

Seismic Detection of Vuggy Porosity: Example from Lawyer Canyon Outcrop, New Mexico, U.S.A.

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One of the important issues in the characterization and modeling of carbonate reservoir strata that remains to be effectively addressed is the seismic characterization of touching-vug pore systems and the integration of seismic information into fluid-flow models. The lower San Andres carbonate sequence exposed in the Lawyer Canyon outcrop, New Mexico, provides an excellent example of ramp-crest grainstones having both interparticle porosity and touching-vug porosity. Using an outcrop-based 3-D lithofacies/porosity geocellular model, we calculated velocity from porosity using a linear relationship and generated 3-D synthetic seismic models to study seismic responses to vuggy porosity.

Under the assumption that the seismic P-wave misses all the vuggy porosity and seismic detects vuggy porosity only by responding to density changes, we created 3-D wedge models by changing vuggy zone thickness and the ratio of interparticle porosity and vuggy porosity within the zone, assuming the same host-rock condition. We then estimated seismic sensitivity by calculating the vuggy porosity ranges that can be detected reliably from amplitude measured in a noisy data set. Major conclusions are (1) seismic sensitivity of vuggy porosity is controlled by rock physics, stratal geometry, seismic frequency, and data quality, (2) a highly vuggy zone behaves similarly to a tight zone seismically, (3) amplitude anomaly created by a 10-ft vuggy zone should be detectable in 60-Hz, fair-quality ($S/N = 10$) seismic data, and (4) with good well control that reduces the ambiguity in total porosity and thickness estimation, it should be possible to map the vuggy zone by conducting seismic inversion.