Mapping Subsurface Faults with Lightning and Resistivity

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- **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

TITLE: Harnessing Lightning in the Hunt for Hydrocarbons.

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Lightning occurs everywhere & its energy is now being used by the petroleum & mining industries to find natural resources. This naturally-sourced electromagnetic energy, comprised of billions of worldwide cloud to earth electrical discharges, produces millions of usable attribute data that can be tracked, stacked & mapped for use as a geophysical exploration tool.

Natural Sourced Electromagnetics (NSEM) is a patented emerging technology that offers the petroleum & mineral exploration industries a green & relatively quick, scalable & inexpensive mapping tool. Although lightning is guided by meteorological conditions, the precise location of strikes & their individual attributes appear to be influenced by lateral inhomogeneity caused by faults, fractures, mineralization, pore-fluids & salinity variations. Empirical results suggest faults may facilitate the upward flow of positive & negative currents that can in turn influence lightning, in much the same way that faults are believed to facilitate micro-seepage of hydrocarbons to the surface.

Examination of worldwide lightning data shows lightning strikes are not uniformly distributed. An analysis of 16 years of recorded North American lightning data also reveals non-random strike patterns. After the raw lightning data is stacked & mapped much like multi-fold seismic data, lightning strike density & geologically diagnostic lightning attribute maps show interesting & at times remarkable correlations to surface & subsurface geology.

3-D apparent resistivity volumes can be generated from lightning data & displayed in the same fashion as 3-D seismic data, with all wells, curves & synthetic seismograms posted & correlated in the usual manner. Lines, traces, arbitrary lines & apparent resistivity slices can then be extracted, calibrated, interpreted & integrated with available seismic & subsurface data to expand interpreted areas beyond the bounds of existing conventional data.

The case studies presented will reveal how lineations, lightning-sourced data clusters & offsets appear to correlate to geologic features, electrical rock properties & hydrocarbon accumulations. One such example will demonstrate how several well-documented active surface faults in the vicinity of two salt domes could be identified in the subsurface.

In addition to mapping faults, NSEM maps electrical rock properties which can be used to distinguish lithology, & if calibrated to well logs, identify favorable hydrocarbon-bearing intervals.

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 also does not connect with a step leader to produce a strike. Illustrates competing factors influencing strike location, one of which is geology.

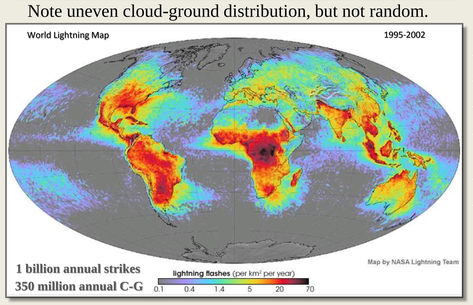
PRIMARY LIGHTNING INFLUENCE - GEOLOGICALLY CONTROLLED TELLURIC CURRENTS

POSTER OUTLINE

- **Lightning, what is it and why it is tracked, stacked & mapped!**
- **Natural Source Electromagnetics (NSEM) – a new geophysical data type.**
- **Example of using NSEM to map active faults.**
- **Conclusions.**

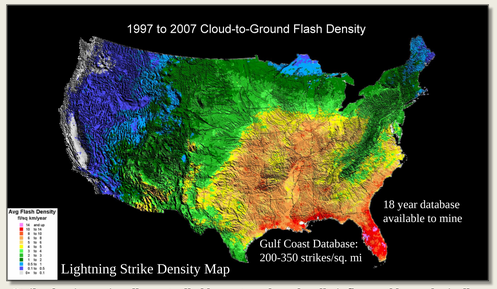
WHY IS LIGHTNING TRACKED & MAPPED?

Note uneven cloud-ground distribution, but not random.



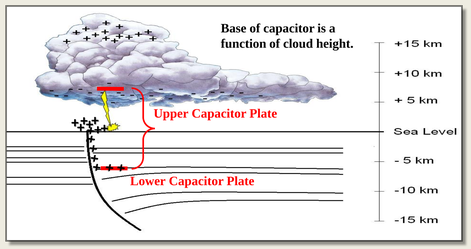
- **Storm tracking**
- **Safety warnings**
- **Insurance**
- **Forest fire forecasting**
- **Hurricane tracking**
- **Research & now…natural resource exploration!**

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 ("Terralevis" currents).

EACH STRIKE REPRESENTS A UNIQUE CAPACITOR

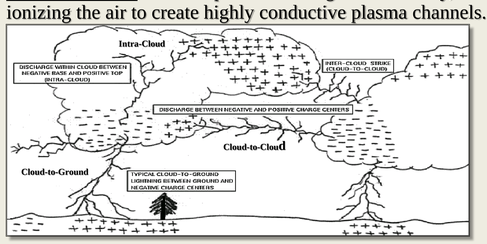


The top or base of the cloud (the originating point for positive or negative lightning strikes respectively), represents the top of the Earth capacitor. The base capacitor depth utilized to derive apparent resistivity volumes is derived from "Peak Current."

"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.

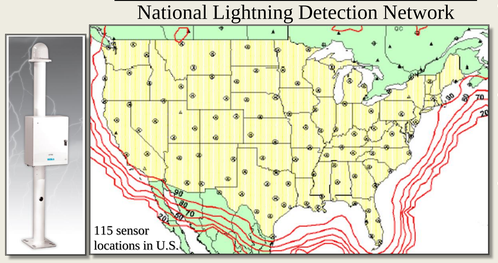
LIGHTNING: an atmospheric discharge of electricity, ionizing the air to create highly conductive plasma channels.



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: + ions carried to top of clouds, and - ions gravitate to base.
4. Static charge buildup: when charge strength exceeds insulating property of atmosphere, sudden high-voltage static discharge occurs.

COLLECTION of LIGHTNING DATA

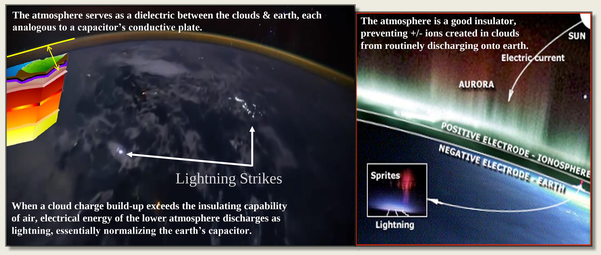
National Lightning Detection Network



- **Typical Texas lightning strike recorded by 16 -24 sensors.**
- **Sensors within 600 mi. of strikes contribute to triangulation.**
- **Empirical results show location error from reasonably dense database 35-70'.**

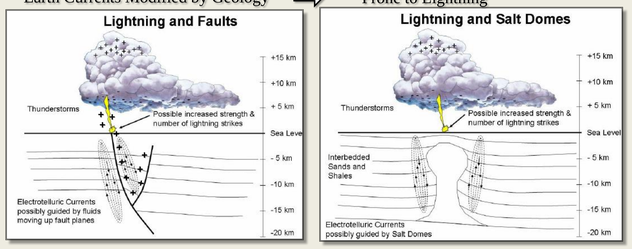
4. Static charge buildup: when charge strength exceeds insulating property of atmosphere, sudden high-voltage static discharge occurs.

EARTH: A SELF-REPAIRING CAPACITOR



TELLURIC CURRENTS: LIGHTNING & GEOLOGY

Earth Currents Modified by Geology ⇨ Prone to Lightning



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