Pb-Zn mineralization.  *Pb-Zn in association with ganitoids.
	Tirich Mir Suture Zone	* As  * Au  * Ni-Zn/As	*Orpinment–realgar–flourite in Tirich valley.  *Very fine grained sulphide dissemination in crystalline rock (decalcified carbonates?) in Tirich.  *Signifying the geology of Tirich Mir Suture Zone and the Pyrite-pyrrohotitel bearing siltite & matabasites.	* Fault related sediment hosted As & Au-Ag.  * Zn mineralization in association with mafic/metabasite .  *Fault-related structurally controlled and/or sediment hosted gold-silver mineralization.
Karakoram Block	Northern Sedimentary Belt	* Cu -Pb-Zn/Hg	* Calcareous sandstone hosted Cu-Pb-Zn mineralization of metamorphogenic type in Mulko area.	* SEDEX/Stratabound massive sulphide and associated Au mineralization of primary nature deep in the system, possibly graben structure between TSZ & RFZ.
	Reshun Fault Zone	*Au -Ag -Sb/Hg	*Signifying Geochemical signature of RFZ & the occurrences of ply-metallic mineralization along the fault including Boulangerite & Sb-Pb-Ag in Krinj-Partsan area & elsewhere along the fault Au-Ag bearing boulangerite.	* Fault-related structurally controlled and/or sediment hosted Au-Ag mineralization.  & Fault related, structurally controlled metamorphogenic type polymetallic sulphides and sulphosalts.

T.Block	Geological Belt	Anomalous Metals/Path Finders	Known Mineralization	Possible Exploration Targets
	Southern Metamorphic Belt intruded by Kohistan Axial Batholith	* Au-Pt/Hg±As  *Cu–Mo-Sb/Hg±As±Cd	*Pyrite-Magnetite bearing Koghazi Green Schist/metabasalt in Chitral.  *Fe Skarn & Cu/Malachite staining in Yarkhun .	*Metabasalt hosted Au mineralization in association with massive sulphide.  *Porphyry style Cu (Au, Mo) mineralization.
Kohistan Block	Northern Suture Zone intruded by Kohistan Batholith	* Ni- Fine Au ±Sb	* Signifying the suture zone between Karakorum Block & Kohistan Magmatic Block. However no significant occurrence related to the anomaly is reported.	*Cyprus & Bisshi type Volcanogenic Massive Sulphide.  *Structurally controlled fault related Au mineralization along NSZ.
	Kohistan Island Arc including Kohistan Batholith	* Sb-Ag  *Cu-Au-Pb-Zn-Ag-Sb/Hg, As, Te, Cd, Ba & Bi	* Kaldam gol Cu-Pb-Sb of metamorphogenic type.  *Cu-Fe-Au in Dommel Nissar & Ashret area+breccia hosted gold upto 80ppm values in Ashret.	*Metamorphogenic type polymetallic & fault related Au mineralization.  *Porphyry style Copper (Au, Mo) & related skarns, base metals replacement and distal products of Au-Cu–Ag mineralization.

**Table 3: Summary of Geology and Mineral Potential of Chitral Region**

Tectonostratigraphic belt	Related Intrusives	Geological Modelling	Metallogenic Modelling		Know Mineral Occurrence		Others
			Conceptual	Empirical (based on drainage deochemistry and geology)	Metallic Minerals	Non metallic (dimensional/ gemstone potential)	
<p><u>Wakhan Sedimentary Belt</u></p> <p>Permian to Triassic-Jurassic dark grey slate with intercalations of calcareous schist, limestone granular marble.</p>	<p>Tirich Mir Pluton of Hindukush Batholith (crustal-melt related k. feldspar megacryst intrusions 115 Ma and post-collisional leucogranite sheets and pegmatities.</p>	<p><u>Continental</u> deep marine to shallow water palaeo – Tethys sedimentation including continental rift related sedimentary cycle along TMF.</p>	<p>Stratabound W and Pb-Zn-Cu.</p> <ul style="list-style-type: none"> <li>SEDEX massive sulphide</li> <li>SWUM and Beblip porphyry and related greisens.</li> </ul>	<ul style="list-style-type: none"> <li>Stratabound W.</li> <li>SWUM and Beblip type Pb-Zn in leucogranite sheets.</li> </ul>	<ul style="list-style-type: none"> <li>Calcsilicate hosted stratabound W. in Garam Chashma.</li> <li>Marble hosted stratabound? W Pb-Zn-Cu in Arkari</li> <li>Prograde Mo Skarn in Rich valley.</li> <li>Pb-Zn and Mo-Cu leucogranite veins in Lotkho and Rich respectively.</li> <li>Pyrite dissemination in aplite dykes in Rich valley.</li> </ul>	<ul style="list-style-type: none"> <li>Megacryst granite in Lotkho valley.</li> <li>Pegmatite hosted beryl (aquamarine) and garnet in Lotkho valley.</li> </ul>	<p>Mica sheets in pegmatites in Lotkho valley.</p>
<p><u>Tirich Mir Suture Zone</u></p> <p>Early carboniferous? volcanites and metabasites.</p>	do-	<p>Continental possibly a failed intra-plate rifting along peri-Gondwana fringe.</p>	<ul style="list-style-type: none"> <li>Fault-related structurally controlled Au-Ag</li> <li>Fault-related sediment hosted Au-Ag (Carlin type)</li> <li>Zn bearing massive sulphide.</li> </ul>	<ul style="list-style-type: none"> <li>Fault-related structurally controlled metamorphogenic type Au-Ag.</li> <li>Fault-related sediment hosted metamorphogenic type Au-Ag.</li> <li>Zn Bearing massive sulphide in association with Cu.Ni mineralisation.</li> </ul>	<ul style="list-style-type: none"> <li>Metamorphic quartz veins up to 1 ppm Au in Rich valley.</li> <li>Carbonate hosted As-Hg-F veins of metamorphogenic type (Talus sample 2ppm Au) in Tirich valley.</li> <li>Very fine grained sulphide (?) dissemination in banded siliceous rocks (decalcified rocks?) in Tirich valley.</li> <li>Pyrite pyrrohotite in siltite rocks in Rich valley.</li> </ul>	<ul style="list-style-type: none"> <li>Dark green gabbro amphibolite in Rich valley.</li> </ul>	

Tectonostratigraphic belt	Related Intrusives	Geological Modelling	Metallogenic Modelling		Know Mineral Occurrence		Others
			Conceptual	Empirical (based on drainage geochemistry and geology)	Metallic Minerals	Non metallic (dimensional/ gemstone potential)	
<p><u>Northern Sedimentary Belt</u></p> <p>Ordovician to Devonian ± early Carboniferous argillaceous rocks i.e shale, slate, and siltstone with intercalation of calcareous schist and quartzite's and fossiliferous carbonate beds transgressed over a crystalline basement of Pre-Ordovician age. The belt includes the Chitral fault along the unconformity of Shoghore limestone.</p>	No significant intrusion.	Continental. Deep marine to shallow water platform sedimentation of Palaeo Tethys on peri-Gondwana land.	<ul style="list-style-type: none"> <li>• Stratabound massive sulphide.</li> <li>• Sedimentary exhalative (SEDEX) polymetallic massive sulphide.</li> <li>• Fault related structurally controlled Au-Ag.</li> <li>• Fault related sediment hosted Au-Ag.</li> </ul>	<ul style="list-style-type: none"> <li>• SEDEX type polymetallic massive sulphide.</li> <li>• Fault related structurally controlled metamorphogenic type Au-Ag rich polymetallic veins.</li> <li>• Red carbonate hosted fine Au-Ag mineralisation.</li> </ul>	<ul style="list-style-type: none"> <li>• Metamorphogenic type Cu-Pb-Zn bearing quartz veins hosted in calcareous sandstone along axial planes of a fold in Pakhturi, Mulkho.</li> <li>• Au-Ag rich boulangerite veins along Chitral fault in Shoghore.</li> <li>• Metamorphogenic type Cu-Pb veinlets in red carbonate in Shoghore.</li> <li>• low grade Au bearing red carbonates in Shoghore.</li> </ul>	<ul style="list-style-type: none"> <li>• Carbonate beds more or less metamorphosed to marble.</li> <li>• Fossiliferous carbonate beds.</li> <li>• Slabs of slate rocks.</li> </ul>	
<p><u>Reshun Fault Zone</u></p> <p>Includes Cretaceous carbonate beds and red argillaceous to arenaceous beds and Tertiary conglomerate along Reshun Fault.</p>	May be related to Tirich Mir pluton.	Continental shallow marine to fluvial sedimentation post-suturing of Hindukush-Karakorum block to Eurasian continental plate and may be Post-India suturing.	<ul style="list-style-type: none"> <li>• Fault related structurally controlled Au-Ag.</li> <li>• Fault related sediment hosted Au-Ag.</li> </ul>	<ul style="list-style-type: none"> <li>• Fault related metamorphogenic type polymetallic veins.</li> </ul>	<ul style="list-style-type: none"> <li>• Fault related structurally controlled quartz Sb veining of metamorphogenic type in Krinj Kamal Gol in Partsan.</li> </ul>	<ul style="list-style-type: none"> <li>• Dimensional stone potential in pink to maroon pale blocks of sandstone and conglomerate.</li> </ul>	

Tectonostratigraphic belt	Related Intrusives	Geological Modelling	Metallogenic Modelling		Know Mineral Occurrence		Others
			Conceptual	Empirical (based on drainage deochemistry and geology)	Metallic Minerals	Non metallic (dimensional/ gemstone potential)	
<p><u>Southern Metamorphic Belt</u></p> <p>Permian to Triassic succession of Chitral slate, Kohazi green schist and Shoghor limestone ± Carboniferous succession of Darkot Group ± Mesozoic succession along southern margin.</p>	<p>Kesu-Booni Zome pluton of Karakorum Batholith. Mid-Cretaceous to Miocene subduction related calc-alkaline to sub-alkaline.</p>	<p>Continental margin of Hindukush-Karakorum block syn Permo-Triassic rift related deep marine to shallow platform sedimentation during opening of Neo-Tethys along peri Gondwana and later Mesozoic sedimentation, related to back arc basin of K.1 A ± pre-Permo-Triassic succession of Palaeo-Tethys.</p>	<ul style="list-style-type: none"> <li>• Andean type porphyry Cu(Au, Mo) and related distal and proximal systems</li> <li>• Sediment hosted massive sulphide.</li> <li>• Basalt (Koghazi green schist) related massive sulphide and/or metamorphic gold.</li> </ul>	<ul style="list-style-type: none"> <li>• Porphyry Cu(Au, Mo) and related skarn.</li> <li>• Metamorphic gold.</li> </ul>	<ul style="list-style-type: none"> <li>• Malachite staining in Karakorum batholith and Fe skarn in Yarkhun valley.</li> <li>• Pyrite dissemination in Fe-rich quartz veined and malachite bearing green metavolcanics in Chitral and Koghazi.</li> <li>• Iron stones in Golen and Booni</li> </ul>	<ul style="list-style-type: none"> <li>• White and grey marble (Gahiret marble).</li> <li>• Green granite potential in Koghazi green schist.</li> <li>• Granite potential in Kesu Booni Zome pluton.</li> <li>• Other dimensional stone potential in metasediments of Mastuj-Laspur valley.</li> </ul>	
<p><u>Northern Suture Zone</u></p> <p>Cretaceous limestone and mafic ultramafic blocks in a slaty matrix.</p>	<p>Mir Kani Pluton Andean type subduction related calc-alkaline activities of Tertiary period. + porphyry sills</p>	<p>Suture zone along back arc/inter-arc of Kohistan Island Arc.</p>	<ul style="list-style-type: none"> <li>• Cyprus type and Besshi type volcanogenic massive sulphide.</li> <li>• Back arc rift/fault related Au-Ag.</li> </ul>	<ul style="list-style-type: none"> <li>• Back arc rift/fault related fine Au mineralisation.</li> </ul>	<p>Not known</p>	<ul style="list-style-type: none"> <li>• Marbalised block of limestone in Shishi valley.</li> <li>• Dimensional and gemstone potential in mafic ultramafic blocks in Shishi valley?</li> </ul>	

Tectonostratigraphic belt	Related Intrusives	Geological Modelling	Metallogenic Modelling		Know Mineral Occurrence		Others
			Conceptual	Empirical (based on drainage geochemistry and geology)	Metallic Minerals	Non metallic (dimensional/ gemstone potential)	
<p><u>Kohistan Island Arc</u> Jurassic to Cretaceous tholeiitic basalts and sediments and Cretaceous to Tertiary calc-alkaline volcano-sedimentary sequence.</p>	<p>Subduction related calc-alkaline Kohistan Arc Batholith including Mir Kani pluton + porphyry sills and sub-aerial calc-alkaline volcano-sedimentary rocks.</p>	<p>Pre-suturing intra-oceanic island arc and intra oceanic continental margin followed by post suturing Andean type continental margin.</p>	<ul style="list-style-type: none"> <li>•Porphyry Cu(Au, Mo) and related system</li> <li>•Kuruko type and rhyolite hosted massive sulphides.</li> </ul>	<ul style="list-style-type: none"> <li>•Porphyry Cu(Au, Mo) and related systems.</li> </ul>	<ul style="list-style-type: none"> <li>•Cu sulphide dissemination in Demmel Nisar.</li> <li>•Cu-Au iron Skarn</li> <li>•Epithermal? Au or breccia Au-Cu mineralisation in Ashiret.</li> </ul>	<ul style="list-style-type: none"> <li>•Dimensional stone potential in carbonates, green schist and granite etc.</li> <li>•Dolerite dykes along Arandu road.</li> <li>•Pink to maroon granite (volcano-sedimentary rock).</li> <li>•Potential in Shishi Kaldam Gol, Naghar of Drosh area.</li> </ul>	



## 6. Gemstone Resources

Few occurrence of gemstone are known in Chitral. The most prominent one is aquamarine, hosted by pegmatite bodies of Garam Chashma and Kafiristan localities. Geologically the pegmatite bodies (isolated megacrystal rock bodies of irregular shape) of the Garam Chashma and Kafiristan localities together with megacrystal bodies of Tirich Mir pluton should have potential of a gemstone clan beryl-topaze-tourmaline-garnet. Few occurrences of aquamarine with or without Topaz and tourmaline are known in Garam Chashma area e.g. Gobbar, Manurgol. Blue tourmaline has also been reported/known from upper Lutkho valley north of Garam Chashma. Topaz is reported from Gobor-o-Bakh locality (Zaki Ahmed, 1968).

Prospecting for further localities along the pegmatite belt bordering Afghanistan are recommended. At places the pegmatite rocks are associated with the occurrence of quartz crystals of commercial use.

Geologically the rock belt of Northern Suture Zone along Shishi valley and Mir Khani-Arandu valley, particularly the talc carbonate rocks in association with the serpentinite blocks, are good host rocks for emerald. Recently some green beryle and/or emerald have been reported from Shishi valley. A similar belt of rocks along Tirich and Rich valleys of Mulkho-Torkho areas is inferred for occurrences of green beryl and/or emerald.





Block No (Area)	Geology	Anomalous Metals/Path Finders	Known Mineralization
Block-03 <b>Morich</b> Ni-Zn  (188 Km <sup>2</sup> )	Argillaceous rocks i.e shale, slate, and siltstone with intercalation of calcareous schist and quartzite's and fossiliferous carbonate beds transgressed over a crystalline basement of Pre-Ordovician age. The belt includes the Chitral fault along the unconformity of Shoghore limestone.	* Ni-Zn/As	*Also signifying the geology of Tirich Mir Suture Zone and the Pyrite-pyrrohotitel bearing siltite & matabasites.
Block-04 <b>Pakhturi</b> Cu-Pb-Zn  (175 Km <sup>2</sup> )	As above	* Cu -Pb-Zn/Hg	* Calcareous sandstone hosted Cu-Pb-Zn mineralization of metamorphogenic type in Mulko area.
Block-05 <b>Mastuj</b> Au-Ag-Ni  (184 Km <sup>2</sup> )	Reshun Fault Zone Includes Cretaceous carbonate beds and red argillaceous to arenaceous beds and Tertiary conglomerate along Reshun Fault. Also covering altered green schist rocks	*Au -Ag -Sb/Hg	*Signifying Geochemical signature of RFZ & the occurrences of poly-metallic mineralization elsewhere along the fault Au-Ag bearing boulangerite.
Block-06 <b>Reshun</b> Au-Ag-Sb  (191 Km <sup>2</sup> )	Reshun Fault Zone Includes Cretaceous carbonate beds and red argillaceous to arenaceous beds and Tertiary conglomerate along Reshun Fault.	*Au -Ag -Sb/Hg	*Signifying Geochemical signature of RFZ & the occurrences of poly-metallic mineralization along the fault including Boulangerite & Sb-Pb-Ag in Krinj-Partsan area & elsewhere along the fault Au-Ag bearing boulangerite.
Block-07 <b>Bang gol</b> Cu-Mo-Fe  (180 Km <sup>2</sup> )	Succession of slate, green schist, Carbonate intruded by pluton of Karakoram batolith (Calc-alkaline to sub-alkaline)	*Cu-Mo- Sb/Hg±As±Cd	*Fe Skarn & Cu/Malachite staining in Yarkhun .
Block-08 <b>Koghazi</b> Cu-Au-Pt  (136 Km <sup>2</sup> )	Koghazi green schist and Chitral slate intruded by Kohistan Axial Batholith	* Au-Pt/Hg±As	*Pyrite-Magnetite bearing Koghazi Green Schist/metabasalt in Chitral.

Block No (Area)	Geology	Anomalous Metals/Path Finders	Known Mineralization
Block-09 <b>Laaspur</b> Ni-Pt-Au  (126 Km <sup>2</sup> )	Northern Suture Zone intruded by Kohistan Batholith	* Ni-Pt- Fine Au ±Sb	* Signifying the suture zone between Karakorum Block & Kohistan Magmatic Block. However no significant occurrence related to the anomaly is reported.
Block-10 <b>Arandu</b> Cu-Au  ( 115Km <sup>2</sup> )	Kohistan Island Arc including Kohistan Batholith	*Cu-Au-Pb-Zn-Ag-Sb/Hg, As, Te, Cd, Ba & Bi	*Cu-Fe-Au in Dommel Nissar & Ashret area +breccia hosted gold in Ashret to the south & north-east of this block.
Block-11 <b>Shah Sadin</b> Gemstones  (197 Km <sup>2</sup> )	Low to high grade metamorphic rocks (biotite+mascovite +garnet+ staurolite quartz schist) intruded by sheets of licogranite and pegmatite bodies	---	Aquamarine±tourmaline± topaz+garnet hosted in pegmatite body. Garnet mica schist also common
Block-12 <b>Ughuthi gol</b> Gemstones (143 Km <sup>2</sup> )	Low to high grade metamorphic rocks (biotite+mascovite +garnet+ staurolite quartz schist) intruded by sheets of licogranite and pegmatite bodies	---	Aquamarine±tourmaline± topaz+garnet hosted in pegmatite body. Garnet mica schist also common
Block-13 <b>Garam Chishma</b> Gemstones (143 Km <sup>2</sup> )	Low to high grade metamorphic rocks (biotite+mascovite +garnet+ staurolite quartz schist) intruded by sheets of licogranite and pegmatite bodies	---	Aquamarine±tourmaline± topaz+garnet hosted in pegmatite body. Garnet mica schist also common
Block-14 <b>Monur gol</b> Gemstones (180 Km <sup>2</sup> )	Low to high grade metamorphic rocks (biotite+mascovite +garnet+ staurolite quartz schist) intruded by sheets of licogranite and pegmatite bodies	---	Aquamarine±tourmaline± topaz+garnet hosted in pegmatite body. Garnet mica schist also common
Block-15 <b>Bomboret</b> Gemstones  (136 Km <sup>2</sup> )	Slate and carbonate rocks intruded by tirichmir pluton (megacryst) & pegmatite	---	Aquamarine±tourmaline± topaz+garnet hosted in pegmatite body. Garnet mica schist also common

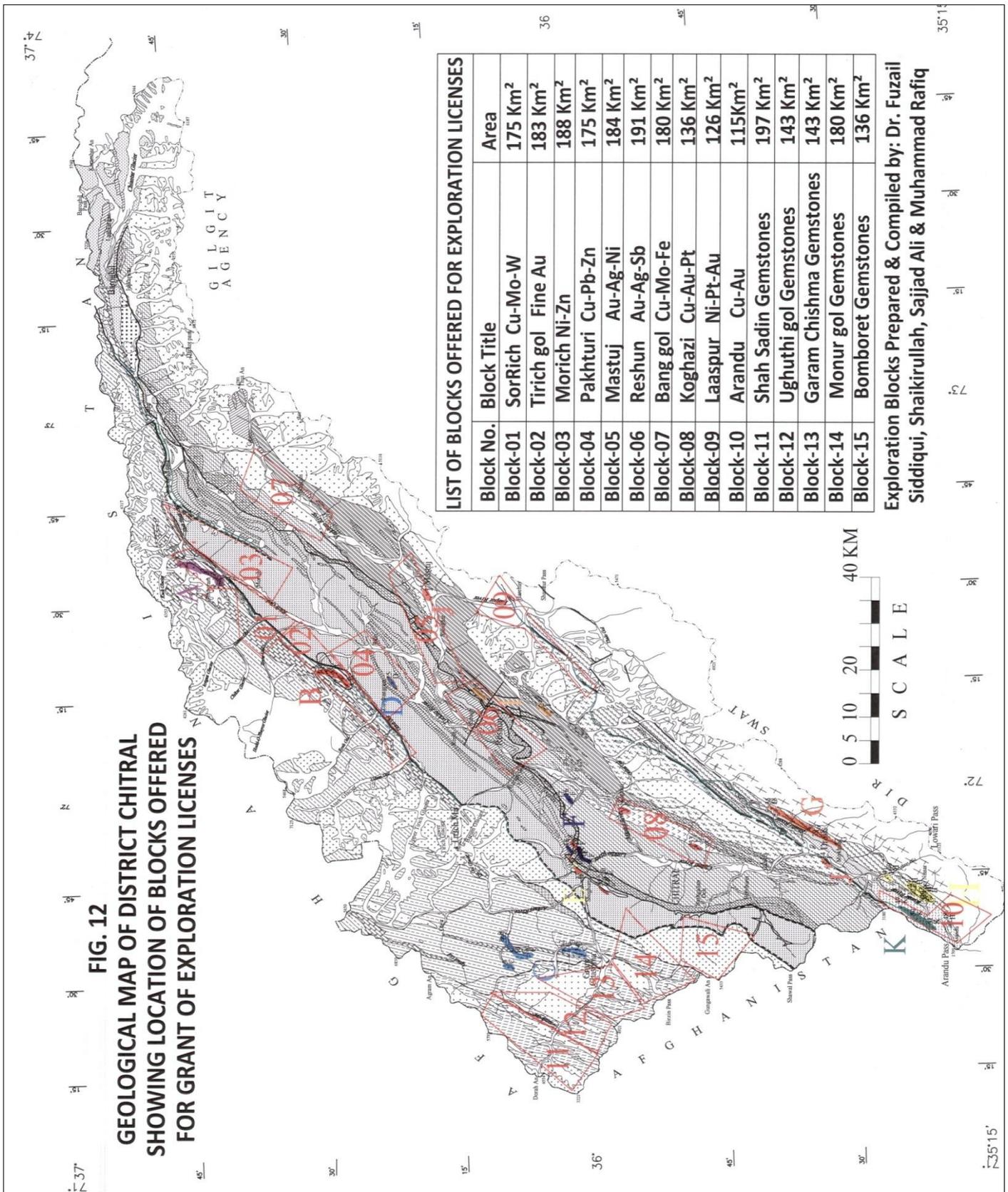


Figure 11: Geological Map of District Chitral, showing location of blocks offered for grant of exploration licenses

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