

Porosity Evolution in Eocene Carbonate Gas Reservoirs, Sulaiman Sub-Basin, Pakistan

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ABSTRACT

The Kirthar Formation (Middle - Late Eocene) of the Sulaiman sub-basin is conformably underlain by evaporites of the early Eocene Ghazij Formation and unconformably overlain by the sandstones of the Oligocene Nari Formation. The Kirthar Formation consists of four members, in ascending order: Habib Rahi limestone, Sirki shales, Pirkoh limestone & marl and Drazinda shales. The carbonates are comprised of three dominant lithofacies (1) deep marine, basinal facies (2) shallow marine, carbonate sand shoal facies and (3) shallow, semi-restricted lagoonal facies. The Habib Rahi limestone and Pirkoh limestone members are the main reservoirs at Mari Gas Field - the second largest gas field in Pakistan (6 TCF in-place reserves). Subsurface cores from the field area and nearby outcrop samples reveal that porosity development in these carbonates is closely related with depositional lithofacies and diagenetic modifications.

After deposition the carbonates of the Kirthar Formation were subjected to marine phreatic, meteoric phreatic and meteoric-marine mixed environments. Primary intra-bioclastic pores and fractures created by mechanical compaction were enlarged by early diagenetic dissolution. These pores were subsequently occluded by pyrite, calcite and dolomite cements. The influx of undersaturated subsurface fluids resulted in burial dissolution of cement in intra-bioclastic cavities and in the matrix along with other unstable finer grains.

The very good reservoir quality of these carbonates is mainly attributed to secondary porosity development (15-20%), observed in shallow marine shelf facies only. Common porosity types include (1) microvuggy 'matrix' and (2) solution-enlarged intra-bioclastic with subordinate moldic and vuggy types. The pore system is generally fabric-selective and is lithofacies related. Porosity development is associated with the reaction of the limestones to aggressive subsurface fluids - possibly related to hydrocarbon maturation under burial diagenetic conditions.

The results of this study would help to develop the Mari and nearby existing gas fields in the study area and can also contribute to exploration activities in adjoining unexplored areas of Punjab Platform and Sulaiman Depression.