Lightning Sparks Interest in the Unconventional Mapping of Active Subsurface Faults

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ABSTRACT

Lightning occurs everywhere and its energy is now being used by the petroleum & mining industries to find natural resources. This electromagnetic energy, sourced by billions of naturally occurring cloud to earth electrical discharges, has been harnessed for use as a geophysical exploration tool. Natural sourced electromagnetics (NSEM) is a patented technology that offers the petroleum industry a relatively quick & inexpensive reconnaissance mapping tool. Although lightning is guided by meteorological conditions, the precise location of strikes, and their individual attributes appear to be guided by shallow geologically related perturbations of the earth's deeply penetrating telluric currents. These electrical currents are influenced by lateral geological inhomogeneity caused by faults, fractures, mineralization, pore-fluids, and salinity variations. Examination of worldwide lightning data shows uneven distribution of lightning strikes. Similarly, an analysis of sixteen years of recorded North American lightning data reveals non-random patterns. After raw lightning data is tracked and then stacked and mapped much like multi-fold seismic data, lightning strike density and newly-defined lightning attribute maps show interesting and at times remarkable correlations to surface and subsurface geology. 3D apparent resistivity volumes can be generated from lightning data and displayed in the same fashion as 3D seismic data, with all wells, curves, and synthetic seismograms posted and correlated in the usual manner. Lines, traces, arbitrary lines, and apparent resistivity slices can then be extracted, calibrated, interpreted, and integrated with available seismic and subsurface data to expand interpreted areas beyond the bounds of existing conventional data. NSEM can be used to validate subsurface fault cuts and in sparse data areas can help determine fault strike. It can be used to tie local faulting to regional or sub-regional fault trends. Because of its scalability NSEM can identify anomalies and areas of interest for follow-up investigations whether they are prospect-size or regional in extent. NSEM apparent resistivity maps can be generated in support of unconventional exploration models that rely on resistivity as one of its key components. Fault plane maps can be interactively generated from resistivity profiles and slices, thereby providing similar quality control measures routinely employed by seismic interpreters during fault analysis. Several Gulf Coast examples will be presented that show how lightning-sourced data clusters, lineations, and offsets appear to correlate to salt domes, near surface fluvial depositional patterns, and hydrocarbon

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accumulations. One in-depth study demonstrates NSEM's ability to map known active radial faults. Confirmation of these faults is provided by 2D resistivity imaging and surface field mapping. The data even suggests the intriguing possibility that NSEM can be used to map subsurface erosional and depositional features, hence stratigraphic trapping opportunities. Two additional in-depth studies show how NSEM's latest patent pending geophysical signature successfully located several Arizona porphyry copper deposits and how the lessons learned from this project can be applied to unconventional exploration. NSEM is shockingly unconventional because in six to eight weeks more than 100 square miles of data can be acquired, processed, and interpreted for the same cost of acquiring a single square mile of 3D seismic data.