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GEOLOGY

The Age and Tectonic Setting of Volcanic and Cherty Sequences in the Ophiolite Complex of the Atbashe Ridge (Southern Tien Shan)

D. V. Alekseev, V. A. Aristov, and K. E. Degtyarev

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Dating the sedimentary and volcanic rocks in ophiolite complexes is of fundamental importance for reconstructions of oceanic paleobasins. The ophiolite belt of the southern Tien Shan, which extends from northwestern Uzbekistan to western regions of China (Fig. 1a), traces the suture of the Turkestan paleocean closed at the end of the Carboniferous. In the western part of the belt, the age of volcanic–cherty sequences of the ophiolite association corresponds to the Early Ordovician–Early Carboniferous interval [6]. Data on the age of similar rocks in eastern regions are rather scanty. Therefore, several issues related to evolution of the Turkestan paleocean in the region between the Kazakhstan and Tarim continental blocks remain open. To fill this gap, we have carried out micropaleontological study of cherty–volcanic sequences developed within the ophiolite belt in the Atbashe and Dzhangdzhir ridges (Fig. 1b).

The structure of Paleozoic complexes in these regions represents a packet of nappes deformed into NNE-striking longitudinal folds. The upper nappes—Shirekty, Balykty, and Atbashe—are mainly composed of metamorphic schists. They are structurally underlain by the Tashrabat and Dzhangdzhir nappes composed of terrigenous, volcanic, and siliceous rocks. Most of the ophiolite thrusts occur at the same level. The Ulan and Chirmash nappes of carbonates lie at the base of the nappe packet (Fig. 1b) [1, 3, 5, 8, 11].

Major fragments of ophiolites and volcanic–cherty sequences were revealed in the Sarybulak Ravine on northern slopes of the Atbashe Ridge, 18 km southwest of the Sarybulak district center [5, 11]. As a rule, ophiolites are intensely disintegrated and represented by serpentinite melange with blocks of dunites, pyroxenites, gabbroids, and metamorphic and siliceous rocks. The melange is overlain by a sheet of cherts, jasperoids, and basalts, which are comparable with rocks of the old oceanic plate cover. The age of rocks was thus far conditionally attributed to the Early Ordovician–Devonian interval based on the similarity with the Sartale section in the Alai Ridge [5, 11]. However, the lack of fauna in the Sarybulak section, the remoteness of both regions, and their possible affiliation with different tectonic zones [1, 8] make such correlation insufficiently reliable.

In the Sarybulak Ravine, conodonts were collected 5 km southeast of Dzhany-Kyuch Settlement (azimuth 150° from the site 41°02′ N, 75°40′ E) along the watershed of the Kurgak and Taldysu river valleys with a complete intersection of the cherty–basalt sequence (~500 m). Conodonts were also collected from a chert sheet in the melange directly north of the mentioned site (Fig. 2). Predominating in the section are green and brown thin-platy cherts and sealing-wax clayey jasperoids with jasper interlayers, including pillow basalt flows up to 20 m thick and a few clay and siliceous shales, mudstones with chert interlayers, platy limestones, and foliated clayey limestones (Fig. 3a). Rock metamorphism does not exceed the phyllite grade.

Conodonts of the profile were found in 15 localities, 14 of them in cherts and one in jasperoids. Based on the conodonts, rocks were dated at the D_1p–D_2, D_2gv, $D_{2–3}$, D_3f_1, D_3f_2, D_3fm_1, and $D_3fm_{1–2}$ levels. Figure 3 shows lists of conodonts and sampling sites. Conodonts *Panderodus* sp. and *Parallelocostatus* sp. ($D_{1–2}$) were also found in sealing-wax jasperoids 1.8 km south-southwest of the profile. No analogs are available in the eastern Tien Shan in terms of the accuracy of dating (up to the substage and often even the conodont zone) and the detailed subdivision of the section on the main profile.

Two areas were studied in the Dzhangdzhir Ridge (Fig. 1b). On the western slope of the Dzhilanach River valley (41°17.81′ N, 76°48.38′ E) in the green chert member (~30 m thick), we dated the following levels:

Geological Institute, Russian Academy of Sciences, Pyzhevskii per. 7, Moscow, 109117 Russia; e-mail: degtkir@ginras.ru

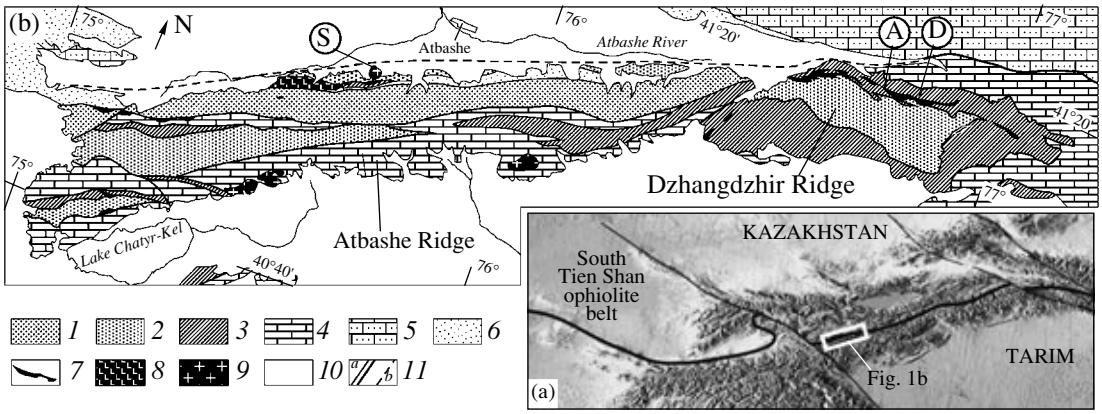

Fig. 1. (a) Location of the study region and (b) the geological structure of the Atbashe and Dzhangdzhir ridges (modified after [2, 3, and 5]). (*1–4*) Tectonic nappes in the southern Tien Shan zone: (*1*) Atbashe, (*2*) Shirekty, (*3*) Dzhangdzhir and Tashrabat, (*4*) Ulan and Chirmash; (*5*) terrigenous–carbonate complexes of the Median Tien Shan (D_2gv–C_2b_1); (*6*) terrigenous complexes (C_2m–P_1as); (*7*) ophiolites; (*8*) gabbroids; (*9*) granitoids (PZ_3); (*10*) Cenozoic deposits; (*11*) major faults: (*a*) exposed, (*b*) hidden under the cover. Studied areas: (S) Sarybulak Ravine, (A) Archaly River, (D) Dzhilanach River.

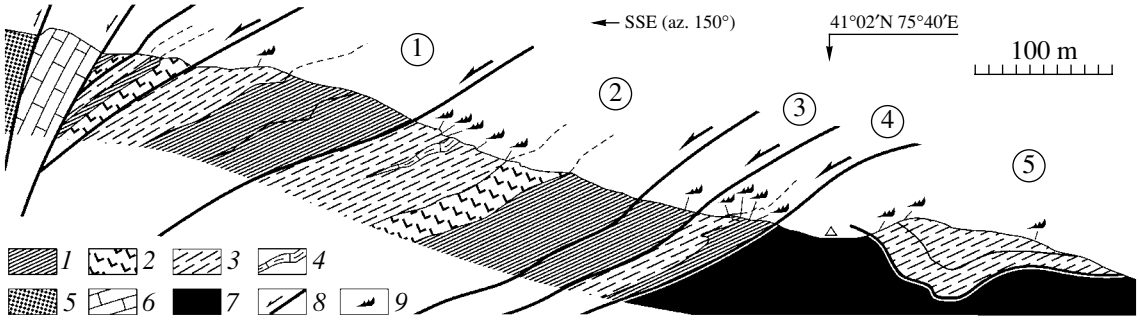

Fig. 2. Geological section along the Sarybulak profile. (*1, 2*) Volcanic–cherty sequence ($D_{1–3}$): (*1*) jasperoids, cherts, and shales, (*2*) basalts; (*3, 4*) cherty sequence (D_3f–fm): (*3*) cherts and shales, (*4*) platy limestones; (*5*) metamorphic schists of the Atbashe Formation ($PZ_{1–2}$?); (*6*) limestones (C_3); (*7*) serpentinite melange; (*8*) faults and direction of displacements; (*9*) conodont sampling sites. Numerals in circles designate sheet numbers corresponding to column numbers in Fig. 3.

D_3fm_2, $D_3fm_{2–3}$, and D_3–C_1t (Fig. 3b). They are underlain by jasperoids, green cherts, and basalts. The similarity with the Sarybulak Ravine section suggests an Early and Middle Devonian age of these rocks. However, a search for fauna in them was unsuccessful. In the second area southwest of the Archaly River mouth, a block of black phtanite in the melange was dated at C_1t (Fig. 3b). Previously, D_3f conodonts were collected in variegated cherts (with beds of volcaniclastic rocks) and D_3fm_2 conodonts were found in green cherts (A.V. Neevin, personal communication).

The obtained dates suggest that rocks older than the Devonian are absent in the studied volcanic–cherty sequences. The section previously regarded as a unified one represents a series of sheets characterized by repetition of coeval fragments of the stratigraphic succession tens to hundreds of meters thick (Figs. 2, 3). We can distinguish two members of different compositions. The lower member (red jasperoids, green cherts, and basalts) corresponds to the Early Devonian–early Frasnian interval. The upper member (mainly green cherts and cherty shales) ranges from early Frasnian to the Early Carboniferous. The composition of rocks and the condensed nature of the section indicate a considerable depth of the sedimentation basin. The sedimentation rate in the Frasnian is estimated at 5–6 mm/ka, which slightly exceeds the values characteristic of open ocean facies (<2 mm/ka). The fine terrigenous material consistently found in the section suggests a relative proximity of provenances. Conodonts are represented in the studied rocks only by cosmopolitan taxons, suggesting a free connection of the basin with open water areas.

In terms of the rock composition and the section structure, the studied sequences are similar to coeval complexes in adjacent nappes—the Shirekty nappe on the west of the Atbashe Ridge and the Dzhangdzhir nappe in the ridge of the same name [1–4]. Wide development of terrigenous facies of the continental rise and

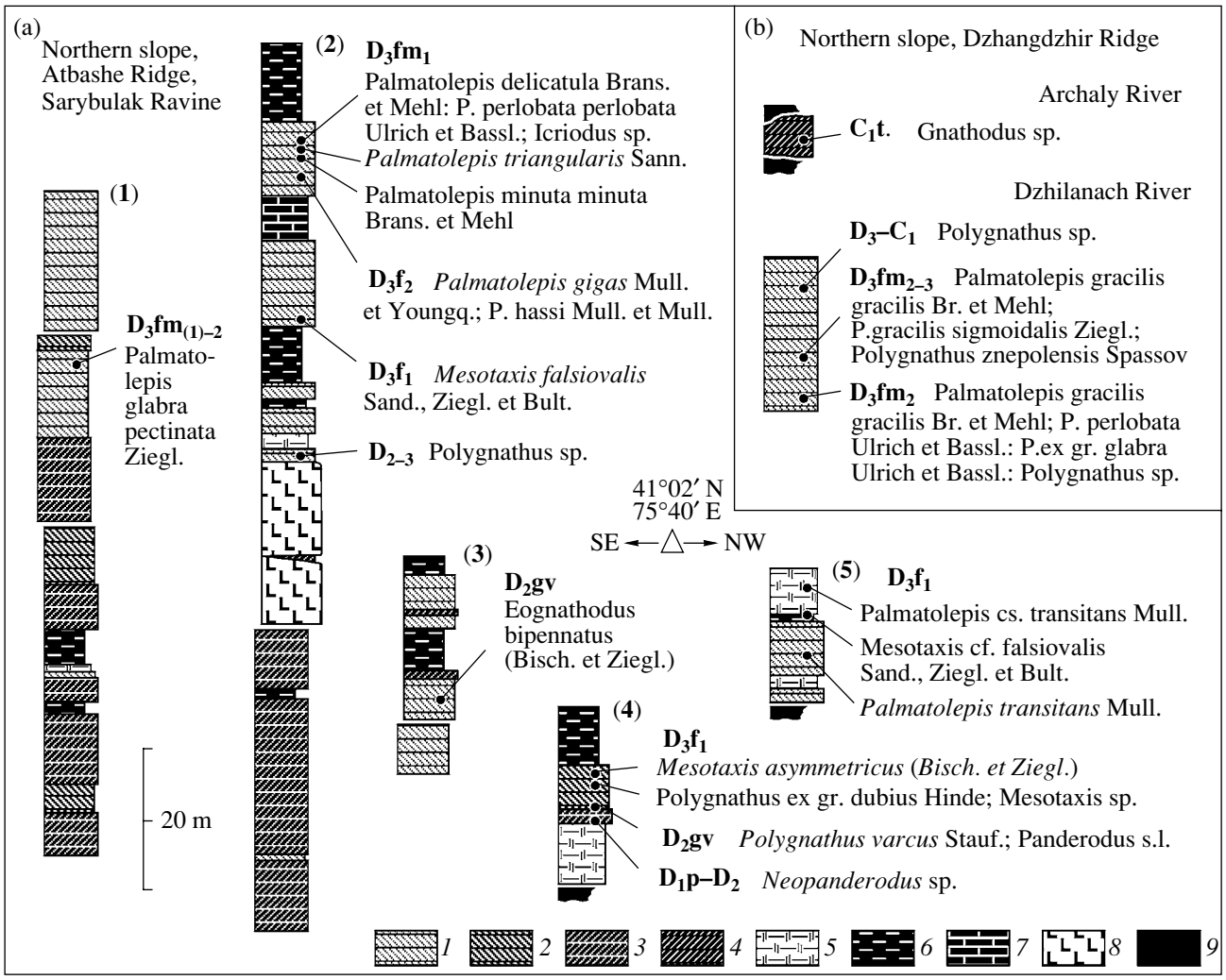

Fig. 3. Stratigraphic columns and conodont identifications. (*1*) Green cherts; (*2*) brown cherts; (*3*) sealing-wax jasperoids; (*4*) phtanites; (*5*) siliceous shales; (*6*) mudstones and cherts; (*7*) limestones; (*8*) basalts; (*9*) serpentinites. Zonal forms in conodont lists are given in italics.

pelagic regions (in the Shirekty and Dzhangdzhir nappes, respectively) in the Silurian and Early Devonian, as well as an overlapping of ophiolites by these terrigenous series in the Fergana Ridge [10], indicates that the study area was in the peripheral (near-continental) part of the basin with the pre-Silurian ocean-type crust [1, 3, 8]. Geochemical data indicate that the volcanic activity in the Early and Middle Devonian was governed by repeated spreading or intraplate volcanism [1, 4]. The similarity of the Devonian and Lower Carboniferous sections in different sheets suggests that identical paleotectonic settings existed in the whole area. As in neighboring nappes, volcanic–cherty sequences developed in the ophiolite belt are likely to be initially underlain by Silurian and Lower Devonian deepwater sediments and tectonically superposed with formations of the melanocratic basement during deformations.

Determinations of the conodonts mentioned above allow us to refine the details of the inner structure of the complex. The existence of numerous overthrusts, which combine the section fragments into series of thrust sheets, has been proved in the Sarybulak Ravine (Fig. 2). Fault planes extending nearly parallel to bedding exhibit southern and southeastern dips. Rocks in the sheets are characterized by normal bedding. Overthrusts are accompanied by recumbent and plunging folds, the structural pattern of which indicates thrusting southward and southeastward. The latter direction corresponds to the main direction of overthrusting in the southern Tien Shan at the first stage of Late Paleozoic deformations [7] and supports the model of a monovergent motion of tectonic nappes in this region [1]. Southward dips of thrusts observed in the studied zone are related to the bending of a nappe packet into synforms and antiforms at the second stage of deformations. Locally, rocks are also deformed into S-shaped folds

with steep flexures indicating the ENE-oriented sinistral strike-slip faults at the third stage of deformations. Later displacements, probably in the Cenozoic time as well, were responsible for the northward thrusting of the whole complex over Upper Carboniferous and Permian terrigenous rocks.

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