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Organic and Inorganic Geochemistry of Cenomanian to Turonian Oil Shales, Tarfaya Basin, Morocco: A Classification Based on Organic Sulfur Richness and Organic Petrography

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ABSTRACT

An integrated organic and inorganic geochemical as well as organic petrological study revealed excellent oil shale potential for the Cenomanian to Turonian in Tarfaya Basin, southwestern Morocco. Organic sulfur concentration and petrological characteristics subdivide the Mid-Cretaceous succession into four intervals. The study assessed 240 core samples from the Songdage-4 well for organic and inorganic carbon contents and selected samples for total sulfur and major element concentrations. Rock-Eval pyrolysis and organic petrology were conducted to characterize the source rock potential. The depositional environment and organic matter type were determined by molecular geochemistry of source rock extracts. As a proxy of organic sulfur/organic carbon ratio, the ratio of thiophenes/benzenes was calculated from kerogen pyrolysates. The lower Cenomanian section is characterized by high silicate contents and is moderately rich in TOC (< 4.5%), whereas hydrogen index (HI) varies between 295 and 697 mgHC/gTOC. It is dominated by unstructured organic matter (UOM) and has a very low Sorg/Corg ratio. Organic and inorganic geochemical data indicate anoxic to suboxic bottom water conditions and an environment rich in Fe that consumed the majority of S to form pyrite during early diagenesis. This suggests oil prone kerogen Type II. The upper Cenomanian section is rich in UOM with fair presence of visible liptinite and bituminite-II particles. It has maximum TOC nd HI values of 8.1% and 795 mgHC/gTOC, respectively, indicating oil prone source rocks and moderate Sorg/Corg ratio indicating kerogen Type II/IIS. The samples representing the Cenomanian-Turonian boundary event (CTBE) demonstrated the highest TOC, Sorg/Corg ratios and HI values. The TOC and HI values exceed 18% and 870 mgHC/gTOC, respectively. Probably due to early diagenetic vulcanization, all kerogen became unstructured. The Turonian samples illustrate similar high TOC and HI values, but slightly lower Sorg/Corg ratios and higher bituminite-II and litptodetrinite contents. The CTBE and Turonian sections are rich in organic sulfur, having kerogen Type IIS, and will generate sour oil upon thermal generation or oil shale retorting. The new classification scheme provides essential information for both academic and industrial sectors.