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REVIEW OF STRATIGRAPHY OF THE UPPER HUNZA VALLEY (UHV), NW KARAKORAM, PAKISTAN

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ABSTRACT

Recent collaborative work of Pakistani and Chinese scientists has established five mapable stratigraphic units which, from old to young, are: i. Gircha Fm., ii. Pak-China Friendship Fm (Dih Fm.)., iii. Passu Slate, iv. Gujal Dolomite, and v. Shanoz Conglomerate. A NNW-SSE trending Sost Anticline is the major structure in this area which bifurcates the stratigraphic net of this valley. The oldest formation exposed in the core of Sost Anticline is Gircha Fm. The base of the Gircha Fm is not exposed in UHV. The age of stratigraphic sequence in the UHV, based on fauna, ranges from Late Permian to Late Cretaceous-Early Tertiary.

INTRODUCTION

The well known Upper Hunza Valley, spanning the northwestern stretch of the Karakoram Belt constitutes a part of the southern marginal mass of the Eurasian plate (Desio & Martina, 1972). It is surrounded by the two very important geological provinces, the Pamir knot (syntaxis) on the north-west and the Higher Himalayan Nanga Parbat-Haramosh naze (syntaxis) on the south. The valley cuts across the strike of the rocks thus exposing fresh-cut easily accessible sections along the newly built Karakoram Highway.

The elevation of the UHV at Karimabad is over 2134 m, at Passu 2439 m, at Sost 2744 m, at Dih 3110 m, and culminates to 4878 m at Khunjerab Pass. The elevation of the mountain peaks surrounding the valley ranges from 3963 m in the south to over 6098 m in the north.

The Kulunjili Mountain Belt which hosts the Khunjerab Pass demarcating the political boundary between Pakistan and China, forms a water-divided between the Khunjerab river (upper reaches of the Hunza valley) in Gilgit Agency in Pakistan and Taghdumbash river, a tributary of Yarkland (or Zarfshan) river in Sinkiang in China.

The results being presented in this paper are an outcome of a joint field work in the UHV during the fall of 1989. This programme was sponsored jointly by the Chinese Academy of Sciences and the Pakistan Science Foundation.

The senior author's contribution to field work during this trip was confined to the area lying between Karimabad and Khunjerab Pass. Most of the work was confined to fresh-cut sections exposed along the KKH. This paper is intended to review the stratigraphy of the Upper Hunza Valley and report on the pivotal role played by the newly discovered Sost Anticline which brought about a significant change in the already established stratigraphic net of this region.

PAST RESEARCHES

The geologist's sojourn to the UHV started in 1990 - when McMahon during his army duties studied a few rock samples and produced a lithological description of some rock outcrops encountered en route. During his brief visit to the UHV, Hayden (1916) reported spirifer and small Bryozoans in the limestone in the vicinity of Misgar village. Kuenen (1928) also described some rock outcrops in the UHV but did not elaborate much on the stratigraphy and age of the rocks. Ivanac et al. (1956) mentioned the findings of Clark (1984, unpublished), who collected fossils at Khaiber, Misgar and Shimsal which were considered to belong to the Upper Carboniferous - Lower Permian. Schneider (1957) described the geological sections located towards south of Khaiber village and considered the Passu Slates as a separate unit with a tectonic contact on both of the flanks.

Several members of the Italian expedition to the Karakoram and Hindukush reported Permian fossils; Foraminifera and Epimastopora (Calcareous Alga) from the UHV (for references, see Desio, 1979). Desio & Martina (1972) produced a geological sketch map of the UHV and pioneered to establish a stratigraphic base by differentiating the following six sedimentary formations, two metamorphic formations and four igneous bodies.

A. Igneous Bodies
    i. Axial Karakoram Batholith
    ii. Giraf Syenite
    iii. Granite-aplaite-pegmatite
    iv. Porphyritic dykes intruding the Misgar Slate, Gircha Fm. and Gujal Dolomites.
B. Metamorphic Formations
    i. Dumordu Fm.
    ii. Migmatitic Gneisses
C. Sedimentary Formations
    i. Misgar Slate
    ii. Kilik Fm.
    iii. Gircha Fm.
    iv. Passu Slate
    v. Gujal Dolomite
    vi. Shanoz Conglomerate

Tahirkheli (1982) described in detail the lithologic characteristics of the rock formations of the Upper Hunza Valley, without altering the stratigraphic order produced by Desio & Martina (1972). Among later workers Khan et al. (1987) published a report on a traverse covering the geological sections between Hassanabdal and Khunjerab Pass. In the UHV they followed the stratigraphic sequence established by Desio & Martina (1972).

Recently a well documented paper by Gaetani et al. (1990) has provided fresh and detailed information on the sedimentology, stratigraphy and tectonics of the Upper Hunza Valley and the adjoining areas. This paper was received when the manuscript was in the final stages. However, wherever necessary the results of this paper have been cited. The geologists of the Natural History Museum, Pakistan Science Foundation (Baqri et al., 1987-88) have started remapping the UHV and results of their research are being awaited.

SOST ANTICLINE: STRUCTURAL CONTROL

The first sketch map of Desio & Martina (1972) provided a geological base to tie the stratigraphy of the Upper Hunza Valley with the regional stratigraphic net of the northwestern stretch of the Karakoram and adjoining areas. Based on the tectonic orientation of the outcrops in the UHV, it appears that the rock formations encountered here have a regional strike swinging between WNW-ESE and NNW-SSE and with this trend, the rock formations can be followed towards Wakhan (Little Pamir) in the west

and on the southern fringe of K-2 in the east (Fig. 1). However, so far no attempt has been made for such correlation.

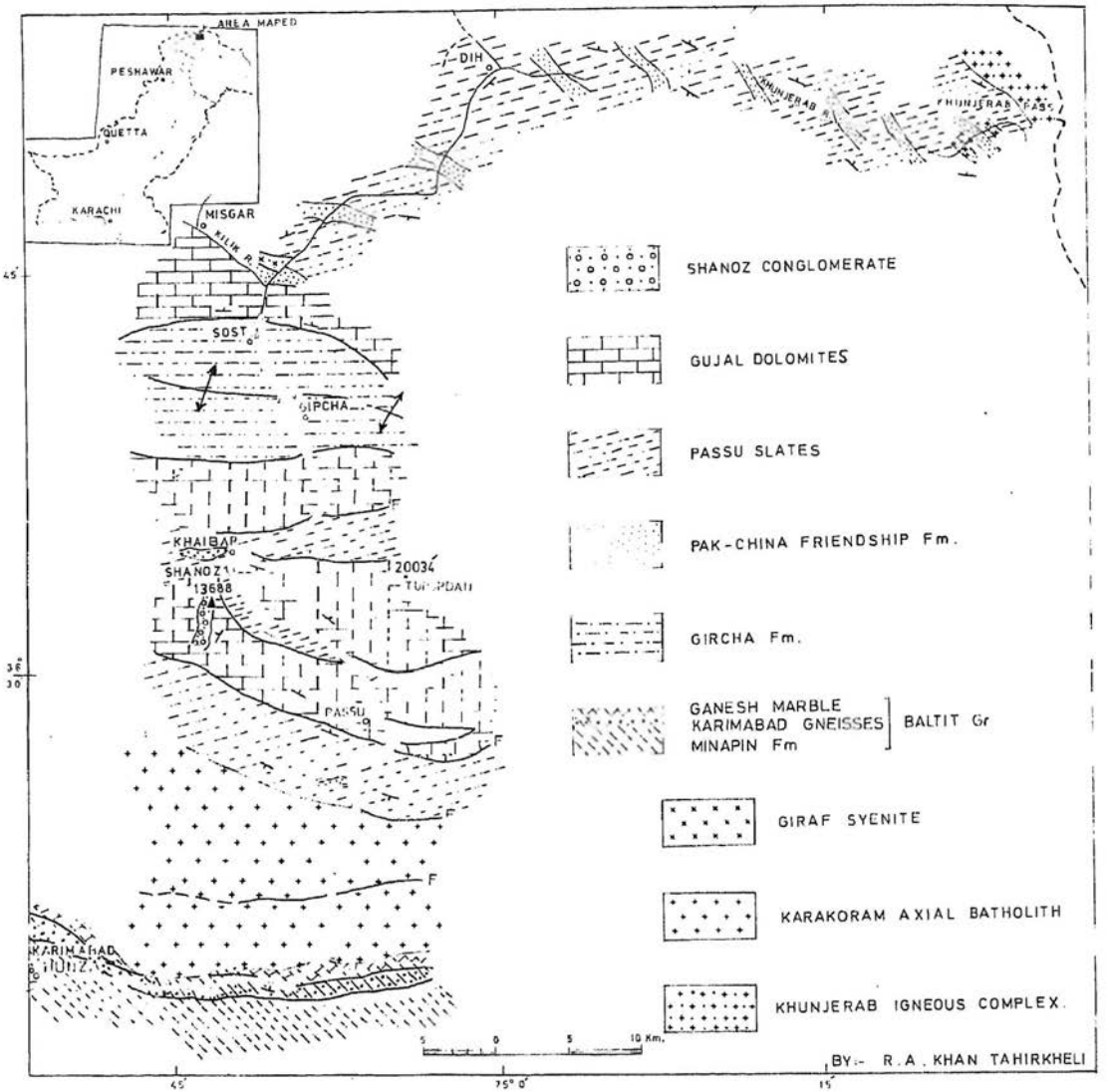

Fig. 1. Geology along road-traverse in the Upper Hunza Valley, Northern Pakistan.

Desio has not dwelt much on the regional structural frame of the UHV, except mentioning the contact relationship of the rock formations. However, during recent investigations a mega-anticline has been located at Sost which controls the stratigraphic frame of the UHV. This anticline has NNW-SSE axial trend with its flanks dipping at approximately moderate angles towards NE-SW. Gircha Formation occupies the core of the anticline and is the oldest rock formation exposed in the UHV.

The base of Gircha Formation is not exposed in the UHV and it is presumed that it overlies unconformably the Dumordu Fm. of Desio or Baltit Group of Tahirkheli (1982) which crop out in the Hunza Valley along the road sections between Chalt-Minapin and Karimabad. The axial Batholith separates these rocks from the rock formations (Passu Slate) of the UHV.

Recent work of Gaetani et al. (1990) in the Chapurasan and Shimshal valleys in Upper Hunza (N. Karakoram) has brought forth a store of informations on the tectonostratigraphic frame of the northern margin of the Karakoram plate. The Sost anticline, as described before controls the stratigraphic net of this part of the Karakoram. Thus the three tectonic divisions, Gujal, Sost and Misgar as proposed by Gaetani et al. (1990) also need a reappraisal under the framework of Sost megafold, because the Chapurasan and Shimshal valleys are tectonically controlled, respectively by the northeastern and southwestern flanks of this megafold. Most of the major faults including the thrusts involving the NE and SW flanks of the Sost anticline belong to syn- and post-folding deformations. The mini-thrust slices developed between Passu and Khyber which disturb the contacts of the Passu Slate and Gujal Dolomite in the southwestern flank of the fold are also attributed to syn-folding deformations. On the basis of these observation, the tectonostratigraphic division of the Upper Hunza valley may be carved as:

Sost (Anticlinal) Zone
1. Chapurasan (NE flank subzone)
2. Shimshal (SW flank subzone)

The Sost anticline plays a vital role in structural sculpturing of the stratigraphy of the UHV. All the rock formations of the UHV are involved in this fold which are bifurcated and are developed on both of its flanks (Fig. 2). Thus the slate outcrop which was divided into two formations by Desio, e.g., Passu Slates and Misgar Slates actually belong to one stratigraphic unit. No fossil has been reported from the slates yet, but on lithological basis these rocks look alike. Similarly the Kilik Formation mapped on the northern flank of Sost Anticline in Misgar Valley is a part of the folded block of the Gujal Dolomite which is developed on the southern flank of the Sost Anticline.

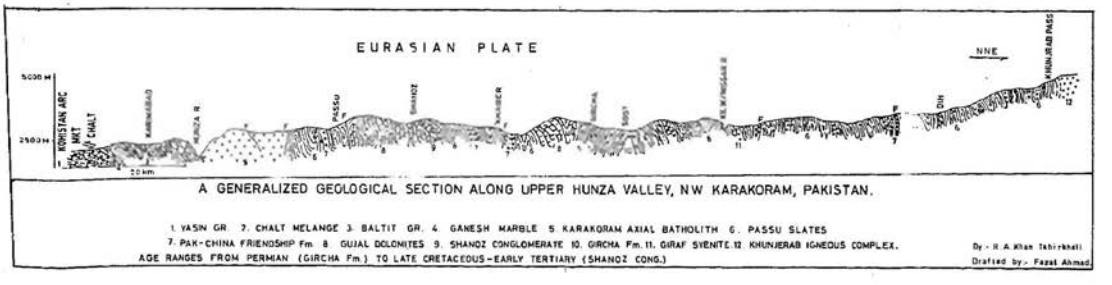

Fig. 2. A generalized geological section along Upper Hunza Valley, NW Karakoram, Pakistan.

On the basis of this find, the new stratigraphic order of the UHV, as devised by the authors drop two nomenclature, Misgar Slate and Kilik Formation, in their scheme and retain only Passu Slates and Gujal Dolomites.

STRATIGRAPHY

In a reappraisal of the stratigraphy of the Upper Hunza Valley after the discovery of Sost Anticline, the following mappable units are distinguished.

A. Sedimentary-metasedimentary Fms.
   - v. Shanoz Conglomerate
   - iv. Gujal Dolomites
   - iii. Passu Slates
   - ii. Pak-China Friendship Fm. (PCF Fm)
   - i. Gircha Fm.

B. Igneous Rocks
   - iii. Giraf Syenite
   - ii. Khunjerab Igneous Complex
   - i. Karakoram Axial Batholith

In this stratigraphic scheme of the UHV, most of the formational names assigned by Desio & Martina (1972) have been retained. Two formations, i.e., Misgar Slate and Kilik Formation which are developed on the northern flank of Sost Anticline and are the continuation of Passu Slate and Gujal Dolomite have been withdrawn. Two new names, Khunjerab Igneous Complex and PCF Fm. are the fresh additions in the present stratigraphic scheme.

The PCF Fm. is a new discovery which has not been mentioned in the earlier literature. This formation has won this name to commemorate the collaborative efforts of the Chinese and Pakistani geologists to explore and reappraise the stratigraphy of the Upper Hunza Valley which for centuries remained a link to groom two of the oldest cultures of the world.

LITHOLOGICAL CHARACTERISTICS

Gircha Formation

This name was assigned by Desio & Martina (1972) to a complex sequence of argillaceous arenaceous-calcareous beds which according to them lies between the Kilik Formation and Gujal Dolomite. Present investigation reveals that this formation is

located in the core of the Sost Anticline and is the oldest rock formation of the Upper Hunza Valley.

Gircha Formation consists of dominantly argillaceous rocks which constitute nearly 85 % of its total rock assemblage. The rest in descending order of abundance are semi- to medium crystalline yellowish brown, thin bedded limestone and light coloured flaggy quartzitic sandstone. These are intruded by dolerite, diorite, granite, aplite and vein quartz. The argillaceous component includes garnet (little developed) -mica schist, chlorite schist, quartz schist, sericite phyllitic schist and splintery slaty shales. On both the flanks of the Sost Anticline, the Gircha Formation incorporates thin tectonic slices of Gujal Dolomites and PCF Fm.

The lower contact of the Gircha Formation is not exposed in the UHV. It is presumed that it overlies the Dumurdu Formation of Desio & Martina (1972) or Baltit Group of Tahirkheli (1982) which is developed on the margin of the Eurasian plate between Chalt-Minapin and Karimabad. Its upper contact with the overlying PCF Fm. is unconformable and faulted.

On the basis of fossils reported by Desio & Martina (1972), the age of this formation is referred to be Lower Permian. During this study a new fossil locality was discovered about 3 km north of Sost. These fossils are being examined by Sun Dongli and results will be reported in his publication.

Pak-China Friendship Formation (PCF Fm.)

This formation was differentiated during present investigation at a road section located about 3 km south of Dih. It is developed on both the flanks of the Sost Anticline.

PCF Fm. occurs as isolated, tightly packed upfolded pockets within the Passu Slate. It consists of quartzite and quartzitic sandstone with thin to thick bedded, medium to fine textured slates which on weathered surface display light yellowish brown and brownish grey sheen. The quartzites incorporate very coarse to fine, thin erratic conglomerate bands. The clastics in the conglomerate include sub-angular to sub-rounded quartzite pebbles and granules and angular to sub-angular chips of slates derived from PCF Fm. and Passu Slate, respectively. The binding material is siliceous. The stretched pebbles in the conglomerate indicate their involvement in the post depositional tectonic deformation. In two sections in the vicinity of Wadhun, granite, diorite and dolerite are found intruding the PCF Fm.

Most of the outcrops of the PCF Fm. are folded and their maximum thickness varies from 10 m in the vicinity of Passu and Khaiber on the southern flank of the Sost Anticline to over 30 m south of Dih on the northern flank. The outcrop exposed in the road section, about 3 km south of Dih, may be considered its type section. At the type

section, the PCF Fm. has got an unconformable and tectonic contact within the overlying Passu Slate. Its lower contact with the Gircha Fm. is also faulted.

One of (S.D.) has collected some samples from quartzites with poorly preserved fossils in the PCF Fm. in an outcrop near Dih and may be reporting on its age in his ensuing publication. It may be mentioned here that in the earlier work (Desio & Martina, 1972; Gaetani et al., 1990) this dominantly siliceous bed has been shown as a part of the Misgar Slate. But the present authors have assigned this bed a separate stratigraphic entity on the basis of the following field evidences.

i. The PCF Fm. occurs as an anticline within the slates, indicating its stratigraphic position to be older than the slates.

ii. A well defined conglomerate bed (Dih section) near the top of PCF Fm. confirms a disconformable contact with the slates.

iii. At a few sections where the contact relationship is clearly observable, the PCF Fm. has also indicated faulted contacts with the upper (slates) and the lower (Gircha Fm.) formations.

iv. The PCF Fm. as referred by the previous workers is not confined to the slates (Misgar Slate) occurring north-east of Sost but also found in association with the slates (Passu Slate) located towards southeast. Thus this formation has a widespread distribution in the stratigraphic net of the Upper Hunza Valley.

Passu Slate

In this study, the Passu Slate and Misgar Slate are considered as parts of one formation which were doubled by the Sost accident. As a result, Desio & Martina (1972) mapped these outcrops as Passu Slates on the southern and Misgar Slates on the northern flank of the fold. No fossil has been reported from the slates horizon so far, but lithologically these are indistinguishable.

The Passu Slates are light to dark grey, thin to medium bedded and incorporate slaty shale, slate and phyllitic slate with subordinate calcareous and arenaceous partings. Sporadic intrusions of granite, diorite, dolerite, aplite and vein quartz in the Passu Slates are noteworthy. Their weathered product is splintery.

The slates show isoclinal and assymetrical foldings with their axes locally swinging between east-west and NNW-SSE. These overlie the PCF Fm. with a well marked unconformity and have a faulted contact. Along the southern contact the Passu Slates are intruded by the Karakoram Axial Batholith and their contact is also faulted. On the northern flank, where the slates have got an enormous thickness, these are intruded by

the Khunjerab Igneous Complex. This contact, located across the border inside China, has not been closely observed but it may be deformed.

Gujal Dolomite

This name was assigned by Desio & Martina (1972) to a dominantly calcareous formation which forms high ridges and cliffs in the lower part of the UHV. On the basis of lithological characteristics, three types of calcareous beds are distinguishable in this formation: i. semi-crystalline argillaceous limestone, ii. semi- to medium crystalline dolomitic limestone and dolomite, and iii. semi- to medium crystalline arenaceous dolomitic limestone. Thin, grey, yellowish grey and pinkish red argillaceous and arenaceous shales occur as intercalations within the calcareous bed. Besides, two conglomerate horizons, one in the middle and the other near the bottom of the bed are also recorded in the Gujal Dolomite. These conglomerates are intraformational and incorporate clastics derived from the Gujal Dolomite (abundant), PCF Fm., and Passu Slate (rare). Stretched pebbles in the conglomerate point out to their involvement in the post-depositional tectonic activities.

The limestone and dolomitic limestone are thin to thick bedded with some massive outcrops at higher level near the cliffs. These are fine to medium grained and weather light grey to yellowish brown, whereas fresh faces are white to light grey in colour.

In the UHV, after Passu Slate, the Gujal Dolomite are the next thick sequence which forms bold outcrops between Passu and Khaiber on the southern flank of the Sost Anticline. In the northern flank, the Gujal Dolomite thins out and extends as far as Kilik river valley where its contact with the older Passu Slate is faulted.

The enormous thickness of the Gujal Dolomite is attributed to folding during and after the formation of the Sost Anticline. The post-Sost movements have not only changed the axial trend of the already existing folds but were also responsible for the creation of faults which are manifest along the southern and northern contacts of the Gujal Dolomite with the Passu Slate and Khunjerab Igneous Complex respectively. Tectonic slivers of the Gujal Dolomite are also noticed in the Gircha Fm. and Passu Slates in the vicinity of Mor Khum and along Kilik valley.

Earlier, Hayden (1916) described some calcitized shells derived from Gujal Dolomites as Happurites and Rudistes, while Desio & Martina (1972) considered these shells to look like Megalodonts. On the basis of lithological correlation of Gujal Dolomites with some formations in Shaksgam valley, Pamir and Mt. Tupopdan, Desio & Martina (1972) assigned this formation a Permo-Triassic age.

Shanoz Conglomerate

It is the youngest formation of the UHV, as described by Desio & Martina (1972). During this investigation, its type section located higher up near Mt. Shanoz peak could not be reached. However, some transported boulders derived from Shanoz Conglomerate have been observed in some streams in the vicinity of Khaiber village. The conglomerate is pinkish red, medium textured and among the clastics it incorporates, in ascending order of abundance, limestone-dolomite (Gujal Dolomite), slate and schists (Gircha Fm. and Passu Slate) and quartzite (PCF Fm.) in siliceous-argillaceous matrix. The clastics are subangular to subrounded which indicate their restricted transportation. The Shanoz Conglomerate appears to have been deposited after the major tectonic episodes affecting this valley, as a result it is not much deformed.

Earlier, this conglomerate bed has been described by Hayden (1916) and Schneider (1957) who correlated it with the Reshun Conglomerate in Chitral, which on the basis of fossil-bearing boulders have been assigned Upper Cretaceous-Lower Tertiary age. Desio also considered Shanoz Conglomerate to be equivalent to Reshun Conglomerate but no fossil bearing clastics are present in the former as has been noticed in the latter beds in Chitral.

Karakoram Axial Batholith

The Karakoram Axial Batholith intervenes the Precambrian Baltit Group comprising the southern marginal mass of the Eurasian plate exposed along the road section between Chalt-Minapin and Karimabad in the Lower Hunza Valley and the rock assemblage (Passu Slate) belonging to the UHV, where the oldest rock formation exposed is the Gircha Fm. of Permian age. The westernmost outcrop of this batholith is located near Mastuj in upper Chitral in Hindukush. It extends westward in an arcuate bend for over 400 km and terminates in Ladakh Trans-Himalayan domain, north of the Indus Suture Zone. In the Hunza valley this Batholith has 12-15 km width and exhibits a wide range of textural and lithological variation.

The Axial Batholith incorporates multi-phased acid and basic igneous emanations which in sequential order from old to young in descending order are: porphyritic biotite granodiorite and hornblende granodiorite intruded by two generations of granite, two generations of pegmatite, aplite and vein quartz. Among the basic intrusions, diorite and dolerite belong to post-granite phases. Feeble foliation is recorded in the granodiorites near the contacts with the country rocks. A northeast-northwest trending fault is recorded in the middle part of the batholith in which granodiorite and at least one phase each of granite and pegmatite are involved. This fault runs parallel to the Main Karakoram Thrust and the Hussaini Fault located on the south and north respectively. Which fault is responsible to create this shear is still to be worked out.

Khunjerab Igneous Complex

This complex intrudes the Misgar Slate (Passu Slate) on the northern flank of the Sost Anticline. The contact of this complex with the Passu Slates is located across the political border in China, as a result it could not be studied in-situ. Some drifted boulders and pebbles from this complex strewing the Khunjerab Pass were examined to discern the composition and lithology of the complex. On the basis of this study, the rock types which constitute the main component of the complex are tonalite, porphyritic granodiorite, granite, pegmatite and aplite, whereas diorite, dolerite and amphibolite belong to the basic suite.

Giraf Syenite

It was first described by Desio & Martina (1972). This pluton intrudes the Passu Slate (and Misgar Slate of Desio) and is located in the Kilik Valley on the northeastern flank of the Sost Anticline. During this investigation, this pluton was studied in a small outcrop exposed at the confluence of Kilik and Khunjerab rivers.

Giraf Syenite displays greyish-pink colour and incorporates hornblende, biotite and augite among the famic minerals. It is medium grained and porphyritic with well developed kaolinized feldspar crystals. Desio reports its absolute age by using Rb/Sr method on two samples to be 53 m.y.

CONCLUSIONS

To sum up the results of present investigation, following conclusions are drawn:

1. The Sost Anticline is a newly discovered megafold which controls the stratigraphic net of the Upper Hunza Valley. Therefore, the Passu Slate, Misgar Slate, Gujal Dolomite and Kilik Fm., which were mapped as separate stratigraphic units by the earlier workers (Desio & Martina, 1972) actually belong to two argillaceous and calcareous lithologic domains which were bifurcated by the Sost Anticline. Thus the Passu Slate and Gujal Dolomite are located in the SW flank and Misgar Slate and Kilik Fm are exposed in the NE flank of this fold.

2. In the new stratigraphic scheme devised by the authors, the Misgar Slate and Kilik Fm. are withdrawn and only two names Passu Slate and Gujal Dolomite are re tained. On the basis of this change, the following stratigraphic order of the rock units of the UHV is established.

e. Shanoz Conglomerate
d. Gujal Dolomite
c. Passu Slate

b. Pak-China Friendship (PCF) Formation
a. Gircha Formation

3. The Gircha Fm. occupies the core of the Sost Anticline and constitutes the oldest rock formation exposed in the Upper Hunza Valley.

4. A new formation has been added in the stratigraphic domain of the UHV which disconformably overlies the Gircha Fm. This formation has been named the Pak-China Friendship Formation.

5. On the basis of fossils so far reported from the erratic sites in various sections, the age of the formations range from Permian (Gircha Fm) to Late Cretaceous-Early Paleocene (Shanoz Conglomerate).

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