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Neotectonic inversions in the Baikal Rift System

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Abstract

Cenozoic continental rifting in southern East Siberia and northern Mongolia has been associated with subsidence and broadening of rift basins at the account of their mountain borders. This neotectonic trend is, however, superposed with continuous or periodic tectonic inversions in which the basin floor may uplift while marginal fault steps and saddles between basins may subside. Cenozoic geomorphic inversions are expressed in changes of river flow out of Lake Baikal.

Keywords: rifting; tectonic inversion; neotectonics; Baikal rift system

Introduction

Investigation of geological and geomorphic structures commonly implies revealing some evolution trends meant as some order in their geodynamic regime. However, order always coexists with disorder (or order change) in the evolution of complex phenomena. This rises the question of their classification, including the matter of hierarchy because disturbances to the geodynamic regime are normally expected to produce smaller-scale hierarchic elements. The geodynamic regime may undergo inversions. The meaning of an inversion, which has been little discussed in the literature, most often refers to tectonic motions or processes, evolving in space or time, with their trends opposite to the general evolution trend. Inversions are studied through comparison in the pair "normal-reverse motion", and this drives one at a rather efficient principle of analyzing (comparing) the opposites. They are commonly the binary opposites, of which the Baikal rift zone (Fig. 1) offers multiple examples.

Tectonic inversions

Theoretically, there may be three types of tectonic inversion associated with the general process of continental rifting: (i) inversion as part of the rifting process in which structural elements or their parts change the polarity of motion; (ii) inversion superposed as disturbance on the rifting process; (iii) inversion as a change from continental rifting to a different geodynamic setting. We note in anticipation that the Baikal rift displays all the three types of inversion.

Inversions as part of the rifting process (specific inversions in rift valley shoulders). Florensov (1965) interpreted the general neotectonic trend in the Baikal rift as follows: rift valleys (grabens), being active tectonic elements, experience both subsidence and lateral growth at the account of the bordering mountains. Lateral basin propagation goes by detachment of narrow blocks, or intermediate fault steps (Schetnikov, 1999; Ufimtsev, 1984, 1985, 1992; Zamaraev and Mazukabzov, 1978), from the basin borders and their involvement in subsidence (Fig. 2). The two processes make together the "remnant-block or Baikal mechanism" of neotectonic mountain building (Florensov, 1965). There are two important points to note in this respect. The intermediate steps subject to subsidence within broad zones of border normal faults (i) maintain repeated geomorphic rejuvenation of fault scarps on the rift shoulders and (ii) being the former parts of the rift shoulders, experience tectonic inversion as a typical element of continental rifting. Intermediate steps in zones of normal faults of rift borders go through several stages of detachment (Fig. 3). In the beginning of the process, marginal blocks detach from the borders along kinks on crests of river divides (Fig. 3, *a*). Then the detaching marginal step decreases in elevation (subsides), and a back scarp arises above it looking like steep range-front facets (Fig. 3, *b*). Simultaneously, the back fault facets bordering the valley heads (the latter are not yet filled with sediments at that time), begin to detach in the

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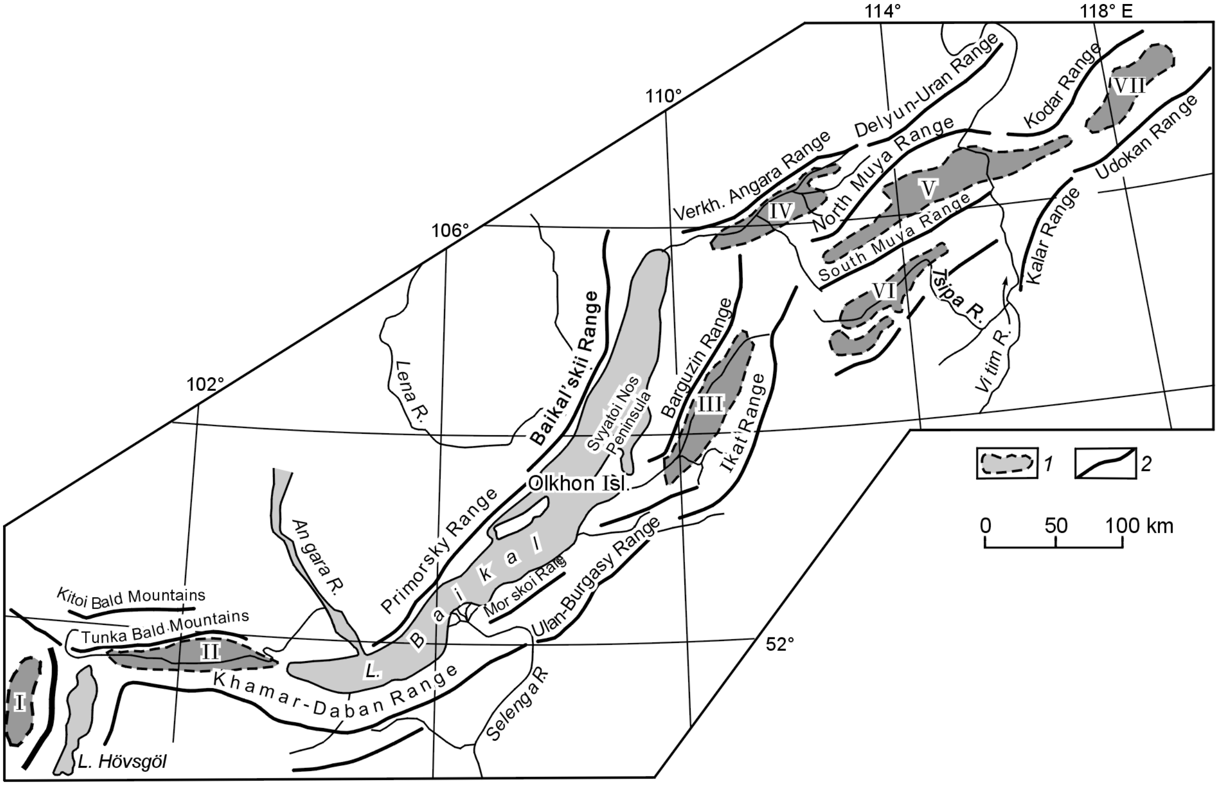

Fig. 1. Baikal rift zone. *1*, onshore rift basins; *2*, major ranges. Roman numerals stand for rift names: I, Darhat, II, Tunka, III, Barguzin, IV, Verkhnyaya Angara, V, Muya-Kuanda, VI, Tsipa-Baunt, VII, Chara.

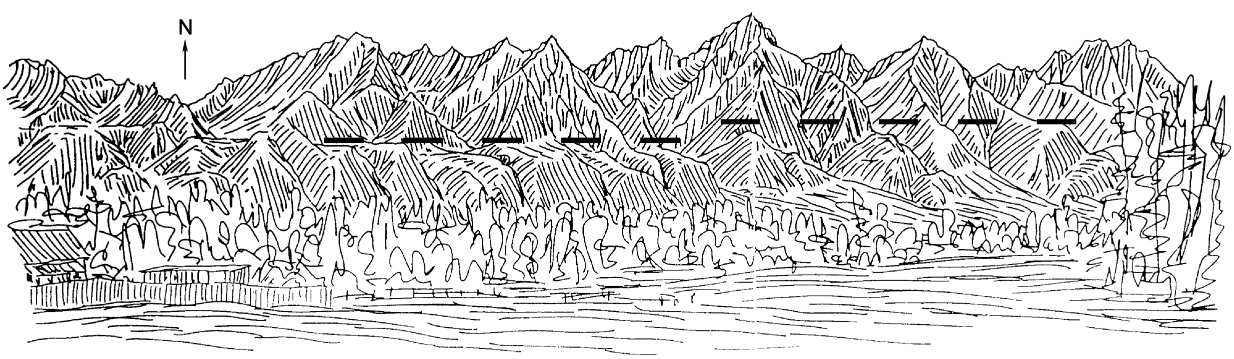

Fig. 2. Intermediate step in northern side of Hoytogol basin, Tunka rift.

upper part of the scarp (Fig. 3, *c*) thus marking the future position of the marginal fault scarp which experiences continuous morphological rejuvenation associated with rift valley broadening due to subsidence of the narrow blocks (steps).

The marginal fault scarps in the Baikal rift system (Fig. 4) are located most often in the western and northwestern sides of basins with arch uplifts in their opposite eastern and southeastern sides (Ufimtsev, 1992). The rift margins become involved with the limbs of the growing arches and broaden the latter. This is specific tectonic inversion, because the very process of arch uplifting is opposite to rifting (Florensov, 1965). The structural and geomorphic features produced by this specific inversion are (i) uplifted steps composed of Neogene deposits in the southern Baikal shore beneath the Khamar-Daban arch and (ii) tilted foothills, composed of Pleistocene sand, with their surfaces extending the limbs of the Khamar-Daban, Ikat, and other arches (Shchetnikov and Ufimtsev, 2004; Ufimtsev, 1992). Especially spectacular in this respect are cuesta-like foothills (locally called *kuituns*) in the Barguzin basin (Florensov, 1960) which extend the western limb of the Ikat Range for up to 10 km in some places. The same limb encloses a small basin of Yassy with its floor elevated considerably above the Barguzin rift (Ufimtsev, 1992).

A typical case of inversion subsidence (Fig. 5) is found in the Tsipa–Baunt rift, where the rift valley includes large hills of different heights with large lake basins (Baunt, Kapylyushi, and other lakes) sheathed into their depressed parts thus indicating lake ingression into the mountains. In most cases, large lakes and flood lakes are off the geophysically detected