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Paleoearthquakes in the Uimon basin (Gorny Altai)

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Abstract

Paleoseismological studies confirm that the Uimon basin is thrust by its northern mountain border along the active South Terekta fault. The latest motion along the fault in the 7–8th centuries AD induced an earthquake with a magnitude of $M_w = 7.4–7.7$ and a shaking intensity of $I = 9–11$ on the MSK-64 scale. The same fault generated another event ($M \geq 7$, $I = 9–10$), possibly, about 16 kyr ago, which triggered gravity sliding. The rockslide dammed the Uimon valley and produced a lake, where lacustrine deposition began about 14 ± 1 kyr ago, and a later $M \geq 7$ ($I = 9–10$) earthquake at ~6 ka caused the dam collapse and the lake drainage. Traces of much older earthquakes that occurred within the Uimon basin are detectable from secondary deformation structures (seismites) in soft sediments deposited during the drainage of a Late Pleistocene ice-dammed lake between 100 and 90 ka and in ~77 ka alluvium. The magnitude and intensity of these paleoearthquakes were at least $M \geq 5.0–5.5$ and $I \geq 6–7$.

Keywords: paleoseismology; primary and secondary seismic deformations; large paleoearthquakes; Uimon basin; Gorny Altai

Introduction

The northern Altai (Gorny Altai) intracontinental orogen is a territory of quite high seismic risk, with active faults responsible for large earthquakes both inside the area and in the adjacent parts of the Rudny, Mongolian, and Chinese Altai mountains (Adija et al., 2003; Khilko et al., 1985; Lukina, 1996; Radziminovich et al., 2016; Timush, 2011). According to the latest seismic risk map of the Russian Federation (Ulomov et al., 2016), faults in southeastern and central Gorny Altai can generate $M = 7.0–7.5$ events, with a shaking intensity of $I \geq 8–9$ (MSK-64 scale) depending on recurrence time in the range from 500 to 10,000 years. Seismological and paleoseismological data (Deev, 2016; Deev et al., 2017; Rogozhin et al., 1999, 2008) support this inference for southeastern Altai, but neither historic nor Holocene earthquakes of these magnitudes and intensities are known in central Gorny Altai, except for the Katun fault zone (Deev et al., 2015, 2016).

North–south trending ridges, 4–6 km long, a few tens of meters wide, and 4–5 m high, in the Uimon basin (central Gorny Altai) were misinterpreted as fault scarps produced by large paleoearthquakes (Platonova, 1999). However, we infer that the ridges are rather alluvium fan deposits of the Kastakhta and Kurunda Rivers. Massive or trough cross-bedded alluvial pebble and sand accumulated during marine isotope stage 2 (MIS-2). The ridges originated during ice melting by transformation of synform channel deposits into antiform ridges, i.e., they are inverted topographic features. Numerous normal faults, flexures, systems of fractures and microfaults detectable in alluvium are genetically related with slumping and sliding of ridge slopes during the topographic inversion.

Later we discovered structures of secondary seismogenic soft-sediment deformation (seismites) in sections of Late Quaternary sediments in the Uimon basin and other adjacent basins east of it. The seismites resulted from brittle deformation and liquefaction of soft sediments caused by seismic

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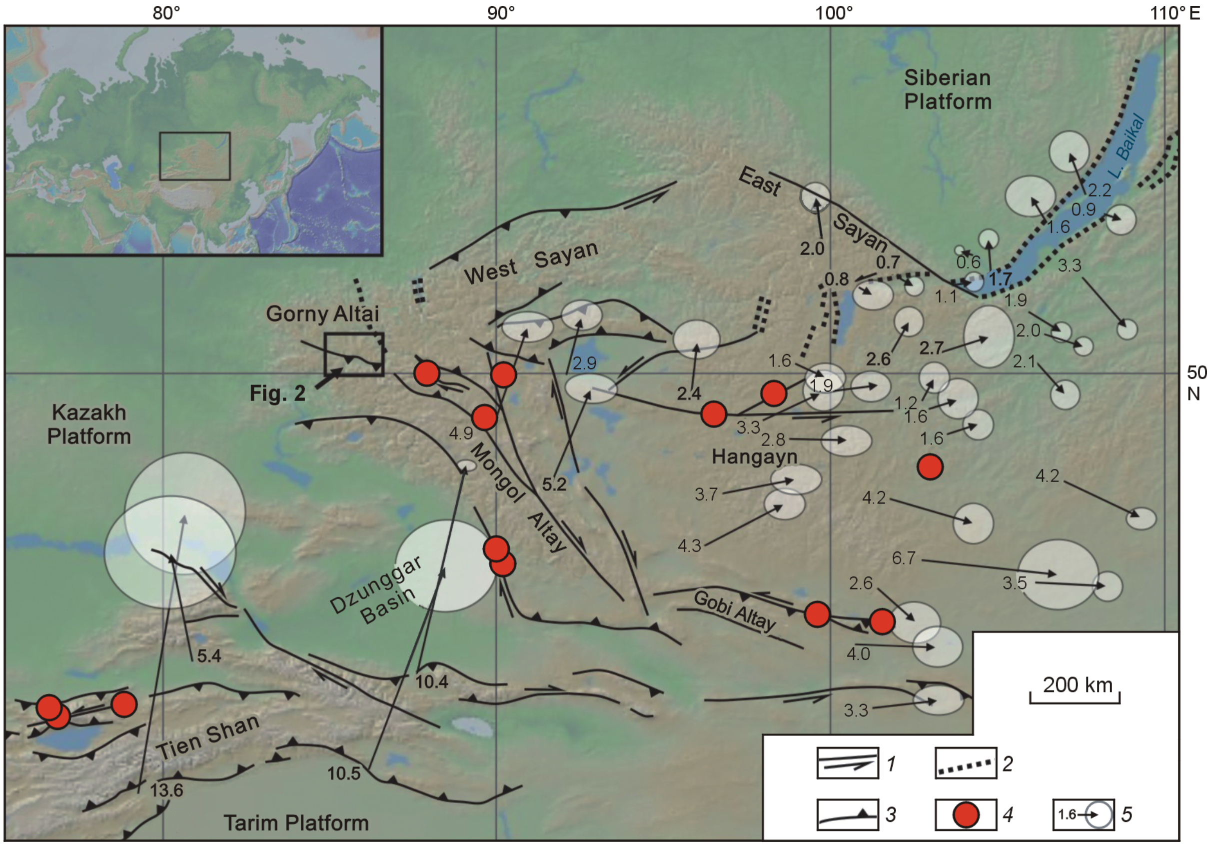

Fig. 1. Location map of Gorny Altai and study area in the Central Asian framework, after (Deev et al., 2017). *1–3*, active faults of strike-slip (*1*), normal (*2*), and reverse (thrust) (*3*) geometry, after (Cunningham, 2007; Kalmetieva et al., 2009; Rizza et al., 2015; Trifonov et al., 2002; Yang et al., 2008); *4*, $M \geq 7$ earthquakes. Locaitons of historic and instrumental events are according to (Kalmetieva et al., 2009; Kondorskaya and Shebalin, 1977; Radziminovich et al., 2016); *5*, GPS horizontal velocities with respect to the Eurasian reference frame are according to (Calais et al., 2003), numerals are motions in mm·yr^{-1}, ellipses are measurement errors within a 95% confidence interval.

shocks. Therefore, large earthquakes, at least $M \geq 5$–6 ($I \geq$ 6–7) shook the area in Late Pleistocene and Holocene time (Deev et al., 2013a,b). The new sections with seismites we have documented in recent years, along with isotope age constraints obtained for Late Quaternary deposits, expand significantly the knowledge of paleoseismicity in the Uimon basin area.

Neotectonics of the Uimon basin

Altai is an active Cenozoic orogenic belt (Fig. 1) that owes its origin to a far-field effect of the India–Eurasia collision (Le Pichon et al., 1992; Molnar and Tapponnier, 1975; Yin, 2010). Crustal deformation produced fault-bounded blocks in the northern part of the orogen (Gorny Altai) with ridges rising up to 4500 m asl. The amount of vertical offset inferred from elevation contrasts between fragments of the preorogenic Cretaceous–Paleogene peneplain reaches 3000–4000 m in three largest intermontane basins of Chuya, Kurai, and Uimon (Deev et al., 2012a,b; Devyatkin, 1965; Nevedrova et al., 2014). The fault pattern in Gorny Altai mainly consists of strike-slip faults that evolved in settings of transpression, transtension, and rotation (Deev et al., 2017; Delvaux et al., 2013; Lukina, 1996; Novikov, 2001; Thomas et al., 2002).

The Uimon basin (300 km^2) is the third largest basin in Gorny Altai. It extends for 30 km in the W–E direction and is about 10 km wide on average. Together with the Katanda, Tyungur, and Turgunda basins in the east and the Tyuguryuk and Abai basins in the west, the Uimon basin forms a chain of depressions along the Uimon fault, which separates the Terekta Range (2200–2900 m) from the Katun (2800–4500 m) and Kholzun (2000–2500 m) Ranges in central Gorny Altai (Figs. 2, 3).

In the southwestern Uimon basin, the NE trending segment of the Katun River includes a branch narrowing to the south (Figs. 2 and 3), where the river flows southeastward along the southern basin side after an almost 90° bend. The southward offset of the braided river follows the asymmetric transversal profile of the Uimon basin which descends gradually from 1100–1150 m asl on the northern side to 850–900 m in the south. Large alluvial fans of the Kastakhta, Kurunda, Terekta, Chendek and Margala Rivers occupy most of the basin's northern and central parts.

The Uimon basin is located within an active fault zone called Uimon (Lukina, 1996; Trifonov et al., 2002), which partly inherits the Paleozoic South Terekta thrust with a