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Holocene environment changes in Lake Balkhash reconstructed by high-resolution XRF-core analysis and geomorphic survey

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Lake Balkhash is the largest terminal lake in central Asia. The lake sediment provides us to reconstruct climate changes during the Holocene. We obtained several sediment cores with a length of 5-6 m in the eastern part of the lake in 2009 under the Ili project, RIHN. This paper reports Holocene depositional environment changes in and around the eastern part of the lake based on high resolution (0.1 mm) XRF analysis of the longest two cores named as 901and 902 coupled with the analysis of the Lepsy river deposits. Site 901 is about 20 km distant from the present Lepsy river mouth, while site 902 is 40 km, where is the heart of the eastern part of the lake and its deepest point. The lake bottom topography between proximal site 901 and distal site 902 is almost flat with a water depth of about 20 m. In contrast average slope gradient between 901 site and Lepsy river mouth is about 1/1000, almost equal to the slope of the lower reaches of the Lepsy river bed. For detail near the river mouth, the slope of delta plain is gentler and the slope of the delta front slope is steeper than 1/1000. Under such geomorphic conditions, water-level fall and rise cause quick incision and accumulation of the river channel.

Lepsy river valley had been filled with fine and partly organic sediments with a thickness of several meters from the early Holocene to 5500 years ago. Then, dominant process changed from accumulation to incision. River terraces were formed and well-sorted sandy sediments were transported downstream. At around 2000 years ago, the river turned to accumulation phase again. The river bed and river terrace sediments contain SiO2 of 40-60% and CaO of 15-20%, while Fe2O3, MnO, and Al2O3 of less than 10 %.

Both 901 and 902 cores can be divided into three sedimentary units, the top and bottom units are whitish clayey sediments with high Ca content, indicating lots of calcium carbonates which include calcite, aragonite, and dolomite according to XRD analysis (Montani et al, 2011). The middle units deposited from 6000 to 3000 years ago based on AMS -14C dating and showed various kinds of stratified sedimentary structures including sand beds with plant fragments and gastropod fossils, parallel silty lamina (observed only in 901 core) and evaporites (in 902 core). The middle unit contains high SiO2 indicating siliceous deposits driven by Lepsy river.

Using high resolution cps values (near 30,000 points in total with vertical interval of 0.2 mm for each core) of major elements (Si, Ca, Mg, K, Fe, S, Al, etc) provided by micro-XRF analyzer, we calculated Ca / Si ratio to know the change of relative abundance of chemogenic (and partly biogenic) vs. terrigenous components of the sediments. Trend of Ca / Si ratio curves between the two cores were markedly concordant with each other and the ratio of distal core 902 was always larger than that of proximal core 901. This suggests that the lake-level fluctuations dominantly control the sedimentary environment; water level fall brings the river mouth close to the core sits and causes the river channel incision and terrace formation, resulting that chemogenic sediments are remarkably diluted by increase of terrigenous deposits at the core sites. Water level rise should bring the opposite results. At around 5500 years ago, when Ca / Si ratio showed the minimum (nearly zero), evaporites (gypsum and magnesite) deposited at site 902 and fluvial sand deposited at 901. This implies that the lake level dropped almost 20 m below the present level, and the river mouth reached 901 and playa appeared at the center of the eastern part of the Lake Balkhash.

Keywords: Lake Balkhash, kazakhstan, Holocene, chemical analysis, lake level change, Lepsy river