Harris County, Texas Lightning Analysis Fault Interpretation

The power of lightning has been harnessed for mapping structure, stratigraphy & rock properties. Natural-Sourced Electromagnetics (NSEM) has been proven effective for petroleum & mineral resource exploration. It's quick, inexpensive & versatile. Applications include reconnaissance & detailed fault mapping, delineating hydrocarbon accumulations & mapping porphyry copper deposits.

Abstract

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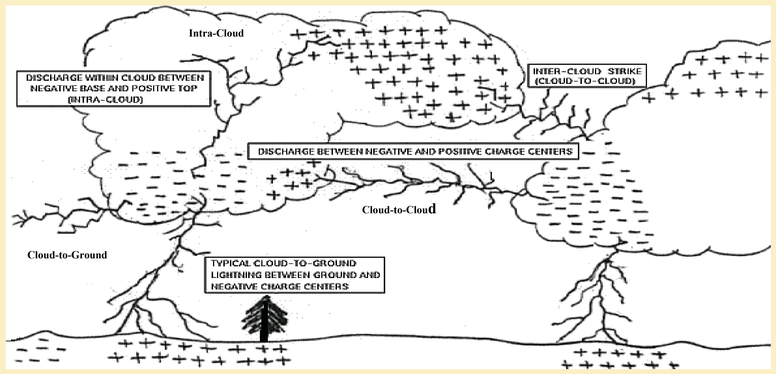
Lightning data collected over western Harris County, Texas and northeastern Pinal County, Arizona provides the primary sources used in this poster presentation. Surface faults, shallow electromagnetic surveys, outcrop geology, and other available public geological and geophysical data are integrated with lightning derived maps and volumes using a standard geophysical interpretation workstation to build the geological frameworks presented. Recognizable and repeatable three-dimensional patterns in the lightning derived maps, cross-sections, and volumes are the basis of the presented interpretations.

Poster Outline

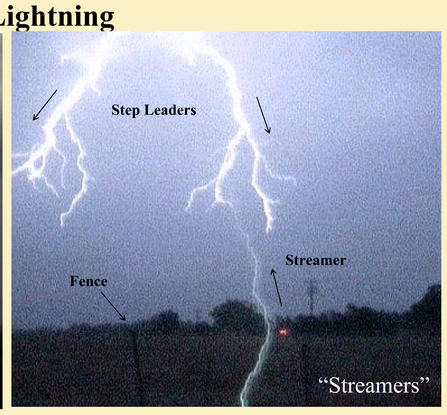
- Lightning, what it is & why it's tracked, stacked & mapped!
- Natural Source Electromagnetics (NSEM) – a new geophysical data type.
- Examples of using NSEM to map subsurface faults, stratigraphic traps, electrical rock properties, minerals & hydrocarbon accumulations.
- Conclusions.

Lightning: an atmospheric discharge of electricity, ionizing the air to create highly conductive plasma channels.



1. Hot moist air rises: freezes to form ice crystals.
2. Turbulent winds: ice, hail, water droplet collisions produce static charges.
3. Clouds become polarized: positive (+) ions carried to top clouds, negative (-) ions gravitate to base.
4. Static charge buildup: when charge strength exceeds insulating property of atmosphere, sudden high-voltage static discharge occurs.

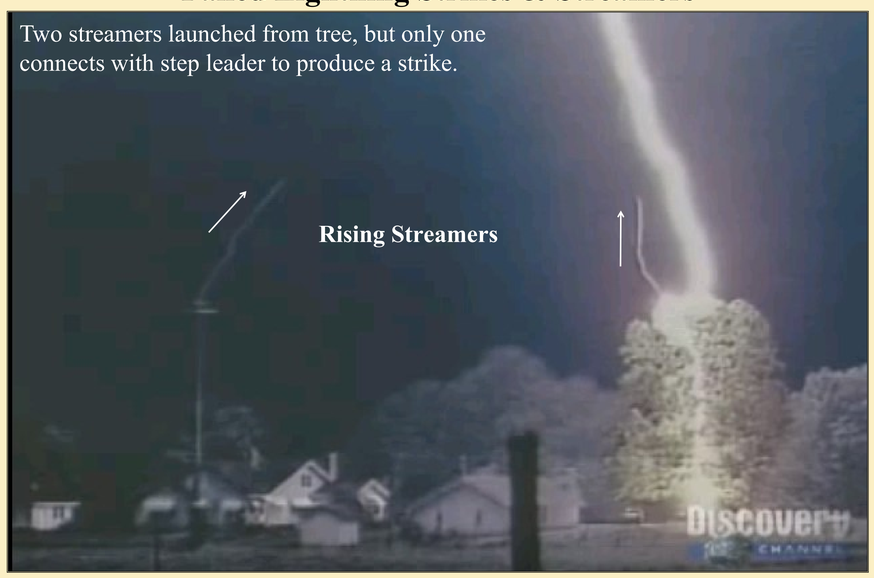
Nature of Lightning



Step Leaders: intensely charged channels of downward zig-zagging/branching electrons seeking positive ions to discharge built-up static energy.

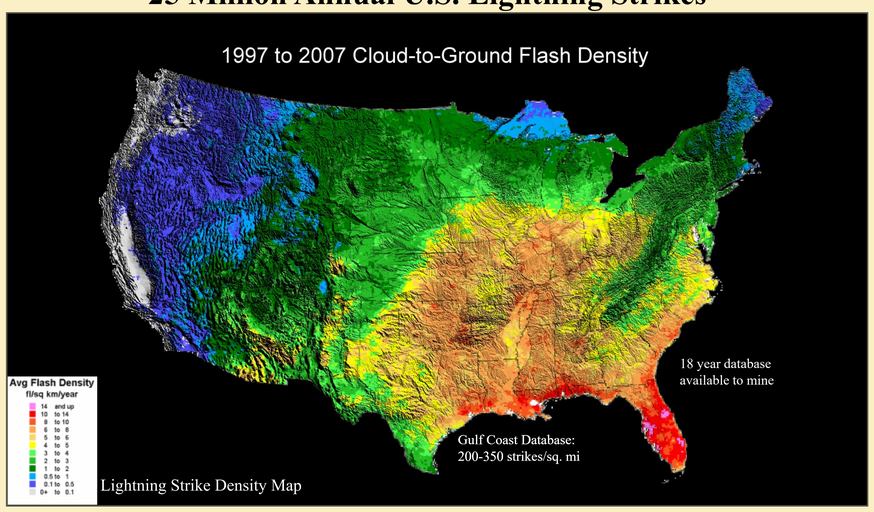
Streamers: rising stream of positive charge attracted to downward seeking electron step leaders when step leaders are within 30' - 300'.

Failed Lightning Strikes & Streamers



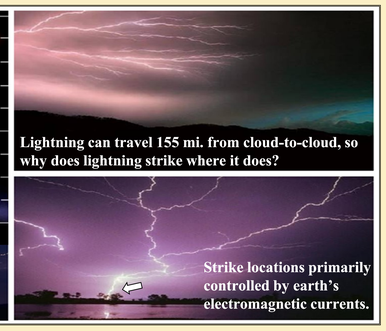
Note streamer launched from telephone pole does not connect with step leader to produce strike. Illustrates competing factors influencing strike location, one of which is geology.

25 Million Annual U.S. Lightning Strikes

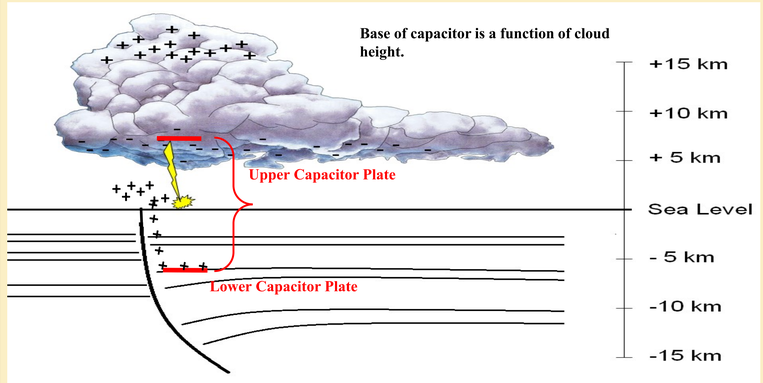


Strike density regionally controlled by meteorology, locally influenced by geologically-sourced perturbations of the Earth's telluric currents.

Primary Lightning Influence - Geologically Controlled Telluric Currents



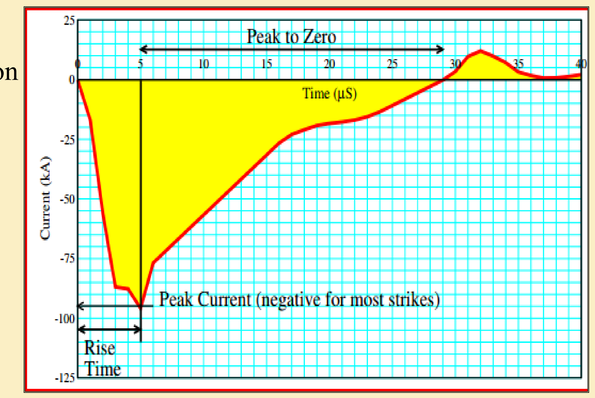
Each Strike Represents a Unique Capacitor



- **The top or base of the cloud (the originating point for positive or negative lightning strikes respectively), represents the top of the Earth capacitor. The base capacitor depth utilized to derive apparent resistivity volumes is derived from "Peak Current."**
- **"Peak Current," one of the lightning attributes collected worldwide, is the maximum current associated with any given lightning strike.**
- **Lightning is believed to be influenced by geology to a depth proportional to cloud height, as derived from the "Peak Current" lightning attribute.**

Lightning Measurements ⇨ Attribute Maps

- Location
- Time & Duration
- Rise Time
- Peak Current
- Polarity
- Peak-to-Zero
- Density

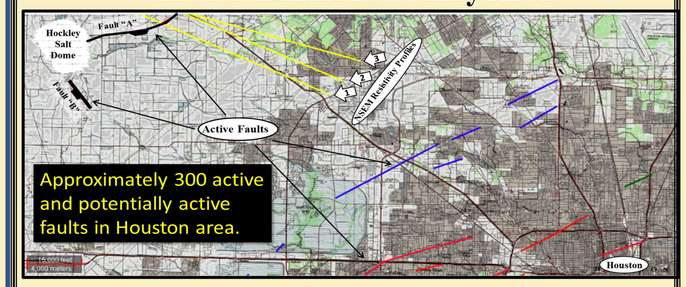


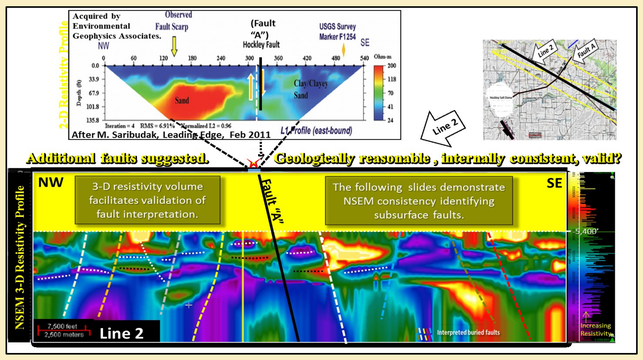
Lightning attribute maps generated & interpreted similar to seismic attributes. These attribute maps have been used to identify regional & sub-regional fault patterns, hydrocarbon accumulations, salt domes, near-surface point bar deposits & porphyry copper deposits. The basis for these correlations is that lightning strike locations, the type of lightning strikes & the electrical attributes associated with each strike can be influenced by lateral inhomogeneity caused by faults, fractures, mineralization, pore fluids & salinity variations.

Harris County Lightning Analysis Fault Interpretation

NSEM: quicker, safer, & less expensive than other geophysical data types. No boots on the ground, no permit fees.

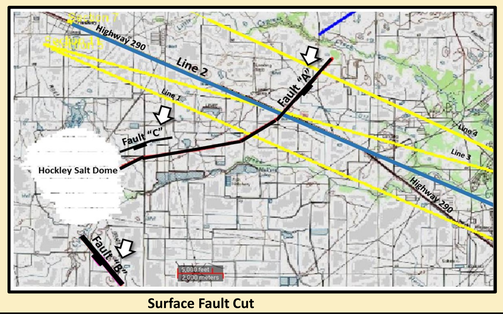
Active Faults
Houston/Harris County Area

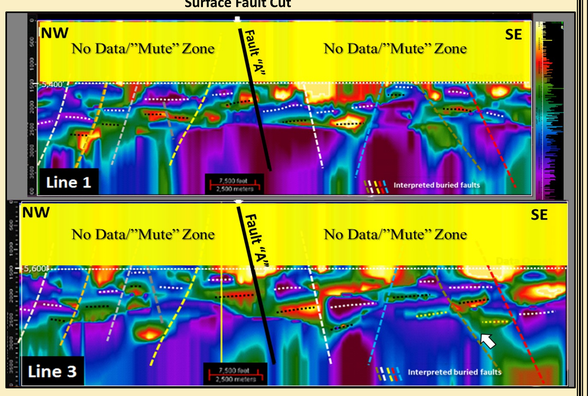




Subsurface fault interpretation of Fault "A" on NSEM apparent resistivity (lower image) is validated by tie to surface fault trace on 2-D resistivity imaging (white arrow, upper image). Resistivity profile provided by Mustafa Saribudak of EGA.

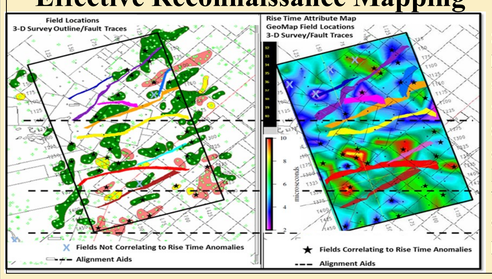
Radial Flt "A" Hockley Salt Dome





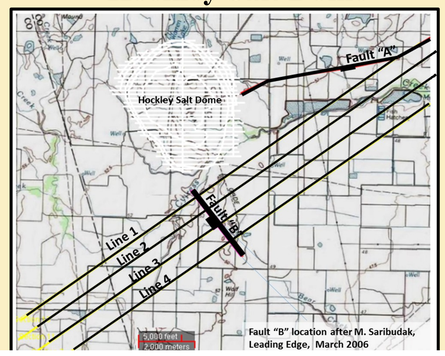
Hockley Fault "A" identified in subsurface on two arbitrary NSEM apparent resistivity profiles. Both fault interpretations validated via tie to surface fault trace.

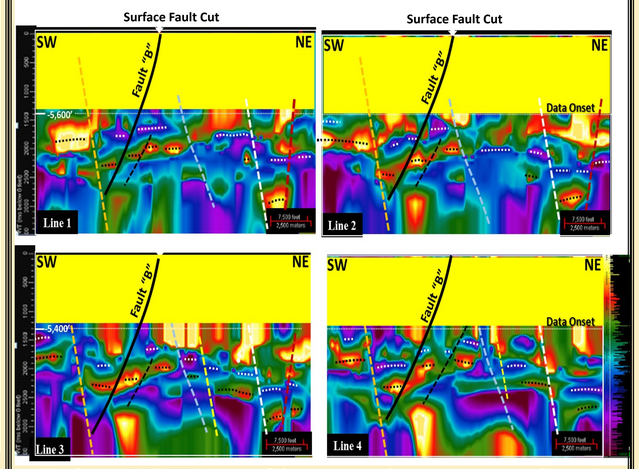
Effective Reconnaissance Mapping



87% of lightning attribute anomalies (Rise Time) correlate to Frio, Vicksburg or Wilcox production.

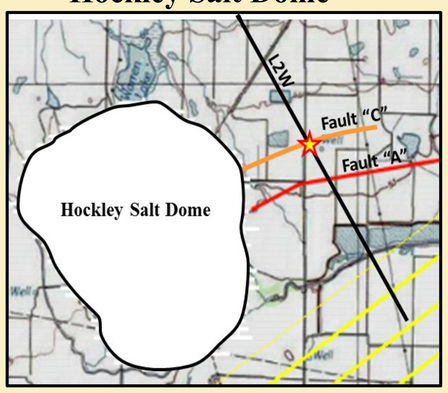
Radial Fault "B"
Hockley Salt Dome

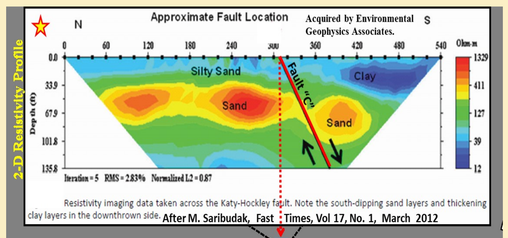


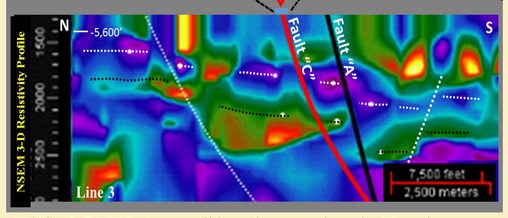


All four NSEM profiles reveal presence of active Fault "B" validated at surface.

Radial Fault "C"
Hockley Salt Dome

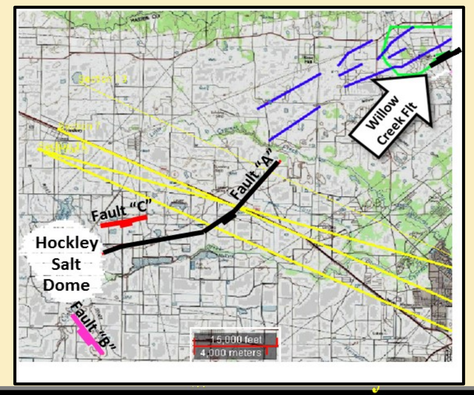


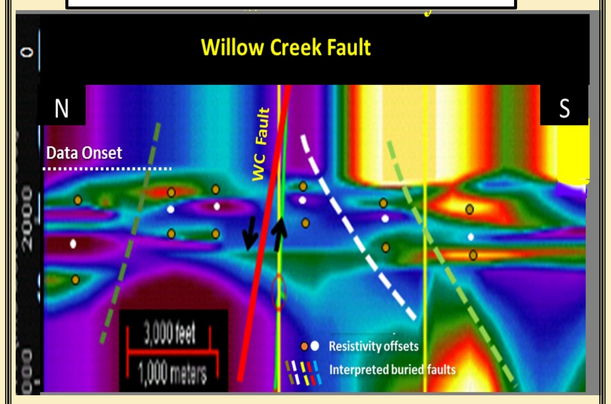




This NSEM profile shows both Faults "A" & "C".

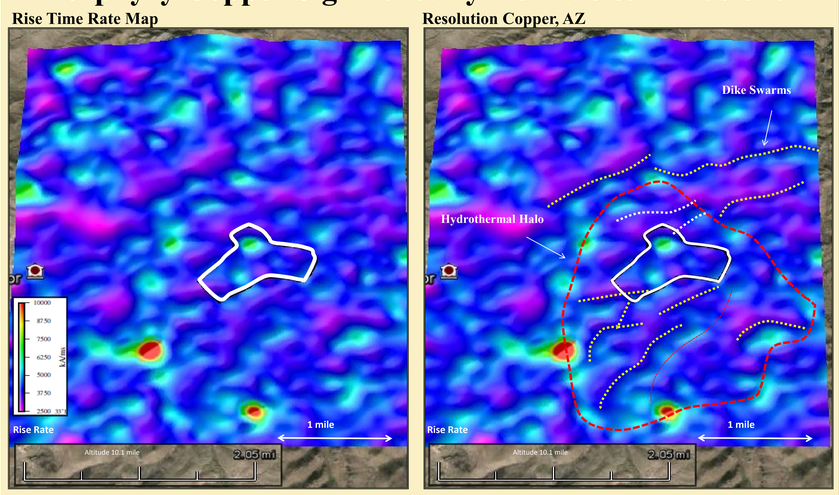
Willow Creek Fault
Northwest Houston



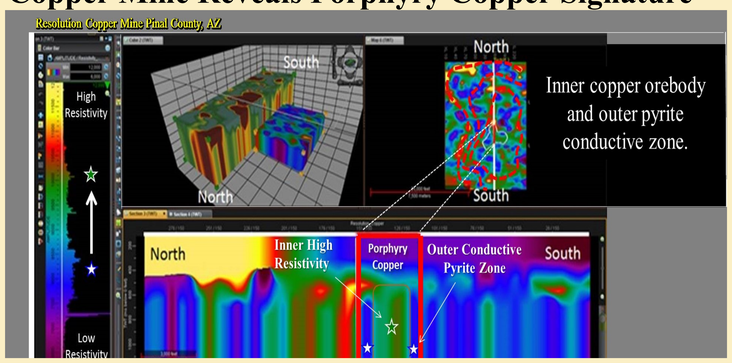


Another active fault in NW Houston (FM 249, south of Tomball) was clearly identified with NSEM resistivity.

Porphyry Copper Signature: Pyrite Halo & Intrusions

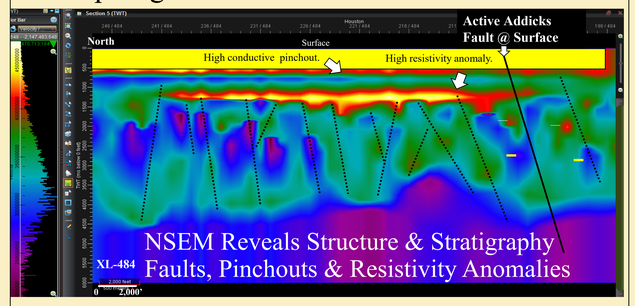


3-D Apparent Resistivity Profile Through Resolution Copper Mine Reveals Porphyry Copper Signature



Seismic Stratigraphy and Prospect Generation - North Houston

- Mapping subsurface faults.
- Calibrating to known active fault systems.
- Mapping resistivity anomalies
- Prospect generation!



- Crossline extracted from north Houston area 3-D resistivity volume.
- Solid black fault ties documented active fault in north Houston.
- Demonstrates ability to map structural & stratigraphic traps, electrical rock properties, lateral variations in fluid content & hydrocarbon accumulations.

Conclusions

Harris County
Hockley Fault Interpretation:

- 3-D NSEM resistivity can be interpreted similar to 3-D seismic data to build structural frameworks.
- It can be integrated with & calibrated to other near-surface & potential field geophysical data to expand the depth & aerial extent of investigated areas.
- NSEM is scalable – providing reconnaissance data in support of exploration or it can focus on specific faults & electrical rock properties in support of development drilling projects.

Mineral & Unconventional
Resource Exploration:

- NSEM can map subsurface electrical rock properties & provide insight into structural & stratigraphic features.
- NSEM has the potential to explore for any mineral commonly found by conventional electrical geophysical prospecting techniques.
- NSEM can be used to help define electrical rock property signatures and sweet spots for use in unconventional resource exploration.

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