Geo-hazard with oil and gas production in Krishna–Godavary Basin

Large-scale production of oil and gas in some parts of the world leads to land subsidence resulting in irreversible environmental damage. Scepticism about such reports is that there are many oil and gas fields without any such incident. Consolidation or volume reduction of the reservoir rocks is possible only when they are unconsolidated or semi-consolidated. The time taken for such manifestation depends on the depth of the reservoir rocks, their thickness and the stage since the pressures dwindled. In fact, the time can be computed if the coefficient of consolidation of the reservoir sediment is known. In the total occurrences of oil and gas in the world, only 24% of the reservoirs are located in the youngest Tertiary formations while the rest are in the older consolidated rocks. The reported incidents of subsidence are confined only to the Tertiary sandstones as in parts of California and Texas in USA, Venezuela coast of South America, in Italy and in Tokyo. Depth of the reservoir formations in those affected areas varies from 2000 to 7000 ft. Subsidence was reported to be in the range of 5 to 25 ft with rates varying from 0.07 to 1.18 ft per year. Subsidence phenomenon is a slow process and it may go unnoticed in the inland area unless the land is surveyed for reduced levels periodically with selected benchmarks. Even horizontal movements along claystones and soft shale were reported, which generated small shallow earthquakes.

The average subsurface geostatic pressure has a gradient of 1.0 psi/ft of depth while the hydrostatic (reservoir) pressure gradient is 0.45 psi/ft of depth. When the oil and gas are fully exploited, the hydrostatic pressure in the reservoir reaches atmospheric pressure. Consequently, the intergranular pressure (difference between geostatic pressure and hydrostatic pressure) in the resrvoir formation is increased, resulting in the compression of the rock. Oil and gas reserves in the Tertiary sandstones of the Krishna–Godavary Basin (K–G) are reported to occur at a depth range of 3000 to 8000 ft. The recent blowouts in the East Godavary district revealed that the reservoir pressure is very high with free flow conditions. A rough and conservative estimate of potential compression of formations in the K–G basin shows it in the range of 0.05 to 0.12 ft/ft thickness of the reservoir rock depending on the depth and considering the Young's modulus of elasticity (E) at 2000 kg/sq cm (The range of E for dense sand is 500–2000 kg/sq cm.) A second method by depth–porosity relation puts it alarmingly high. Laboratory tests in some oil fields have shown that sand grains undergo fracturing at high pressures (intergranular pressure at more than 100 kg/sq cm) and as a result they are as compressible as clays and siltstones and in some cases even more. The compression would be more if the reservoir rocks are intercalated with shales and siltstone and if the impervious roof rock (trap rock) is hydraulically connected to the reservoir rock.

Usually, water injection is done into the oil reservoir for secondary recovery of oil. For the sake of retaining part of the original pressure, huge quantities of water are injected. In some oil fields, the ratio of injected water to the volume of withdrawal was about 1.25. But the economics of such a remedial measure in the K–G basin has to be worked out for an effective implementation. However, in the case of gas field, water injection is said to be un-economical even for secondary recovery. Therefore, there is no remedial measure in their case and hence it remains a potential danger.

Krishna–Godavary basin draws special attention from the environmental point of view. Geologically, the region appears to be fragile with a thick pile of argillaceous sediments dipping towards the sea and underlain by faults. It is a delta land on the coast at an elevation of 3 to 10 ft above mean sea level. Subsidence of the region even by a small amount of this would devastate the whole region due to changing of the courses of the two mighty rivers, and sea incursion along the coast. If horizontal slip and slow continuous creeping along claystone and shale at depth happens, as has been reported in some oil fields, it would be catastropic. The region is densely populated and is one of the major rice bowls of the country. The country cannot afford to lose such a developed area on purely economic consideration.

As there is a potential danger with subsidence of the delta region due to exploitation of oil and gas, it is desired that the Oil and Natural Gas Corporation take up detailed investigations with modelling studies. An expert committee needs to be constituted to study the problem in detail before they go into full scale production and work out strategies to avert subsidence in the region. *Suggested reading*: 1. Halbouty, M. T. (ed.), *Geology of Giant Petroleum Fields, Memoir 14*, 1970, APPG, USA. 2. Poland, J. F., *Guidebook to Studies of Land Subsidence due to Groundwater Withdrawal*, UNESCO, 1984. 3. Rao, G. N., *J. Geol. Soc. India*, 1993, **41**, 444–454.

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