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Mineralogy, major and trace element geochemistry of oil shale (Middle Eocene), Shamakhi Gobustan and Absheron regions, South Caspian Basin, Azerbaijan: implications for provenance, palaeoenvironment and tectonic setting

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Shamakhi-Gobustan and Absheron regions are a part of The South Caspian Basin, which is located in the collision zone between the Arabian and Eurasian plates. The intensive rate of sedimentation process creates a favorable condition for the formation oil shale, hydrocarbon and as well as mud volcanoes in these regions.
About 60 oil shale outcrops were recorded in the study regions, mainly associated with the Middle Eocene. Along with outcrops, oil shale was also found in eject products of mud volcanoes, which are widely spread in the study regions.
Two samples from the outcrops and eight samples from ejects of mud volcanoes were taken. The samples are black, gray and brown in color with a laminated structure. The concentrations of major and trace elements and minerals in selected oil shale samples were measured by “S8 TIGER Series 2 WDXRF”, “Agilent 7700 Series ICP-MS” mass spectrometers and XRD “MiniFlex 600”. The microscopes “Loupe Zoom Paralux XTL 745” and “MC-10” and a digital camera “OptixCam” were used to determine the age of samples.
Oil shale samples are rich in SiO_2 (49.81%), followed by Al_2O_3 (14.64%) and Fe_2O_3 (6.84%). The major element oxides in the composition of samples were compared with average shale, NASC and average black shale studied in the published literature. The SiO_2 and Al_2O_3 values correspond to the average shale, the Fe_2O_3 values proper to NASC and the CaO, Na_2O, K_2O, MgO, TiO_2 and P_2O_5 values coincide with both shales. It was found that the studied samples coincide with the average black shale in terms of Al_2O_3 value and alkaline compounds.
The correlation of Al_2O_3 and oxides of other major elements indicates a strong positive correlation with K_2O ($r = 0.65$) and TiO_2 ($r = 0.57$). A similar relationship between SiO_2 and Al_2O_3, as well as each of them with K_2O and TiO_2, characterizes the effect of detrital sorting of shale deposits during migration. In addition, a positive relationship with K_2O determines the distribution of aluminum in potassium-containing minerals. This indicates the linkage of most aluminum and potassium with clay minerals.
Discrimination diagrams based on geochemistry and some ratios of elements indicate that oil shales show moderate to high degree of weathering. A weathering tendency of all samples plots close to the illite mineral. The sediments were deposited in shallow water environments (lagoons, small closed gulfs, peripheral zones of the deltas, etc) with arid climates and reducing redox conditions, and the original sediments were derived from mafic and intermediate source terrain. Geochemical data for oil shales suggest an active continental margin setting.