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By

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ILLUSTRATION

ABSTRACT

The mapped area lies within the southern Kohistan island arc terrane. The Kohistan arc terrane has been considered to form due to the northward subduction of the Neo- Tethyan oceanic lithospheric plate under the Eurasian plate during Cretaceous time. Two suture zones delineate the arc from the continental plates, viz. the main Mantle Thrust (MMT) and the Main Karakoram Thrust (MKT). The Main Mantle Thrust (MMT) passes through the southeastern part whereas the MKT is exposed to the north of the island arc.

Rock formations ranging in age from Cretaceous to Recent include Kiner amphibolite, metasediments and metavolcanics of Jaglot group, Chilas complex, Kohistan batholith and glaciofluvial deposits. Kiner amphibolites (metagabbro and metadiorite) occur in Kiner and Hodar gahs which are sheared and deformed in Dang Phhar area. They have intrusive contact with the Chilas complex and the Kohistan batholith. Metasediment and meta volcanics of the Jagilot group occur as xenoliths within the Chilia complex and Kohistan batholith. They are schists and paragneisses interlayered with amphibolites. They are hybridized and at places migmatized. The Chilas complex comprises gabbro-norite, pyroxene quartz diorite, hornblendite with minor ultramafic rocks. This sequence intruded by the Kohistan batholith which occupies about 70% of the northern part of the mapped area. It is composed of multiphases plutons of diorite, tonalite, quartz diorite, granodiorite, adamellite, granite and leucocratic dykes. The diorite and tonalite show deformation whereas quartzdiorite, granodiorite and granites are partly deformed.

Tectonically, the area is characterized by a number ofnortheast dipping high angle faults and many shear zones are developed which accommodate the neotectonic uplift of the NPHM.

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INTRODUCTION

Purpose and Scope

The purpose of this project is to prepare the geological map of the Kiner area on 1:50,000 and to investigate the mineral potentials. The area falls within the administrative boundary of the Diamir District which is covered by Survey of Pakistan toposheet No. 43-I/2. The field work was carried out in two seasons, i.e., June 1989 and June-July, 1991.

Location and Accessibility

The Kiner Gah quadrangle area lies between the latitude 35°30′ and 35°45′ and longitude 74° and 74°15′. The southern border of the quadrangle is approachable upto 20 km by jeepable roads along the Kiner Gah and Hodar Gah from Karakoram Highway (KKH), whereas the northern part constitutes high altitude areas.

Chilas which is the main town to connect Kiner Valley by an all-weather, metalled Karakoram Highway (KKH) with Islamabad at a distance of 587 km.

Physiography

The investigated area covers part of the Kohistan island arc, western Himalayas and lies at the southwestern margin of the Nanga Parbat. The minimum height in the area is 1,374 m (ASL) in Hodar Valley and maximum 5,409 m (ASL) at the ridge between Khandbari Gah and Shinghai Gah (Fig. 1). The watershed line passes almost along the 35°40′ N latitude. The height increases gradually from the Indus towards north up to the watershed area. The valleys are in youth stage.

This watershed area drains the Kiner Gah and Hodar Gah and ultimately fall in Indus River. Shinghai Gah and Pahot Gah fall in Kar Gah and Sai Nala, respectively and Khandbari Gah towards west fall in the Khandbari Gah. The drainage pattern is dendritic and radial.

Climate and Habitation

The climate varies from almost arid in low to subtropical in the high altitude areas. Vegetation is scanty around the Indus and thickly forested along tributaries in the highly precipitated areas. The precipitation is almost in the form of snow with little rainfall. The permanent snow line is at about 4,500 m (ASL) which descends up to 2,5000 m in winter.

Winter is severe and summer is pleasant in upper reaches. The forest vegetation is in the form of pine and chalghoza, whereas principal fruits grown are apricot, mulberry, walnut and grapes. Wheat and maize are the major crops. Due to rough terrain and less cultivated land, the population is sparsely distributed.

Previous work

Kohistan island arc has been thoroughly investigated in the past. The pioneer workers who conducted geological investigations included Ivanac, et al., (1956), Bakr (1965), Desio (1974) and Gansser (1964). By the late seventies, sufficient geological data was geographical represented and first geological regional Tectonic map of northern area was prepared (Tahirkheli and Jan, 1979; Tahirkheli, 1979). It was proposed that Kohistan island arc represents an ancient island arc trapped between Indian and Eurasian plates. Several studies have been conducted on various aspects of the lithologies of the arc in terms of field relationships, mineralogy, petrology, metamorphism, structure and radiometric dating (Bard, 1983; Coward, et al., 1986; Ghazanfar, et al., 1991; Jam, et al., 1984, 1993; Khan, 1988; Khan, et al., 1989, 1996; Khan, T., et al., 1989, 1994, 1996; Kubo, et al., 1996; Petterson and Windley, 1985; Treloar, et al., 1989,1996). Kiner Gah area was traversed by Khan, T., et al., (1989) and reported preliminary geology of the area.

GEOLOGY

The mapped area constitutes part of the Trans Himalaya which lies to the west of Nanga Parbat Haramosh Massif (NPHM). It also constitutes the central part of Kohistan island arc sequence. This island arc is bounded by two suture zones viz. Main Mantle Thrust (MMT) in south and Main Karakoram Thrust (MKT) in north. (Tahirkheli and Jan, 1979). For more detail, see Coward, et al., 1986, Petterson and Windley, 1985, Khan, T., et al., 1994 and Jan, et al., 1984.

The Kohistan island arc sequence in the mapped area consists of (1) Chilas complex, (2) Northern amphibolites (Kiner amphibolites) and Jaglot metasedimentary group. This sequence intruded by multi phases of Kohistan batholith (Petterson and Windley, 1985). Here is the stratigraphic set-up of the rock units of the Kiner Gah.

Quaternary	Unconsolidated Deposits (Alluvium, scree, talus and glacio fluvial deposits)
Tertiary	Kohistan batholith Undeformed plutons (granophyric granite, pegmatite and aplite) Partially deformed plutons (quartz diorite, granodiorite adamellite and granite)
Late Cretaceous	Deformed plutons (diorite and tonalite) Chilas complex (diorite, pyroxene quartz diorite, gabbronorite, hornblendite, mafic and ultramafic cumulates)
Early Cretaceous	Northern amphibolites (Kiner amphibolites) Metasediments and metavolcanics of the Jaglot group (biotite schists, paragneisses and migmatite)

Metasediments and Meta Volcanics (Jaglot group)

The metasediments of the Jaglot group occur in the form of linear beds from Khomar to Pajal area. A screen is also exposed in Nilobare between tonalite and quartz diorite. The 16 to 17 m thick two beds of metasediments are interlayered with amphibolite in Gutumsar area. However small screens in the diorite in upper reaches of Shinghai Gah are also observed.

The metasediments consist of biotite schists and paragneisses locally migmatized and interlayered with amphibolite. They are hybridized and cross cut by intrusions of granitoids. These metasediments are defined as Jaglot group (Khan, T., et al., 1994), Jaglot schist belt (Treloar, et al., 1996). These metasediments include schists and paragneisses interlayered with quartzite bands (minor). At places the metasediments are deformed and migmatized.

The biotite schists are fine to medium grained. Minerals constituting the biotite schists include quartz, biotite, plagioclase, epidote, chlorite, calcite, opaque ± garnet ± kyanite and ± graphite while the paragneisses are medium to coarse grained and composed of plagioclase, quartz, biotite and garnet with minor amount of hornblende, epidote, muscovite and opaque minerals. Fine grained metavolcanic rocks occur as xenolith within the Chilas complex at the Gutumsar. They are amphibolized, banded and associated with the metasediments at Pajal area and upper reaches of Shinghai Gah. They may be equivalent to the Chalt volcanics exposed in the northern zone of the Kohistan arc terrane.

The metasediments and the metavolcanics of Jaglot group may represent stratigraphically the lowest unit of the northern part of the Kohistan island arc sequence. It is to be noted that the Jijal complex which is the basal part of the Kohistan island arc has been assigned Lower Cretaceous age (Sm-Nd mineral isochron age of 118 ± 13 Ma; Yamamoto and Nakamura, 1996). So the metasediments may be assigned Early Cretaceous age.

Northern amphibolites (Kiner amphibolites)

The name Northern amphibolite was given by Bard (1983) to a group of amphibolite occurring in Dir area. The same type rocks are traceable along the northern contact of the Chilas complex at Tangir/Khanbari (Shah, et al., 1992) and extend in the investigated area in Hodar and Kiner gahs. As these are well exposed at Kiner Gah between Darshe and Dusi, so the name Kiner amphibolites have been given.

These amphibolites are metagabbroic and metadioritic in composition. Garnet-bearing amphibolite is noticed in central part, while banded amphibolite is found along the northern contact at Biali and Shai area. The amphibolites are generally medium grained with grey to dark grey colour. In the banded amphibolites individual bands range in thickness from streak to about 5 cm. They are alternating amphibole and quartz-feldspar rich bands. The amphibolites are composed of various proportion of plagioclase, hornblende, quartz and small amount of opaque minerals, epidote, apatite, and accessory biotite, sphene, rutile and chlorite. The amphibolite of the mapped area locally contain the relics of hypersthene and clino pyroxene. The garnets in the garnet amphibolite, are small and evenly distributed except for some porphyroblastic where upto 3 cm in size

garnet have been observed. The ultramafic cumulate so occur as small bodies, patches and lenses in the Kiner amphibolites. In the vicinity of ultramafic, the amphibolites contain an increasing number of dykes, veins and patches of hornblendite. Moreover, these amphibolites are intruded by fine grained metamorphosed dolerite dykes. The contact of amphibolites is shear and faulted with the diorite of the Chilas complex and tonalite of Kohistan batholith. They have intrusive contact with the quartz diorite and adamellite of the Kohistan batholith. The amphibolites may be older than Chilas complex. They may be equivalent to the southern amphibolites. They may be assigned Early Cretaceous age.

Chilas complex

Chilas complex occurs in the form of a linear belt in EW direction along both banks of Indus River. It extends toward west up to Dir, whilst towards east it is truncated by the Raikot fault.

This complex is composed of mainly gabbronorite and pyroxene quartz diorite associated with mafic - ultramafic cumulates. These rocks are cut by thin dolerite (amphibolite) dykes and metasomatic hornblende plagioclase pegmatites.

Description of each of the rock unit is as under:

Ultramafic Rocks

Ultramafic rocks are present within metagabbronorite of the Chilas complex and form one of the Mafic-ultramafic components of the layered magmatic cumulates. The mafic-ultramafic and anorthosite association of Jan, et al., (1984) and Khan, et al., (1989) occur as lensoidl bodies in the NW and SE directions. In the mapped area, the ultramafic rocks, which are mainly dunite and wehrlite with subordinate anorthosite veins occur in Shiar Gah, Dudar Gah, Darshe, Biali and Dang Phhar These rocks are intruded by gabbronorite, hornblendite and mafic to ultramafic pegmatite.

Thin section/study reveal that the ultramafic rocks (dunite and wehrlite) are generally medium to coarse-grained and contains olivine, pyroxene, amphibole as mafic minerals together with plagioclase. At places at the boundary of olivine with plagioclase, hornblende and spinel have developed depicting Corona structure.

Hornblendites

These rocks are found at several places in the Kohistan island arc. The hornblendites mostly extend in EW direction, with an average width of about 100 metres. The length of

hornbendites at Pakor in Hodar Gah cover more than 3 km in length. At the base of Baset Gah, the hornblendites are profusely inter mixed with gabbronorite. In addition to these large bodies, numerous veins and patches also occur in the Chilas complex. These patches are variable in shape and they range from less than a metre to several metres. They are mostly coarse grained, locally medium grained, whereas the pegmatitic varieties contain up to 18 cm long crystals of hornblende. They are essentially composed of hornblende and plagioclase, with locally variable amount of pyroxene. Minor amount of magnetite, apatite, rutile, quartz, sphene, chlorite, epidote and carbonate are found.

Gabbronorite

The gabbronorite rocks are exposed at the base of Hodar Gah and Marin Gai area. They are generally grey, weather to brownish grey. They consist of plagioclases and two pyroxenes, with secondary minerals as chlorite and epidote. The orthopyroxenes exhibit pinkish green colour whereas clino-pyroxene is green. Plagioclase is generally white but at places fresh pinkish coloured is also noticed. Amphibolite is also found around some pyroxene grains. The opaque minerals include magnetite, ilmenite and pyrite.

Diorites

The diorites crop out in at base of Hodar Gah, Kinokot and upper reaches of Shiar Gah. They are medium grained, grey, weather to rusty brown and pale grey. The texture is hypidiomorphic to granular. They range in composition from biotite rich to hypersthene-quartz diorite.

The diorites are composed of black to dark green amphibole, plagioclase ± pyroxene ± biotite and ± quartz and ± orthoclase. In Kinokot area, biotite is commonly found. Pyroxene is common in the upper reaches of Shiar Gah and Hodar Gah. Chlorite and epidote are secondary minerals. Locally the pyroxene diorites have small stocks of gabbro and norite.

Kohistan batholith

The Kohistan batholith is considered as the northwestern component of the Trans-Himalayan batholith which runs parallel to the entire length of Himalayas for about 2,700 km in the east-west direction. Tahirkheli, et al., (1979) and Jan, et al., (1989) described the major rock formation in the Kohistan island arc, which were later termed as the Kohistan batholith by Petterson and Windley (1985). The northern part of mapped area is covered about 70% by the Kohistan batholith. The Kohistan batholith comprises tonalite and diorite which are deformed. The quartz diorite, granodiorite, granite and adamellite plutons of the batholith are partly deformed. The undeformed acidic and granitic dykes are also present.

Deformed plutons

The deformed plutons are exposed in the watershed, Pajal and Dangdalash areas. They may be early phase plutons of (Petterson and Windley, 1985).

Diodre:– The diorite is well exposed around the watershed area of Kiner Gah and Shinghai Gah and also in upper reaches of Khat Bar Gah. It is a heterogenous unit of meso-to melanocratic nature, containing xenoliths of metavolcanic and metasedimentary rocks which is profusely intruded by quartz monzonite, granophyric granite dykes, pegmatites and aplites on top ridge between Shinghai and Kiner Gah. Mostly diorites are hybridized. Hornfels of pyroxene rich ultramafic rocks occur as xenoliths. It contains pods of monomineral layers which composed entirely of mafic enclaves of hornblende. The diorite is predominantly sheared and amphibolitized. The diorite is composed of essentially plagioclase, hornblende and biotite with minor quartz. Plagioclase ranges from 50-70% by vol. It is euhedral to subhedral with albite and percline twinning. The hornblende partially alters into chlorite, epidote and biotite.

Tonalite:–The tonalite occurs as a linear belt from Monin to Dangdalash area and another sill intrudes metasediments and amphibolite in the Pajal area. It is intruded by granite and quartz diorite. This unit is highly deformed and gneissose. Its foliation may be marked by elongation of mineral especially amphibole and flattening of microgranular inclusions. Micro granular inclusions, layering of mela and leucocratic types are common within the tonalite. It is generally light grey, weathering to light brown, medium to coarse grained, and hypidiomorphic granular. Its colour index is 15-25%. It is composed of plagioclase, hornblende and biotite. Epidote, opaque minerals, sphene, calcite and muscovite are common accessories. The colour of feldspar is generally white but occasionally light fresh. Biotite is black with bronze sheen.

Augen gneissic and mortar textures are developed in Dusi and Pajal area where the tonalite has faulted contact with the Chilas complex and intrusive contact with granite and quartz diorite.

Partially deformed plulons:

The partially deformed plutons are exposed from Monin to Totam area and upper reaches of Pahot Gah. They include.

Quanz diorite:–The quartz diorite is exposed from Monin to Totam area and associated with granodiorite and the deformed plutons. It is slightly foliated, light grey to grey, medium grained and hypidiomorphic granular. Augen, gneissic and mortar texture are locally developed and at places porphyritic. It is mainly composed of plagioclase, hornblende, biotite and

quartz with subordinate k-feldspar. Epidote, muscovite and opaque minerals are also found. The quartz diorite is intruded profusely by granodiorite, granite and pegmatites resulting slight hybridization.

Granodiorite: The granodiorite occurs around the top slopes and between Bariban Gah and Pahot Gah. It is intruded profusely by the granite apophyses and acidic pegmatites. It includes metasediment, metavolcanic rocks, diorite and quartz diorite as xenoliths which are aligned in NW-SE direction. It is grey and weathers to brownish grey. It is medium to coarse grained and hypidiomorphic. It is mostly equigranular whereas toward east of Bateli, it is subporphyritic. The contact of the granodiorite is intrusive but sheared contacts with tonalite and diorite are also seen. Mineral composition of granodiorite is quartz, plagioclase, perthitic orthoclase, hornblende, biotite with minor epidote. chlorite ± muscovite ± sericite ± sphene and ± apatite.

Quartz ranges from 10-30% which is anhedral, fresh, at places strained. Plagioclase (25 to 45%) occurs as euhedral to subhedral grains. They are partially altered at places to sericite. Orthoclase ranges from 5 to 15%. Homblende ranges from 5 to 10% and altered to biotite, chlorite and epidote. Biotite (5-15%) occurs in the form of flakes. Some of the biotite flakes are developed at the expense of hornblende.

Adamellite: The adamellite occurs north of Dusi village in Kiner Gah as a lensoid body. It measures about 9.5 km in length and the central part is about 200 metres in thickness and tending NWW to SEE. A small adamellite lensoid body also occur in Hodar Gah within the pyroxene diorite. It is fine to medium grained, showing pot hole structure. It is partially foliated. The xenoliths of meta gabbro is and metasedimentary rocks are frequently present which are ranging from a metre up to tens of metres. In thin section, the adamellite is fine to medium grained. It is composed of orthoclase, quartz, plagioclase, muscovite biotite ± epidote ± sphene and magnetite. Quartz is often of irregularly shape and commonly interstitial, and amounts up to 30-32% by volume. Plagioclase amounting about 15% is generally euhedral to subhedral and tabular, twinned. Orthoclase making up to 45%, are strained, fractured and having got the inclusions of quartz. Biotite amounting about 10% is subhedral, often occurs as clusters and sometime intergrown with muscovite. Magnetite amounts up to 2% whereas chlorite, epidote and muscovite occur in minor amounts. Limonite and apatite are found in traces.

Granite: The granite is exposed in the upper reaches of Kbandbari Gah and its dykes are found throughout the northern part of the mapped area. It is medium to coarse grained, porphyritic and undeformed. It contains xenoliths of diorites, metavolcanic and metasedimentary rocks.

In thin section, the granite reveals hypidiomorphic granular, medium to coarse grained and porphyritic texture. Minerals are quartz, plagioclase, perthitic felspar, biotite and hornblende. Traces of chlorite, spbene, apatite, sericite and magnetite are also found. Quartz range from 20-40%, anhedral, fresh and locally strained. Plagioclase (15 to 30%) occur as euhedral to subbhedral grains, altered and twinned with combination of the carlsbad, albite and pericline. Orthoclase up to (30%) occurs mainly as perthite. The orthoclase grains are strained and fractured. Biotite and hornblende amounts to some 15-20%. The biotite is altered into chlorite. The contact of granite with surroundings is sharp and intrusive.

Undeformed plutons

The leucocratic dykes are the latest intrusions which started after the culmination of the major tectono -metamorphic event. They are probably the product of crust melting and occurred after the terminal collision between India and Eurasia (Petterson and Windley, 1985). These rocks comprise granophyric granite, pegmatite and aplite.

Granophyric granite: The granophyric granite is exposed in the form of a dyke at the top ridge between Shinghai Gah and Kiner Gah. It is leucocratic and medium to coarse grained.

Under the microscope the granophyric granite is holocrystalline, hypidiomorphic and granophyric in texture (Khan, T., et al., 1989). Mineral constituent are quartz, orthoclase and biotite with minor plagioclase and magnetite. Quartz are anhedral, plumose and vermicular within orthoclase. Orthoclase (up to 65%) are anhedral to subhedral having micro perthitic (braid) and granophyric texture. Plagioclase amounts up to 2%. Sericitization is noted in some grains of orthoclase and plagioclase. Biotite flakes and magnetite grains occur within quartz and orthoc]ase. Chlorite and sphene occur in traces.

Pegmatite and aplite dykes: Pegmatitic and aplitic dykes cross cut the early phase plutons, at top ridges and also intrude the second phase plutons at lower altitude.

The pegmatites and aplites which are the dominant leucocratic dykes are generally cornposed of quartz, orthoclase, microcline, biotite and muscovite ± garnet ± tourmaime. The aplites and pegmatites show simple homogenous textures and are unzoned.

Unconsolidated Sediments

The unconsolidated sediments are wide spread in the Nalas (Gahs) and at mountain slopes. They are alluvium, screes and glacio-fluvial deposits.

The glacio-fluvial deposits covered the upper reaches ofthe Nalas. They are loose,

massive, brownish to buff in colour and composed of material of almost every size. However, they are slightly consolidated at lower levels and changed into alluvium.

STRUCTURE

The Kohistan arc is bounded by two suture zones viz. Main Mantle Thrust (MMT) and Main Karakoram Thrust (MKT). The MKT in the north, separates the arc sequence from Asian plate whereas the MMT marks the boundary of Kohistan arc sequence with Indo-Pak plate. The investigated area lies in the central part of Kohistan arc. The area is profusely intruded by the Kohistan batholith.

The formation of the northern suture between 100 and 90 Ma resulted the formation of north verging folds and thrust in northern Kohistan, upright folds in the middle Kohistan and S-verging folds, axial-plane fabric and shear zones in Chilas complex. The subsequent Eocene collision between the Kohistan arc and Asia plate resulted in back-steeping of fold-thrust structures in the Kohistan arc. (Coward, et al., 1986; Khan, M.A., et al., 1989; and Khan. T., et al., 1994).

The investigated area is effected mainly by the closure of the northern suture. Deep seated shear zones are found within Chilas complex in Dang Phhar, Morin Gai, in NW to SE direction. They show high temperature tectonic flow and mylonitization. The microfolds are mostly upright, however, some are dipping toward south.

The northern margin of pyroxene diorite with amphibolite is marked by mylonite zone which is also deformed. The beds and lenses of metasediments are located within the shear zone. The shear zone is narrow toward west and traced up to Thilkush through Biali area. In the Biali area, shear zone exhibit a sharp fault between metasediments and tonalite. Toward east, it bifurcates into more than one branches (Figure 1).

Another shear zone is traced from Khomar to Pajal area, within the pyroxene diorite. It comprises mica schists, gneisses and amphibolites. It is 800 metres thick in Khomar area which is the extension of Thalpan shear zone (Khan, N.A., and Khan, T., 1998). The drag and isoclinal folds are developed which dip toward NE. Towards west in Panjal area, these metasediments have faulted contact with metagabbro and tonalite.

The tonalite and diorite exposed as linear belt from Monin to Gomas area is metamorphosed and sheared. A screen of meta-sediments is located between quartz diorite and tonalite in Nilobare area, The metasediments are disturbed, crumpled and oriented in NW-SE direction with development of microfolds plunging 20° NE.

A small shear zone is also observed in the upper reaches of Dudar Gab within metagabbro which trends NW-SE, and dips 50° NE.

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