Monitoring Reservoir Fluids Using Microearthquake Technology in a Middle East Carbonate Oil Field

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Majority of the giant oil fields in the Middle East produces from prolific carbonate rock reservoirs. Collectively these carbonate reservoirs hold well over 50% of the world oil reserves. The high rigidity of the limestone-dolomite reservoir rock matrix, a small contrast between the elastic properties of pore fluids, low GOR oil and mixed salinity water are responsible for the weak 4D seismic effect from oil production in the reservoir under study. An alternative reservoir fluid monitoring technique, between wells, was therefore considered. Permanent seismic sensors installed in a borehole and on the ground surface over a producing field will record passive monitoring of microseismic activity from reservoir pore pressure perturbations. Reservoir production and injection operations create these pressure or stress perturbations that are induced by shear stress release along zones of weakness in these rocks. The injection operation generates reservoir pore pressure increase which creates shear stress increase affecting the stability along the planes of weakness in reservoir rocks like joints, bedding planes, faults and fractures. Similarly reservoir production operation or fluid withdrawal creates a pore pressure sink that affects the stability in zones of weakness. The microseisms or minute earthquakes emanated from the reservoir would be recorded simultaneously at a large number of multicomponent seismic sensors that are deployed permanently at various levels in the borehole and over a surface area surrounding the borehole. Special geophones capable of measuring frequency response over 100-1000Hz frequency range would be installed. Reservoir heterogeneities affecting the fluid flow could be mapped by recording the distribution of hypocenter locations of these microseisms or small earthquakes.