ISSN 1028-334X, Doklady Earth Sciences, 2007, Vol. 417, No. 8, pp. 1198–1201. © Pleiades Publishing, Ltd., 2007.
Original Russian Text © S.V. Ruzhentsev, V.A. Aristov, O.R. Minina, B.G. Golionko, G.E. Nekrasov, 2007, published in Doklady Akademii Nauk, 2007, Vol. 417, No. 2, pp. 225–228.

GEOLOGY

Hercynides of the Ikat–Bagdarin Zone in Transbaikalia

S. V. Ruzhentsev[a], V. A. Aristov[a], O. R. Minina[b], B. G. Golionko[a], and G. E. Nekrasov[a]

Presented by Academician Yu.M. Pushcharovsky November 4, 2006

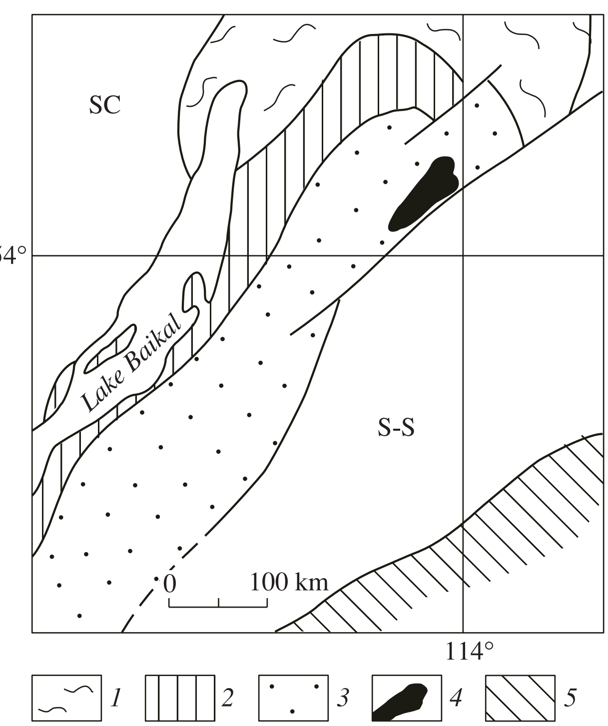
Received November 13, 2006

DOI: 10.1134/S1028334X07080144

The Ikat–Bagdarin zone occupies the internal part of the western Transbaikal region. Granitoids of the Angara–Vitim batholith and metamorphic rocks of unknown age are widespread in this region. Stratified sequences are represented by terrigenous, carbonate, and volcanogenic rocks. According to [1], this zone is one of the Baikalian–Caledonian terranes accreted in the Early Paleozoic to the southern margin of the Siberian Craton. The age of these sequences is considered Neoproterozoic–Early Paleozoic [2, 3, and others]. The Lower Cambrian carbonate sequence with archaeocyaths, trilobites, and brachiopods represents the reference level in this region. At the same time, our work in the Bagdarin area (Bol'shoi Amalat–Tsipikan interfluve) revealed that various Neoproterozoic and Lower Paleozoic formations in this region are supplemented with thick sequences of Middle and, probably, Upper Paleozoic rocks that make up the Hercynian structural stage. This fact changes cardinally the concept of the geological structure of the internal zone of the western Transbaikal region and implies a substantially younger age of its geodynamic evolution.

This issue is investigated in the NE-trending Bagdarin Synform (approximately 100 km long and 30–40 km wide) located in the basin of the Bagdarin, Usoi, and Toloi rivers (Fig. 1). In structural terms, the zone represents a fold–thrust structure with tectonically juxtaposed different lithotectonic complexes thrust over the adjacent Tsipikan and Amalat blocks of metamorphic rocks. The Bagdarin Synform includes the following rock complexes (from the base to the top).

The *Tocher Complex* includes rocks of the Sivokon, Usoi, and Tocher formations, which form the lower sheet (relative autochthon). They are largely exposed along the southern slope of the Shaman Ridge at upper reaches of the Tocher, Aunik, and Bagdarin rivers. The basal part of the section is composed of albite–epidote–actinolite schists (Sivokon Formation) with gabbro, diorite, and plagiogranite bodies and isolated serpentinite protrusions. Amphiboles, which replace colored mineral in gabbros, and plagioclases from pegmatoid gabbros yielded the Sm–Nd isochron age of 545 ± 19 Ma [5].



Schematic tectonic zoning of the Transbaikal region. (*1*) Baikal–Muya Massif, (*2*) Ol'khon and Barguzin zones, (*3*) Ikat–Bagdarin zone, (*4*) Bagdarin Synform, (*5*) Mongol–Okhotsk Belt. (SC) Siberian Craton, (S–S) Selenga–Stanovoi and Stanovoi zones.

[a] *Geological Institute, Russian Academy of Sciences, Pyzhevskii per. 7, Moscow, 119017 Russia; e-mail: Nekrasov@ginras.ru*

[b] *Geological Institute, Siberian Division, Russian Academy of Sciences, ul. Sakh'yanovoi 6a, Ulan-Ude, 670042 Russia*

According to our data [6], the greenschist sequence is developed after migmatized amphibolites intruded by minor granite bodies. Zircons for isotopic dating were sampled from vein amphibolite plagiogranites in migmatized amphibolites exposed on channel scarps along the middle courses of the Aunik River (right tributary of the Bagdarin River). We carried out U–Pb dating with the SHRIMP-II ion microprobe at the Center of Isotopic Studies of the All-Russia Geological Institute (St. Petersburg). The measurements provided a concordant age of 971.9 ± 14 Ma (MSWD = 2.1). Zircons from leucocratic granites from the upper reaches of the Polyutovskii Creek yielded 908 ± 7.6 Ma (MSWD = 0.083). These values determine the minimal age limit for the metamorphic granite basement of the Shaman Ridge with amphibolites of Neoproterozoic or, probably, older age.

The Usoi Formation is included conditionally in the Tocher Complex. Its rocks constitute separate tectonic wedges at the upper reaches of the Usoi River. They are represented by rhyolites, trachyrhyolites, dacites, and subordinate andesites, basalts, their tuffs, and volcanic sandstones. For U–Pb dating of the Usoi Formation, we analyzed zircons from rhyolites exposed along the left bank of the Usoi River (0.7 km upstream from the mouth of Endola Creek). The zircons yielded concordant ages of 837 ± 11 Ma (MSWD = 0.13) and 789 ± 8 Ma (MSWD = 0.98).

The Tocher Formation rests unconformably with basal conglomerates (up to 20 m thick) on rocks of the Usoi Formation. The conglomerate consists of large pebbles and boulders. The pebbles are represented by granitoids, vein quartz, amphibolites, greenschists, acid volcanics, sandstones, and rare marbles. The formation includes three members. Its basal part is represented by a sequence (300–350 m) of shales and phyllitized graywackes with thin interbeds of clayey limestones. One such interbed exposed along the left wall of the Aunik River valley (western slope, height 1369.4 m) yielded conodonts *Palmatolepis* ex gr. *triangularis* Sann, *P.* cf. *perlobata* Ulrich et Bass., *Polygnathus* sp., and *Ozarkodina* sp. indicating a Famennian (most likely, early Famennian) age of the host rocks. The sequences resting higher in the section are composed of sandy–shaly flyschoid sediments (900–1000 m) and largely thick-bedded graywackes (up to 800–900 m) with rare flows of rhyolites, their tuffs, and occasional dolerite sills. Taking into consideration the large thickness of the formation (up to 2 km in total), we assume that the age of its upper part may be Carboniferous.

The *Orochen Complex* consists of the Suvanikha, Orochen (Tilim), and Yaksha formations and the black shale sequence of the Shaman Ridge.

The Suvanikha Formation is composed of the greywacke flysch. Its age is unknown, but it is certainly pre-Devonian. The flysch is unconformably overlain by the Orochen Formation with basal conglomerate (up to 50 m). The conglomerate contains pebbles of underlying graywackes, as well as greenschists, acid volcanics, and granitoids. In terms of the pebble composition, the conglomerate described above resembles the basal conglomerate of the Tocher Formation.

The Orochen Formation (200 to 800 m thick) is composed of dolomites with interbeds of limestone (locally carbonaceous–clayey) and siliceous shales with phosphates. The age of this formation is considered Late Riphean–Early Cambrian [2, 3].

The Lower–Middle Cambrian Yaksha Formation consists of two sequences. The lower sequence (250–300 m thick), which rests with gradual transition on dolomites, is represented by limestones with shale interbeds. The upper sequence (up to 800 m thick) consists of shales and phyllitized graywackes.

Dolomites of the Orochen Formation are frequently represented by algal varieties with Cyanophyceae, Siphonophyceae, and Charophyceae remains. In the opinion of V.A. Luchinina, who studied our collections, the algae composition indicates a Devonian (most likely, Early Devonian) age of enclosing rocks. In addition, dolomites from some localities (for example, the Bo'shoi Kiro and Krutoi creeks) contain stromatoporids (*Stromatopora*? sp. and *Amphipora* sp., identifications by R.V. Goryunova), which are consistent with Devonian age of the Orochen dolomites. The lower Yaksha limestones (Bol'shoi Kiro Creek) yielded bryozoans (Middle Ordovician–Devonian *Ceramopora* sp., identification by R.V. Goryunova), Upper Silurian–Devonian tabulates (*Graciolopora* sp. and *Pachypora*? sp., identification by T.T. Sharkova), and poorly preserved colonial Rugosa corals. In thin sections of samples collected along the Korotkaya Yaksha Creek, R.V. Goryunova discovered remains of corals *Chaetetes* sp. (Devonian–Permian). The Yaksha limestones exposed along the Krutoi and Polyutovskii creeks provided conodonts *Palmatolepis* cf. *transistans* Mull. (lower Frasnian) and *Spathognathodus* sp. (Upper Devonian–Lower Carboniferous). It should be noted that some microfaunal and palynological samples from detrital limestones of the lower Yaksha sequence also contain fragments of chitinozoans, archaeocyaths(?), foraminifers, graptolites, gastropods, ostracods, sponge spicules, radiolarians, and acritarchs. Occurrence of pre-Devonian organic remains is explained by reworking of the pre-Orochen rocks. Plant detritus is also abundant. The palynological spectra examined in many samples imply their Middle Devonian–Early Carboniferous age. The Upper Devonian palynocomplex is most representative.

The upper Yaksha terrigenous sequence is almost barren of fossils. The conodont species *Neopolygnathus communis* Brans. et Mehl (upper Famennian–Lower Carboniferous) was found only in the bituminous clayey limestone interbed among alternating graywacke, clayey–siliceous, and shaly sediments in the section exposed in excavation along the Bagdarin–Troitskoe road.

Thus, we believe that the Orochen dolomites belong to the Silurian–Devonian, the Yaksha limestones belong to the Upper Devonian (largely, Frasnian), and the Yaksha terrigenous sequence belong to the Famennian–Lower Carboniferous. In terms of age, structure, and composition of terrigenous sediments, the upper Yaksha Sequence (Subformation) correlates with the Tocher Formation.

The *Bagdarin Complex* is represented by rocks of the Bagdarin Formation. This is a thick sequence of Cambrian–Early Ordovician terrigenous variegated rocks [1, 8]. It rests upon the Orochen and Yaksha formations. However, they are separated by tectonic contacts at all exposures. The complex is most widespread in the Bagdarin area. Its section universally contains three members.

The lower red-colored sequence (up to 600 m thick) is composed of alternating gravelstones and coarse-grained sandstones grading upward into medium-grained calcareous sandstones and sandy limestones. Sandstones exposed at the mouth of the Bol'shaya Yaksha Creek (left tributary of the Bagdarin River) yielded plant remains. According to S.V. Naugol'nykh, they demonstrate morphological similarity with Propteridophyta (Rhyniophyta) shoots indicating most likely a Late Silurian–Devonian age of host rocks. The middle gray-colored sequence (200–300 m thick) is represented by rhythmically alternating sandstones and shales with occasional interbeds (up to 3 m) of oolitic limestones. The microfossil assemblage extracted from these rocks is characteristic of the Middle Devonian–Lower Carboniferous. The upper red-colored sequence (up to 500 m thick) consists of sandstones and silty pelites with a variable amount of calcareous material.

Detrital material in the Bagdarin Formation is represented by quartz, feldspars, mica, and amphibole. Lithoclasts are represented by basic, intermediate, and acid volcanics, granites, schists, sandstones, and siltstones.

The upper sequence encloses organic remains. Its sections exposed in the Bol'shaya Yaksha, Alekseeevskii, and other areas contain the bryozoan assemblage that includes *Rhombotrypella* sp., *Ascopora* sp., *Rhabdomeson* sp., *Primorella* sp., *Fistulipora* sp., and *Fenestella* sp. (identifications by R.V. Goryunova). Such a taxonomic composition of bryozoans suggests a Carboniferous (probably, Middle–Upper Carboniferous) age of the enclosing rocks, because *Rhabdomeson, Primorella,* and *Ascopora* genera occur beginning from the Lower Carboniferous, whereas representatives of the genus *Rhombotrypella* are reported from the Middle Carboniferous. According to E.Ya. Leven, rocks from this section (Bol'shaya Yaksha Creek) contain recrystallized fusulinid(?) tests. If this is correct, the upper sequence of the Bagdarin Formation should be referred to the Middle Carboniferous–Permian. Therefore, we assign the entire formation to the Devonian–Late Carboniferous.

The Bagdarin Formation is characterized by the wide development of red-colored rocks, their polymictic composition, the presence of intraformation hiatuses, the coarse cross-bedding of rocks, the development of ripple marks, and the presence of oolitic limestone interbeds. These features indicate the predominance of shallow-water sedimentation settings, the partial overcompensation of the basin, and the influx of edaphogenic material (redeposition of red-colored terrigenous rocks). These are largely coastal-marine and partly subaerial sediments.

Thus, the northern part of the Ikat–Bagdarin zone contains two (Baikalian–Caledonian and Hercynian) structural stages. The first stage includes Neoproterozoic–Lower Paleozoic lithotectonic complexes. Reconstruction of paleotectonic structures of this period is rather difficult because of the fragmentary nature of the available data. Therefore, we shall only note that the zone represented a geodynamic system, which included a trough with the oceanic crust [9, 10] and island arc (differentiated volcanics of the Usoi Formation and metagraywackes of the Suvanikha Formation).

The Hercynian structural stage comprises the Orochen, Yaksha, Tocher, and Bagdarin formations. They fill in the spacious Tocher Trough [4]. The composition of detrital material and the geochemistry of terrigenous rocks [11] show that the formations mentioned above are products of the erosion of ensimatic island-arc complexes (ophiolites included). Black shales of the Shaman Ridge mark the axial (deepest) part of this trough. In contrast, sediments of the Bagdarin Formation (molasses) were deposited along the southern (present-day coordinates) wall of the Tocher trough. The northern wall of the Tocher Trough is marked by the Urma Sequence (Upper Devonian) of the Lesser Khamar-Daban Range, which is compositionally similar to the Bagdarin Formation.

As was noted, all the above-mentioned complexes were juxtaposed during the Hercynian tectogenesis to form a complex system of repeatedly dislocated tectonic sheets thrust onto metamorphic rocks of the Tsipikan and Amalat blocks. The eventual structure was crosscut by discordant granitoid intrusions of the Vitimkan Complex (320–290 Ma) [12]. In the study area, they are represented by the Usoi Massif (a neoautocthon) that marks termination of the fold–thrust deformations. Its granitoids intrude the Suvanikha, Usoi, Orochen, Yaksha, and Bagdarin formations. Zircons extracted from the Usoi granitoids yielded a concordant age of 288 ± 2 Ma (MSWD = 0.055), which corresponds to the middle phase of the Early Permian. Taking the above data into consideration, we believe that the Tocher flysch trough was closed and transformed into the fold–thrust structure in the Late Carboniferous–Early Permian.

ACKNOWLEDGMENTS

This work was supported by the Russian Foundation for Basic Research, project nos. 05-05-65027 and 05-05-97228.

REFERENCES

1. I. V. Gordienko, Geol. Geofiz., **47** (1), 53 (2006).
2. V. G. Belichenko, *Caledonides of the Baikal Mountainous Region* (Nauka, Novosibirsk, 1977) [in Russian].
3. Yu. P. Butov, *Paleozoic Sedimentary Sequences of the Sayan–Baikal Fold Zone* (BNTs SO RAN, Ulan-Ude, 1996) [in Russian].
4. S. V. Ruzhentsev, V. A. Aristov, O. R. Minina, et al., in *Problems of the Tectonics of Central Asia* (Geos, Moscow, 2005), pp. 171–198 [in Russian].
5. E. Yu. Rytsk, A. F. Makeev, E. S. Bogomolov, et al., in *Isotopic Geochronology for the Solution of Geodynamics and Ore Genesis Problems* (St. Petersburg, 2003), pp. 440–442 [in Russian].
6. G. E. Nekrasov, S. V. Ruzhentsev, S. D. Presnyakov, et al., in *Geodynamic Evolution of the Lithosphere of the Central Asian Mobile Belt: From the Ocean to Continent* (IZK SO RAS, Irkutsk, 2006), Vol. 2, pp. 58–60 [in Russian].
7. V. A. Aristov, Yu. P. Katyukha, O. R. Minina, et al., Vestn. Voronezh. Univ. Ser. Geol., No. 2, 19 (2005).
8. *The Geological Map of East Siberia and Northern Part of the Mongol People Republic. Scale 1: 1 500 000*, Ed. by A.L. Yanshin (Mingeo SSSR, Moscow, 1983) [in Russian].
9. G. A. Mitrofanov and N. N. Mitrofanova, in *Magmatism and Metamorphism of the BAM Zone and Their Role in the Formation of Mineral Resources* (Nauka, Novosibirsk, 1983), pp. 60–63 [in Russian].
10. L. M. Parfenov, A. N. Bulatov, and I. V. Gordienko, Tikhookean. Geol. **15** (4), 3 (1996).
11. E. F. Letnikova and S. V. Vesheva, in *Geodynamic Evolution of the Lithosphere of the Central Asian Mobile Belt: From the Ocean to Continent* (IZK SO RAS, Irkutsk, 2006), Vol. 2, pp. 29–32 [in Russian[.
12. V. V. Yarmolyuk, V. I. Kovalenko, A. B. Kotov, and E. B. Sal'nikova, Geotectonics **31**, 359 (1997) [Geotektonika, **31** (2), 18 (1997)].