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211 Baker Road #382
Barker, TX 77413
281.579.0172
dynamicmeasuremnt.com

2155 W 700 S #31
Cedar City, UT 84720

Mining and Oil & Gas Applications of Lightning Analysis

Dr. D. James Siebert, Kathleen S. Haggar, and H. Roice Nelson, Jr.

- Skin Depth – Meteorologists & Geophysicists
- Predicting Strike Locations
- Gold Mine San Bernardino Co., CA
- Copper Porphyry Mine Pinal County, AZ
- West Texas Oil & Gas Midland County, TX
- South Texas Oil & Gas, Nueces and San Patricio Counties, TX
- Conclusions

Skin Effect

Meteorologists:

- See lightning as an atmospheric event with little interaction with geology
- Fulgurites and skin depth formulas implies lightning penetrates a few hundred meters.
- Skin Effect is the depth the current is reduced to 1/e (about 0.37 of surface current).

Geophysicists:

- See lightning as a primary charging source of telluric (earth) currents all the way to the Mohorovičić discontinuity (base crust).
- Given δ is skin depth in meters, μ_r is relative magnetic permeability of the medium, ρ is the resistivity of the medium in ohm-meters, and f is the frequency of the current in kilo-hertz:

$$\delta = 503\sqrt{\frac{\rho}{\mu_r f}}$$

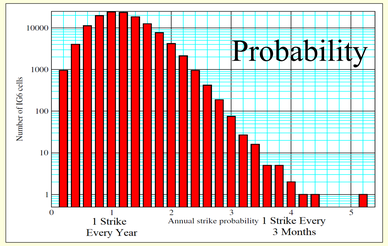
, and at 2,000 meters current density is still about 2% of near-surface value.

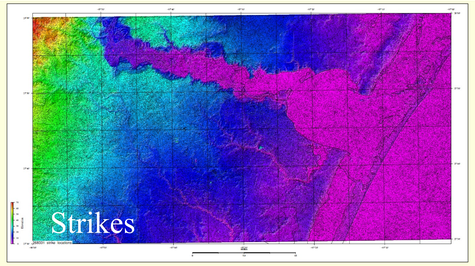
- A 20 kA Peak Current strike effects an area of 0.01 m^2, with a current density of 2,000 kA/m^2. At 2% of the initial value, it will still be 40,000 A/m^2.
- Lightning, like current along a wire, inducing a magnetic field, which interacts with telluric currents to 12,000 m or 40,000 foot depths.
- A 30 foot tall oak tree does not control lightning strike locations.
- Telluric currents control strike locations.

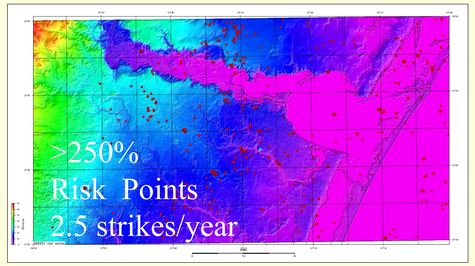
Predicting Strike Locations

Lightning strikes are impacted by the geology.

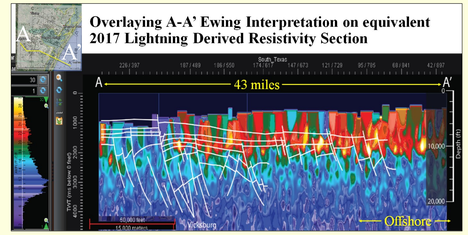
- Lightning strikes cluster.
- Shown are strikes in 250x150 meter IG6 cells.
- Clusters predictable (others examples each use 50x30 m IG7 cells to calculate Risk Points).
- Patent Pending status.
- Risk Points in the 60x45 mile South TX area calculated from 130,682 IG6 cells.

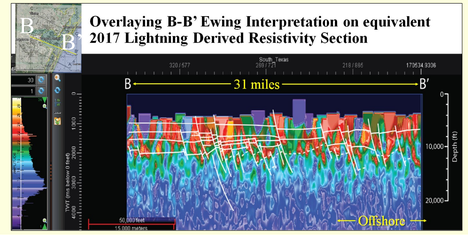






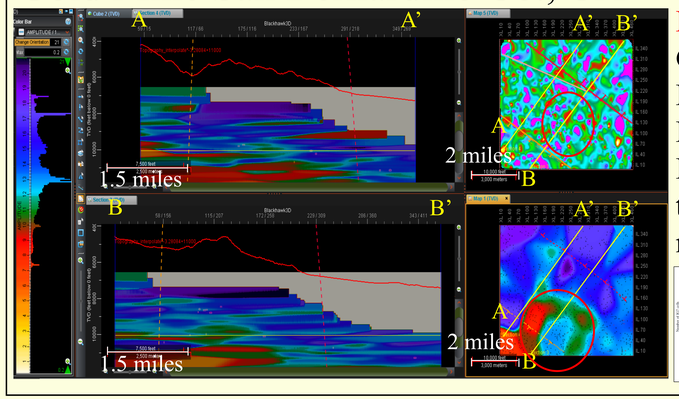
Oil & Gas, South TX



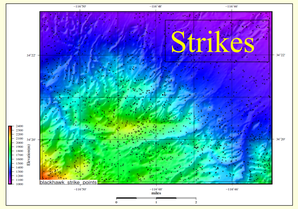


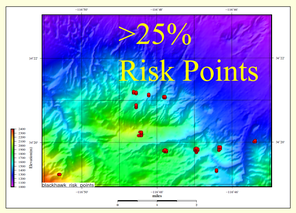
Ewing's 1986 cross-sections match the lightning derived resistivity 2014 cross-sections, possibly showing oil & gas migration.

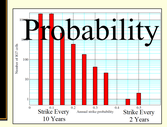
Gold Mine San Bernardino Co., CA



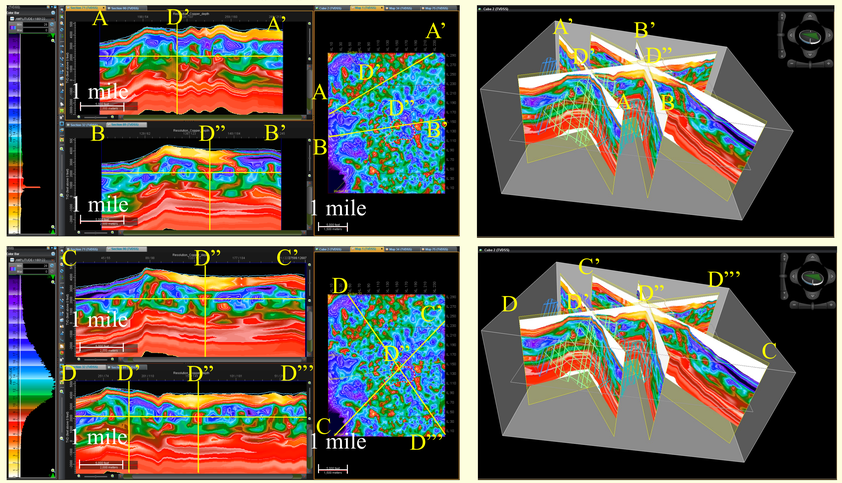
Faults & Halos fit Geology. Patent Pending Risk Points tie geologic model.



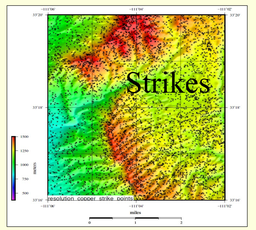


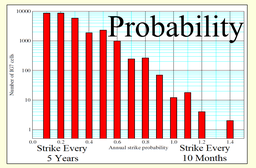


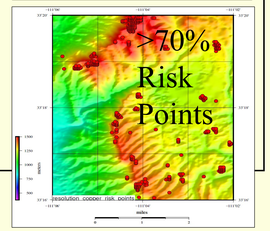
Copper Porphyry, Pinal Co., AZ



Faults & Geology Interpreted

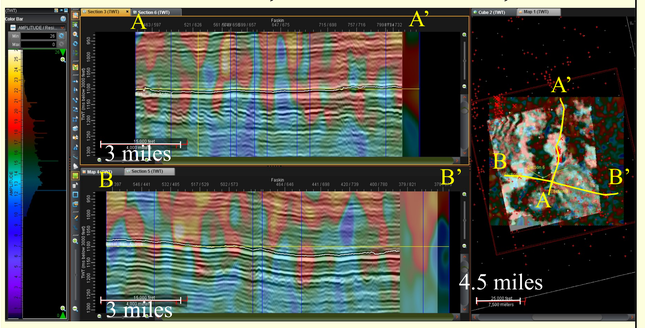




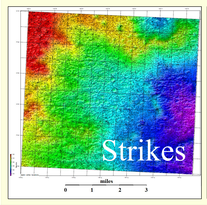


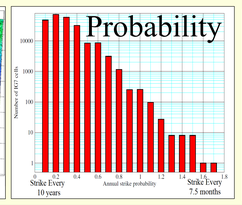
Quicker, safer, & less expensive than other geophysical data types.
No boots on the ground to do a lightning analysis.

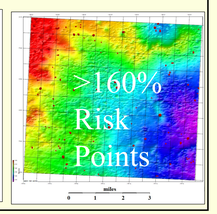
Oil & Gas, Midland Co., TX



Patented resistivity on seismic via Risk Points.







Conclusions

- Skin Effect does not impede lightning charging telluric currents to base of crust.
- Lightning strikes are impacted by geology.
- Patent Pending Risk Point predictions have an economic impact beyond geology.
- Both mining and oil & gas projects tie available geologic and geophysical data.
- Lightning Analysis is a new branch in the geophysical services industry.