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Barguzin rift valley: Sedimentogenesis and paleogeography (Baikalian area, Russia)

V.L. Kolomiets, R.Ts. Budaev*

Geological Institute SB RAS, 670047 Ulan-Ude, Russia

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ABSTRACT

Research on subdivision of sediments in the Barguzin rift valley based on paleofluvial studies and paleogeographic reconstructions showed that the deposits of high terraces (VII–IV) formed mostly in alluvial-lacustrine environments, whereas the lower terraces (III–I) are essentially fluvial. The Late Cenozoic activation of the tectonic movements was marked by the rise of the Baikal Lake level and the lake water inundation into river valleys and dry depressions. During the Late Pleistocene the flood water flowed gradually, a set of low terraces being formed in the process.

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1. Introduction

One of the interesting, though not solved yet, problems of the Pleistocene sedimentary process of the Pre-Baikalian and Western Transbaikalian regions is the problem of the genesis and age of the sands. The sands are very thick (a few hundreds of meters) and occur in all the large depressions of the Baikal rift zone and in the Selenga drainage basin. At present, there are several opinions. The first investigators considered the sands to be lacustrine sediments deposited at the time of a high stand of the Baikal Lake level (Chersky, 1886; Obruchev, 1937). Later they were thought of as limnoglacial and fluvioglacial deposits, former outwash fields in the intermountain basins (Florensov, 1960; Logachev, 1974). There were specialists that attributed the sand genesis to aeolian and slopewash processes (Olyunin, 1961; Shevchenko and Ivanova-Radkevich, 1976). There exists a popular opinion, however, that the sands are essentially polygenetic formations and were formed over a long period (Bazarov et al., 1981; Bazarov, 1986; Rezanov, 1988). This paper presents some new data on the genesis, facies characteristics, lithology and stratigraphy, and the age of the sand series in the Barguzin rift valley, the latter being one of "key" regions in the solution of that problem (Fig. 1).

* Corresponding author.
E-mail addresses: kolom@gin.bscnet.ru (V.L. Kolomiets), budrin@gin.bscnet.ru (R.Ts. Budaev).

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2. Methods

Research used the standard lithological-facies methods, with quantitative characteristics of sedimentation: accumulation curves with sedimentation coefficient (S_0), asymmetry (S_k) and median diameter (M_d) (Trask, 1932); sorting coefficient (σ), asymmetry coefficient (α), variability coefficient (ν), average weighted particles (x), excess (τ), restored after first four central moments of variation. The basis for the calculation of these characteristics of clastic sediments is sieve analysis that determines the content of the particles of various sizes (fractions). Particle size is an important structural feature that reflects the dynamic conditions of the transport and deposition of the material and it is widely used in lithostratigraphic and paleogeographic reconstructions (Rukhin, 1947; Krumbein and Sloss, 1963; Pettijohn et al., 1972).

Parameters of river flow of fluvial genesis, transport, and sedimentation of material, were determined on the basis of their relationships and hydrodynamic features. Sediment texture is the basis for such reconstructions. The following parameters of paleoflows can be estimated: 1) near-bottom flow velocity and rate of sedimentation; 2) flow depth in low-land period and in high-water-period; 3) flow velocity of the depth vertical; 4) size limit of moving sediments; 5) Lyapin's criteria (β) – parameters of clasts deposits movement in the channel bottom, 6) parameters of bottom flow ridges – weight, length, transporting velocity; 7) inclination of water-level (I); 8) paleochannel roughness, which numerical can say about hydrological features of channel, flow pattern and bottom contour (n); width of flow (B); 10) φ-criteria of channel stability, giving rate of channel conversion and estimating

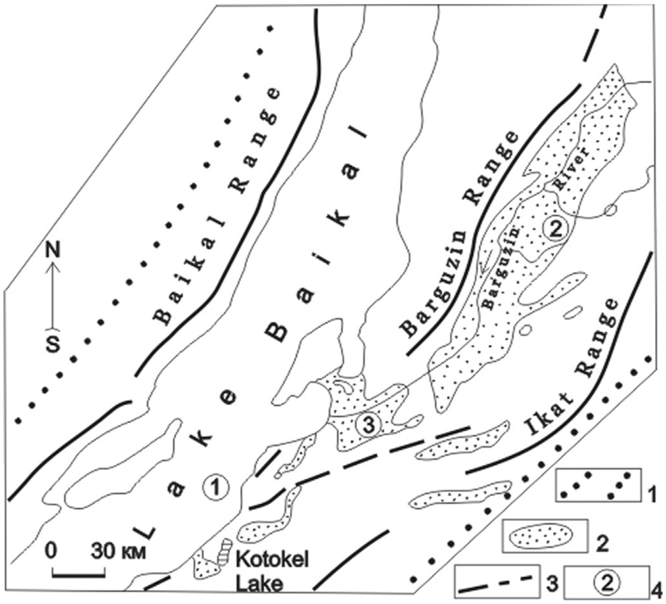

Fig. 1. Location of the studied region. 1 – Baikal rift zone; 2 – dry intermountain basins; 3 – "shoulders" of rift valleys; 4 – rift valleys (circled numbers: 1 – Baikalian, 2 – Barguzin, 3 – Ust'-Barguzin).

rate of deformations; and 11) Froude number, determining flow feature, types, subtypes of river channels and drainage area (Kolomiets, 2008).

During the reconstruction of the general and regional changes in climate and physiographic conditions of the region we used the paleopalynological method, which is based on the study of plant remains (spores and pollen), buried in different sediments (Traverse, 1988). Paleopalynologic data indicate the flora and the age of the studied deposits, as different geological epochs are characterized only by their peculiar flora. For each of the terrace level of the Barguzin depression we obtained a series of spectra, allowing us to characterize the paleoclimatic changes during the Pleistocene and Holocene of the Barguzin depression.

Numerical dating of the sediments has been obtained by the thermoluminescence method. Determined age is from a few thousand to hundreds of thousands of years, and sometimes up to 1 million years (Tite, 1970; Perevalov and Rezanov, 1997). The set of methods used by the authors in this study has been widely applied in the investigation of the sedimentation features and paleogeography of the other regions of the Baikal Rift Zone, as well as Transbaikalia and Northern Mongolia (Lbova et al., 2005; Kolomiets, 2008; Kolomiets et al., 2009a, 2009b).

3. Results and discussion

The Barguzin rift valley is a constituent of the Barguzin branch of the Baikalian rift zone, located between the Barguzin and Ikat mountain ranges. The valley, 20–35 km wide, extends for 200 km from NE to SW. The rift valley shows a typical "Baikalian" asymmetry in the cross-profile. It is bounded on the northwest by a steep slope of the high Barguzin Range, and its relatively gently sloping southeastern side is formed by the Ikat Range.

The floor of the Barguzin rift valley consists of several morphological units: the sloping piedmont plain adjoining the base of the Barguzin Range; a complex of fluvial landforms of the Barguzin R. valley; and a zone of sandy hills (kuytuns) fringing the Ikat Range slope at an altitude of 30–50 to 160–180 m. The Barguzin River is one of the largest rivers flowing into Lake Baikal. Its length is 480 km, and the basin area is 21,100 km^2. The main tributaries of the Barguzin are: the Garga, the Argada, the Ina, the Ulan-Burga, the Zhargalanta, the Suvo from the left; the Ulyun and the Ulyugna from the right.

The hills are well pronounced topographically, Upper and Lower Kuytuns being distinguished within the zone. The name "Kuytun" comes from the Buryat language and means "open hills", the vast, flat and elevated steppe areas which are away from forests. In addition, this name is used as a geological and geomorphological term of Eastern Siberia for the elevated terraced surface – ridges composed of loose deposits, mainly of sand composition.

The hill surfaces are noticeably altered by wind. The hills are composed of thick series of sands forming no less than seven terrace levels (Fig. 2). Lithological characteristics of the sands permit the series to be divided into two parts corresponding to the stages of sedimentation of high (VII–IV) and low (III–I) terraces.

3.1. *High terrace complex*

3.1.1. *VII terrace level*

The highest VII terrace level, 110–160 m high, dated to Early Quaternary occurs at the highest part of kuytuns where the uppermost horizons of the sequence are exposed. The basal part of the series may be seen in the Ulan-Burga basin. Overall, the series consists of yellowish-gray and light gray fine-to medium-grained sands (weighted average particle size $x = 0.3–0.5$ mm), medium to fine-grained sands ($x = 0.2–0.3$) and silty fine-grained sands ($x = 0.1–0.2$ mm) (Table 1). There is an admixture of clayey material (up to 5–20 %) and a small quantity of coarse sand and small-size gravel (no more than 2%). The sands display a subhorizontally laminated texture, and the mineral composition is dominated by quartz and feldspars, with some dark-colored grains and micas. The grains are well rounded. Sorting coefficient values 0.1 to 0.4 characterizes the sediments as well to moderately sorted. The asymmetry coefficient $S_k < 1$ and $\alpha > 0$ with the mode shifted towards larger size particles are indicative of relatively high energy levels of the streams at that time. In most cases, the kurtosis is positive which indicates a steady dynamics of the stream, an active processing of the load keeping pace with, or being in advance of the sediment supply throughout the sedimentation period and, therefore, a relatively quiet tectonic regime. Variability coefficient values vary from 0.5 to 0.8 all over the series, which strongly suggests aqueous genesis of the sands (the values fall in the field of mixed alluvial and lacustrine genesis).

Table 1
The average values of the statistical parameters of the Barguzin depression terrace complex.

Terraces	Average-weighted particles diameter, mm	Sorting coefficient σ, mm	Trask's asymmetry coefficient, S_k	Excess, τ	Variability coefficient, ν
$a^1Q_3^4–Q_4^1$	0.44	0.66	<1	0	1.23
$a^2Q_3^2$	0.39	0.47	<1	0	1.12
$a^3Q_3^1$	0.35	0.46	<1	>0	1.11
$la^4Q_2^{3+4}$	0.34	0.34	<1	>0	1.01
$al^5Q_2^{1+2}$	0.32	0.24	<1	>0	0.78
$al^6Q_1^2–Q_2^1$	0.32	0.25	<1	>0	0.75
$al^7Q_1^1$	0.32	0.24	<1	>0	0.79

Notes. a – alluvium, l – lacustrine deposits, $al^7 \dots a^1$ – terrace levels, $Q_1^1 – Q_3^4$-Q_4^1 – age of the terrace levels (Q_1 – Early Pleistocene; Q_2 – Middle Pleistocene; Q_3 – Late Pleistocene; Q_4 – Holocene).

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