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Middle–Late Paleozoic geodynamic complexes and structure of Gorny Altai and their record in gravity data

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Abstract

Middle–Late Paleozoic geodynamics and structure of Gorny Altai are studied with reference to gravity data. The northern and central parts of the area belong to the Gorny Altai terrane consisting of Late Precambrian–Paleozoic rocks originated in different tectonic settings on the Siberian continental margin, including Devonian active-margin volcanoplutonic complexes. In the south and east, the Gorny Altai terrane borders the Altai–Mongolia terrane along the Charysh–Terekta–Ulagan shear zone. The Altai–Mongolia terrane is composed of Early Paleozoic turbidites of the Kazakhstan–Baikal continent, Middle Paleozoic collisional garnet–disthene–andalusite schists, and Late Paleozoic zoned andalusite–cordierite schists, with granitic plutons on their periphery. The pattern of these complexes is similar to that of Cenozoic volcanoplutonic and metamorphic domes in the Kamchatka and Chukchi Peninsulas. The Devonian volcanoplutonic complexes from the Gorny Altai terrane and the Middle–Late Paleozoic metamorphic complexes from the Altai–Mongolia terrane are well evident in the gravity field. In general, gravity anomalies in the two terranes strike in different directions: NW in the Gorny Altai terrane and W–E in the Altai–Mongolia terrane, which highlights the structural heterogeneity of the Gorny Altai region. New dates have been obtained for magmatic detrital zircons from Paleozoic sedimentary rocks of the Anui–Chuya basin in the Gorny Altai terrane. The inferred source areas of zircon hosts are igneous rocks of the Precambrian craton basement and the Vendian–Early Ordovician Kuznetsk–Altai island arc. Early Neoproterozoic (1.00–0.75 Ma) detrital zircons are abundant in the Early Paleozoic turbidites of the Altai–Mongolia terrane but are absent from samples of the Gorny Altai terrane. Populations of detrital zircons in the the Gorny Altai terrane contain Devonian and Early Neoproterozoic specimens. The reported data prove that the Kazakhstan–Baikal and Siberian continents amalgamated in the Middle–Late Paleozoic. The resulting Gorny Altai tectonic framework of that time is recorded in the gravity field and in the provenance of detrital zircons.

Keywords: tectonics; geodynamics; shear zone; detrital zircons; granites; volcanoplutonic complexes; zoned metamorphic complexes; gravity field; Gorny Altai

Introduction

Gorny Altai is a key area where to study tectonic and geodynamic history of the Central Asian Orogenic Belt (Berzin et al., 1994; Buslov, 2011; Buslov and De Grave, 2015; Buslov et al., 2000, 2003, 2004, 2013; Cai et al., 2016; Dobretsov, 2003, 2011; Dobretsov and Buslov, 2007; Dobretsov et al., 1995, 2003, 2013; Yolkin et al., 1994). Much knowledge has been gained recently due to advanced zircon U–Pb geochronology and apatite fission-track thermochronology. U–Pb dating of detrital zirocns constrains the lower age bound and reveals the presumable provenance of their sedimentary hosts. U–Pb zircon ages also have implications for tectonic and geodynamic regional division based on correlation of sedimentary complexes (Buslov, 2011, 2014, Buslov and Cai, 2017; Buslov et al., 2013; Cai et al., 2014, 2016; Chen et al., 2014a,b, 2015a,b, 2016a,b). Apatite fission-track thermochronology has been broadly used for Gorny Altai to reconstruct the thermal-tectonic history of rocks and surface topography necessary for updating geodynamic models (Dobretsov et al., 2016; De Grave and Van den Haute, 2002; De

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Grave et al., 2007a,b, 2008, 2009, 2011; Glorie et al., 2012; Vetrov et al., 2016).

This paper presents the first detailed description of volcanoplutonic and metamorphic complexes, as well as the general Paleozoic structure of Gorny Altai with reference to the gravity database of Andersen et al. (2014). The patterns of the Gorny Altai Paleozoic complexes are compared with those of Cenozoic volcanoplutonic and metamorphic domes in the Kamchatka and Chukchi Peninsulas. New dates are reported for magmatic detrital zircons from Paleozoic sedimentary rocks of the Anui–Chuya basin in the Gorny Altai terrane.

Paleozoic complexes of Gorny Altai and new LA-ICP-MS U–Pb ages of detrital zircons

The Gorny Altai region has undergone a complex geodynamic history consisting of several stages with different tectonic settings (Buslov, 2011, 2014; Buslov and De Grave, 2015; Buslov et al., 2013; Dobretsov and Buslov, 2011): (1) Venidan–Early Ordovician (Tremadocian) Kuznetsk–Altai active continental margin of Siberia; (2) Ordovician–Early Devonian (Pragian) passive continental margin of Siberia; (3) Devonian active continental margin of Siberia; (4) Ordovician–Early Carboniferous subduction and collision events which led to amalgamation of the Kazakhstan–Baikal and Siberian continents sutured along the Charysh–Terekta–Ulagan shear zone. Activity within the shear zone included strike-slip and thrust faulting, folding, and collisional metamorphism and formation of a blueschist belt; (5) Late Carboniferous–Permian continental collision of Eastern Europe and Northern Asia, molasse deposition, strike-slip and thrust faulting, and syncollisional metamorphism and magmatism; (6) Late Permian–Early Triassic plume activity which produced the 245–232 Ma Belokurikha, Aya, and Aturkol granodiorite-granite-leucogranite plutons (Glorie et al., 2011; Shokalsky et al., 2000). The plutons bear no traces of deformation and intrude Late Paleozoic strike slip and thrust faults. Their age constrains the upper time bound of large-scale Late Paleozoic collisional events in Gorny Altai (Buslov et al., 2013).

The tectonic framework of Gorny Altai (Fig. 1) includes the Gorny Altai terrane in the northern and central parts of the area, consisting of Late Precambrian–Paleozoic rocks that originated in different tectonic settings on the Siberian continental margin. In the south and east, the Gorny Altai terrane borders the Altai–Mongolia terrane composed of Early Paleozoic turbidites of the Kazakhstan–Baikal continent along the Charysh–Terekta–Ulagan shear zone.

The Gorny Altai terrane comprises Vendian–Early Ordovician rocks of the Kuznetsk–Altai island arc buried under Ordovician–Early Devonian passive-margin sediments and Devonian active-margin rocks which compose the Biya–Katun', Kurai, and Anui–Chuya zones. The complexes of the Gorny Altai terrane are autochthonous while those of the Altai–Mongolia terrane are allochthonous. Middle Paleozoic regional-scale fold-thrust belts and strike-slip faults (Fig. 1) are abundant within the Charysh–Terekta–Ulagan suture and are associated with Middle Paleozoic metamorphic complexes described below.

Recent advance in U–Pb dating of detrital zircons from sedimentary rocks has important tectonic and geodynamic implications. It has augmented the knowledge on the ages of sediments all over Central Asia and provided guides to their provenance. Below we report U–Pb ages of zircons from Paleozoic sediments of the Anui–Chuya zone of the Gorny Altai terrane (Figs. 2, 3, 4) which stores an almost continuous record of the ~200 Myr long Cambrian through Carboniferous history of the Siberian continental margins (Buslov et al., 2013).

The Anui–Chuya zone, extending for more than 500 km and up to 200 km wide, is the largest structure in Gorny Altai bounded by major Late Paleozoic strike-slip faults and oblique ramps. Its section comprises several units: (i) Late Cambrian–Early Ordovician turbidites that fill a fore-arc basin of the Kuznetsk–Altai island arc lie under (ii) 6–8 km thick Middle Ordovician–Early Devonian passive-margin sediments having conglomerates at the base; the deformed passive-margin rocks are, in their turn, overlain by (iii) 3 km of Early–Middle Devonian active-margin volcanic-sedimentary rocks; both stratigraphic boundaries (between i/ii and ii/iii) are discordant, with structural unconformities and gaps. Upsection, there follow more that 2 km of Upper Jivetian–Frasnian molasse upon basal conglomerates. The section is topped by Famenian–Visean molasse, about 750 m thick, lying transgressively over Early and Middle Devonian rocks. All quoted U–Pb ages of detrital zircons are new results of this study.

The Anui–Chuya Late Cambrian–Carboniferous rocks lie upon an accretionary-collisional complex of the Kuznetsk–Altai island arc (with Kurai, Katun, and Kaim accretionary wedges in its southern, eastern, and northern parts, respectively). The complex consists of fault-bounded oceanic-island volcanic-sedimentary rocks, ophiolites, and paleotrench olistostromes and trubidites (Buslov and Watanabe, 1996; Buslov et al., 2002, 2013; Dobretsov et al., 2004).

More exact constraints on the ages of clastic sediments in the Anui–Chuya zone and on their possible provenance were obtained by dating detrital zircons from nine Late Cambrian to Late Carboniferous sandstone samples. The U–Pb dating was performed using laser ablation inductively coupled plasma mass spectrometry (LA ICP-MS), on a *Nu Instruments ICP-MS* analyzer attached to the *Resonetics RESO-lution M-50-HR* Excimer Laser Ablation System at the Department of Geosciences of the Hong Kong University, following the procedure detailed by Xia et al. (2011).

Zircons extracted from paleotrench sandstones that belong to the Kaim and Kurai accretionary wedges exhibit similar age populations with main peaks at 509, 524 and 539 Ma for the Kaim Formation (from 53 concordant grains) and 502 Ma for the Kurai Formation (from 106 concordant grains). The lower age bounds, according to the youngest peaks in the probability density curve, are ~509 Ma and ~502 Ma for the Kaim and Kurai deposition, respectively.