Geological Outline of Neelum Valley (Azad Kashmir, NE Pakistan)

POSTER

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More than fourteen hundred square km area is being intensively mapped at the scale 1:50.000, between the Neelum river and the watershed separating the Neelum Valley from the Kaghan Valley. New ground is broken in the sense that it is the first time that a systematic regional mapping is undertaken in a zone, which is often forbidden to foreigners due to the political instability between the Indian and the Azad Kashmirs. Geological data collected since 1991 greatly improve the understanding of the Higher Himalayan Crystalline (HHC) of Neelum Valley and relatively complete previous field observations made by other authors near the Hazara Kashmir Syntaxis.

Stratigraphy

In the HHC unit of Neelum we have distinguished a **basement** and a **cover**.

The **basement** comprises a thick sedimentary sequence intruded by leucocratic garnet-bearing granitoids of pre-Himalayan age (presumably Early Paleozoic). The sedimentary rocks consist of a monotonous alternance of psammitic to pelitic schists with minor intercalations of impure marble. The contact between the granitoids and the schist is generally tectonized. Evidence of intrusive contacts are still observable: spotted schists with andalusite relics and skarn in the Jagram-Kalapani area and magmatic contact in the Shardi-Surgun-Gumot area.

Basaltic dykes cross-cut at low angle the regional banding of the basement.

The **Cover** has been divided into three units (from bottom to top):

- unit A: a siliceous sequence made of impure quarzites associated with minor metaconglomerates, and a thick sequence of kyanite-bearing paragneisses.
- unit B: an alternance of impure marble (frequently ruby-bearing), calcschist, and amphibolite.
- unit C: a thick sequence made of graphite-bearing garnet micaschists.

The conctact between the basement and the cover is believed to be an old tectonised stratigraphic unconformity. The question remains open due to the lack of well accessible outcrops.

Metamorphism

The regional Himalayan metamorphism of the studied area has been shown to be of Barrovian type (from biotite-chlorite zone to sillimanite zone) with an early eclogitic stage present only in the Shardi-Surgun-Gumot area.

In the cover sequence of the Shardi-Surgun-Gumot, a typical kyanite-staurolite assemblage of high temperature amphibolitic facies, is wide-spread developed. Beside this assemblage, a few relics of previous prograde metamorphism are present. Some chlorite crystals, discordant on the schistosity, attest for a not intensive retrometamorphism in the green schist facies.

The sedimentary sequence of the **basement**, well developed in the Jagram-Kalapani area, shows a metamorphic zonation consisting in a biotite-chlorite zone, a kyanite-staurolite zone and a sillimanite zone.

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Rocks with biotite-chlorite assemblages were encountered near Kundalshahi. These assemblages may represent relics of a prograde phase of Barrovian metamorphism or a pre-Himalayan low grade phase associated with the emplacement of the granitoids.

Kyanite-staurolite bearing assemblages are not common on the field. The typical assemblage consists in white mica, biotite, garnet, epidote and amphibole. Kyanite and staurolite, visible only in thin section, are associated with the spotted schists. They growth on old andalusite grains, already replaced by white mica and quartz. This suggests that the time of re-equilibration to the amphibolitic condition was relatively short.

Sillimanite appears in the sedimentary sequence with anatectic rocks (agmatites) as small needles or flakes. It is associated with the first appearance of K-feldspar.

In the granitic rocks, the old magmatic white mica is partially or totally replaced by fibrous sillimanite. In the migmatitic gneisses, sillimanite coesists with kyanite and an incipient melting appears in small (dm) shear zones .

In the Shardi-Surgun-Gumot area, basaltic dykes cross-cutting the migmatitic gneisses are characterised by eclogitic assemblages (omphacite + garnet). These eclogitic assemblages are only preserved in the centre of the dykes. Sometimes, they are partly replaced by later discordant growth of hornblende and biotite and along the border zone, by green schist assemblages.

Eclogites, in the same metamorphic setting, have been found also outside the mapped area. They appear in the Lilian Basti area (Kaghan Valley) as strongly deformed pillow lavas and, in Kel area, as dykes cross-cutting migmatitic rocks.

Eclogitic assemblages are not found in the Jagram-kalapani area where the basaltic dykes show an amphibolitic paragenesis with relics of the magmatic texture.

The fact that eclogitic assemblages have been found in the Shardi-Surgun-Gumot area and that they are absent in the Jagram-Kalapani area, suggest a different metamorphic P-T-t path for both of them.

Structure

The basement- and the cover rocks of the Higher Himalaya Crystalline of Neelum Valley illustrate the prevalent ductile nature of a complex Himalayan deformation. Four successive phases of folding have been distinguished on the field in both mapped areas ("Jagran-Kalapani" area and "Shardi-Surgun-Gumot" area).

An over spread penetrative schistosity (S1), derived from the preferred orientation of platy and acicular minerals lies subparallel to the banding. It is probably related to a large ductile shear at deep level, associated with isoclinal and intrafolial foldings (F1). This first phase (F1) developed an East oriented stretching lineation (L1) well expressed in some granites and amphibolites of the "Jagran-Kalapani" area.

A second phase (F2) folded isoclinally the main schistosity and the banding. This phase brought off the transposition of the basement and cover sequence initiated by F1.

Later, a third phase of tight folding crenulated the main schistosity to develop a crenulation cleavage S3, 15° to 25° oblique to the banding.

The geometry of all these structures is disturbed by the fourth folding phase, which produced open folds repeated with a wavelength of several kilometres. Their axial planes are subvertical and strike NE-SW. From place to place, the fold axes are subhorizontal, gently plunging to the NE or to SW. This suggests further gentle deformations expressed in the rocks with a very large wavelength (>20 km).

We mention finally a set of small early deformations including kinking of the previous structural planes, different fracture sets and local subhorizontal thrust planes, constantly characterised by a displacement of the roof to the SW.