Biogeochemical processes in volcanic crater lakes and their effect on the oil potential of sediments filling in the craters

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The aim of this work is to show that the amount and chemical composition of petroleum is controlled not only by the biological precursor of its source organic material but also by biochemical processes which occur in water column as well as in recent sediment and which result in transformation of biopolymers to geopolymer (kerogen). Petroleum generation from organic-rich sedimentary rocks filling in Pliocene (4-4.5 Ma) volcanic crater lakes (Hungary) was studied by experiments simulating natural oil window in 6 steps.

Different preservation

A different portion of the organic matter could be converted to petroleum and a very different amount of oil was produced by artificial maturation of lipid-derived kerogens formed in two (Pula and Gérce) of these craters. Aerobic decomposition of large amounts of detritus resulting from algae blooms, which formed a mat on the water surface, led to severe depletion of oxygen in the water of the Pula crater and it promoted the selective preservation of the resistant aliphatic macromolecules building up the thick outer walls of Botryococcus algae. Results presented here revealed that homogenous aliphatic kerogen formed from nearly pure algal material is thermally stable. Structural heterogeneity of the Gérce kerogen can be attributed to the extensive bacterial alteration of B. colonies is probably related to the arid periods.

Role of sulphur

Thermal degradation of kerogens of very different sulphur content, taken from volcanic twin crater deposits, resulted in oil of similar amount and dissimilar quality. Medium sulphur-rich kerogen proved to be thermally more labile and yielded sulphur-containing heavy oil at lower temperature than its low-sulphur containing counterpart which produced paraffinic oil. Different sulphur content is considered to be the consequence of different extent of microbial sulphate reduction.

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^{21}Ne versus ^{10}Be surface exposure ages of quartzite: A comparison

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While both ^{21}Ne and ^{10}Be are produced by cosmic rays in silicates such as quartz and can be used for surface exposure dating, there is a fundamental difference: ^{10}Be decays with a half-life of 1.5 Ma, whereas ^{21}Ne is stable. In consequence, any non-cosmogenic ^{10}Be, if produced at all, decays and cannot accumulate to a significant level over geological time. In contrast, processes that lead to the production or incorporation of non-cosmogenic ^{21}Ne in quartz must carefully be evaluated in order to derive geologically meaningful exposure ages. Apart from atmospheric Ne, non-cosmogenic Ne sources include (i) nucleogenic ^{21}Ne produced by ^{18}O(α,n) reactions and (ii) Ne in fluid inclusions derived from crustal fluids with an isotopic composition different from air (air: ^{21}Ne/^{20}Ne=0.002959 and ^{22}Ne/^{20}Ne=0.1020).

We analysed quartz from river terraces near the town of Yumen at the NE-margin of the Tibetan Plateau for both Ne and Be. The clasts are derived from quartz veins present in the low-grade metasediments of the source area and contain abundant fluid inclusions. As the quartz clasts are monomineralic, ^{18}O(α,n) reactions due to the decay of U or Th cannot have produced significant amounts of nucleogenic ^{21}Ne. Nevertheless, for some samples ^{21}Ne ages are significantly higher than the ^{10}Be ages. Such high apparent ^{21}Ne ages may be due to a Ne component trapped in fluid inclusions, which carries excess ^{21}Ne relative to the atmospheric composition Analyzing Ne in the fluid inclusions by crushing these quartz samples in the vacuum system of the mass-spectrometer indeed revealed a Ne component with elevated ^{21}Ne/^{20}Ne ratios, varying from the atmospheric value to ~0.0039 among different samples. Using the ratio obtained from crushing for the Ne age calculation, instead of the atmospheric ^{21}Ne/^{20}Ne ratio, results in ^{21}Ne ages that agree with the ^{10}Be ages.

Our results demonstrate the feasibility of ^{21}Ne surface exposure dating even under circumstances where non-cosmogenic ^{21}Ne components with an isotopic composition different from air are present. Implications for future exposure dating studies using quartz-rich sediments will be discussed.