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PERMIAN AND TRIASSIC OF THE RUSHAN-PSHART ZONE (PAMIR)

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Riassunto. Nel nodo strutturale del Pamir, tre blocchi tettonici isolati, Rushan, Pshart e Dunkeldyk, sono convenzionalmente raggruppati nella zona Rushan-Pshart. Per le loro differenze stratigrafiche e strutturali, è bene considerarli separatamente. Il presente articolo tratta essenzialmente del blocco Pshart, che viene suddiviso in Pshart Occidentale ed Orientale. Questo tipo di suddivisione si può applicare anche al blocco Dunkeldyk. Una rassegna delle caratteristiche delle formazioni vulcano-sedimentarie di età Paleozoica superiore e Mesozoica conferma che esse si sono formate in un regime estensionale, accompagnate da vulcanesimo basaltico. I modelli precedenti tuttavia postulano l'esistenza di una vasta area oceanica che separava lo Pshart Orientale dal SE Pamir durante il Permiano superiore, il Triassico ed il Giurassico. Questo oceano si sarebbe chiuso durante il Cretaceo inferiore. Invece l'interpretazione presentata in questo articolo privilegia l'esistenza di una via d'acqua più piccola, che si chiuse prima del Cretaceo.

Abstract. Three isolated tectonic blocks Rushan, Pshart, and Dunkeldyk have conventionally been grouped into the Rushan - Pshart zone. Because of stratigraphic and structural differences, they should be considered separately. The present paper mostly deals with the Pshart block, which is subdivided into East and West Pshart. This kind of subdivision may also be applied to the Dunkeldyk block. A summary of the characteristics of Upper Paleozoic and Mesozoic volcano-sedimentary successions confirms previous hypotheses, which suggest that these sequences have formed under crustal extension, accompanied by basaltic volcanism. These earlier models, however, postulated the existence of a vast oceanic area separating the East Pshart from SE Pamir during Late Permian, Triassic, and Jurassic. This ocean closed during the Early Cretaceous. The interpretation preferred in this paper suggests a narrow sea-way, which closed before the Cretaceous.

Introduction.

V. I. Dronov (1964) was first to single out the Rushan-Pshart zone as an independent structure between the Central and SE Pamirs. In a number of short papers he and his co-workers also supplied a brief characteristic of the Paleozoic and Mesozoic volcano-sedimentary sequences within this zone (Dronov, 1963, 1990; Dronov & Gavrilova, 1990, 1991; Dronov & Budanov, 1991). Tectonic and paleogeographic interpretations of the Rushan-Pshart zone were introduced by Karapetov et al. (1975), Shvol'man (1978), Pashkov & Shvol'man (1979) and Shvol'man & Pashkov (1986). These authors suggested that the basaltic volcanism which is typical for this zone is evidence for rifting along the Gondwana margin, ultimately leading to an oceanic basin. As a result, the Rushan-Pshart zone was interpreted as a major tectonic suture, stretching into Afghanistan and Tibet and marking the consumption of a Permo-Triassic ocean, closed during the Jurassic. In some paleotectonic reconstructions, the oceanic basin is more than 2000 km wide (Sengör, 1990).

Although such views on the Rushan-Pshart zone are now almost universally recognized (Girardeau et al., 1989; Burtman & Molnar, 1993), their substantiation cannot be accepted as complete. I here present data collected during field seasons between 1971 and 1973 on the northern slope of the Pshart Range, with emphasis on Paleozoic and Mesozoic units. Data collected by V. I. Dronov are also incorporated, as they match well, with rare exceptions, the authors observations.

In accordance with Dronov (1964), the Rushan-Pshart zone is grouped, from west to east, into three unconnected, lens-shaped tectonic blocks: Rushan, Pshart and Dunkeldyk (Fig. 1, 2). They outline the boundary between the Central Pamir and SE Pamir. All these blocks have Permian volcanics in common. Moreover, Triassic volcanic rocks occur both in the Pshart and Dunkeldyk blocks. This common occurrence of Permo-Mesozoic volcanic rocks was the main evidence provided to group the three blocks in the Rushan-Pshart Zone (Dronov, 1964). However, this approach can be questioned. Firstly, two separate zones with quite different Permian and Triassic sections are distinguished within the Pshart and Dunkeldyk blocks. Secondly, the succession of the supposed Permo-Triassic deposits of the Rushan block is peculiar and hardly correlates with the age-equivalent rocks of the Pshart and Dunkeldyk blocks.

Because of these differences, the Rushan block should be more properly considered as a separate zone. Furthermore, two distinct tectono-stratigraphic units can be discriminated in the Pshart and Dunkeldyk

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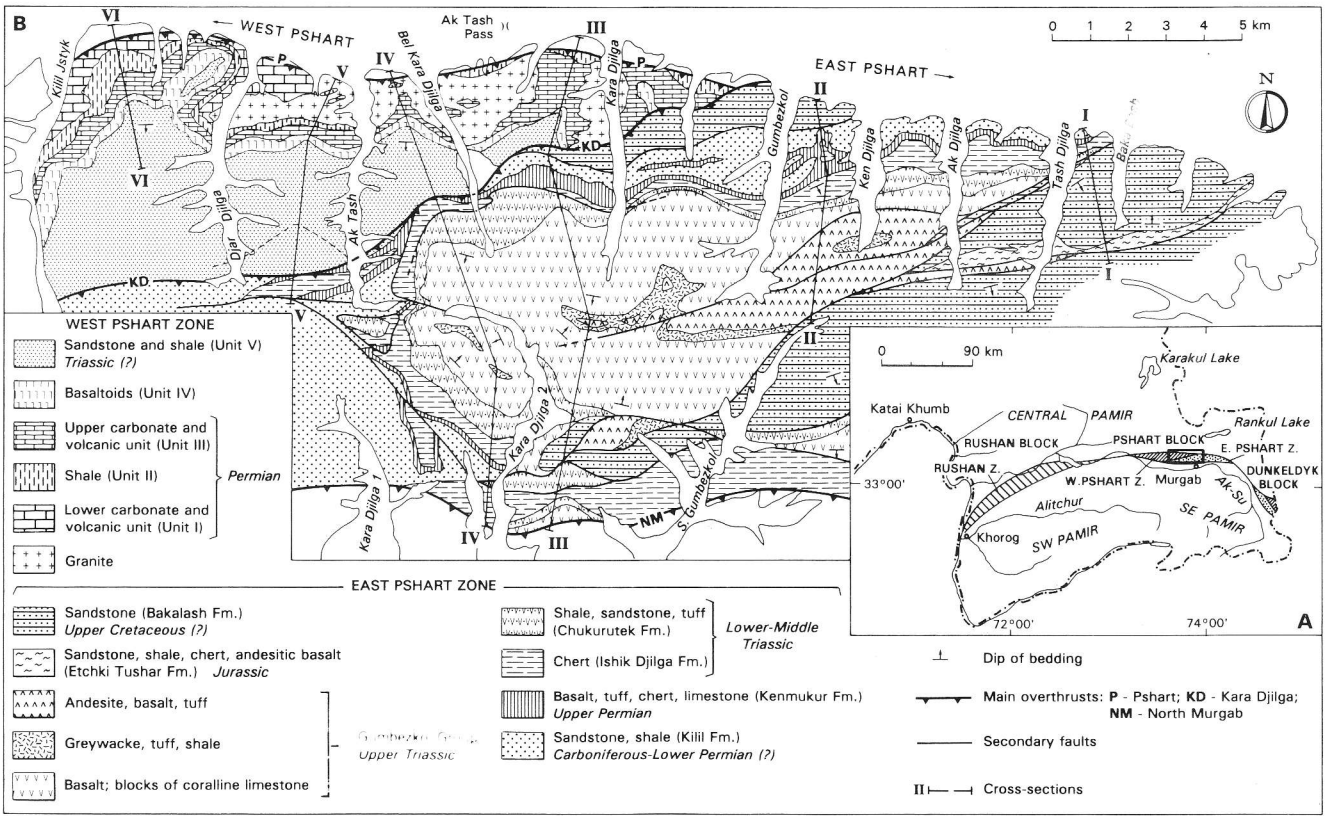

Fig. 1 - Schematic geological map of the East part of the Pshart Range.

blocks. These were distinguished for the first time in the Pshart block and named the West Pshart and East Pshart zones (Leven, 1973; Paskov & Shvol'man, 1979). Later, Dronov (1990) identified them also in the Dunkeldyk block, where they are described as the North Rushan-Pshart and South Rushan-Pshart zones.

The present paper is devoted to the description of the Pshart block, where they are better exposed and studied. A brief description of the Rushan and Dunkeldyk blocks is also added, in order to make comparisons with the Pshart block.

The Rushan block.

According to Dronov's data (1963), the base of the sections consists of metaquartz-feldspathic sandstone, phyllite and micaschist of the Raumid Formation (800-1000 m) (Fig. 3). They are overlain by the marbles of the Shuvdara Formation (200-250 m). Carbonaceous shale (300 m) of the Pardzhavandara Formation follows. The succession ends the Bardara Formation consisting of quartzo-feldspathic sandstone, phyllite, claystone and carbonaceous shale (more than 1500 m). Diabase, 100 m-thick, including lenses of organogenic limestones is found at the contact with the Pardzhavandara Formation. Other diabase horizons are encountered higher in the section as well. In the middle part of the Bardara Fm. thin interlayers of felsic tuff are observed.

Fossils have been found in the limestone within the diabases. Upper Permian fusulinids (*Neoschwagerina* cf. *margaritae* and *Parafusulina* sp.) and corals (*Heterocoenites variabilis* and *H.* cf. *crassus*) were identified. These fossils would suggest a Permian and a possibly Triassic age for the Bardara Fm., whereas the underlying formations might be attributed to the Carboniferous and Permian. However, according to our observations, the diabase with organogenic limestone lenses do not belong to the stratigraphic succession, but occur as tectonic slices between the Pardzhavandara and Bardara Fms. (Fig. 3). This fact hampers a firm age assignment to the Bardara Fm. and makes premature the correlation of this part of the Rushan block with the Permian and Triassic deposits of the Pshart and Dunkeldyk blocks. Consequently, the Rushan block should be considered separately.

The Dunkeldyk block.

Characteristic sections have recently been described by Dronov (1990) and are summarized here, using his nomenclature. Two zones are distinguished within the Permian and Triassic sections. The first is the North Rushan-Pshart zone, which is subdivided into two groups, the Chottukoi and Bel'sk groups.

The Chottukoi Group is made up of crystalline rocks in amphibolitic facies and quartzo-chloritic and sericitic schist, marble, mafic volcanites, and chert. The

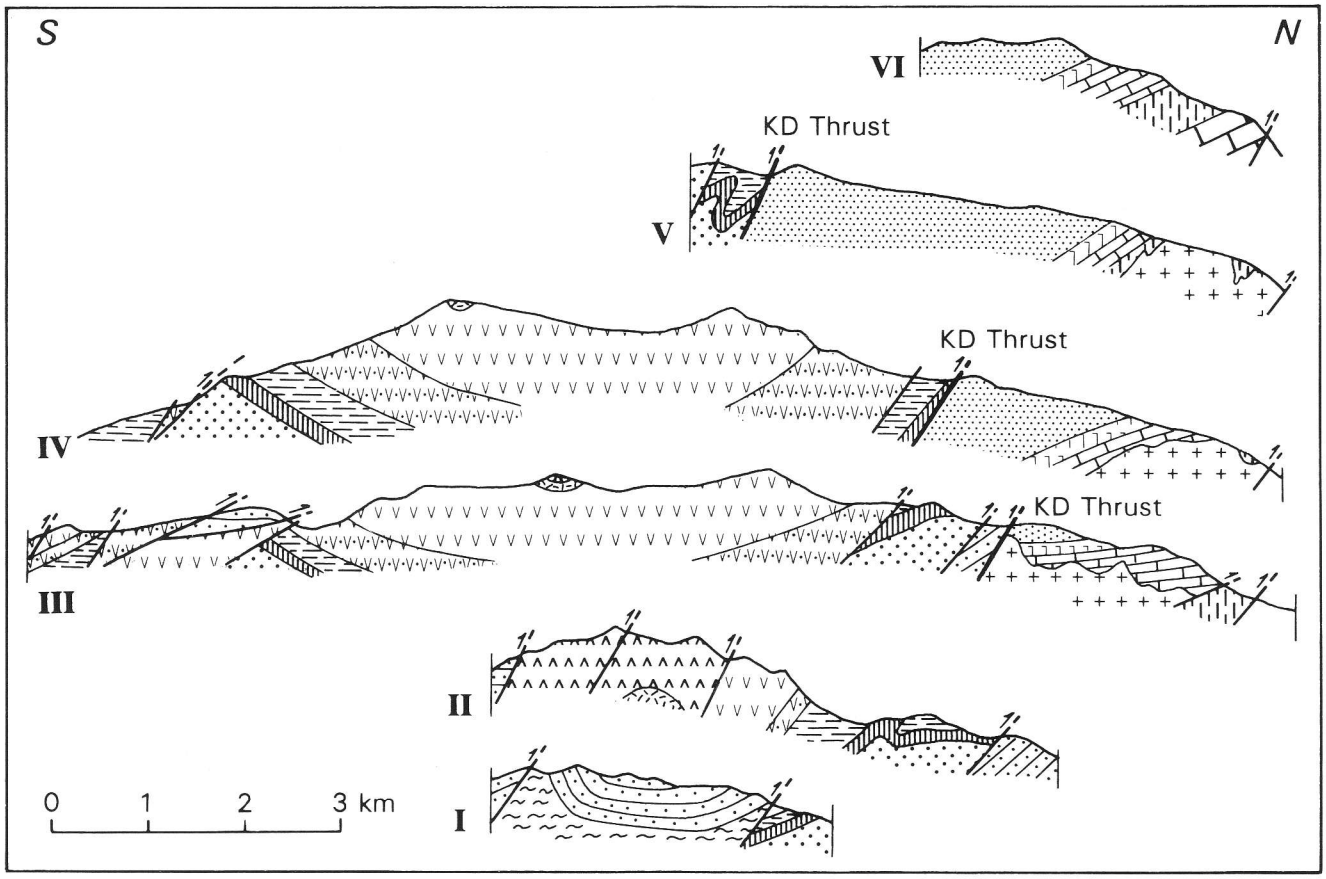

Fig. 2 - Geological sections through the Pshart Range.Their position is reported on the geological map of Fig. 1. Stratigraphic subdivision as in Fig. 1. Vertical scale double than the horizontal.

total thickness is 2500 m or more. The base of the section is not known. No fossils have been found and the group is assigned to the Carboniferous-Permian by convention. The Bel'sk Group comprises of black shale (100 m), marbles (50 m) and metabasalts (20 m). Again, no fossils have been found in this group. A Permian age was suggested (Dronov, 1990) because of comparisons with the carbonate-chert sequence of the West Pshart zone of the Pshart block which will be described later.

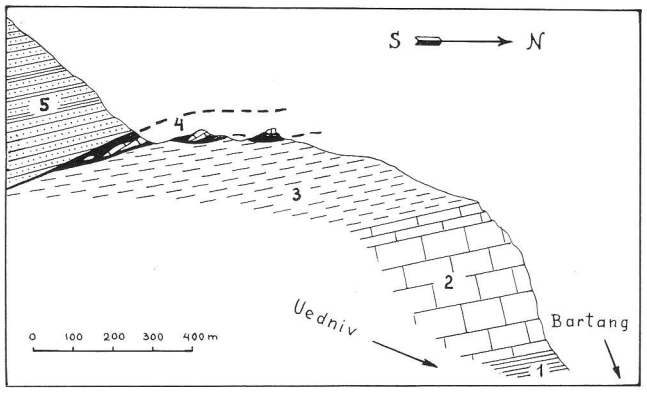

Fig. 3 - Rushan block. A profile through the Permian and ? Triassic on the left bank of the Uedniv (Pardzhavandara) river, left tributary of the Bartang river. 1) Raumid Fm.; 2) Shuvdara Fm.; 3) Pardzhavandara Fm.; 4) Basalts and limestones *Neoschwagerina*; 5) Bardara Fm.

In Dronov's South Rushan-Pshart zone, the Karabalgyn Group, which is represented by quartz- and quartzo-feldspathic sandstone interbedded with shale and siltstone is at the base of the succession. The thickness of the group is about 2000 m. Its base is unknown. By convention a Carboniferous-Early Permian age is assumed.

Higher in the section, cherts and cherty schists with the Permian conodont *Anchignathodus* sp. ind. (50 m), crystalline limestones (6 m) and basalts (8-9 m) occur. They are overlain by a thick sequence of Triassic rocks beginning with the cherts of the Ishikdjilga Formation (30-50 m) with Lower Triassic (Induan) conodonts: *Neogondolella* cf. *carinata* (Clark), *Neospathodus* cf. *dieneri* Sweet, *N.* cf. *cristagalli* Sweet.

Above this sequence, from bottom to top, the following rocks occur:

1) Siltstone; 20-50 m.
2) Mafic tuffs and tuffitic conglomerates; 50 m.
3) Basaltic lava and brecciated lava with interlayers and lenses of limestone and calcareous conglomerate; 300-400 m.
4) Mafic lava flows and brecciated lava; 300 m.
5) Polymictic sandstone with interlayer of schists; 300-500 m.
6) Mafic volcanites; 50-100 m.
7) Sandstone and shale; 200-300 m.
8) Sandstone, fine and coarse conglomerate; 50 m.

Due to the position in the section and because of the lithology, this part of the section is well correlatable with the Middle and Upper Triassic succession of the East-Pshart zone of the Pshart block (Chukurutek Formation and Gumbezkol Group).

Pshart block.

The Pshart tectonic block bounds against the Central and SE Pamirs by the Pshart and North Murgab thrusts, respectively (Fig. 1, 2). The West and East Pshart zones within the block are separated by the Kara Djilga fault.

West Pshart zone.

The zone was examined in the upper drainage system of the West and East Pshart rivers along the streams descending from the Pshart Range: Kara Djilga, Bel Kara Djilga, Ak Tash, Djar Djilga, and Kilil Istyk (Fig. 1). The volcaniclastic and carbonate sequences are intruded by granites belonging to the Khidjis Complex, Late Triassic-Early Jurassic in age (Peikre, 1978). Locally, the volcano-sedimentary complex is strongly metamorphosed. They strike from east to west, dipping south at a low angle. Their succession is apparently simple. However, contacts between the different units are often disrupted by faults. In absence of accurate timing, it is difficult to prove that the succession is normal. The stratigraphic scheme of groups and formations proposed by Dronov (1991) appears to be somewhat premature, because of the incomplete biostratigraphic control.

The most complete stratigraphic succession may be found in the area between the Kilil Istyk and Djar Djilga rivers. To the north, this succession is thrusted over the black shales, reminiscent of the Triassic. From bottom to top, the section shows five more or less persistent units (Fig. 1):

I - Lower carbonate and volcanic rocks.
II - Shales.
III - Upper carbonate and volcanic rocks.
IV - Basaltoid rocks.
V - Sandstone and shales.

UNIT I. The lower carbonate-volcanic unit is composed of marmorized limestone, dolomite, and calcareous breccia in complex relations with green altered picritic metabasalts and their tuffs. To the mouth of the Djar Djilga river, on the left bank and ascending along the slope, the following section has been observed (Fig. 1, 4):

1) Light grey and white, locally banded marmorize limestones with recrystallized segments of crinoids; 20 m.
2) Poorly exposed basalt that may form a single flow; 25 m.
3) Light recrystallized limestone; 15 m.
4) Dark green, almost black basalt; 4 m.
5) A breccia composed of marmorized crinoidal limestone up to 1 m in size, cemented by basalts; 2 m.
6) Basalt; 6 m.
7) Basaltic brecciated lava; 17 m.
8) Fine-banded marmorized crinoidal limestone; 20 m.
9) Basalt; close to the contact with the limestone in the footwall full of limestone fragments. A lens-shaped body of limestone breccias is enclosed in the basalts. The amount of limestone breccia in the metabasalts increases eastwards; 40 m.
10) Brecciated, dolomitized and marmorized limestone that locally grade into breccia, with basalt as cement; 50 m.
11) A lens of basalt, rapidly wedging out along the strike, which includes more or less abundant calcareous clasts. One of the boulders was found to contain a layer full of large, fully recrystallized and undeterminable fusulinids; 7 m.
12) With a sharp contact, a coarse-clastic limestone breccia follows. The fragments are various limestones and dolomites, some of them well rounded. Closer to the top of the level, the fragments become smaller in size and better rounded. Nests of basalt appear occasionally rich in limestone fragments. In turn, more or less well rounded fragments of mafic volcanic rock can also be observed in conglomerate and breccia; 55 m.
13) Grey fine-bedded limestone, crinoidal in the upper part; 20 m.

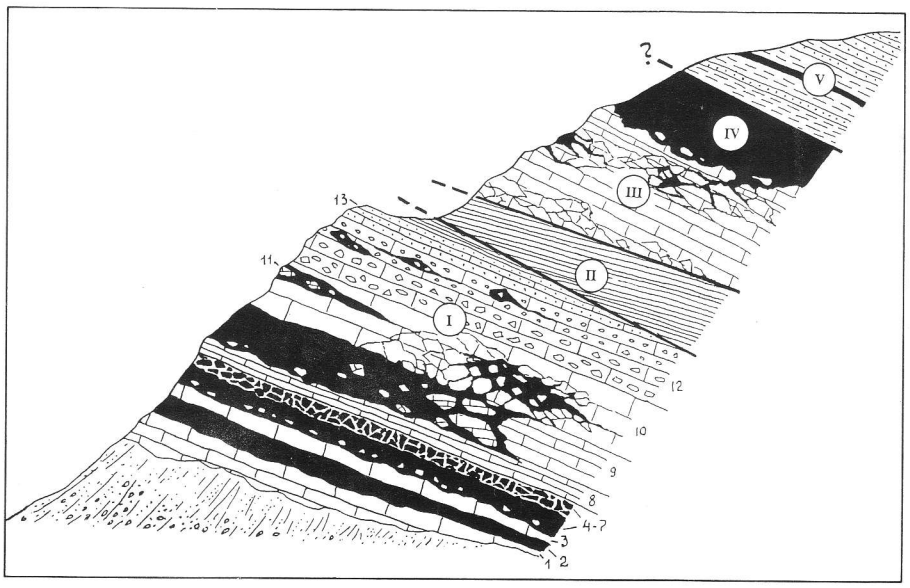

Fig. 4 - Stratigraphical section of the volcanogenous-sedimentary rocks of the West Pshart zone (left bank of the Djar Djilga river). Roman numbers refer to the five main Units; arabic numbers in Unit I correspond to the layers described in the text at p. 6.

In this section the overall thickness of the unit described is 281 m. The presence of large fusulinids suggests a Permian age, although due to their poor preservation a more precise timing is not possible.

UNIT II. The base of Unit II consists of black and grey shale with beds of brown grey calcareous sandstone which gradually grade into the shale layers which form the bulk of the unit. Unit II is locally disrupted by faults. The shales are traced as a continuous band between the two carbonate-volcanic units from the Kilil Istyk to the Ak Tash river, gradually wedging out to the east due to faulting. A few outcrops were examined between the Bel Kara Djilga and Gumbezkol rivers (Fig. 1).

The sequence is uniform, dominated by black, fine-bedded, clayey-sericitic shales. There are thin layers of fine-grain quartzo-feldspathic sandstones and siltstones. The full thickness of the sequence cannot be inferred because of the faulting. It is thicker to the west (300-400 m), thinning to a few dozen metres to the east.

UNIT III. The upper carbonate-volcanic succession covers the shales with a low-angle thrust. However, it is believed that the stratigraphic succession remained intact despite the faulting. The unit is composed of altered clayey, crinoidal and clastic limestone, calcareous breccia, dolomite and volcanic rocks represented by basalt, andesite, diabase, amygdaloid pyroxene porphyrites and their tuffs. The relationship between the sedimentary and volcanic rocks is complex (Fig. 4). The limestone is crushed, with fragments cemented by diabase. I suggest that effusive processes crushed the calcareous rocks of the substratum rock during the emplacement. The effusive processes could not have occurred too far from the depositional site of carbonate rocks as these are sometimes rich in fine-graded pyroclasts of altered volcanic glass.

The apparent overall thickness of the upper carbonate-volcanic unit ranges between 150 and 200 m. There are almost no fossils to characterize the unit. Apart from crinoids, we observed poorly preserved fusulinids *Schubertella* sp. Probably the fusulinids collected by Dronov (1990) from the Gumbezkol and Kara Djilga watershed were also from this unit. They are described as *Darvasites contractus* (Schellwien) and *Chalaroschwagerina* cf. *globosa* (Schellwien), typical for the Yahtashian and Bolorian stages of the Lower Permian.

UNIT IV. Continuing upwards through the Djar Dijlga section, this unit follows, in a normal stratigraphic relation with the underlying unit. It is composed of green altered basic effusives, with basalts and andesitic basalts dominating. Basic and intermediate tuffs are subordinate. There are thin layers of clayey shales. Fragments of the limestone from Unit III can be found enclosed at the base of the succession. The overall thickness is 100-150 m.

UNIT V. The sand-shale unit is widespread in the upper stream sections of the Kilil Istyk, Djar Djilga and Ak Tash rivers. To the east, it is gradually cut out by the Kara Djilga thrust; it cannot be found farther up the left bank of the Kara Djilga river. The contact with the effusive Unit IV in the footwall is largely tectonic, although the normal stratigraphic sequence is still preserved in a few outcrops.

The sequence can roughly be split into three parts. At the bottom, brown and dark grey thick-bedded, quartz sandstones with micaceous shaly matrix and carbonate cement. There are layers of clayey-sericitic shale and siltstone. The characteristic lithozone of this unit are 10 m-thick beds of green altered basalt and intermediate and acid tuffs. The central part of the succession is dominated by shales which are replaced upwards by sandstones, possibly arkose, that are lighter than the ones at the bottom of this unit. Intercalated with the sandstones are layers, up to a few dozen metres thick, that consist of green or violet siliceous shale. On the bedding surface, the rocks often show burrows, some have been identified as *Nereites*.

The total thickness of the sequence has been tentatively estimated as more than 1500 m. The only age constrain is given by a single find of spores sampled by B.R. Paskov (pers. comm.) and identified by I. A. Siverstseva as *Coriferites* sp., which indicates a Mesozoic age.

Discussion and conclusions on the W Pshart Zone.

(1) The described sequence is considered as a stratigraphic succession, although it is locally heavily dislocated. The numerous faults have in general small displacements and complicate the general monocline structure, which generally dips gently southwards. It cannot be totally excluded that the simplicity of the structure is only apparent. The lower and upper calcareous units may be a single unit imbricated by thrusting or by isoclinal folding (Fig. 2). Without reliable stratigraphic control on the sequences, this question cannot be solved.

(2) The sequence is unsatisfactoraly dated. Only the Lower Permian (Yahtashian-Bolorian) portion of the upper volcano-carbonate sequence is reliably dated. The lower calcareous unit might also be Permian, as suggested by recrystallized large fusulinids. The age of the terrigenous strata is unclear, and can be inferred only from their relation with the limestone.

(3) The volcanic rocks found within the West Pshart zone belong to the picrite-basalt formation and show "excess total alkalinity along with noticeable amounts of K and high Ti" (Tadjidinov, 1988). Such volcanism is typical of continental rifting, which is con-

sistent with the conclusions of Pashkov & Shvol'man (1979). Basalt emplacement under conditions of crustal extension is supported by the brecciation of the limestone.

The precise timing of volcanism is unclear. The presence of clastic lavas and tuffs in carbonate-volcanic and sand-shale sequences is evidence of the eruptions taking place more or less synchronously with the formation of these sequences, i.e. Permian or even Lower Triassic.

East Pshart zone.

The zone consists of volcano-sedimentary units spanning in age from the Carboniferous to probably the Cretaceous (Fig. 5). Between the Ak Tash and Gumbezkol rivers, they form a syncline whose limbs are affected by numerous south-dipping faults. As a result, in the northern limb of the syncline, the faults often cause interlayer breaks, while at the southern limb they crosscut the bedding (Fig. 1, 2).

East of the Gumbezkol, the syncline is cut by faults. The East Pshart volcano-sedimentary sequences stretch eastward as major tectonic lenses across the Ak Baital valley to crop out in the valleys of Etchki Tushar and Djaambay. At the Ak Su and Murgab watershed they are intruded by Cretaceous (88-137 Ma) porphiry-like granites of Dzhizev-type (Akramov, 1988) and are locally heavily metamorphosed (age of the metamorphism unknown).

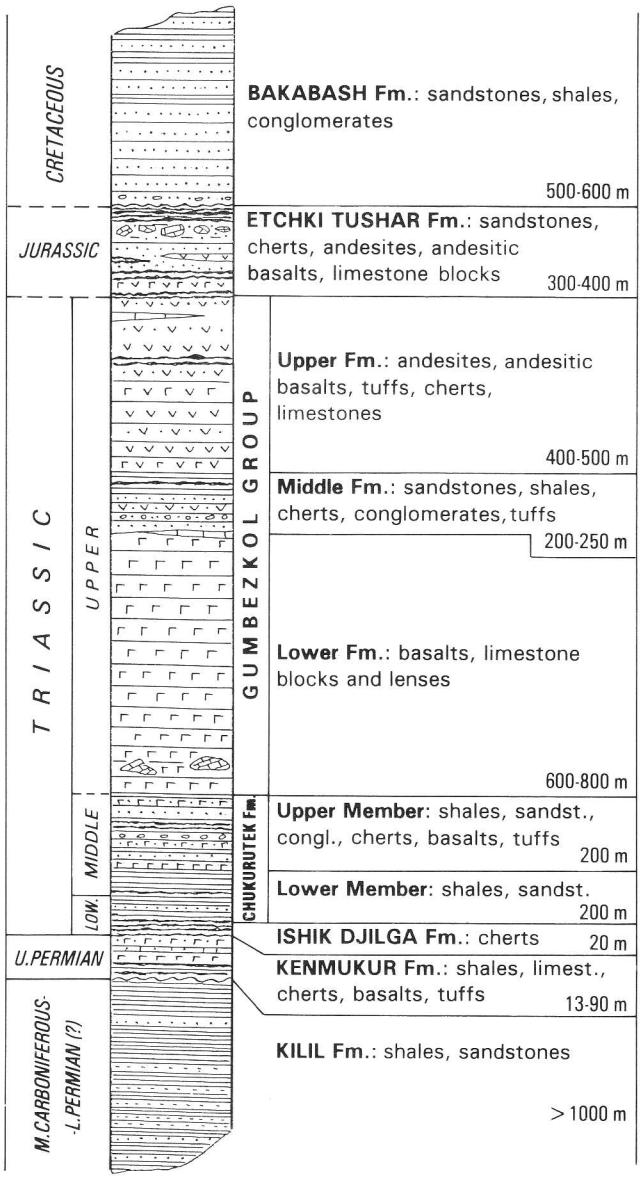

Fig. 5 - Comprehensive log of the volcanogenous-sedimentary succession of the East Pshart zone.

The lower part of the section is better exposed along the right tributaries of the East Pshart river: Kara Djilga, Gumbezkol, Ken Djilga and Ak Djilga. The uppermost section is best represented in the Etchki Tushar and Djaambay valleys.

After many years of studying these successions, Dronov (1991) provided a detailed stratigraphic scheme for the lower part of the section, introducing the names of the units 1 to 5. The upper part has been reconstructed jointly by the present author and B. R. Pashkov and formation names for units 6 and 7 are introduced here for the first time. The following formations and groups have been recognized, bottom to top (Fig. 5, 6):

1) *Kilil Fm.*: terrigenous sedimentary rocks; Middle Carboniferous-Lower Permian (?);

2) *Kenmukur Fm.*: effusive rocks, siliceous shales, and limestones; Upper Permian (Midian to Dorashamian);

3) *Ishik Djilga Fm.*: siliceous rocks; Lower Triassic (Lower Induan);

4) *Chukurutek Fm.*: tuffs, terrigenous and siliceous rocks; Lower and Middle Triassic (Upper Induan-Lower Ladinian) with two members: (a) shales and (b) tuff shales;

5) *Gumbezkol Group*: volcano-terrigenous rocks; Middle Triassic (Upper Ladinian)-Upper Triassic with three subdivisions: (a) effusive rocks, (b) terrigenous rocks, and (c) effusive rocks;

6) *Etchki Tushar Fm.*: volcano-terrigenous rocks; Jurassic;

7) *Bakabash Fm.*: terrigenous rocks; probably Lower Cretaceous.

Kilil Formation.

The Kilil Formation is traced across the northern slope of the Pshart Ridge as a discontinuous band from the mouth of the Tash Djilga river to the upper stream of Kilil Istyk. On the southern slope, it is found in the upper stream of Kaindy, Southern Kara Djilga 1 and Southern Kara Djilga 2. The base of the unit is not exposed. Dronov (1991) considers that the Kilil Fm., at the mouth of Gumbezkol and farther to the west in the Kara Djilga valley might be underlain by light quartz

sandstones, he designated as the Kishtau formation. In my opinion they are in a tectonic contact. The sandstones are wedged into this zone by the Kara Djilga fault and may be part of the Bakabash Formation, tentatively Cretaceous in age.

The Kilil Fm. was studied on the northern slope of the Pshart Ridge. There, in its lower portion, it is represented by fine-grained arkosic sandstone and siltstone. Higher up, the formation is composed of black shale. The section may lack continuity, as it shows zones of intense crushing. The apparent thickness is up to 400 m. In the southern slope of the Pshart Ridge it is over 1000 m.

The age of the formation is given by Bashkirian goniatites recovered from the southern slope of the Kara Djilga valley and in the upper part of the Djar Djilga river. According to Ruzhentsev & Bogoslovskaya (1978), they are represented by *Epicanites* sp. ind., *Stenopronorites uralensis* (Karpinskyi), *Paradimorphoceras* sp. ind., *Proshumardites* sp. ind., *Syngastrioceras dronovi* Ruzhentsev & Bogoslovskaya, *Homoceras pamiricum* Ruzhentsev & Bogoslovskaya, *Ramosites* sp. ind. This assemblage is considered to be typical of the *Homoceras* zone that is presently considered to initiate the Bashkirian stage of the Middle Carboniferous. In the upper part of the unit B. R. Pashkov (in Pashkov & Shvol'man, 1979) found the following spores, identified by I. F. Sivertseva: *Vitatina striata* Luber, *Falcisporites* sp. ind., *Coniferites* sp. ind., *Pinites* sp. ind., *Paravesicaspora* sp. ind. They occur from the Kungurian stage of the Lower Permian through the Upper Permian. However, Pashkov failed to precisely position his findings. They might as well be associated with the base of the overlying Kenmukur Formation. If so, the age of the Kilil Formation should be restricted to the Carboniferous, because goniatites were collected in the upper part of this formation. If the spores originate from the Kenmukur Fm., a large gap occurs between these two units.

Kenmukur Formation.

According to Dronov's scheme (1991), this name was given to a unit with the rank of group, including volcanic, terrigenous, carbonate and siliceous rocks, divided into 9 formations. Such high number (9) of formations seems to be unjustified as they are wedging out along strike and are replaced by lithologically different rocks. It appears to be more appropriate to combine them all in a single formation, characterized by high lithological variations, retaining the name given by Dronov to the group.

The Kenmukur Formation is widespread both on the northern and southern slopes of the Pshart Range. It is represented to the fullest extent in the basins of the Kara Djilga, Gumbezkol and Ken Djilga rivers. The sections start with dark grey, green or violet mudstones, occasionally alternating with siliceous shales (Fig. 6, layer 1). The transition from the black Kilil shales below appears to be gradual. However, the contact sometimes show small lenses of fine-graded conglomerate with pebbles of various rocks, granitoids included. There are also large blocks (1-2 m) of crinoidal limestones with numerous Upper Permian fusulinids: *Codonofusiella* aff. *ussuriensis* Toumanskaya, *Lantschichites* sp., *Minojapanella* sp., *Schubertella* sp., *Neofusulinella* sp., *Yangchienia* cf. *iniqua* Lee, *Y.* cf. *haydeni* Thompson, *Chusenella* sp., *Presumatrina* cf. *neoschwagerinoides* (Deprat), *Sumatrina* sp., *Neoschwagerina* cf. *simplex* Ozawa, *Armenina* sp., *Pseudodoliolina* sp. All this is evidence of a possible stratigraphic hiatus at the base of the unit. The total thickness of this part of the section is 20-30 m.

The next part above consists of a mixture of sedimentary and volcanic rocks, including clayey and siliceous shales, limestone, basalt, tuffs and tuffitic conglomerates (Fig. 6, 7, 8). The entire sequence is distinctly layered with violet and green shales, easily recognized and mapped. The best examples are the sections on the left slopes of the Kara Djilga and Ken Djilga valleys.

In the Kara Djilga section, variegated mudstones and siliceous shales are overlain by the following sequence of beds, from bottom to top:

1) Limestone intercalated with platy and shaley cherts (Fig. 6, layers 2-4). Limestone predominates in the lower part of the section where they occur in 0.1-0.3 m-thick layers alternating with thinner layers of cherts. The limestone is dark grey, fine-grained, detrital, and contains a certain amount of volcanic detritus. They contain numerous small foraminifera and fusulinids. Higher in the section, shaley cherts start to dominate with bright red-violet and olive green colours. Closer to the top, thin layers of micritic limestone occur. They are occasionally fractured, and their fragments are cemented with siliceous mass. Thickness is 30-35 m.
2) Dark green basalts, hard and massive, locally also with pillow lavas (Fig. 6, layers 5-6). The contact with cherts below is sharp and irregular. At the contact, fragments of cherts and micritic limestones are enclosed in the basalts. Upwards, the basalts give way to loose tuffs with layers of siliceous shales, and then massive effusive rocks occur again. Thickness is 40-50 m.

Higher portions of the section cannot be reconstructed, because the beds are too heavily dislocated. The section described here is the thickest for the Kenmukur Formation. In other sections, particularly in the southern limb of the Gumbezkol syncline, the thickness is much less. In the section on the left bank of the Ken Djilga valley (Fig. 1, 7), the Kilil shales are overlain by:

1) Black, occasionally greenish, siliceous shale with thin beds of fine-grained limestone; 7 m.
2) Alternating green and grey clayey-siliceous shale and fine-detrital limestone; 3 m.
3) Violet siliceous shale with layers of white and yellowish micritic limestone; 3 m.

4) Grey thick-bedded fine-grained calcarenite; 2-3 m.
5) Basalt, andesitic basalt with inclusions of clasts from the underlying rocks at the base; 5 m.
6) Tuff including more or less rounded pebbles of basalt, limestone and chert from the underlying beds; 12 m.
7) Alternating black siliceous shale and grey fine-grained clastic-detrital limestone with a certain amount of volcanic material; (Fig. 6, layer 7) 4 m.
8) Dark green and brown massive tuff breccias. Fragments, which are unrounded or poorly rounded, derive mostly from underlying siliceous shale and limestone. The cement is tuffitic; (Fig. 6, layer 8) 6 m.
9) Light grey banded fine-grained tuffs; (Fig. 6, layer 9) 1 m.

At the top, the black chert of the Ishik-Djilga Formation follows (Fig. 9).

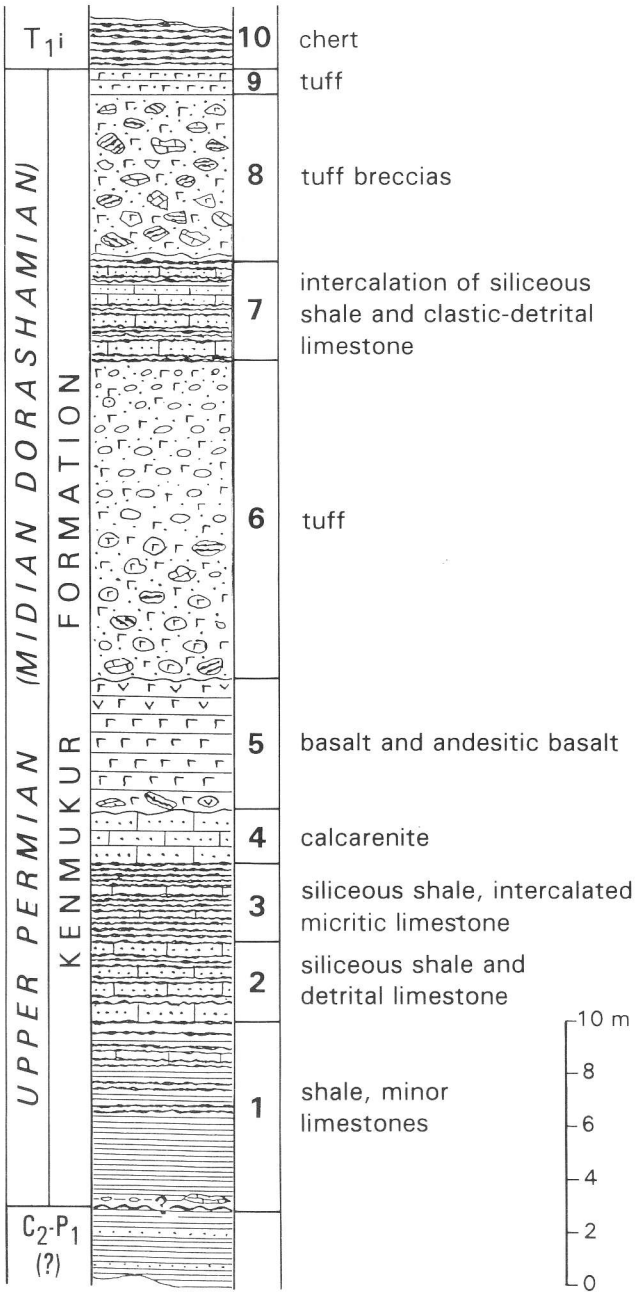

Fig. 6 - Stratigraphic section of Kenmukur Formation in the Ken Djilga valley.

Levels 1 to 4 easily correlate with level 1 and the underlying mudstones and siliceous shales of the previous section. Levels 5 and 6 correlate with level 2 of the previous section. The overall thickness is 43 m. It is much reduced in thickness by comparison with the Kenmukur Formation in the previous section. Dronov (1991) instead suggests a thickness for this unit (Group according to Dronov) of 230-450 m in a section in the Gumbezkol valley, close to the one described. These figures appear to be overestimated and may be due to the disregard of repetition by folding and faulting observed at the watershed between the Ken Djilga and Gumbezkol valleys.

An even more reduced section of the Kenmukur Formation was examined at the southern limb of the Gumbezkol syncline, on the left side of the right-hand tributary of the Southern Kara Djilga 2 river. There, Kilil black shales, siltstones and sandstones are covered by, from bottom to top:

1) fine-grained biocalcarenite; 0.3 m;
2) crinoidal limestone; 0.2 m;
3) biocalcarenite; 0.4 m;
4) sandstone grading to medium-sized conglomerate, with rare poorly rounded pebbles from the underlying rocks; 2 m;
5) black siliceous shale; 2 m;
6) sandy limestone with thin intercalations of bedded chert; 3.5 m;
7) silty limestone; 2.5 m;
8) black siliceous shale; 2.3 m.

This section is capped by the black platy cherts of the Ishik-Djilga Formation, considered to be of Early Triassic age (Fig. 9). The absence of volcanic rocks in this section is to be noted; in contrast they dominate in the northern limb of the Gumbezkol syncline.

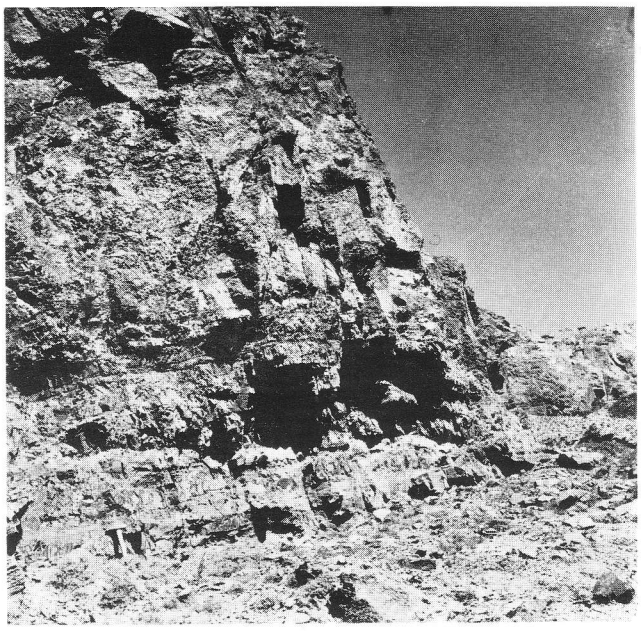

Fig. 7 - East Pshart block. Cherts and limestones (below) intercalated in the massive tuff conglomerates (above). Kenmukur Fm.; left flank of the Ken Djilga river valley.

Fossils collected from the Kenmukur Formation are represented by radiolarians, foraminifers, crinoids and calcareous algae. Radiolaria found in layers of micritic limestone and siliceous shale are badly preserved and are not identifiable. Foraminifers are present in variable amounts in the biocalcarenites. They are mostly small foraminifers and the shell-size of fusulinids match the size of the carbonate fragments in the rock. Larger fusulinids are rare and only in fragments. The same is true of crinoids and algae. The organic remains have been redeposited and sorted, suggesting a redepositional origin for the limestone, as confirmed by their association with pelagic radiolarites.

In addition to the fusulinids already listed from the limestone blocks at the base of the Kenmukur Formation, highest in the section, (level 1 of the Kara Djilga section, level 4 of the Ken Djilga section and boulders in the tuff-conglomerates) the following fossils have been identified: *Kahlerina* aff. *ussurica* Sosnina, *Pseudokahlerina discoidalis* Sosnina, *Dunbarula nana* Kochansky-Devidé & Ramovs, *Codonofusiella* aff. *guebleri* Tien, *Lantschichites* sp., *Reichelina* sp., *Rauserella* sp., *Chusenella* sp., *Misellina* sp., *Neoschwagerina* sp., *Sumatrina* sp. Among small foraminifers are: *Pachysphaerina pachysphaerica* (Pronina), *Sphairionia sikuoides* Tien, *Baisalina* cf. *pulchra* Reitlinger, *Dagmarita* sp., *Langella* cf. *ocarina* Civrieux & Dessauvagie, *Pachyphloia* sp., *Neoendothyra* aff. *parva* (Lange), *Endoteba controversa* Vachard, etc.

The microfauna suggests that the age of the formation cannot be older than Midian. Typically Midian *Codonofusiella* and *Lantschichites* have also been recovered from limestone blocks. The Murgabian forms associated with them must have been redeposited. The upper age limit of the formation is controlled by the rocks of Induan age that occur on top.

The presence of Midian fusulinids at the base of the Kenmukur Formation supports the hypothesis that it unconformably covers the Kilil Formation which contains Early Bashkirian goniatites. In Kara Djilga, where they have been found, the Kilil Formation is always thicker than 400 m. It is hard to consider that this thickness accounts for the whole Middle and Upper Carboniferous and most of the Permian. It is more likely that part of the sedimentary expression of this age span was not deposited, cut out by faults or eroded. The transgressive nature of the Midian stage is found elsewhere in Tethyan realm (Leven, 1993). In the Permian sections of the Central Pamir, lying close to the ones described here, Midian limestones occur directly on top of the Sakmarian or older Sarez formation (Dronov & Leven, 1971).

Ishik-Djilga Formation.

The Ishik-Djilga Formation overlies the previously described Kenmukur Fm. It occurs with a clear stratigraphic contact with no apparent evidence of unconformity. The formation is represented by dark grey and black chert, distinctly bedded and platy, and it is easily separated from the variegated cherts of the Upper Permian. It is not thicker than 15-20 m. In the region discussed, the formation has yielded no fossils to characterize it. Its Early Triassic (Induan) age is inferred

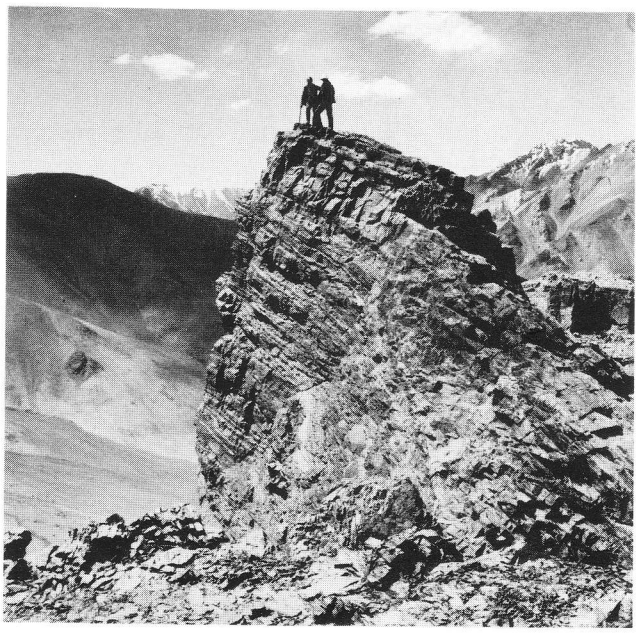

Fig. 8 - East Pshart block. Bedded cherts with limestone interlayers (lower part of the Kenmukur Fm.). Watershed between Gumbezkol and Ken Djilga valleys.

Fig. 9 - The contact between the Ishik Djilga Fm., above (thin bedded cherty limestones, Lower Triassic) on the Kenmukur Fm. (banded tuffs, Upper Permian). Left slope of Ken Djilga river valley.

indirectly by correlation with a similar sequence of cherts in the Dunkeldyk block, where they occupy the same stratigraphic positions and contain Early and Late Induan conodonts: *Neogondolella* cf. *carinata* (Clark), *Neospathodus* cf. *dieneri* Sweet, *N.* cf. *cristagalli* Sweet (Dronov, 1990). The cherts are also similar to Triassic cherts in the SE Pamir.

Chukurutek Formation.

The Ishik-Djilga Formation is followed by the Chukurutek Formation. The latter forms a continuous belt along the northern slope of the Pshart Ridge from the Tash Djilga to Kara Djilga and, changing strike, it farther continues into the area of the upper stream of Bel Kara Djilga and Ak Tash. Eventually, it crops out in the Southern Kara Djilga-2 basin on the southern limb of the Gumbezkol syncline. The formation is divided into 2 members.

The lower member largely consists of grey and black clayey shale that splits into flat plates with even and shiny surfaces. In the lower part, layers of siltstone and fine-grained sandstone are also present. All over the section there are layers, 10-15 m thick, of dark grey or occasionally greenish platy chert that upsection are intercalated with layers of splintery tuff and micritic limestone. The total thickness of the member is up to 200 m.

The upper member follows with gradual transition. It is distinguished by the motley composition of rocks that are colored light green or yellow-green. In thin sections chloritized tuffs of basaltic and andesitic basalt composition are predominant. They alternate with shales, quartzo-feldspathic sandstone, platy chert and siliceous shale. Quite common are also lenses of conglomerate, tuffitic conglomerate and breccias whose components contain limestone, sandstone, shale, chert and effusive rock. All over the section there are lenses of micritic or arenaceous limestone. The upper member varies in thickness, attaining locally 150-200 m.

The lower member has no fossils to characterize it; it is tentatively referred, by its geometric position in the stratigraphic succession to the uppermost Induan-Lower Ladinian interval of the Triassic. Poorly preserved fossils from the upper member were found in the limestone lenses. They mostly comprise of segments of crinoids, or more rarely, algae and hydroids. From one outcrop in the upper stream of the Bel Kara Djilga, B. K. Kushlin and the present author collected the corals *Margarosmilia* aff. *septanectens* Lorentz. This form was considered by T. G. Iljina (pers. comm.) to be typical of the upper Middle or lower Upper Triassic. The same outcrop contains rare dispersed and well rounded pebbles of limestones with Upper Permian (Murgabian) fusulinids: *Yangchienia* cf. *iniqua* Lee, *Chusenella* sp., *Pseudofusulina* sp., *Parafusulina* sp., *Armenina* sp., *Pseudodoliolina* aff. *ozawai* Yabe & Hanzawa, *Neoschwagerina* cf. *margaritae* Deprat, *Presumatrina* cf. *neoschwagerinoides* (Deprat), *Sumatrina* sp.

Gumbezkol Group.

The mostly shaley unit of the Chukurutek Formation is followed by the Gumbezkol Group. It is divided into 3 formations, the lower and upper ones being volcanogenic, the middle one mostly terrigenous. They have not been named up-to-now.

The lower formation forms the watershed portion of the Pshart Ridge between the upper streams of the Ak Djilga and Ak Tash rivers. Its relationship to the Chukurutek formation is unclear. The contact is mostly tectonic, however, locally seems to be stratigraphic. The formation largely consists of basic effusive rocks. They have been described by Dronov & Gavrilova (1990), who emphasized the difference in petrographic compositions of the volcanic rocks in the southern and northern limbs of the Gumbezkol syncline.

In the southern limb, the rocks consist by more than half of picritic porphyrite associated with orthoamphibolite, spilite, pyroxene dolerite, and quartz leucocratic diabase. Petrochemically, these volcanic rocks, along with the Upper Permian ones, have been classified as Na-K subalkaline melanobasaltes (Tadjidinov, 1988). In the northern limb, there are various diabases that differ in metamorphic grade. The overall thickness of the formation is 600-800 m.

In the lower part of the formation, the volcanic rocks enclose blocks of marmorized coralline limestone which yielded *Volzeia* cf. *laevis* (Munster), *Margarophyllia* sp., *Margarosmilia* sp., *Craspedophyllia* cf. *alpina* (Loretz), and *Elysastrea* sp. typical of Cassian beds of the Southern Alps and dated as Early Carnian. Lens-shaped layers of coralline limestone have also been found at the top of the formation. G. K. Melnikova (Dushanbe) identified from our collection *Thecosmilia* ex gr. *sublichotoma* (Munster) and *Pinacophyllum* sp. of Carnian age.

The second formation of the Gumbezkol Group has a restricted development along the Pshart Range watershed: it conformably covers the volcanic rocks of the lower formation. It mostly consists of terrigenous rocks, like greywacke alternating with andesitic tuff, and siliceous shale, conglomerate and breccia in the lower part. Lenses of crinoidal limestone and layers of andesitic porphyrite also exist. Upwards, dark grey sericitic shale predominates with subordinate layers of chert and tuff. The formation has a total thickness of 200-250 m. Fossils are scarse in the middle formation. Apart from crinoids, Pashkov (in Pashkov & Shvol'man, 1979) found in the limestone beds of the upper part radiolarians like *Cenosphaera* cf. *bakoniana* Rust, *C. ligustica* Vinassa de Regny, *Spongotripes* sp. that

T. G. Parfenova (pers. comm.) classified as earliest Late Triassic.

The upper formation crops out on the watershed of the Pshart Range corresponding to the upper-streams of Ken Djilga, Gumbezkol and Southern Gumbezkol rivers. To the east, its outcrops were recorded at the watershed between Ak Su and Djaambay valleys. The upper formation covers conformably the middle formation. The upper formation is composed largely of volcanic rocks: andesite, andesitic porphyrite, andesitic basalt and their tuffs. Rarely, there are basalt, diabase and spilite. The tuffs increase in volume upwards, where they alternate with tuffite and tuffitic sandstone. Also occasional layers of sericitic shale and chert, rarely limestone, are present. The volcanic rocks are commonly green with a brownish tint. The color of sandstone and shale is often red or violet. Total thickness is 400-500 m.

The formation is faunistically poorly characterized. Crinoids and corals discovered in limestone layers are poorly preserved. The Late Triassic age of the formation is inferred tentatively on the basis of its position in the section.

Etchki Tushar Formation.

The Etchki Tushar Formation follows the Gumbezkol Group. Its most complete outcrops are on the left bank of the southern Ak Baital river, in the valleys of Etchki Tushar, Djaambay and at the Djaambay-Ak Su watershed. In the Pshart Range, a narrow strip of outcrops is traced, from the upper stream of Ak Djilga, east as far as the East Pshart valley.

Because of the complex tectonics, the formations relationship with the Gumbezkol Group is not always clear. In the most representative section on the left side of the Djaambay valley, the following succession was recorded, bottom to top:

1) Amygdaloid andesitic basalt alternating with chert; 20 m.
2) Violet and olive green chert and cherty shale. Closer to the top of the section thin layers and lenses of calcarenite and arenaceous limestone appear, which occasionally grade into a carbonate megabreccia; 30 m.
3) Bedded, medium to fine-grained, pinkish or red polymictic sandstone. There are thin beds of siliceous shale, andesitic basalt and their tuff; 70-80 m.
4) Chert and cherty shale similar to (2). There are a lot of boulders and large blocks of limestone (several meters across), mostly crinoidal, in the basal part; 50-60 m.

The pink sandstone of the Bakabash Formation follows with a small but distinct angular unconformity.

The Etchi Tushar Fm. is characterized in the Djaambay valley section by the presence of exotic limestone blocks in the level 4), that locally may compose a continuous olistostrom horizon. The limestone blocks differ both lithologically and chronologically; they contain Silurian, Devonian, Upper Permian and Jurassic fossils. The approximate thickness of the formation is 300-400 m. The age of the formation is supported by the Jurassic crinoids *Pentacrinus* sp. and *Eugeniacrinus* sp. found by B. R. Pashkov in limestone lenses, and Jurassic-Cretaceous spores of *Granulafisporites (Cleichenia) pseudomarginatus* Semenova from layers of shales. These finds suggest a Jurassic age for the formation, but the data is unsufficient.

Bakabash Formation.

The Bakabash Formation covers the eastern tip of the Pshart Range from where it stretches eastwards into the Djaambay and Ak Su watershed. Apparently, the sandstones that occur along the Kara Djilga thrust from the left bank of the Kara Djilga river to the mouth of the Gumbezkol also belong to this formation.

The formation consists mostly of sandstones, in general, they are medium to coarse-bedded, composed of quartz or feldspar and quartz, with mica-siliceous, ferruginous-siliceous, chlorite-siliceous cement. Brecciation is quite typical. Due to the weak metamorphism, the sandstones are light in colour, light grey and pink. Whenever the metamorphism is stronger, the colour changes to grey and greenish grey. Occasionally, the sandstones contain blocks of marmorized limestone. In the upper part of the formation, sandstone more frequently alternates with shale; the latter becomes more important upwards.

At the Djaambay-Ak Su watershed there is a clear angular unconformity between Etchki Tushar cherts and Bakabash sandstones. At the base of the latter there are common medium and fine-grained conglomerates rich in quartzitic pebbles. The formation is covered with an abrupt angular unconformity by red Neogene conglomerates. The apparent thickness is 500-600 m.

The age can be only tentatively inferred as Cretaceous (minor hints are towards a Jurassic age). A few spores of Taxodiacea and *Foraminisporites asymmetricus* (Cooks & Dettmann) were extracted from samples collected by B. R. Pashkov. I. A. Severtseva (pers. comm.) believes the former can be found both in the Jurassic and Cretaceous, while the latter was described from the Cretaceous of Canada, Australia, and the Far East.

A comparison between the West Pshart and the East Pshart zones and a comparison of the Pshart zones with the Central and Southeastern Pamir.

According to the reconstructions made by Pashkov & Shvol'man (1979), the West and East Pshart zones, together with the SE and the Central Pamir, were incorporated into the northern margins of Gondwana before the Early Permian. During the Triassic the continental area rifted and ultimately an oceanic basin

formed. Both Pshart zones remained linked to the Central Pamir microcontinent, making up its rifted margins. Since that time, the SE Pamir evolved independently.

These reconstructions suggest, on the one hand, a certain similarity between the East Pshart, West Pshart and Central Pamir zones, and on the other hand, a pronounced difference between the East Pshart zone and the SE Pamir. According to Pashkov & Shvol'man (1979), this is because they were separated by an oceanic basin since the Triassic.

In order to assess this inference, we need to compare the described sections of the Pshart zones with those of Central and SE Pamir.

West Pshart. The poor dating of the volcanosedimentary sequences of the West Pshart hampers comparisons with neighboring zones. Nevertheless, we may definitely rule out a similarity between the West and East Pshart zones. The only common feature is the presence of basalts. However, the basalts of the East Pshart zone are Late Permian and Triassic in age, whilst those of the West Pshart are of Early Permian. Younger volcanites are not proven in the West Pshart.

More common features appear when the West Pshart is compared with the Central Pamir. In both zones the Permian part of the section is represented by limestone and dolomite, which may be part of a former single carbonate platform. In the Central Pamir, the Permian limestones are overlain by the lower-middle Triassic limestone and dolomite of the Djilgakul Formation (Kushlin, 1963). These seem to be absent in the West Pshart. However, the poor palaeontological definition of the carbonate sequence cannot exclude a Triassic age for some parts of them. Should a Triassic age be proven for the upper shaley sequence of the West Pshart, this could be correlated with the Upper Triassic-Lower Jurassic terrigenous Vomar Formation of the Central Pamir. Although there are different environmental conditions for these sequences, marine in the West Pshart and continental to coastal-marine in the Central Pamir.

As far as volcanic rocks are concerned, those in the Central Pamir are not characteristic. Only thin interlayers of altered mafic effusives are found in the Upper Permian succession (Leven, 1962). It is not improbable that the bauxites within the Permian succession and near the Permo-Triassic boundary are linked to the volcanic rocks as well.

East Pshart. This zone differs greatly from the West Pshart and has a lot in common with the SE Pamir, especially as far the lower part of the volcanosedimentary successions is concerned. This holds true for the Carboniferous-Lower Permian terrigenous formations with similar composition (the Kilil Fm. in the East Pshart zone and the Bazardarin Group in the SE Pamir zone), that occur at the base of the succession in both zones (Leven, 1967). Also a hiatus seems to preceed the deposition of the overlying sequences in both zones (Kenmukur Fm. in East Pshart and Kotchusu Fm. in SE Pamir). Siliceous sediments interbedded with calcilutites and calcarenites played a significant role in the Upper Permian in both areas. Basalts are absent in the Upper Permian of the SE Pamir, although basaltic tuffs (the Takhtabulak Fm.) similar in composition to volcanic rocks of the East Pshart zone are encountered in some sections. Novikov (1979) considers these volcanites and tuffs as a single volcanosedimentary formation. In his opinion, the centers of volcanism were located in the East Pshart zone and pyroclastic rocks were derived from it and deposited into the adjacent SE Pamir zone.

In the SE Pamir, the Triassic deposits unconformably overlay the Permian successions (Novikov, 1979). An unconformity is also supposed to occur in the East Pshart zone, where the contact of the Lower Triassic cherts of the Ishikdjilga Fm. with the underlying tuffs is very abrupt.

The Triassic record of the East Pshart zone greatly differs from that known in SE Pamir, where volcanogenic complexes are untypical. But exposures of Triassic volcano-sedimentary sequences similar to those of the East Pshart zone occur in the northern and western peripheries of the SE Pamir (Kainda-Sai river valley, which is a right tributary of the Murgab river, in the Katta Mardjanai river basin south of the Sarez lake and in the Alitchur river basin) (Dronov, 1988; Dronov & Budanova, 1986; Dronov & Gravilova, 1991). The Upper Ladinian-Carnian coral limestone associated with volcanic rocks emphasizes the similarity (Dronov, 1988).

Shvol'man (1986) and Pashkov & Budanov (1990) believe that the Triassic volcanites of the peripheral parts of the SE Pamir were formed within the East Pshart zone and then were overthust towards the south. But there is reason to suppose that their autochthonous nature and the mafic volcanism occurred in peripheral parts of the SE Pamir. In fact, in the Alitchur river basin, metabasalts are described within the central part of the so-called North-Alitchur Group (Dronov & Budanova, 1986), which is composed mainly of metaterrigenous rocks. The age of the group is possibly Triassic, as indicated by the findings of Late Permian fusulinids in limestone boulders inside the terrigenous rocks (Dronov et al., 1989). According to unpublished data on geological mapping (T. A. Akimova, pers. comm.) coinciding with my own observations, the North Alitchur Group is gradually passing eastward into the Istyk Formation (Upper Triassic), a terrigenous unit widely developed over the entire SE Pamir. They differ only in the grade of metamorphism and in the

presence of limestone blocks in the North Alitchur Group. Consequently, there is some evidence against the interpretation of the volcanic rocks as a nappe emplaced from the E Pshart zone.

Paleogeographic and paleotectonic conclusions.

1. Paleogeographic data (Leven, 1993) indicate that all the above considered zones including Central Pamir were positioned on the Gondwana margin during the whole Permian.

2. The differences in the lithology and stratigraphy of sections and thus in evolutionary history of the separate zones discussed in the present paper indicate the tectonic differentiation and the mobility of the northern margins of the Gondwana continent during the Permo-Triassic. The range of these differences, which sometimes are very substantial, and the lack of transitional parts between the zones indicates that in the present structure we deal only with fragments of previously existing paleogeographic pattern. The original size of the zones could have been much larger and the zones could have been spaced further. This assumption mainly concerns the West and the East Pshart zones.

3. There is no clear answer yet as to what domains separated the zones. The idea suggested by Pashkov and Shvol'man (1979) about the existence of an oceanic basin between the SE Pamir and the East Pshart zones has so far not been confirmed. Actually, as pointed out by Pashkov and Shvol'man, nowhere within the considered region have ophiolites been found, which can be considered as fragments of oceanic crust. Picritic basalts, sometimes interpreted as oceanic, occur within the normal section of sedimentary deposits which are unlikely to be abyssal. In the West Pshart zone they are correlated with deposits of the carbonate platform. It is most likely that the Permian-Triassic volcano-sedimentary sequences of the East Pshart zone accumulated on a continental slope. One is entitled to agree with Pashkov and Shvol'man that the basalts are related to rifting processes. However, it is not possible to judge about their intensity and consequences.

4. If the rifting resulted in the formation of an oceanic basin, it should be located between the two Pshart zones, and not between the East Pshart and the SE Pamir, as suggested by Pashkov & Shvol'man (1979). This conclusion is supported by the previous comparison between the tectonic zones.

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