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APPLICATION OF PASSSIVE SEISMIC IMAGING TO A GULF COAST SALT DOME

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Abstract

Passive seismic imaging uses the earth's background seismic 'noise', predominantly in the form of surface waves, to illuminate the subsurface. The technology takes advantage of the dispersive nature of surface waves to develop a mapping of shear wave velocity versus depth. We recently tested the use of passive seismic imaging to delineate the Markham salt dome in the Texas Gulf Coast.

The goals of the project were three-fold:

1. To generate a measure of the salt structure independent of 3D active seismic imaging
2. To provide a shear-wave velocity model in support of PS converted wave processing.
3. To evaluate the use of passive seismic imaging as a low-cost, low-impact means of imaging other salt domes

The test was run in conjunction with the recording of a 3D seismic 'active' survey. During the 3D survey, 10-Hz geophone nodes were recording continuously, 12 hours per day for several weeks. Over 10,000 nodes were used in the 3D survey. In the center of the survey, nodes were in place continuously for up to 11 weeks. Since the nodes were recording not just active sources but all seismic signals, including noise from road, agricultural, wind and ocean wave sources, they provided the raw data for the passive seismic test.

Initially a suite of 50 nodes was selected in a spiral pattern about the known center of the dome to evaluate the potential for using passive seismic imaging at the site. That noise test showed that strong ocean wave noise was reliably present in the area, arriving from the southeast in the 0.2Hz to 1Hz bandwidth. These were Rayleigh and Love surface waves generated by ocean waves crashing on the Gulf of Mexico beach 30 miles (50 km) away.

The initial noise test results were used to select 500 receivers to image the salt dome using those Rayleigh surface wave trains as recorded in vertical geophones. Using the principle of interferometry, each of the 500 receivers can be considered as a virtual source point for all the other receivers in the survey by cross-correlating the 499 pairs of vertical component traces for each virtual source point. This leads to many thousands of cross-correlations; each is then converted to a dispersion plot of group velocity versus period. A best-fit dispersion curve was determined for each plot and the dispersion curves inverted for shear velocity versus depth. Additional, numerically intensive processing generated a 3D volume of shear wave velocity versus depth over the salt dome

All three of the project goals were met, but to varying degrees of success. The final inversion result gives a coarse image of the salt dome location down to about 1000 m (3300 ft) depth, showing possible dips to the flanking sediments. The resolution of this dataset is much less than active 3D surface seismic but was useful in the PS converted wave processing, as it revealed the shear velocity in the shallow subsurface which lead to significant improvement of PS imaging. Based on these results at Markham the technique could be used at other salt domes, at low cost, to provide a low-resolution image of a dome's location. The technique could be improved by using lower frequency geophones than were available for this test; this would improve signal:noise and increase depth of measurement.

Key words: Passive Seismic, Seismic Imaging, Surface Wave Inversion, Markham Salt Dome.