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GEOGRAPHY

Asymmetry of Sediment Drift to the Central Baikal Basin

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The asymmetric pattern of sediment drift to the Central Baikal Basin (hereafter, the Central Basin) is an unexplored but important property that affects the functioning of the complicated lake geosystem. The asymmetry of the sediment drift is predetermined by the fact that the northwestern wall of the rift valley formed along the large deep-seated fault is six times steeper than the opposite wall [1]. The drainage area related to the basin morphology shows even greater asymmetry. About 99% of the drainage basin extends to the southeast from the lake basin. Such structural–tectonic and drainage basin asymmetries were responsible for the no less sharp disproportion of sediment drift to the Central Basin from the northwestern and opposite sides. The present paper is an attempt to elucidate the character and degree of asymmetry of sediment drift, an unexplored issue in the study of Baikal.

MATERIALS AND METHODS

Long-term measurements of the rate of exogenous processes preceded the quantitative estimation of asymmetry in the sediment drift to the Central Basin (Fig. 1). Data on the drift of loose material to Baikal due to abrasion, creep, sheet wash, mudflows, landslides, and rockfalls were obtained for the first time and reported in [2, 3]. With allowance made for the number of small rivers and measurements carried out in some of them (Davshe and Shumilikha rivers [4]), previous data on suspended and raft materials delivered to the basin were refined by extrapolation. Evidence on the river runoff of chemically dissolved matter [5] and eolian drift [6] were also used.

On the north, the Central Basin is limited by the line extending from the northern edge of Olkhon Island along the watershed of the Akademicheskii Ridge and Bolshoi Ushkany Island to the Orlov Cape of the Svyatoi Nos Peninsula. The boundary between the Central and Southern basins of Baikal is traditionally drawn from the Buguldeika River mouth to the Ust-Kharauz Channel (a branch of the Selenga River in the delta). The provenance of the studied basin is bounded by the Selenga River on the west. We also took the following fact into consideration: the suspended and dissolved material transported by the Buguldeika River is turned round in the lake by currents toward the Southern Basin and diverted from the Central Basin. About 60% of the suspended load of the Selenga River settles in its delta [7], and no less than 60% of the remaining part reaches the Central Basin. It is likely that the same amount of raft sediments is deposited in the delta. When calculating the drift, we summed up the material delivered to the lake and deposited on Baikal-facing deltas, fans, and so on. Many of these deposits are short-lived: they appear and then are washed out during storms.

Asymmetry of Sediment Drift. Calculations showed that sediment drift to the Central Basin is very asymmetric. We revealed two opposite regularities: slope processes (landslides, rockfalls, talus deposition, creep, sheet wash, and others) predominate in the drift of weathered rocks from the northwestern slope steeply diving into the lake, whereas channel processes prevail on the opposite southeastern slope in accordance with the asymmetry of the drainage basin (Fig. 2). Abrasion, atypical of processes mentioned above, predominates on the southeastern slope of the basin.

The amount of sediments delivered by slope processes to the Central Basin is ~116 kt/yr from the northwestern part of the drainage basin and only 60 kt/yr (i.e., 1.9 times smaller) from the opposite bank, which is two times longer. Channel processes (drift of dissolved, suspended, and raft materials by rivers, as well as mudflows in them) from the northwestern part of the drainage system deliver an amount of sediments to the Central Basin that is 95 times less than that from the opposite bank (Fig. 2).

We integrated all drift types and revealed that the amount of dissolved and solid material transported to the Central Basin from the southeastern side is 26 times greater (5400 kt/yr, Fig. 2) than from the northwestern side (205 kt/yr). The extremely asymmetric SE-trend-

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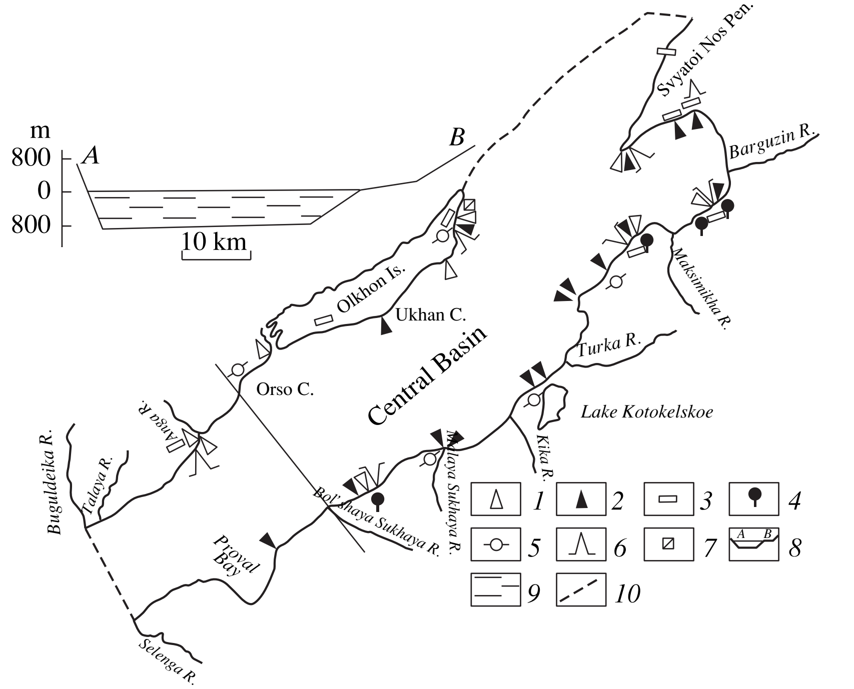

Fig. 1. Network of stationary observation stations and measurements of rates of sediment drift into the Central Basin. (*1*) Weathering; (*2*) shore abrasion; (*3*) transportation of surface boulders by stone-streams; (*4*) reculation (retreat of scarps in loose cover of slopes); (*5*) eolian drift; (*6*) creep; (*7*) sheet wash; (*8*) characteristic transverse profile *A–B* of the basin; (*9*) Baikal watermass; (*10*) underwater boundary of the Central Basin.

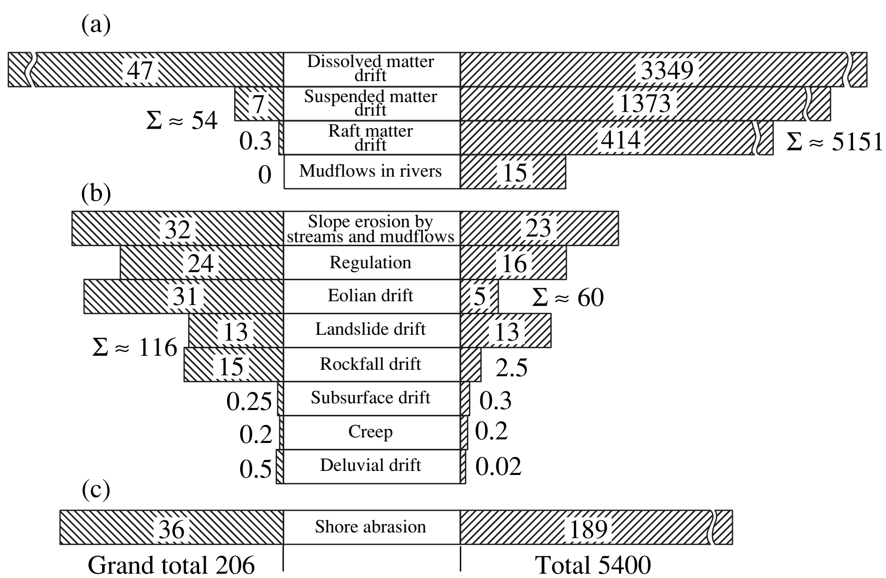

Fig. 2. Sediment drift into the Central Basin, kt/yr. (a) Channel, (b) slope, (c) abrasion processes on the northwestern (left column) and opposite (right column) shore of the lake.

ing pattern of the sediment drift into the basin is governed to a great extent (73%) by large tributaries. For example, the Selenga River delivers about 3956 kt of dissolved and solid mineral substances. The contribution of the Barguzin River is 15% (815.7 kt). However, even if we omit these rivers, the shares of the northwestern and the opposite sides of the drainage basin in the delivery of weathering products to the Central Basin would differ by three times (206 and 628 kt/yr, respectively).

Series of Lithodynamic Significance of Processes. Exogenous processes on the shores under comparison can be arranged in order of their significance in the transport of sediments to the Central Basin. On the southeastern side of the basin, the processes will occupy quite ordinary and expected positions in the series with respect to the amount of drifted material: the first four positions will be held by channel processes and abrasion, whereas slope processes will occupy the lower positions. No such customary succession is observed on the opposite side of the basin, where the river drift of the suspended and raft material is insignificant (8th and 10th positions, respectively) owing to the small runoff and shallowness of tributaries on the northwestern side of the Central Basin. According to the topographic map (scale 1 : 100 000), the number of tributaries is 18, and only two of them are rivers (Anga and Talovka) more than 10 km long. On the opposite side of the basin, 84 tributaries fall into the lake. Among them, 13 rivers are 12 to 400 km long (not taking into account the Selenga River, which is about 1000 km long). Most of them are superior to all tributaries of the northwestern side in terms of the water volume.

A high value of the eolian material input from the northwestern shore (the fourth position in the series of significance) is related to steppes developed on it and squalls reaching a hurricane velocity (>40 m/sec).

The fifth position in the sediment drift from the northwestern shore belongs to reculation, which implies the destruction and retreat of scarps formed as a result of undercutting of loose cover of slopes [8]. Intense development of this process is accounted for by the fact that lake waves undercut the northwestern slope of the basin formed on the fault plane, resulting in the systematic development of scarp in the loose cover. Seismic impacts; freezing and thawing; ground soaking and drying; and quakes due to rockfalls, surfs, and mudflows provoke frequent micropulsations that foster significantly the drift of fragments to the scarp on the slope with the unsupported loose cover. The process does not attenuate with time, since the scarp is constantly restored due to new abrasion undercutting and retreats at a rate of n–10n cm/yr [8]. Downfalls of rock fragments, fine earth (melkozem), and other materials from scarps are numerous, but they are scattered throughout the space and hardly perceptible. Therefore, the process of reculation was not previously taken into account in sediment drift into Baikal.

Since the northwestern slope with steppes is very steep and rainfall is very intense, ephemeral streams (the third position in the series of significance) grade from time to time into slope mudflows. In rivers, flooding is recorded during such episodes, but mudflows do not take place (Fig. 2).

Thus, the shores under comparison differ greatly in terms of the series of significance of exogenous process in the sediment drift.

Asymmetry in denudation. The regions under comparison differ in the intensity of surface denudation. More than 5.6 Mt (or 3 114 400 m^3) of physical and chemical weathering products annually drift into the Central Basin from the surrounding area of 385 000 km^2 (Fig. 2). The rate of denudation averaged for the whole region from which sediments drift to the basin under consideration makes up 0.008 mm/yr. About 206 kt (or 114 400 m^3) of drift is supplied annually to the Central Basin from the northwestern side of the drainage basin with an area of 2050 km^2. About 5.4 Mt (or 3 000 000 m^3) of sedimentary materials are delivered to the Central Basin from the southeastern side. Thus, the rate of denudation is 0.0078 mm/yr. One can see an obvious discrepancy. The northwestern shore, which is 187 times larger than the southeastern one, delivers an amount of sediment 26 times less to the Central Basin, although denudation is seven times more intensive. Hence, the area of the sediment drift basin (more precisely, the sediment transport path) has an inverse correlation with the denudation-induced decrease of its surface.

CONCLUSIONS

The results obtained have made it possible to elaborate a quantitative model of sediment drift to the Central Basin with an emphasis on scrutinization of the specific property (asymmetry) of the basin. The model will be refined with accumulation of new data. Nonetheless, even at the present-day level of knowledge, the model has great significance for understanding the structure of the descending sediment flow and elucidating its numerous consequences. The model demonstrates the following fact: although sediment drift is related to the same processes, the regions under comparison are asymmetric in terms of the amount of their weathering products delivered to the Central Basin. Moreover, they differ greatly in the series of significance of exogenous processes in the descending flow of sediments and the rate of surface denudation. The elucidation of such distinctions provides deeper insight into the lithodynamics of relief, the formation of loose sediments in the lake, and the functioning of the Baikal ecosystem. Such studies can be extended to the remaining basins of the Baikal rift zone and other geosystems with a sharp asymmetry of the sediment drift.

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