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Editorial

Editorial for the Special Issue "Heavy Metals in Marine and Lake Sediments"

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In recent decades, due to global warming and the continuing exploration in the search for mineral resources, the scientific attention paid to contamination problems has increased noticeably. In the catchment areas of marine basins and lakes, where many mining, manufacturing and pulp/paper industry plants are located, solid and liquid wastes contain heavy metals, including toxic ones. In the water columns of seas and lakes, heavy metals are involved in various biogeochemical processes before sedimentation on the seabed or lake floor. The notable consequences of heavy metal contamination are most evident in shallow lake sediments, in which chemical elements are accumulated more intensively than in seas. In this Special Issue, six research articles bring together our current knowledge on the heavy metal spatiotemporal variability in different types of marine and lake sediments, including the main processes of their accumulation and redistribution during diagenesis. One of the tasks is to estimate the degree of anthropogenic contamination by potentially toxic elements such as As, Cd, Hg, Pb, Sb, Zn and U in lake and marine sediments. The articles contained in this Special Issue contribute to a more comprehensive understanding of the environmental behavior of these heavy metals. This Special Issue presents scientific results obtained by researchers investigating lake sediments [1–5] and surface sediments of some Arctic seas [6].

In lakes of the north temperate zone, sapropel sediments with high content of organic matter (>15%) are widely distributed. These lakes are sensitive to climate change and anthropogenic impacts; therefore, a study of sapropel sediments is of great importance. Sapropel sediments serve as a potential raw material in agriculture, livestock farming, the construction industry and medicine. The high concentrations of potentially toxic compounds thus pose a risk to the natural environment and human health. Heavy metal distributions within sapropel cores contribute valuable information about the paleoenvironmental conditions and dynamics of lake ecosystems. Two articles are devoted to sapropel sediments [1,2]. Strakhovenko and coauthors [1] present a quantitative assessment of the concentration levels and changes in the regional geochemical background of potentially toxic Cd, Hg, Sb, Zn and Pb in sapropel deposits of southwestern Siberia throughout the past 200 years. Their main conclusion is that the final chemical composition of sapropel is influenced not only by the catchment soils but by various biogeochemical processes occurring in the water columns of lake ecosystems. The Cd, Hg, Zn, Pb and U contents in sapropel lakes depend on the amount of organic matter in the bottom sediments. The growth of Cd and Hg contents in the upper part of sediment cores suggests increasing anthropogenic stress in Western Siberia over the last 70 years.

Ignatovicîus and coauthors [2] show that anthropogenic factors and paleoenvironmental conditions are reflected in the heavy metal distribution in cores from sapropel lake sediments from suburban territories of Vilnius, Lithuania. Based on geochemical and lithological characteristics, combined with pollen data and radiocarbon 14C dating, the authors suggest that the intensity of Pb, Cr, Cu and Zn accumulation in sapropel sediments has changed over the Subboreal and Subatlantic chronozones of the Holocene. In most

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cases, elevated concentrations of Pb, Cr, Cu and Zn were detected in the upper sapropel layers, indicating the impact of anthropogenic activity throughout the last eight decades.

Skorbiłowicz and coauthors [3] identify the metal sources in the surface coastal sediments of Ełckie Lake in the area of the "Green Lungs of Poland" by applying multivariate statistical techniques in combination with elemental analysis. The authors demonstrate a different pattern of heavy metal distribution depending on the catchment land use (urban, agricultural, forest areas and beaches). Analysis of variance (ANOVA) shows that the contents of Zn, Cu, Co and Na in the sediments from urbanized areas are statistically significantly higher than in the sediments from other areas (rural/forest, beaches). It should be noted that the Pearson correlation coefficients indicated no relationship between the heavy metals and organic matter contents, nor between sediment pH and the metals.

Budko and co-authors [6] characterize the distribution features of 47 major and trace elements, including heavy metals, the metalloid As and the Cs-137 technogenic radionuclide, in surface bottom sediments of the Arctic region (Barents, Kara, Laptev and East Siberian Seas). According to the criteria of ecological risk assessment, all examined areas have a low degree of contamination risk for most studied potential toxic elements, with the exception of As. The latter exhibited a strong enrichment factor (up to 20) in the western and central Kara Sea sediments, as well as in the Vilkitsky Strait (between the Kara and Laptev Seas). An insignificant correlation between the As and Fe-Mn distributions allowed the authors to assume that along with natural processes of adsorption contributing to the association of As with Fe-Mn oxyhydroxides, an additional source of the As enrichment exists. This could be anthropogenic input related to the combustion products of As-enriched peat and/or coal, which are transported to the Arctic seas in the atmosphere. Data on the specific activity of Cs-137 correspond to the background average values characteristic for these regions. The highest levels of Cs-137 concentration (Bq/kg) were detected in sediments from the Ob and Yenisei River estuaries, reflecting anthropogenic activity in their respective catchment areas.

Maltsev et al. [4] present new data on early diagenesis based on the examination of sediment cores and pore water from the glacial lakes in Arctic Siberia (Norilo–Pyasinskaya Water System) that were formed during the Last Glacial Maximum. Sediments transitioned from oxidized to reduced conditions at depths of ~10 cm, as was indicated by the downcore SO42− depletion and increase in the HCO3−/Ca2+ ratio in the interstitial water. Diagenetic changes caused by bacterial sulfate reduction resulted in the formation of solid phases of authigenic calcite and iron sulfide (pyrite). The authors suggest that elevated concentrations of sulfate ions, as well as the heavy metals Zn, Ni, Co, Cu, Mo and V in the interstitial water of sediments, when compared to those in the Pyasino lake water, result from the technogenic pollution from mining and metallurgical operations.

Shevchenko and coauthors [5] investigated the geochemical peculiarities of two lake sediment cores collected in the Ob River valley of Western Siberia. The cores differ in their landscape position, content of the organic matter and rate of sedimentation. These main factors cause the different contents and patterns of heavy metal accumulation, as well as diagenetic transformation in sediments of the two studied lakes. In the cores, significant enrichment factors (>3) were revealed only for Cd and Sb, indicating that their input was also from an additional source. The upper layers of the sediment cores are characterized by an enhanced recent input of Cr, Co, Cu, Zn, Cd, Sb, Pb and Bi compared to pre-industrial sediments. Elevated concentrations of heavy metals can be associated with both the features of the lake's watershed and global anthropogenic pollution.

On behalf of the Guest Editors, I would like to thank all the authors who submitted their papers to this Special Issue. I am grateful to the reviewers, who contributed significantly to the improvement of manuscript quality. Finally, many thanks are due to the *Minerals* editors who assisted us with the publication process.

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