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GEOMORPHOLOGICAL INDICATIONS OF HAZARDOUS PHENOMENA IN THE BAIKAL RIFT ZONE (**)

Abstract: UFIMTSEV G.F., *Geomorphological indications of hazardous phenomena in the Baikal rift zone.*

In the marginal sections of the Baikal rift zone, some landforms produced by natural disasters are identified. Most of them have seismic origins. Pure tectonic landforms are piedmont scarps and trenches. They originate during seismic rejuvenations of faults at the rift valley slopes. In the subsurface segments of the young faults high-grade tectonic disintegration of rocks is observed. Therefore seismogenic trenches and scarps are accompanied by great rock falls, rock slides and gravity faults. Geomorphological indications of high-grade disintegration of rocks in the zones of young faults are badlands and rock streams.

In the Barguzin rift valley traces of major outbursts of rock material from the ridge along the valleys of large rivers are revealed. These are aggregations of angular blocks in the marginal parts of the depressions near the mouths of the large valleys. Near the basin slopes they are represented by compact heaps of boulder. The sizes of individual boulders amount to 200 m^3 and over. At a distance from the mountains their scatter over the surface of the piedmont fans is observed. Evidently, quick outbursts of large volumes of rock material into the basin occurred after the destruction and collapse of landslide dams which barred the valleys during earthquakes.

KEY WORDS: Geomorphological hazard, Morphotectonics, Baikal rift zone, East Siberia.

Riassunto: UFIMTSEV G.F., *Indizi geomorfologici di fenomeni di rischio nella fossa tettonica del Baikal.*

Nelle zone periferiche della fossa tettonica del Baikal si trovano morfologie prodotte da disastri naturali. Di solito esse hanno un'origine sismica. Morfologie strutturali sono le scarpate pedemontane e i solchi che si originano presso i versanti della fossa durante il ringiovanimento sismico di faglie. Sono state osservate anche forti demolizioni di rocce presso le faglie recenti; così i solchi sismogenetici e le scarpate sono accompagnate da grandi frane. Indicazioni della degradazione del rilievo nelle zone delle faglie recenti sono le colate di detrito sui versanti e i calanchi.

Nella fossa di Barguzin sono state osservate tracce di grandi cadute di materiale roccioso lungo le valli dei fiumi. Si tratta di ammassi di blocchi spigolosi di roccia situati nelle parti marginali della depressione presso lo sbocco delle valli. Le dimensioni dei singoli blocchi variano fino 200 m^3 e oltre. Ad una certa distanza dai versanti si osserva la loro sovrapposizione ai mantelli alluvionali pedemontani. Evidentemente il franamento di queste grandi quantità di materiale nel bacino si verificò dopo il collasso e le frane che avevano sbarrato le valli durante i terremoti.

TERMINI CHIAVE: Rischio geomorfologico, Morfotettonica, Fossa tettonica del Baikal, Siberia Orientale.

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INTRODUCTION

The slopes and marginal segments of the rift valleys of southern East Siberia (Baikal rift zone) display the results of many different hazardous processes associated with mountainous relief. The period of obtaining the information on these processes is rather short (no more than 300 years). That is why in geological and geomorphological studies of the region attention is concentrated upon the geomorphological evidence of their previous occurrence. Special methods are developed, e.g. the paleoseismogeological method of predicting the seismic regime based on investigation of the effects of prehistoric earthquakes (FLORENSOV, 1960; SOLONENKO, 1962).

FACTORS OF MANIFESTATIONS OF HAZARDOUS PROCESSES

Two factors produce manifestations of hazardous geomorphological processes on the slopes and in the margins of the rift valleys of the Baikal rift zone. Seismic activity of the region is the first one. Strong earthquakes result in instantaneous tectonic deformations of the landforms, and high seismic background evidently stimulates movement of loose weathering products on inclined surfaces. That is why on the steep basal facets of the fault scarp on the rift valley slopes the thickness of the slope sediments often amounts to many tens of metres.

The second factor is increasing disintegration of the bedrock in the subsurface portions of the zones of young faults limiting the rift valleys. The young faults usually develop within the wide zones of ancient (Precambrian) faults and therefore they include tectonics of several generations. Among the fault zones tabular blocks of rocks cut by fissures are distributed. In the mountainous relief strong tectonic disintegration of bedrock on the marginal tectonic scarps result in formation of numerous rock and debris slopes located lower. We call such areas «rocky badlands» (figg. 1, 2).

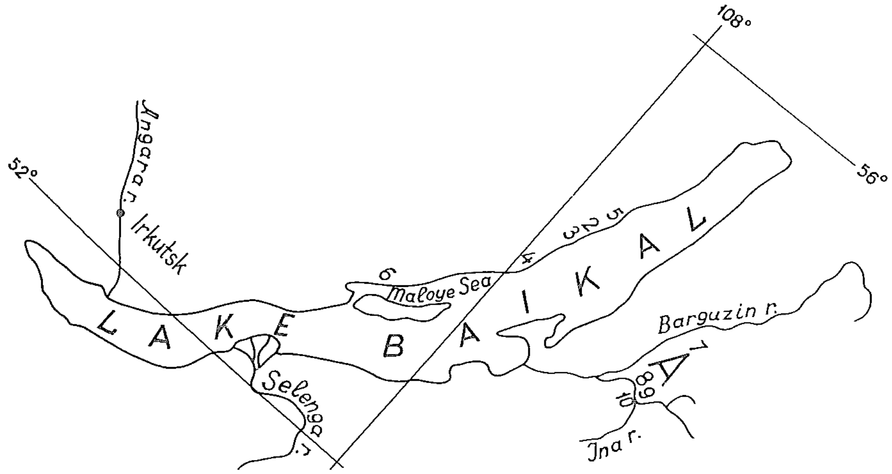

FIG. 1 - Distribution of the traces of hazardous processes in the Baikal and Barguzin rift valleys analysed in the paper. Numbers in the scheme show the numbers of the corresponding illustrations.

Circulation of underground waters, including thermal and highly mineralized fluids, along the zones of marginal faults favours acceleration of morphogenic processes on the rift valley slopes.

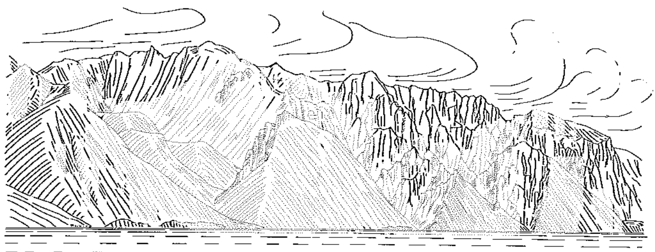

FIG. 2 - Rocky badland in the zone of the marginal faults on the western Baikal shore near the Northern Kedrovi Cape.

WESTERN SHORES OF LAKE BAIKAL

Strong earthquakes result in tectonic deformations of the landforms followed by gigantic collapses, rockslides and soil avalanches on the rift valley slopes. Two major varieties are distinguished among young tectonic deformations: seismic scarps and trenches cutting the bases of fault-scarp facets and the upper portions of piedmont alluvial fans, and faults combined with collapses.

The seismic dislocations of the first group may be exemplified by a system of young faults on the western Baikal shore near the Middle Kedrovi cape (FLORENSOV & GALKIN, 1967). There is a long fault scarp no more than 10 m high. This crosses the shore slopes at the bases of facets where they are changed by a steep piedmont slope composed by merging alluvial fans and debris slopes (fig. 3). Along its strike the fault scarp gives place to seismic trenches in debris and bedrock. In other cases trenches are accompanied with

FIG. 3 - System of paleoseismic dislocations on the western Baikal shore near the Middle Kedrovi Cape.

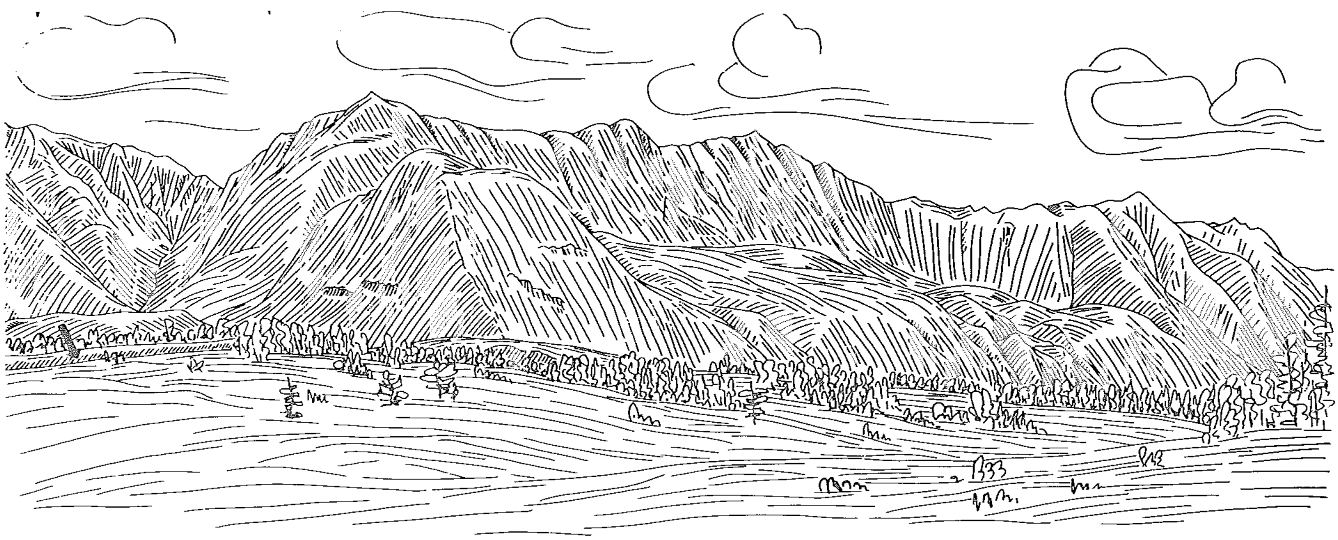

FIG. 4 - Shartla intermediate step on the western slope of the Baikal rift valley. The fault is combined with a gigantic collapse on its subsided wing. Arrow shows the fault scarp cutting the alluvial fan.

FIG. 5 - Steps of gravity faults and a rock stream (shown by thick dotted line) overlying the seismogenic scarp and the trench at the foot of the basal facet of the tectonic scarp. The Malaya Kosa bay in the western Baikal shore.

scarps. The age of the seismic dislocations evidently amounts to many hundreds of years. The above seismic forms are distinctly expressed in the topography due to absorption of the debris by the fault zone which opens up-dip. Paleo-seismic dislocations of this kind, the ages of which amount to thousands of years, are widely distributed on the marginal tectonic scarps of the western Baikal shore and in the other rift valleys of southern East Siberia (SOLONENKO, 1962).

Faults combined with collapses belong to the other variety of seismic dislocations. They result from simultaneous manifestations of the following two processes: (1) seismogenic subsidence of a tabular block on the marginal tectonic scarp, and (2) a gigantic collapse of disintegrated rocks or a rockslide within this block. As a result, on the rift valley slope an intermediate tectonic step appears limited in the rear part with a steep amphitheatre-like slope. The Shartla seismic dislocation (fig. 4) has a rear scarp about 880 m high. This was created instantly (in geological sense) as a result of a seismic event.

Traces of large-scale dislocations of debris material on the slopes are usually associated with young seismic dislocations on the marginal tectonic scarp. Strong disintegration of the rocks in the zones of young faults contributes to the formation of large rock streams on the basal facets of tectonic scarps (fig. 5). These rock streams appear on the piedmont and overlap seismic trenches and scarps. Those on the basal facets are associated with narrow tabular blocks. They are not large tectonic steps subsiding along gently dipping gravity faults. The zones of the latter open dip-up and thus favour disintegration of the bedrock and collapse of their narrow blocks.

In other cases the gravity faults are widely distributed on marginal tectonic scarps forming systems of narrow terrace-like steps (fig. 6). This indicates general gravitational instability within these sections of the rift valley slopes and promotes the formation of rockslides.

THE INA PHENOMENON

In the Barguzin rift valley we have revealed traces of another type of natural disaster. In the east the rift valley borders the Ikat domal uplift, the slopes of which gradually decline towards the graben (fig. 7). There is no high fault scarp on the rift valley slope and the convex curve of the

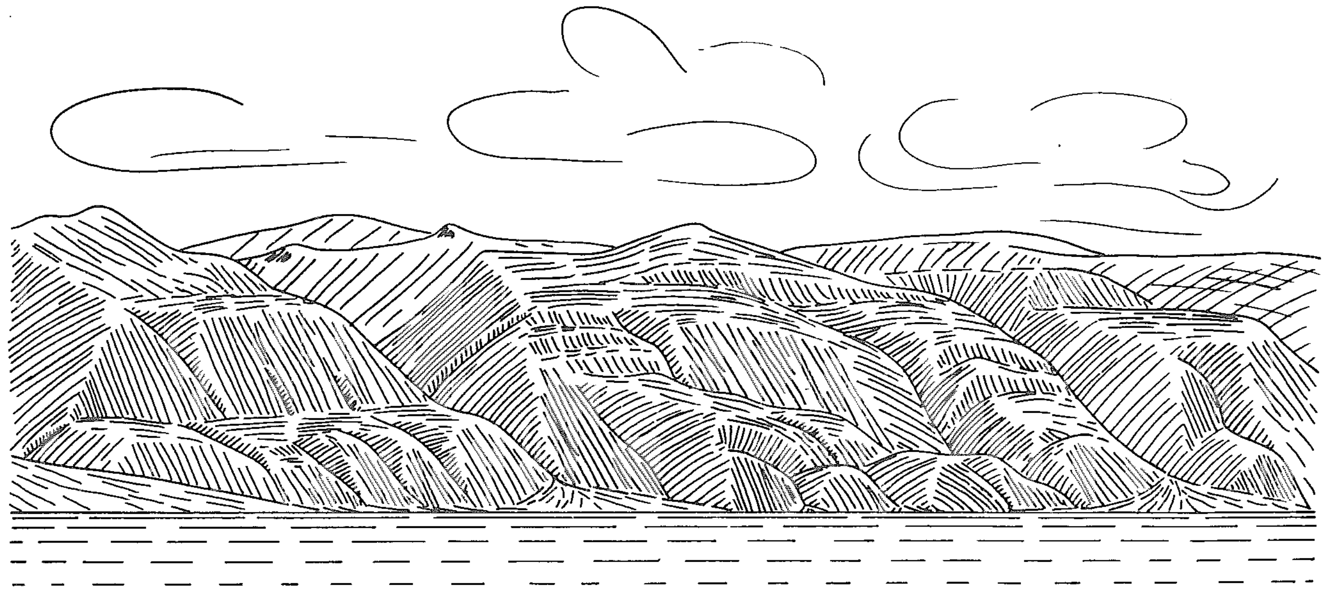

FIG. 6 - Narrow steps on the tectonic scarp produced by gravity faults. The north-western shore of the Maloye Morye bay near the Yadyrtui Cape.

FIG. 7 - Ikat ridge (domal uplift) and the eastern margin of the Barguzin rift valley in the region of the Ina river outflow from the mountains (shown by arrow). View from northeast.

summit surface of the ridge is well seen. In the marginal part of the Barguzin basin near the site where the Ina river flows out of the mountains, thousands of large angular granitic blocks cover an the area of 10 km^2 (fig. 8). They form a picturesque landscape which we first called «a herd of stones» (UFIMTSEV, 1986) and later A. Imetkhenov named this «a stone garden».

The stone garden where the Ina emerges from the mountains can be traced for a distance exceeding 5 km and consists of two elongated block masses, the major one of which is located on the right bank. Angular blocks of varying shapes reach to 10 m and over in diameter. Near the site where the Ina emerges from the mountains they form compact accumulations (fig. 9). The mode of occurrence of individual blocks indicates that they have been thrown out from the mountainous segment of the Ina valley. They gradually become more scattered towards the central part of the basin. Granitic blocks outcrop on the flood plain, the cross section of which ends with a layer of angular gruss with an admixture of perfectly rounded pebbles.

The occurrence of the blocks in the flood plain sediments indicate that the event that created the stone garden took place in the Holocene. The nature of the occurrence of the granitic blocks and their unrounded shapes testify that an individual massive outburst of blocky material from the mountain part of the Ina river took place. The distance of transport of the blocks was rather small.

In the mountainous part of the Ina river above its emergence from the mountains other traces of the event can be observed. On the scarp and on the low basement terrace

FIG. 8 - Stone garden on the flood plain near the Ina river mouth. The Ikat ridge on the background. Drawn from photo.

FIG. 9 - Heapt of blocks on the right Ina shore near its emergence from the mountains. Drawn from photo.

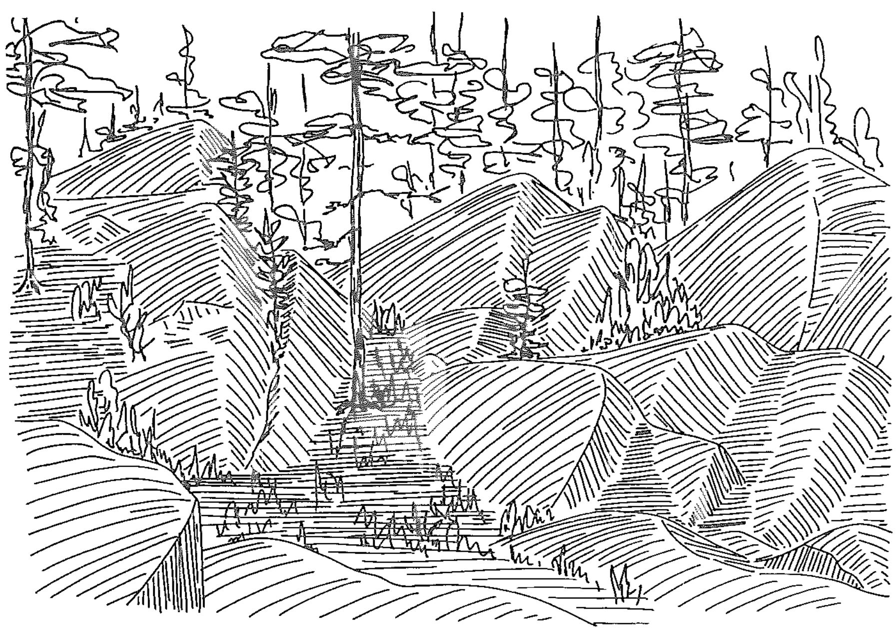

FIG. 10 - Trenches on the rocky surface of the terrace in the Ina valley above its emergence from the mountains.

numerous trenches strike which came into being due to removal of granitic blocks along joints (fig. 10). As a result, the scarp and the river terrace look like a unique ribbed surface.

The evacuation of large granitic blocks from the mountainous part of the valley and their concentration in the marginal segment of the basin may have been produced by a single disastrous mudflood. In the Ina valley, 10 km upstream from the basin, relics of a dam, including granite-gneiss blocks 15-18 m high and 50-60 m long, are observed on the low terrace. On the valley slopes above a washed-out natural dam there are unique slope amphitheatres formed apparently during the major collapse of a rockslide. It is most likely that they were produced by seismic events. The Ina valley is confined to a wide zone of a young fault, and disintegration of rocks there also favoured the creation of the natural dam.

The gigantic outburst of boulders from the Ina valley seemingly included the following successive events:

(1) collapses and rockslides on the slopes of the mountainous part of the valley and the formation of the dam (most likely during earthquake),

(2) formation of a dam lake,

(3) breaking of the dam and the outburst of water, mud and boulders,

(4) on the Ina emergence from the mountains the mudflood carried the large granitic blocks and transported them into the basin,

(5) at the margin of the basin the mudflow was divided into two streams. The flood deposited a layer of unsorted material and large blocks, which formed the stone garden.

Such accumulations of blocks near the emergences of large rivers into rift valleys indicate that phenomena similar to the Ina one manifested themselves repeatedly in the Baikal rift zone.

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