minerals

Editorial

Editorial for the Special Issue "Environment and Geochemistry of Sediments"

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The geochemical characteristics of environments can be determined via geochemical studies of sedimentary rocks. Different geochemical indicators can be used for the paleoenvironmental reconstruction of sedimentation processes. Trace and major elements in sedimentary rocks are extremely sensitive to paleoenvironmental changes, making them informative in studying the paleoclimate, paleoenvironment, as well as ancient and modern anthropogenic activity. The distribution of pollutants in sediments is important for modern geoecological processes. Isotopic research of sediments is essential for paleoreconstructions, geochronology, and ecology. The application of different analytic methods to study the geochemistry and mineralogy of sediment processes is also important in the context of these investigations.

The Special Issue "Environment and Geochemistry of Sediments" includes ten papers devoted to these problems. The topic of the first paper, by Bezrukova et al. [1], is the geochemistry of lacustrine deposits from high-latitude regions, for example, Lake Kaskadnoe-1 in the East Sayan Mountains, South Siberia, Russia (2080 m above sea level). The lake deposits contain a unique record of geochemical cycles pertaining to the last 13,200 years. They reflect sedimentation depending on environmental changes during the Late Glacial and Early Holocene. The Late Glacial sediments (13,200–12,800 cal yr BP) are characterized by high values of CIA, Mg/Al, K/Al, and Mn/Fe, and are depleted in Si/Al, Fe/Al, and Ca/Al. During the cold episode of the Younger Dryas, LOI enrichment was probably caused the presence of by less oxic conditions, as seen in the lower Mn/Fe values, due to a long period of lake ice cover. The Early Holocene (12,000–7500 cal yr BP) is associated with a decreasing trend of mineral matter with fluvial transport to Lake Kaskadnoe-1 (low K/Al, Mg/Al) and increasing chemical weathering in the lake basin. The increase in Ti/Al, K/Al, and CIA values over the last 7500 years suggests increasing terrigenous input into the lake. These data allow a reconstruction of the paleoenvironment in the lake basin during its development.

The second paper, by Malov et al. [2], is devoted to the problem of accumulation and distribution of a hazardous contaminant, mercury (Hg), in the basin of Lake Onega, Russia, the second largest lake in Europe. In this paper, the first investigations of the lateral distribution of total mercury in the water-suspended matter-bottom sediments system are presented. The total mercury content in the water of Lake Onega averages 0.32 ± 0.07 µg/L. The most common form of Hg in water is the dissolved and colloid form, except for water samples from the Kondopoga and Povenetsky Bays. In the material of the sedimentation traps, the Hg content is 0.5 ± 0.3 µg/g, and in the upper and lower parts of the bottom sediment section, this value is 0.067 ± 0.003 and 0.041 ± 0.001 µg/g, respectively. The main factors responsible for the increased Hg include anthropogenic pollution, the migration of Hg, and its redeposition at the geochemical barrier together with Fe and Mn.

In the third paper, by Shuncun Zhang et al. [3], the processes of the sedimentary environment and climate evolution of the Mosuowan area in the central Junggar Basin (China) during the Late Carboniferous–Early Permian are reconstructed. The investigative methods used in this paper include petrothermal methods, the use of a lipid biomarker,

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and a consideration of the isotopic composition of mud shale core samples, thus enabling the exploration of the tectonic–climatic events and Central Asian orogenic belt evolution that contributed to the sedimentary environment. The authors conclude that the Late Carboniferous–Early Permian period was influenced by global changes, Paleo-Asian Ocean subduction, and continental splicing, which resulted in a continuous increase in levels of terrestrial organic matter, water desalination, and oxidation-rich sediments in the Mosuowan region, but a P–T biological mass extinction event was not recorded.

The fourth paper, by Druzhinina et al. [4], considers the enrichment of Pb, Ni, Zn, As, Co, and Cu in sediments from Kamyshovoe Lake, Kaliningrad Oblast, Russian Federation, in the process of prehistoric anthropogenic activity. The enrichment factors (EF) combined with the results of the lithological, geochronological, magnetic susceptibility, and microcharcoal studies reveal the possible anthropogenic sources of metals in south-eastern Baltic Lake sediments from the Neolithic to the Medieval period. Increasing Co EF values and peaks of the Pb EF in Kamyshovoe Lake sediments, starting from ~6000 cal yr BP in the Neolithic period are considered evidence of the usage of metals as dyes and fixatives during that period. Since ~3100 cal yr BP, at the end of the Bronze Age, a simultaneous increase in the content of indicators of metallurgical production, Pb, Ni, Zn, and As, coinciding with the growth of the microcharcoal curve, indicates the expanding demand for metal objects in the southeastern Baltic region and the input of the local or regional ancient metallurgy into the lake sediments.

In the fifth article, by Ghandour et al. [5], a study of the mineralogical and geochemical contents of the bottom sediments of Al-Kharrar Lagoon, Rabigh, Saudi Arabia, is conducted in order to assess the ecological state of the lagoon. Three main elemental groups were determined via statistical analysis. The first group includes the positively correlated SiO_2, TiO_2, Al_2O_3, Fe_2O_3, MnO, MgO, K_2O, Na_2O, V, Cr, Ni, Zn, Rb, and Ba, which are concentrated in the southern sector of the lagoon and associated with siliciclastic-related minerals (quartz, clay minerals, k-feldspars, and plagioclase along with traces of amphiboles). The second group consists of the carbonate-related elements (CaO and Sr) that dominate the northern sector. The distribution patterns of P_2O_5 and Cu vary significantly across the lagoon. Enrichment factors reveal moderate levels of Cu in some sites, supporting its anthropogenic source. The results indicate that the ecological status of the bottom of the lagoon is hospitable despite the presence of local anthropogenic stressors such as the influx of flood water that contains a mixture of lithogenic and dissolved Cu from local agriculture.

The sixth paper, by Kulkova [6], represents a new approach with which to determine the functional zones of prehistoric archaeological sites in Eastern Europe via geochemical indication. The application of mathematical statistics for processing the geochemical data of cultural deposits at archaeological sites allowed the identification of groups of interrelated chemical elements that reflect the processes of natural sedimentation and anthropogenic activity. Abnormal concentrations of P_2O_{5antr}, CaO_{antr}, and Sr_{antr}, which are associated to each other, in sediments are attributed to the zones of accumulation of bone remains. Anomalous concentrations of a group of elements (K_2O_{antr} and Rb_{antr}) in deposits are associated with wood ash and fireplaces, ash residues from ritual activities, and fires. The group of elements Ba, MnO, and C_{org} reflects the accumulation of humus and organic remains, and may characterize areas with food residues, skins, and rotten wood. Aided by the distribution of the main lithological elements (SiO_2 and Al_2O_3) in sediments, it is possible to consider the paleorelief at the sites. These functional zones were reconstructed at the sites of the Neolithic period, Early Metal Age, and Bronze–Early Iron Age in Eastern Europe.

In the seventh article, by Karavaeva et al. [7], the distribution of arsenic in the soils of the Verkhnekamskoe potassium salt deposit, Perm Krai, Russia, is discussed. The danger of arsenic (As) pollution is determined by its high toxicity and carcinogenic hazard. The content of arsenic in soils was determined via inductively coupled plasma mass spectrometry (ICP-MS). Statistical methods were used to analyze the features of As distribution in the soils of background areas and potash mining areas near production facilities. Three types of landscapes were studied within each territory, each of which was distinguished by the leading processes of substance migration. Arsenic concentrations in both the background areas and the potash mining territories vary considerably, ranging from $n \times 10^{-1}$ to $n \times 10$. The arsenic concentrations in the soils of saline areas were found to be higher than those in the rest of the territories. Outside of saline areas, the identified patterns of As distribution in the soils of the Verkhnekamskoe potassium salt deposit indicate that potash operations are not a determinant of the technophilic accumulation of As.

The eighth paper, by Ullah et al. [8], focuses on studying the Goru Formation in the Chutair Section, Sulaiman Range, Pakistan, representing part of the eastern Tethys. The paleoenvironment and bio-sequence stratigraphy were studied in the Cretaceous pelagic carbonate succession. Based on the facies variations and planktonic foraminiferal biozones, the sea level curve in the data from the Goru Formation could be reconstructed. Fluctuations between the outer ramp and deep basin, showing the overall transgression in the second-order cycle in the study area, coincide with the global sea-level curve. At the same time, the third-order cycle represents the local tectonic process during the deposition of the strata.

The authors of the ninth article [9] present the results of geochemical multi-element, LOI, MS, and geochronological analyses of a cultural layer at the Voorthuizen archaeological site, The Netherlands, which was occupied in the Iron Age and early Roman periods. The study has provided a deeper insight into the agricultural techniques applied on the site and on the so-called Celtic fields, known as ancient field systems dating from the same period that were widespread throughout Northwestern Europe. It seems that household waste was not used as a fertilizer in Voorthuizen, while the application of manure is characteristic of Celtic fields. However, the phosphorous values in the Voorthuizen agricultural horizon are comparable to those in the Celtic fields, suggesting similar sources of P in both cases. Elevated Si and "mobile" Fe, Mn, V, Pb, As, and Sn, along with higher MS measurements, are indicative of the use of extra mineral matter for the fertilization of the ancient arable field in Voorthuizen.

The final paper [10] presents the results from a study of the ecological state of the northern and southern Al-Shuaiba lagoons, Red Sea, Saudi Arabia. The authors consider the impact of technogenic processes and building on the geochemical pollution of the lagoons of the Red Sea. The lower unit of the core is enriched in elements (Mo, As, U, and Re) suggesting the occurrence of deposition under anoxic conditions, this being possibly related to the Medieval Climate Anomaly. The middle unit is enriched in carbonate-related constituents ($CaCO_3$, Ca, and Sr). The upper unit is enriched in elements that co-vary significantly with Al, thus implying the presence of an increased terrigenous supply associated with the construction of a road between the two lagoons. The enrichment of elements in the lower and middle units was naturally driven, whereas the enrichment of lithogenic elements in the upper unit, though they are of geogenic origin, was induced after the road's construction.

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References

1. Bezrukova, E.V.; Amosova, A.A.; Chubarov, V.M. Geochemical Records of the Late Glacial and Holocene Paleoenvironmental Changes from the Lake Kaskadnoe-1 Sediments (East Sayan Mountains, South Siberia). *Minerals* **2023**, *13*, 449. [CrossRef]
2. Malov, V.; Subetto, D.; Strakhovenko, V.; Ovdina, E.; Belkina, N. Distribution of Mercury in the Water-Suspended Matter-Bottom Sediments System of the Lake Onego Water Area. *Minerals* **2022**, *12*, 1410. [CrossRef]

3. Zhang, S.; Wang, T.; Guo, H.; Zhang, S.; Chen, B. Lipid Biomarker and Stable Isotopic Profiles through Late Carboniferous–Early Triassic of the Deepest Well MS-1 in the Junggar Basin, Northwest China. *Minerals* **2022**, *12*, 1299. [CrossRef]
4. Druzhinina, O.; Gedminienė, L.; van den Berghe, K. Metals in Lake Sediments as Indicators of Human Activities in Prehistory: Case Study of the Southeastern Baltic, Kamyshovoe Lake. *Minerals* **2022**, *12*, 1216. [CrossRef]
5. Ghandour, I.M.; Mannaa, A.; Alharbi, O.; Masoud, A.A.; Aljahdali, M.H. Major Factors Controlling the Elemental Composition of Al-Kharrar Lagoon Bottom Sediments, Rabigh, Saudi Arabia. *Minerals* **2022**, *12*, 1096. [CrossRef]
6. Kulkova, M. Geochemical Indication of Functional Zones at the Archaeological Sites of Eastern Europe. *Minerals* **2022**, *12*, 1075. [CrossRef]
7. Karavaeva, T.; Menshikova, E.; Belkin, P.; Zhdakaev, V. Features of Arsenic Distribution in the Soils of Potash Mines. *Minerals* **2022**, *12*, 1029. [CrossRef]
8. Ullah, S.; Jan, I.U.; Hanif, M.; Latif, K.; Mohibullah, M.; Sabba, M.; Anees, A.; Ashraf, U.; Vo Thanh, H. Paleoenvironmental and Bio-Sequence Stratigraphic Analysis of the Cretaceous Pelagic Carbonates of Eastern Tethys, Sulaiman Range, Pakistan. *Minerals* **2022**, *12*, 946. [CrossRef]
9. Druzhinina, O.; Gedminienė, L.; van den Berghe, K. Geochemical Study of the Iron Age Settlement Occupational Layer and the Early Roman Time Agricultural Layer at Voorthuizen, The Netherlands. *Minerals* **2022**, *12*, 373. [CrossRef]
10. Ghandour, I.M.; Aljahdali, M.H. Elemental Enrichment in Shallow Subsurface Red Sea Coastal Sediments, Al-Shuaiba, Saudi Arabia: Natural vs. Anthropogenic Controls. *Minerals* **2021**, *11*, 898. [CrossRef]