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Short notes on Tirich Mir geology (Hindu Kush range)

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Geologia. — *Short notes on Tirich Mir geology (Hindu Kush range)*. Nota di FRANCO FORCELLA, presentata (*) dal Socio A. DESIO.

RIASSUNTO. — Lo studio dei campioni raccolti durante due spedizioni alpinistiche al Tirich Mir (1965 e 1967, capospedizione K. Diemberger) ha permesso il riconoscimento delle seguenti associazioni litologiche: *a*) rocce intrusive di tipo granitico, granodioritico e tonalitico con locali intercalazioni di rocce con ugual composizione ma con tessitura gneissica o porfirica; *b*) rocce metasedimentarie costituite da meta-arenarie, meta-siltiti e filladi ascrivibili ai Black Slates paleozoici; *c*) filoni basici discordanti e/o ammassi porfiritici iniettati in entrambe le associazioni litologiche sopraindicate.

Il confronto con i dati reperibili in letteratura suggeriscono di ascrivere il corpo granitico del Tirich Mir ad una culminazione del batolite della catena dell'Hindu Kush orientale di deformazione eoalpina. Più ardua è un'esatta attribuzione dei Black Slates data l'enorme diffusione di facies litologiche simili in zone tettoniche diverse ed in intervalli cronostratigrafici diversi.

INTRODUCTION

The area under examination is located in the north-western part of Pakistan comprised between the Arkari and Mastuj rivers.

From a geological point of view this area belongs to the tectonic zone of the eastern Hindu Kush which was involved in the early-alpine tectogenesis and where intrusive granitic batholiths are recorded. This tectonic zone continues southwards in Nuristan (Desio, 1977).

During two expeditions in 1965 and 1967, the latter of which reached the top of the Tirich Mir (altitude 7690 m), the climbers collected a set of samples which were kindly made available to me for petrographic studies. A geological sketch-map of the surveyed area is included in the expedition report of Diemberger (1968).

DESCRIPTION OF LITHOLOGICAL ASSOCIATIONS

The lithological associations occurring in Tirich Mir and neighbouring mountains can be broadly subdivided as follows:

– intrusive rocks of granitic, granodioritic and tonalitic types with local intercalations of rocks of similar composition but with gneissose or porphyric texture;

– meta-sedimentary rocks, through which those previously mentioned intruded, made up of meta-sandstones, meta-siltites and phyllites, attributable to the Paleozoic " Black Slates " formations (Norin, 1974);

(*) Nella seduta del 16 dicembre 1978.

– unconformable basic veins and/or porphyric masses injected into both aforementioned lithological associations.

Thin sections of granite samples (65–6, 65–24, 67–2 [(1)]) show an ipidiomorphic granular structure with steady association of biotite and white micas. The K-feldspar is in large crystals with Carlsbad twinnings and perthite exsolutions; plagioclase crystals have polysynthetic twinning according to albite or albite-Carlsbad laws, with irregular zoning showing a more calcic core, underlined by a deeper alteration, and perthitic intergrowths along the edges; heterodimensional quartz crystals have undulose extinction and sutured boundaries. Brown mica prevails over white micas, often partially chloritized with sagenitic rutile, its laminae studded by pleochroic halos of minute crystals of zircon; with these are associated laminae of white micas showing a decussate structure or microimplications due to repeated alternations along the basal planes.

In addition to rocks with an ipidiomorphic structure others, of similar petrographic composition, show a clearer porphyric structure (65–5, 65–31) because of the presence of large phenocrystals of centimetric size of plagioclase, quartz and biotite, imbedded in a medium-grained (0.3–0.5 mm) groundmass of granitic composition.

Plagioclase phenocrystals are idiomorphic, zoned, and have albite-Carlsbad twinnings, whereas quartz is represented by allotriomorphic crystals or by an aggregate of grains with sutured boundaries. From a descriptive point of view these rocks can be called dacites and probably suggest the presence of crystallized granitic bodies under more superficial conditions.

With granitic-type rocks are associated, probably as differentiated veins, less acidic terms such as leucotonalites (67–17, 67–23) and leucogranodiorites (67–18); they generally show a cataclastic structure with partial recrystallization. The K-feldspar is less abundant, in scattered crystals with spotted extinction; the plagioclase prevails in subidiomorphic zoned prisms, with a more calcic core (50 % An) and polysynthetic twinnings; quartz occurs in heterodimensional crystals, sometimes minutely granoblastic, caused by polygonalization as a result of strong mechanical stress. White micas show deformed laminae, often corroded from leucocratic phases, with kink-bands; large chloritic laminae probably derive from a complete transformation of previous biotites. Zoned tourmaline, epidotes, sphene, apatite and zircon are the accessory minerals.

A definite gneissose texture is present in other samples (67–21, 67–24) where laminae of brown biotite add up to phacoides within which the single laminae, partially regressed to chlorite, maintain a decussate structure; brown biotite is preferentially associated with Fe-epidote whose abundance, however,

(1) The convention adopted consists of two numbers for each sample; the first points out the year of collection and the second is the progressive number given by Mr. Diemberger.

is inconsistent with the accentuated zoning still present in plagioclase; this zoning is underlined by brownish transformation products in the more calcic cores and by myrmechitic structures in more sodic peripherical rims. The K-feldspar is present in a small amount and mostly as microline; quartz is granoblastic with a polygonal structure.

The top of Tirich Mir is constituted by rocks with a gneissose structure (67–21 [(2)]). Gneissose rocks also occur in the Arkari Valley and are likely to represent, together with gneissic amphibolites, tectonic wedges of the basement outcropping among the surrounding Black Slates.

Basic veins or hornblende and plagioclase " porphyrites " and augite " porphyrites " [(3)] intrude into both the granitic body (65–26) and the enveloping Black Slates.

These rocks have a porphyric structure with phenocrystals in the millimetric range constituted by mafic minerals (pyroxene or amphibole) and clearly zoned plagioclases with a more calcic core deeply transformed in sericitic felts sometimes joined by epidotes; the carbonate occurs as a later phase.

The sedimentary sequence is constituted by terrigenous rocks ranging in size from very minute to sandy, always affected by a low-grade regional metamorphism so that they are now attributable to meta-sandstones, meta-siltites and schists of variable composition. In some cases a retrograde metamorphism is marked by the recession of biotite into chlorite (with sagenitic rutile) and by the sericitization of feldspars.

Close to the granitic batholith these rocks are intersected by unconformable veinlet-swarms with a quartzitic or granitic composition. From the thin sections examined it is impossible to determine if the intrusion of the granitic body produced a thermal metamorphism. One can notice only an enrichment of zoned tourmaline crystals in the salbands of the injected veinlets or within the schists lying adjacent to the granitic body.

The quartzitic meta-sandstones (being transition to quartzites and quartz-rich schists) characterized by and advanced mineralogical maturity do not show a good textural maturity an sorting, form indices and matrix percentages do not show consistent uniformity in the thin sections examined (65–23, 67–6, 67–10).

In some cases the metamorphic action produced the suturing of the various clasts or the development of a granoblastic structure with triple joints. White micas, zircon, tourmaline and opaque minerals occur in a very small amounts as accessory phases; the carbonate is present as a later phase in the fractures of the rock.

(2) According to Mr. Diemberger this sample is representative of the type of rocks from the top: in this case some changes must be introduced into his geological sketch-map (Diemberger, 1968, pag. 145).

(3) Field data are too poor to establish if those rocks belong to unconformable basic veins or are massive rock bodies.

With the increasing amount of clasts of feldspathic nature the rock is defined as a feldspathic meta-sandstone (65–3, 65–14, 65–30, 65–28). The texture becomes more visibly schistose because of the increasing abundance of thin mica flakes, mostly isooriented, condensed into thin beds or in elongated phacoids. The trend of schistosity probably underlines the original sedimentary lamination made up by the intercalation of small lenses and/or layers of pelitic nature within coarsely grained layers.

Only in sample 65–21 is the composition essentially carbonatic with a granoblastic structure and zoned schistose texture; another sample (65–2) collected closer to the granitic intrusion and intersected by small veinlets of acidic composition can be attributed to an amphibolic schist.

Schistosity becomes more and more evident with decreasing grain sizes (65–7, 67–7, 67–26) and intersects the original sedimentary lamination under variable angles; it comes out shifted with the formation of similar folds of millimetric size.

Phyllites (67–16, 67–19, 67–31) show textural characteristics similar to those of the meta-siltites described above, except for the smaller grain size. A common characteristic is the presence of large chloritic laminae transversally arranged with respect to the schistosity (0.5–1 mm); they are supposed to be the products of a retrograde metamorphism on prekinematic aggregates of a coarser size than the sorrounding matrix, which cannot any longer be positively recognized. The very small opaque granulations, concentrated preferentially in the mica-rich layers, are responsible for the dark grey to black colors of the rocks.

Correlations and comparisons

Because of its geographical and structural setting the Tirich Mir pluton can be compared with the Hindu Kush batholiths on the one hand and with those from the Western Karakorum on the other.

Comparison on the basis of petrographic characteristics is not very diagnostic, both plutonic bodies and batholiths being very similar in composition. Radiometric ages may instead serve to differentiate such bodies. An absolute age of 115 ± 4 M.Y., then Early Cretaceous, was obtained from a sample of granite belonging to the Tirich Mir (see Desio *et al.*, 1968). This age would clearly differentiate the Tirich Mir granitic body from the Western Karakorum batholithes dated recently as old as 19 to 56 M.Y. (Casnedi *et al.*, 1978).

Nevertheless Gamerith and Kolmer (1973) , on the basis of the chemical compositions, suggested that the granitic body of the Tirich Mir, attributed according to them to the Cenozoic, can be related to the Western Karakorum batholiths (op. cit., see geol. sketch-map and Fig. 4 c); however, they remain separate from the Tirich Mir, the Kishim Khan–Noshaq pluton outcropping northwards of it.

The absolute age of the Hindu Kush granites is still poorly documented. Only the small granodioritic body from Zebak (about 50 km NW of the Tirich Mir) was dated, and has an age comprised between 86 and 93 M.Y. (Desio *et al.*, 1964, 1975). No age is available for the Munjam granite (about 260 km SW of the Tirich Mir) which is attributed to the Oligocene on the Afghanistan geological map.

Taking into account the major regional faulting systems which delineate two different tectonic zones, the Western Karakorum eastwards and westwards the Eastern Hindu Kush, respectively [4], it seems more likely that the Tirich Mir granitic body may be related to the Eastern Hindu Kush, in agreement with what has already been suggested by Desio *et al.* (1968).

Concerning other useful elements for correlations, it is worth mentioning the dacites (65-5, 65-31), even if the field data on their relationships with the contiguous rock units are scarce and do not allow reliable statements. The climbers mention " xenoliths into the granites close to the contact " [5]. Such dacites could be considered analogous to the intrusions of dark igneous rocks injected ubiquitously into the Little Pamir Slates (Hayden, 1916, pag. 301) which, according to Walker, who studied Haydin's samples, should be regarded as dacites and quartz andesites.

Desio *et al.* (1968) correlated the aforementioned rocks with the porphyritic textured plagiotrachytes from the close Wakhan region, where they constitute some sills in the transitional zone between the Qala Wust Gneiss and the Khandut Black Slates.

The stratigraphic position of the Black Slate formations from the Tirich Mir within the regional succession is difficult to establish: in fact, similar lithothypes are widespread over very large now tectonically differentiated areas (Karakorum, Hindu Kush, Pamir) and occur several times within the Paleozoic to Lower Mesozoic stratigraphic sequence. Moreover, on a more local scale according to the available descriptions, and in agreement with what has been already noticed by Norin (1974, pag. 258), samples of Black Slates from Chitral, the upper Hunza Valley and Baltoro show a strong structural as well as petrographical similarity.

At the present stage of our knowledge only lithological similarities and no correlations between the metasedimentary rocks described above and units from other areas can be evidenced, in particular with the Kandut Slates formation outcropping slightly farther north in the Wakhan area (which has been already tentatively correlated with the Misgar Slates from the upper Hunza Valley, Desio *et al.*, 1968). Moreover, both units are crossed by dikes and sills constituted by porphyrites and rocks with a porphyritic texcture.

(4) See tectonic scheme by Desio (1977, Fig. 1).

(5) In all probability with the enveloping Black Slates.

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