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Commentary

Comment on: Geochemical and isotopic (Sr, U) variations of lake waters in the Ol'khon Region, Siberia, Russia: Origin and paleoenvironmental implications by F. Chabaux, M. Granet, P. Larqué, J. Riotte, E.V. Skliarov, O. Skliarova, L. Alexeieva, F. Risacher [C. R. Geoscience 343 (2011) 462–470]

Commentaire sur : variations géochimiques et isotopiques des eaux des lacs de la région d'Ol'khon en Sibérie méridionale, Russie : origine et implications paléoenvironnementales [C. R. Geoscience 343 (2011) 462–470]

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In a recent paper in this journal Chabaux et al. (2011) explained the varied salinity of the water in small lakes in the Pre-Ol'khon region solely by the duration of evaporation, the most concentrated waters being the oldest. Their conclusions rise several questions and concerns.

Freshwater and salt lakes occur close to one another in southeastern Siberia over a wide range of rock types and tectonic structures. Therefore, we have to find other explanations for the varied salinity, perhaps in the geomorphologic evolution and environmental history of the lakes themselves. The Pre-Ol'khon region, lying between 51° and 53° North, is in the temperate zone. Its climate is strongly continental, however, with temperatures fluctuating from −25° to 25°C on annual average. The ground is frozen to at least two metres for more than half the year. Annual average precipitation is 250 mm on the lowlands, more than 1000 mm on the surrounding high land, with 70% falling in summer. Taiga mantles the mountain slopes, while dense grass and agricultural crops occupy the lowlands, which does not suggest water deficit. We cannot therefore explain the salinization of the lakes solely by evaporation; we must seek more widely in the landscape for an explanation.

Chabaux et al. seem to have overlooked the role of permafrost, which is continuous on the east-facing slopes and patchy in the depressions (Franz, 1973), resulting in patterned ground (Fig. 1) and other cryogenic features. Permafrost affects the hydrological regime, but the authors did not evaluate its impact on the water chemistry of the lakes. What they mean by 'cryogenesis' is not clear. The lakes are fed by rain and with water from local springs, but the authors say nothing about the origin of the spring waters and their potential for mixing, nor do they mention the aquifer flows. Solutes in the interstitial water in the lake-bottom sediments and those in the surrounding ground-water are prone to mix, but again the authors do not mention their potential contribution to the hydrology.

Analyses of the water from springs, rivers and lakes reveal marked chemical and isotopic differences, especially among the springs. That is understandable in view of the varied kinds of rock and small sizes of the catchments. Nevertheless, the authors claim: "There is no simple relationship between the value of Sr isotope ratio and the

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location of the water sample in the basin, nor the kind of outcropping bedrocks". Yet, they could have postulated hypotheses and tested them. For example, the small, oval, shallow lakes resemble the 'thermokarst' lakes in the lowlands of Alaska, Canada and elsewhere in Siberia, which fill and disappear with the permafrost thawing and refreezing. The behaviour of the Ol'khon lakes should have been compared with the meteorological cycles. The occurrence of gypsum, mirabilite and carbonates is not unique to the Pre-Ol'khon lakes; these minerals are well known in salt lakes of Antarctica (Snyder et al., 2006), and Wang et al. (2003) described mirabilite layers from the Last Glacial Maximum and the Younger Dryas in the salt lakes of the Qilian Shan mountains in China. In the Great Plains of Canada and the United States, at the same latitude as Baikalia, thousands of small saline lakes occur in a similar cold continental climate (Kelley and Holmden, 2001). These salts could result from cryogenic weathering of the bedrock (Vogt and Larqué, 2002; Vogt et al., 2010) and by freezing be precipitated in characteristic forms easily recognizable by scanning electron microscopy (Vogt and Corte, 1996). Lenses of liquid water called 'taliks' exist within the permafrost, as the freezing water rejects the solutes that progressively concentrate in the unfrozen liquid, and which lower the freezing point of the water. Those lenses of water can persist for many years, even millennia, and their long-lasting contact with the host rock can spontaneously increase the concentrations of solutes further. The chemical and isotopic composition of the solutes are probably the same as those of the other waters of the catchment. If permafrost thaws down to such strongly mineralized waters, that water will mix with water of the springs, and the chemical and isotopic composition of lake waters will depend on the mixing. Therefore the isotopic analyses do not reveal the ages of the lakes, but rather those of the talik captive waters, that are highly variable in the Pre-Ol'khon region as a whole.

The effects of the last glacial period definitively ended in the Baikal region approximately 8100 years ago (Karabanov et al., 2002), which is about the time the lakes formed according to the ^{14}C datings of Sklyarov et al. (2010). Yet, the climate has oscillated many times since (Abzaeva et al., 2006; Bezrukova et al., 2008) with subsequent changes in the Siberian lakes (Bazarova et al., 2011; Sklyarov et al., 2010). In the Pre-Ol'khon region, if the bottom sediments kept their original age then clearly they do not date the waters of the small lakes, which filled and dried in response to the later changes in the climate and the consequent evolution of permafrost. The implication is that the water now in the lakes might have been there for no more than a few decades. It seems doubtful that the thin lake-bottom sediments and discontinuous existence of the lakes themselves can add palaeoenvironmental information to that supplied by the cores from Lake Baikal and the nearby Khubsugul/Hovsgol and Kotokel lakes which were studied for pollens, diatoms, organic matter, clay minerals and other mineralogical and sedimentary characteristics with a resolution of 100–150 years for the last 28,000 years (Shichi et al., 2006). The Pre-Ol'khon lakes might, however, provide information about the local permafrost.

The varied salinity of the lake waters from Pre-Ol'khon cannot be explained solely by the duration of evaporation unless the environmental characteristics, the origin of the waters and potential mixing and the evolution of the local permafrost have been shown to have no effect on the isotopic signature. Chabaux et al. make no mention of these possible, indeed likely, sources of variation. The usefulness of isotopic analysis does not clearly appear in the author' discussion.

This does not mean to deny the impact of evaporation on the chemical and isotopic composition of the water of the lakes studied by Chabaux et al., but the authors did not assess that evaporation has been the sole process by which the lakes have become saline. The role and behaviour of permafrost was not even considered in the author's explanation of the varied compositions of the lake waters. Further research is needed on the source of the salts. The methods, even if routine and old-fashioned, need to be broadened so as to assess the impacts of the environmental and geomorphic evolution, and the results be integrated so that we can understand more fully the variation in composition of the solutes.

Fig. 1. Patterned ground at the border of a salt lake in the Pre-Ol'khon region.

Fig. 1. Sol polygonal au bord d'un lac salé dans la région de Pre-Ol'khon.

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