Science Camp #170802.8

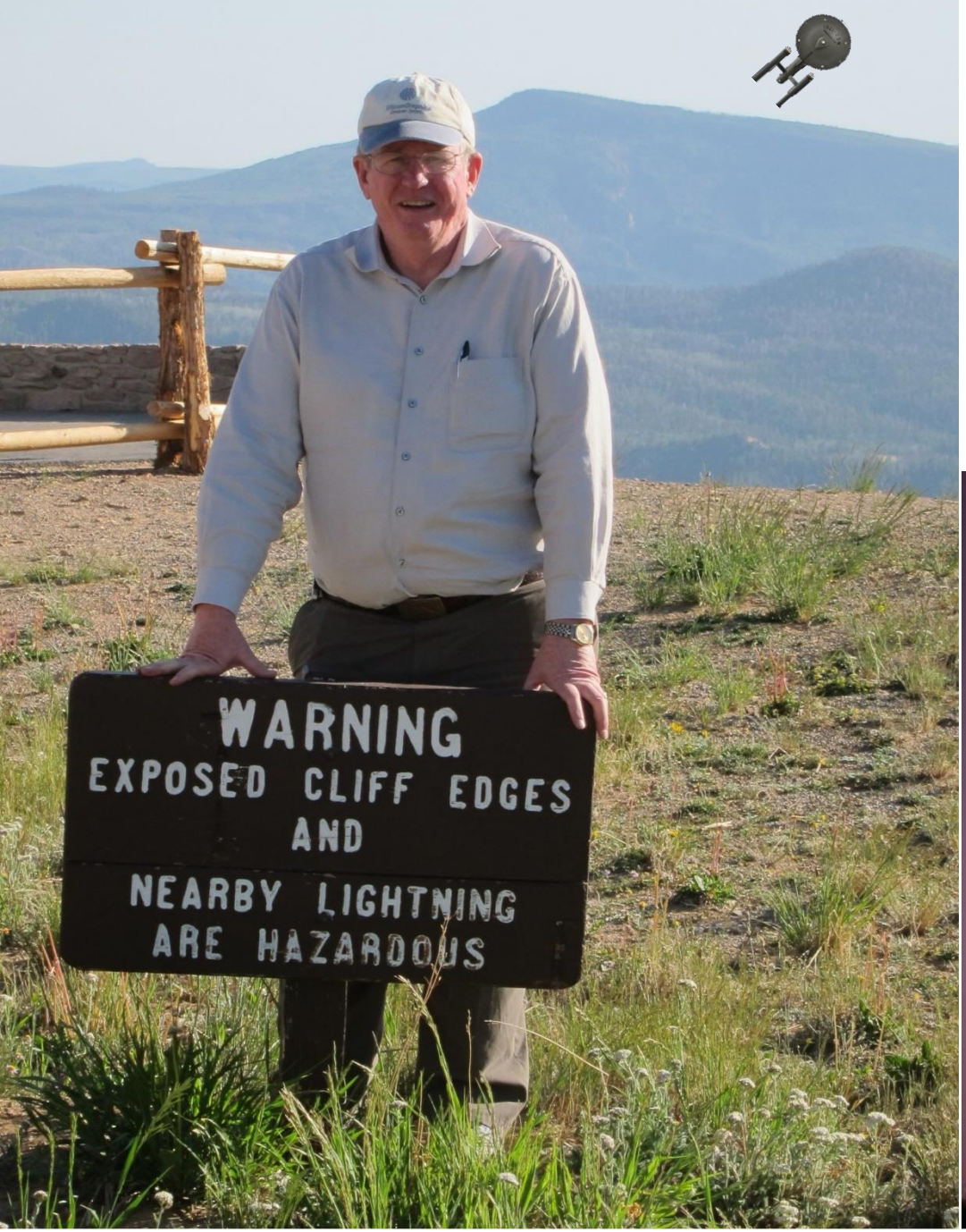
02-04 August 2016 @ the Condo, the Nelson Cabin, and surrounding area

Advisors

H. Roice Nelson, Jr., Andrea S. Nelson,
Paul F. Nelson, Benjamin B. Nelson

Attendees

Ethan E. Nelson, Grant M. Nelson, Colby C. Wright, Taylor R. Wright, Ella D. Nelson, Halle N. Wright, Bobbie Sophia Waldron, Dallin Spencer Nelson, Avalyn Joyce Wright, Rachel Lee, & Ian Lee

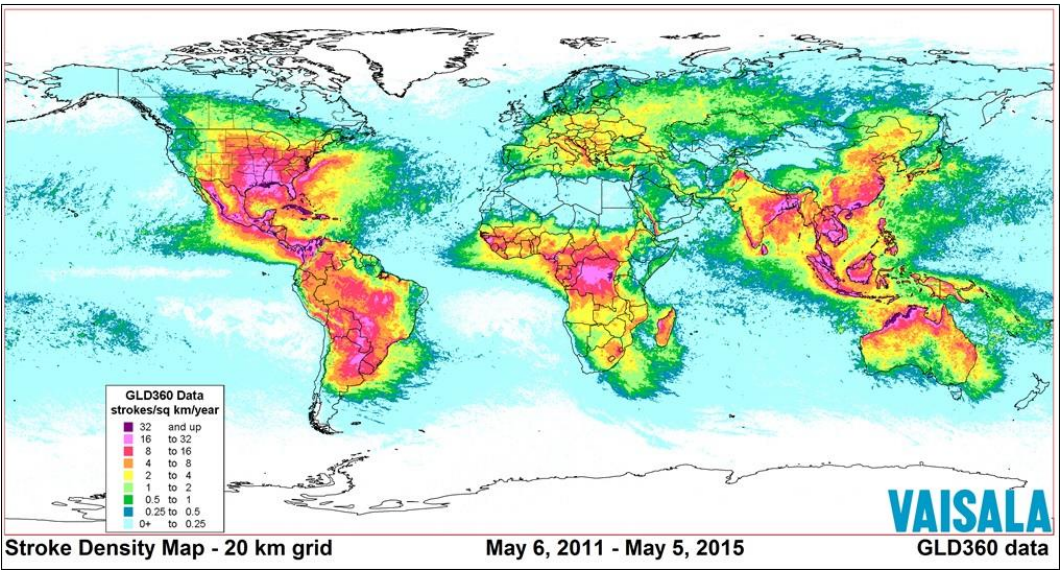


How can we find and optimize natural resources?

http://www.walden3d.com/photos/Grandkids_Science_Camps/170802-04_Science_Camp/7_Geophysics-Lightning.pdf

Lightning Occurs Everywhere

5+ Years of Data in GLD-360 Data Base



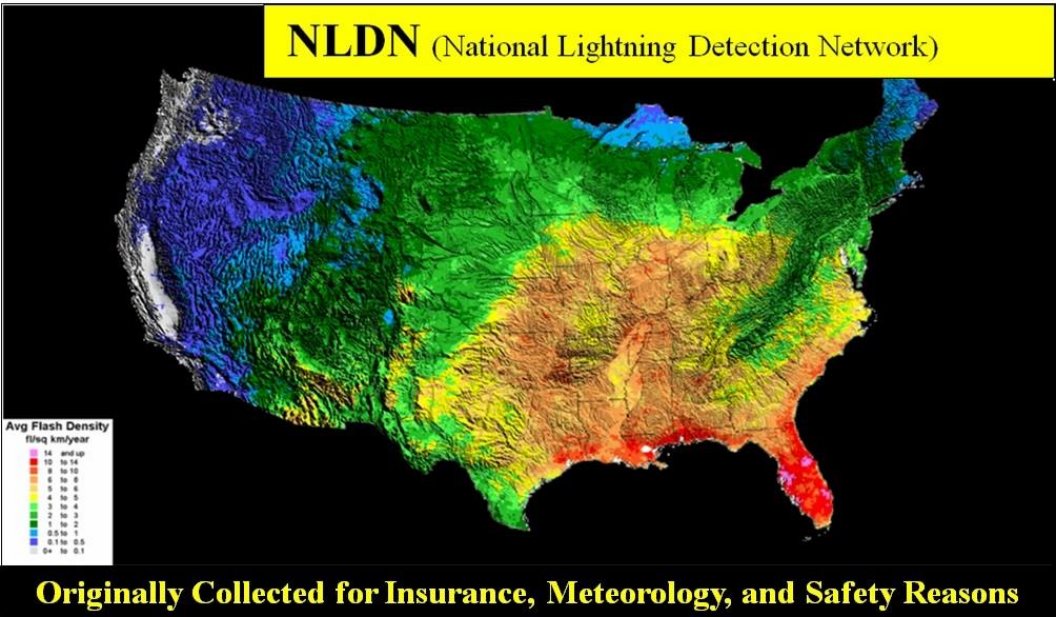
Stroke Density Map - 20 km grid | May 6, 2011 - May 5, 2015 | GLD360 data

Lightning Data

Was Only Used For Insurance, Safety, & Meteorological Purposes

The U.S. has the most complete database

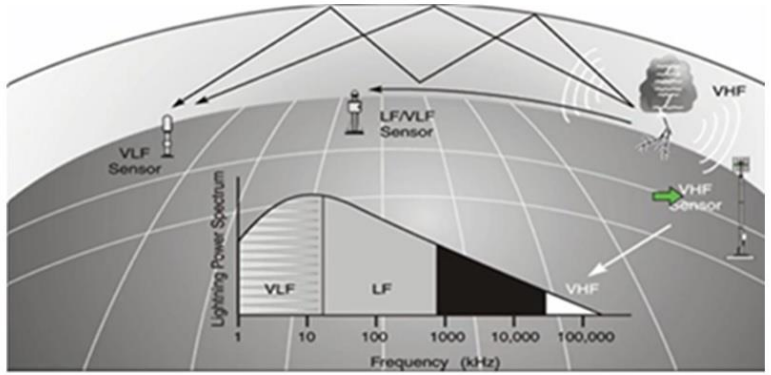
18+ Years of Data in the NLDN Data Base



Originally Collected for Insurance, Meteorology, and Safety Reasons

Sensors measure Direction to strike & Lightning Attributes

Strike Triangulated & Measurements Reconciled



Vaisala: Martin Murphy
2016 Webinar used with permission

We Discovered Strike Locations Are Controlled by Telluric Currents

DYNAMIC MEASUREMENT

US009523785B2

(12) **United States Patent**
Denham et al.

(10) **Patent No.: US 9,523,785 B2**
(45) **Date of Patent: Dec. 20, 2016**

(54) **METHOD FOR DETERMINING GEOLOGICAL SURFACE AND SUBSURFACE RESISTIVITY**

(71) Applicant: **Dynamic Measurement, LLC**, Cedar City, UT (US)

(72) Inventors: **L. R. Denham**, Houston, TX (US); **H. Roice Nelson, Jr.**, Cedar City, UT (US); **D. James Siebert**, Katy, TX (US)

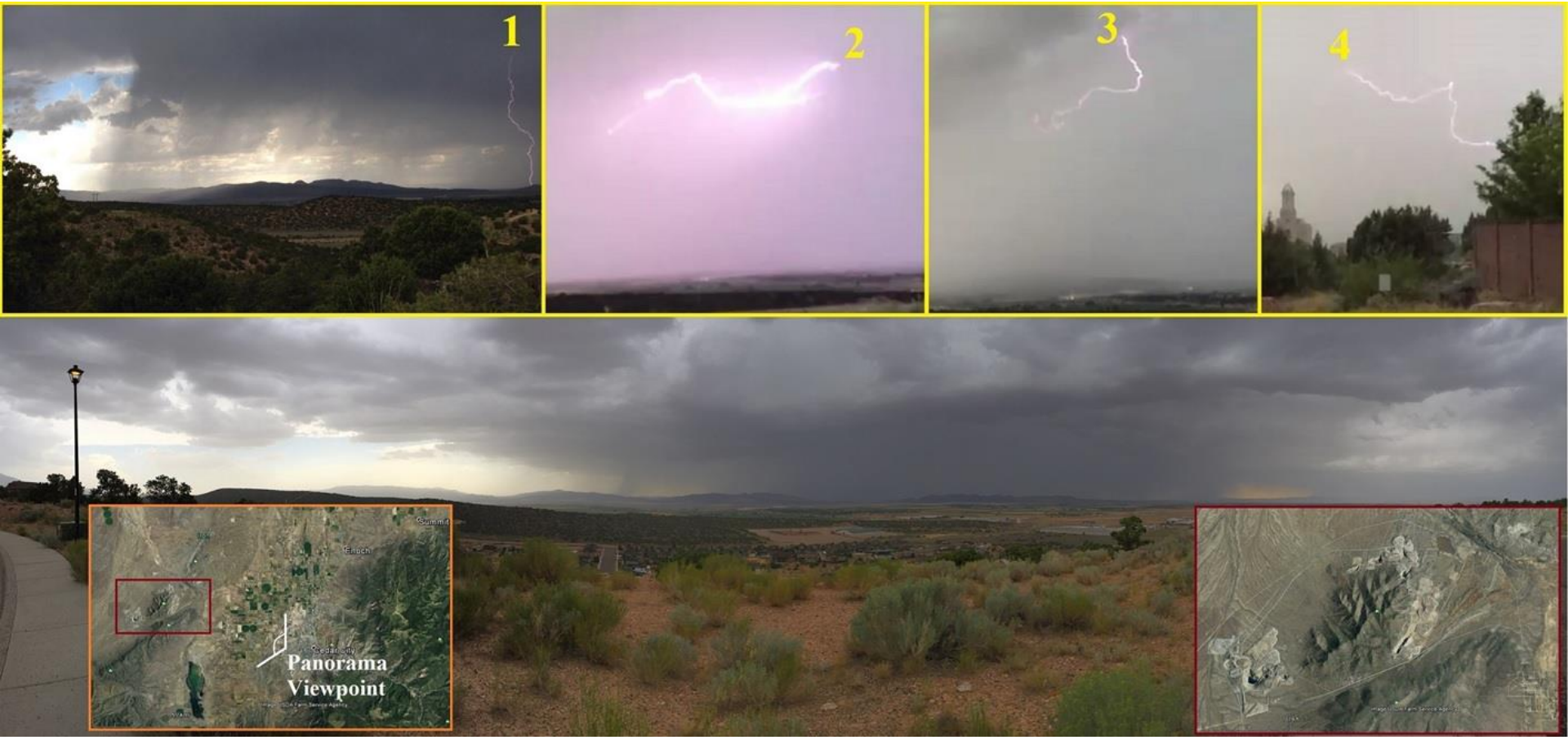
(73) Assignee: **Dynamic Measurement, LLC**

(57) **ABSTRACT**

A method for determining geological subsurface resistivity. The method includes obtaining a set of lightning parameters associated with a lighting strike received by a geological volume of material, the set of lightning parameters including an indicium of the current of the lightning strike at a first initial time and an indicium of the current of the lightning strike at a first decay time subsequent to the first initial time, and inferring the resistance of the volume of geological material, at least in part, from the set of lightning parameters.

6 Claims, 2 Drawing Sheets

The Magnetite at Iron Mountain Attracts Lightning Strikes



Lightning Strikes Encourage Rock Hounding

What is a Lodestone?

Lodestones are rocks that are magnetized. They are made of Magnetite , a type of iron ore. Magnetite itself is not necessarily magnetic. A piece of magnetite that is magnetic qualifies as a lodestone.

What makes a Lodestone magnetic?

For a piece of magnetite to become magnetized it must be exposed to a magnetic field. The weak magnetic field of the earth is not strong enough so another source must be looked to. One way it may occur is by lighting strikes on magnetite causing the magnetite particles to align in the right way to produce a magnetic field.

The first compasses were made over 2000 years ago using lodestones. If a long piece of lodestone is freely suspended it will rotate until it ligns up with the Earth's poles. Early navigators were able to use lodestones to help them find their way.

Lodestone Examples

Utah is a major source of iron ore and in particular, natural magnetic ore called lodestone or magnetite. These particular specimens both very rich in iron, making them magnetic.

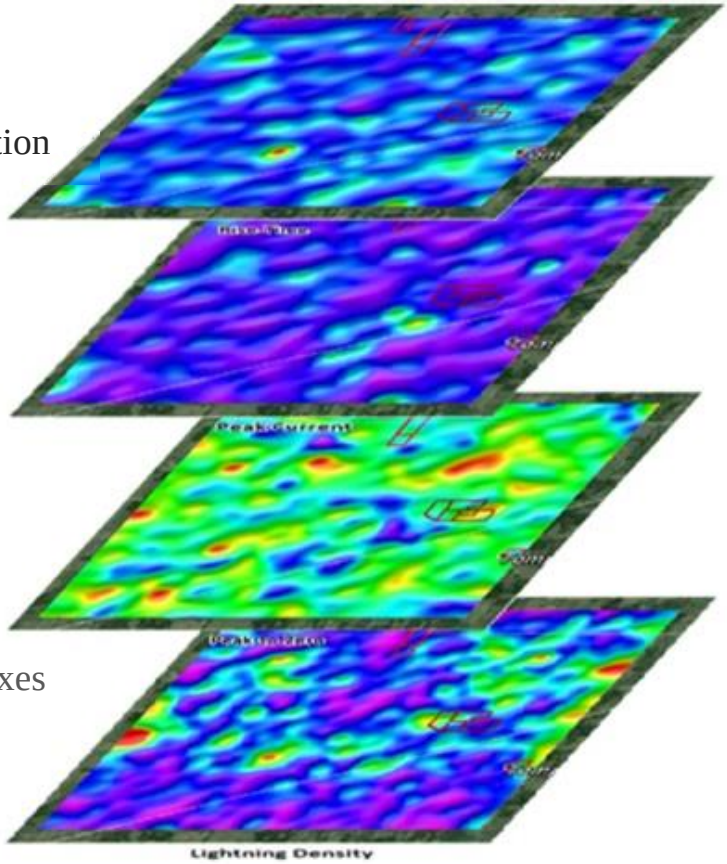
Fulgurites are fused sand from lightning strikes

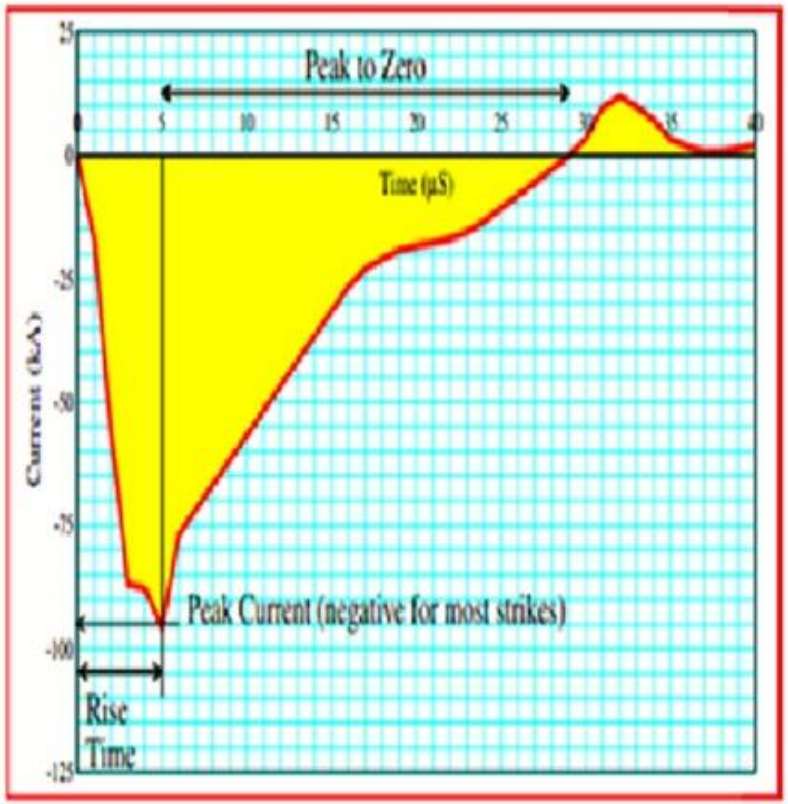
Sand fulgurites found on the top of Mount Raymond. U.S. quarter for scale. 1 / 2

Rock fulgurite (circled in white) found on quartzite at the summit of Mount Raymond in the Wasatch Range, Salt Lake County, Utah. Hammer for scale. 2 / 2

Lightning Measurements

- Location
- Time and Duration
- Rise Time
- Peak Current
- Polarity
- Peak-to-Zero
- Density
- Major/Minor Axes
- Chi-Squared

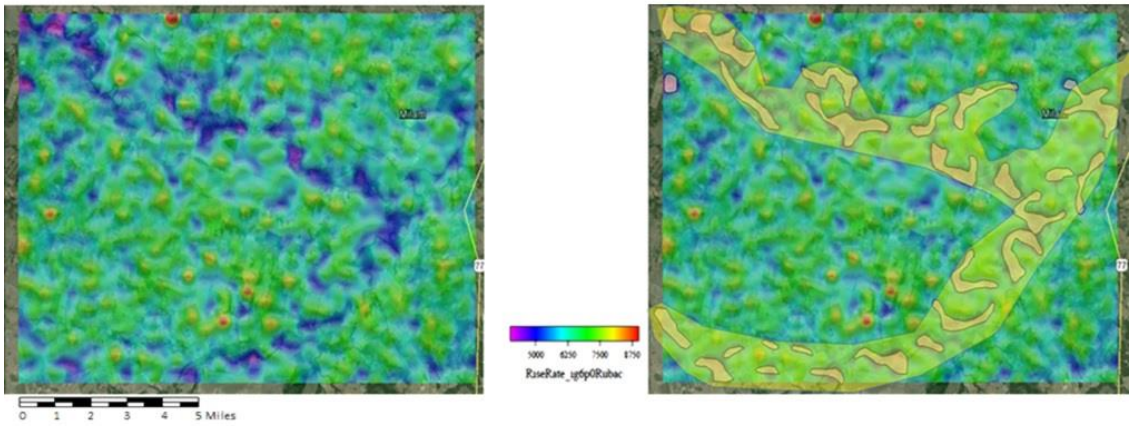




- Other attributes calculated from these measurements.
- The time of the lightning strike is correlated with solar and lunar tides.
- Measurements separated by time.

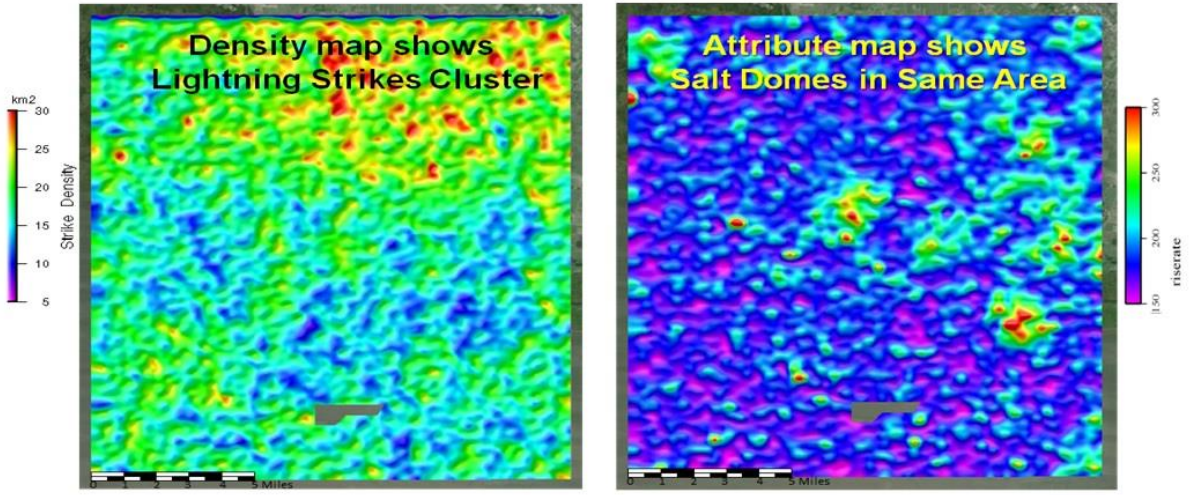
Lightning Analysis & Attributes

1. **Analysis area selected.**
2. **Patented and Patent-Pending Processes produce maps and volumes of derived rock properties and lightning attributes.**
3. **Existing geology and geophysics integrated with new data.**



Lightning Attribute: Rate of Rise-Time – Milam County, Texas

Louisiana Example

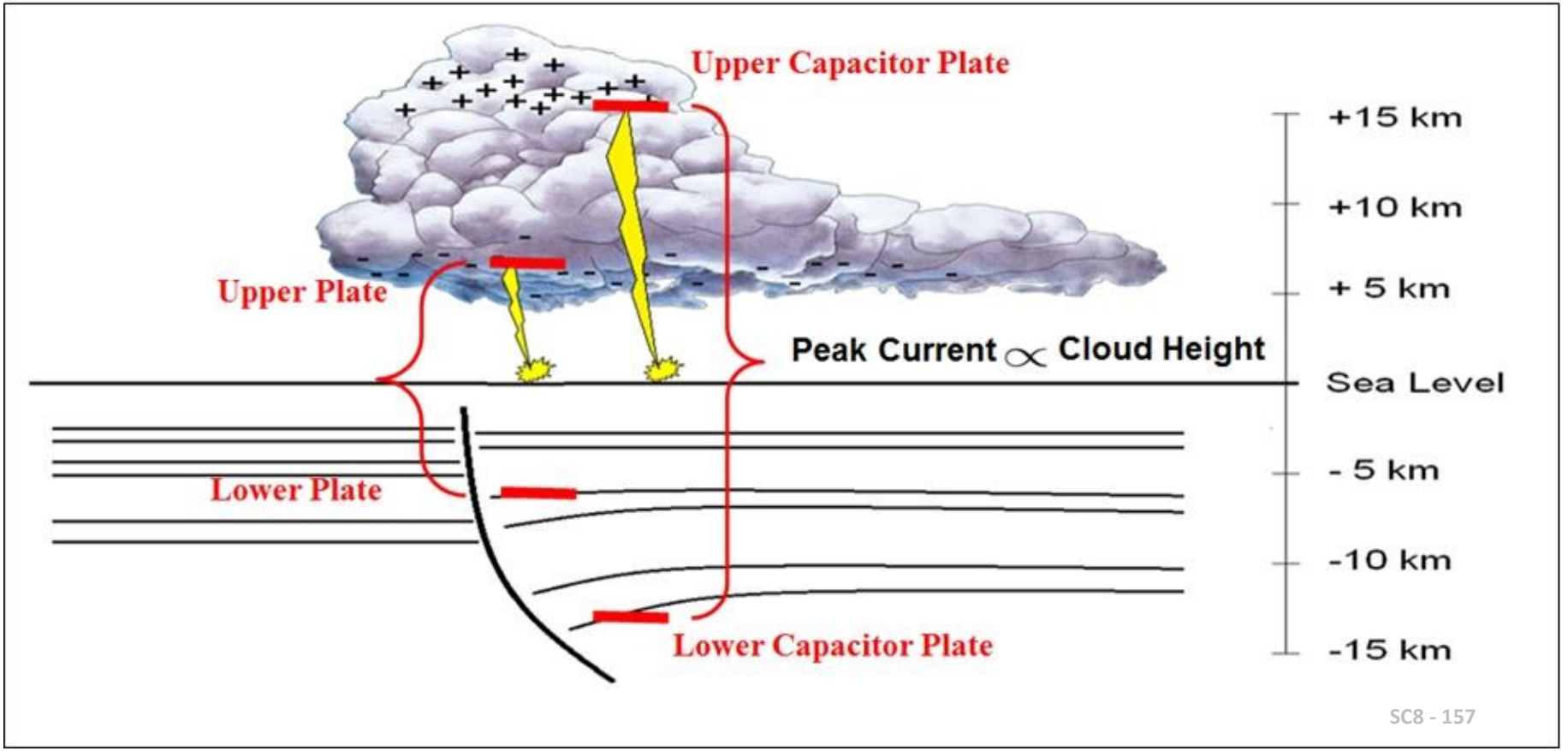


Density Map & Rate-of-Rise-Time Map

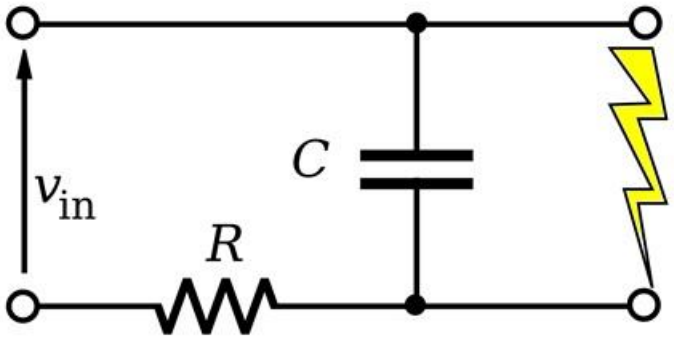
Rock Property & Attribute Maps & Volumes

Key Assumptions:

1. Lightning occurs when there is sufficient charge to bridge the capacitor.
2. Lightning is affected by geology to a depth proportional to cloud height, as derived from Peak Current

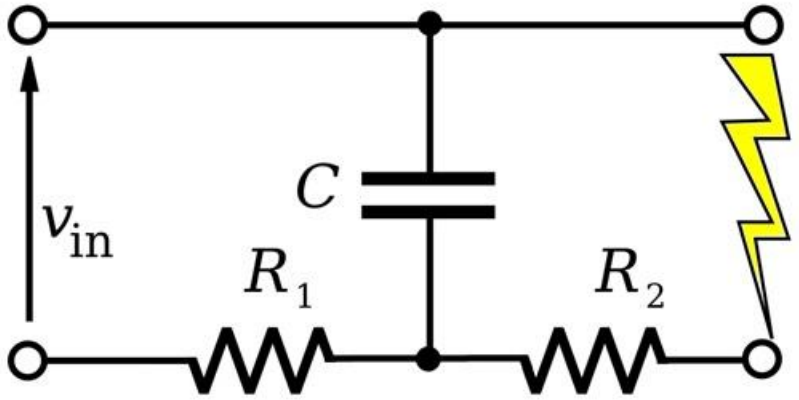


Relaxation Oscillator Physics and Lightning (a giant neon tube)

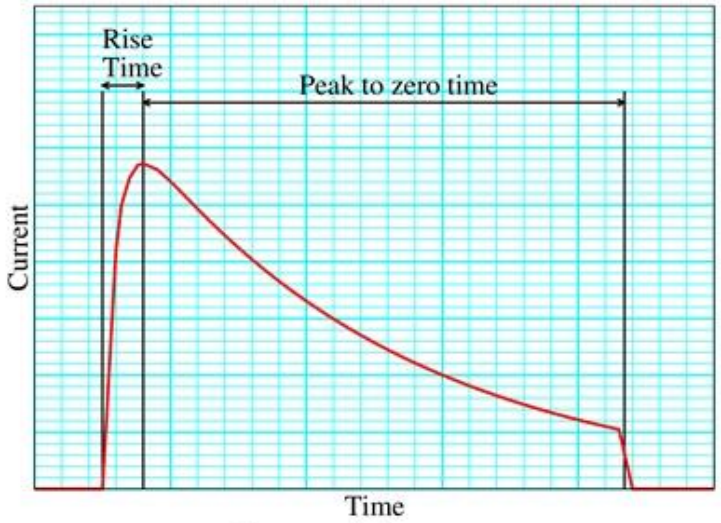


- The atmospheric capacitor is like a relaxation oscillator
- Just an additional resistance (R_2) limiting the current

- R_2 is the resistance between the lightning strike point and the bottom plate of the capacitor

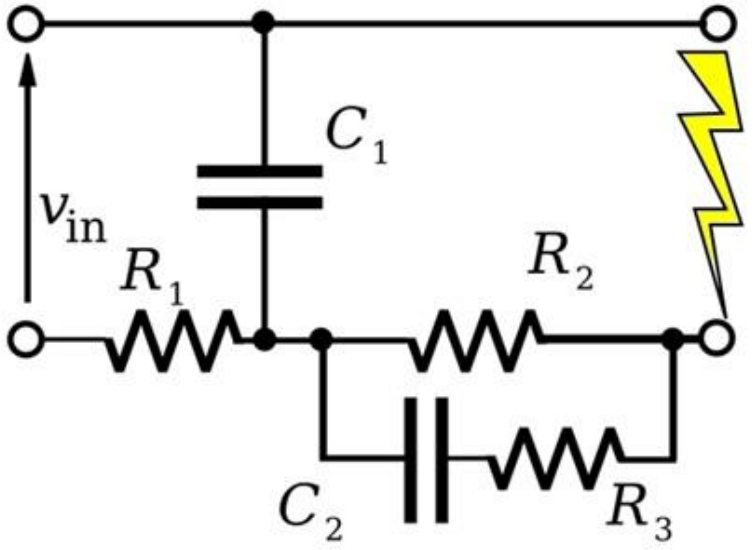


Lightning and the Induced Polarization Effect



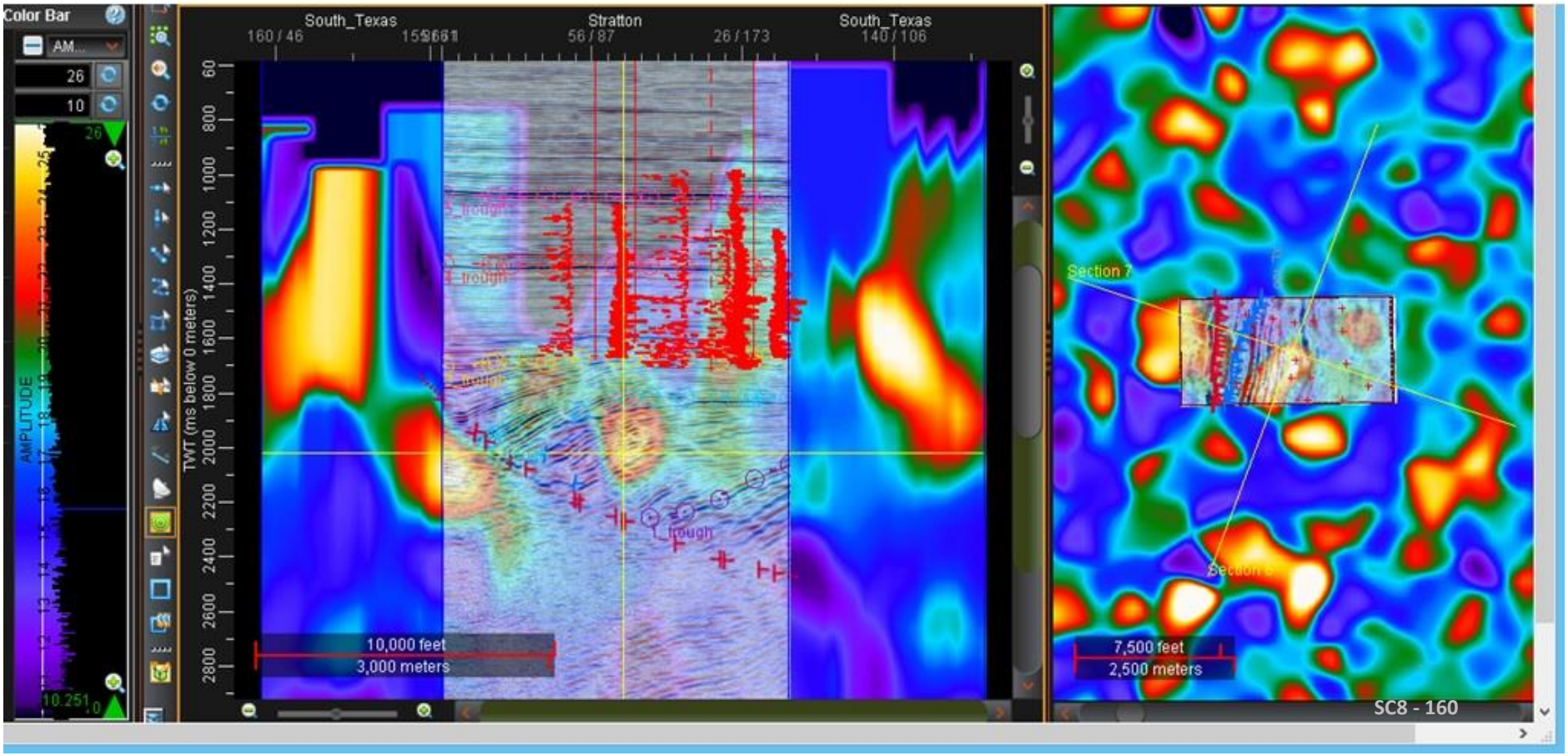
- Lightning does not have a square waveform
- But it does have a very steep onset
- Variations in the onset as measured (rise-time) show the IP Effect

- By treating this steep onset as charging a capacitor (C2) through a resistor (R3), an apparent capacitance can be calculated.
- From the apparent capacitance a value for average permittivity can be calculated

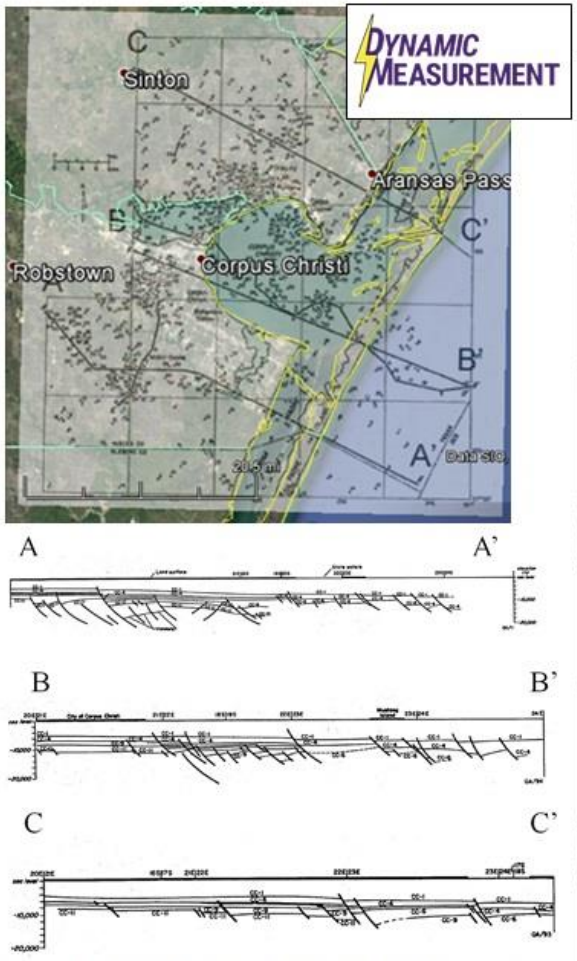


Dynamic Uses Seismic Techniques

Stratton Apparent Resistivity Sections

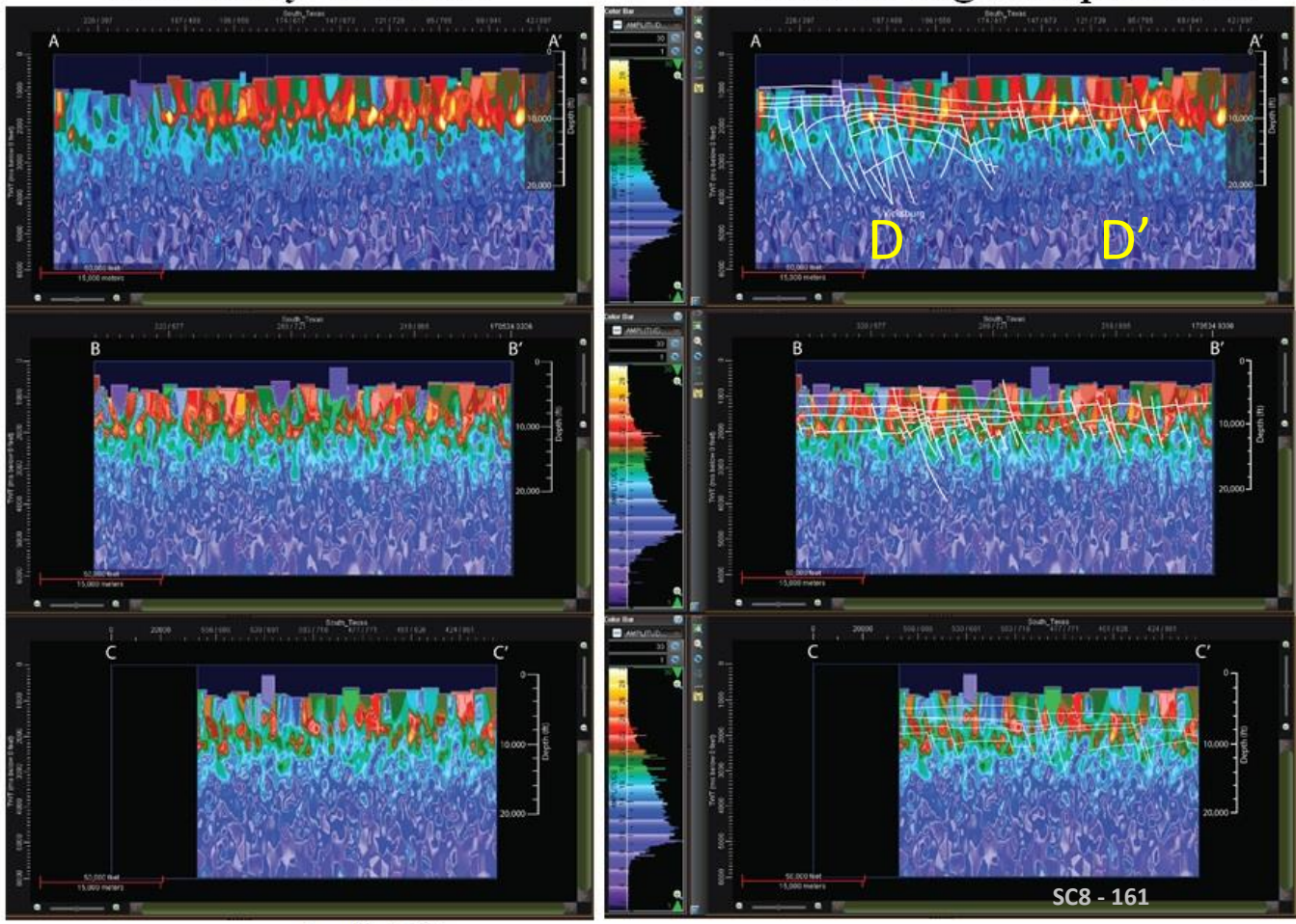


South Texas Example



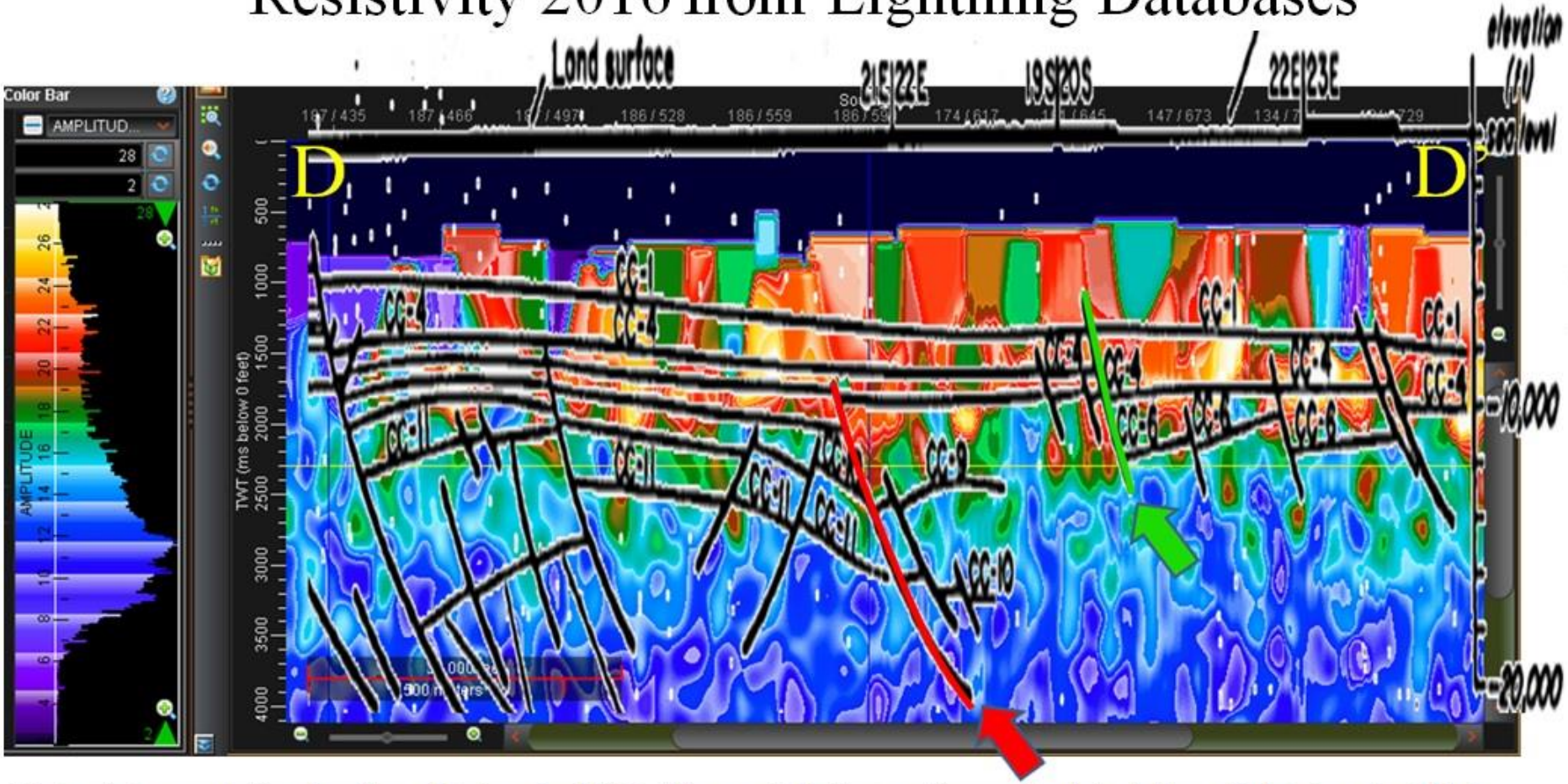
Ewing, T.E., 1986, Structural Styles of the Wilcox and Frio Growth-Fault Trends in Texas: Constraints on Geopressured Reservoirs: BEG, Report of Investigations, 154, 27-56.

Resistivity Sections with Ewing interpretation



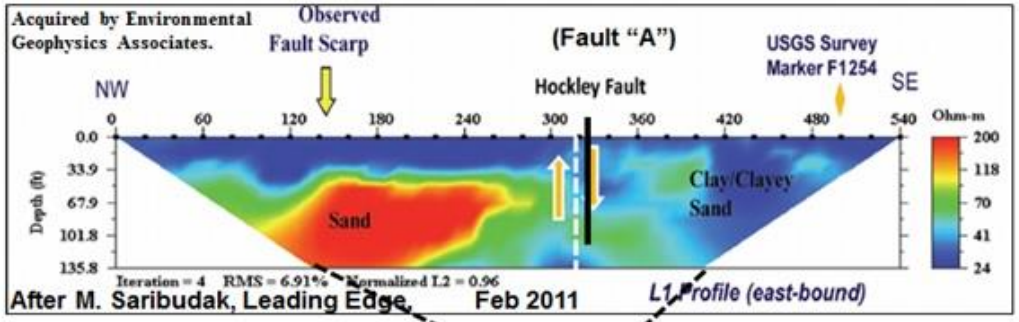
D-D' Close-Up on Graben to the west

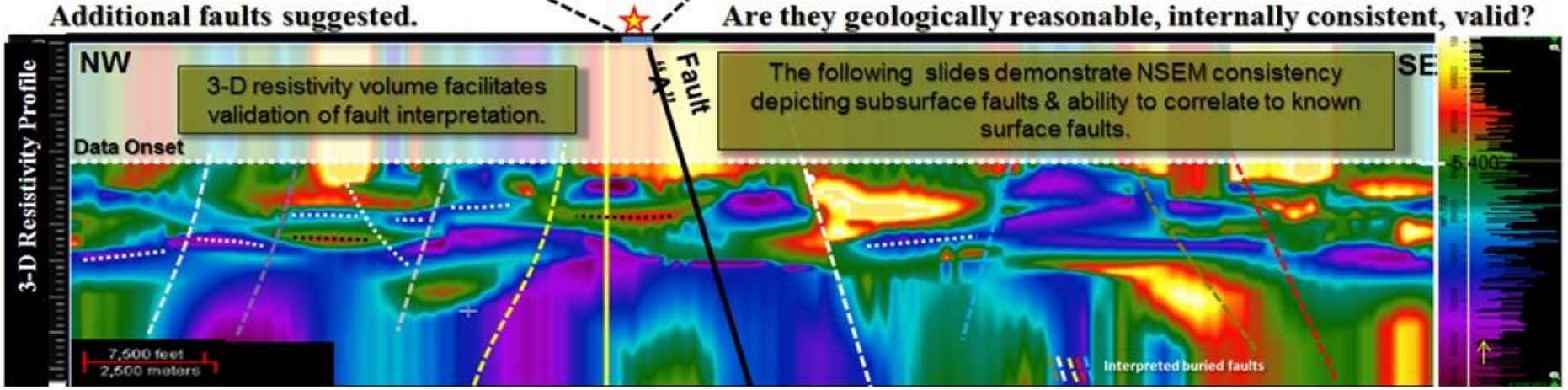
Interpretation 1986 by Tom Ewing, Apparent Resistivity 2016 from Lightning Databases



Note: interpretation by Tom Ewing in 1986. The resistivity section calculated from lightning in 2016. Co-located sections show breaks where faults were interpreted. There are resistivity plumes tied to faults.

Hockley, Texas
(where it all started)
Texas Example

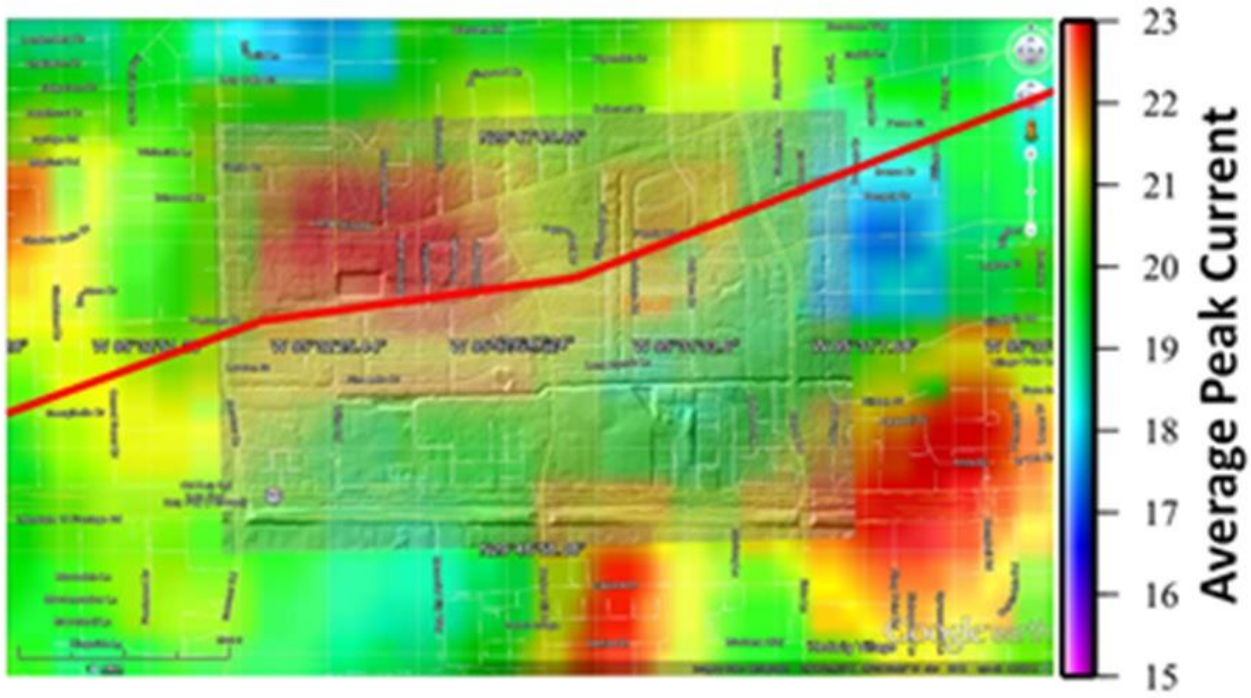


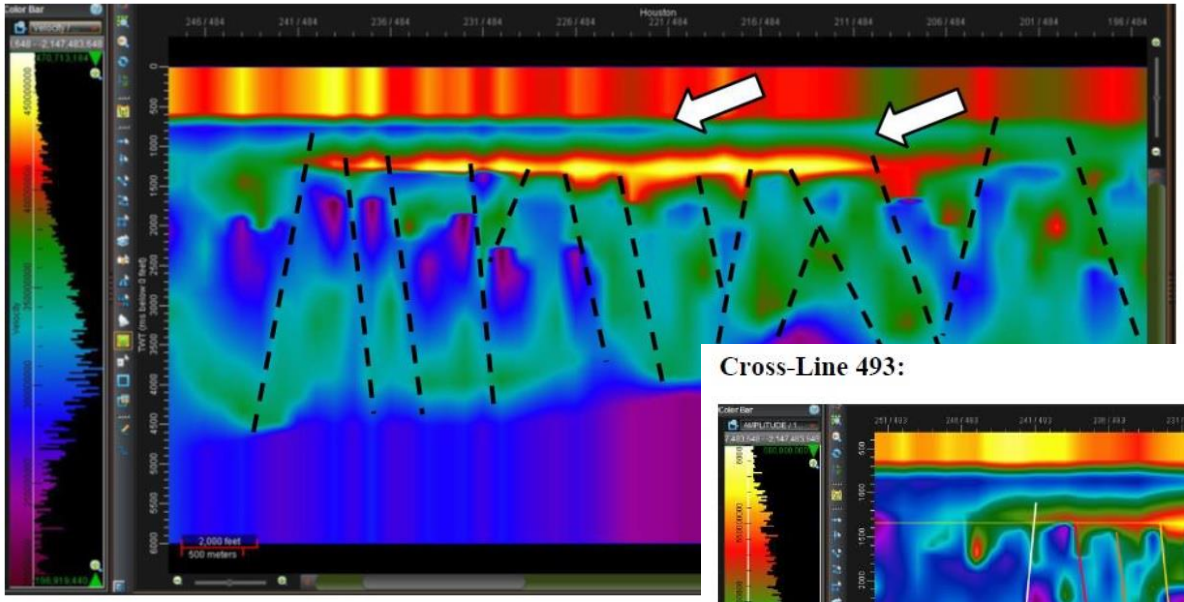


2-D Resistivity Survey ties Lightning Derived Resistivity Cross-Section

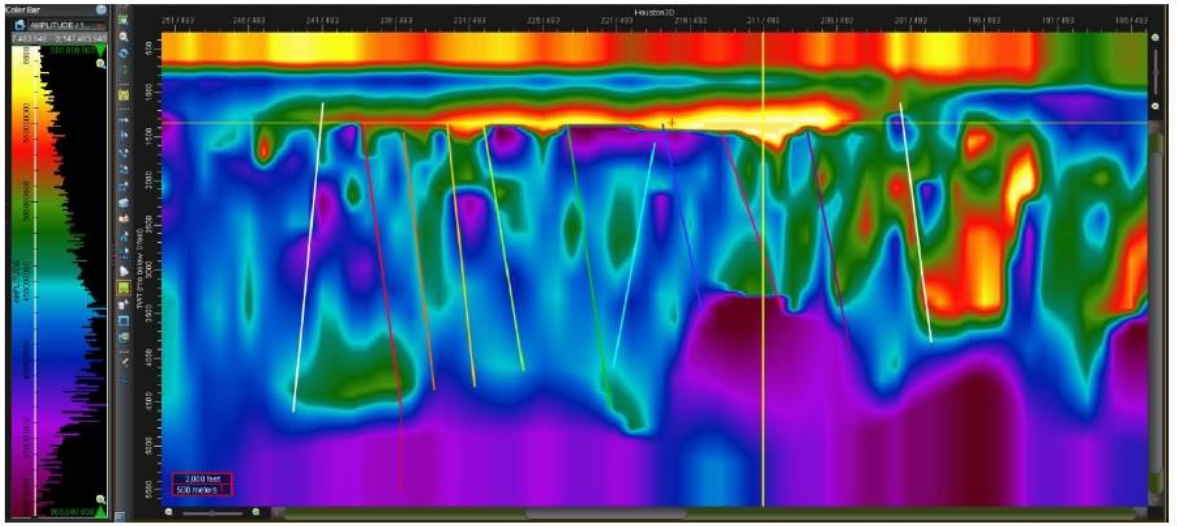
Average Negative Peak Current vs. Density

Peak Current Zoom with LIDAR & Long Point Fault



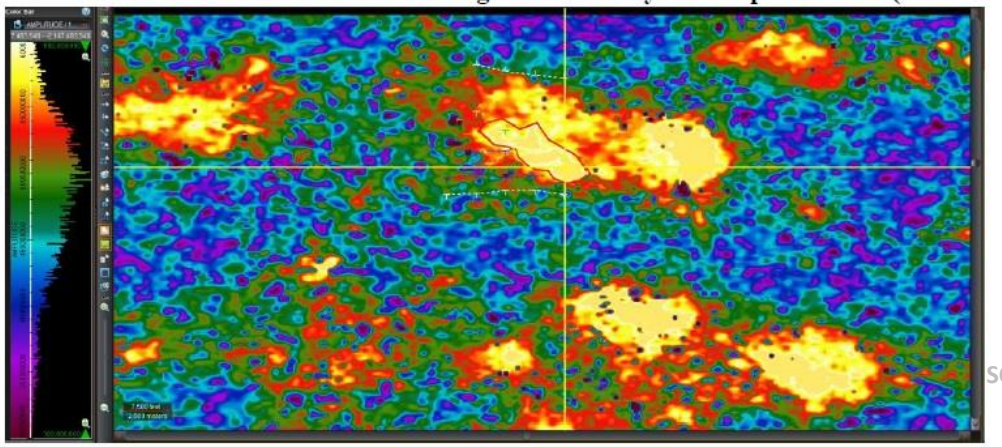


Cross-Line 493:



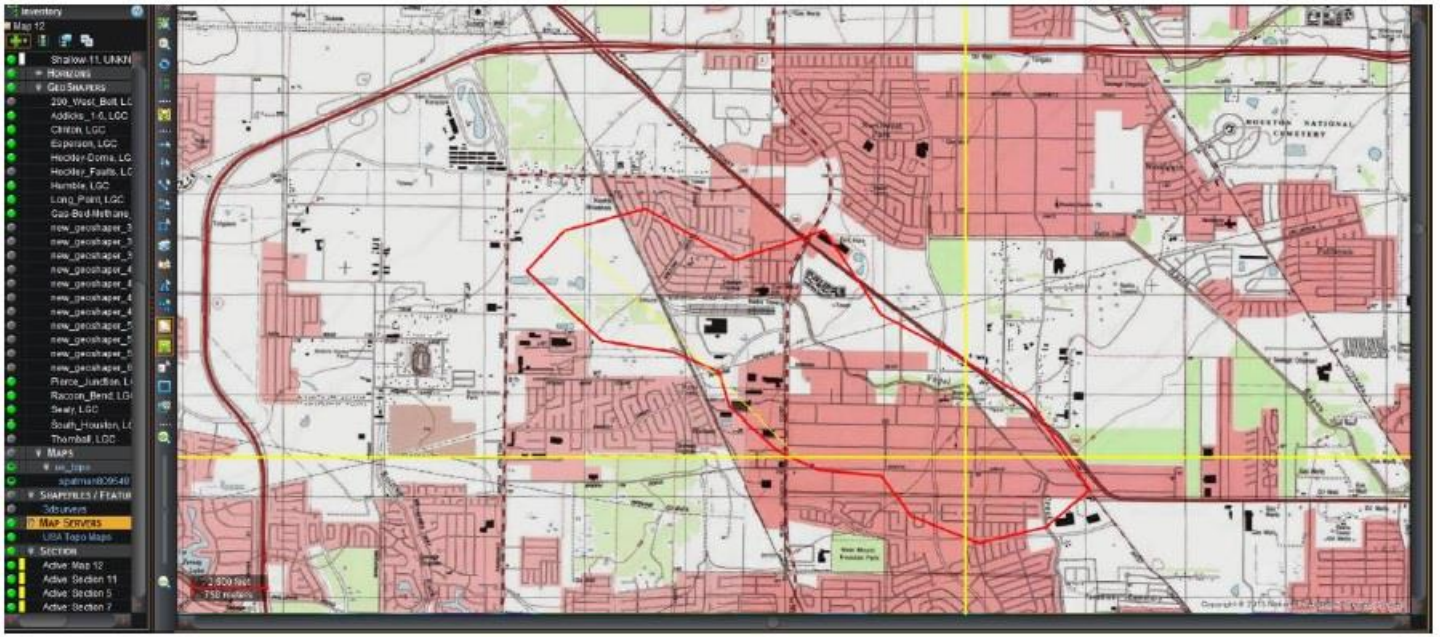
Possible Gas Field in Northwest Houston

Time-Slice 1345 ms and red outline of highest resistivity in interpreted area (note other anomalies):



Location & Economics

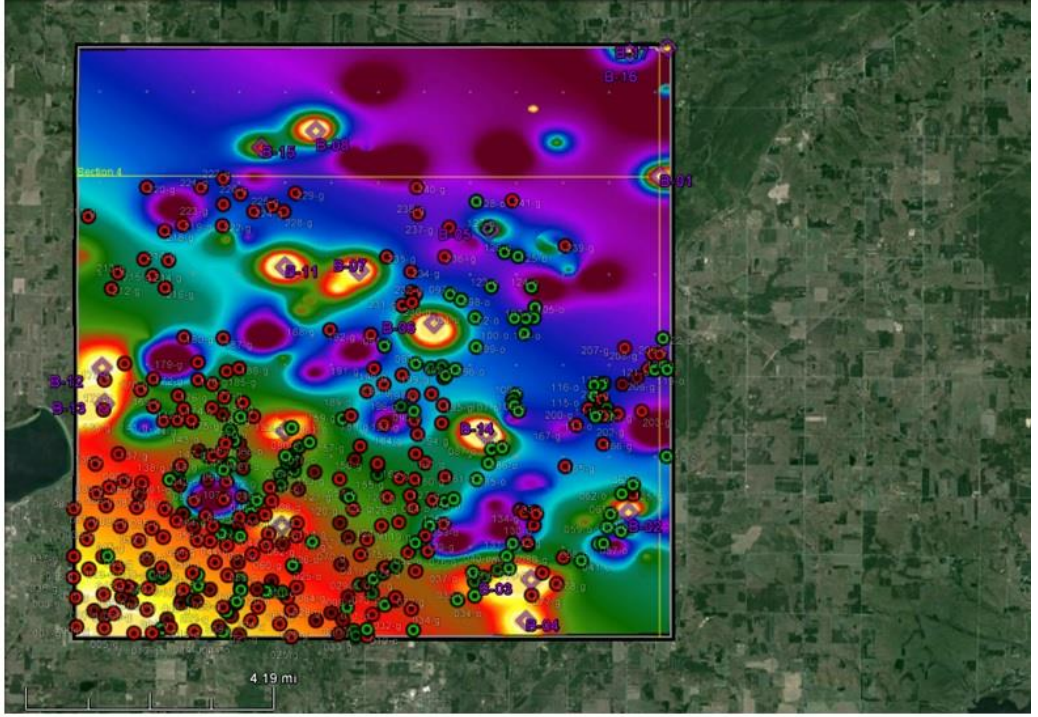
Zoom on Houston Infrastructure for this area:

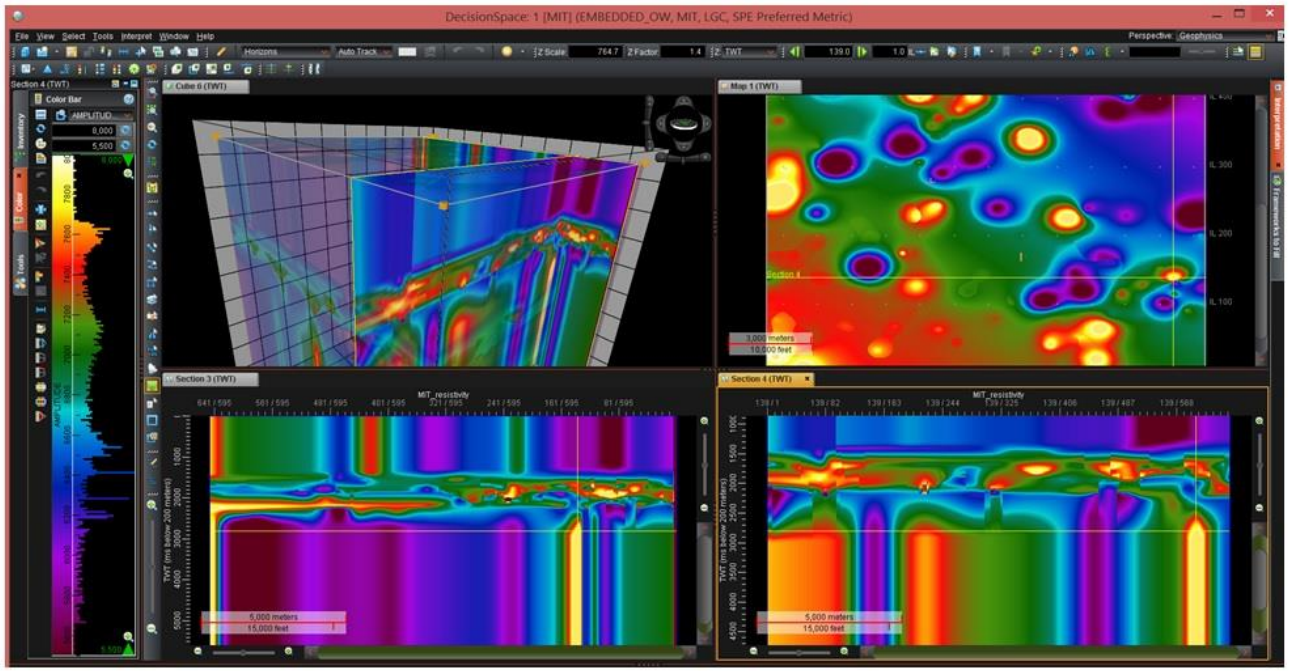


Quick Overview Economics for a 3 square mile area:

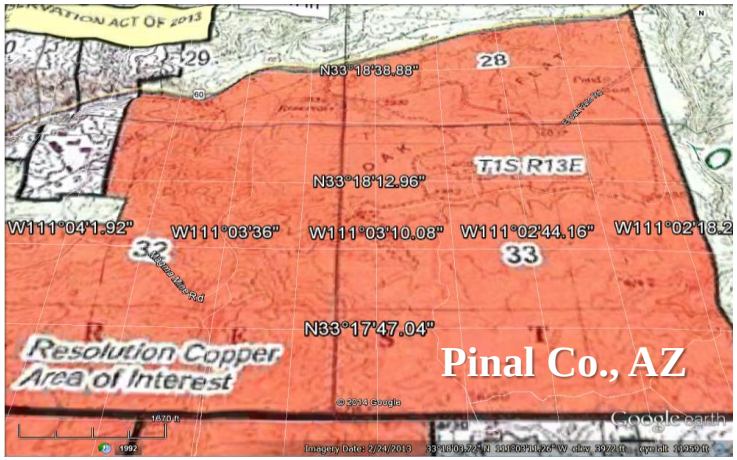
	Area	acre-feet	barrels	MCF @ 15 cf/b	MCF @ 23 cf/b	MCF @ 100 cf/b
Square Miles	3					
Acres	1920					
10 foot sand		19200	148,960,655	2,234,410	3,426,095	14,896,066
50 foot sand		96000	744,803,273	11,172,049	17,130,475	74,480,327
100 foot sand		192000	1,489,606,546	22,344,098	34,260,951	148,960,655
Value 10 foot sand at $2/MCF				$ 4,468,820	$ 6,852,190	$ 29,792,131
Value 50 foot sand at $2/MCF				$ 22,344,098	$ 34,260,951	$ 148,960,655
Value 100 foot sand at $2/MCF				$ 44,688,196	$ 68,521,901	$ 297,921,309

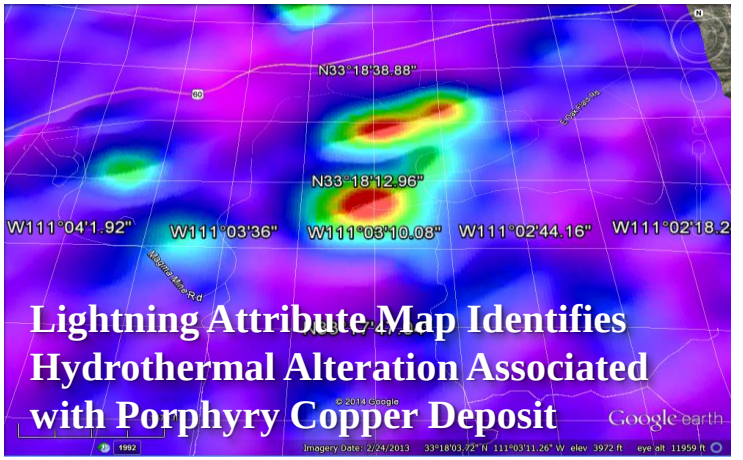
Reefs in Michigan

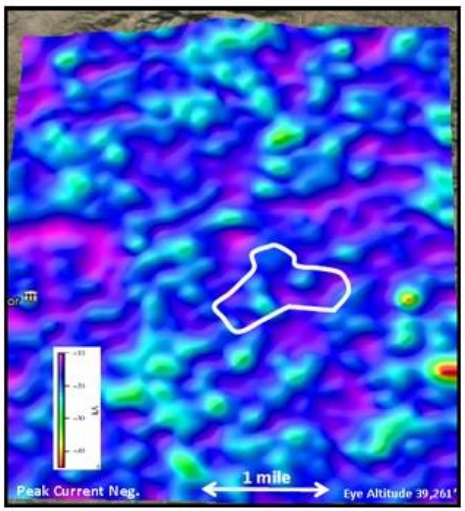




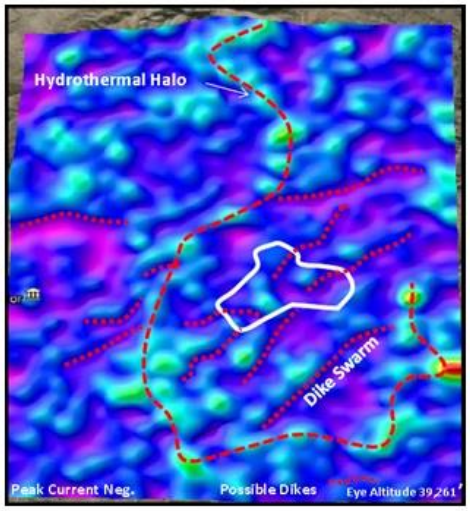
$6 Billion Resolution Copper Mine Superior, Arizona



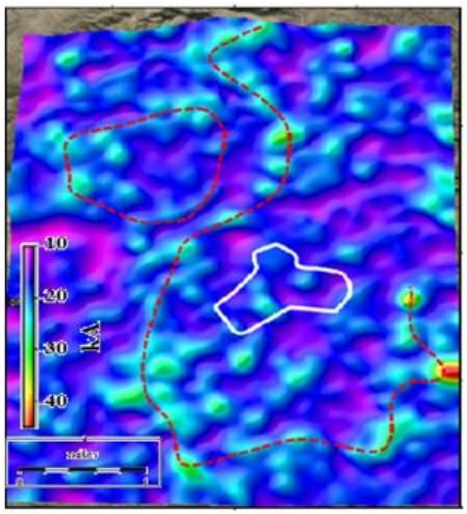




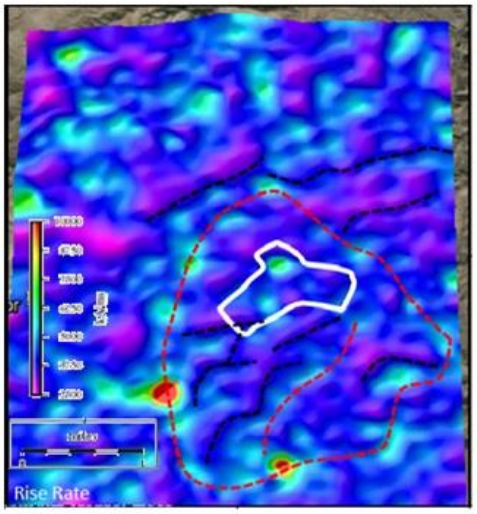
Negative Peak Current



Negative Peak Current



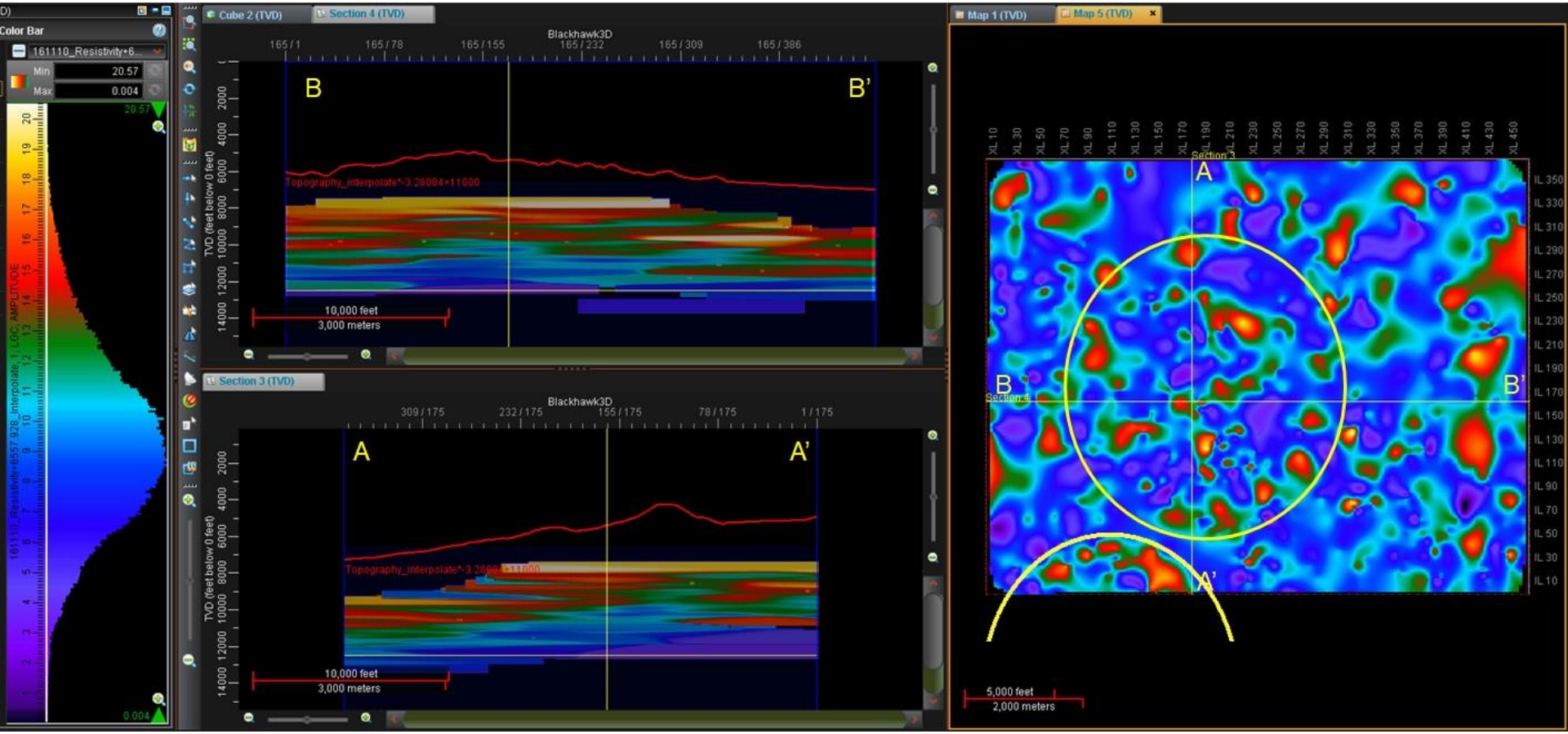
Peak Current



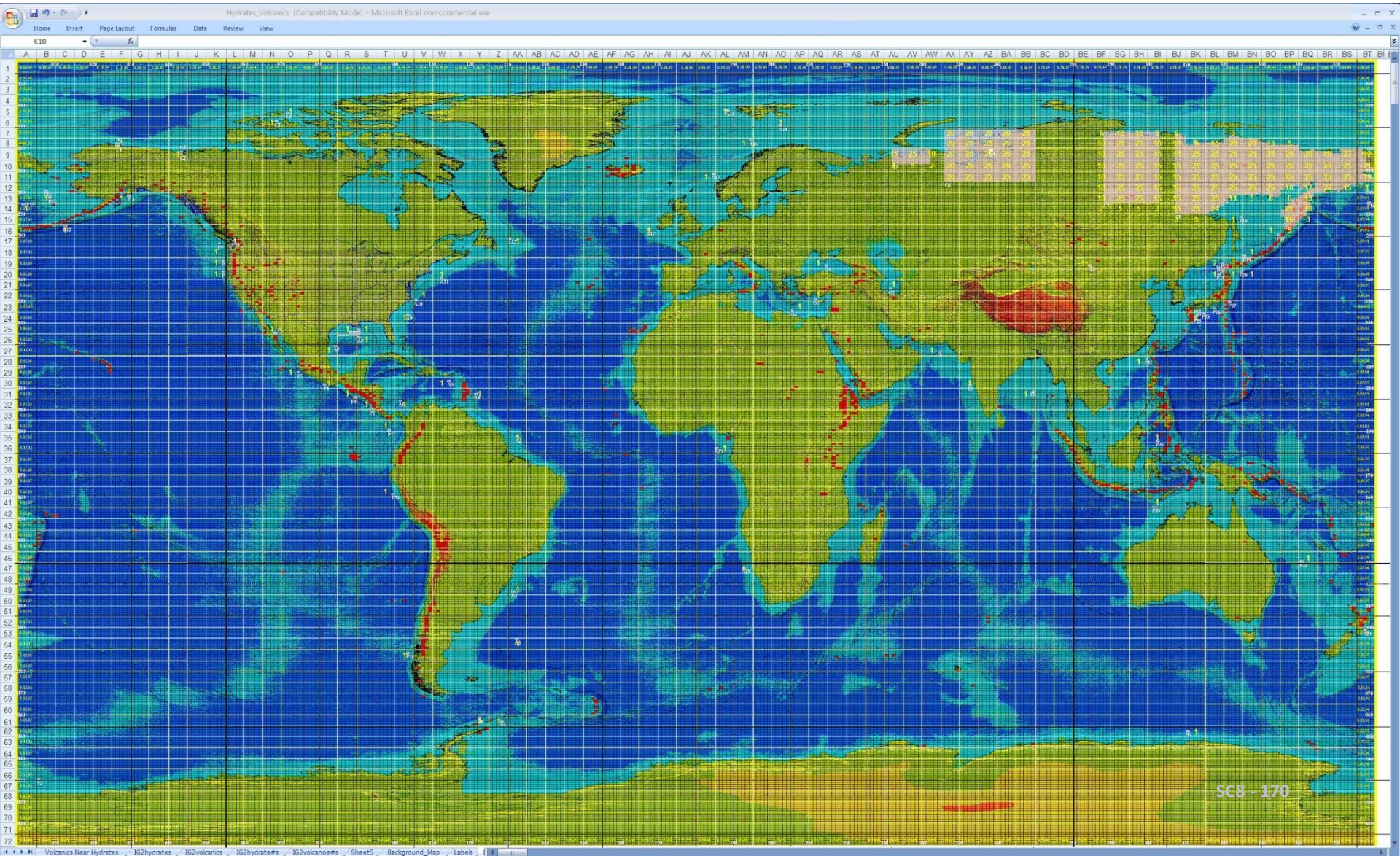
Rise-Rate

Gold Mine, San Bernardino County, CA

Interpretation of Anomaly on Surface Resistivity Map



A Future Project: Gas Hydrates



Notes

2017 Science Camp

- What was best about 2017 Science Camp?
  - _____
  - _____
  - _____

- What would be your ideal 2018 Science Camp Theme?
  - _____
  - _____
  - _____