

Outcrop studies, an analogues of the diagenetic and depositional fabric of subsurface reservoirs: a synthesis from Late Cretaceous and Early Paleocene sandstones in eastern Sulaiman Range, Pakistan

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Abstract

In the presence of the Eocene Sui Main Limestone, a major producing reservoir of the region, the secondary reservoirs like Maastrichtian Pab Sandstone and the Danian Khadro Formation received very little attention. Although small discoveries have been made from the Pab Sandstone in the Lower Indus Basin, yet it is considered as tight in most of the drilled wells of the region and is, therefore, ignored. In order to improve the understanding about the reservoir potential and the diagenetic effects on these reservoir sandstones, a 551 m thick section of the Pab Sandstone and 128 m section of the Khadro Formation has been measured and logged in detail in Rakhi Nala section of eastern Sulaiman Range. The measured units are mainly composed of thin to thick bedded sandstone with subordinate mudstone and occasional marls that were deposited in the western passive margin of the Indian Plate. Eight and four depositional facies have been identified in the Pab and Khadro formations respectively and are grouped into pro-delta, delta-front and delta-plain facies associations, which were deposited in fluvial, wave dominated deltaic settings. Samples of sandstones from Pab Sandstone and Khadro Formation have been collected for reservoir studies and classified as quartz arenite, subarkosic, sub-litharenite and wackes. These are fine to coarse grain, subangular to rounded, and poorly to moderately sorted. SEM and XRD analyses showed that the intense burial diagenesis resulted in compaction, extensive cementation and authigenic mineralization, which cause low values of porosity/permeability. Calcite, siliceous overgrowth and iron oxide, both as goethite and hematite, are the major observed cement types. Both inter-granular and intra-granular porosity have been observed, which are mostly filled by cements and authigenic clay minerals that blocked the pore throats and thus resulting in major destruction of permeability. The late stage dissolution of unstable framework grains and cements have resulted in appreciable increase in secondary porosity. The inferred paragenetic sequence of the studied sandstone include both physical and chemical compaction, dissolution of feldspars and kaolinitization, chloritization and illitization of smectite, quartz overgrowth, calcite cementation and dolomitization, uplifting and deformational bands formation, and iron oxide/hydroxide cementation and its partial dissolution. The petrographic studies and plug porosity/permeability results of outcrop samples suggest that laterally continuous and vertically stacked thick sandstone sequences of delta-plain and delta-front facies associations possess good values of porosity and can constitute very good hydrocarbon prospects in the region.