Lightning, A Shockingly Unconventional Technology for Exploration

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Abstract

Lightning occurs everywhere and its energy is now being used by the petroleum industry to find hydrocarbons. 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 Electromagnetism (NSEM^{SM}) is a patented technology that offers the petroleum industry a relatively quick and 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 that lightning strikes are not uniformly distributed. Similarly, an analysis of sixteen years of recorded North American lightning data reveals non-random patterns. After raw lightning data is edited and stacked, 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. 3-D resistivity and permittivity volumes can also be generated from lightning data and displayed in the same fashion as 3-D seismic data, with all wells, curves and synthetic seismograms posted and correlated in the usual manner.

Evaluation of NSEM data reveals how lightning clusters and lineations appear to correlate to fresh water, near surface fluvial depositional patterns, hydrocarbon seeps, salt domes, and mineralization. A case study from the Texas Gulf Coast provides a visual display showing how the majority of the lightning clusters correlated to known oil and gas fields, and how none of the area's regional faults cut across a single lightning cluster lineation.

Another Texas Gulf Coast case study shows a "Rise Time" lightning attribute map that revealed twenty-eight NSEM anomalies, each correlating back to a Tertiary aged oil or gas field. If NSEM had been used for reconnaissance mapping to generate leads and to serve as a guide for follow-up purchase and/or acquisition of seismic data, an 87% drilling success rate would have been realized.

A case study from Arizona, a dramatically different climate from the two Gulf Coast examples, demonstrates NSEM's ability to identify hydrothermal alteration zones associated with a porphyry copper deposit. In addition to illustrating how NSEM can be utilized in hard-rock mineral exploration in an area experiencing less lightning, it further documents NSEM's capability to capture rock properties that may be relevant to both conventional and unconventional petroleum exploration.

NSEM is a new and effective reconnaissance tool that can 1) extend the reach of any given 3-D data set; 2) fill in between widely separated 3-D surveys; 3) complement and supplement existing 2-D data; 4) rapidly generate leads in areas having little to no seismic data and well control for follow-up seismic data purchase and acquisition and 5) allow companies to quickly prioritize open or expiring acreage. With proper subsurface calibration, a potentially powerful 3-D resistivity volume could be obtained and integrated with existing 3-D seismic data.

NSEM is shockingly unconventional because in six to eight weeks one could have more than 100 square miles of data acquired, processed and interpreted for what it would cost to only acquire a single square mile of 3-D seismic data.