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Geological reconnaissance in the Yasin Valley (NW Pakistan)

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Geologia. — *Geological reconnaissance in the Yasin Valley (NW Pakistan)*. Nota di RAFFAELE CASNEDI, presentata (*) dal Socio A. DESIO.

RIASSUNTO. — Nell'ambito del « Karakorum Geophysical Project » sono state condotte delle ricerche geologiche nella valle di Yasin che attraversa normalmente, in direzione N–S, le principali strutture del Karakorum occidentale. Particolare interesse riveste, nella parte alta di questa valle, la zona di Darkot, caratterizzata dall'affioramento di una serie sedimentaria del Paleozoico superiore compresa fra il batolite assiale del Karakorum e il cristallino dell'Hindu Raj Range. Detta serie sedimentaria viene suddivisa su basi litostratigrafiche e cartografata per la prima volta.

INTRODUCTION

The " Karakorum Geophysical Project " was effected in August 1975; Italian, Pakistani and Russian scientists and technicians completed a deep seismic sounding outline through the chains of the Western Karakorum. The Geophysical Project had its natural achievement during September 1975, with the execution of a series of geological itineraries programmed and directed by Prof. A. Desio and carried out by geologists of the Universities of Milan and Pavia. In particular, the Author carried out studies in the Yasin Valley which is parallel (at a distance of about 30 Km W) to the Ishkuman Valley where the geophysical stations were situated.

The Yasin Valley (1) is particularly interesting because of the outcrop of sedimentary series with slight metamorphism; moreover the valley offers a very good natural section because it is oriented N–S, perpendicular to the general development of the geological structures of Western Karakorum.

PREVIOUS INVESTIGATIONS

The Yasin Valley was completely covered by Hayden (1916), from the Yarkhun Valley through the Hindu Raj Range; Hayden identified igneous rocks (Darkot Pass Granodiorite), then a sedimentary series which was ascribed to the Permian-Carboniferous owing to the recovery in Darband of a rich fauna of Brachiopods and *Fusulinae*. Near Yasin, Hayden found Cretaceous Hyppurites and *Orbitolinae*.

The stratigraphical outline, given by Hayden, was completed by Ivanac, Traves and King (1956) with structural remarks; the Paleozoic outcrop

(*) Nella seduta del 13 dicembre 1975.

(1) The Author refers to the Yasin Valley from Darkot Pass to the confluence in the Gilgit River, even if the valley has various place-names along its course (Gakushi Bar as far as Darkot, Darkot Bar as far as Umalsit).

(Darkot Group) was explained as the northern flank of an anticline, produced by the intrusion and the raising of the batholith of the middle Yasin Valley. The above-mentioned Authors think that the Yasin Valley may be related to the axial granitic massifs of Karakorum (" Karakorum Granodiorite "). Ivanac attributes the outcrops south of the batholith to the same Darkot Goup.

The Yasin Valley was visited, only in the south of Darkot, by a Japanese expedition (Huzita, 1965); Huzita gives a tectonic interpretation different from Ivanac's; the igneous structure of the middle Yasin Valley is thought of as a secondary structure with an axis plunging eastward. The axial granite of Karakorum is therefore attributed to the " Darkot Pass Granodiorite ".

Observations near Yasin and south of it were carried out by Desio (1959) in order to point out the Cretaceous succession. The collected fossils have been studied by Rossi Ronchetti (1965) who ascribes them to the Lower Albian.

STRATIGRAPHY

Although the geological route lay essentially along the river-bed [2], except for the upper part of the valley, I was able to make observations which, owing to the absolute absence of vegetation and the evidence of outcrops, allowed for the drafting of a schematic geological map.

I can propose a generalized subdivision into:

– An Upper Paleozoic sedimentary series (Ivanac's Darkot Group) with various formations belonging to two distinct tectonic units.

– A Cretaceous series (Yasin Group), which is not described in this work because it has already been worked on.

– Crystalline formations of the Hindu Raj Range (partly Darkot Pass Granodiorite) of Tertiary Age [3].

– Miocene (?) Granodiorite of the middle Yasin Valley (Umalsit area) or Ivanac's Karakoram Granodiorite.

SEDIMENTARY FORMATIONS

The Upper Paleozoic Series outcrops in two different areas along the sides of the Umalsit batholith.

The northern side.

The series is more evident along the northern flank: the general attitude clearly dipping northward, permits the observation of the succession in cross

(2) As far as Barkulti, I was accompanied by dr. F. Forcella of the Geology Institute of Milan, and from Barkulti to Rawat by Mr. Sadakat Ali Jafry of the Geological Survey of Pakistan.

(3) The dates of the crystalline rocks are based on absolute age measurements on samples coming from formations of the Hunza Valley (Desio, Tongiorgi and Ferrara, 1964; Desio and Martina, 1972); the correlations between the above-mentioned formations and the formations of the Yasin Valley will be discussed because of. A lot of samples have been collected in order to verify these correlations and dates; but, further on bureaucratic difficulties, the samples are still in Pakistan; their study is therefore not possible for the present.

section along the upper part of the Yasin Valley and the subdivision of the following lithostratigraphic units from the bottom:

1) Shaly and phyllitic schists, dark grey, with brown weathering. It is possible to recognize a lower member (south of Darkot), more compact, with a metamorphism due to the intrusion of Umalsit Granodiorite; near the contact a thick net of dikes and light coloured acid sills originates from the batholith. The upper member (north of Darkot) is slightly metamorphosed, more incoherent and fissile. These schists are about 2000 m thick; their age is undetermined.

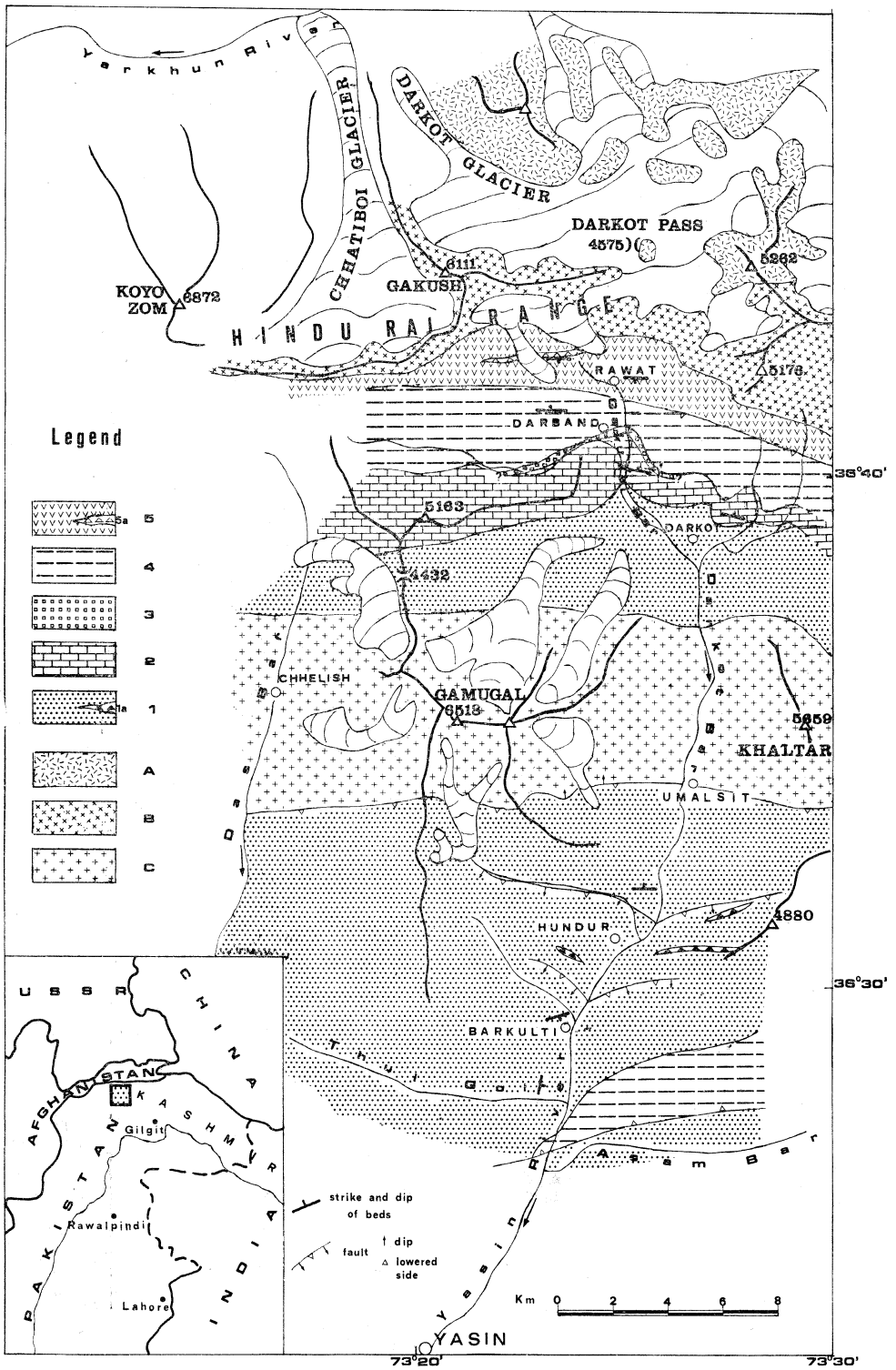
2) Bedded or massive dolomitic limestones, grey or reddish due to weathering, with frequent re-cemented calcareous-dolomitic breccias and scarce levels of grey shales and siltstones. The formation is intensely fractured and locally metamorphosed: there are crystallized layers with saccharoidal or microcrystalline texture (marbles). This formation is about 1600 m thick; the age is probably Carboniferous. The whole, on the sides, gives rise to subvertical, southward slopes with a clear relief on the schists below; the main water course (locally known as Gakushi Bar) cuts the formation in a characteristic gorge south of Darband.

3) Dark grey bedded limestones with a lot of nodules and lenses of blackish chert. It is a level of very limited thickness (some ten meters). Its age could be the transition between Carboniferous and Permian.

4) Alternations of levels of blackish, slaty limestones, often clastic, and shales with fissile siltstones. In particular, the sequence, from the bottom, along the eastern side of the valley, is as follows: 700–800 m of slaty limestones with shales; zone with thick folds with probable repetition of series; 300 m of limestones; 60 m of dark shales with siltstones and sandstones; 80 m of bituminous limestones; 100 m of fissile shales; 200 m of limestones interrupted at the top by a fault.

Many fossils in the slaty dark limestones can be observed on the western slope of the valley, near Darband, at the beginning and along the ascent which laterally steps over the Gakushi Bar gorge; it is the fossiliferous place already found by Hayden and characterized by the presence of *Fusilinae*, Molluscs, Brachiopods, Briozoa etc., attributed to the Lower Permian. This place should correspond to the lower part of the formation, not much over the contact with the cherty limestones.

Fig. 1. – Geological sketch-map of the Yasin Valley. LEGEND. *Sedimentary rocks*: 1) Shaly and phyllitic schists; 1a) red schists and marls. 2) Dolomitic limestones (Kilik Fm. of the Upper Hunza Valley). 3) Cherty limestones. 4) Limestones and shales (Gircha Fm.). 5) Slates, micaschists with porphyritic dikes (Misgar Slates); 5a) red schists. *Crystalline rocks*: A) Micaschists of the Hindu Raj. B) Igneous rocks of the Hindu Raj. C) Granodiorites of Umalsit-Gamugal (Axial Granodiorite?).


Yarkhun River
CHHATIBOI GLACIER
DARKOT GLACIER
DARKOT PASS
4575
6111
GAKUSH
5282
KOYO ZOM
6872
HINDU RAJ RANGE
RAWAT
5178
DARBAND
36°40'
5163
DARKO
4432
CHHELISH
GAMUGAL
6513
5859
KHALTAR
UMALSIT
4880
HUNDUR
36°30'
BARKULTI
Thuit Gol
Yasin
YASIN
73°20'
73°30'
Legend
5a 5
4
3
2
1a 1
A
B
C
USSR
CHINA
AFGHANISTAN
KASHMIR
Gilgit
PAKISTAN
Rawalpindi
INDIA
Lahore
strike and dip of beds
fault
dip
lowered side
Km 0 2 4 6 8

It is not possible to know the thickness of this formation because the upper part is cut by a fault which passes under Rawat; it should be over 2000 m.

The above-described succession seems to be in regular stratigraphic continuity. But the field observations on the carbonate series and on the clastic levels do not make it possible at present to establish the polarity or to test sedimentologicy paleontologicy. The following rocks outcrop to the north of the Rawat fault:

5) Slates, phyllites, micaschists, carbonatic schists, red and green schists with porphyritic dikes or sills, whose thickness can be 10 m or more. Compact micaschists outcrop to the north, in connection with the Hindu Raj Range granodioritic massif (from 3700 m of altitude to 3900 m along the path to the Darkot Pass). Other lithotypes develop from below 3700 m to Rawat. In particular the red schists form a level which is 100 m thick, outcropping on both sides of the glacier which slopes down towards Rawat. The exposed thickness is about 1500 m; the age is unknown.

The southern side.

Lithotypes whose correspondence with the formations mentioned is not verified, outcrop along the Yasin Valley included between Umalsit and the Thui Gol. In fact this southern area is more metamorphosed and tectonically complicated: it does not allow a clear subdivision on lithostratigraphical bases. Black slates with thin silty-arenaceous intercalations prevail to the north (Hundur), while to the south the intercalations are quartzitic-conglomeratic (Barkulti-Thui Gol). Variegated levels some ten m thick are frequen. They are formed by red and green schists (two levels can be seen on the mountain of 4880 m) or by red marls (near Hundur).

Very fractured limestones with irregular stratification outcrop in front of the Thui Gol confluence; the limestones are very developed on the eastern slope of the Yasin Valley (north of Asam Bar), while they are reduced on the western slope (perhaps for tectonic reasons) to few calcareous beds intercalated in the black slates. This formation probably corresponds to the above-mentioned calcareous formations of the Darband area.

Crystalline formations

We can describe only the macroscopic lithological aspects of the crystalline formations, because at present the samples are lacking.

These formations outcrop in two massifs divided by the Darkot sedimentary series. We can distinguish two formations in correspondence with the Hindu Raj Range:

A) Garnetiferous micaschists outcropping from the Darkot Pass toward the north: from the observations made from a mountain over the Darkot Pass, I could see that this formation forms the peaks which rise on the Darkot

Glacier and on the neighbouring glaciers toward the Yarkhun Valley. These peaks develop on the northern slope of the Hindu Raj and outcrop quite detached from the main range.

B) Igneous-metamorphic rocks of different nature, which form the main frame of the Hindu Raj Range, at least in the area near the Darkot Pass. White and pink granites, diorites, gneisses can be observed.

The Umalsit-Gamugal Crystalline Range is formed by more homogeneous lithotypes (C). The most developed is the coarse-grained biotitic granodiorite. The biotite is in various concentrations: it is more frequent along the flanks of the structure and it gives a characteristic lineation to the rock.

TECTONIC OUTLINE

The marked cuts of the valley allow the direct observation of the imposing tectonic phenomena linked to the raising of two batholiths: the Umalsit-Gamugal and the Hindu Raj Range; the tectonics of the interposed sedimentary rocks are directly determined by this raising.

The middle Yasin Valley perpendicularly crosses a granodiorite mass for about 6 Km from Umalsit toward the north. The Khaltar (east) and the Gamugal (west) rise along the valley sides, with subvertical walls (4).

Along the southern side, the contact is tectonic with a vertical course at the bottom, while, higher up, the granite is inclined with an oblique contact overturning the near formation. The dislocation goes E–W and it may be correlated eastward to the Holojut fault (Ishkuman Valley) according to Huzita's (1965) interpretation.

As already noted by Ivanac (1956), the raising of the batholith caused a fold of the sedimentary formations nearby. The northern flank is much more regular especially between Darkot and Rawat. The calcareous-dolomitic and shaly formations dip toward N–N 20 E and show inclinations between 40° and 70°. Various dislocations can be seen in the southern flank, with fault-plains dipping southward (near Hundur) or subvertical (near Asam Bar) and folds of different size and orientation.

The schist series outcropping to the N of Rawat shows similar raising determined by the Hindu Raj Range batholith as can be seen particularly following the red schist levels, with a vertical course over Rawat. Such a series is intensively tectonized with thick folds and is interrupted by a dislocation with a WNW strike under Rawat. This dislocation divides this tectonic unit from the one outcropping to the south.

While the Hindu Raj crystalline rocks outcrop in correspondence with the main Range which divides the Gilgit basin, in the south, from that of the

(4) Owing to communications of alpinistic expeditions, the granites seem to develop toward west till they join the main chain of the Hindu Raj Range.

Yarkhun in the north, the Gamugal-Umalsit structure is cut by the Yasin Valley as well as by other consequent parallel valleys (Das Bar, etc.). The structures show an E-W strike which forms an intermediate orientation (Himalaian syntax) between the Eastern Karakorum (SE-NW) and the Hindu Kush (NE-SW) directions. The faults and the axis strike of the folds are prevailingly longitudinal; it is not excluded that transversal or oblique tectonics may exist too, but, given the direction of the route covered, their evaluation is more difficult.

Correlations and general considerations

New names of formations have not been introduced in the stratigraphic description because this area is fit for possible correlations with the Hunza Valley in spite of the distance (more than 120 Km) and the scarcity of geological data in the interposed zone. The Hunza Valley has been studied recently and a subdivision with lithostratigraphic criteria has been introduced (Desio and Martina, 1972).

The sedimentary series of the Upper Hunza Valley is included between two igneous formations: the Axial Karakorum Granodiorite in the south, and the Giraf Syenite in the north. Some considerations, of a regional character, relative to the orientation of these igneous structures and the lithological analogies (not yet confirmed by microscopic study) lead to a hypothesis of a correlation between the above-mentioned igneous masses and those outcropping in the Yasin Valley: the Gamugal-Umalsit Granodiorite should correspond with the Axial Karakorum Granodiorite and the Hindu Raj Range Crystalline, even if it is more heterogeneous in its lithological composition, with the Giraf Syenite. The last correspondence, as said before, is not accepted by the Japanese Authors: they tend to correlate the Axial Karakorum Granodiorite with the Hindu Raj Range; the Giraf Syenite, moreover, has a more septentrional position, as clear in Desio (1963) and in the Geological Map by the same Author (1964). The absolute data on the samples collected in the two crystalline masses of the Yasin Valley could lead to the solution of the problem: the axial batholith is Miocene while the Giraf Syenite is Eocene (Desio, Tongiorgi and Ferrara, 1964).

As regards the interposed sedimentary series, while in the high Hunza Valley, chronologically, the stratigraphic succession is from north to south, in the Yasin Valley the succession is the opposite, if we do not admit a total overturning of the series. A good lithological analogy links the schists with porphyritic slates (5) and the Misgar Slates outcropping near the Giraf Syenite of the Hunza Valley. As regards the formations of the unit between the Rawat fault and the Gamugal-Umalsit Crystalline, the one with shaly-calcareous alternations (4) can be correlated even on paleontological bases (association with *Fusulinae*) with the Gircha Formation, as was already supposed by Desio, 1963. Taken as a whole, the formations underneath, (3) and (2), show analogies with the Kilik Formation. The calcareous-dolomitic formation (2)

even shows a likeness with the Gujal Dolomite to which it could be correlated if the series were overturned.

As far as the paleogeographic evolution is concerned we can observe a first phase with thick sedimentation in deep sea facies, with shales intercalated by quartzites and conglomerates; the metamorphism, to which they were subsequently, subjected masks their probable torbiditic origin linked to an active sedimentation derived from the erosion of prevailingly acid reliefs (Devonian?-Carboniferous). Then we have carbonatic facies of shelf and reef in subsidence during the Permian (Paleotethys). Evidence of similar facies is observed in the Cretaceous of Yasin; then the Tertiary raising follows in different phases, at present still in the course of development.

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