PETROGRAPHIC DESCRIPTION OF ROCK SPECIMENS FROM THE HUNZA VALLEY IN THE KARAKORAM

BY

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With plates 8—10.

INTRODUCTION.

During his second Karakoram expedition in 1925 Mr. PH. C. VISSER collected some 70 rock specimens from the valley of the Hunza and its tributaries [1]). The following is a petrographic description of these specimens and I gladly take this opportunity of thanking Mr. VISSER for entrusting me with his valuable material.

Geologists are much endebted to this energetic explorer for bringing together such a considerable number of samples under circumstances in which all carriage had to be reduced to a minimum and when so many other calls were being made on his time and energy. A collection made by a layman and therefore taken without many observations on mode of occurrence, must naturally be of limited value. When, however, it concerns a region that is almost terra incognita from a geological as well as from a geographical point of view, it may serve to give us an insight into the more salient features, especially petrographic and to some extent structural as well, and therefore constitute an important contribution to geological knowledge. Geologists will all hope that Mr. VISSER will soon be in a position to add to the collections he has already made.

Fig. 1 is a map showing the geographical position of the investigated area.

PETROGRAPHIC DESCRIPTIONS.

For purposes of description the investigated specimens will be grouped together as far as possible from a petrographic point of view.

[1]) For the geological results of Mr. VISSER's first Karakoram expedition see bibliography.

The positions of the specimens may be taken from the accompanying map, for which the geographical data were kindly supplied by Mr. VISSER. The area supposed by Mr. VISSER to be essentially constituted of the same type of rock as each sample that I have examined, is shewn on the map. Of the numbers I, II, III, and IV the labels, have been lost.

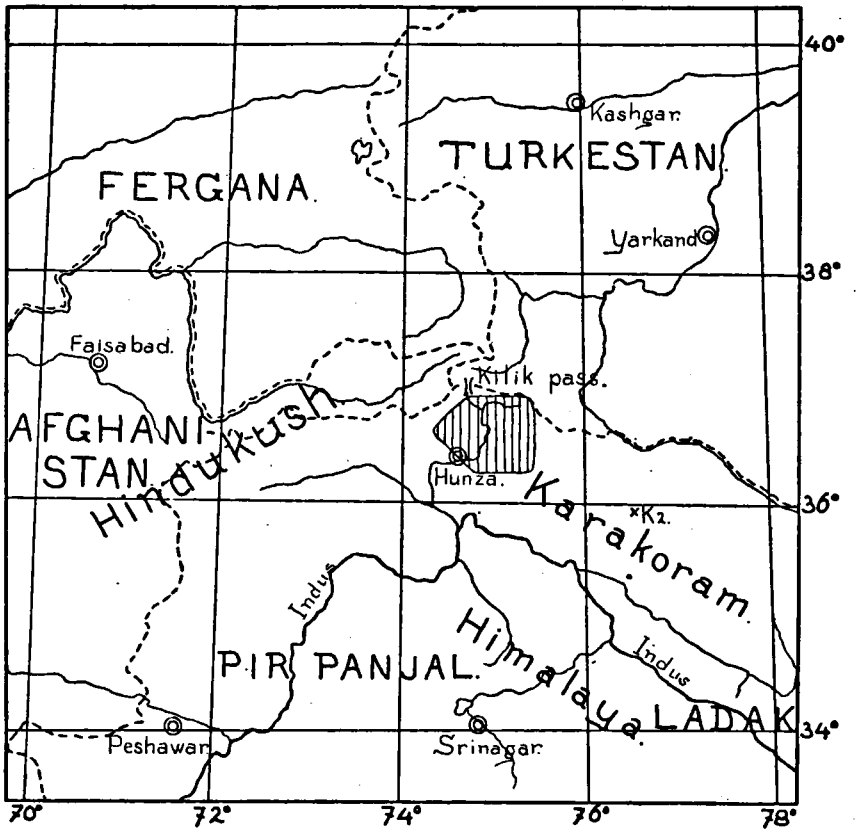

Fig. 1.

Map showing the position of the investigated area.

Plutonic rocks.

Granites (28, 41, 47, 49, 51, 70, 73, 74, 76, 77, 79) [1].

The samples of granite are all fine grained, light in colour and generally without any indications of schistosity or banded structure. U. t. m. the major constituents are seen to be: quartz, with strain shadows,

[1]) The numbers refer to the numbering of the collection and are the same as those used on the map.

plagioclase (acid oligoclase to basic andesine), orthoclase in large crystals often with perthite lamellae, reddish or greyish brown biotite. Accessory constituents are: apatite, zircon and titanite; secondary chlorite, sericite and zoisite are also met with.

The granites can be divided into two groups:

The muscovite-biotite-granites (47, 49, 51, 76, 77, 79). These contain some muscovite in addition to the minerals enumerated above. The plagioclase contains 28—35 % An. [1]). Myrmekite is also present. Nos. 47 and 79 contain some microcline (Pl. 9, fig. 1); no. 51 pyrite and rutile; no. 77 orthite.

The biotite-granites (granitite) lack muscovite as primary constituent but in specimen 28 and 74 it occurs as decomposition product. The plagioclase in no. 28 contains 27—31 % An. in the centre and 10 % An. in the outer zones. In no. 74 the plagioclase contains 20—22 % An. and shows irregularly shaped parts without twinning lamellae. This specimen and no. 73 further contain a fair amount of microcline and some of the plagioclase contains myrmekite. Specimens 41 and 73 contain some common green hornblende. The plagioclase contains 51—52 % An. in the centre and 30 % in the outer margins of no. 49 and 35—40 % An in those of no. 73. The plagioclase in no. 70 contains 11—14 % An. (it is not impossible that this should be 27—30 %). Sample 76 is strongly pressed and contains many large almandine crystals (½—1 c.m.). The mica has been somewhat concentrated in bands.

The nos. 41 and 73 probably belong to Mc. Mahon's Baltit hornblende-granite the others to the Hatu Pir granite group.

Diorites (37, 38, 67, I, IV).

The diorites may be divided into two groups:

Quartz-diorites.

These rocks, except I, are fine grained and light of colour, with a massive structure. Besides felspar and quartz some biotite or hornblende is visible.

U. t. m. the plagioclase is seen to be zonal, the centre contains 40—45 % An. the outer border 20—30 % An. (in IV 8 %). The orthoclase that shows perthite in parts, occurs in a few large crystals and is subordinate in amount to the plagioclase (in IV nearly equal to the amount of plagioclase). The quartz, that shows strain shadows, occurs in smaller or larger grains.

No. 37 is a biotite-quartz-diorite, the biotite is reddish brown (decomposition to chlorite) apatite and zircon are the accessories. This rock contains a fair number of microcline crystals with crosshatched structure.

[1]) All percentages of An. in the plagioclase have been measured by the method of Fedorov.

No. 38 is also a biotite-quartz-diorite, that differs from the former by the presence of a subordinate amount of green hornblende.

No. IV is a hornblende-quartz-diorite. The abundant green hornblende shows a strong tendency to twinning. Brown biotite is a frequent dark constituent, diopside-augite occurs generally poikilitically intergrown with the hornblende. Accessories are: titanite zircon, apatite, magnetite.

No. I differs from the former quartz-diorites in that it is a very fine grained variety, probably a border facies or dyke rock. The idiomorfic plagioclase contains 50—60 % An. The abundant dark constituents are biotite, common green hornblende and diopside and are often intergrown with one another. Quartz fills the interstices between the rectangular felspars and hypidiomorphic dark constituents.

Diorite.

No. 67 is a hornblende-diorite. It is a medium grained dark rock. The plagioclase contains 35—37 % An. and is slightly zonal. The dark constituents are: common green hornblende, diopside-augite and biotite, the latter two in smaller amounts and poikilitically intergrown with the hornblende. The abundant accessory constituents are: magnetite, pyrite, apatite and titanite.

Extrusive and dyke rocks.

Hornblende-dacite (26, 27, Pl. 9, fig. 2).

Dark reddish brown rocks with phenocrysts of quartz, plagioclase (40—55 % An., zonal, twinning laws acline A, albite Carlsbad A), hornblende, some diopside and orthoclase. The groundmass is hyalopilitic and fluxional, with laths of felspar (partly plagioclase) and hornblende. Accessory constituents: magnetite, zircon, apatite. Secondary products are: chlorite, epidote and sericite.

Vogesite (20, Pl. 10, fig. 1).

A dark grey, fine grained rock with a few phenocrysts of hornblende in a groundmass formed by a felt of idiomorphic hornblendes with a mesostasis of quartz and orthoclase. Accessory constituents are pyrite, magnetite and secondary titanite, carbonate (siderite) serpentine, epidote and zoisite.

Syenite-porphyry (granitic) (68).

A light, greenish grey rock with a few large phenocrysts of orthoclase, very few small quartz and biotite phenocrysts. The groundmass is fairly coarse grained and contains plagioclase in idiomorphic laths, irregular orthoclase and intersticial quartz. Accessory constituents are titanite, zircon, epidote, zoisite, orthite, apatite and magnetite. One diaclase bears a dark layer of biotite, another a layer of quartz crystals with pyrite, epidote and a fair amount of molybdanite[1]). As the quartz

[1]) This mineral occurs in large quantities in the investigated region according to Mr. VISSER.

does not show strain shadows it seems likely that the rock was intruded after the principal orogenetic period.

Metamorphic schists (75, II, III).

Sillimanite-gneiss (75, Pl. 10, fig. 2).

This rock is a paragneiss from the kata zone, yellowish brown with almandine, biotite, felspar and sillimanite needles.

U. t. m. we see plagioclase (35—38 % An.), orthoclase and quartz in about equal amounts, zircon, zoisite and some muscovite. The sillimanite occurs in needles with sharp crystallographic shapes, being 0,1 m.m. thick.

Plagioclase-gneiss (II). This rock is probably a metamorphic diorite.

Biotite-schist (III).

Sedimentary rocks.

Slates and phylites (1, 3, 11, 12, 16, 18, 19, 21, 23, 33, 36, 39, 40, 46, 55, 56, 58, 60, 72).

These rocks are more or less distinctly laminated and jointed and black or brownish black in colour, giving off a clay-smell when wetted. U. t.m. they are seen to be built up of quartz, orthoclase or microcline and acid plagioclase in rounded grains with a dark sericitic base in varying quantities. In small amount the following minerals were observed: pyrite, titanomagnetite, zircon, muscovite, biotite and zoisite in veins. In nos. 3 and 58 a quartz-felspar injection occurs in layers.

Sandstones and quartzites (6, 7, 24, 25, 32, 34, 35, 42, 48, 50, 52, 54, 63).

These rocks are grey in various tints, white or yellow and are fine grained. Many show quartz crystals on the joints, No. 7 is covered with fairly large yellow quartz and felspar crystals.

Pyrite and chalcopyrite are also observed. No. 50 is a felspatic grit and contains, besides quartz, felspar and sericite, some tourmaline and apatite.

Calcareous sediments (2, 4, 9, 10, 13, 17, 29, 31, 43, 44, 45, 53, 57, 61, 64, 66, 71).

The nos. 29, 61, 64 and 66 are fine grained dolomites with a greyish-white colour. Nos. 10, 43, 44 and 71 are white, fine grained marbles. The nos. 2, 4 and 9 are white dolomitic marbles, no. 45 is a brecciatic limestone consisting of dark, angular limestone fragments in a pink crystalline base. No. 13 is a dark, fine grained, crystalline limestone interbedded with very thin layers of black slate. No. 17 is a dark limestone with yellowish veins. No. 31 is a yellowish green rock with pyrite cubes (3 m.m.) and containing u. t. m. in a base of calcite: biotite, quartz, felspar, zoisite, apatite and amfibole (?). No. 53 is a dark blue limestone with a reddish brown weathered surface. It is crowded with organic remains, **probably bryozoa,** but unhappily too much crystallised to allow further determination.

Miscellaneous (5, 8, 14, 15, 59, 62, 69).

Nos. 5 and 59 are fine kaolin-clay, no. 8 is a loosely cemented breccia probably of recent origin, no. 14 and 15 are calcite deposits (tufa), no. 62 is a microcline crystal, no. 65 is a mass of markasite, no. 69 is a large crystal of phlogopite, denoting therefore a metamorphic limestone.

GENERAL REMARKS ON THE GEOLOGY OF THE AREA COVERED BY Mr. VISSER'S EXPEDITION.

Our geological knowledge of this region is very limited indeed. Towards the end of the last century specimens were collected in the valley of the Hunza as far up as the Kilik pass by Mr. ROBERTS and Mr. A. H. Mc MAHON and were described by C. A. Mc MAHON. Further, of the numerous specimens collected by CONWAY and described by BONNEY and Miss RAISIN, some are from the valley of the great Hispar glacier. Finally ROCCATI has described a few rocks and samples of sand from this same valley, which were obtained by Calciati during the Bullock-Workman expedition in 1908.

From the work of LYDEKKER on the geology of Kashmir, published when nothing was known about the Hunza district, and from the work of LEUCHS on Central Asia, who evidently based his statements on LYDEKKER's study, it was to be expected that these parts should be found to consist in general of granites and metamorphic schists. Mc MAHON, however, described a number of sedimentary rocks, so that it was already certain that the north western Karakoram must be of younger and less metamorphic structure than might have been supposed. Also in other parts more to the south east large tracts of sedimentary rocks were afterwards discovered.

Mc. MAHON found the following rocks in the valleys to the west of the Hunza valley and in this valley west and south of Hunza: granite (with veins of other granitic rocks), diorite, amphibolites, slates, quartzites, sandstones, marble and dolomite, and limestone. South of the Hunza valley and along the Hispar valley Conway and Calciati found the same rocks and in addition Kinzigite, sillimanite-schist, garnet-gneiss, phyllite, mica-gneiss and epidosite.

Mc. MAHON describes the Hunza valley from Hunza to the Kilik pass as follows: Hunza to Ata-abad, marble and mica-schist with dykes of granite and aplite; on to Pasu, mica-schist with granite veins and further along with slates; then up to Gircha, limestone with thin layers of dark slate; thence to Misgah, slatey schists veined by granite; to the Kilik pass micaceous grit, with granite intrusions; on the pass itself fine, slatey micaceous grit. North of Gircha the rocks are said to be younger, less metamorphic and with less steep dips. From these observations we must conclude that our no. 73 is a large intrusion of granite in mica-schist. The quartzite no. 7 had not yet been observed.

From the Hispar valley opposite to our no. 77 (garnetiferous, gneissic granite) ROCCATI describes a garnet gneiss without orthoclase or dark constituents and quartzite and a gneissic granite with biotite. The principal component of the Hispar-terminal moraine was biotite-granite. From the same side as our no. 77 he describes epidosite and mica-schist.

To the rocks already described this collection adds: lamprophyre, dacite, syenite porphyry and the minerals (macroscopically) microcline, phlogopite, molybdanite, markasite and a limestone with indisputable organic remains (bryozoa?).

As might be expected of rocks from such high altitudes the chemical weathering is but slight, wheras the mechanical weathering is very pronounced.

Only very little is to be deduced about the age of the rocks. LYDEKKER distinguishes the following elements.

A.	Alluvial	system.	
B.	Tertiary	„	
C.	Zanskar	„	(Cretaceous-Carboniferous).
D.	Panjal	„	(Prae-carboniferous).
E.	Metamorphic	„	(Palaeozoic and Archaean).

As the groups D and E contain no calcareous rocks or fossils we must suppose our area to be formed in large part by the Zanskar system. It even seems possible, that this is the only system represented as it contains in the neighbouring districts: limestone, dolomite, shale, slate, flaggy gneiss, garnetiferous gneiss, sandstones and granitoid gneiss, and granite intrusions. MC. MAHON arrived at the same conclusion; believing that besides a Carbo-Triassic series, there are also older and younger rocks present. He also points out that all the intrusive rocks are younger than the sediments and therefore post-Triassic. As they cut off the ends of the folded sediments they are evidently also younger, at least in part, than the tectonic movements. As the Karakoram range forms part of the tertiary mountain belt, I believe we may tentatively conclude that the intrusive phase was also tertiary.

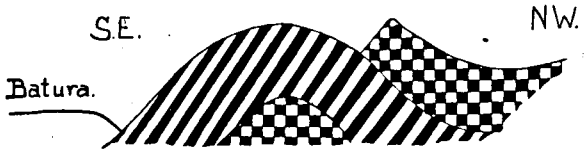

Fig. 2.

Section along the Hunza valley north of the Batura glacier.
After Mr. VISSER.

The next question is what may be deduced about *the structure of the Hunza district* and here again we can only suggest a few possibilities while awaiting more detailed information.

In the first place we have two sections taken by Mr. VISSER. Fig. 2 shows part of the Hunza valley just north of the Batura glacier and

shows dolomite and slate in a regularly shaped syncline and anticline, the axis of which may be anything but from N.W. to S.E. The sections in fig. 3 are from the eastern parts of the district and represent an exposure in a large intrusive granite mass in slates. Mc. MAHON mensions several measurements of strike and dip in the Hunza valley, which show these parts to have a west, to east dominating strike. Mr. VISSER also made three measurements in the Hunza valley at no. 1: strike N.W.—S.E., 72° S.; at no. 11: strike W.—E., 70° S.; at no. 16: strike W.—E., 70° N. The position of the dolomites and marbles taken as a whole also suggests a N.W.—S.E. direction with a less metamorphic zone to the north. We have, further, the section along the Hunza valley given by Mc. MAHON in his fig. 3, between Gulmit and Misgah, that shows the rocks with a steady northerly dip.

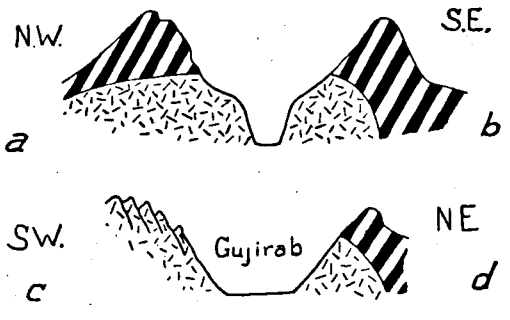

Fig. 3.
Sections from the valley of the Gujirab river (for directions see map).
After Mr. VISSER.

From these observations it would appear that the structure is mainly dominated by a direction N.W.—S.E. or W.—E., the direction of the whole Karakoram range. Minor folds occur and further steep dips and the almost complete absence of fossils also points to strong diastrophism. Mc. MAHON believes that isoclinal folds form an important feature of the structure and I am inclined to agree with him. It is quite possible, however, that not isoclinal folds, but an imbricate structure causes the regular east to west strike.

Whether these features are superimposed on block faults or were followed by these, or that they were the accompaniment of large overthrust sheets, remains for the present a matter of conjecture. Nothing, however, directly suggests an Alpine structure; neither do the large amount of intrusive rocks, combined with a comparative low degree of dynamometamorphism indicate Alpine conditions.

Finally I should like to point out that the important glacialogical results of Mr. VISSER's expedition have been laid down by himself in an article in Zeitschrift für Gletscherkunde. The great importance of the glaciers of the investigated area can readily be seen on looking at our map on which they have been marked. For all details I must refer the reader to this article.

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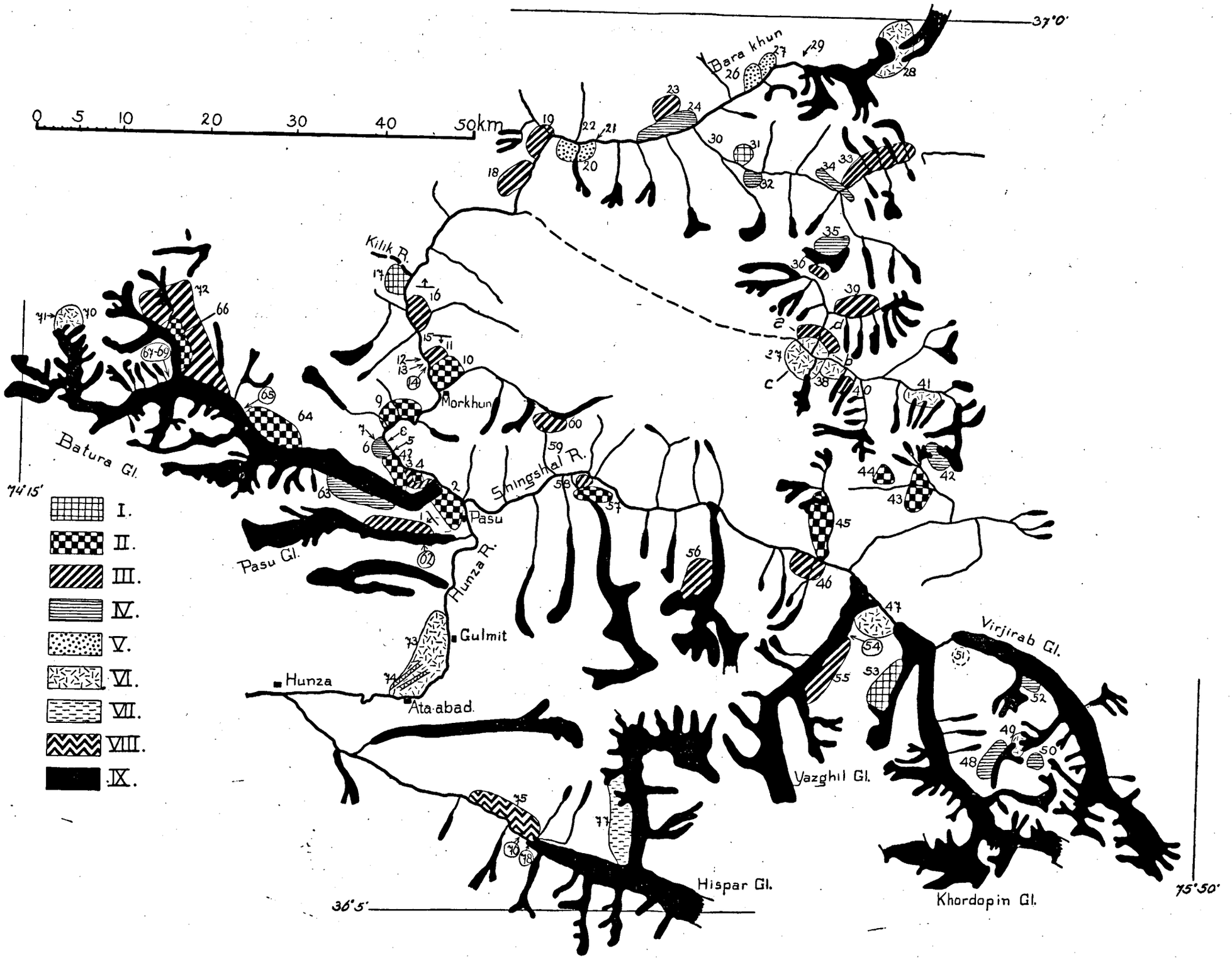
Map of the region traversed by Mr. PH. C. VISSER in 1925.



Map of the region traversed by Mr. PH. C. VISSER in 1925, Showing roughly the area's supposes by Mr. VISSER to be occupied by the rocks of which a sample has been examined.

I limestones, II dolomites and marbles, III slates, schists and phyllites, IV sandstones and quartzites, V extrusive and dyke rocks, VII dynamo-metamorphic plutonics, VIII crystalline schists, IX glaciers.

The numbers denoting specimens that were found loose have been encircled.

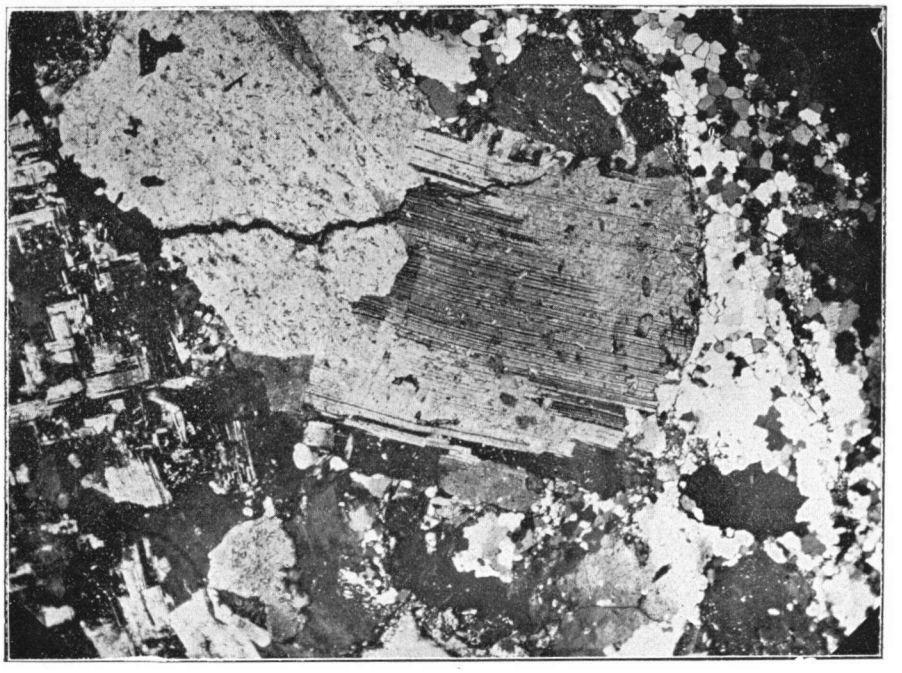


Fig. 1.

Crushed granite No. 79 (30 ×). Nicols crossed.

Fig. 2.

Hornblende dacite No. 27 (30 ×). Nicols crossed.

Fig. 1.

Vogesite No. 20 (50 ×).

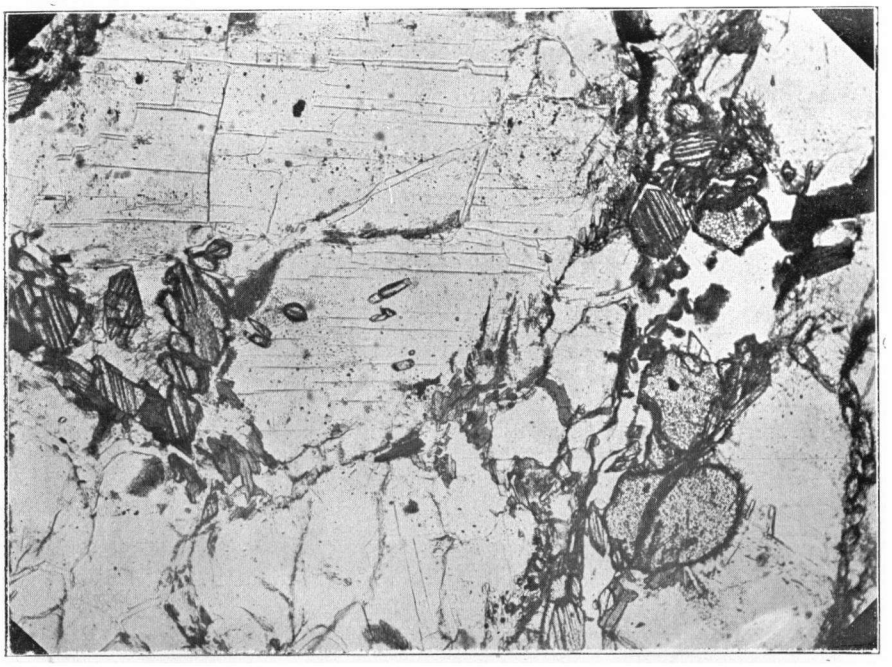


Fig. 2.

Sillimanite gneis No. 75 (68 ×).