Petrographic and geochemical analyses of Cretaceous Chichali Formation, Chichali Nala section, Pakistan: Implication for source and reservoir rock characterization

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Abstract

The studied Chichali Nala section is part of the east-west trending Surghar Range, which represents the eastern extremity of the Trans Indus Ranges. It is separated from Western Salt Range by Kalabagh Fault. The Cretaceous Chichali Formation within the studied section is composed of fine to coarse grained sandstone with intervening carbonaceous shale. The outcrop studies reveal that the Chichali Formation is composed of three facies; the base of Chichali Formation is composed of Fine Grained Sandstone Facies, which shows the deltaic or deltaic beach deposition, Glauconitic Sandstone Facies is present in the middle part of the Chichali Formation, which is characterized by the presence of substantial amounts of glauconite and thus believed to be deposited in the deeper shelfal environment, and the upper part of Chichali Formation is comprised of Glauconitic Dolostone Facies, which represents deposition on mixed clastic-carbonate dominated shelf. The petrographic analysis reveal that the studied sandstone samples possess great amounts of variations ranging from mature quartz dominated sandstone of the Fine Grained Sandstone Facies to mature-to-submature sandstone of Glauconitic Sandstone Facies and immature Dolostone of the Glauconitic Dolostone Facies. The prominent diagenetic features observed during the petrographic study are compaction, intense cementation and authigenic mineralization that result in a major decrease in the porosity within the studied sandstone samples. However, late stage dissolution of cement/matrix along fractures has also appreciably increased secondary porosity. X-Ray Diffraction (XRD) and Scanning Electron Microscopy (SEM) reveal the pore nature and clay mineralogy of the studied sandstone. Both intergranular and intragranular pore spaces are observed during the analyses. The presence of authigenic minerals has plugged the throats of these interconnected pore spaces, hence resulting in low values of permeability. Among the three observed sandstone facies, the Fine Grained Sandstone Facies holds a reasonable amount of interconnected pore spaces. These facies capped by impermeable shales, an interformational seal, possess prospects of a good future reservoir in the region. The TOC and Rock-Eval analysis for the studied shale show good to very good source rock potential. The modified van-Krevelen diagram shows that the overall organic matters within the shale are of kerogen type III, thus supporting a gas window for the shale. The geochemical parameters suggest that the overall trend of the selected samples is mature to post mature with 'good' hydrocarbon potentiality. The environment of deposition, associated with Type III kerogen is inferred to be terrestrial and characterized by no transportation of organic debris under oxidizing conditions. The lower values of HI and type of kerogen also support gas prone tendency for the suggested samples. Overall, the studied formations show fair to good reservoir potential and good source rock potential.