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Tectonics of the Urals and adjacent part of the West-Siberian platform basement: Main features of geology and development

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ABSTRACT

The Urals had undergone two main complete cycles of geodynamic development in the Riphean–Mesozoic time. The first one took place in the Riphean and Vendian and was completed by formation of the Timanides; the second is dated as Paleozoic–Early Mesozoic, belongs to the Uralides and can be divided into eight stages: (1) Continental riftogenesis (Cambrian – Early Ordovician). (2) Oceanic spreading (Middle-Late Ordovician). (3) Main subduction (Late Ordovician – Early Carboniferous). (4) Early collision (Late Devonian – Early Carboniferous) between the Magnitogorsk island arc and the passive margin of the Laurussia continent. (5) Late subduction of a relict oceanic crust of the Paleouralian ocean (Early-Carboniferous-Bashkirian). (6) Collision of Laurussian and Kazakhstanian continents. (7) A limited post-collisional extension and superplume magmatism (Triassic). (8) Thrust-and-fold deformation in the Early Jurassic time. Structure of the West Siberian plate is divided into three structural stages: (1) Folding of basement composed of rock complexes of almost exclusively Paleozoic age; (2) Riftogenesis with eruption of Early Triassic basalts (occasionally with some rhyolites), covered by terrigenous series of the Middle and Upper Triassic; (3) Deposition of a platform cover comprising Jurassic and younger sedimentary complexes, practically undeformed, which contain almost all deposits of oil and gas in the Western Siberia. The basement of the western part of the West Siberian plate is a prolongation of the structural zones of the eastern sector of Uralides, while the basement of the eastern part of the plate belongs to the Siberian craton and its folded margin. A huge block of the Kazakhstanides is situated to the east of the Uralides, beneath the platform cover and pinches out to the north. These main domains of the basement are divided by two major ophiolite sutures – Valerianovsk and Chara. Wide distribution of Triassic volcanogenic complexes under the platform cover of the West Siberian plate makes a principal difference from the Urals. Ophiolites are widely distributed under the platform cover of the West Siberian plate (especially in its central and western parts). Completion of Paleozoic geodynamic evolution of this region resulted from the collision of three continents (Laurussia, Siberia and Kazakhstania) accompanied by folding, highamplitude thrusting, intrusion of granite plutons, metamorphism and formation of a new crust of continental type. The time of these events which consolidated Paleozoic complexes of basement of future West Siberian megabasin is determined as Early Permian for the Cis-Uralian part of the platform. In the beginning of Triassic rifting, formation of a graben system, took place. A final stage of compressional deformation, mostly in the exposed part of the Urals, Pay–Khoy and Novaya Zemlya, occurred in the Lower Jurassic.

1. Introduction

The Urals is one of the most famous examples of fold belts with a complete Wilson cycle of evolution. A large number of publications including numerous monographs are devoted to problems of geological structure and evolution of Urals (Peive et al., 1977; Puchkov, 2000, 2010; Ivanov et al., 1986; Ivanov, 1998; Yazeva and Bochkarev, 1998; Brown et al., 2002; Morozov, 2006; Kashubin et al., 2006; Gee and Pease, 2004 and many others). In the last 10–15 years several major geological–geophysical projects were carried out; seismic and structural profiles across the Southern and Middle Urals were acquired (URSEIS-95 and ESRU-SB: position of the profiles is shown in Fig. 1).

The Urals is distinguished by a number of specific features such as an exceptionally wide distribution and good preservation of

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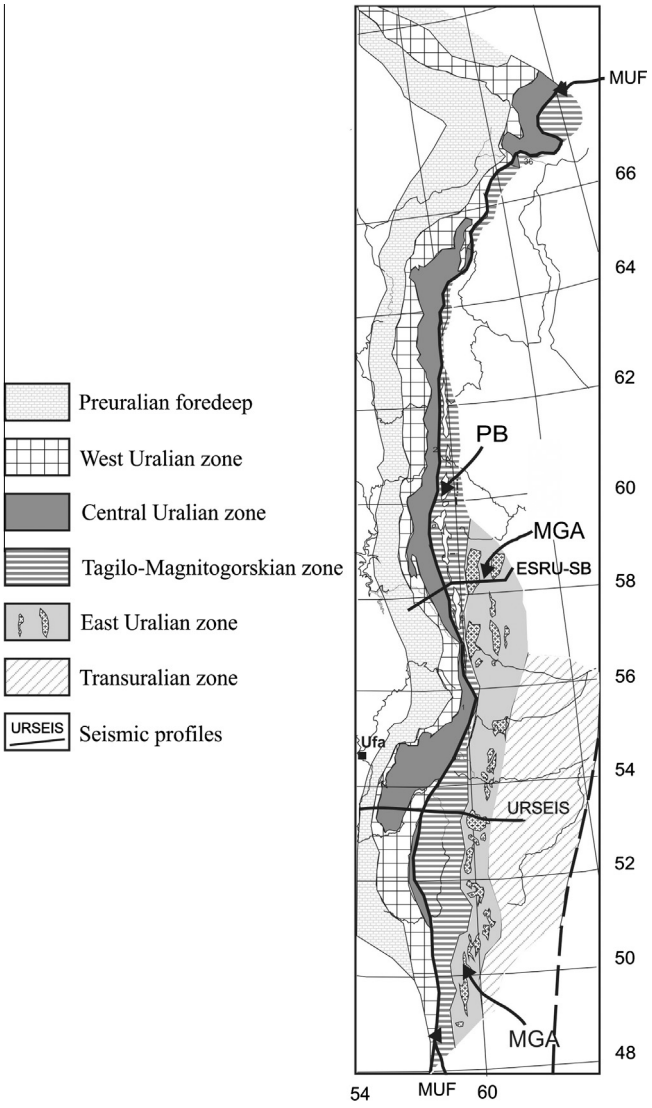

Fig. 1. Tectonic zones of the Urals (Uralide stage). Abbreviations: MUF – Main Uralian Fault, PB – Platiniferous Belt, MGA – Main Granitic Axis, described in the text.

ophiolites and island arc complexes, presence of Platinum-bearing intrusive belt and a Uralian belt of high-pressure metamorphism. Geophysical data show the presence of a "cold", isostatically equilibrated "mountain root" under the central part of the Uralian bivergent orogen.

Geographically the Urals is divided into five segments – Southern (including Mygodzhary), Middle, Northern, Cis-Polar and Polar. Further to the north the western Uralian structural zones are continued into the Pai-Khoy – Novaya Semlya fold belt.

The Urals is divided into six meridional structural megazones subparallel to the margin of the East European platform. The western megazones are traced at the earth surface along the whole extent of the belt; the eastern ones are exposed only in the Southern and Middle Urals and disappear gradually to the north under the Mesozoic–Cenozoic sedimentary cover of the young West Siberian basin. The South Tien Shan fold belt is a most probable prolongation of the Urals to the southeast. The comparative study of the Urals and Tien Shan indicates that analogs of many Paleozoic complexes of Urals are situated in South Tien Shan (although between the structures of these two regions there are quite essential distinctions); at the same time, the Uralian-like Paleozoic rock assemblages (Devonian ophiolites and island-arc volcanics, Famennian–Tournaisian flysch series) are traced to Caucasus beneath the Pre-Caspian depression.

Of six megazones of the Urals (Fig. 1), the westernmost three form the Uralian paleocontinental sector – a former passive margin of Baltica/Laurussia paleocontinent, and the last three – a paleooceanic sector, a collage of ophiolites, island arcs and microcontinental terranes of Paleo-Uralian ocean. The boundary between these sectors is represented by an ophiolite-hosting suture of the Main Uralian fault (Fig. 1).

2. The tectonic megazones of the Uralides

The Pre-Uralian foredeep (in Fig. 1) filled up by terrigenous sediments (pre-flysch deep-water condensed sediments, flysch, evaporites and molasse) of the Upper Paleozoic and partly Triassic age with thickness up to 5–6 km. In the south of the Urals the initiation of the foredeep was accompanied by accumulation of the Late Carboniferous – Early Permian flysch series. The flysch grades to the west into condensed (so-named pre-flysch) series composed mostly of alternation of relatively deep-water dark-colored shales, marls and limestones. Usually it is supposed (Peive et al., 1977) that the formation of the condensed pre-flysch series at the bottom of the flysch succession was connected with a subsidence of a continental margin under the weight of tectonic sheets composed of island arc complexes and thrust from the east. A forebulge and an east-facing structural step have formed along the western side of the unloaded part of the depression. They were migrating with time to the west, being marked, respectively, by erosional gaps and a chain of reef massifs.

The flysch series, dated as the Mid-Carboniferous to Lower Permian, was formed during the epoch of active collision, thrusting and orogeny. This process was accompanied by a migration of the depression to the west, onto the platform, which is well determined by the age change of the carbonate (platform) base of the depression. In the Kungurian time the flysch was partly substituted by evaporites, which finally filled up and obliterated the deep-water depression.

Shallow-water and subaerial molasse, Upper Permian to Triassic in age, migrated to the west in relation to the flysch and have been formed at the stage of attenuation of the orogenic processes in the Urals. Probably the load on the platform margin decreased and the platform began to rise. The age of the basal layers of the foredeep becomes younger to the west and north, reflecting a migration of the basin from east to west and probably from south to north. The western parts of the depression are mainly characterized by gently sloping platform structures. Crest-shaped, swell-like, box-like and more compound compressed folds (including overturned and isoclinal ones) of Uralian strike belonging to the Uralian linear folding are typical for the eastern parts. The above-described folds are complicated by linear sulfate-salt diapiric folds and thrusts, flattening gradually at depth and merging with detachment surfaces.

The West-Uralian megazone (in Fig. 1) was in the Paleozoic a passive (Atlantic-type) margin of the East European platform, i.e. transitional area from the platform to the Uralian paleoocean situated in the east. Here two regional zones of sedimentation are distinguished, in the Ordovician to Carboniferous time: the western – Belsk-Elets one, comprising paleoshelf terrigenous–carbonate series and the eastern – Zilair–Lemva, with terrigenous-siliceous-shale deposits, interpreted (Puchkov, 1979 and others) as an area of passive continental margin. Only in the Carboniferous time the new structure (above-described Pre-Uralian foredeep depression) has originated.