STRUCTURAL AND PETROLOGICAL CHARACTERIZATION OF THE TUMEY GIANT INJECTION COMPLEX, CALIFORNIA (USA), AND ITS VALUE AS OUTCROP ANALOGOUS FOR SUBSURFACE ANALYSIS

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ABSTRACT: Large-scale sand injection complexes besides being special and intriguing geological phenomena play a very important role in the evolution of sedimentary basins and as hydrocarbon-bearing sandstone intrusion reservoirs. They are typified by evidence of sand fluidization and injection in the shallow crust and are recognized extensively in outcrops and in the subsurface. In terms of hydrocarbon exploration, large-scale intrusions are important reservoirs with complex geometries usually characterised by excellent intra- and inter-reservoir connectivity. They may act as long-term fluid conduits implicating in hydrocarbon migration, increasing cross-stratal fluid flow over hundreds of metres of section. The Tumey Giant Injection Complex (TGIC) is a large-scale interconnected sandstone intrusion net emplaced into deep marine mudstones and shales of the Kreyenhagen Formation (Eocene), cropping out along the western central margin of the San Joaquim Basin, California (USA). It was formed by an overpressure event where the pore fluid pressure of depositional sandstones (parent units) reached and overcame the fracture gradient of mudstone and shales (host rocks) triggering generalized hydrofracturing and brecciation, along with remobilization and injection of sand and fluids from the parent units into the fracture system. Detailed geological mapping supported by stratigraphic, structural and petrological analysis of TGIC allowed the definition of the spatial and petrogenetic relationships between parent units, sandstone intrusions (sills/dykes/injection breccias), and hydraulically-fractured host rocks. The intrusive complex developed two main distinct regional-scale injection geometries extending through up to 3 km and cross cutting ca. 450 m of deep marine strata. In the lower interval a lower intrusive zone is defined by saucer-shape intrusions with multi-layered sills (0,1 – 2 m apertures) connected by thinner dykes (0,1 – 0,8 m apertures), intruding ca. 300 m of smectite-dominant mudstone and shales. In the upper interval the intrusive zone is defined by injection breccias, and stepped dykes and sills forming wing-like intrusions (up to 12 m aperture) that can extend laterally up to 600 m, and upward intruding 150 m of biosiliceous-dominant mudstones and shales. Structurally the intrusive networks of the complex are comprised by near to bedding-parallel sills with erosional surfaces and bedding-discordant dykes emplaced in a NW-SE oriented fracture system mostly plunging to NE. The complex is eroded by turbidites of the Tumey Sandstone Lentil, constraining the time of the injection event to the upper Eocene. The petrography of sandstones from the turbiditic bodies of Kreyenhagen Formation and injected sandstones reveals similar petrogenetic features. Both are lithic sandstones cemented by gypsum and with provenance signatures of recycled orogen; confirming a common genetic link. They strongly differ from sandstones of the underlying formations (Lodo and Domengine) which have completely distinct mineral assemblage, different diagenetic evolution and provenance signatures. The TGIC is an excellent outcrop example of a giant sand injection complex that is valuable analogue for subsurface analysis. The mutual relationships studies of its elements can strongly support the exploration and development of hydrocarbon-bearing sandstone intrusion reservoirs in subsurface occurrences.

KEYWORDS: SAND INJECTION COMPLEX, INTRUSIVE GEOMETRIES, SUBSURFACE ANALOGUE