MOUNTJOY CARBONATE
RESEARCH CONFERENCE III
AUGUST 14-18, 2022 | Banff Centre, AB, Canada

Stylolites in limestones: Conduits to fluid flow?

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The Cenozoic sedimentary succession of the Bombay Offshore basin, western India developed over the undulating topography of the Deccan Traps. The Eocene lithology of the Mukta field from this basin is dominantly composed of limestone punctuated with shaly intercalations. The limestones are compact and indurated, with moderate to poor porosity developments, where the primary and most of the secondary porosities are occluded by recrystallization and later generation cementation. The sediments, with its profuse biogenic contents mainly benthic foraminifers, were deposited in an open marine setting. Burial diagenesis have played a major role in this field which led to the formation of chemical sedimentary structures, known as stylolites, as one of the prominent sedimentary features in this field.

Stylolites are planar features, formed as a result of pressure dissolution, and are demarcated by the accumulation of insoluble minerals after the removal of the soluble portion. Based on their mechanism of formation, they are predominantly horizontal to the bedding plane in our field of study, since their origin is attributed to burial and compaction mechanism. Because of their planar geometry and relative abundance within the limestone reservoir, they can have an influence on the regional fluid flow, and may act either as conduits or barriers. The following study was carried out on core samples from three wells of the Mukta field where, in an otherwise tighter limestone horizons, porosity development is seen to occur along these planes. The more argillaceous horizons have dissolution seams whereas the cleaner sections have prominent stylolitic formation, where the porous development occurs.

In terms of elemental compositions along these chemical sedimentary structures, micro-XRF analysis show concentrations of Al and Fe along these bands, which correlates to lining up of mostly clay minerals along them. Thus the idea established that because stylolites are lined up with mostly clay minerals and are formed as a result of compaction; so they were considered to be the ones that impedes fluid flow rather than acting as fluid conduits. This idea persisted for a long time, until later when various experimental studies and field/core data showed them to act even as conduits in cases. Such a case has been identified in the following study area. This study reveals the presence of an association of secondary macro-porosity developments with the stylolites, i.e. there is a preferential development of visible moldic, vuggy pores and hairline fractures in the immediate vicinity of the stylolite planes. The general trend of the porosities within this field is poor, often occluded by later generation cement types. However the ones formed in association with the stylolites are majorly unfilled. Our study also shows hairline fractures and vein formations at the stylolite tips, thereby forming an interconnected network. Studies have significantly shown the impact of stylolites on the transport properties of reservoirs, where the permeability along the stylolites are enhanced in comparison to the flow transverse to them or in no stylolitic rocks where its effect is low to negligible.