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THE GEOLOGY OF THE NORTH-WEST PORTION  
OF THE GILGIT AGENCY, PAKISTAN

BY



J. F. IVANAC, D. M. TRAVES AND D. KING

DEPARTMENT OF EXTERNAL AFFAIRS  
CANBERRA, A.C.T.

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## INTRODUCTION

Three geologists left Australia in 1951 to conduct geological surveys in Pakistan, under the auspices of the Colombo Plan ~~under the auspices of the Colombo Plan~~ which provides technical assistance for the member countries in South and South East Asia.

The main objects were to conduct an economic and general geological survey of a selected part of the Gilgit Agency, to examine the alluvial-gold prospects of the Chitral River, and, if time permitted, to discuss the Sind and East Bengal lignites with the Director of the Pakistan Geological Survey. J.F. Ivanac and D.M. Traves, of the Bureau of Mineral Resources and D. King, of the South Australian Mines Department, arrived in Pakistan in May to carry out the work. After discussion with the Director of the Pakistan Geological Survey, it was decided to commence investigations in the Gilgit Agency, and examine the Chitral alluvial-gold deposits at the conclusion of this work. Mr. A. Bakr and Mr. M.H.A. Namazie, Assistant Geologists of the Pakistan Geological Survey, accompanied the party. This report is confined to the geological surveys in the Gilgit Agency.

The Agency is situated in the North-West Frontier Province of Pakistan and adjoins Russian Turkestan, Chinese Turkestan and Afghanistan, in the north; the disputed section of Kashmir to the east; and Chitral State to the west. The region surveyed lies in the north-western section of the Agency, and is found in Survey of India  $\frac{1}{4}$ -inch (4 mile) sheets, 43I, 42L, 42H and 42D. In June 1951, the party commenced field work from Gilgit, and spent three months in the region. Several reported mineral occurrences were examined in the Hunza, Nagir, Gilgit, Haramosh, Gupis, Ishkuman and Yasin areas; a regional geological survey of approximately 5,000 square miles was completed.

### Previous Investigators

Geological investigations in the north-west Portion of the Gilgit Agency have been few, and, owing to the extremely mountainous terrain, have been restricted to isolated reconnaissance traverses along the major valleys. Detailed geological mapping in this region would be a long and tedious task. Hayden (1914) made the first important geological traverse through the region. His route was through Chitral, over Darkot Pass, down the Yasin Valley, east to Gilgit, then north along the Hunza River Valley. This traverse gave two good sections approximately normal to the regional trend, so that although this journey was very hurried, Hayden's notes contain valuable descriptions and correlations for future workers. Many years elapsed before other workers entered this region.

In 1948, Dr. Clark, an American geologist, followed a route similar to that taken by Hayden, except that he came over Shandur Pass instead of Darkot Pass. Since then he has been working in the area but so far has not published any geological report. He has written some short unpublished reports for the Minister of Kashmir Affairs, Pakistan. A.H. Kazmi, Geological Survey of Pakistan, spent a field season in 1950-51, examining mineral deposits and mapping the regional geology. He has prepared a preliminary report on the geology and mineral occurrences of the lower Hunza River valley. Other geologists have worked in the neighbouring areas of Chitral and the Indus valley, and their reports are of value for comparison and correlation.

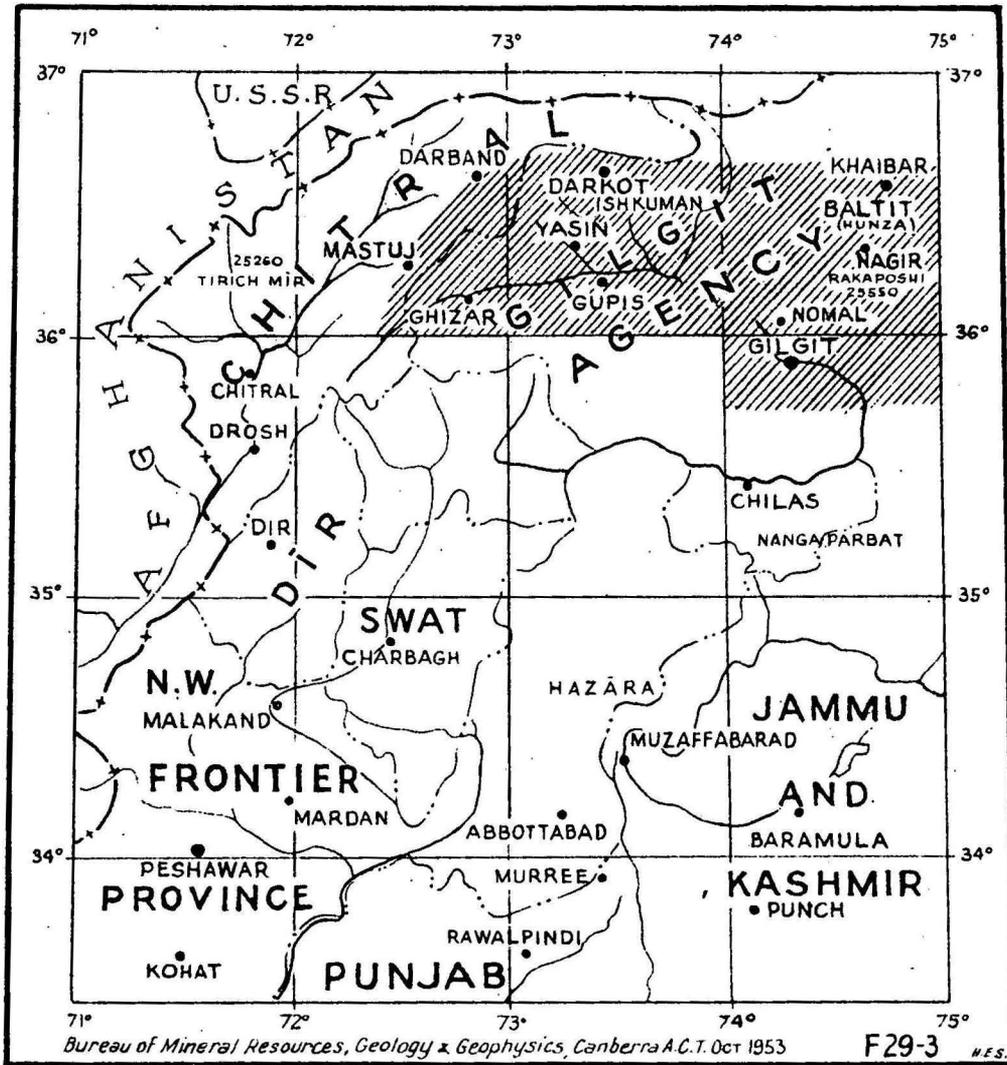
### Climate and Vegetation

The region is situated in the southern marginal portion of the Central Asian Desert. The mean annual rainfall at Gilgit - elevation 4,700 feet - is five inches, and northwards the rainfall decreases appreciably. Hunza, for example, receives only three inches annually. At high altitudes precipitation is mostly as snow; in summer the snowline is above 15,000 feet, whereas in winter it descends to approximately 6,000 feet. Temperatures in the valleys range from very low in winter, to very high in summer.

The summer season, May-November, is the only practical period for field work.

Natural vegetation is very sparse below 9,000 feet. Above this altitude summer herbage is abundant; low scrub, locally known as "jungle", occurs on some alluvial flats, and isolated pine forests grow on slopes. Habitation is confined to the valleys, where crops are grown on irrigated areas of alluvial.

Plate 1.



# LOCALITY MAP

SCALE  
0 100 200 300 400 MILES

## Topography

Gilgit Agency, situated in the north-west portion of the Himalayan Mountain System, has extremely mountainous topography. The eastern portion of the region consists of five well-defined ranges - aligned in a north-westerly direction, slightly curvilinear, and convex to the south - which form a continuation of the general Himalaya Arc. Towards Chitral, the mountain system swings to the south-west, and this results in an acute inflexion convex to the north. The Hindu Kush and Karakoram Ranges of north Gilgit Agency conform to this north-facing arcuate arrangement. The Kailas, Ladakh and Great Himalaya Ranges in the south-west (Plate 2), terminate along a zone approximating to the axis of the same arc, where mountain trends are poorly defined and irregular.

The highest peak in the region is Rakaposhi (25,550 feet) in the Kailas Range. Nanga Parbat (26,620) and Tirichmir (25,320 feet) are situated a short distance outside the region (Plate 1). At high altitudes, the ranges are snow-covered and glaciated. The Karakoram Range, in Hunza State, is the most glaciated area in the region and contains Batura Glacier, the fourth largest in the world. This glacier is 37 miles long and terminates at 8,500 feet in the Hunza River valley. The topography below the present snowline shows the effects of former glaciation. Matterhorn-type peaks and sharp-crested aretes are separated by broad glacial troughs which have a low gradient. The valley sides are characterised by cirques and minor hanging valleys. The valley floors contain terminal moraines which merge into high lateral moraines, piled against the truncated spurs of the valley walls. Glacial lakes are common where streams are dammed by morainic material.

The region is deeply dissected by streams fed by melting ice and snow. The drainage has a dendritic pattern and constitutes portion of the Indus River System. The Indus River crosses the south-eastern section of Gilgit Agency, and its major tributaries in the region are the Gilgit River, draining south from the Hindu Kush and Karakoram Ranges. The level of the Gilgit and Hunza Rivers at the point of confluence is 4,500 feet, and their average gradient, between 8,000 feet and their junction, is 35 to 40 feet per mile. The larger rivers generally occupy narrow gorges. The extreme relief, resulting from deep dissection, is the outstanding topographical feature. Rakaposhi, for example, is 19,550 feet higher than the Hunza River at Maiun, situated only 9 miles distant, the mean fall being 2,172 feet per mile. In some places where the valleys are wider, and at the junctions with major tributaries, extensive alluvial terraces and fans are formed marginal to the rivers.

## Accessibility and Transport

The village of Gilgit, situated at the intersection of trade routes to Chitral, Central Asia, Kashmir and Punjab, is the centre of communications and administration in Gilgit Agency. The shortest route to Rawalpindi and Peshawar is along the Indus River valley, via Astor and Abbottabad. The road is trafficable by jeep for a few months in summer, but closed for the rest of the year by snow to all forms of traffic. The trade-route to Chitral via Shandur Pass, which is usable for most of the year, is an alternative way to Peshawar. The lack of regular communications led to the introduction of a freighter air-service to Gilgit, in 1949. This is operated from Rawalpindi by a private company under Government charter. The service is frequently interrupted by bad weather.

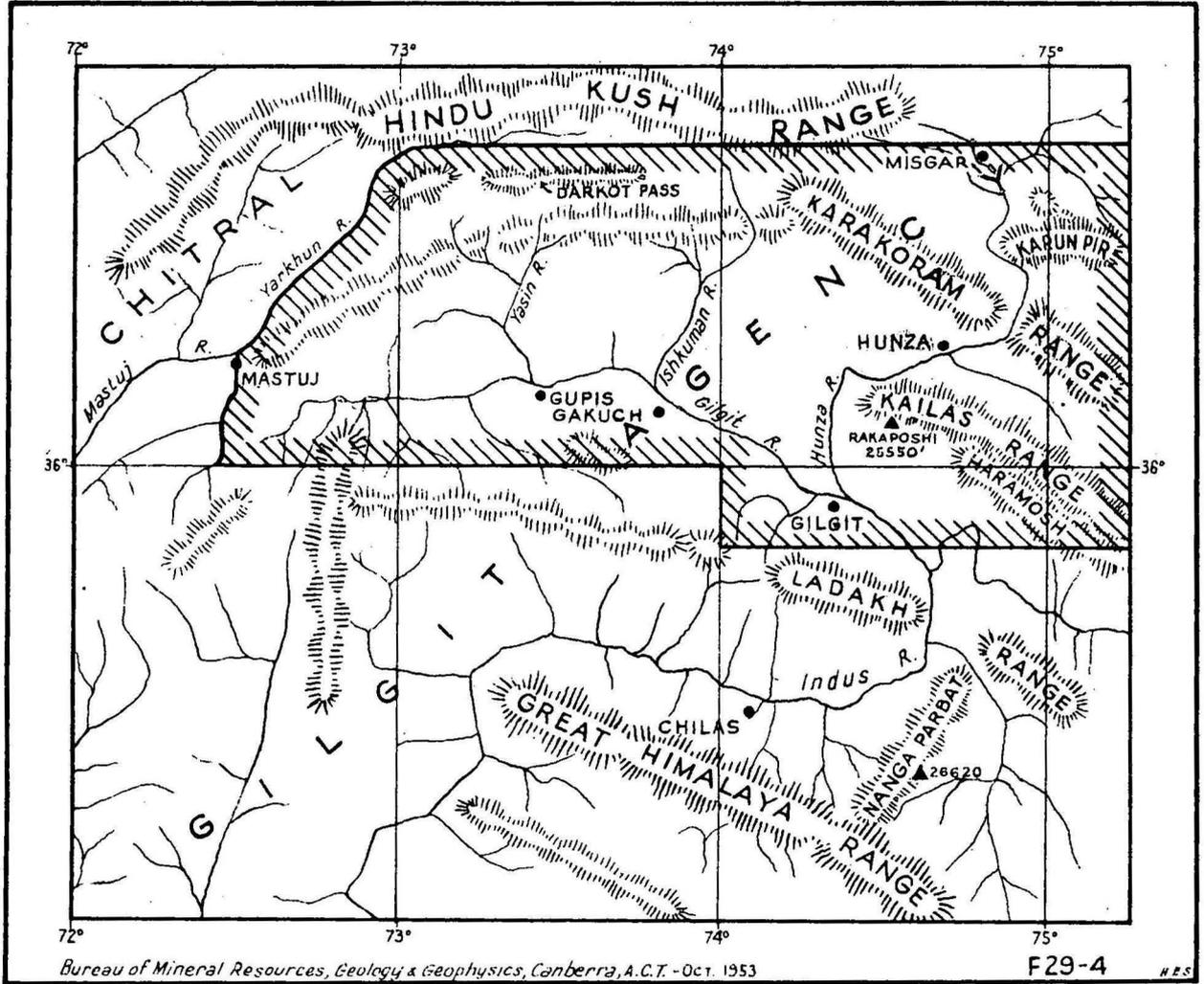
The trade routes in Gilgit Agency generally follow the main river valleys. They are trafficable by jeep for short distances from Gilgit; to Hanuchal in the Haramosh District, along the Hunza River valley to Chalt, and westward along the Gilgit River valley to near Gulapur. Apart from the trade routes, there are pack-tracks along the major tributary valleys, and, in places, these tracks are connected by mountain passes, open for part of the year. Pack - or foot-tracks follow up most of the small valleys.

The main routes are divided into day-stages with rest houses, where accommodation is available. Pack-animals - horses, mules and donkeys - are the usual mode of transport and can be obtained at most villages. In summer, most of the horses are taken to high level pastures, and then it is difficult to obtain riding - animals in large numbers. The average cost of riding-horses, and pack animals which carry a standard load of 160 pounds, is four annas ( $8\frac{1}{2}$  pence, Australian) per mile. Coolies are usually available in limited numbers for transport requirements in areas where pack-animals cannot be used.

Plate 2.

# GILGIT AGENCY, PAKISTAN

## MAJOR MOUNTAIN CHAINS AND RIVER SYSTEM



Suspension bridges have been built at most stream crossings. North of Hunza, on the Central Asian Route, bridges are few, and in summer it is only possible to ford the glacial torrents in the early morning or late evening, when the melting of snow and ice is at a minimum. Rope bridges and skin rafts are used by the local people at places off the main routes.

## REGIONAL GEOLOGY

### Introduction

The regional geology has been compiled from traverses in the vicinity of Gilgit, Hunza Valley, Ghizar River, Shandur Pass and Mastuj. This region is covered by the Quarter Inch (four mile) Map Sheets of No. 431, Gilgit; No. 42L, Hunza; No. 42H, Yasin; and No. 42D, Mastuj. Traverses were made from Gilgit to Iskere in the Haramosh Range; along the Hunza Valley to Khaibar, 24 miles south of Misgar; along the Gilgit and Ghizar Rivers; over Shandur Pass to Mastuj; and many other short detours. Plate 8, a compilation from the Four Mile Map Sheets, shows the geology along all traverses. Plate 3, at the scale of 16 miles to 1 inch, shows the regional geology of the area. This plate was compiled from the traverse map by interpolation and extrapolation of known boundaries, from general topographical features, regional trends, and any other observations such as materials brought down by streams. The division of the boundaries into three types, as shown on the map, gives an approximation of the accuracy to be expected.

### Stratigraphy

In the past, very little geological work has been done in the Gilgit Agency, and the stratigraphical sequence and the stratigraphical units have not been defined. Previous workers have described rock types and certain groupings, and have made correlations with other parts of Asia, but they have not officially named any unit within the region, or compiled a stratigraphical table. Because of this lack of unit names, it has been necessary in this report to name all units described. The nomenclature of these stratigraphical units is in accordance with the nomenclature accepted in Australia, as presented by Glaessner, Raggatt, Teichert and Thomas (1948). This code of nomenclature was used because no code has yet been advanced in Pakistan.

The stratigraphical sequence has been divided into the Darkot Group, Greenstone Complex, Yasin Group, Ladakh Granodiorite, Karakoram Granodiorite, and Darkot Pass Granodiorite. Each of these units is described separately in the following text, with definitions and explanations of the nomenclature used. Petrographic notes on some rocks from the Groups are given in Appendix A.

### Darkot Group

The Darkot Group is the name given to the sediments and metamorphics, of Upper Palaeozoic age, which outcrop between Darkot village and Darkot Pass. In this section, slates, limestones, quartzites and garnet-mica schists, comprise the Group. The Group name has been extended to include all rocks of similar conditions of deposition and age in the region, and includes the "Khaibar Series", provisionally named by Clark\*, and the "Mishgar Limestones" as named by Kazmi (1951).

Rocks of this Group were first examined and described by Hayden (1914), when he traversed down the Yasin valley from Darkot Pass. He described the slates, shales, shaly limestones and massive limestones, and collected fossils from a locality at Darband. He correlated the fossiliferous limestones and shales with the Fusulina limestone and associated beds of Baroghil area, but did not map or name the Group. The slightly more metamorphosed section of the Darkot Group, south of the Karakoram Granodiorite in the Yasin valley, was also examined by Hayden, but he did not equate it to the northern section at Darkot. Similarly, he examined the metamorphics between Chalt and Sarat but made no correlations. He noted the slates, quartzites and limestones, between Pasu and Misgar and remarked that they were the equivalents of "the Palaeozoic and Mesozoic beds of Chitral and Yasin". Although Hayden's trip was very hurried, his notes on the lithology and correlations of the Darkot Group are of great use.

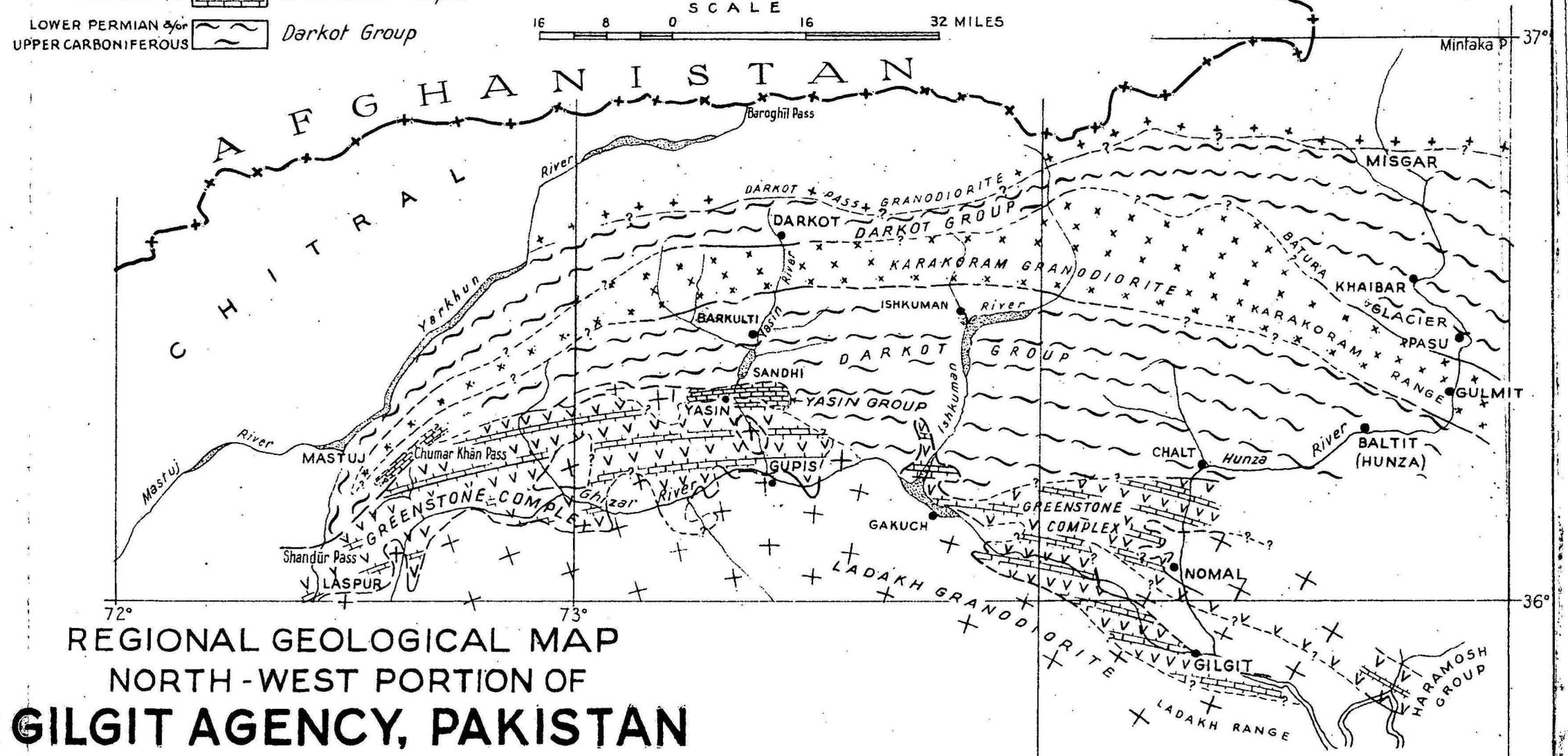
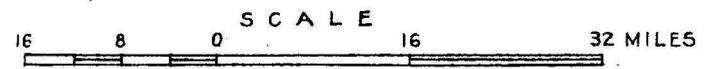
Clark, in his investigations, since 1948, of the Hunza Valley, has studied the slates, limestones and quartzites, which outcrop to the north of the Karakoram Granodiorite. He has provisionally named them the "Khaibar Series", and

\* Personal communication.

# Reference

- + + Ladakh Granodiorite
- TERTIARY x x x Karakoram Granodiorite
- + + + Darkot Pass Granodiorite
- LOWER CRETACEOUS ||||| Yasin Group
- TRIASSIC (?) v v v Greenstone complex
- LOWER PERMIAN <sup>or</sup> UPPER CARBONIFEROUS ~~~~~ Darkot Group

- BOUNDARIES
- Established - position accurate
  - Established - position approximate
  - ? -? - Inferred or probable
  - BOUNDARY OF PAKISTAN



REGIONAL GEOLOGICAL MAP  
 NORTH - WEST PORTION OF  
**GILGIT AGENCY, PAKISTAN**

Geology by J. F. Ivanac, D. M. Traves & D. King '40

STRATIGRAPHY

Period	Unit	Rock Types	Fossils
Quaternary		Mixed Alluvia	-
Tertiary	Ladakh Granodiorite Karakoram Granodiorite Darkot Pass Granodiorite	Granodiorites, diorites, granites Hornblendites, gneisses	-
Cretaceous	Yasin Group	Lavas, tuffs, agglomerates limestones, sandstones	Gastropods, lamelli-branches, corals, and forams
Jurassic			
Triassic	Greenstone Complex	Lavas, tuffs, agglomerates, gneisses, quartzites, limestones	-
Permian Carboniferous (?)	Darkot Group	Slates, limestones, quartzites conglomerates, schists, marbles, gneisses, volcanics.	Bryozoa forams, brachiopods, crinoids, corals, gastropods

from the evidence of fossils collected from the Khaibar Nala, has placed it in the Upper Carboniferous or the Lower Permian Epoch. "Khaibar Series" or Khaibar Group (in accordance with the stratigraphical nomenclature used in this report) is not a suitable name for the whole Group, as the Khaibar section is extremely faulted and, at present, the sequence is not fully known. For this reason the term "Khaibar" was rejected and the name and type section of the Group was chosen as Darkot. Kazmi (1951) examined the more metamorphosed portion of the Darkot Group between Chalt and Baltit and placed it in the Pre-Cambrian Era. He gave the name "Mishgar Limestones" to the limestones near Misgar on the report by Clark that fossils in limestone had been found in that vicinity. Kazmi was prevented from visiting the area by bad weather. The name "Mishgar Limestones" obviously cannot be used.

The Group crops out over a large area in the north of the region and forms two long belts, trending meridianally, divided by the Karakoram Granodiorite and bordered to the north by the Darkot Pass Granodiorite.

Field relationships of the Darkot Group with the Karakoram Granodiorite, Darkot Pass Granodiorite, Yasin Group and Greenstone Complex were examined. Both batholiths have intruded the Darkot Group although in many places the intrusive nature is not well marked, but is shown only by small granite and quartz veins penetrating a short distance into the slates. At Yasin, the Darkot Group overlies the Yasin Group of Lower Cretaceous age - the result of a large overfold. Elsewhere along the southern contact it is overfolded onto the Greenstone Complex. The Darkot Group contains the oldest rocks of the region, although it is generally found overlying the younger groups. The marked variation in the lithology of the Darkot Group is largely the result of varying metamorphic effects. A gradual increase in regional metamorphism has been traced from west to east. In the western portion between Mastuj and the Yasin Valley the sediments of the Darkot Group are only low-grade metamorphics such as slates. The limestones present have not been converted to marbles. In the Ishkuman Valley regional metamorphism is higher, and slates and some marbles are found. In the east of the region, in the Hunza Valley in the vicinity of Baltit, high-grade metamorphics, the product of thermo-dynamic regional metamorphism, are found. Garnet staurolite schists, gneisses and coarsely crystalline marbles form the metamorphosed portion of the Darkot Group. Also, in this area, the susceptibility of the gneiss to a magma of approximately similar composition and the favourable attitude of the beds to the Karakoram Granodiorite has led to a higher degree of contact metamorphism than found elsewhere along the borders of the Granodiorites.

In the Yasin Valley, between Darkot village and Darkot Pass, rocks of this group outcrop over a distance of six miles. At Darkot, abutting the northern side of the Karakoram Granodiorite, are slate beds with some slaty schist and quartzite, approximately 4,000 feet thick, dipping steeply northwards. Metamorphism by the intruding batholith is slight, marked only by an increase in the concentration of quartz veins near the intrusion. Massive crystalline limestones overlie the slate beds north of Darkot village. The limestones, approximately 7,000 feet thick, are slightly folded and sheared; the average dip is  $65^{\circ}$  north. Interbedded slates and limestones, which overlie the massive limestones, are fossiliferous near the contact. These beds dip  $40^{\circ}$  north, and this decrease in the angle of dip is probably due to the difference in competency of the rocks during folding. Higher in the section, the dip gradually steepens to  $60^{\circ}$  -  $70^{\circ}$ , and quartzites are interbedded with the slates and limestones. This portion of the section has a thickness of approximately 5,000 feet - the top of the section being at Rawat. The measured section between the northern edge of the Karakoram Granodiorite and Rawat has a minimum thickness of 16,000 feet.

Between Rawat and the contact of the Darkot Pass Granodiorite, folding has interrupted the regular northerly dip. The sediments have been metamorphosed to black micaceous slate and garnet-mica schist, with highly altered basic or ultra-basic intrusives. These rocks form the contact metamorphic zone of the Darkot Pass Granodiorite and are the metamorphic equivalents of sediments which outcrop immediately south of Rawat.

The sequence of beds in the section south of Karakoram Granodiorite is not so well defined. Dark slates and quartzites border the Granodiorite, and this sequence, with interbedded thin limestones, continues to Barkulti. The dip ranges from  $60^{\circ}$  to  $80^{\circ}$  north-north-west. Immediately south of Barkulti, on the east side of the valley, a massive limestone, approximately 5,000 feet thick, is exposed. Immediately south of this limestone are interbedded slates and limestones which dip  $70^{\circ}$ , south. They are very similar in appearance and fossil assemblage to the slates and limestones which overlie the massive limestone in the Darkot section at Darband. The southerly dip of the beds at river level is only a local reversal and higher up the slope they appear to revert to the normal north dip of the sequence. The succession farther down the valley is steeply dipping slates, quartzites and limestones, which, between Assam Bar and Qurkulti Bar, are

intruded by a small tongue of granite. On the west side of the valley, south of Barkulti, slates, dipping  $60^{\circ}$  -  $70^{\circ}$  north-north-west, are the main rock type, with one small intrusion of porphyry. On the north and south side of Thui Gol, massive quartzites are exposed; farther south, massive limestone, slates and quartzites, outcrop to Naz Bar, where they overlie the Cretaceous Yasin Group.

Rocks of the Darkot Group crop out between Baruk and Mastuj on the Shandur Pass-Mastuj road. Between Baruk and Gasht, slates are predominant, with some limestones and quartzites, but at Gasht they are overlain by quartzites and calcareous conglomerate which outcrop to Mastuj. On the north side of the river, opposite Mastuj, black slates with some quartzite beds are exposed.

In the Ishkuman valley, the outcrops between Hasseis and Bad Swat are included in the Darkot Group. The main rock types are limestone, marble, slate and quartzite. The section shows increasing effects of metamorphism towards the Karakoram Granodiorite north of Imit, where the rocks are marbles, garnet-mica schists and gneisses.

Rocks of the Group, which outcrop in the Hunza Valley, have suffered more regional metamorphism than the rocks mentioned in previous sections. A gradation of metamorphism can be traced from the slightly altered slates and limestones which outcrop near Darkot, to marbles, schists and gneisses of the Hunza Valley. The type section of the Darkot Group exhibits low-grade metamorphism between Rawat and the contact of the Darkot Pass Granodiorite. Here, dark micaceous slate and garnet-mica schist show a stage of metamorphism comparable to that of the succession between Chalt and Tashot; namely, spotted slate, phyllite, slaty quartzite, calcareous conglomerates and spotted garnet-mica schists. Towards the Karakoram Granodiorite the grade of metamorphism increases and between Tashot and Sarat there is a complex of highly metamorphosed sediments consisting of garnet-staurolite-mica schists, strongly foliated micaceous gneisses and coarse crystalline marbles. A few miles to the east of Sarat, the meta-gneisses grade imperceptibly into the ortho-gneisses and granodiorites of the Karakoram Granodiorite.

North of this batholith, Darkot Group rocks are not highly metamorphosed. The rock types are similar to those of the type section, but the sequence is broken by a complex system of fault structures. Slates and limestones are the main rock types of the area, with interbedded quartzites near Khaibar. The contact between the batholith and slates is sharp, and the intrusive nature of the granodiorite is revealed only by small veins which intrude a few yards into the slates. Near the contact, the slates dip  $70^{\circ}$  south-south-west. They outcrop to the bank of Pasu Nala where they are faulted against grey to black, massive limestones. Similar rock types continue to Khaibar, and in the Khaibar Nala, slates, quartzites, and limestones are exposed; the dark slaty limestones are fossiliferous. To the east is the large mass of faulted limestones forming the Karun Pir Mountains.

Fossils have been found in some of the beds of the Darkot Group. Collections were made from three localities, namely, Darband, north of Sandhi, and Khaibar Nala. A palaeontological report of these fossils is given in Appendix B. Hayden (1914) collected from the Darband locality and noted the occurrence of bryozoans, forams, and brachiopods. The fossiliferous beds of limestone and slate outcrop on the north slope of Darband Hill, where they overlie massive crystalline limestone. At Chhelish, fossils were seen in boulders in the stream. These had been carried down from the westward continuation of the Darband beds. Between Barkulti and Sandhi, on the eastern side of the Yasin Valley, a similar sequence of beds was examined, where the thinly bedded limestones and slates underlie, but stratigraphically overlie, the massive limestones. Poorly preserved bryozoans, and brachiopods were collected from the well-bedded sediments.

Hayden (1914) found a block of limestone near Khaibar, in the Hunza Valley, that possibly contained forams and he found bryozoans in the moraines below Misgar. In 1948 Clark\* collected fossils from Khaibar Nala and Misgar and in 1949 from Shimshal. These fossils have been examined by the United States National Museum, but lists of species have not been published. During the present survey, brachiopods, corals, bryozoans and forams were collected from a dark slaty limestone exposed on the south side of Khaibar Nala, about  $\frac{1}{2}$  mile west of the village.

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\* Personal communication

The age of the fossils collected by Clark was given as Upper Carboniferous or Lower Permian by the United States National Museum. J.M. Dickens, Bureau of Mineral Resources, after a study of the fossils recently collected, states that a Permian age is indicated for the Darband and Khaibar Nala localities and an Upper Carboniferous or Permian age for the Sandhi locality. Thus the age of the Darkot Group may be given as Permian with the possibility of the lower beds extending into the Carboniferous.

### Greenstone Complex

An assemblage of lavas, tuffs, agglomerates, meta-gneisses, quartzites, limestones and calc-silicate rocks which crops out in an almost meridionally trending belt between Hanuchal and Hopar, and Roshan and Sor Laspur, is named the Greenstone Complex. It includes the metamorphic succession south of Gilgit and many basic xenoliths in the Ladakh Granodiorite. This unit has been called a Complex because there is no certainty of the continuity of volcanic activity or sedimentation. The field term "Greenstone" has been used as it describes the broader characteristics of the colour and lithology of the Complex. In accordance with the code of Nomenclature adopted this Complex should have been given a locality name but because of the variation in lithology and the lack of a suitable locality name, the term "Greenstone" is used.

Hayden (1914) was the first geologist to describe volcanics in this region. Whilst traversing from Chitral to the Pamir Plateau, he recorded volcanics from Yasin to Gupis. He suggested that they are similar to the Panjal Trap of Kashmir, but stressed that the correlation is only tentative. Between Nomal and Chalt he noticed "metamorphosed traps" associated with gneisses, but he did not correlate the former with the rocks of the Yasin - Gupis section. He includes the "Traps" in his "Metamorphic Rocks". In 1951, Kazmi mapped a similar area of rocks to those described by Hayden in the Yasin-Gupis area, but his results are not yet published. He recorded a section of "gneisses and schists" from Chalt to Jutal. Clark\* has recognized an area of "greenstones, serpentine and chlorite-epidote schists" between Gwach and Chalt.

The discussion of the lithology of the Greenstone Complex falls naturally under the headings of individual traverses. These traverses are as follows:- Haringal Shal to Galinga, Yasin to Gupis, Silpi to Haseis, Gilgit to Chalt, Gilgit to Sor Laspur and other short traverses. The Gilgit to Sor Laspur section is not continuous as it is interrupted by the Ladakh Granodiorite and Darkot Group between Hopar and Roshan (Plates 2 and 8). No type area has been selected within this Complex, and correlation of individual traverses is based solely on lithological similarity.

At Yasin, the Cretaceous rocks of the Yasin Group have been overfolded onto the Greenstone Complex. At Chalt and Um Hatum the Darkot Group has been overfolded onto the Complex. A fault exists along this contact and dips north at a moderate angle. The Ladakh Granodiorite intrudes the Complex in many places.

The most representative section in the Complex has been mapped from the contact of the Darkot Group, a mile south of Haringal Shal to the Ladakh Granodiorite, a mile north of Galinga. One mile south of Haringal Shal, the succession consists of interbedded green and grey quartzite and slightly metamorphosed limestone which dip south at a moderate angle. These rock types continue to Donjo Shal where they are intercalated with bands of fine-grained basalt. From Donjo Shal to Zilkino there is a transition to basaltic lavas interlayered with banded tuffs, bedded quartzites and cherts. The lava flows increase in the vicinity of Bapo Ser where they become the dominant rock type. Amygdaloidal and vesicular, fine and medium grained basalts  $\phi$ , feldspathised basalts, and andesites with a few beds of grossularite calc-silicate rock, are the main members. This succession has been partly altered by epidotisation and serpentinisation.

These rock types persist to  $\frac{1}{4}$  mile south of Casit Gol, where there are also palagonite agglomerate and epidotised agglomerate. From Casit Gol to the contact with intrusive granodiorite at Bahushtar Olat, the rocks are mainly agglomerates. Fragments in the agglomerates are andesite, red and grey chert, tuff, aphanitic basalt and fine to coarsely crystalline marble. In places, vesicular lava fragments were found in the scree. The section is intruded by a tongue of granodiorite, one mile wide, at Bahushtar Olat. From the south side of the contact with the granodiorite to  $\frac{1}{2}$  mile north of Shamran, the rocks are mainly fine and medium-grained basalts; then fine-grained tuffs, agglomeratic tuffs and conglomerate with pebbles of andesite, basalt and fossiliferous limestone (Plate 7, Fig. 2). The fossils are fragmentary and have not been identified. Four miles south of Shamran the Greenstone Complex is in contact with the Ladakh Granodiorite.

\* Personal communication.  $\phi$  Some of these basalts exhibit pillow structures.

The succession from Chalt to Gilgit is interrupted, in many places, by granodiorite intrusions. A mile south-west of Chalt, massive serpentinitised dolerites and basalts are intercalated with epidote-chlorite schist and layers of greywacke and quartzite. This lithology continues to three miles south of Chalt, where massive dolerite abruptly gives way to banded quartzite and greywacke, which crop out for two miles and dip south  $65^{\circ}$ . Near Gwach, the quartzite and greywacke are interlayered with dolerite and serpentinitised pillow lavas containing veins of epidote. Near Nomal these rocks are replaced by intrusive granodiorite. On the western side of the Hunza River, opposite Jutal Village, a narrow belt of rocks of the Greenstone Complex is exposed between intrusive granodiorite and meta-gneiss. Talc schist, quartz-mica schist and serpentinitised hornblende-biotite schist are overlain conformably by marble. There is a lithological similarity between the rocks of this section and those described between Haringal Shal and Galinga, even though the rocks of the former section have been more highly metamorphosed by intrusive tongues from the Ladakh Granodiorite.

One mile south of Gilgit, are  $80^{\circ}$  south-dipping slaty quartzite, banded quartzite and marble, intruded by apophyses of granodiorite. These metamorphics have been included in the Greenstone Complex because, 4 miles north-west of Barma Gah, they are interbedded with characteristic members of the Complex.

The section from Gilgit to Sor Laspur, exclusive of sediments of the Darkot Group and the Ladakh Granodiorite between Hopar and Roshan, has been included in the Greenstone Complex. From Gilgit to Henzal Kain, the rocks are quartzites, grey schists, banded cherts with epidotised pillow lavas. Westwards, the succession shows little variation except a gradual increase in the quantity of basic lavas. From Burbur to Hopar, basalts, tuffs, quartzites, and agglomerates, which contain rounded pieces of marble (Plate 1, fig. 2), are the main rock types. At Silpi, the volcanics are the most prominent members and there, tuffs and basalts, serpentinitised and epidotised in places, crop out. Near Saralokhutu, there is an extensive mass of fine- to coarse-grained olivine basalts, andesites, agglomerates and tuffaceous beds. The agglomerates are similar to those near Hopar. The succession, intruded in many places by granodiorite, continues to Sor Laspur, where some basic gneisses occur. The rocks of this section provide a link between the rocks described from Haringal Shal to Galinga and Chalt to Gilgit.

Wadia (1938) has shown that volcanic rocks-referred to as "Punjal Traps" similar in lithology to those described in this report, occur in north-west Kashmir and Hazara District. They are regarded as Upper Carboniferous to Upper Triassic age in some places, whereas in other places they are not recorded in systems younger than Permian. At Chalt, lavas are found in the upper portion of the Darkot Group, and it is suggested that these volcanic rocks marked the introduction of a period of vulcanicity, which led to the formation of the Greenstone Complex.

#### Yasin Group

The volcanic suite of lavas, tuffs and agglomerates, containing lenses and beds of fossiliferous, massive and shaly limestones, and some sandstones, of Cretaceous age, which outcrops in the hills to the east and west of Yasin village, has been named the Yasin Group. A more appropriate name might have been the Yasin Volcanics, that is, a formational name, but past workers have regarded this unit as mainly a sedimentary one so that the term "volcanics" may lead to confusion. Also, with more detailed field work, this Group may be divided into two formations - one volcanic, and one sedimentary. Hayden (1914) examined the Group in the cliffs west of Yasin Rest House and described crushed and indurated sandstones with thin beds of fossiliferous shaly limestone and conglomerate, unconformably overlying a great mass of "trap". He did not record the presence of lavas and regarded the tuffs as indurated sandstones. Kazmi (1951) examined the rocks of this area but at the time of writing had not completed his report.

At Yasin, the Group extends as a narrow belt, approximately a mile wide, which has been traced for two or three miles each side of the valley. Little is known of its extension. At Carotian Shal, on the track to Chumarkhan Pass, a sequence of tuffs, agglomerates, quartzites, conglomerates and limestones was examined and has been included in this Group. No fossils were found in situ. No other outcrops of the Group were seen although other small isolated outcrops may occur along the contact of the Darkot Group and the Greenstone Complex.

The Yasin Group has been overfolded with the Darkot Group and now rests on the Greenstone Complex to the south, and, to the north, the relationship of this Group to the Darkot Group appears to be disconformable, with the Yasin Group underlying the Darkot Group.

The section, west of the Yasin Rest House, exposes approximately 2,000 feet of rocks dipping 65° N. These beds are characteristically coloured red and green and consist of massive and shaly limestones, slates, trachytic and rhyolitic tuffs, trachytic agglomerates and thin flows of trachyte and olivine basalt. The tuffs and trachyte are characterised by fragments and phenocrysts of sanidine. Beds with a similar lithology and which dip steeply north are exposed in the cliffs to the east of the Rest House. Farther east, south of the village of Ghojalti, the sequence is reversed and the beds dip approximately 30° south. Here, the steeply dipping beds are apparently overturned owing to hill creep, giving a local reversal of section and a southerly dip. This reversal is not of major importance. The limestones of the Group are highly fossiliferous and contain gastropods, lamellibranchs, corals, and forams. R. Brunnschweiler has examined the fossils collected from the cliffs west of Yasin Rest House and he assigns a Lower Cretaceous age to the assemblage. The limestones were deposited as a littoral facies of the Cretaceous epicontinental basin during a period of vulcanicity which interrupted the deposition by ejections of tuffs, agglomerates and thin lava flows.

### Granodiorite Batholiths

Three parallel-tending granodiorite batholiths have been mapped in the region. These are named Karakoram, Darkot Pass and Ladakh Granodiorites.

The Karakoram Granodiorite forms the Karakoram Range in Hunza State and has been traced west to its termination near Mastuj in Chitral State. North of this intrusion, and separated by a belt of sedimentary rocks, is the Darkot Pass Granodiorite, forming a prominent, unnamed range east and west of Darkot Pass. The exact boundaries of this Batholith are unknown but it probably continues east to link with the reported granitic rocks near Misgar (Hayden 1914). The Ladakh Granodiorite forms a large area of granodiorite intrusions in the mountainous belt, which includes the Ladakh Range, south of the Gilgit River. This Batholith extends beyond the limits of the region.

The dominant rock type of each of the batholiths is a pale grey, medium-grained biotite granodiorite. Granites occur locally as differentiates. The marginal facies of the intrusions are generally foliated and more variable in composition, and are characterised by an increase in the mafic contents. The contacts are usually sharp with an absence of any notable alteration of the country rock. The formation of hybrid diorites and related hornblende rocks by assimilation of basic country rock was observed in the north-eastern portion of the Ladakh Granodiorite.

Previous investigators were uncertain of the age of the igneous rocks. Wadia (1932) recognised three separate periods of intrusion in the vicinity of Gilgit; namely post-Lower Cambrian, post-Carboniferous, and post-Permian ages. Kazmi (1951) suggests that "hornblende granites" near Gilgit are of Late Palaeozoic age.

In view of similar composition and general characteristics of the three granodiorite batholiths, their common alignment, and the presence of small bosses of similar rocks occurring at intervals between them, they are regarded as being derived from a single magmatic chamber. Each batholith intrudes Upper Palaeozoic sediments of the Darkot Group, and, in addition, the Ladakh Granodiorite intersects volcanic rocks of the Greenstone Complex which are post-Carboniferous in age. The direct relation of the granodiorites and the Cretaceous rocks of the Yasin Group is not evident as these rocks are not in contact. The Yasin and Darkot Groups, however, are sympathetically folded, and the Karakoram Batholith intrudes an overfold in the latter. Structural considerations thus indicate a post-Cretaceous age for the batholiths, and they are considered to have been emplaced during the general period of the Himalayan Mountain building which existed in Tertiary time.

### Ladakh Granodiorite

The large area of granodiorites and related acid intrusive rocks in the southern portion of the region has been designated the Ladakh Granodiorite as these rocks constitute the Ladakh Range, south-east of Gilgit. Portions of the

batholith have been described by earlier workers. The intrusions in the vicinity of Gilgit were mapped by Wadia (1932), and in the same area Kazmi (1951) has referred to a batholith of "hornblende granite" exposed between Nomal and Gilgit in the Hunza River Valley.

The northern boundary of the Ladakh Granodiorite has been delineated but the southern portion is beyond the region. The batholith occupies a wide belt of mountains terrain, south of the Gilgit and Ghizar Rivers. Traverses have shown that the intrusion is at least 20 miles in width and probably much wider. Extensive areas of similar rocks in the Haramosh District and in the lower Hunza River valley are regarded as outlying portions of the one batholith. Small bosses of igneous rocks, seen north of the main area of outcrop, as for example those of Nazbar An, Bahushtar Olat and Barkhai, are also included as part of the Ladakh Granodiorite.

Traverses up Cupis Gah, Baro Gah and Balti Gol showed that the main mass of the batholith consists of a pale grey, medium-grained biotite granodiorite, containing phenocrysts of sodic plagioclase. In some areas, the granodiorite merges into granite but such variations are not common. The marginal zones of the intrusion are characterised by foliation and variation in grain-size and composition of the granodiorite. Metamorphic effects in the country rock are normally at a minimum but a more mafic contact-facies of the granodiorite is of widespread occurrence. The contact of the intrusion with rocks of the Greenstone Complex at Singal Gah, for example, is sharply defined without conspicuous metamorphism of the intruded rocks. The marginal facies of the intrusion is a dark-coloured hornblende diorite which changes gradationally into the normal pale grey granodiorite in a zone of approximately half a mile. Xenoliths of volcanics within the diorite have angular outlines indicating that hybridisation was insignificant.

Effects of metamorphism and assimilation were seen in the north-eastern portion of the batholith, where a wide variety of metamorphics and hybrid types have been produced by reactions with the volcanic country rock. This applies particularly to the rocks exposed in the Gilgit and Indus River valleys between Hanuchal and Parri. Here, the granodiorite is richer in mafic minerals and is associated with a complex assortment of hybrid diorites and syenites, and includes irregular masses of hornblende, derived from the metamorphism of basic xenoliths. A feature of the complex in this area is the presence of numerous veins of acid intrusives with unusually regular orientation as a rule, striking north-east and dipping north-west at low angles. This phenomenon has been described by Wadia (1932) as giving a misleading appearance of stratification to the south-eastern extension of the complex near Bunji.

Wadia (1932) concludes from his investigations in this area that there were three separate periods of intrusion. He recognised an older group of gneissic granites referred to as the Himalayan "Central Gneiss"; later dolerite, gabbro and pyroxenite; and still younger hornblende granites. He records that the hornblende granites intrude ash beds and lava sheets of the "Permian Panjal Trap Series". The terms "gneissic granites" and "hornblende granites" used by Wadia, no doubt, refer to rocks that have been determined as granodiorites and diorites during the present investigation. The Ladakh Granodiorite intrudes Upper Palaeozoic sediments of the Darkot Group between Hopar and Yangal in the Gilgit Valley and intrudes volcanics of the Greenstone Complex in all other areas where contacts were observed.

#### Karakoram Granodiorite

The Karakoram Granodiorite is the name given to the long belt of granodiorite which has been traced from north of Baltit, in Hunza State - where it forms the Karakoram Range - to near Mastuj in Chitral State. The term, Karakoram Batholith, was first used by Clark\* in 1949 and later by Kazmi<sup>ø</sup> (1951) for the igneous rocks which form the Karakoram Range in Hunza. In this report the name is extended to include the entire length of the batholith.

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\* Personal communication.

ø Kazmi (1951) in his Section on "Physiography and Topographic Forms" mentions the Karakoram Range and suggests that its core may be composed of granitic rocks which he designates the "Karakoram Batholith".

In the Hunza Valley, the Karakoram Granodiorite has a width of approximately six miles where it outcrops between Sarat and Seson. To the west, it follows the regional trend across the Headwaters of the Ishkuman River, and again outcrops for a width of approximately six miles between Darkot and Umalsit, in the Yasin River Valley. Towards Mastuj, the trend changes to south-west and the width of the batholith decreases.

The main rock type in the Hunza River section of the batholith is a pale medium-grained biotite granodiorite, containing porphyritic plagioclase crystals, and is devoid of any directional structure. The southern marginal portion of the batholith near Sarat is comprised of intimately related pale grey, biotite granodiorite and darker hornblende-biotite granodiorite, both of fine to medium grain and slightly gneissic. This zone is characterised by an abundance of pegmatites of regular orientation, striking slightly north of east and dipping north at low angles. Similar rocks are exposed in the Yasin Valley. The southern margin of the batholith at this place is porphyritic granodiorite, which gradually changes to gneissic granodiorite towards the northern margin.

The Karakoram Granodiorite intrudes an overfold in Upper Palaeozoic sediments of the Darkot Group. The southern limb of the fold in the Hunza River valley is intensely metamorphosed, and the boundary of the granite is transitional, with numerous apophyses of granodiorite intruding meta-sedimentary gneisses. The northern contact of the intrusion is quite sharp with a paucity of minor apophyses and an absence of any notable contact metamorphism.

#### Darkot Pass Granodiorite

The name, Darkot Pass Granodiorite, is given to the porphyritic granodiorites and gneisses which outcrop in the range extending westwards from the source of Chiantar Glacier, to form the divide between the Yasin and Yarkhun Rivers. Darkot Pass is the only well-known locality in this unnamed range.

Little is known of the exact distribution of rocks of this Batholith. The contact of porphyritic granodiorites with sediments of the Darkot Group is two miles north of Rawat above the Thermal Spring. The southern boundary can be traced for many miles to the east and west of this place as it forms the scarp at the edge of high country. The northern boundary is unknown but probably occurs between Darkot Pass and the Yarkhun River.

The batholith trends parallel to the Karakoram batholith and probably is connected to the granitic rocks reported by Hayden (1914) to occur a few miles north of Misgar in the Hunza Valley. More field work is needed before the Darkot Pass batholith can be adequately described.

#### Alluvial, Illuvial and Glacial Deposits

Small unconsolidated deposits of alluvial, illuvial and glacial origin occur throughout the region. These irregular deposits have not been mapped or studied in detail. Remnants of high and low-level terraces exist along the valley sides and more recent gravel and boulder beds occur along the rivers. Large illuvial scree, at their maximum angle of rest, have formed on the steeper slopes and now cover extensive areas. Numerous terminal, lateral and medial moraines and glacial lake deposits are found throughout the region although, at the present time, glacial deposition is confined to the higher altitudes. These superficial deposits were formed at different times since the conclusion of the main folding movements.

#### Structural Geology

The axis of Wadia's Syntaxial Bend\* may be extended to the north-west portion of the Gilgit Agency, though in this region the arching of the trends is less abrupt than the strike-changes in the Murree-Abbottabad area. The general direction of trend (Plate ①) gradually changes from west-north-west at Hunza, to west between

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\* Wadia (1931) reported that the main structural unit in the Murree-Abbottabad district was a pronounced bend or flexure of the beds around a north-south axis. To this structural unit he applied the name Syntaxial Bend.

3 R.R.V.

Imit and Darkot, then to west-south-west, and finally to south-west in the Mastuj area. The contacts of the Darkot Group with Karakoram and Darkot Pass batholiths follow this regional strike very closely. The southern boundary of the Darkot Group, owing to marked overthrusting, protrudes south in the vicinity of the axis of the arc and interrupts the continuity of the rocks of the Greenstone Complex. Small outliers of the Yasin Group trend parallel to the main regional strike. The north contact of the Ladakh batholith is conformable with established trends.

The direction of regional dip of the beds is away from the focus of the arc: north-east in the Hunza area, north between Imit and Darkot, and north-west from Darkot to Mastuj. Angles of dip range from moderate to steep. There are many minor reversals in the southern-central part of the region near Chathorkand.

The pattern of regional folding is best seen in the Yasin Valley, where the Darkot and Yasin Group have been overfolded into the Greenstone Complex. The overfold is shown, firstly at Yasin, by beds of Lower Cretaceous Yasin Group which dip north, and appear to underly the north-dipping beds of the Upper Palaeozoic Darkot Group; secondly, there is a marked similarity in the lithological sequence of the Darkot Group, north and south of the Karakoram Granodiorite - a massive limestone serves as a marker-horizon and has been recognised on both sides of the batholith. In the southern section, the marker bed is underlain by interbedded, fossiliferous limestones and slates. At Darband, north of the Karakoram Granodiorite, interbedded fossiliferous limestones and slates overlie the limestone bed. A similar fossil assemblage was collected from both members. The axis of the fold may be extended to the Hunza area. The axial plane of the overfold, in the Yasin Valley, dips at a moderate angle to the north. Section B-B<sub>1</sub>-B<sub>2</sub> (Plate 8) shows the interesting pattern of folding of Darkot Group rock in the Ishkuman valley. There, it is probable that the main fold is more symmetrical and that the axial plane is vertical. The compact southern limb (Section A-A<sub>1</sub> Plate 8) of the overfold observed in the Yasin Valley, has given way to a strongly crenulated limb which has overridden the stratigraphically younger Greenstone Complex. Such minor folds have upright axial planes which range in dip from 70° N to 70° S.

The northern or upper limb of this fold is not greatly affected by tectonic movements, whereas the southern or lower limb, which has been thrust against and over the resistant volcanics of the Greenstone Complex, is highly folded and faulted.

Major thrust faults, striking east-west and dipping north at moderate angles have been mapped near Chalt and Um Hatum at the contact of the Darkot Group and Greenstone Complex. At Um Hatum (Plate 8) the stratigraphically older rock unit, the Darkot Group, has been thrust over the Greenstone Complex, for at least six miles. Faults are common structural features, but they are of secondary importance to overfolding in the distribution of rock units, and formation of mountain chains, in this area.

Major structures found in the region conform to those found in other parts of the Himalayas and are probably due to forces impressed from the north.

### Geological History

In this report, only the history directly connected with the stratigraphic units of the region is given.

The oldest rocks examined were the limestone, slates, quartzites and other metamorphics of the Darkot Group of Upper Palaeozoic age. A few granite pebbles were found in the slates but the pebbles were well rounded and had travelled a great distance. No other signs of this older granite were seen. The Upper Palaeozoic sediments were laid down in the Tethys Sea, which was extensive at that time. The sediments, which are predominantly slates, indicate deep-water conditions; they are generally unfossiliferous although one horizon of interbedded slates and limestones contains abundant marine fauna.

Towards the ends of deposition of the Darkot Group an indication is given of the great volcanic period to follow. Near Chalt, and north of Yasin, pillow lavas are found near the top of the sequence. The volcanic outburst increased in magnitude and gave rise to a great thickness of tuffs, agglomerates and lavas. At least part of the region was submerged during this time; this is shown by the presence

of small lenses of limestones and quartzites in the volcanics, and pillow lavas. Neither the age nor close of this volcanic cycle is known, but there was a period of erosion before Cretaceous deposition commenced.

In Lower Cretaceous time, a shallow arm of a larger epiherc sea entered the region. This sea transgressed the softer sediments of the Darkot Group and probably had its shoreline at the boundary of the Darkot Group and the Greenstone Complex, approximately east and west of Yasin, with the massive resistant volcanics of the Greenstone Complex forming the land which bordered this transgression.

A short period of volcanicity gave rise to tuffs, agglomerates and thin lava flows which are now found interbedded with fossiliferous Lower Cretaceous limestones containing a rich littoral marine fauna. This volcanic action possibly marks the end-phases of the great volcanic period which gave rise to the Greenstone Complex and is definitely related to the Cretaceous volcanicity which occurred farther south in the Indian sub-continent.

At the close of the Cretaceous Period, or early in the Tertiary Period, began the great folding movements which produced the Himalaya Range of today. In this region, the sediments of the Cretaceous Yasin Group and the underlying sediments of the Darkot Group were overfolded upon the massive volcanics of the Greenstone Complex, and batholiths of granodiorite were introduced along the fold axes.

It is not possible to determine the age of the folding and intrusion within the Tertiary Period because of the absence of fossiliferous sediments younger than Cretaceous, but Wadia (1939) and other investigations of Himalayan geology agree that movements commenced late in the Eocene Epoch. The main folding is believed to have occurred in the Middle Miocene Epoch, and was followed by thrusting from the north in the Middle or the Upper Pliocene age. Minor movements have continued into Pleistocene and Recent times. These movements initiated the present cycle of erosion, during which only superficial deposits have accumulated.

#### Geomorphogeny

The extraordinary drainage system (Plate 2) with the main rivers cutting through high ranges suggests antecedence, and in other parts of the Himalaya Range this has been proved by the existence of folded Tertiary deposits in present valleys.

The mountain chains are aligned parallel to the regional geological structure and their distribution depends on the difference of resistance to weathering of the rock types. The prominent mountain ranges are composed of granodiorite. The rivers have cut deep gorges through mountain ranges, and the extreme topographical relief could only be the result of rejuvenation of the rivers by gradual uplift. No Tertiary sediments are present in Gilgit Agency to help establish the age of the orogeny.

Glaciation has played an important part in producing the rugged topography. Glacial erosion reached its maximum during the Pleistocene Epoch but the ice has since receded to much higher altitudes. The lowest observed terminal moraine is at 4,100 feet, near the junction of the Indus and Gilgit Rivers.

Undisturbed high-level river-gravels on the sides of valleys show that the rivers have cut at least several hundred feet since the last orogeny. Alluviation due to blockage of rivers by glacial or landslide debris, has occurred, and resulting terraces are found at many levels.

ECONOMIC GEOLOGYSUMMARY

1. There are no alluvial gold placers of sufficient size to be of economic importance.
2. No metallic mineral deposits of economic value were found.
3. Further investigation of quartz crystal occurrences is recommended.

INTRODUCTION

The main purpose of the geological investigations in this region was to assess the potential wealth of mineral deposits in the area. The localities of known and reported mineral occurrences were shown on a map by an officer of the Pakistan Geological Survey and traverses were planned to visit all these localities. The Australian Geological Party spent three months in the Gilgit Agency.

Previous investigators have been optimistic about the economic potentialities of the region. Clark (1948-50) investigated quartz crystals at Khaibar, gold and copper at Pasu, muscovite and felspar at Baltit, felspar at Hasanabad Nala, garnet near Murtzabad, and gold and "rare minerals" at Minapin. In 1951, he reported the presence of pyrite, chalcopyrite and arsenopyrite in the Gilgit-Nomal district. His results are contained in unpublished reports submitted to the Ministry of Kashmir Affairs, Pakistan. In 1951, Kazmi (Pakistan Geological Survey) carried out a preliminary investigation of mineral deposits in this region. He noted the same deposits as recorded by Clark and reported other occurrences of minerals; galena and stibnite at Hasseis and Chhelish and common beryl and aquamarine in Haromosh district. His results are submitted in two unpublished preliminary reports. In all cases, tracks, in constant use by the villagers, pass within a short distance of the mineral occurrences. The tracks are usually suitable for horses and pack-animals. Transport costs are high.

Local villagers and shepherds are keen collectors of attractive rocks or minerals. Any discovery is reported to the Headman or Rajah, and specimens and information are generally available to visiting geologists.

In this report, the mineral occurrences are discussed under the headings "Metallic" and "Non-Metallic Minerals".

Metallic Minerals

Alluvial Gold: Alluvial gold, in some rivers of the Gilgit Agency, has been known for many years. Parties of gold-washers, from the Agency and from the Punjab, have worked the alluvial deposits from time to time. Their work is seasonal, dependent on the nature of the flood conditions of the rivers. At present, gold-washing is carried out by a few local people, prepared to forgo the prevalent feeling in the region that "goldwashing" is a dishonourable profession. Local authorities state that inhabitants have sampled most of the alluvial deposits, but have worked only those areas described below.

Wadia (1932) recorded that gold was panned from portions of the Hunza and Bagrot tributaries of the Gilgit river. In 1951, Clark reported gold from alluvial gravels at Pasu. His panning investigations also showed that gold was present in the Hunza river gravels near Nomal, but was scarce in other parts of the river course. Other "gold-washing" localities include Hanuchal and one mile west of Torbuto Das, on the Daintar River, but these localities have not been worked for many years. At present, "gold-washing" is restricted to Pasu and is confined to a few people.

It is suggested that the gold is derived from quartz veins which crop out at the contact of the granodiorite and Darkot Group, and from narrow quartz veins disseminated throughout the country rock. The limited number of places in which gold has been obtained may indicate a limited outcrop of source rocks.

Gold occurs as flattened grains and fine dust, and is contained in the fine sands of alluvial gravels in narrow banks of the rivers and streams. There may be some gold in high-level alluvial terraces, but no attention has been paid to these, as the deposits are mostly under cultivation.

The work of the gold-washers at Pasu could be made easier if they could be encouraged to build small water-races, and use the water to wash the sands from the gravels. This would be a decided improvement on the bucket method of washing, and would enable a greater volume of wash to be treated per day.

The investigations show that gold placer deposits have a very limited distribution, and suggest that the deposits do not present economic possibilities on any appreciable scale.

#### Copper Minerals

Copper minerals, chalcopyrite and malachite, have been found in the rocks of the Greenstone Complex. Clark (1951) examined "small blebs of chalcopyrite scattered through granite" in Dainyor Nala, and reported that "these deposits are of no commercial importance". At Dikut and Pasu, Chalcopyrite-pyrite-pyrrhotite boulders have been observed, but their source is unknown. No copper occurrences of commercial value were seen.

#### Lead Minerals

No deposits of lead minerals were seen. A reported "lead and pyrite" deposit at Chhelish was found to be a small pocket of graphite in porphyritic granodiorite.

#### Iron Ores

The iron minerals in this region include pyrite, arsenopyrite, pyrrhotite, hematite and magnetite. Pyrite deposits outcrop in the Gilgit-Nomal area, Jutal and Kargah Nalas, near Batura and Pasu Glaciers, and at Yalter Bar. The pyrite occurs as impregnations in crush zones or associated with pyrrhotite in replacement lenses. The Yalter Bar deposit is typical of pyrite-pyrrhotite deposits in this area and is a replacement of crushed quartz-mica schist at its contact with massive quartzite. The deposit is lenticular in shape and is approximately one hundred feet in length. Such pyrite deposits are too small and too inaccessible to be exploited.

Hematite forms the brilliant red weathering product of pyrite and arsenopyrite, visible on the hills near Maiun and Nomal. The deposits are only stains on the hillsides and are consequently of no commercial use.

Magnetite has been recorded from many localities, generally as segregations in basic lavas. Such occurrences have little economic significance in mountainous terrain.

#### Non-Metallic Minerals

##### Quartz Crystal

The occurrence of quartz crystal was reported from two localities in the Gilgit Agency. At the first locality, one mile south of Iskere in the Haromosh Range, a few scattered, inferior quality crystals of quartz occur in pegmatite veins. Not one crystal of economic value was seen either in situ or in possession of the villagers. The second locality was the Khaibar Nala in the Hunza Valley. Clark examined this locality in 1948 and, in 1950, he reported a quartz crystal deposit and recommended further investigations. Later in that year, he submitted a second and unfavourable report. In the company of Dr. Clarke, this locality was visited and three deposits of quartz crystal were examined. The quartz crystal is found on the walls of vughs in a quartz vein up to 6 feet thick which penetrates the slates and quartzites on the north side of Khaibar Nala,  $1\frac{1}{2}$  miles upstream from Khaibar Village, at a height of 11,000 to 12,500 feet.

The vughs are more common where the quartz vein intersects the quartzite. Some good quality optical quartz, up to 1 inch in length, was collected, and also imperfect large crystals with a length up to  $4\frac{1}{2}$  inches. As small good quality,

and large poor quality crystals were seen, the deposits are sufficiently promising to recommend further investigations. The vughs should be opened up and thoroughly examined farther back from the outcrop where many generations have collected curios. Other reported quartz veins between Khaibar and Misgar should be examined.

The requirements for commercial use are:-

1. The crystal or piece of quartz should weigh more than 4 ounces avoirdupois, or contain more than one-inch cube of apparently flawless quartz.
2. The crystal should be clear and glass-like and contain at least a one-inch cube, which is free from flaws, twinning and other defects.

The price per pound of acceptable crystal ranges from ten shillings (10/- d.A) to five pounds (£5 A).

Good quality quartz crystal is in great demand at the present time, and the prices offered are sufficient to cover the high cost of transport from this remote region.

#### Mica

A muscovite deposit has been reported from Haidarabad Nala, Hunza State. The deposit was examined and was found to consist of a few muscovite books, 6" - 9" diameter, in pegmatite boulders in scree and 1" diameter books in 10-foot-wide pegmatite veins in situ. The source of the large muscovite books was not located, but similar pegmatites in the vicinity of this deposit and in other parts of the region surveyed were investigated with negative results.

The deposits observed are too small to be of commercial value, and, since careful investigation of all pegmatites found along the routes of traverses revealed no trace of additional deposits, prospecting for deposits of commercial mica cannot be recommended.

#### Beryl

Occurrences of beryl in pegmatite veins were reported in the Hunza and Haramosh areas. Crystals of beryl were seen in the pegmatite veins near Bulchidas, in the Hunza area, and at one mile south of Iskere in the Haramosh area.

The pegmatites in the Haramosh area range in width from one to five feet and, owing to the mountainous terrain, could not be traced for more than twenty feet along the strike. One beryl-bearing pegmatite with pale, blue-green crystals of beryl  $\frac{1}{2}$  -  $\frac{1}{4}$  inch diameter was examined, and this deposit was the only one known to the villagers. Only two crystals of beryl were seen.

A reported occurrence near Jutial was not investigated because the deposits are under snow for most of the year. Further investigation of beryl deposits seems unwarranted, because beryl-bearing pegmatites are apparently very rare, and are likely to be snow-covered for part of the year.

#### Precious and Semi Precious Stones

Pegmatite veins in the western margin of the Haramosh Range, in the vicinity of Dache, Iskere and Jutial, were examined for reported occurrences of aquamarine gemstone. These pegmatites are snow-covered for part of the year.

A few crystals of pale green and opalescent blue-green beryls were seen, but the pale green crystals were too pale, and the blue-green crystals too fractured, for use as gemstones.

The poor quality of all the specimens seen in possession of the inhabitants suggests that if there are any deposits of commercial gemstones they will be hard to find.

Abrasives

Two and a half miles east of Hini, staurolite-garnet-mica schists crop out in the steep cliffs of the Hunza Valley. They are accessible from a narrow pack-track which leads from Gilgit along the Hunza River Valley. Clark (1950) submitted samples of the garnets to the Pakistan Geological Survey to be tested for use as an abrasive. Kasmi (1951) suggested a local sandpaper industry. The garnets are orange-red crystals of almandine, 0.5-1cm. diameter, intergrown in places with staurolite. Inclusions of quartz and alteration to biotite are common features. The garnets are highly fractured. Inter-growth with minerals of different hardness to the garnets, alteration to biotite, and a high degree of fracturing, are very undesirable features in an abrasive. Consequently, these garnets would make an abrasive of a quality too poor to pay for the high transport cost and mining operations.

Other Minerals

Soapstone, asbestos, sulphur, feldspar, and tourmaline, have been reported by previous investigators, but examination of the occurrences showed that they are of no economic significance.

ACKNOWLEDGMENTS

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REFERENCES

- Auden, J.B., 1933 - On the age of certain Himalayan granites, Rec. Geol.Surv.India, Vol.66, Part 4, p. 461.
- \_\_\_\_\_, 1935 - The snout of the Biapo Glacier in Baltistan, Rec. Geol.Surv.India. Vol. 68, Part 4, p. 400.
- Blanford, W.T., 1882 - Report on the proceedings and results of the International Geological Congress of Bologna, Rec.Geol.Surv.India, Vol. 15, pp. 64-86.
- Bridges, H.F., 1906 - Hunza and Nagir Glaciers, Rec.Geol.Surv. India. Vol. 37, Part 2, p. 221.
- Clark, J., 1949 - Mineral localities in the Gilgit Agency and neighbouring states, Confidential Report to Minister of Kashmir Affairs, Government of Pakistan - unpublished.
- \_\_\_\_\_, 1950 - Mineral resources of the Gilgit Agency, Confidential Report to Minister of Kashmir Affairs, Government of Pakistan - unpublished.
- \_\_\_\_\_, 1951 - Sulphide ore minerals of the Gilgit-Nomal District, Confidential Report to Minister of Kashmir Affairs, Government of Pakistan - unpublished.
- Coulson, A.L., 1937-38 - Gold in the North-west Frontier Province, Trans. Min.Geol. and Met.Inst. India, Vol. 33, pp. 192-206.
- Dickins, J.M., 1952 - Upper Palaeozoic Fossils from the North West Portion of the Gilgit Agency, Pakistan. Comwlth. of Aust., Bur.Min.Res.Geol. and Geophys., Records 1952-42 (unpublished)
- Douville, H., 1914 - Fossiles recueillis par Hayden dans le Kashmir en 1906 et les Pamirs en 1914. Leur description, Rec. Geol.Surv.India, Vol. 58, Part 4, p.349.
- Glaessner, M.F., Raggatt, H.G., Teichert, C., and Thomas, D.E., 1948 - Stratigraphical nomenclature in Australia, Aust. Journ.Science, Vol. II, Part I, p.7.
- Hayden, H.H., 1914 - Notes on the geology of Chitral, Gilgit and the Pamirs, Rec.Geol.Surv.India, Vol. 65, Part 4, p. 271.
- Holland, T.H., 1926 - Indian geological terminology, Memoirs Geol.Surv. India, Vol. 51, Part 1.
- Kazmi, A.H., 1951 - Preliminary report on the geology and Mineral occurrences in the lower Hunza River valley, Geol. Surv.Pakistan - unpublished.
- Krishnan, M.S., 1949 - GEOLOGY OF INDIA AND BURMA, Madras Law Journal Office, Madras.
- Lydekker, R., 1881 - Geology of part of Dardistan, Baltistan and neighbouring districts, Rec.Geol.Surv. India, Vol. 14, p. 1.
- \_\_\_\_\_, 1882 - Geology of North-west Kashmir and Khagan, Rec.Geol. Surv. India, Vol. 15, Part 1, p.14.
- Middlemiss, C.S., 1910 - Revision of Silurian - Trias Sequence in Kashmir, Rec.Geol.Surv.India, Vol.40, Part 3, pp. 206-260.



APPENDIX A

PETROGRAPHIC NOTES

Unit	Rock No.	Locality	Name	Structure	Mineral Assemblage (In order of abundance)	Accessories	Remarks
1.	2.	3.	4.	5.	6.	7.	8.
	89	Tashot	Staurolite - garnet schist	schistose	staurolite garnet (almandine) quartz biotite	muscovite iron ore	Staurolite and garnet form porphyroblasts
	18	Tashot	Andalusite - staurolite - garnet - biotite schist	schistose	andalusite biotite quartz garnet sericite	staurolite iron ore	Andalusite is present as skeletal crystals
Darkot Group	181	North of Darkot Thermal Spring	Garnet - quartz - mica schist	schistose	biotite quartz muscovite garnet	-	Calcite and epidote replaces plagioclase crystals
	180	Darkot Thermal Spring	Tremolite - actinolite rock	intergrowth	tremolite actinolite	biotite iron ore apatite	A metamorphosed basic intrusive
	179	North of Darkot	Medium - grained granodiorite	massive with granitoid texture	plagioclase quartz orthoclase biotite muscovite	iron ore	Boulder in slate

1.	2.	3.	4.	5.	6.	7.	8.
	275	South of Gasit Gol.	Vesicular augite basalt	Micro-porphyrritic Groundmass has intersertal texture	pigeonite-augite plagioclase iron ore serpentine calcite	epidote ground-mass	Vesicles infilled with calcite. Plagioclase phenocrysts replaced by calcite, epidote and quartz
	272	South of Gasit Gol.	Basalt-palagonite agglomerate	fragmentary	Consist of fragments of micro-crystalline basalt, palagonite, basic plagioclase and olivine, with interstitial serpentine.		
Greenstone Complex	277	South of Gasit Gol.	Epidotised agglomerate	fragmentary	Consists of fragments of andesite, trachytic tuff and basic plagioclase. Secondary epidote is abundant		
	274	South of Gasit Gol.	Calcareous basaltic agglomerate	fragmentary	Consists of fragments of vesicular augite basalt, palagonite and augite crystals; interstitial calcite, epidote and serpentine.		
	11	Chalt.	Gneissic micro-diorite	porphyroblastic and lineated	hornblende plagioclase quartz epidote biotite	iron ore	Hornblende forms porphyroblasts.
	88	Gwach	Hornblende-plagioclase schist	schistose	hornblende plagioclase	quartz iron ore	A meta-dolerite

1.	2.	3.	4.	5.	6.	7.	8.
	87	Chalt	Hornblende quartz-plagioclase schist	schistose	hornblend quartz	plagio-clase iron ore epidote	A metamorphosed grey-wacke. A vein of secondary epidote is present.
	284	Bapo Ser.	Grossularite -zoisite- diopside calc-silicate	porphyro- blastic	grossularite calcite zoisite diopside microcline quartz	dravite	Grossularite forms porphyroblasts.
Green- stone Complex	285	Bapo Ser.	Banded epidote- hornblende calc-silicate	foliated	epidote hornblende calcite (potash feldspar quartz	zoisite	
	256	Chhashi Gol.	Hornblende andesite	micro- porphy- ritic	plagioclase (Ab 75) hornblende iron ore	chlorite epidote prehnite	Pebble in conglomerate.
Yasin Group	169	West of Yasin	Trachyte	micro- porphy- ritic. Ground- mass has inter- granular texture	sanidine (diopsidic augite iron ore epidote	quartz	Sanidine forms phenocrysts

1.	2.	3.	4.	5.	6.	7.	8.
Yasin Group	175	West of Yasin	Prehnitised olivine basalt	massive, with intersertal texture	plagioclase augite olivine serpentine	iron ore	Prehnite is an alteration product of Plagioclase
	172	West of Yasin	Trachytic tuff	fragmental	Consist of small fragments of sanidine, micro-crystalline trachyte, augite, plagioclase and some quartz. Serpentine and iron ore are interstitial.		
	176	West of Yasin	Rhyolitic tuff	fragmental	Consists of small fragments of rhyolite with glassy groundmass, granophyre, potash feldspar, quartz and small amounts of augite and epidote		
Ladakh Batholith	91	Dache, Haramosh	Medium-grained gneissic granodiorite	gneissic	plagioclase quartz orthoclase biotite	apatite epidote zircon	Some plagioclase is anti-perthitic
	297	Bahushtaro Olat, near Shamran	Porphyritic hornblende diorite	porphyritic with medium-grained groundmass	hornblende plagioclase (Zoned). orthoclase quartz biotite	tremolite epidote iron ore muscovite	One hornblende phenocryst encloses relict augite
	190	Hanuchal Indus Valley	Fine-grained banded hornblende diorite	foliated	plagioclase (Ab70) hornblende epidote biotite	sphene quartz	
Karakoram Batholith	83	Pasu Ghar	Medium-grained monzonite	Massive with granitoid texture	plagioclase (Ab70) microcline quartz biotite muscovite	iron ore sphene apatite	

1.	2.	3.	4.	5.	6.	7.	8.
	191	Shutā, Indus Valley	Medium-grained gneissic hornblende syenite	gneissic	microperthite hornblende aegirine-augite plagioclase (Ab70)	iron ore quartz apatite zircon	Aegirine-augite bordered with reaction rims of hornblend
	192	Hanuchal, Indus Valley	Medium-grained gneissic diorite	augen- gneissic	plagioclase actinolite tremolite orthoclase quartz	biotite chlorite	Plagioclase form augen.
Ladakh Batholith	222	Between Singal and Gakuch	Hornblende syenite	Porphy- ritic	microcline microperthite hornblende plagioclase (Ab80) biotite iron ore	quartz apatite sphene	Hornblende encloses relict crystals of augite. Plagioclase forms phenocrysts
	216	Singal Gah	Biotite hornblende granodiorite	Medium- grained massive, with grani- toid texture	plagioclase quartz biotite hornblende	epidote sphene apatite	Some plagioclase is antiperthitic
	29	Upper Hasanabad Nala	Medium-grained biotite granodiorite	porphyritic	plagioclase (Ab70) quartz biotite perthite	muscovite apatite epidote zircon iron ore chlorite	Plagioclase forms phenocrysts
Karakoram Batholith	85	Gulmit, Hunza Valley	Gneissic biotite hornblende granodiorite	foliated	plagioclase (Ab70) biotite hornblende quartz augite	clinozoisite sphene apatite zircon	

## APPENDIX B

## List and Age of the Upper Palaeozoic Fossils from the North-West Portions of the Gilgit Agency - by J.M. Dickins 1.

1. Barband Village, 3 miles north of Darkot, Yasin Valley, Specimens No. 92-109.

Fistulipora yasinensis Reed 1925  
Batostomella sp.  
Fenestella sp. A.  
Polypora? darkotensis (Reed) 1925  
Rhombopora cf. lepidodendroides Meek 1872  
Thamniscus? sp.  
Acanthocladia? sp.  
 Crinoidea gen. ind.  
 Brachiopoda gen. ind.  
 Orthotetidae gen. ind.  
Euomphalus cf. parvus Waagen 1880  
 Hyolithidae gen. et. sp.

It was from this locality that Hayden collected the fossils described by Reed in 1925.

The closest relationship of the fauna is with the Artinsk of the Urals, the Basleo beds of Timor and particularly the Middle Productus Limestone of the Punjab. This relationship would suggest an age towards the top of the Lower Permian (the Lower Permian is taken to include the Sakmarian, Artinskian and Kungurian of the standard sequence in the Soviet Union, and the Upper Permian to include the Kazanian and above).

2. Sandhi Village, 7 miles north of Yasin, Yasin Valley. Specimens No. 110-122 and 186 and 187.

Fenestella sp. B  
Rhombopora cf. lepidodendroides Meek 1872  
 Crinoidea gen. ind.  
 Rugosa gen. A sp.  
 Productidae gen. et sp.

Possibly this locality has a species in common with locality 1 - R. cf. lepidodendroides Meek. However, a comparison is unreliable owing to poor preservation of the specimens at both localities. R. lepidodendroides has been reported from the Upper Carboniferous and Permian of North America. The whole fauna suggests an Upper Carboniferous or Lower Permian age.

3. Khaibar Village, junction of Khaibar Nala and Hunza River Specimens No. 58-69.

Fusulinidae gen. et. sp.  
Fenestella sp. C  
Streblotrypa? sp.  
 Rugosa gen. B sp.  
 Orthotetridae gen. ind.  
 Pelecypoda? gen. ind.

It is possible that the single brachial valve of an orthotetid brachiopod represents the same species that occurs at Locality 1. The fauna would suggest the beds are of a Lower Permian age, possibly slightly older than those of Locality 1.

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1. For a fuller report on these fossils see references.

APPENDIX C

## Lower Cretaceous fossils of the Yasin Group, Gilgit Agency

R.O. Brunnschweiler

Since Hayden (1916, Rec.Geol.S.India, XLV, pt. 4) found a number of fossils in what he erroneously called the "Hippurites Beds" of Yasin, no new material seems to have been collected at the locality until 1951. The present collection comprises a few forms which are new to the Yasin Group, and it is hoped that they can be described in the near future in a special paper.

The fossil assemblage submitted for determination to the writer by Messrs. J. Ivanac, D. Traves and D. King comprises the following species and genera:

Eugyra cf. E. neocomiensis de From.  
Calamophyllia cf. C. gracilis Blainv.  
Thecosmilia sp.  
Isastrea cf. I. regularis de From.  
Montastrea sp.

Horiopleura haydeni Douv.  
Horiopleura cf. H. haydeni Douv.  
Horiopleura cf. H. lamberti (Mun. - Chal.)

Nerinea cf. N. coquandi d'Orb.  
Ptygmatis n. sp.

Foraminifera (see Appendix D)

The only publication on fossils from Yasin known to me is that by H. Douville (1926, Rec.Geol.S.India, LVIII, pt.4). His descriptions are based on material collected by Hayden during the exploration of the area in 1906. Of the genera and species mentioned by Douville Praeradiolites gilgitensis Douv. is absent in the 1951 collection. The latter contains, however, the following new forms:

Thecosmilia sp.  
Montastrea sp.  
Horiopleura cf. H. haydeni Douv.  
Horiopleura cf. H. lamberti (Mun. - Chal.)  
Ptygmatis n. sp.

Of particular interest is the presence of Horiopleura cf. H. lamberti (Mun. - Chal.), a rudiste species common in the lower Cretaceous of the Pyrenees.

The present collection confirms the lower Cretaceous (Barremian - Aptian) age of the Yasin Group as given by Douville, who rectified Hayden's erroneous term "Hippurites Bed", which suggested an Upper Cretaceous age.

Figure 1.



A view, north-east from Hasanbad Glacier.

Photo by D.K.

Figure 2.



Batura Glacier

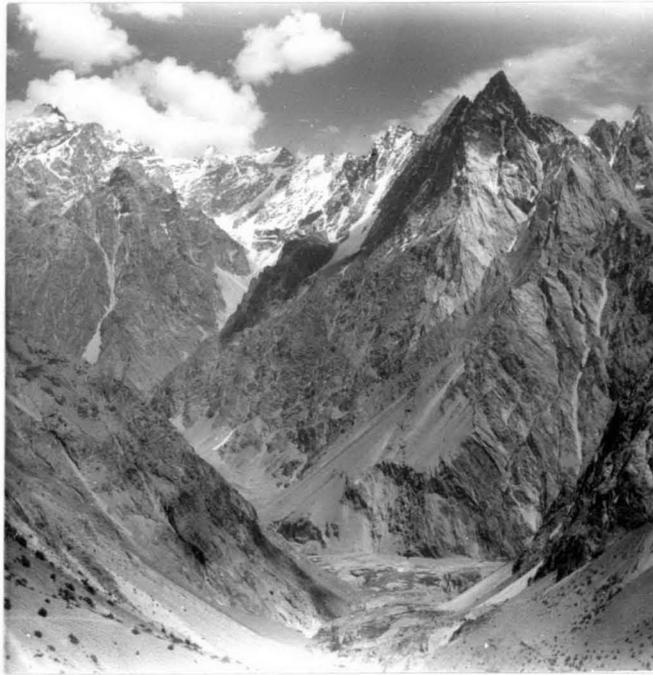
Photo by D.K.



View from Thermal Spring, looking south towards Darkot.

Photo by D.M.T.

Figure 1.



View down Khaibar Nala.

Photo by D.M.T.

Figure 2.

Figure 2.



View, west from Ghamubar Aghost.

Photo by D.M.T.

Figure 1.



Hybridisation at contact of Ladakh Granodiorite  
and Greenstone Complex.

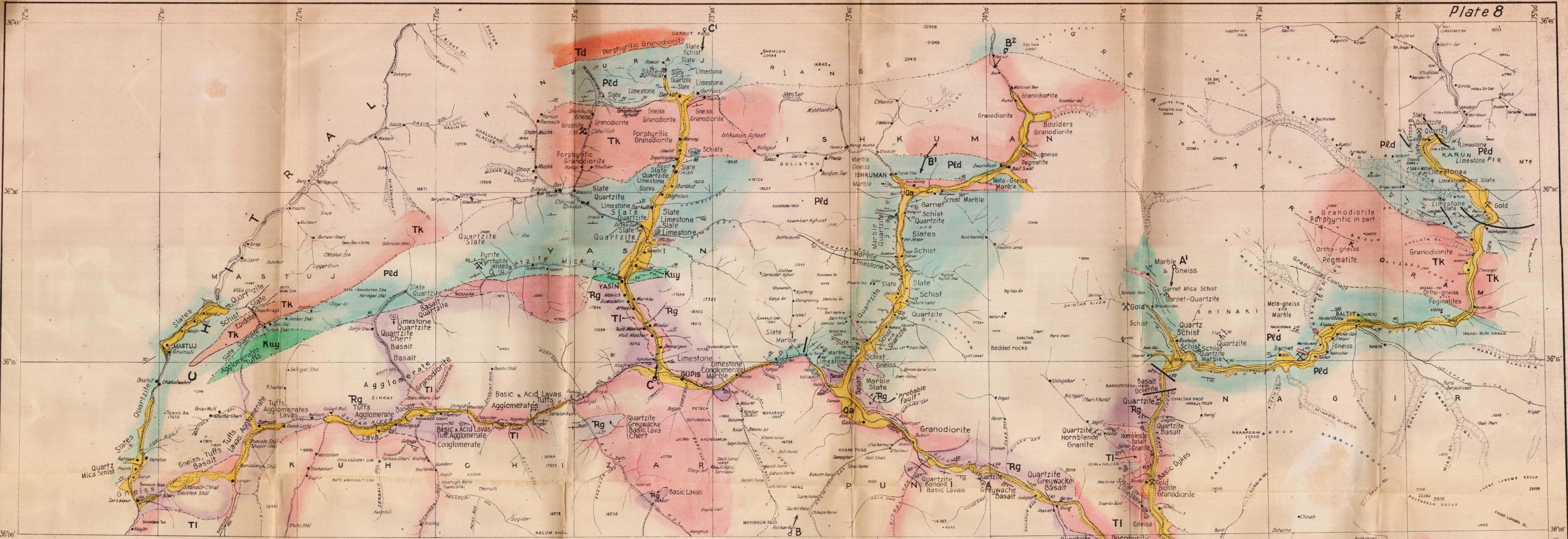
Photo by J.F.I.

Figure 2.



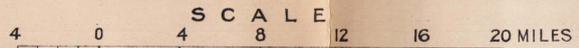
Agglomerate.

Photo by D.K.



# GEOLOGICAL MAP OF TRAVERSES IN NORTH-WEST PORTION OF GILGIT AGENCY PAKISTAN

- QUATERNARY** Qa Mixed alluvia
- TERTIARY** Ti Ladakh Granodiorite - Granodiorite  
Tk Karakoram Granodiorite - Granodiorite  
Td Darkot Pass Granodiorite - Granodiorite
- LOWER CRETACEOUS** Kuy Yasin Group - Lavas, Tuffs, Agglomerates, Limestones, Sandstones.
- TRIASSIC (?)** Rg Greenstone complex - Lavas, Tuffs, Agglomerates, Gneisses, Quartzites, Limestones.
- LOWER PERMIAN &/OR UPPER CARBONIFEROUS** Pld Darkot Group - Slates, Limestones, Quartzites, Conglomerates, Schists, Marbles, Gneisses, Volcanics.
- REFERENCE**
- Established Boundary - position accurate
  - Established Boundary - position approximate
  - Inferred or probable boundary
  - Strike and dip of strata - inclined
  - Strike and dip of strata - vertical
  - Strata with curving dip. (Angles indicate maximum and minimum dips.)
  - Plunge or pitch of minor anticline
  - Plunge or pitch of minor syncline
  - Fold axis (in section)
  - Established Fault - with dip
  - probable fault
  - fossil localities
  - Mines
  - Section lines
  - Spot - heights (in feet)
  - Tracks



GEOLOGY BY J. F. IVANAC, D. M. TRAVES & D. KING

