Compaction Modelling of the Las Vegas Basin: Implications for Fluid Extraction-Related Subsidence and Fault Development

Shaimaa Abdelhaleem[1], Wanda Taylor[1], Craig dePolo[2]
[1]University of Nevada, Las Vegas; [2]Nevada Bureau of Mines and Geology, University of Nevada, Reno

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Abstract

Reduction of formation fluid pressure and the resulting subsidence, compaction and rapid large-scale change in topography is a known problem in producing basins. In some instances, subsidence enhances existing natural fractures and/or creates new ones. In some basins, these fractures may be seismogenic faults. In oil and gas producing fields, increased seismicity can cause an upsurge of gas posing a drilling hazard that can result in enormous fatal fires. Hence, studying subsidence of basins is critical to understanding compaction as well as seismic and fire safety. In this study, we use the Las Vegas Valley, Nevada subsidence case to provide a correlation between subsidence/compaction rates, amounts, and distribution and fault development. Surface subsidence imposed by rapid groundwater extraction has been observed in Las Vegas since the onset of groundwater depletion in 1948. A water reinjection plan started in 1989 in attempts to maintain formation fluid pressure and prevent land subsidence. Nonetheless, subsidence is still being observed, but at a significantly slower rate. Furthermore, Las Vegas Valley is dissected by five scarp-forming faults, named the Las Vegas Valley fault system (LVVFS). Both differential subsidence and tectonic rupture have been suggested to form the LVVFS. Each of those suggested origins results in vastly different seismic hazards. A lack of correlation studies between the amounts and rates of subsidence and fault scarp heights/fault offset leaves the LVVFS origin and its seismicity potential controversial, because the amount of differential subsidence may not be enough to form the large (up to 50 m) scarps. We use lithologic, data from 1500 wells combined with resistivity, neutron log and thin section data from 11 of those wells, to construct hydrostatic and lithostatic compaction models for the Las Vegas Basin. Our models show a very slow rate of compaction with most of the compaction derived from normal burial processes rather than fluid extraction. Decompaction of the sediments across three of the LVVFS faults suggests the presence of fault scarps even before the onset of water level lowering. Consequently, the LVVFS represents natural fractures formed by tectonic processes before the onset of groundwater system depletion.

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