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Geological notes on the area between Astor and Skardu (Kashmir)

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Geologia. — *Geological notes on the area between Astor and Skardu (Kashmir).* Nota di RAFFAELE CASNEDI (*) e CLAUDIO EBBLIN (**), presentata (***) dal Socio A. DESIO.

RIASSUNTO. — L'area compresa fra Astor e Skardu, finora geologicamente inesplorata, è stata attraversata lungo le valli di Urdung e Shigarthang al fine di ottenere informazioni sulla costituzione litologica della regione e sulle deformazioni che l'hanno interessata. Sono stati riconosciuti plutoni granitico-dioritici di dimensioni batolitiche (Stakchun Diorites e Banak Granites): essi sono stati messi in relazione con il corpo intrusivo paleogenico del Deosai che costituisce la maggior massa ignea compresa fra il massiccio del Nanga Parbat e il batolite assiale del Karakorum.

Nella valle di Urdung affiorano rocce con vario grado di metamorfismo (gneiss e marmi probabilmente derivati dalla formazione pre-cambriana di Shalkala, dioriti e meta-areniti). Nella valle di Shigarthang le formazioni sedimentarie prevalentemente calcaree sono da riferire almeno in parte al Cretaceo in quanto sembrano costituire la prosecuzione occidentale della Formazione di Burji affiorante a sud di Skardu. I maggiori eventi deformazionali sono stati distinti in due fasi, la seconda delle quali in relazione alla struttura del Nanga Parbat.

The Bara Deosai, a wide plateau of about 5000 km^2, lies at an altitude of 4–5000 meters between the Indus and Dras valleys. The northern slope of this plateau is cut by large valleys which are left tributaries of the Indus. Those in the vicinity of the Skardu, Satpura and Burji valleys, were visited by A. Desio who found there some fossiliferous limestones (Desio, 1965) which have been referred to the Cretaceous. This discovery permitted him to suggest a chronological correlation with the " Dras Volcanics " (De Terra, 1935) and the " Volcanic Series of Astor–Deosai " (Wadia, 1937) which outcrop south of the Bara Deosai.

The Deosai Mountains, which stretch at the northern end of the plateau, are cut by two wide valleys, the Urdung Gah and Shigarthang Lungma; both these valleys have been covered (the Urdung Gah by Ebblin and the Shigarthang Lungma by both Authors), in order to verify the extension of the above-mentioned Cretaceous formations and their relationship to the metabasites of Astor which have been interpreted as evidence of the upper Indus suture line between Indian and Eurasian Continents (Gansser, 1964; Desio, 1976; Casnedi, 1976). The whole area, as yet geologically unexplored, appeared unmapped on the Geological Map of Desio (1964) and as an area of " Paleozoic rocks, undivided " on the Geological Map of Pakistan (1964).

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LITHOSTRATIGRAPHY

The reconnaissance was made from west (Astor Valley) to east (Indus valley up to Skardu) up along the Urdung valley over the Banak Pass and down along the Shigarthang valley. The main lithotypes were therefore grouped according to their occurrence along the traverse. On the whole a distinction has been made among the following complexes:

1) Astor Metabasites
2) Urdung igneous-metamorphic Complex
3) Banak Granites
4) Shigarthang sedimentary Group
5) Stakchun Diorites
6) Katzarah Schists

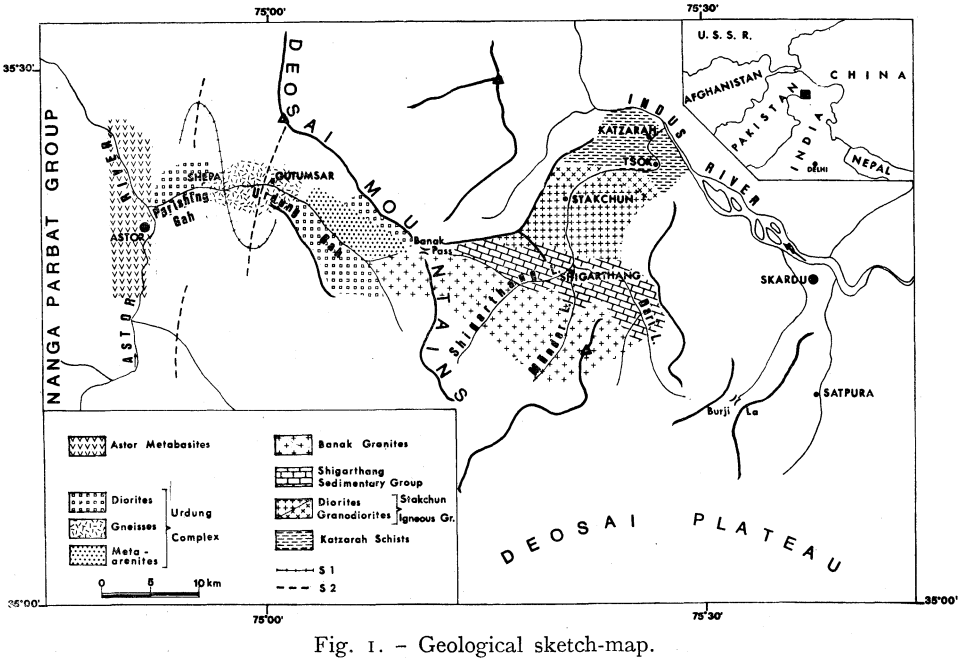

Fig. 1. – Geological sketch-map.

1) *Astor Metabasites.*

A complex of metamorphosed basic rocks outcrops along the Astor Valley. This complex stretches in a N–S direction parallel to the border of the Nanga Parbat complex and according to Misch (1949) is linked to the metamorphic processes of the latter. The N–S trend displayed by the rocks appears quite relevant from the structural viewpoint and petrological and geochemical studies of the various lithotypes are being carried out. The Astor metabasites comprise amphibolites (green schists facies), prasinites and metanorites with layers of marbles.

2) *Urdung igneous-metamorphic Complex.*

Many different rocks outcrop along the Urdung valley. Along its lower part (Parishing valley) igneous-metamorphic types are mostly exposed, while higher up sedimentary rocks (low-grade metamorphic) prevail.

Diorites are exposed east of the village of Astor up along the Parishing valley to the village of Shepa. They are generally coarse-grained and show no preferential mineral orientation; their most frequent minerals are plagioclase, often zoned, hornblende and hyperstene.

East of Shepa these rocks turn into a fine-grained garnet-bearing banded biotite gneiss which often displays folded feldspar-rich layers. Both compositional banding and cleavage are very steep, however, while the former surface exhibits a strike to the NW, the latter one has a northerly strike. The folds, concentric and with dimensions of the order of meters, are seen to bend the schistosity and earlier similar subisoclinal folds. Indeed, here the schistosity of the rock is not parallel to the compositional banding.

The above-mentioned rock type continues up to the intersection with Dirlung valley. Conformable pegmatitic layers, from one to 200 mm-thick, are often observed to be folded concentrically. Most of the larger folds are symmetrical; only occasionally are some minor, S-shaped asymmetric folds noticed.

East of Dirlung valley the biotite gneiss is abundantly cut by gabbroic rocks which occasionally exhibit a distinct banding due to the concentration of plagioclase in layers. All these rocks were subsequently intruded by granitic dykes conformable with the schistosity and then folded, often isoclinally.

Southeast of the village of Gutumsar the biotite gneisses give way to the more massive granitic rocks which rarely show a banding generally trending subvertically to the SSE.

A couple of hundred meters SE of the intersection with Harpo valley metasedimentary quartz-rich rocks are exposed and display a spectacular set of folds. These rocks are completely surrounded by quartz diorites. The compositional banding with the schistosity running parallel to it dips steeply to the south while the axial surfaces of the folds dip slightly less steeply to the SEE. Moreover, the rocks show an extraordinary rodding plunging steeply to the south.

The exposures of the quartzitic rocks are always cut by diorite or quartz diorite which appear to be the constituents of the mountains to the NE. Nevertheless, a row of exposures of quartzitic rocks seems to stretch along the right slope of the valley.

3) *Banak Granites.*

Granitc rocks form the peaks of the mountain chain at Banak Pass. This is a mica-hornblende granite with quartz, K-feldspar and plagioclase; zoned feldspars show cores of 40 % An with rims of 20 %.

The granites seem to outcrop to the south and it is likely that they extend all the way to the Deosai plateau (Deosai Granite of quoted Authors). Towards the north moraines composed almost totally of pebbles of diorites and of amphibolites stretch down from the peaks.

The valley on the NE side of Banak Pass down to the intersection with its uppermost main right tributary valley appears to have developed along the contact between the granite to the south and more basic igneous and lowgrade metamorphic rocks to the north.

4) *Shigarthang Sedimentary Group.*

A group of sedimentary formations is exposed in the Shigarthang zone and stretches along the valleys joining at Shigarthang village.

Owing to their WNW–ESE main strike, the best succession is observable along the Munder Lungma. The sequence is made of shales, thick layers of white limestones, often metamorphosed (marbles), thin bedded sandstones and siltstones, gray brownish fossiliferous limestones (similar to the Burji's limestones collected by Desio, 1964). Some pebbles of whitish algae-bearing limestones have been found, moreover, in the lower Munder valley (biomicrites with Solenoporaceae, Dasicladaceae, Trocholinae and foraminifera of shallow water in facies similar to the Malm-lower Cretaceous of Alpine-type).

At the confluence of the Munder Lungma with the Shigarthang Lungma the whole sequence, which stands vertical, crosses the valley in an ESE direction. From south to north there are a 60 m-thick horizon of calcareous schists, a 200 m-thick one of bluish limestone, a 20 m-thick white marble and then bluish limestone again, quite massive and intruded by gabbroic rock which becomes progressively more abundant.

Along the Shigarthang valley, upstream of the village, the succession displays a low-grade metamorphism and is rich in intrusions. The cleavage cross-cuts the compositional banding at a lower dip suggesting that the exposure might mark the southwestern overturned limb of an antiform.

The trend of the rocks is subparallel to the valley. Overlying the quartzite a layer of diorite conformably follows the rocks; then a spectacular phyllite is overlain by a very fine-grained, green quartzitic rock and by a cataclastic conglomerate.

The basic rocks stretch down the valley to the ESE, still subvertical, but a cleavage dipping moderately south always cross-cuts them. In addition, an occasional open cleavage which dips shallowly to the NNW is also present.

5) *Stakchun Diorites.*

About 1 km downstream of its confluence with the Dari Lungma, the Shigarthang valley is cut in a wide dioritic intrusive body.

In spite of its color index, which is rather dark (dark red), the dominant feldspar is andesine. Large crystals of green hornblende and brown biotite represent the chief mafic minerals. In its central part the principal stock

shows amphibols which are characterized by high pressure structures and garnets. The bulk gives the impression of a huge batholith with a core at Stakchun or slightly north of this hamlet. Pegmatitic dykes are very frequent.

The extent of the mass at the surface is about 10 km along the Shigarthang valley. Where the valley turns eastward a large fault separates the dark diorites from more acidic light-coloured diorites. The contact is marked by tectonic breccias. The composition of the latter rocks is not very different from that of the former ones; but the plagioclase is lime-poor in two different generations (albite and oligoclase); while green and white micas are abundant, epidote is rather frequent and quartz and K-feldspar are rare. This acidic diorite-granodiorite shows a certain degree of metamorphism; it is very hard and compact and the river which cuts a vertical gorge in it flows down a steep slope.

All mountain tops on the western side of the valley are formed by the same lithotypes as the Stakchun intrusion, and the detritus of the whole valley is made of dark red diorites.

The igneous body is bordered by contact aureoles made up of hornfels and allied rocks.

6) *Katzarah Schists.*

Down to its confluence with the Indus (Katzarah) the lower Shigarthang valley is cut in low-grade metamorphites made up of siltstones, shaly schists, slates and quartz-micaceous phyllites. The same lithotypes also seem to occur along the southern slope of the Indus between Katzarah and the Skardu airport, associated with upper grade metamorphites (biotite-garnet-labradorite gneisses, sometimes rich in sillimanite according to Zanettin, 1964). The schists are strongly folded and cut by a big fault which runs N–S through Tsok village. While in the lower valley the schists appear to be quite uniform, 4 km upstream of Tsok quartzitic sandstones rich in biotite and amphibole make 2–3 m thick layers in shaly schists; here the formation is vertical or even overturned. The whole sequence seems to be of flysch-like origin.

THE DEFORMATIONAL EVENTS

In the whole area two deformational phases can be detected. Each of these phases has yielded a set of folds which locally display characteristic features in terms of both shape and cleavage parallel to their axial surfaces. However the presence in the area of numerous intrusive bodies, the emplacement of which has locally deflected the trend of the planar elements of the rocks, makes a regional synthesis very difficult. Furthermore, the contact metamorphism has caused cleavages connected with the same deformational event to change their distinctive peculiarities over short distances making the task even harder.

However macroscopic and megascopic observations suggest that the rocks of the area were first affected by a deformational stage with a principal axis of finite shortening subhorizontal in a NNE–SSW direction. Subsequently the rocks of the western part of the area were deformed by a stage which displays a direction of maximum finite subhorizontal shortening in a roughly E–W direction. The latter event seems to be connected with the emplacement of the rocks of the Nanga Parbat. Thus the superposition of the two deformational phases has probably yielded refolded folds (fig. 2).

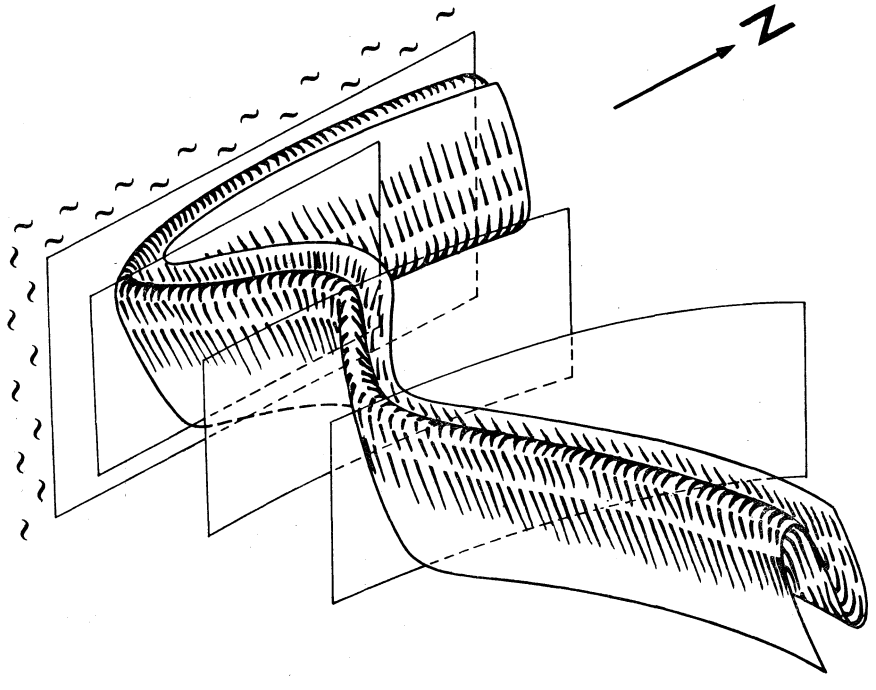

Fig. 2. – Sketch of the interference effects of subsequent stages of folding inferred to be present in the area east of the Nanga Parbat.

STRATIGRAPHIC CORRELATIONS

Owing to the scarcity of fossils due to the general metamorphism of the area, chronological data are very scanty.

The oldest rocks seem to be those outcropping in the Urdung Complex: the banded biotite gneiss observed between the village of Shepa and that of Gutumsar appears to correspond to the non-granitized schists of Salkhalas, possibly of Precambrian age (according to Wadia).

No evidence of Paleozoic or Lower Mesozoic rocks has been found along the traverse. On the contrary, Cretaceous rocks are quite widespread over large areas. Indeed, most of the Shigarthang Group should be Cretaceous and correspond, at least partly, to Desio's Burji Formation, as suggested by lithological and paleontological affinities. The general strike in the Shi-

garthang area is also directed toward the Burji's outcrops of Upper Cretaceous age. Near Shirgarthang pebbles of algae limestones can be dated as Malm-Lower Cretaceous but, as observed near Dras (Casnedi, 1976), it is possible that they had been reworked into younger sequences.

Even if devoid of fossils, the quartzites exposed in the upper Urdung valley could be Cretaceous sediments.

The flysch-like deposits of the Katzarah schists can be also interpreted as Cretaceous. They could be the NE limb of an antiform (the SE limb being the Shigarthang sequence), the core of which is formed by the Stakchun intrusion. Zanettin (1964) interprets the metamorphites outcropping near Katzarah as derived from Cretaceous volcanic-sedimentary rocks.

The Cretaceous seems therefore to provide different facies of shelf, flysch, ophiolitic trench (as in the Dras area) within the general framework of the Himalayan orogeny; however there is no evidence along the traverse of a direct connection between the Cretaceous formations and the Astor metabasites.

The igneous rocks of Banak and Stakchun ought to be younger intrusions. As already mentioned, the Banak granites extend southward to the Deosai plateau where they have been ascribed to the Paleogene by geological evidence (Wadia, 1957) and by radiometric age determinations (Desio, Tongiorgi, Ferrara, 1964). The Stakchun intrusion is probably related to the same main geological event.

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