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Geometry of the fault zone of the 2003 Ms = 7.5 Chuya earthquake and associated stress fields, Gorny Altai

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Abstract

The co-seismic deformations produced during the September 27, 2003 Chuya earthquake (Ms = 7.5) that affected the Gorny Altai, Russia, are described and discussed along a 30 km long segment. The co-seismic deformations have manifested themselves both in unconsolidated sediments as *R*- and *R′*-shears, extension fractures and contraction structures, and in bedrock as the reactivation of preexisting schistosity zones and individual fractures, as well as development of new ruptures and coarse crushing zones. It has been established that the pattern of earthquake ruptures represents a typical fault zone trending NW–SE with a width reaching 4–5 km and a dextral strike–slip kinematics. The initial stress field that produced the whole structural pattern of co-seismic deformations during the Chuya earthquake, is associated with a transcurrent regime with a NNW–SSE, almost N–S, trending of compressional stress axis (σ_1), and a ENE–WSW, almost E–W, trending of tensional stress axis (σ_3). The state of stress in the newly-formed fault zone is relatively uniform. The local stress variations are expressed in insignificant deviation of σ_1 from N–S to NW–SE or NE–SW, in short-term fluctuations of relative stress values in keeping their spatial orientations, or in a local increase of the plunge angle of the σ_1. The geometry of the fault zone associated with the Chuya earthquake has been compared with the mechanical model of fracturing in large continental fault zones with dextral strike–slip kinematics. It is apparent that the observed fracture pattern corresponds to the late disjunctive stage of faulting when the master fault is not fully developed but its segments are already clearly defined. It has been shown that fracturing in widely different rocks follows the common laws of the deformation of solid bodies, even close to the Earth surface, and with high rates of movements.

Keywords: Chuya earthquake; Fault zone; Co-seismic deformations; Stress fields; Gorny Altai

1. Introduction

The Ms = 7.5 Chuya earthquake of September 27, 2003, is the strongest event in the southeastern part of the Gorny Altai (Western Siberia, Russia) over the instrumental period of seismological observations (Fig. 1). In contrast to the Mongolian and Gobi Altai catastrophic earthquakes (Trifonov and Makarov, 1988; Baljinnyam et al., 1993; Leontyev and Rogozhin, 1995; Cunningham et al., 1996; 1997), only two strong earthquakes with M ≥ 6 were recorded in the broader Gorny Altai region before the Chuya earthquake (Novikov, 2004). These are the earthquake of September 21, 1923 (M = 6) and the Zaisan earthquake of June 14, 1990 (M = 6.6). The former earthquake was not field-checked, and its precise location is unknown. The hypocenter of the Zaisan earthquake was at a depth of 35–40 km that suggested the relatively modest "linear morphogenic effects" (according to Caputo, 2005a) at the surface. The recorded ruptures were apparently due to secondary causes, seismovibrational or seismogravitational (Leontyev and Rogozhin, 1995) and could be considered as "areal seismogenetic features" (Caputo, 2005a). Compared to these previous earthquakes, the Chuya earthquake is unique for several reasons. Firstly, its epicenter is located in the center of

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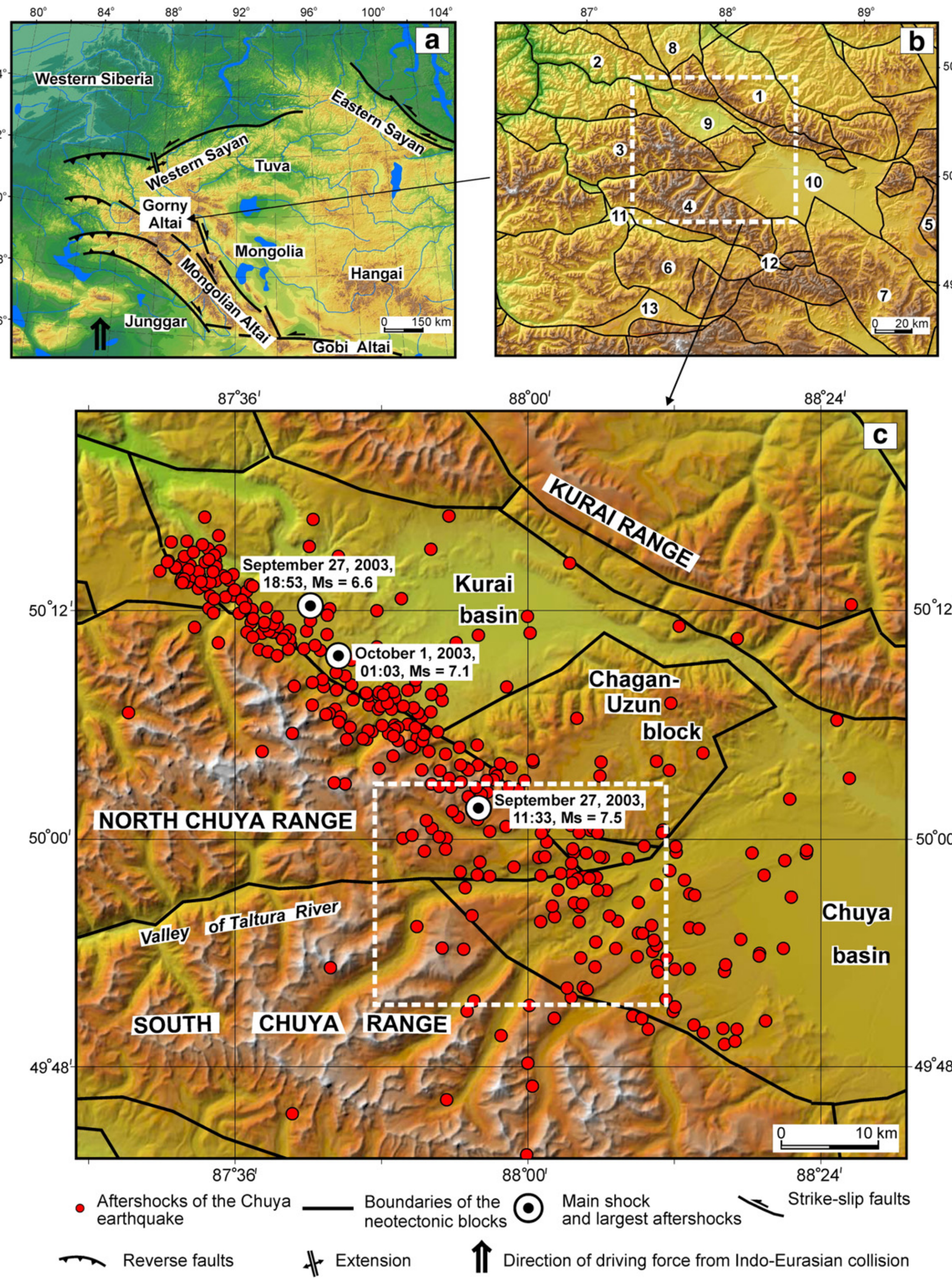

Fig. 1. Framework of the research area: (a) regional topography, geodynamics (after Novikov, 2004) and location of the Gorny Altai; (b) the main morphostructural elements of the Southeastern Altai: ranges: Kurai (1), Aigulak (2), North Chuya (3), South Chuya (4) and Chikhachev (5); plateauxes: Ukok (6) and Sailyugem (7); inter-mountainous basins: Sorulukol (8), Kurai (9), Chuya (10), Samakhin (11), Tarkhatin(12) and Bertek (13); (c) the strongest seismic events in September–October, 2003 and epicenters of aftershocks. The map of the main morphostructural elements of the Southeastern Altai was compiled by Novikov I.S. The data on the aftershock locations have been obtained by Geophysical Survey of the Siberian Branch of Russian Academy of sciences (SB RAS). Magnitudes of the main shock and two strongest aftershocks are presented from the Harvard SMT Catalog of earthquakes (http://www.seismology.harvard.edu). Dotted line in Fig. 1b indicates Fig. 1c. Dotted line in Fig. 1c shows the investigated area represented in Fig. 2.

the local network of ten digital seismic stations (Altai seismological test area) installed by the Geophysical Survey SB RAS in August 2002, therefore allowing specific observations of the seismic process in the epicentral area before and after the earthquake (Goldin et al., 2004). Abundance of qualitative data and applying of new approach gave a quite