ENABLING ORGANIZATIONAL BRILLIANCE

LANDMARK INNOVATION FORUM 2014

# Enhancing Reservoir Characterization using Lightning Strike Data

**H. Roice Nelson, Jr., Dr. Jim Siebert, & Les R. Denham**

**Dynamic Measurement LLC**

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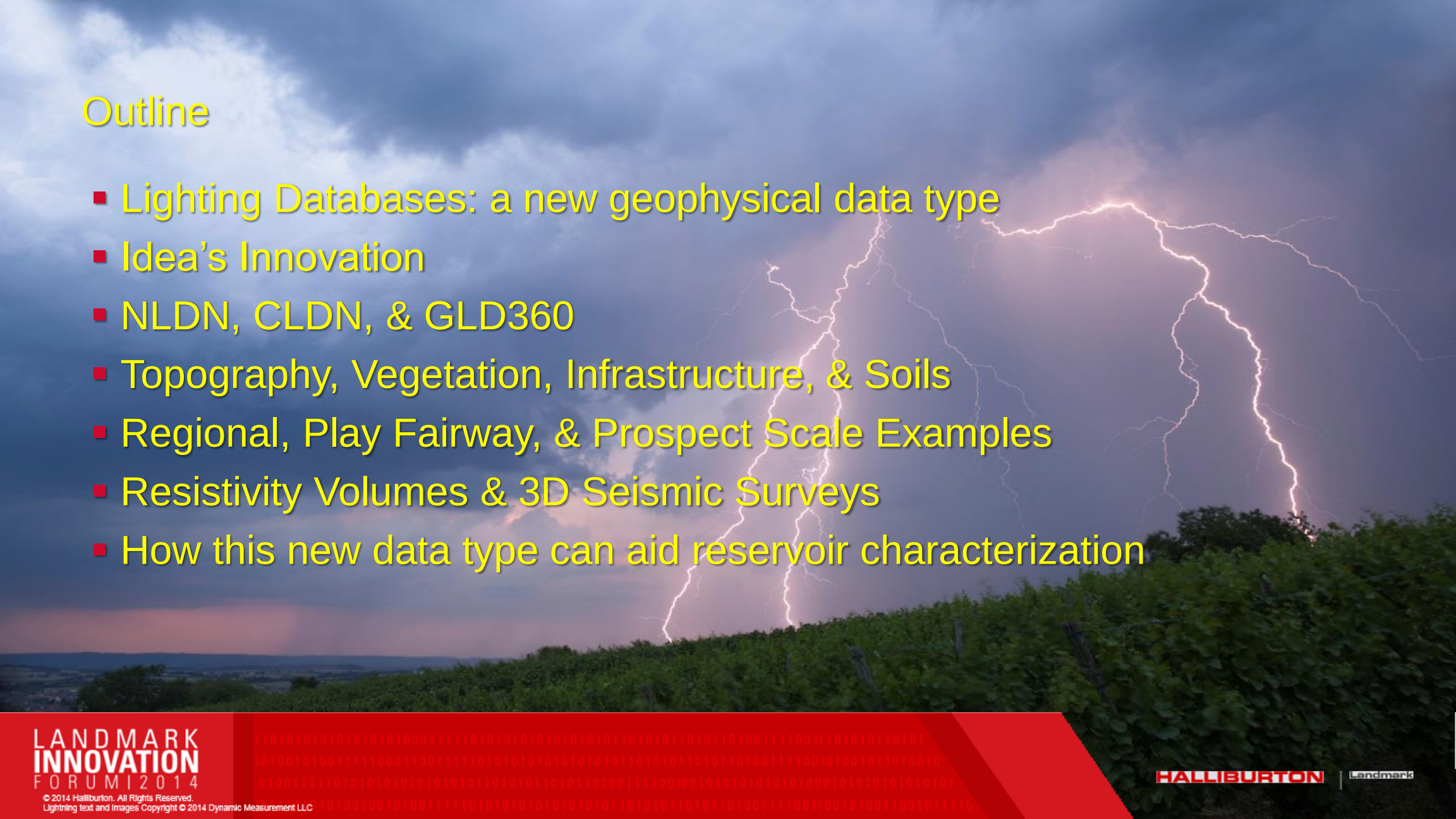

# Outline

- Lighting Databases: a new geophysical data type
- Idea's Innovation
- NLDN, CLDN, & GLD360
- Topography, Vegetation, Infrastructure, & Soils
- Regional, Play Fairway, & Prospect Scale Examples
- Resistivity Volumes & 3D Seismic Surveys
- How this new data type can aid reservoir characterization


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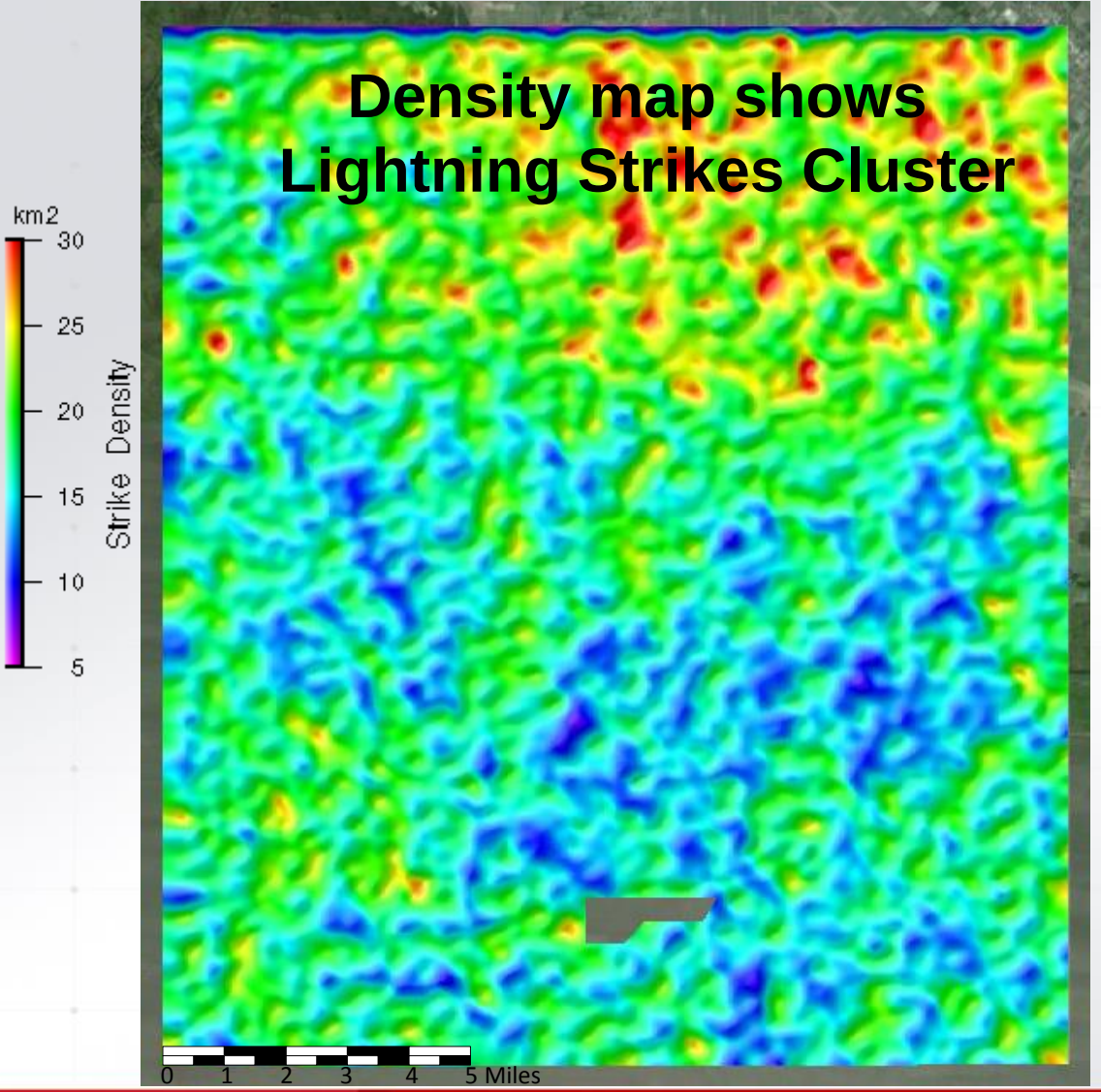


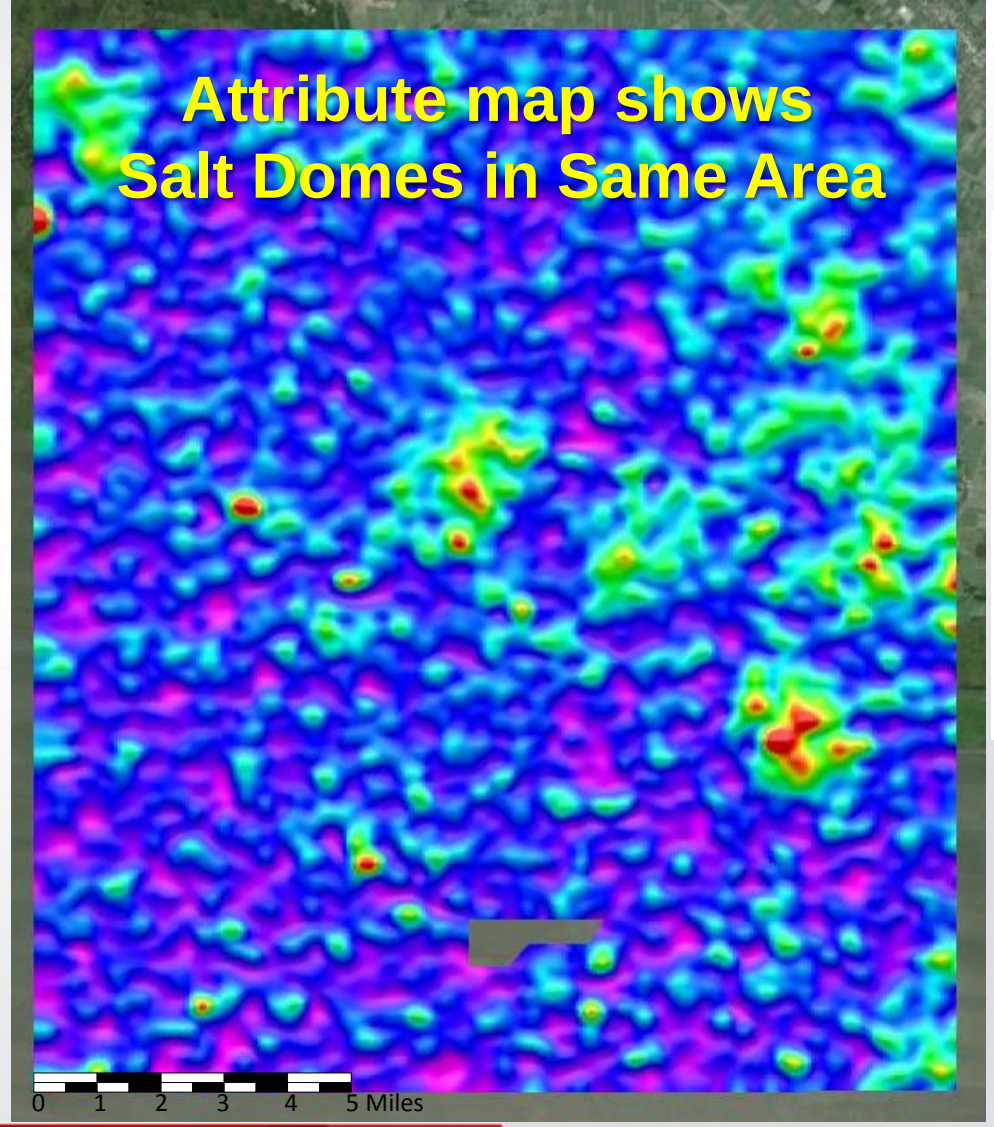




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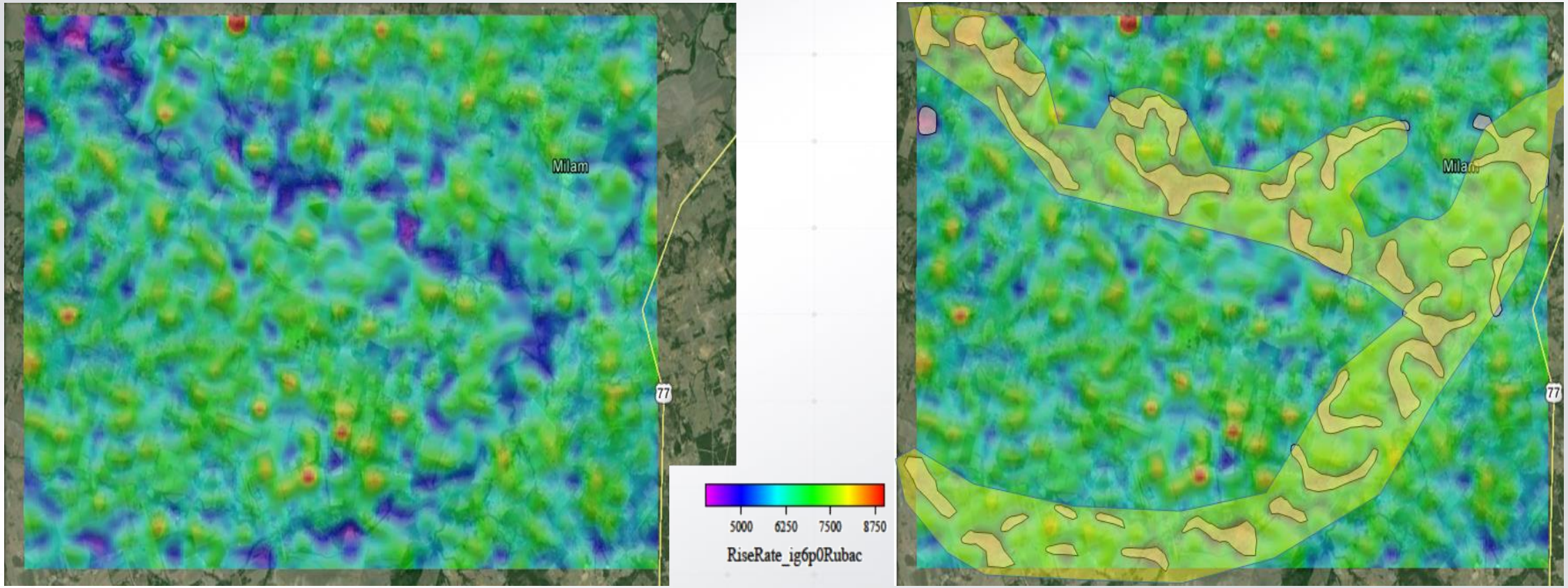
# Lightning Attributes map shallow stratigraphy





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# Lightning Databases: an old & a new geophysical data type

**1752 Benjamin Franklin's kite in the Marcellus Shale Resource Play.**

1833 First magnetic field measurements.

1920's Seismic refraction & reflection surveys.

1927 Schlumberger's first electrical resistivity well log.

1936 First modern Gravimeter.

1950's Magnetotellurics invented, measuring lightning charged earth currents.

1960's & '70's The first image processing of satellite imagery.

1974 First 3-D seismic survey collected for Gulf Oil.

1982 Landmark Graphics' first stand-alone seismic interpretation workstation.

1997 CSEM (Controlled Source Electromagnetics).

**2008 Data mining lightning data as a new Geophysical Data Type.**

**Each new data type sparked millions of dollars in data sales & services.**



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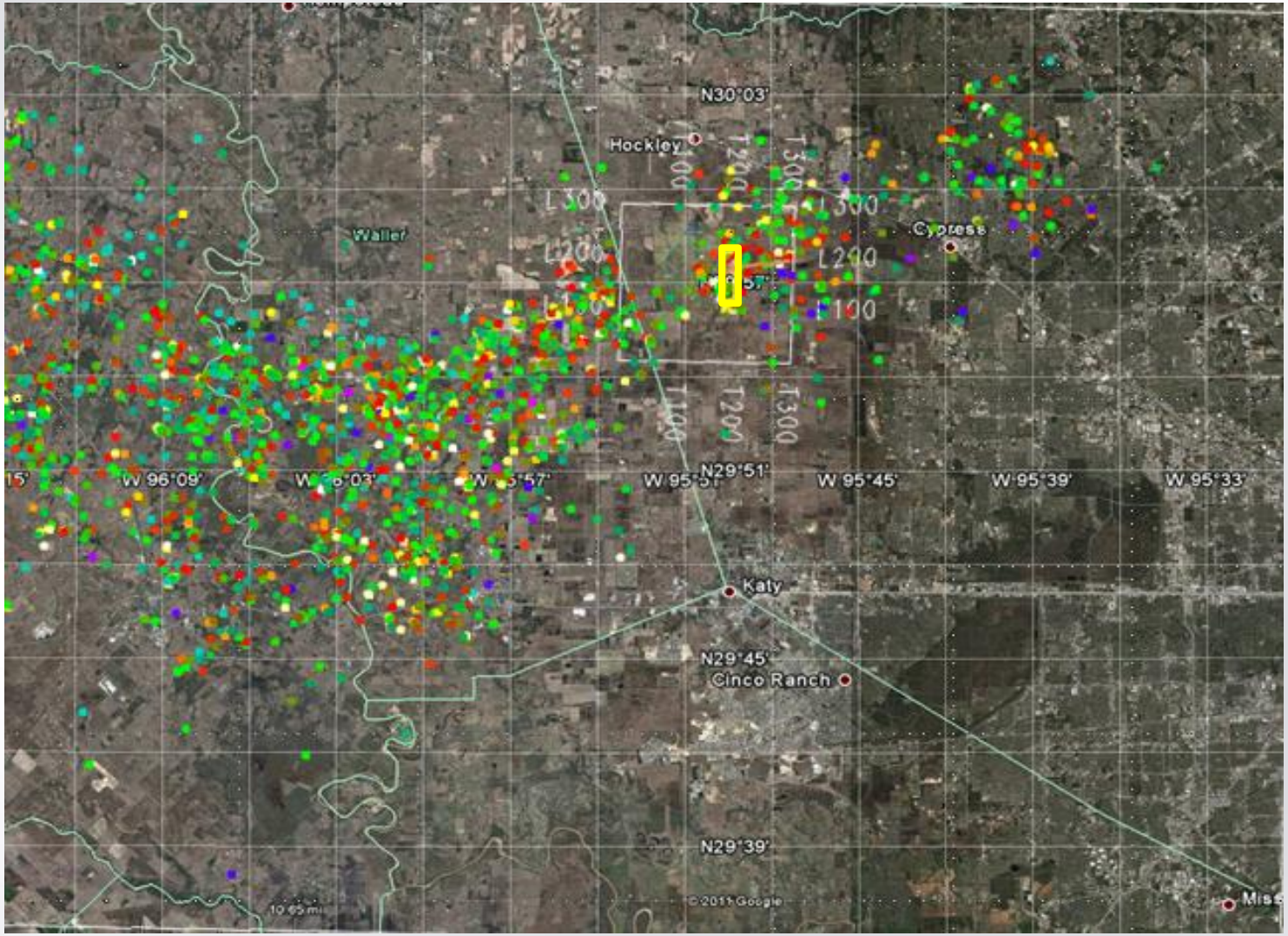
# Idea's Innovation

- Innovation is found someplace between:
  - Inspiration,
  - Perspiration, &
  - Curiosity.
- Joe Roberts was duck hunting by the Hockley Salt Dome, lightning struck twice, separated by a year.





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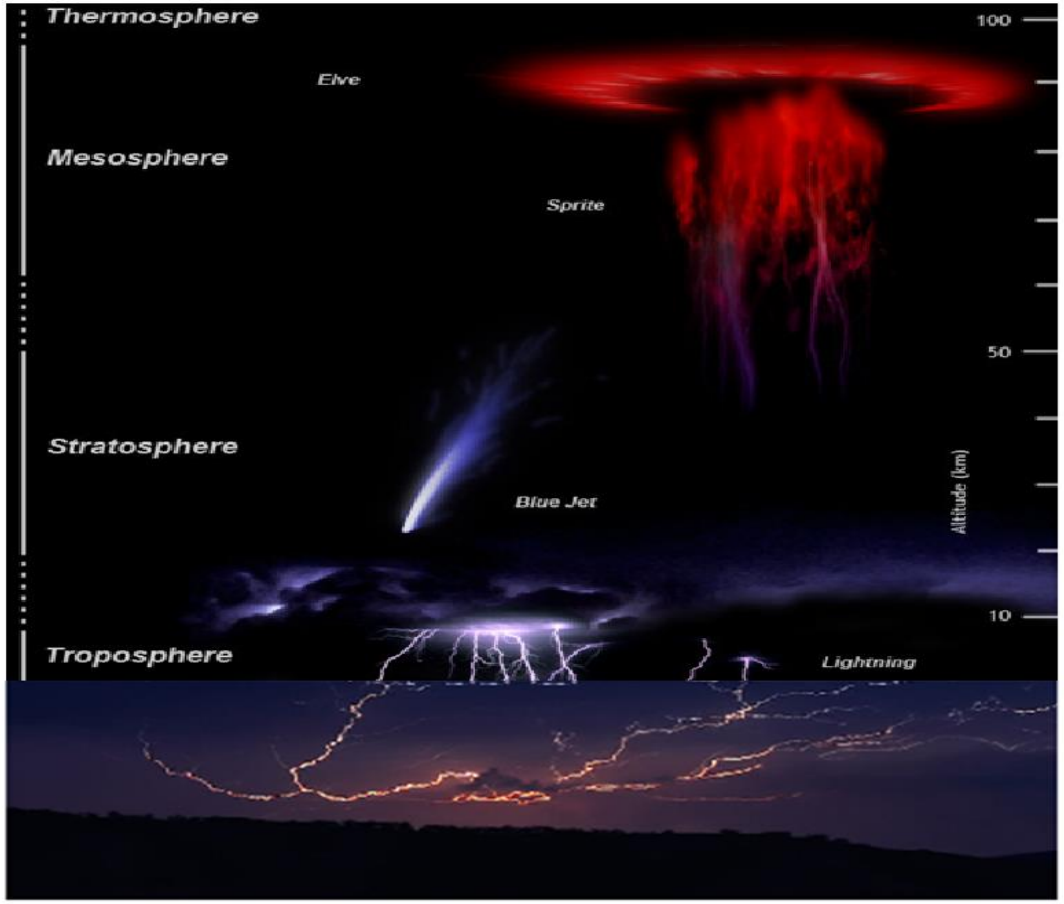
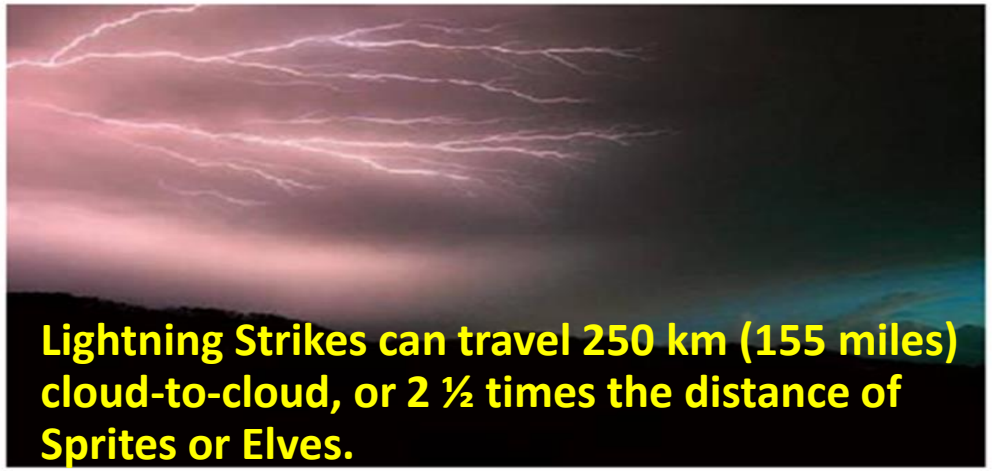
# 350 million annual Lightning Strikes is a rich database to mine



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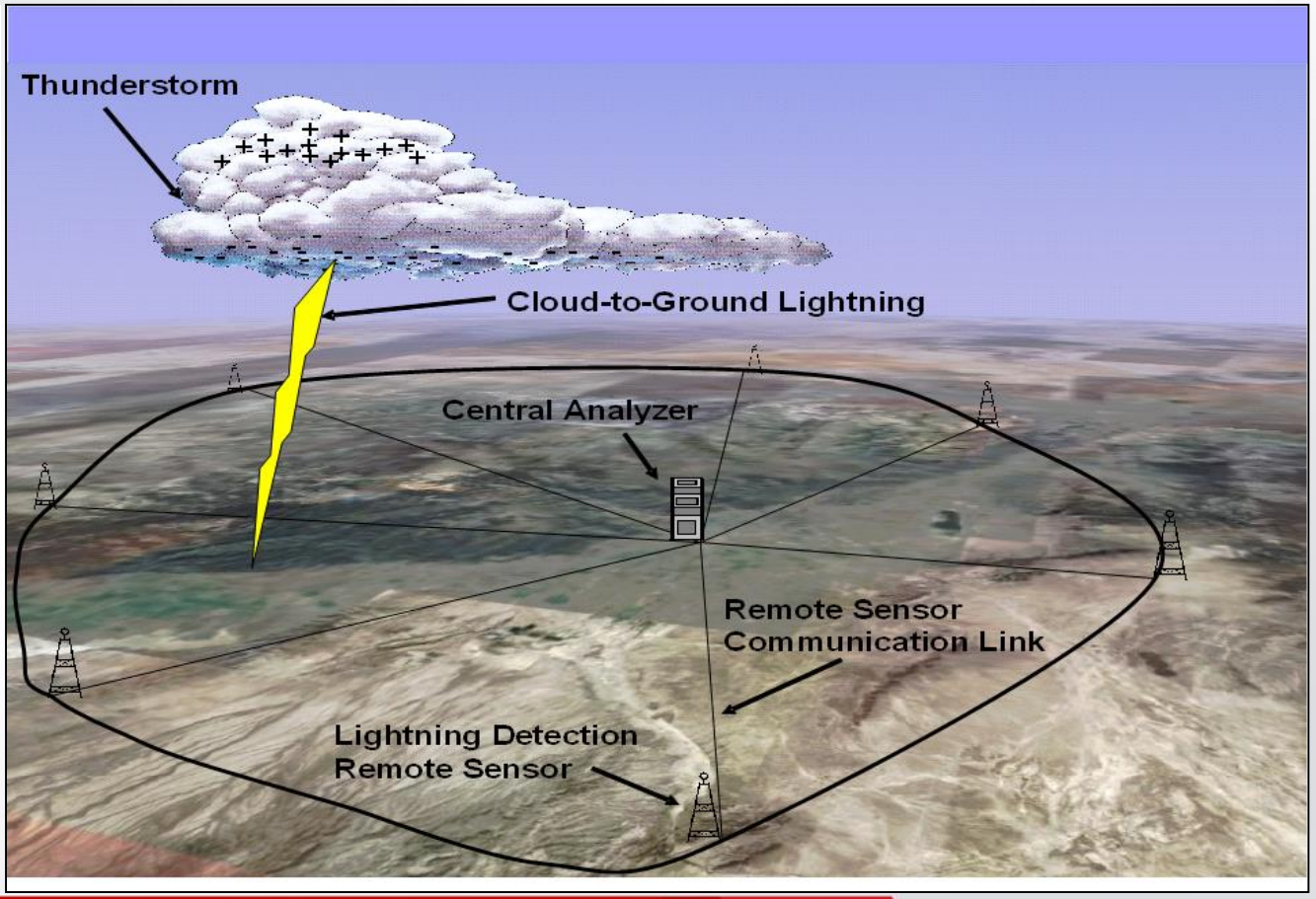
# 330 Sensors record U.S. lightning strike locations with 100-500 foot (30-150 meter) horizontal resolution





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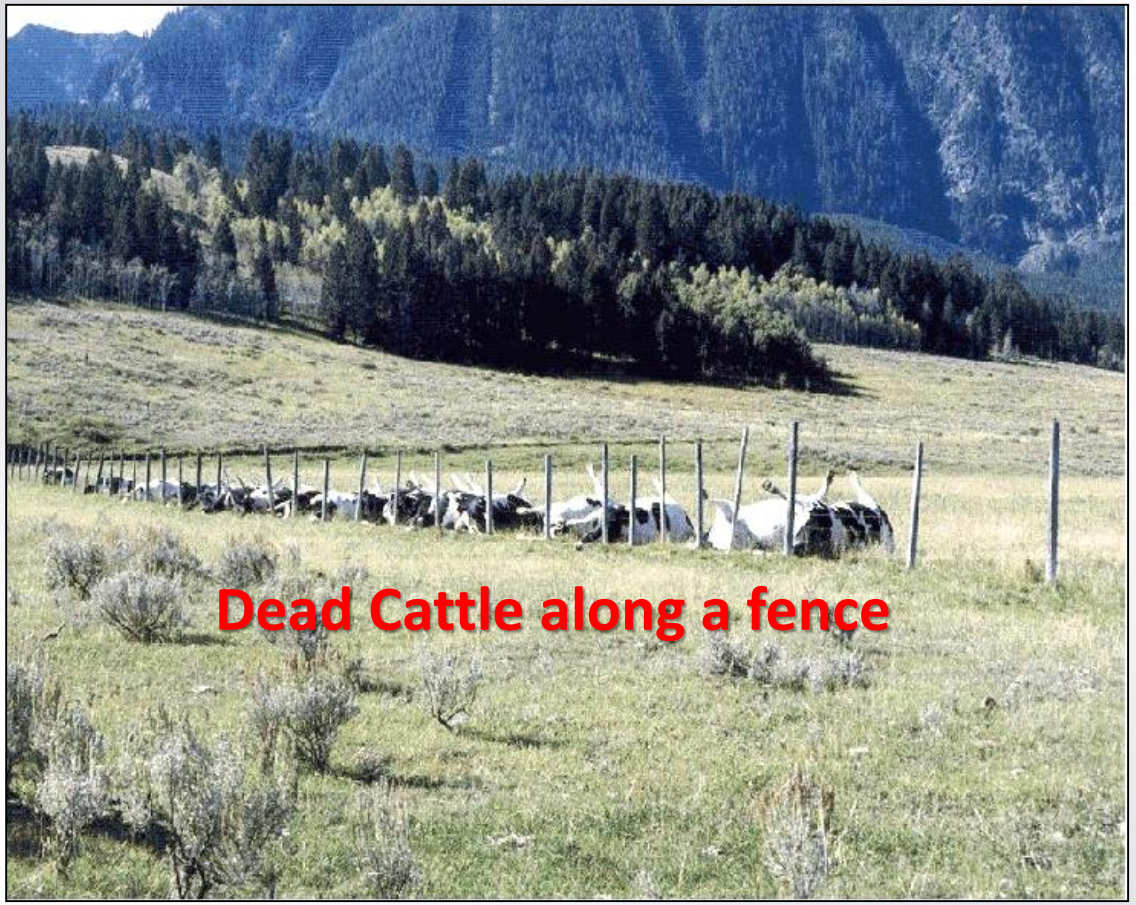
# Lightning recorded for early storm warning, safety, **insurance**, and meteorological purposes



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# Lightning Measurements

- **Location**
- **Time and Duration**
- **Rise Time**
- **Peak Current**
- **Peak-to-Zero**
- **Polarity**
- **Chi Squared**
- **Number of Sensors**

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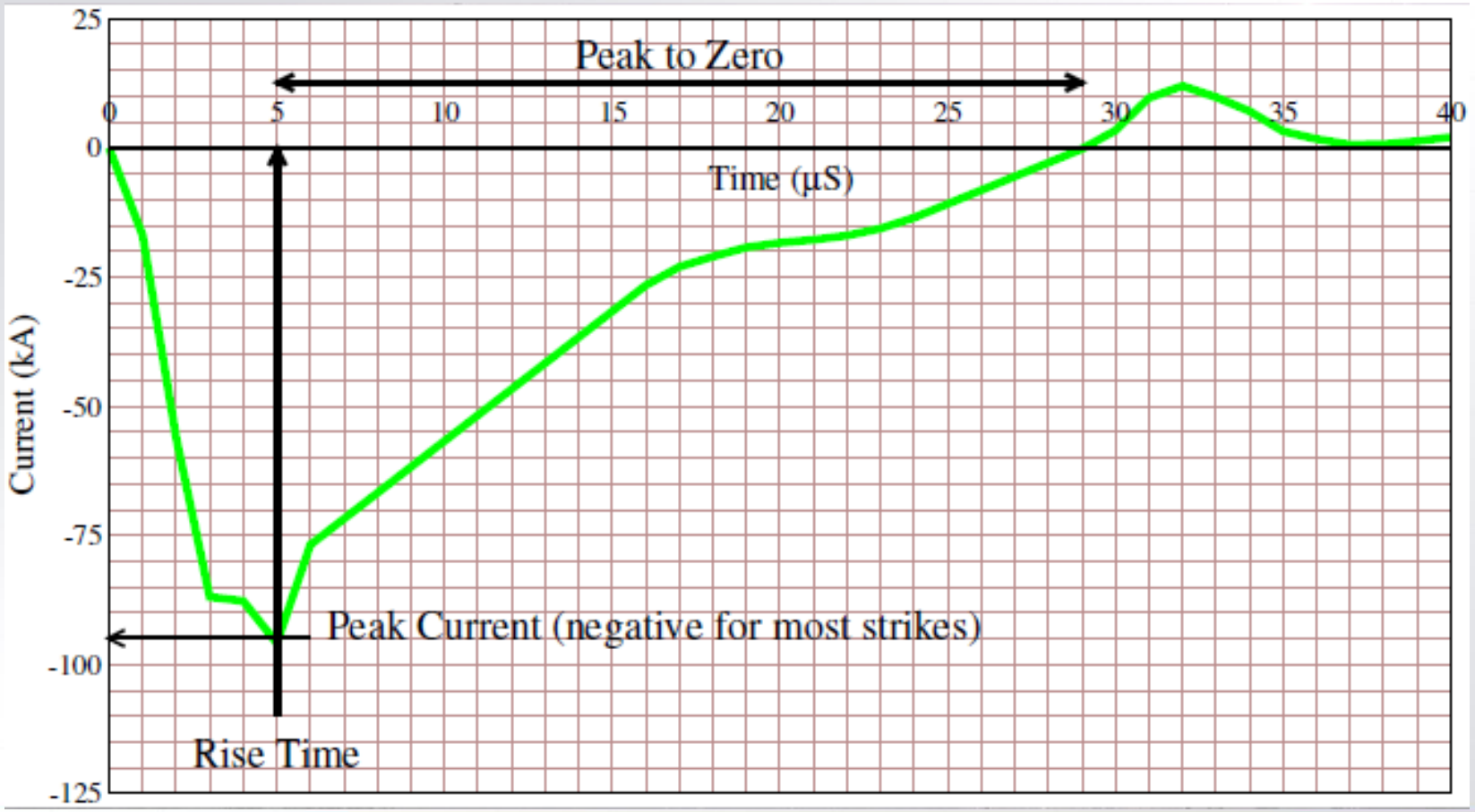
# Lightning Strike Waveform





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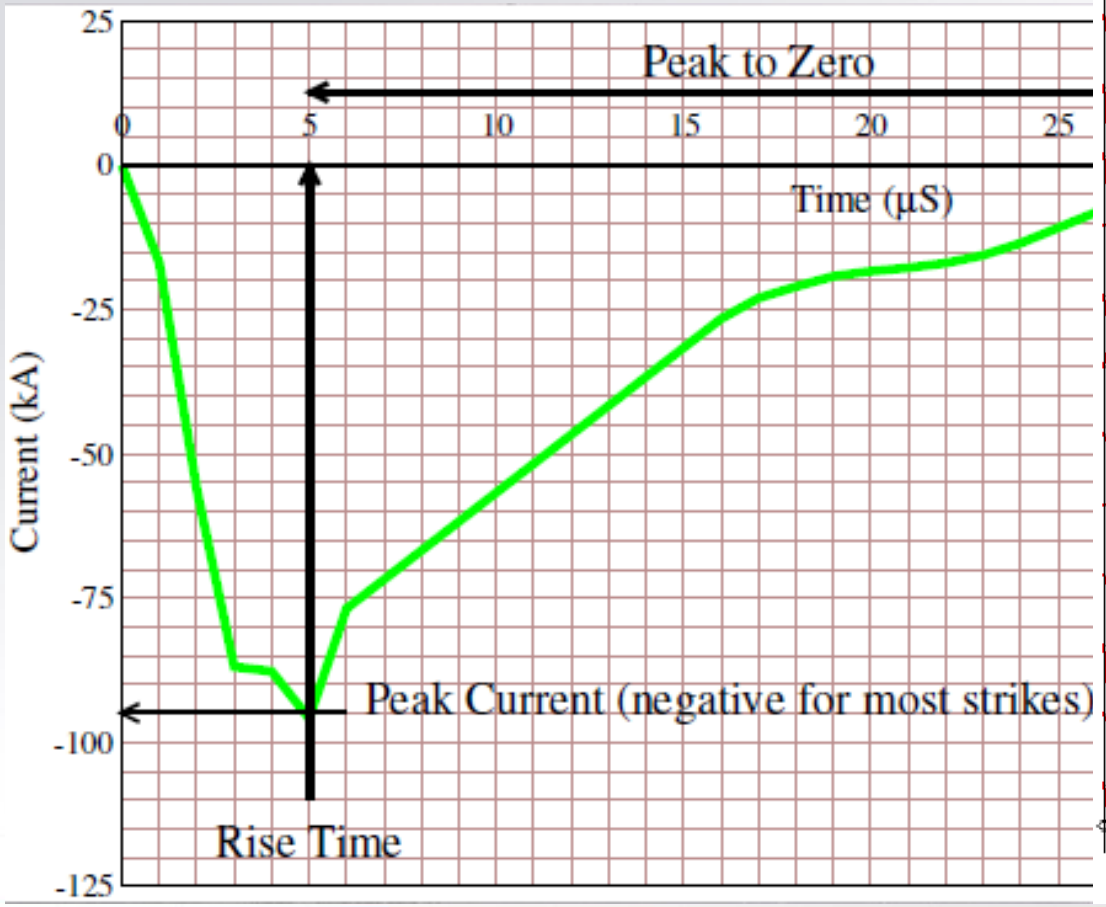
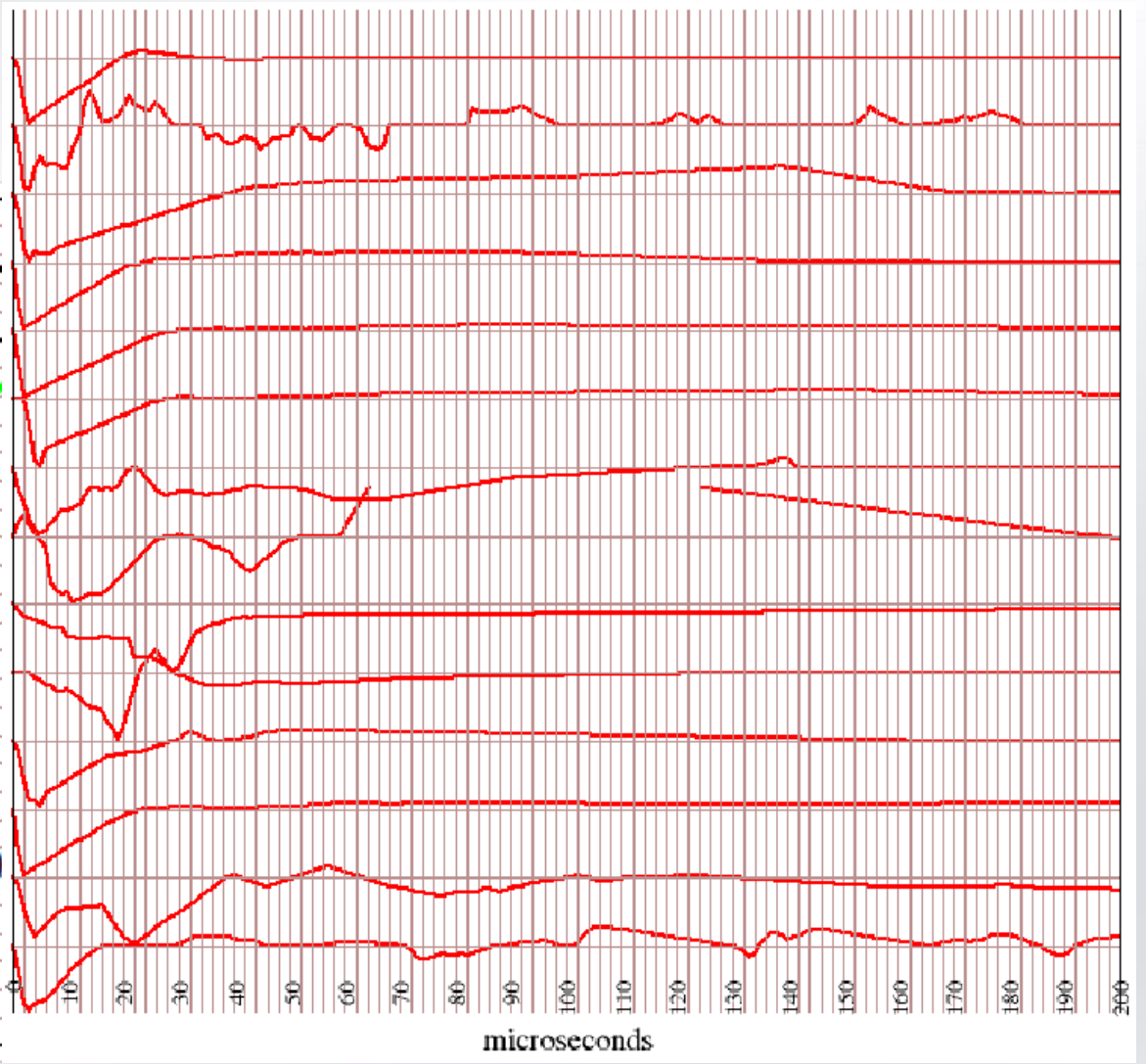
# Lightning Strike Waveform



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# Proven and Patented Technology

Fig. 1

US008344721B2

(12) **United States Patent**
**Nelson, Jr. et al.**

(10) **Patent No.: US 8,344,721 B2**
(45) **Date of Patent: Jan. 1, 2013**

(54) **METHOD FOR LOCATING SUB-SURFACE NATURAL RESOURCES**


(75) Inventors: **H. Roice Nelson, Jr.**, Houston, TX (US); **Joseph H. Roberts**, Houston, TX (US); **D. James Siebert**, Katy, TX (US); **Wulf F. Massell**, Conroe, TX (US); **Samuel D. LeRoy**, Houston, TX (US); **Leslie R. Denham**, Houston, TX (US); **Robert Ehrlich**, Salt Lake City, UT (US); **Richard L. Coons**, Katy, TX (US)



(51) **Int. Cl.**
*G01R 31/02* (2006.01)
*G01N 27/00* (2006.01)
*G01W 1/00* (2006.01)

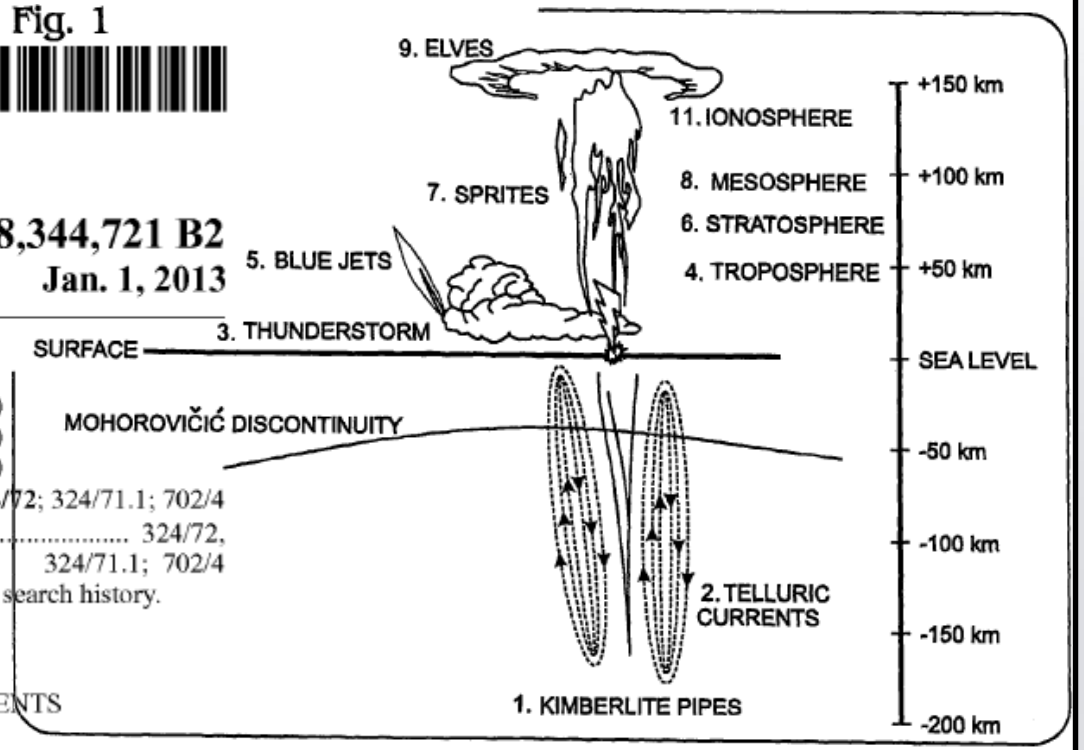
(52) **U.S. Cl.** ..... **324/72**; 324/71.1; 702/4

(58) **Field of Classification Search** ..... 324/72, 324/71.1; 702/4

See application file for complete search history.


(56) **References Cited**

U.S. PATENT DOCUMENTS







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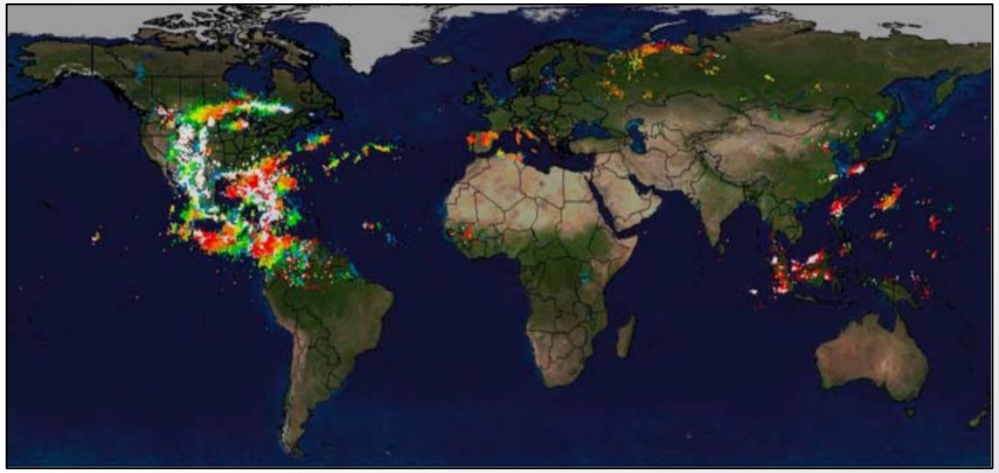
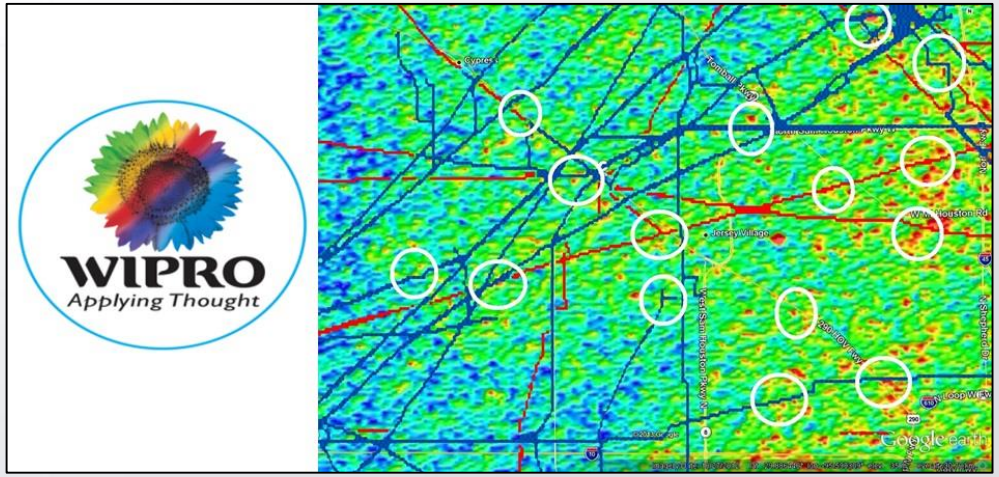
# Vaisala and Wipro Partnerships

- Exclusive worldwide license with Vaisala of Finland to use their data in the NLDN and GLD-360 for natural resource exploration.



- Agreement with Wipro to clean, process, and handle lightning data according to DML specifications





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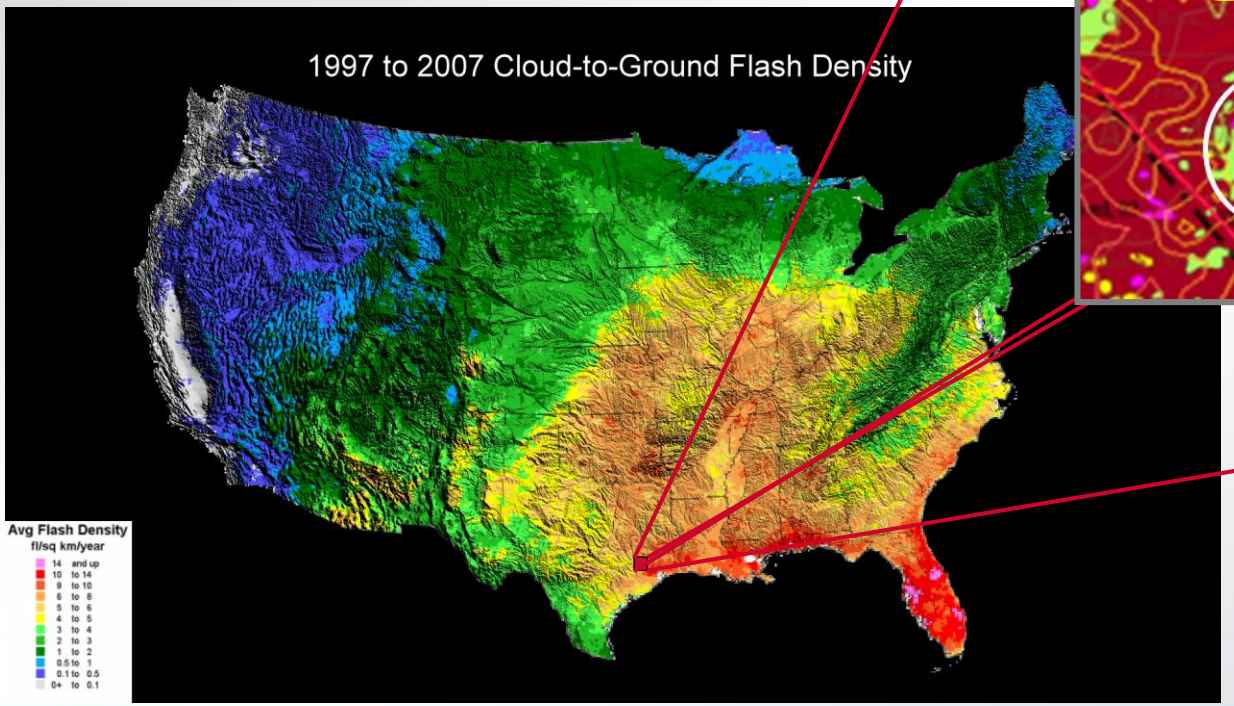
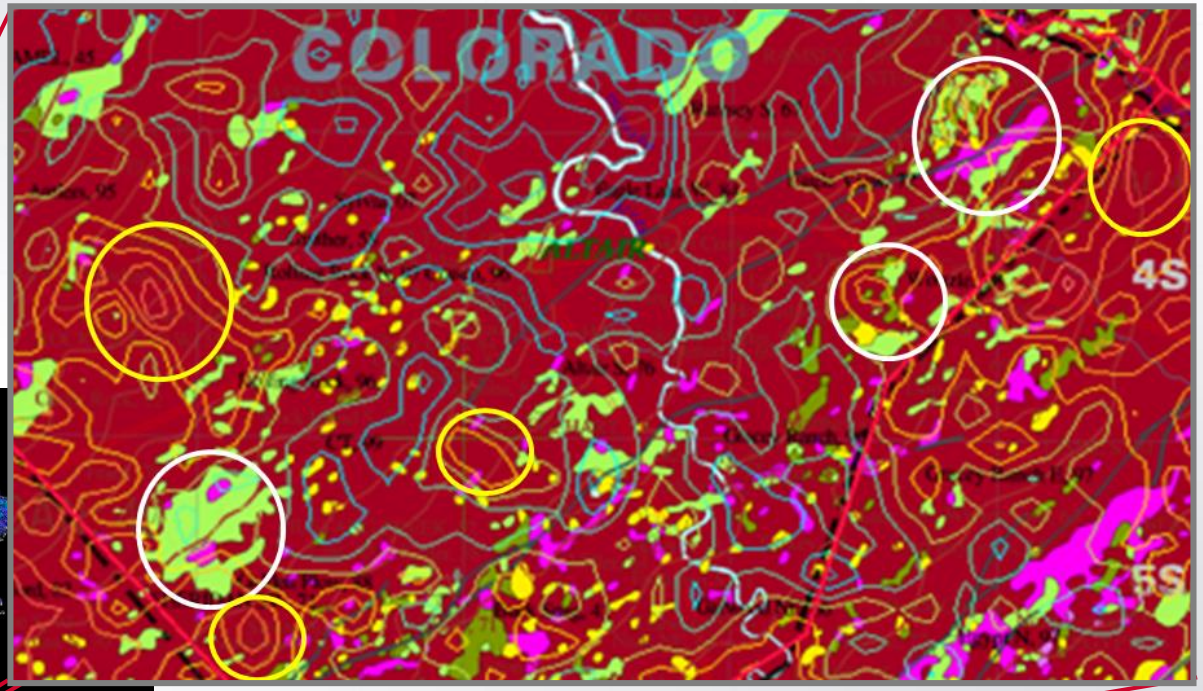
# Lightning Maps and Natural Resources

**Lightning density regionally controlled by meteorology, and locally controlled by terralevis (shallow earth) currents.**




**Colorado County, Texas:**
**White circles known oil & gas fields;**
**Yellow circles new leads from lightning density.**



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# Lightning bypasses tall objects to hit geology

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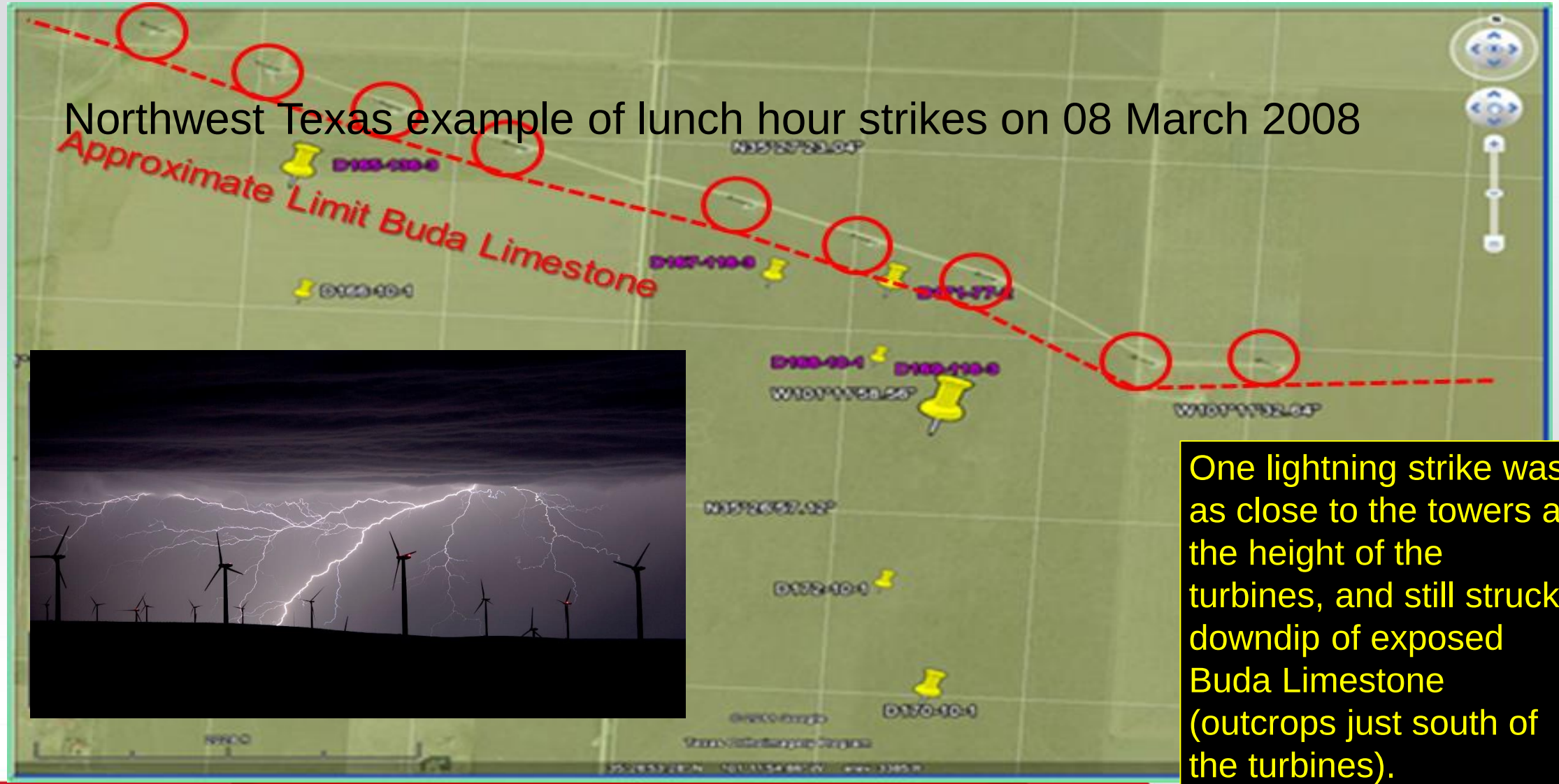
# Northwest Texas example of lunch hour strikes on 08 March 2008




One lightning strike was as close to the towers as the height of the turbines, and still struck downdip of exposed Buda Limestone (outcrops just south of the turbines).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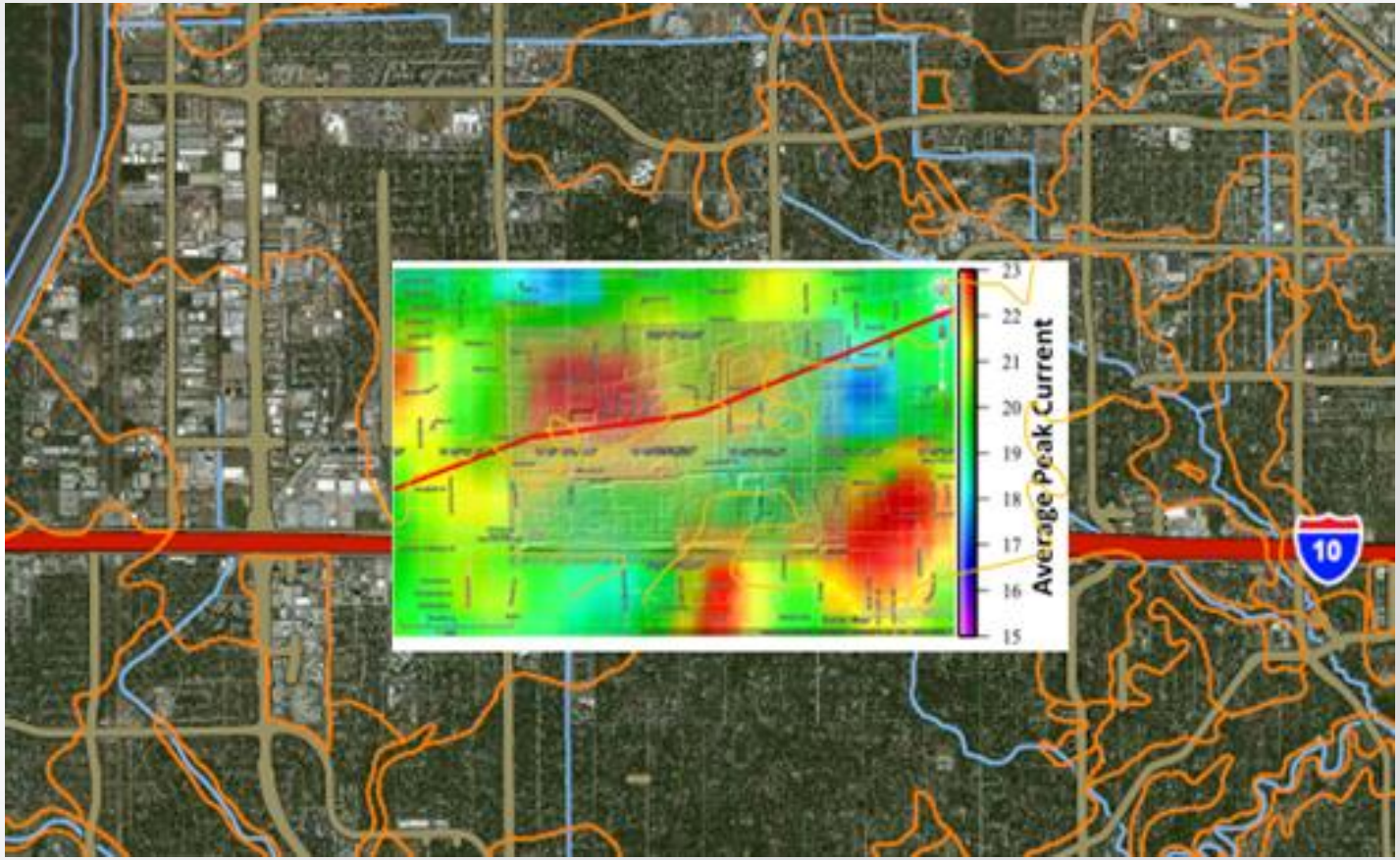
# Topography, Vegetation, Infrastructure, & Soils

Map Layers:

- GoogleEarth base
- Peak Current
- LIDAR
- Interpretation of the Long Point Fault
- Soils Unit vector Map





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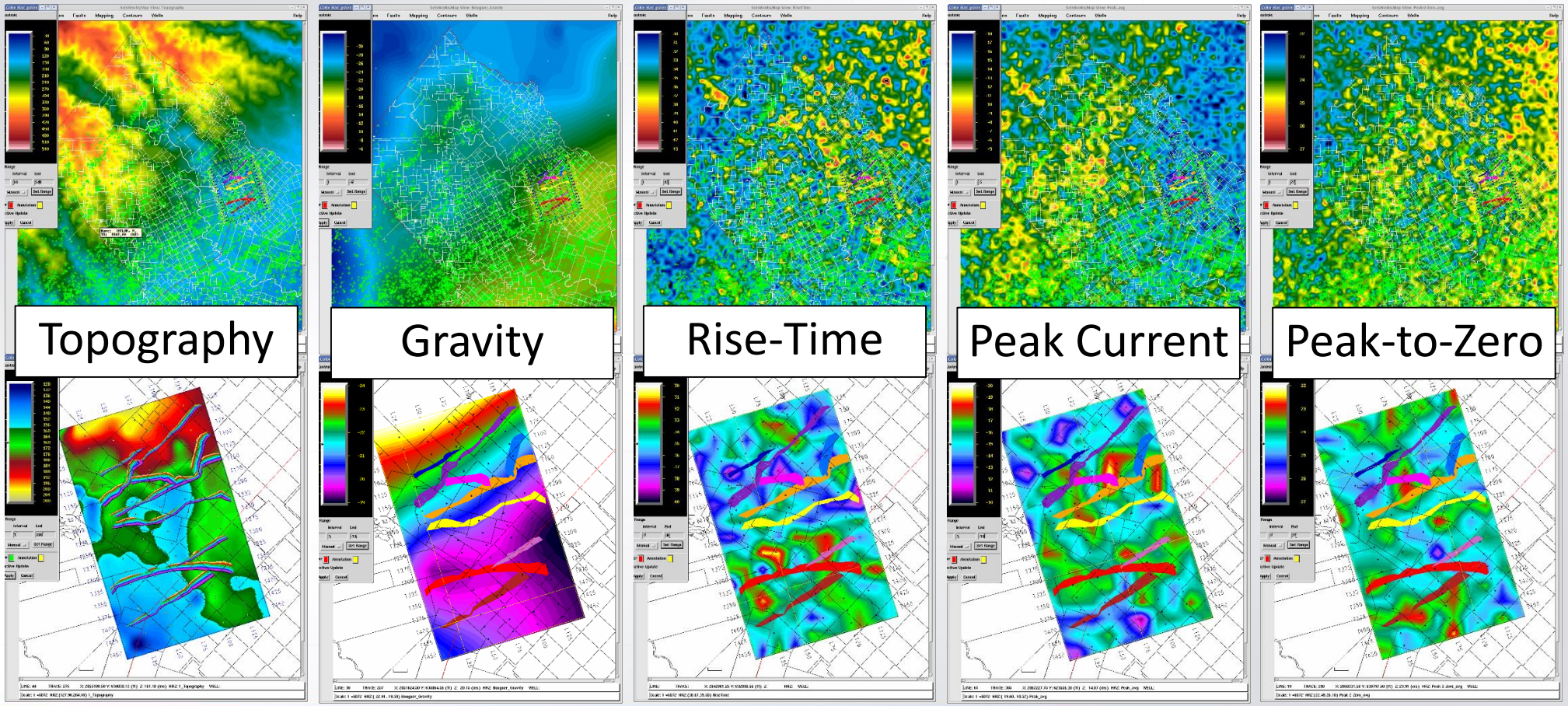
# A New Potential Fields Method, Supplementing Gravity & Magnetics



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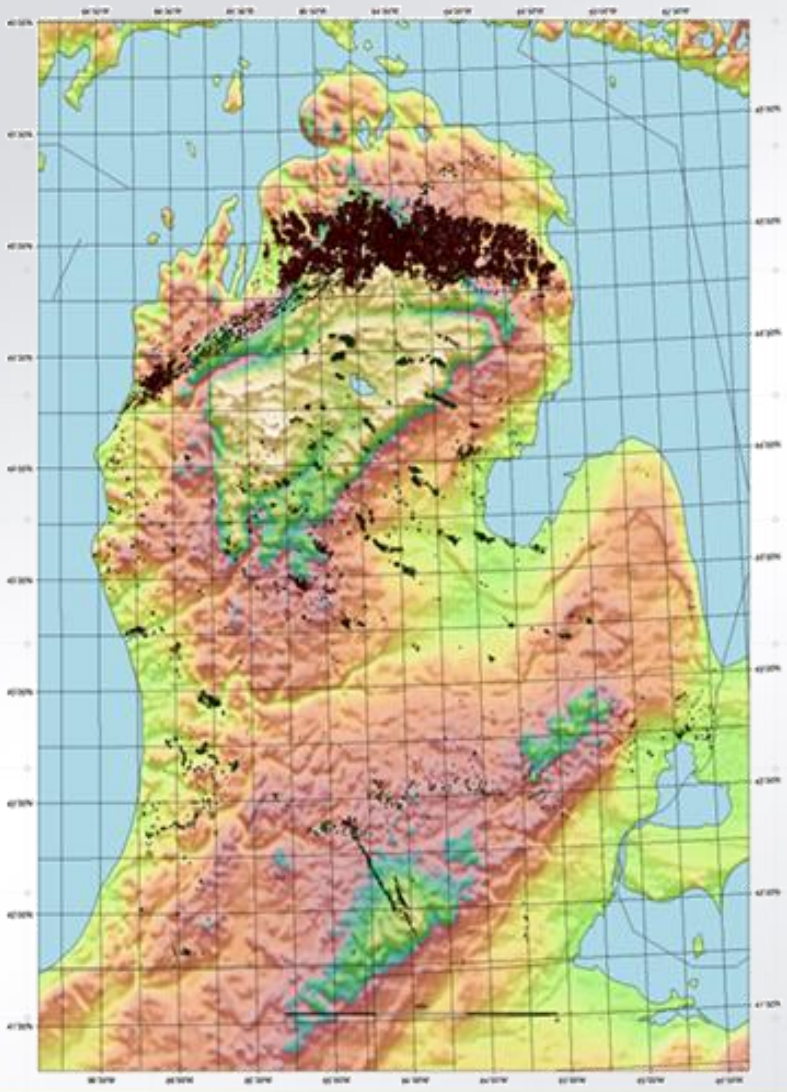
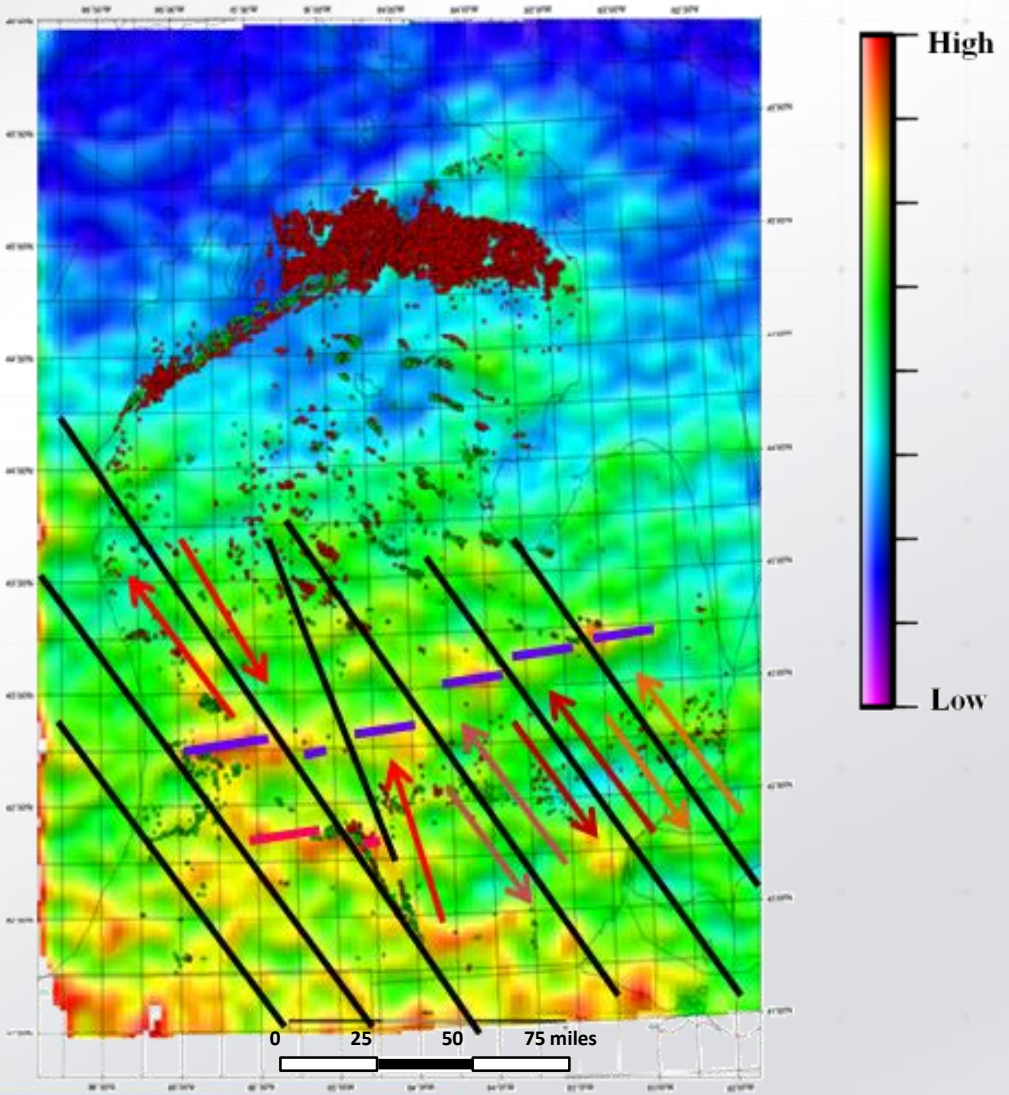
# Michigan Basin Example





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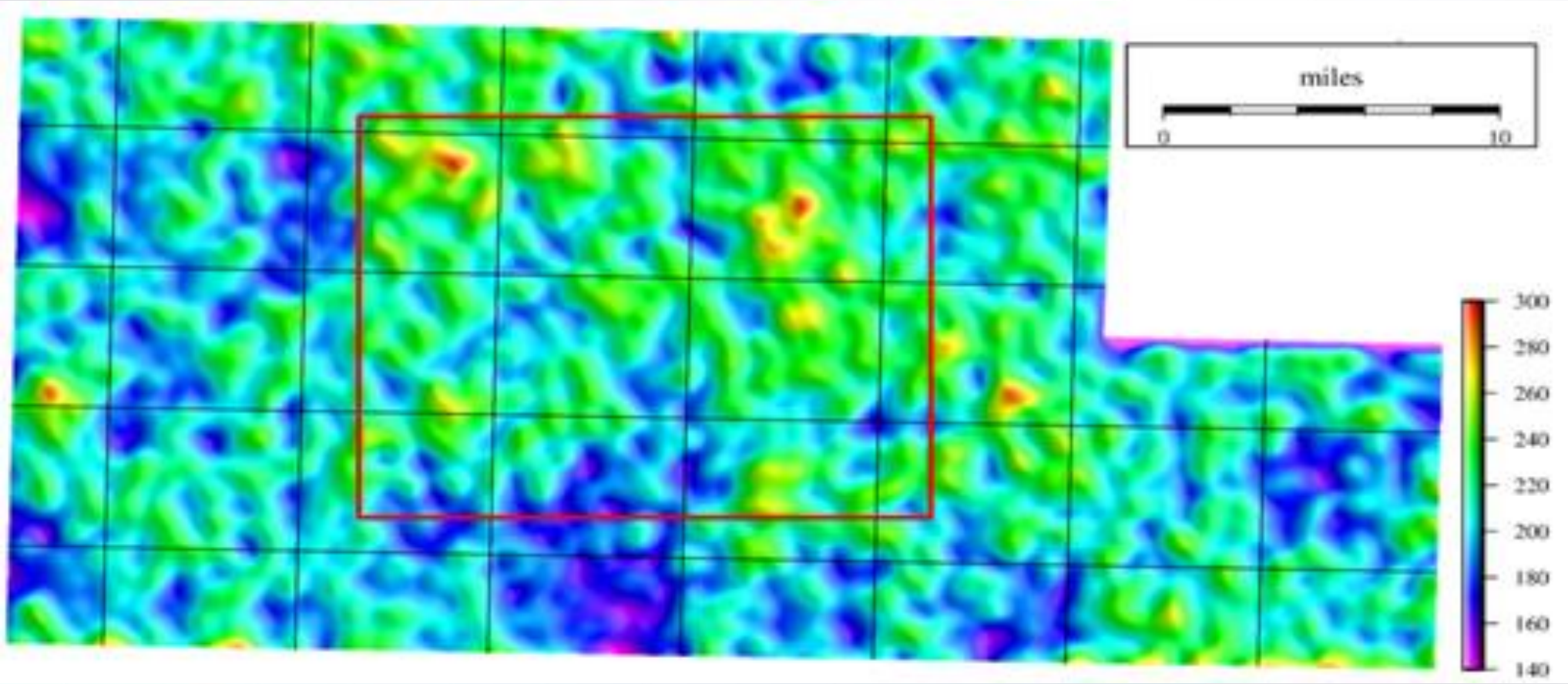
# Lightning Analysis provides a quick regional overview





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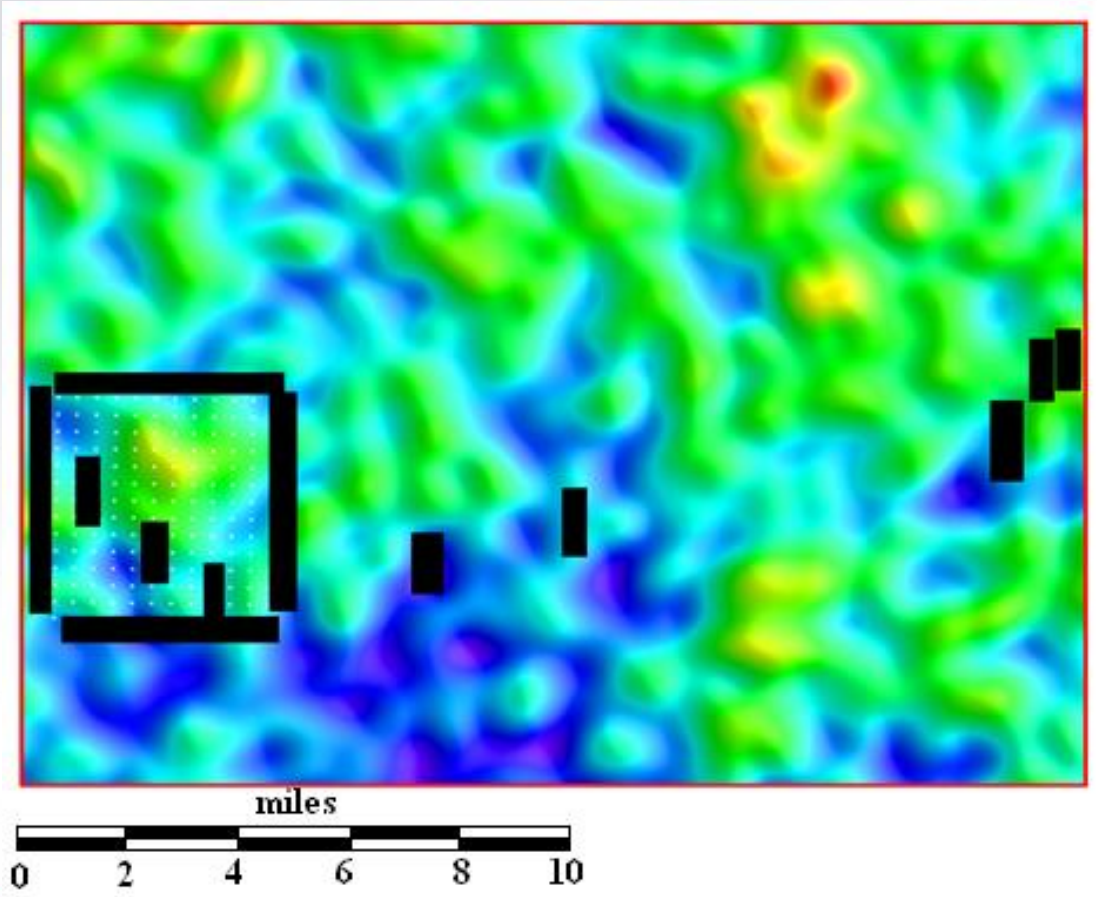
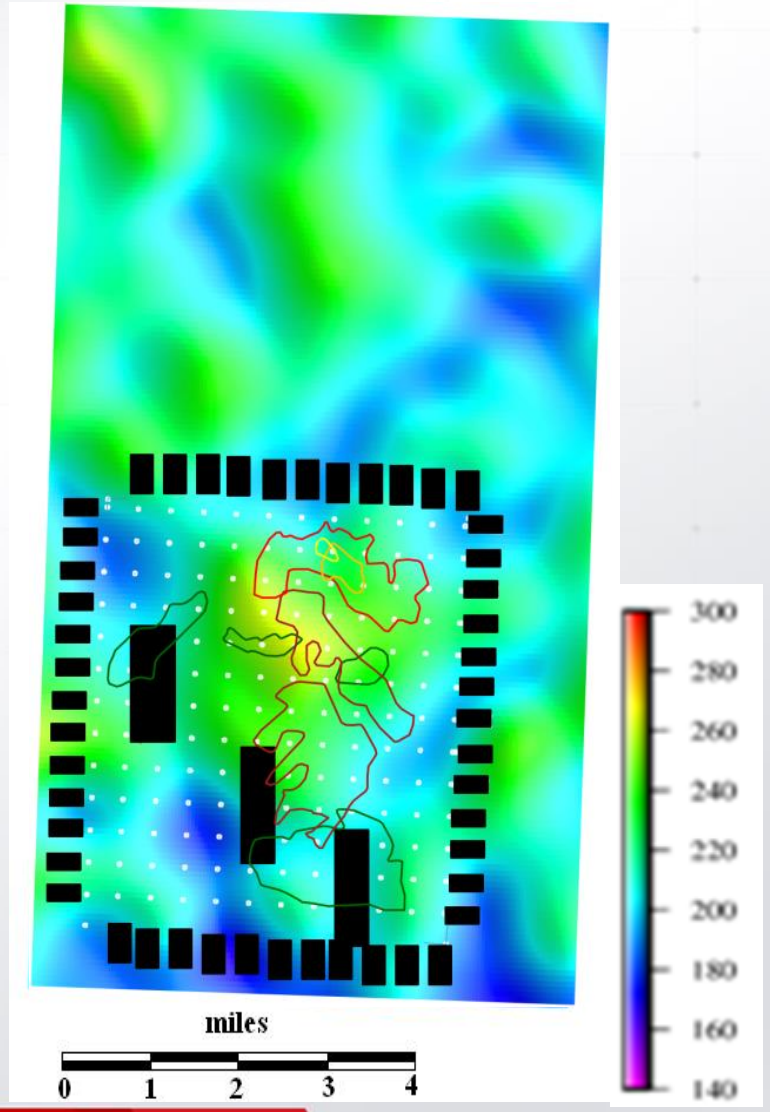
# More details come out at Play Fairway & Prospect Scales



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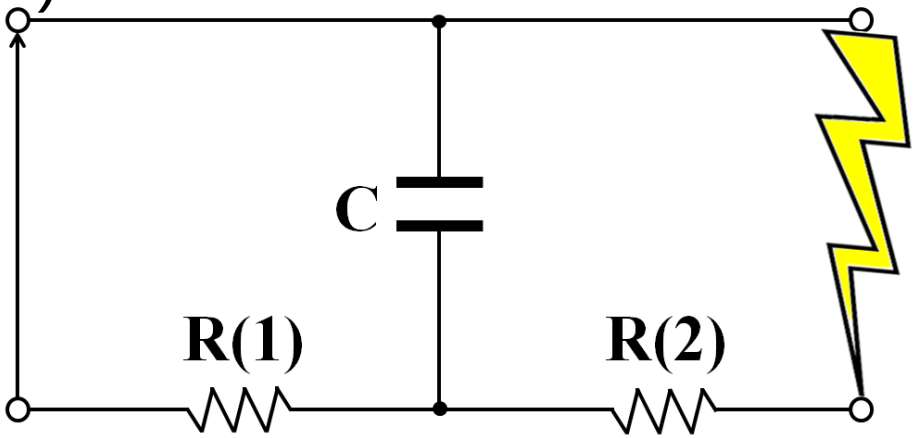
# Resistivity Volumes & 3-D Seismic Surveys

- Lightning as a RC (resistance-capacitor) circuit




- Key:
  - V(out)= Lightning Stroke
  - V(in)=Thunderstorm Static Charge
  - C=Capacitance between cloud & earth
  - R(1)=resistance of earth below thundercloud
  - R(2)=resistance as static charges rebalanced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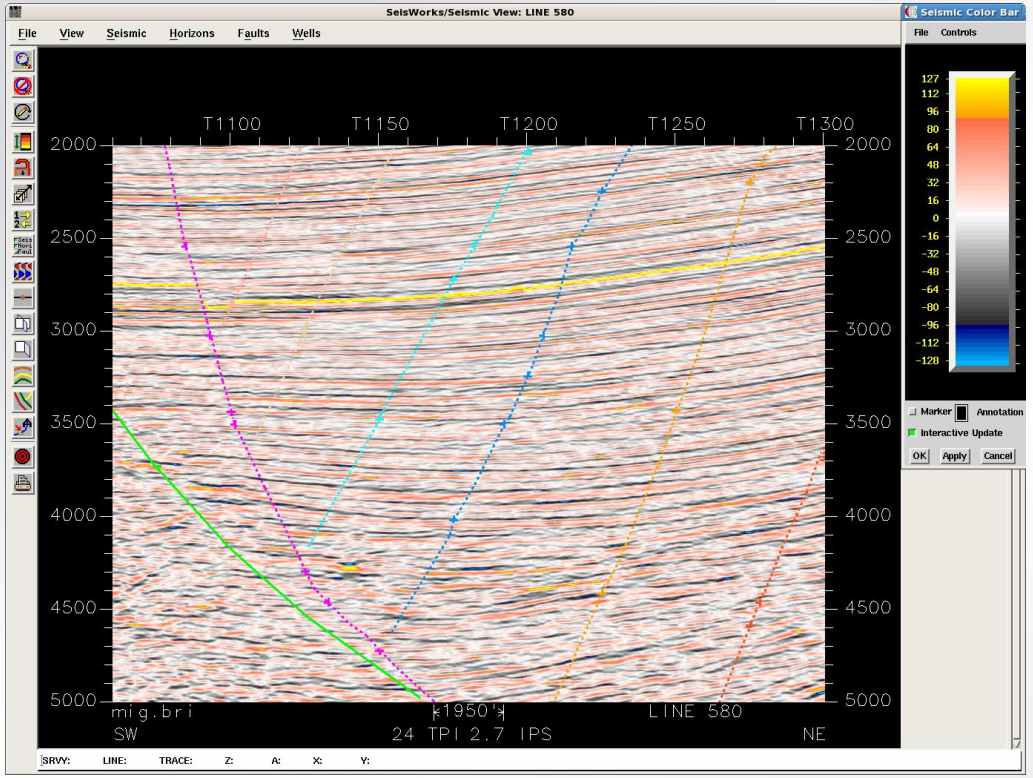
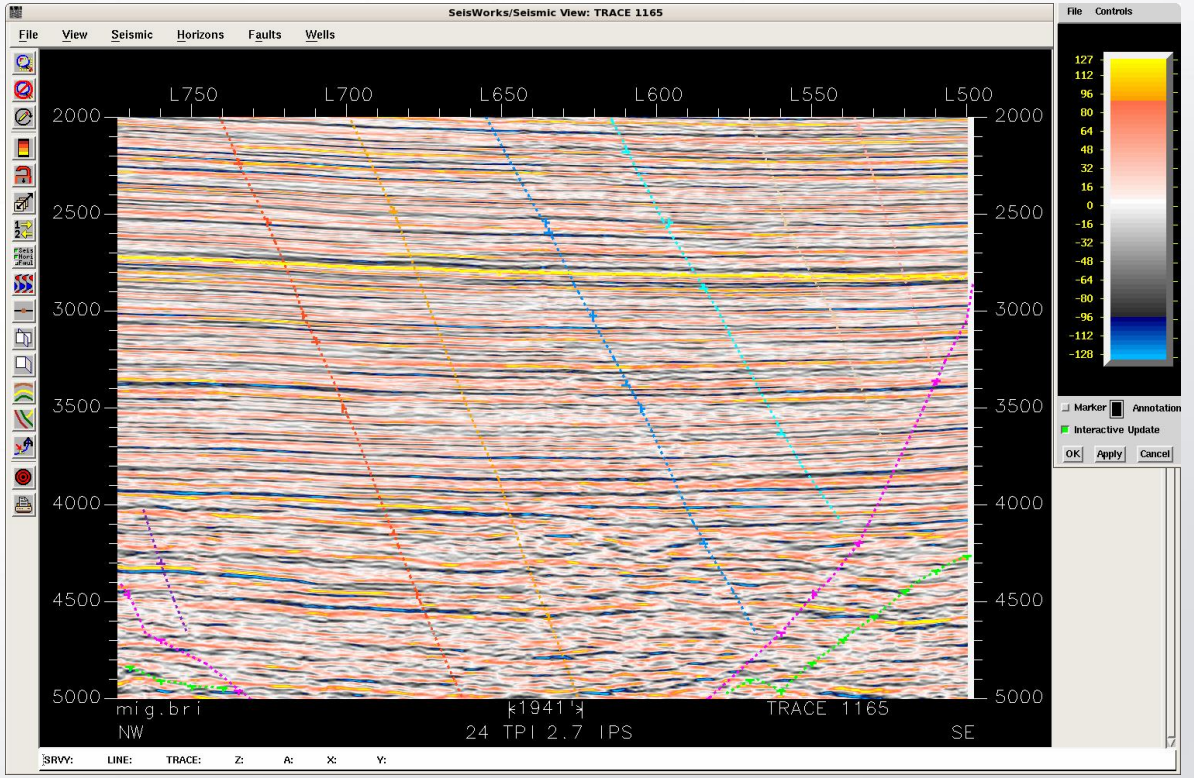
# In-Line 580 and Trace 1165 from Louisiana 3-D seismic survey



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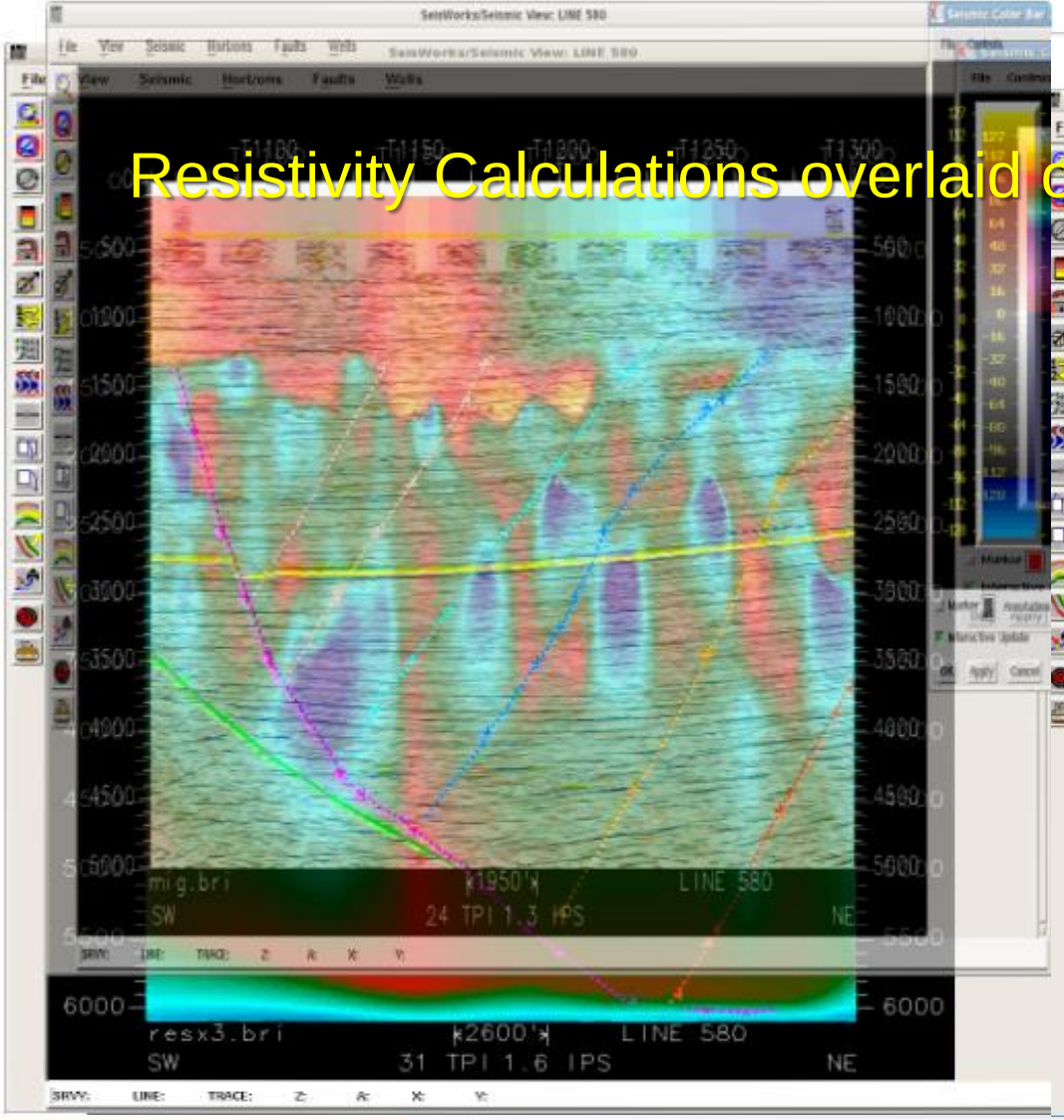
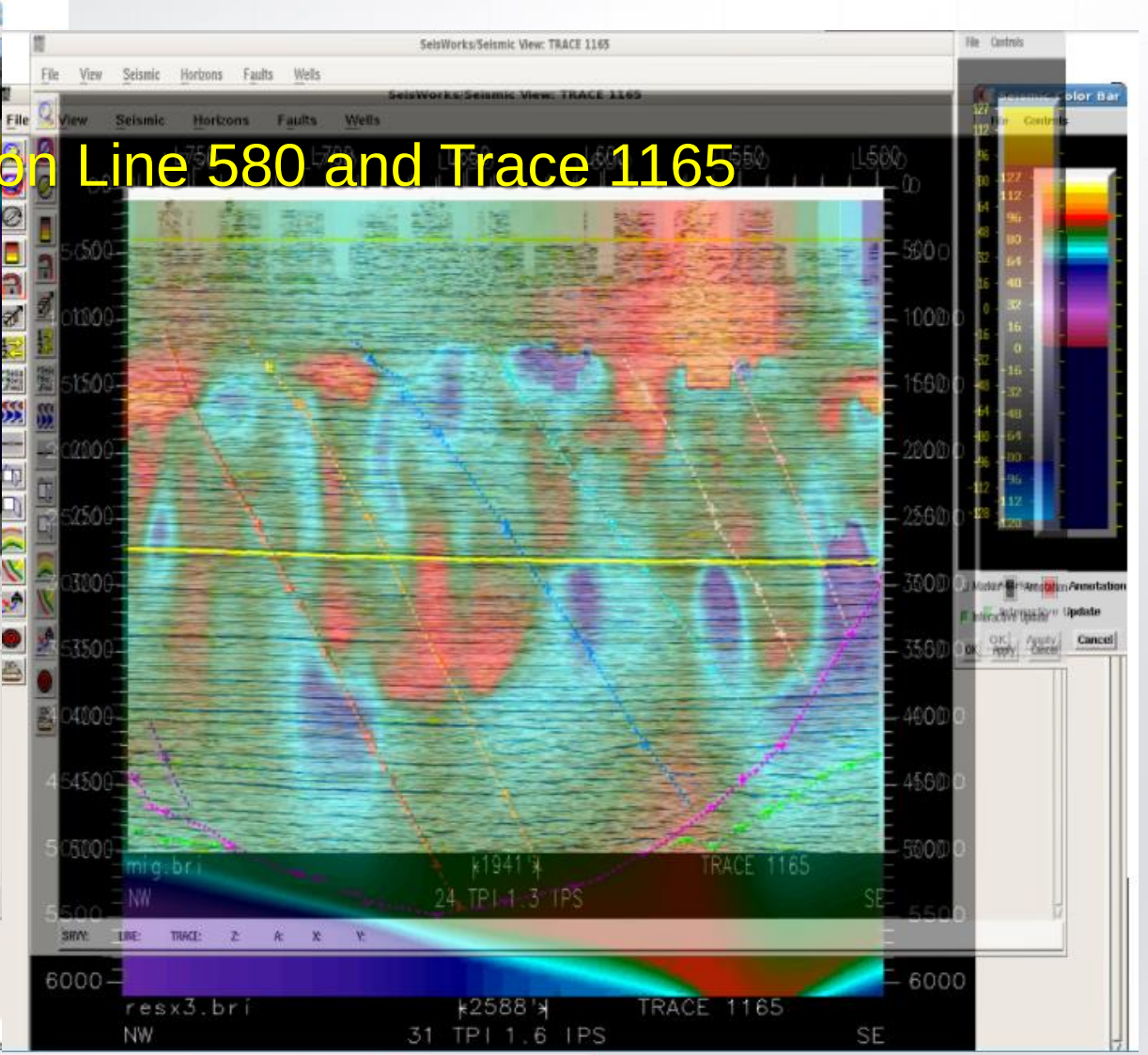
# Resistivity Calculations overlaid on Line 580 and Trace 1165



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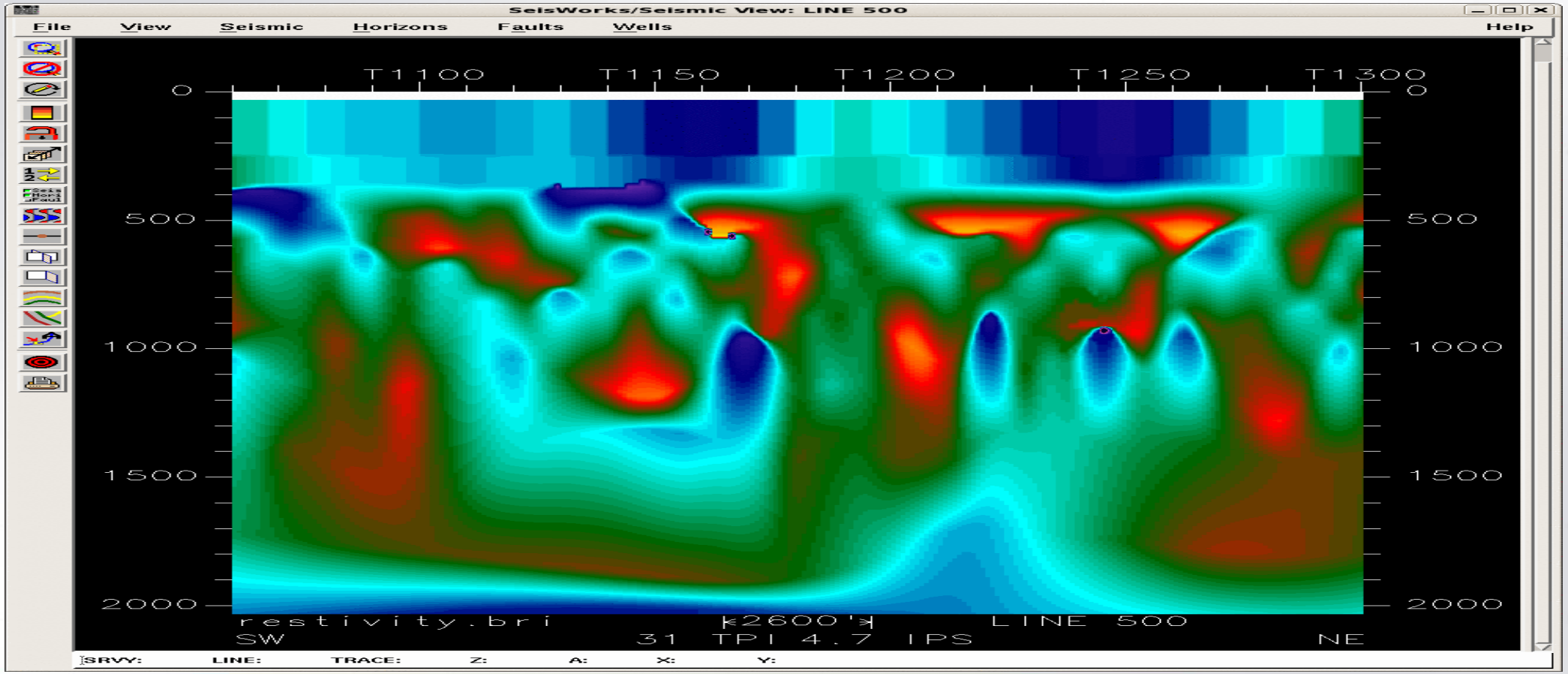
# In-Line Animation of Resistivity Sections



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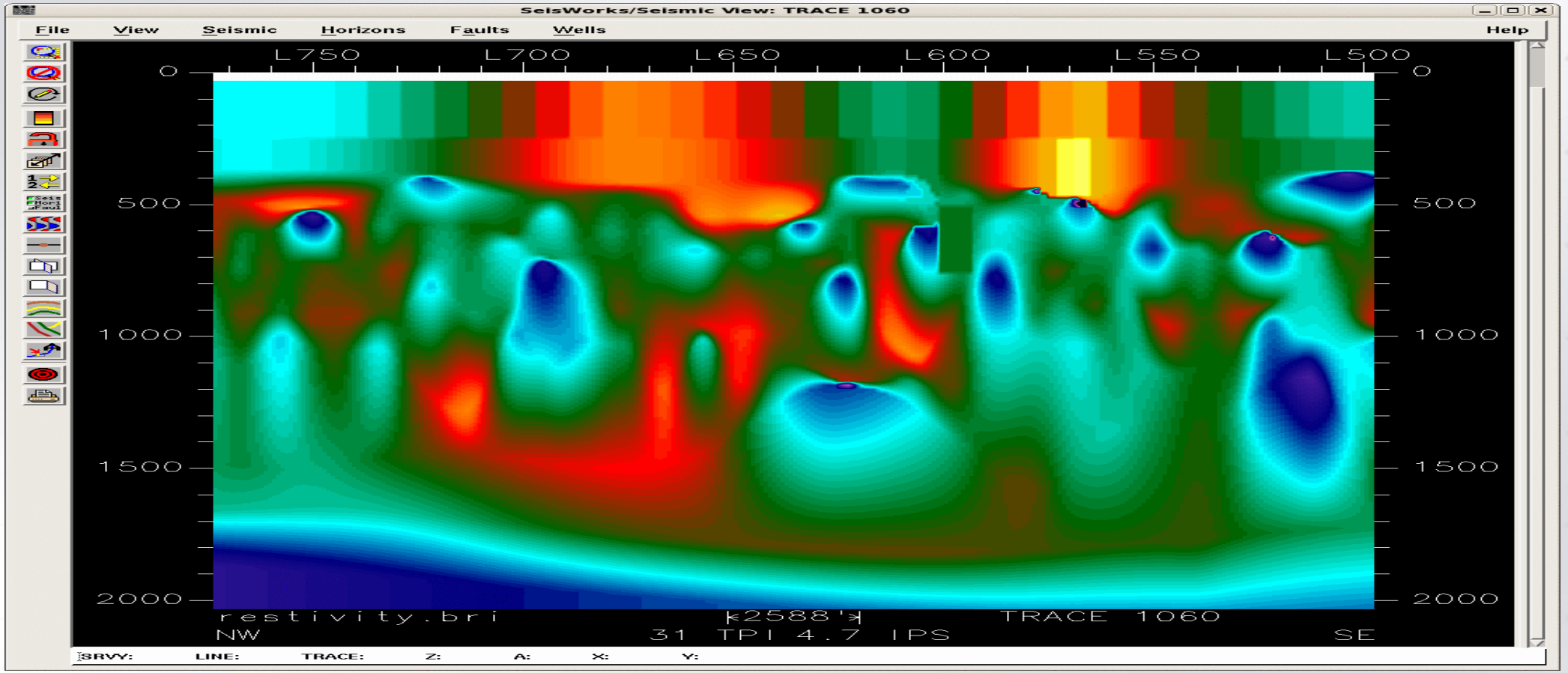
# Cross-Line Animation of Resistivity Cross-Sections



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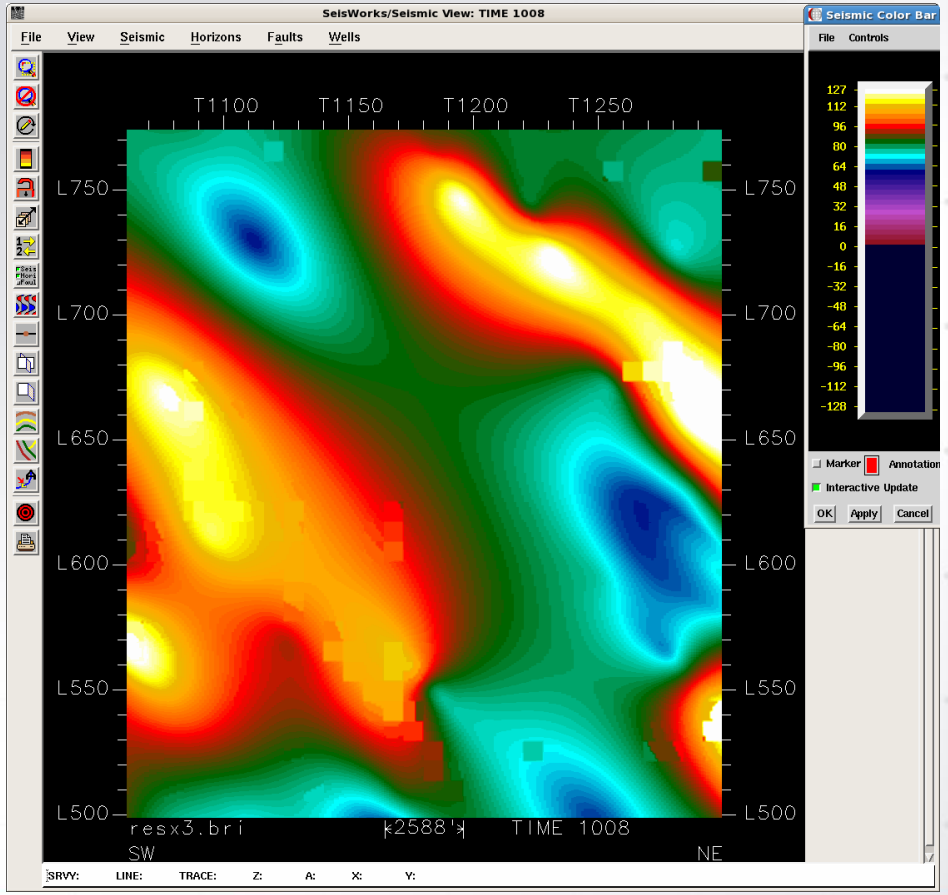
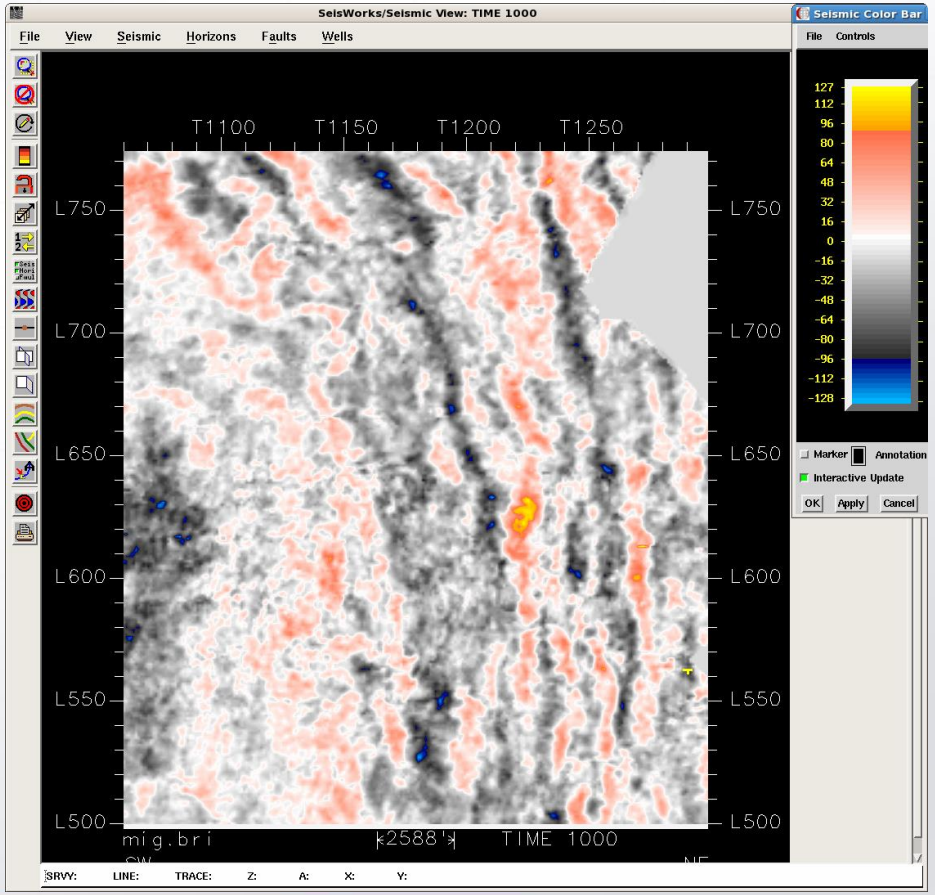
# After First Pass Vertical Calibration, Time-Slice 1000 ms





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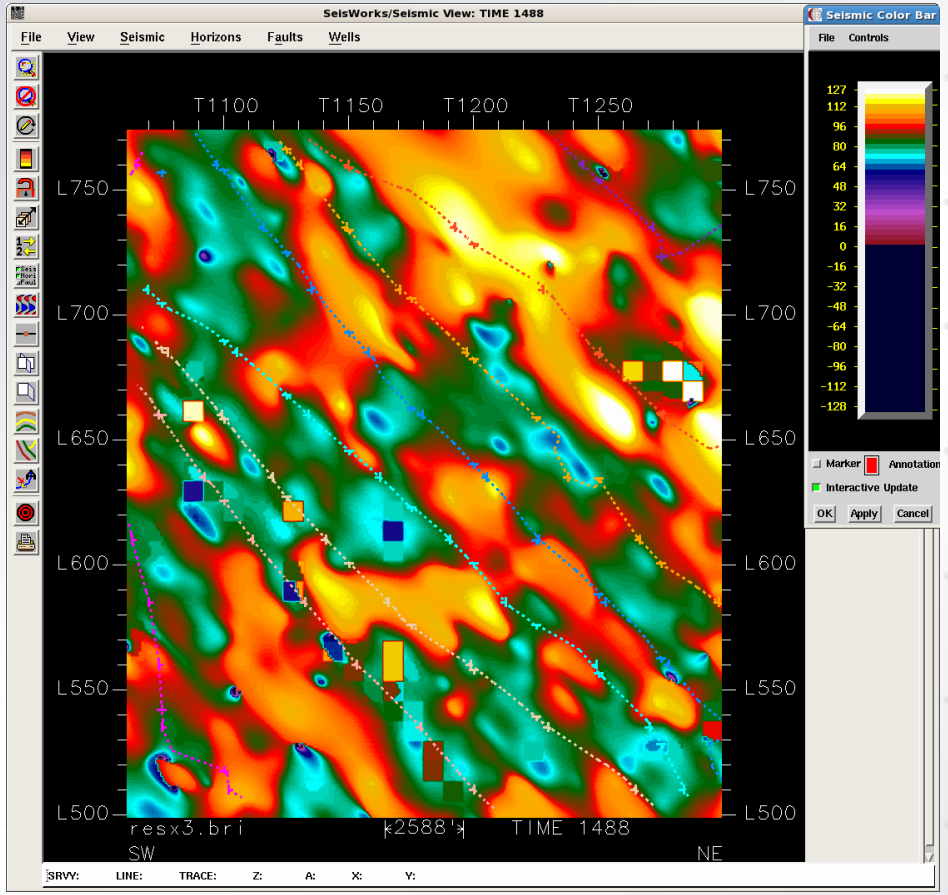
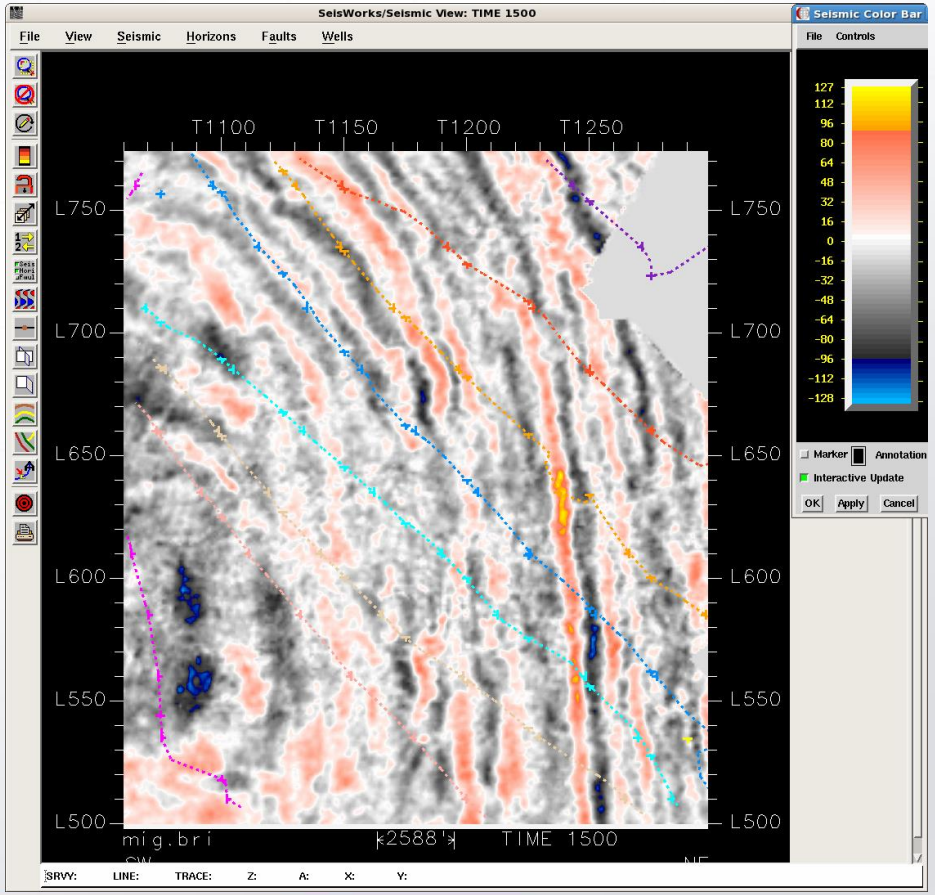
# Resistivity-Slice on left and Seismic Time-Slice at 1500 ms on right





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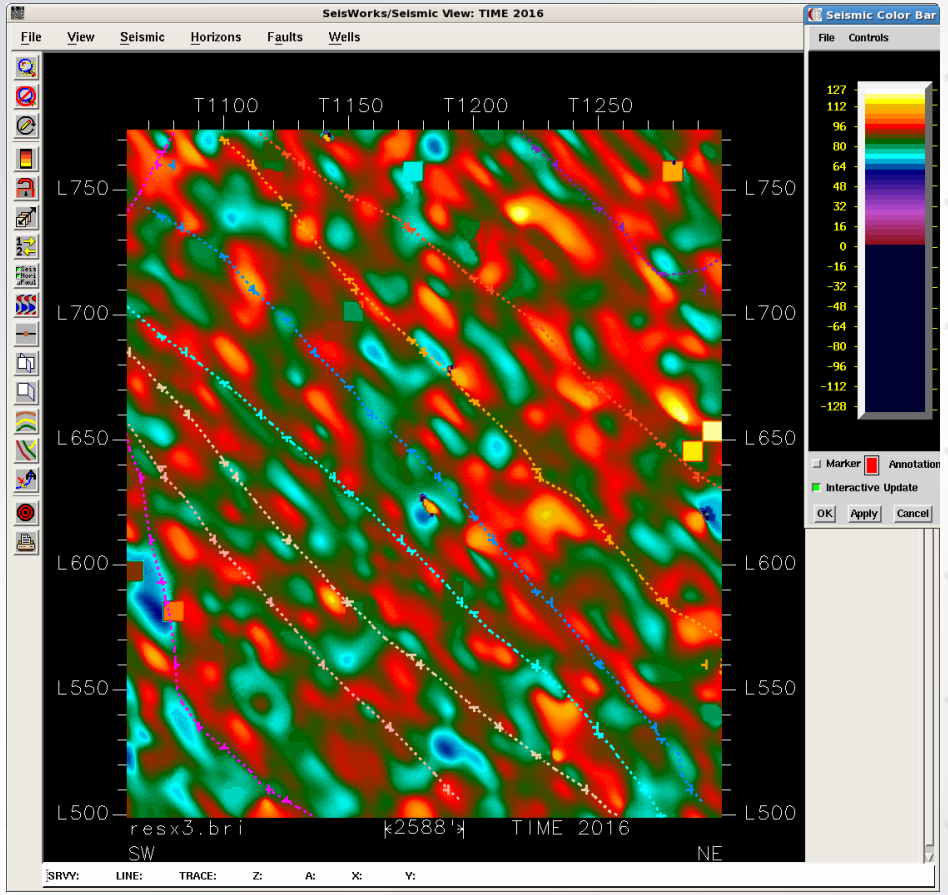
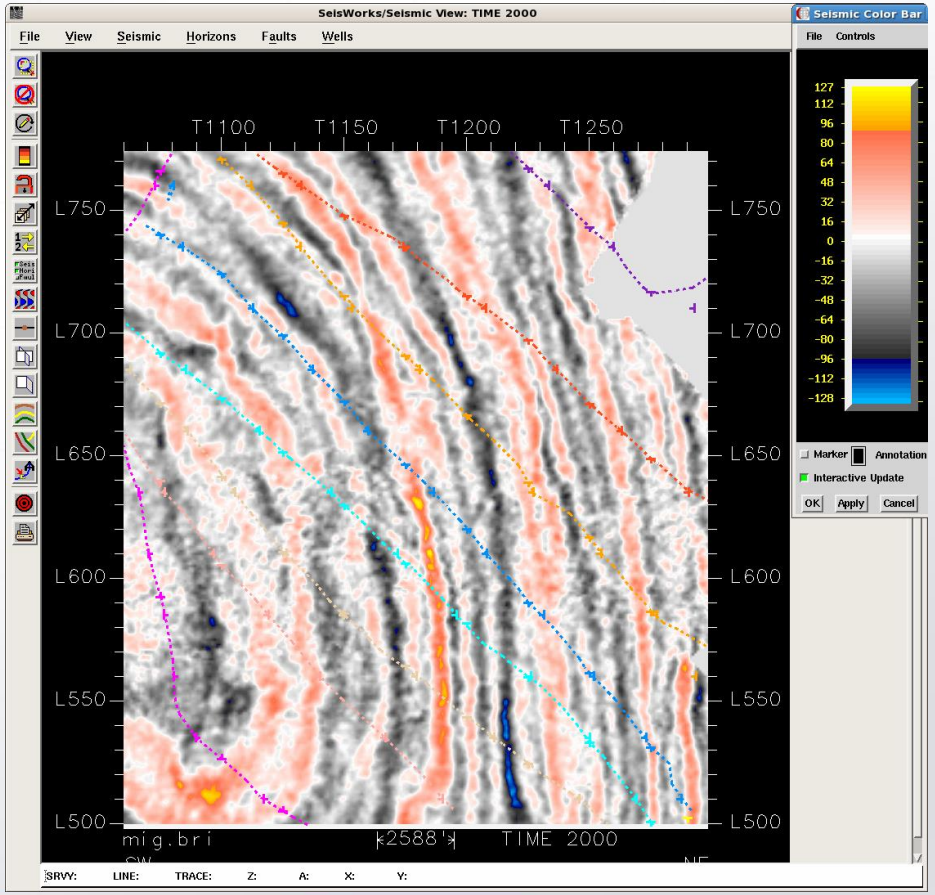
# Resistivity-Slice on left and Seismic Time-Slice at 2000 ms on right





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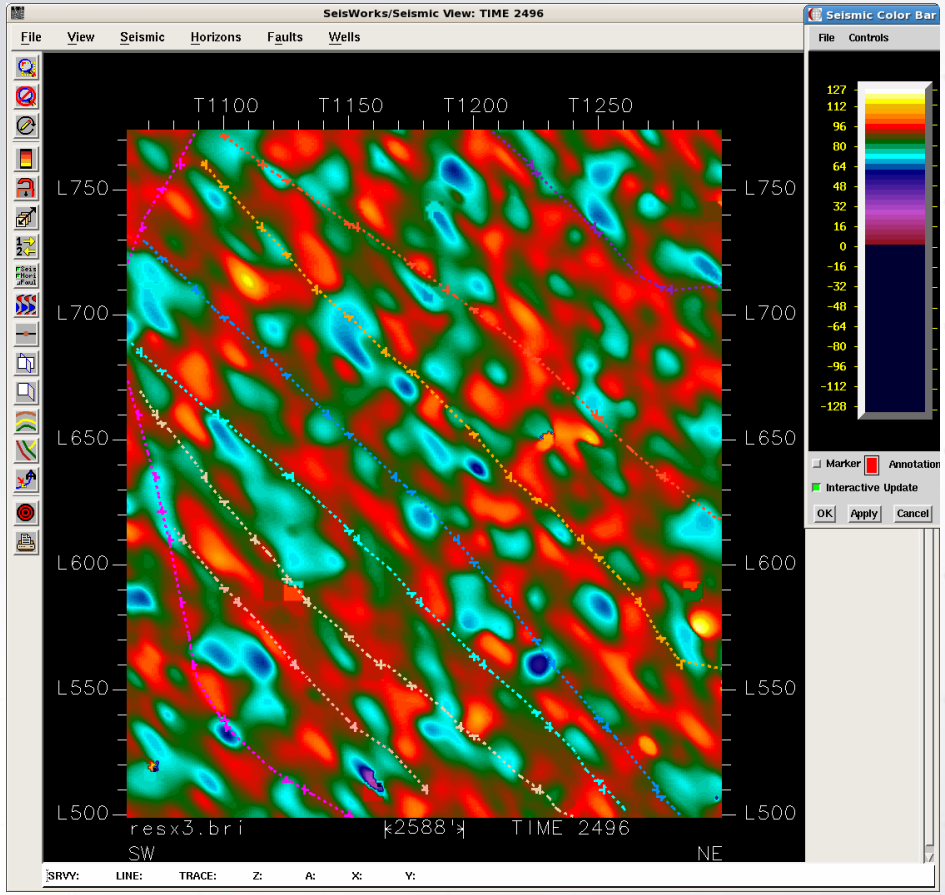
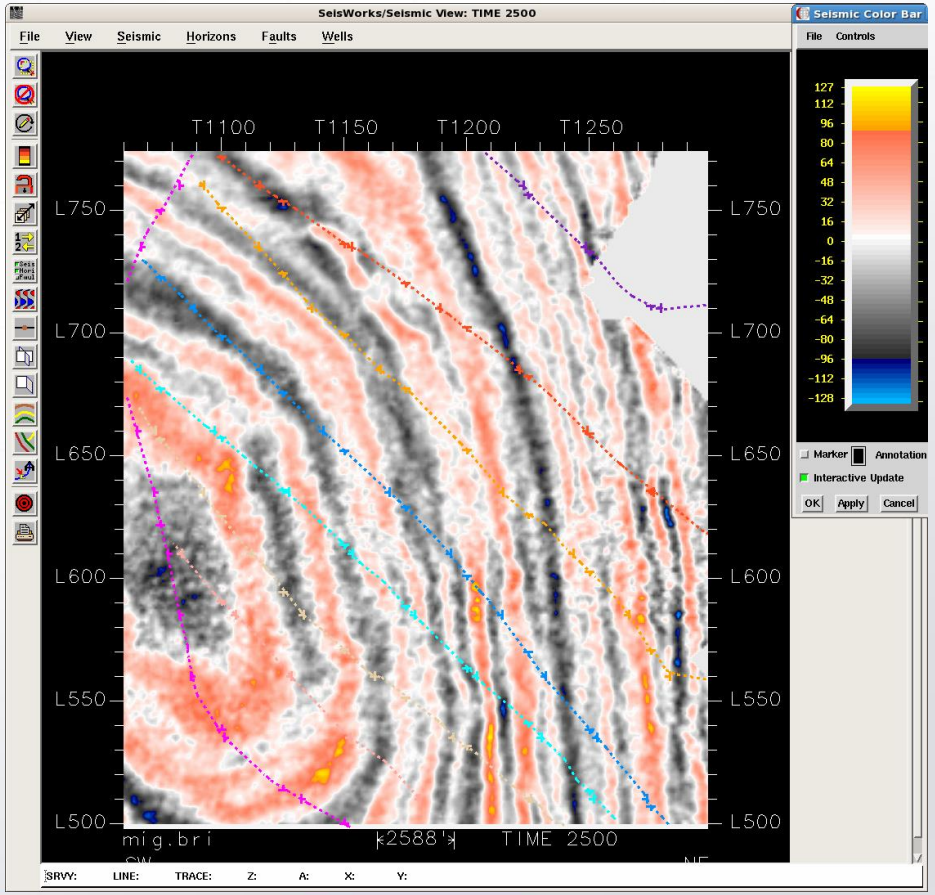
# Resistivity-Slice on left and Seismic Time-Slice at 2500 ms on right





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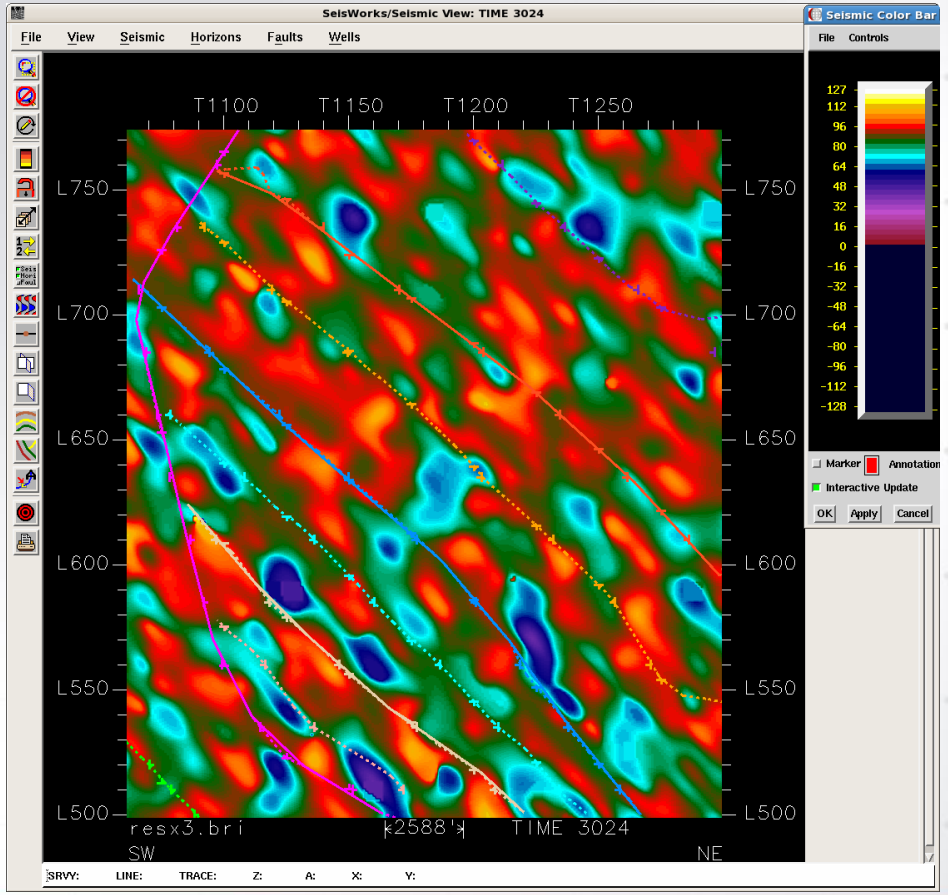
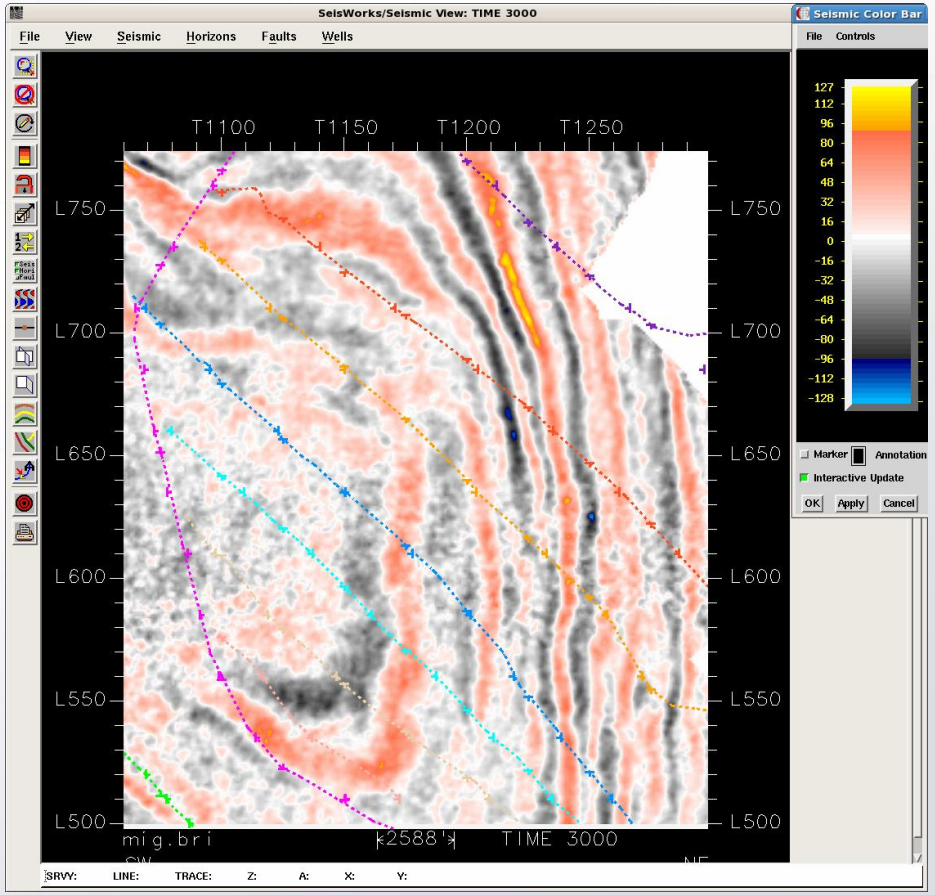
# Resistivity-Slice on left and Seismic Time-Slice at 3000 ms on right





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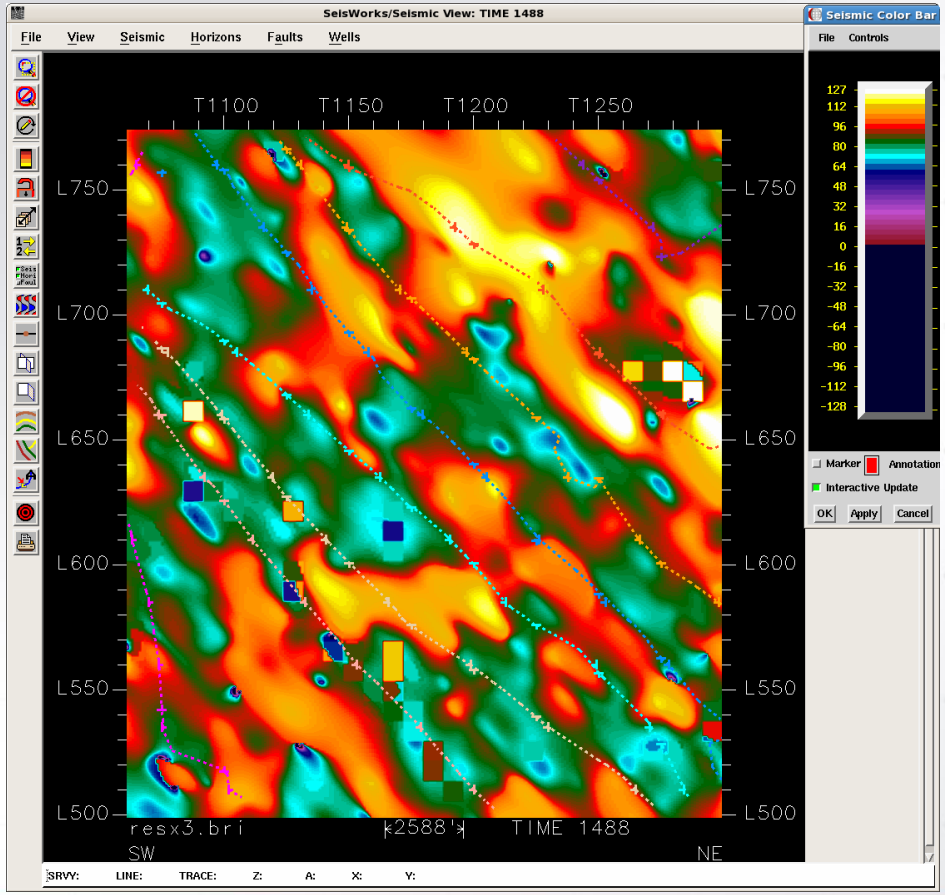
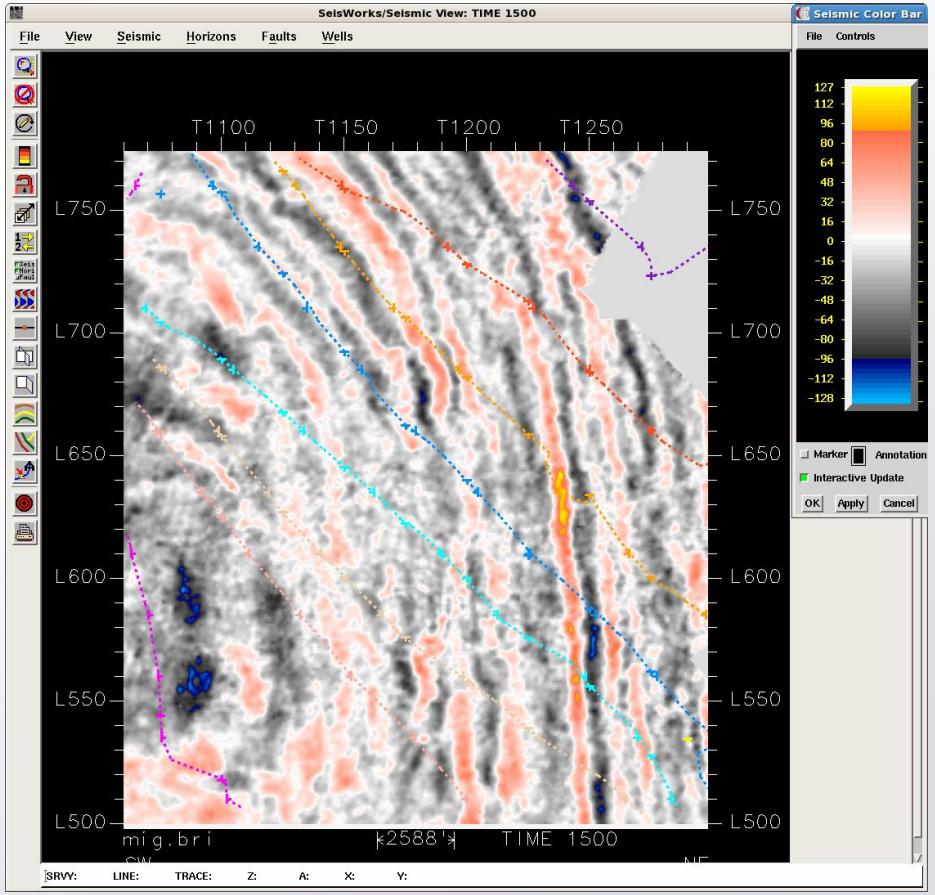
# Resistivity-Slice on left and Seismic Time-Slice at 3500 ms on right





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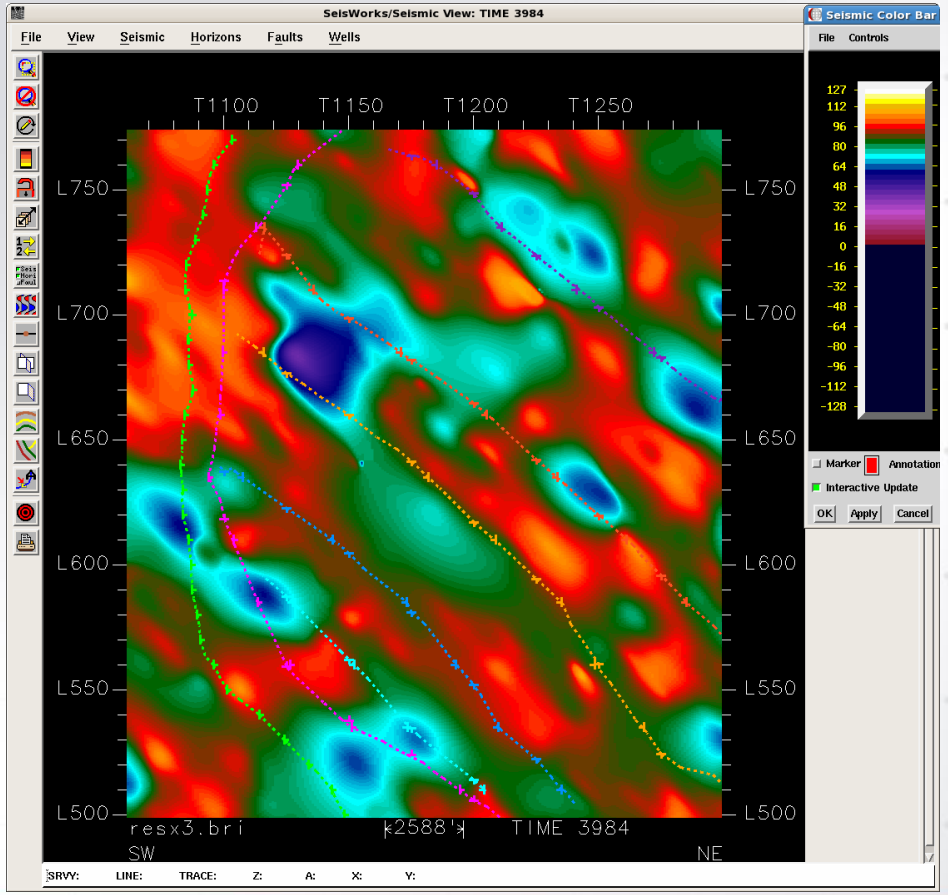
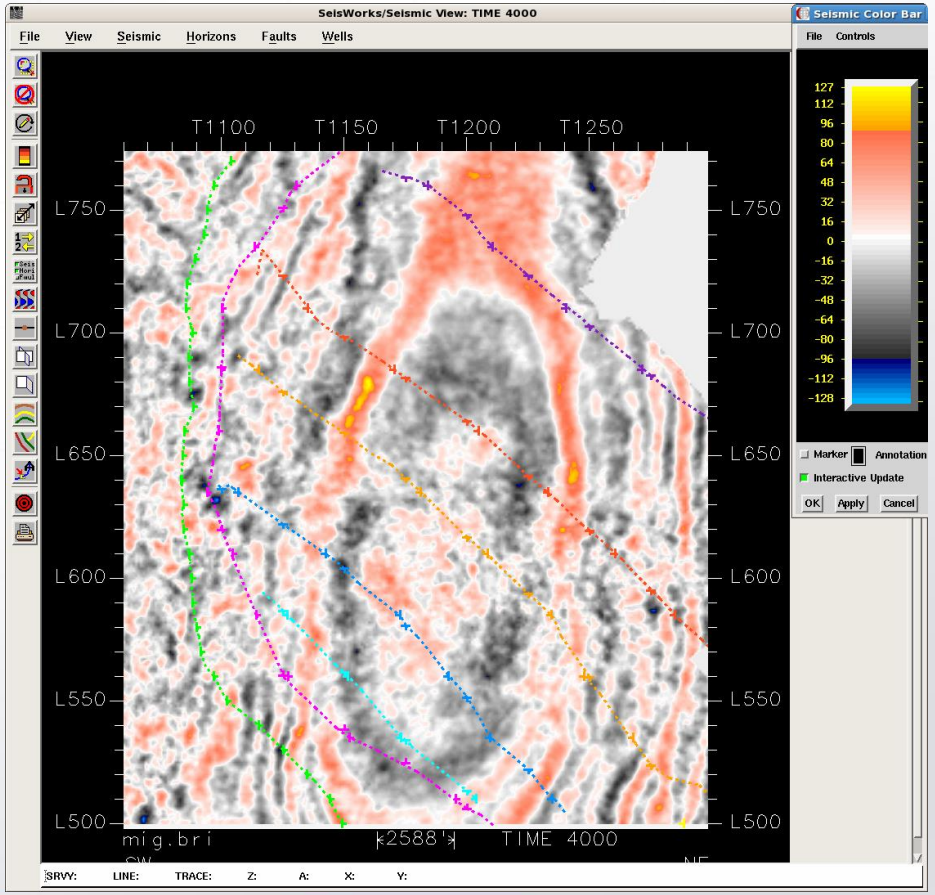
# Resistivity-Slice on left and Seismic Time-Slice at 4000 ms on right





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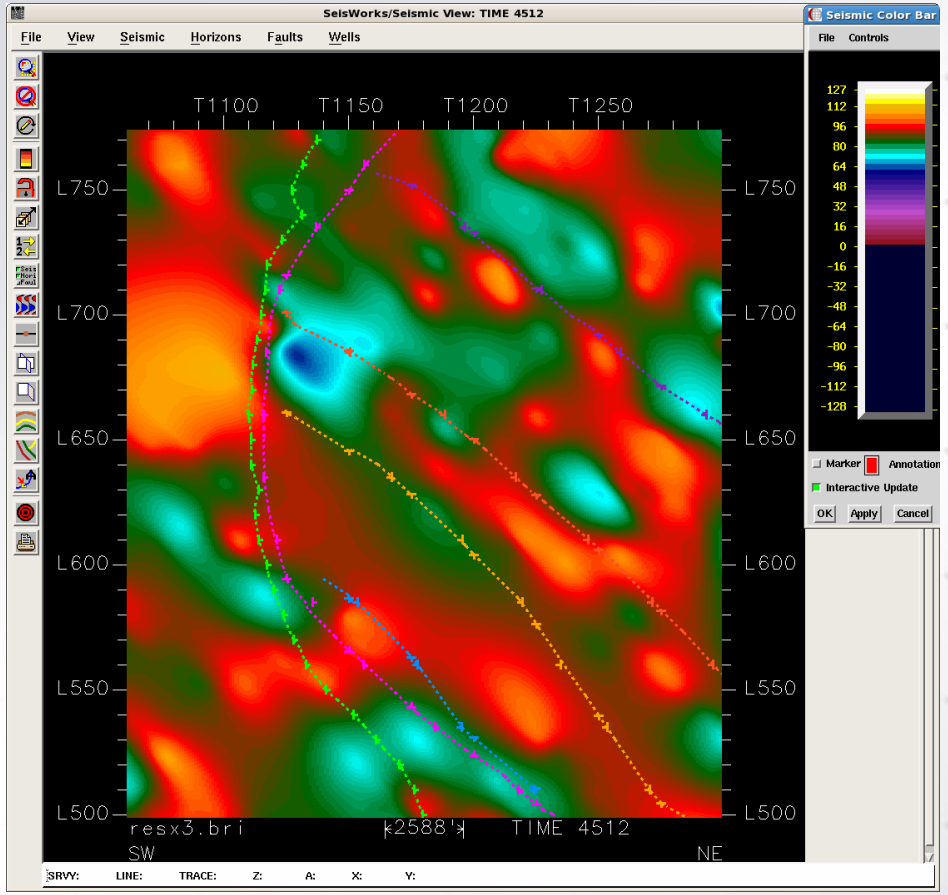
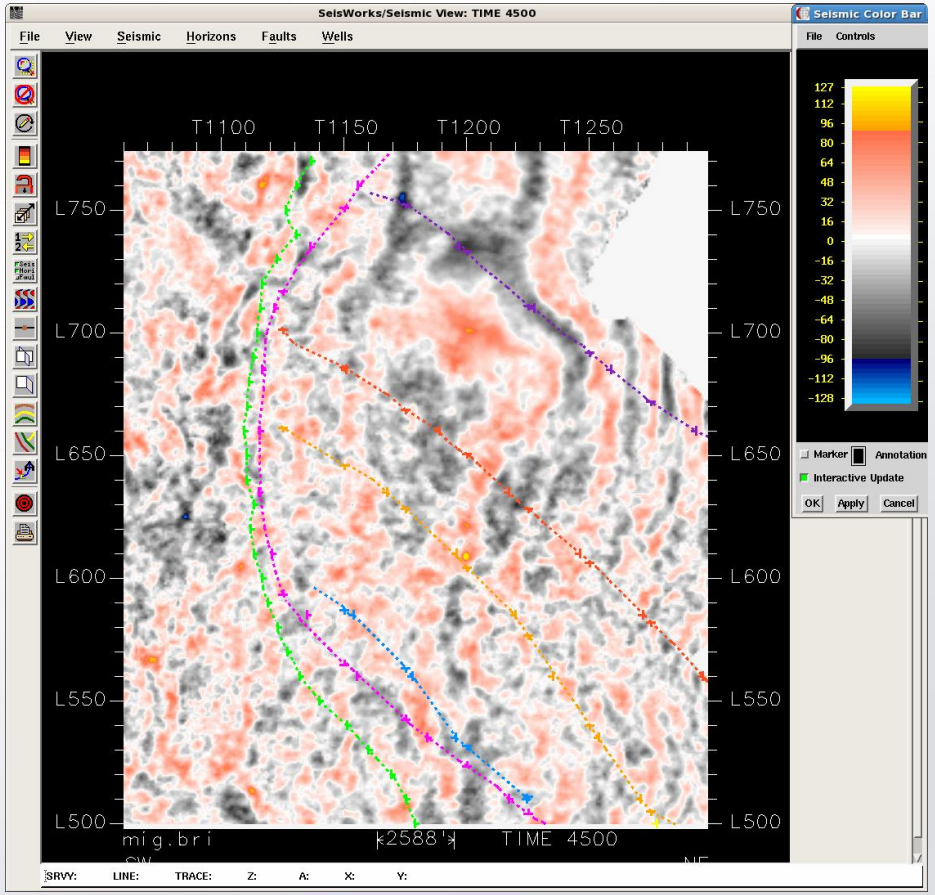
# Resistivity-Slice on left and Seismic Time-Slice at 4500 ms on right





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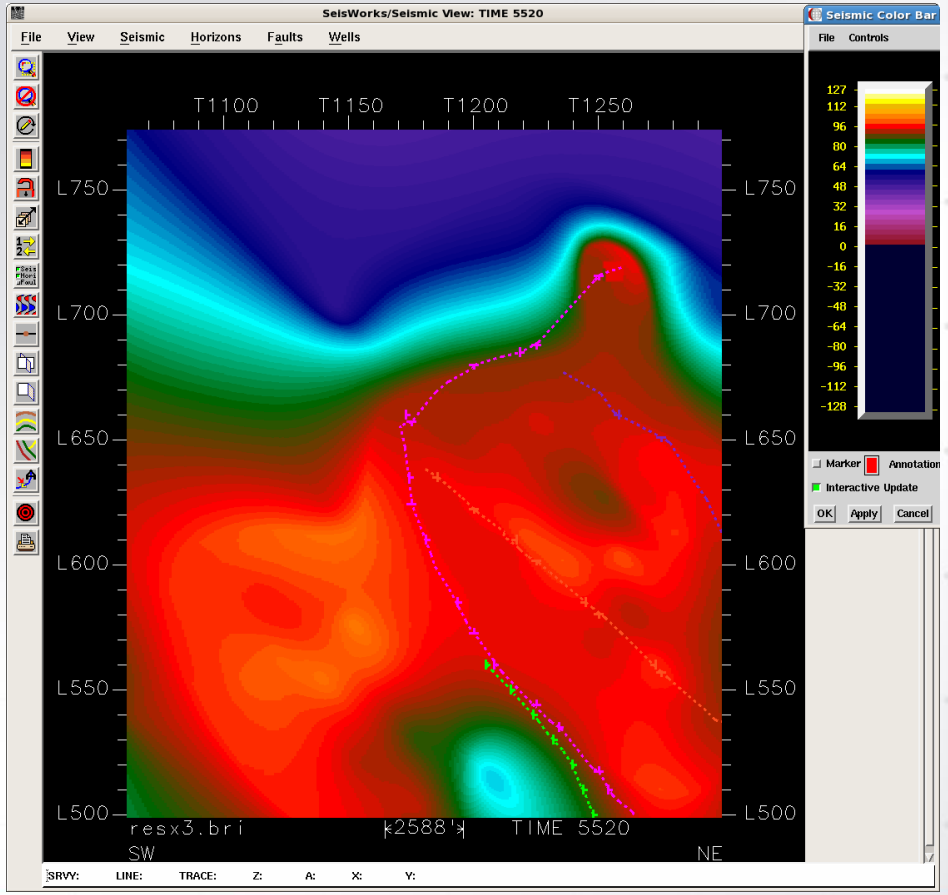
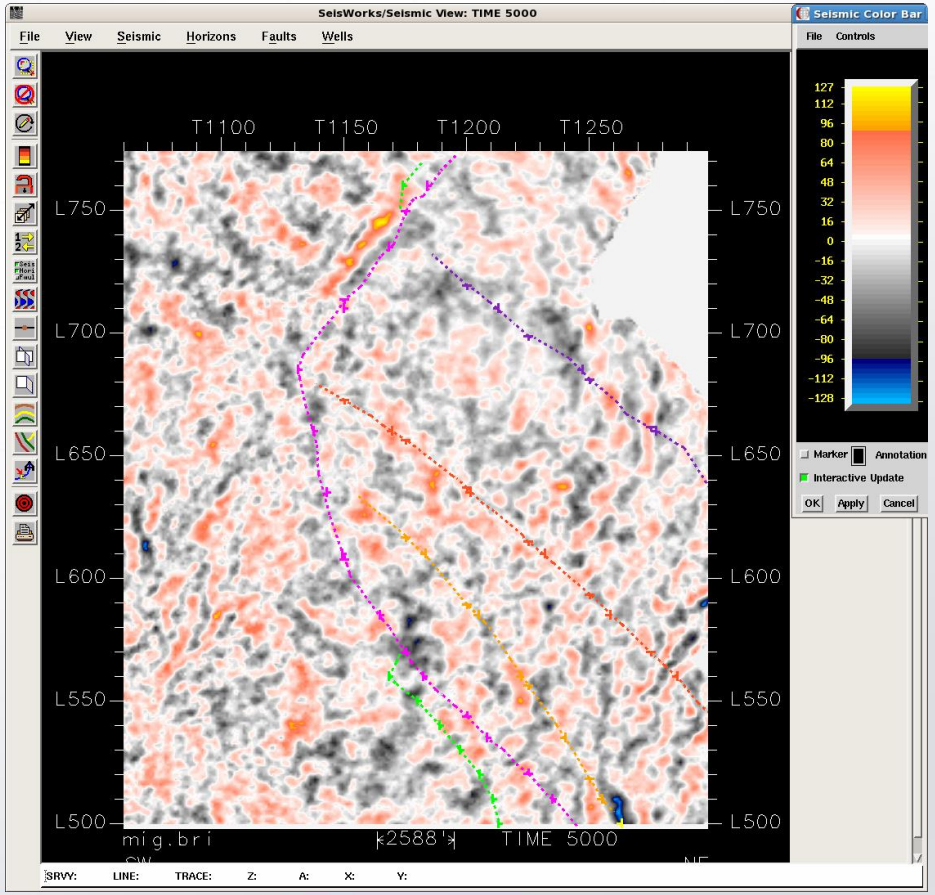
# Resistivity-Slice on left and Seismic Time-Slice at 5000 ms on right

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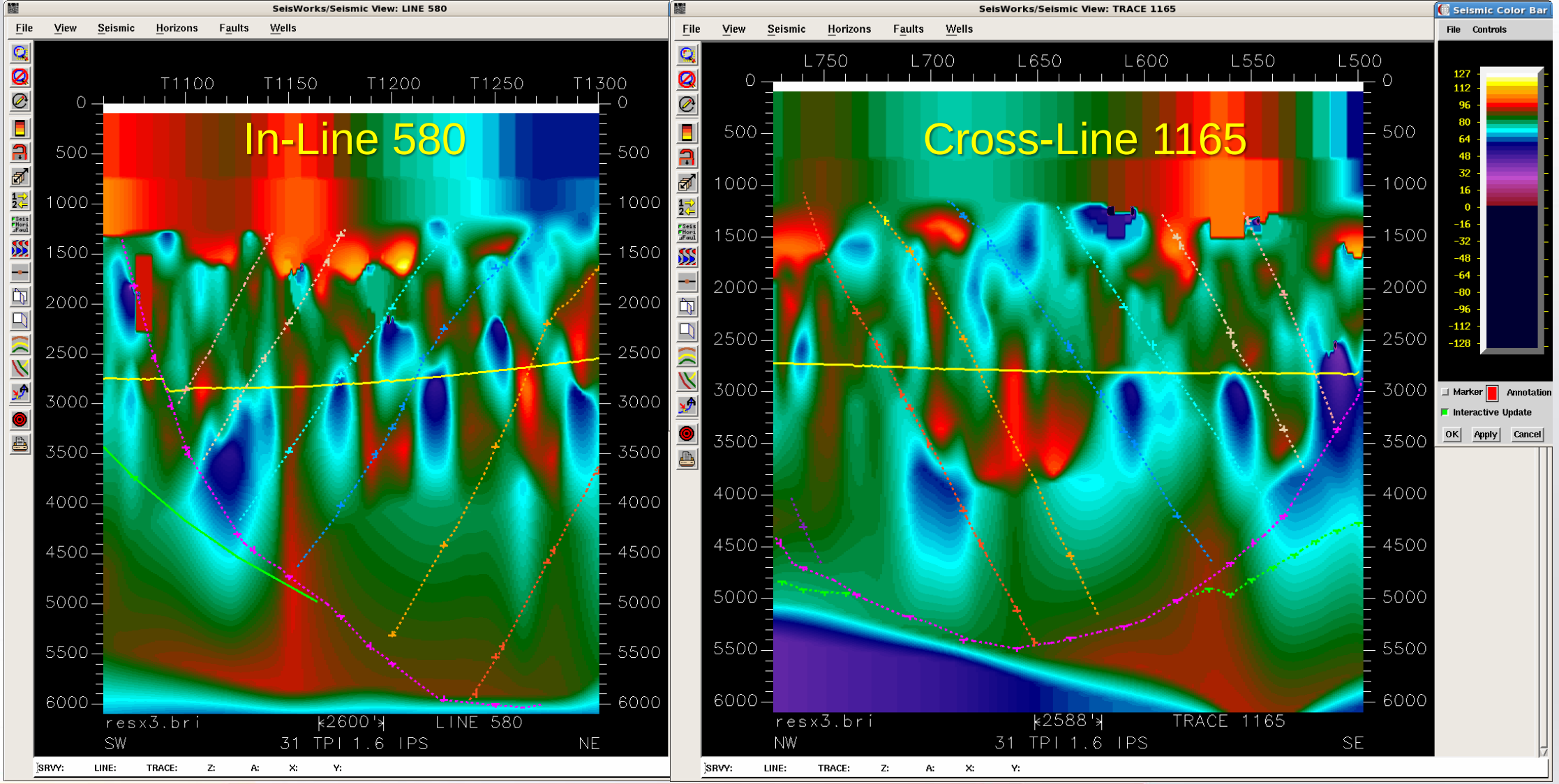




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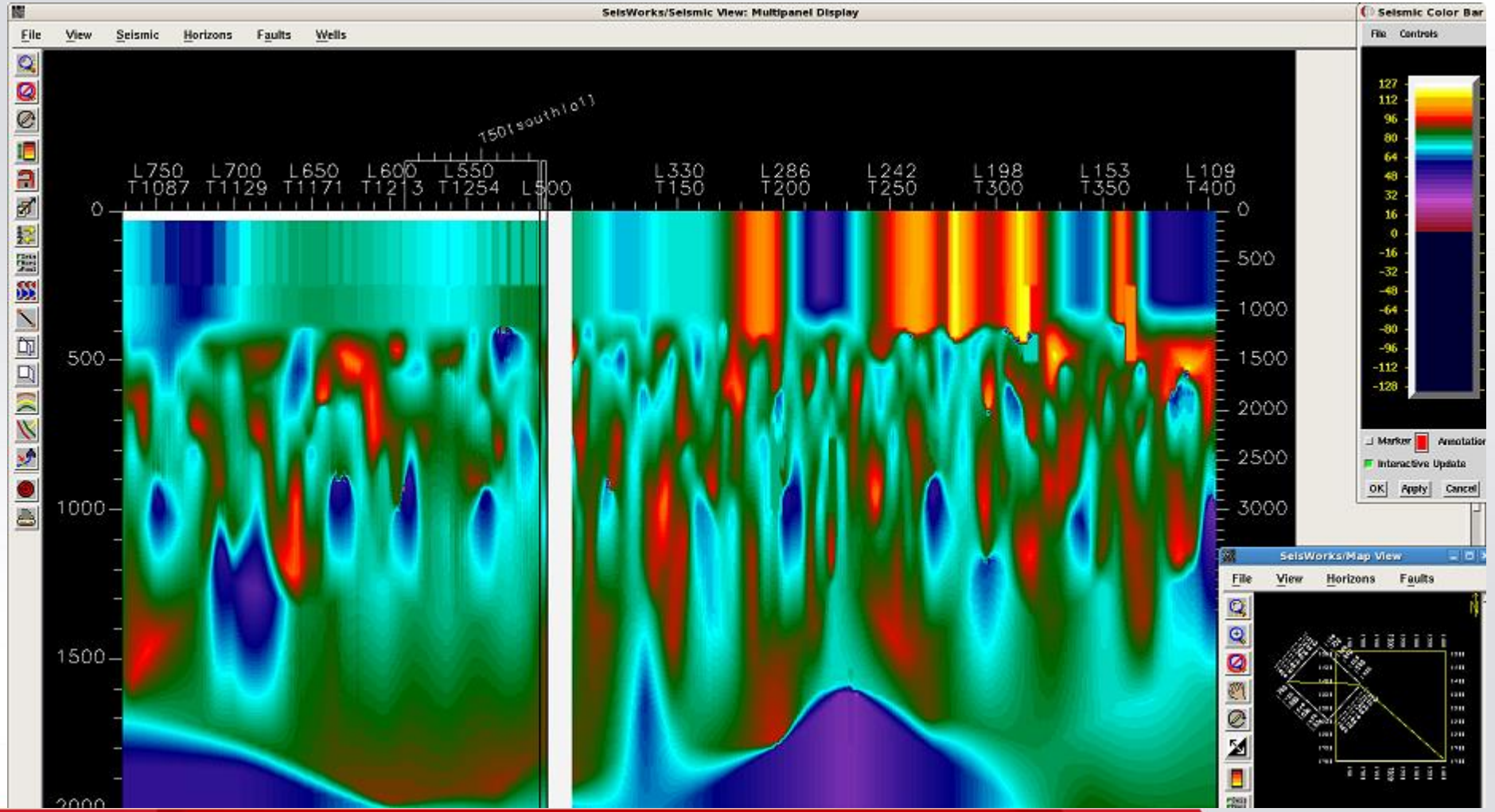
# Giant businesses are built on measuring subsurface resistivity



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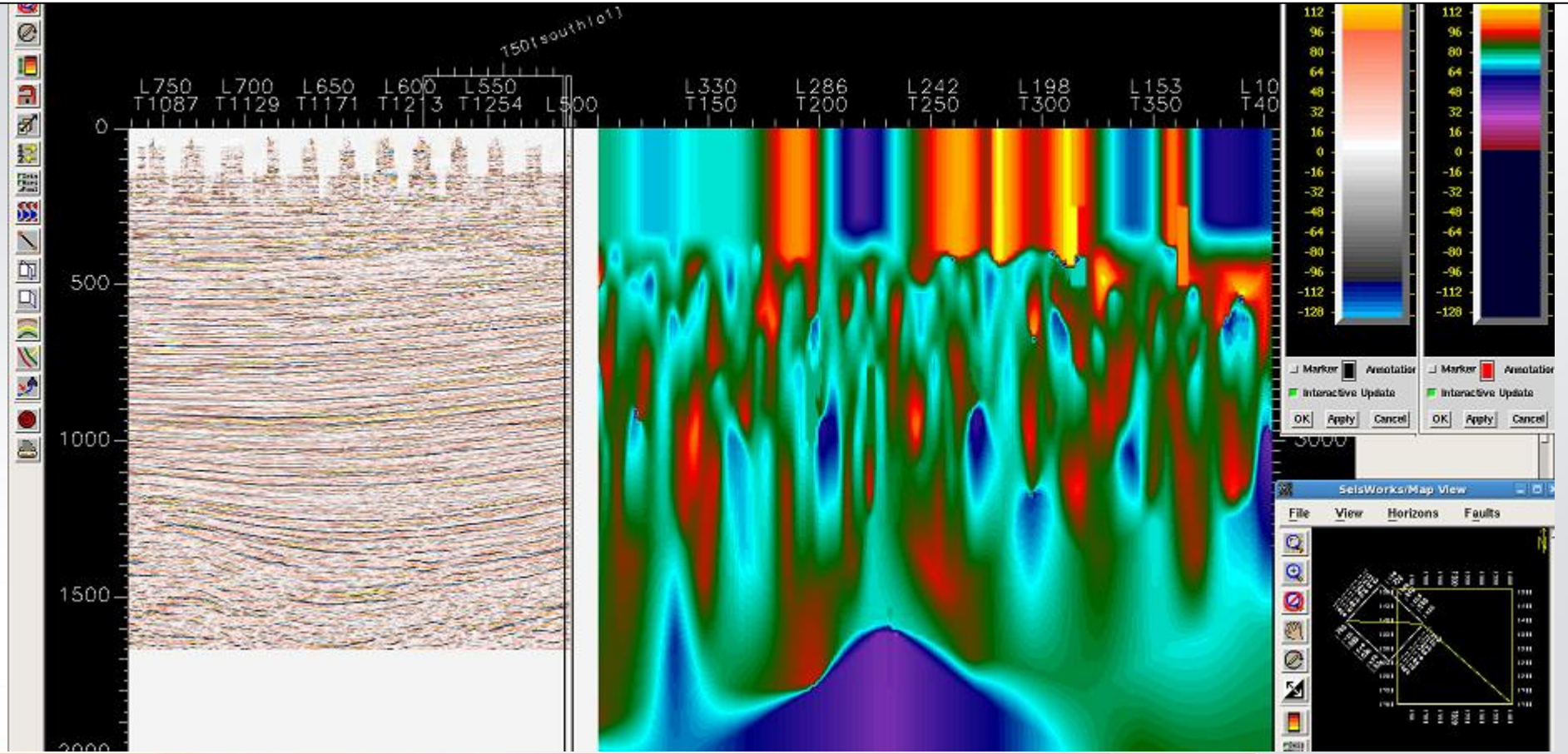
# Giant businesses are built on measuring subsurface resistivity
# DML calculates resistivity volumes at 3-D seismic line & trace spacing



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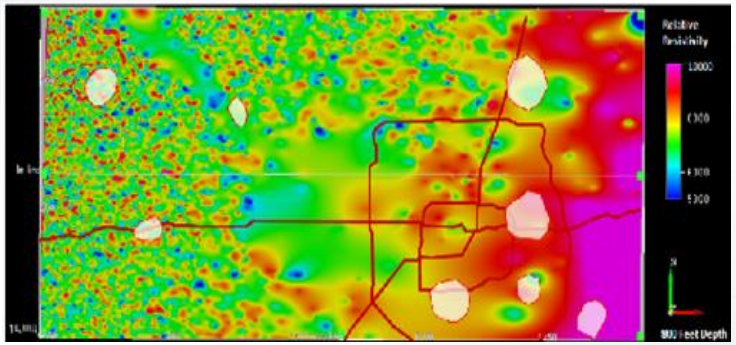
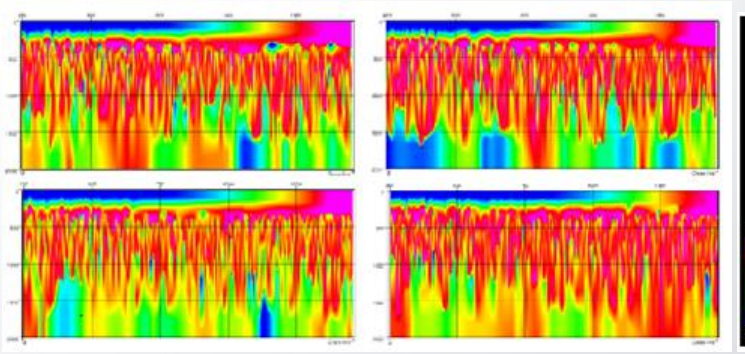
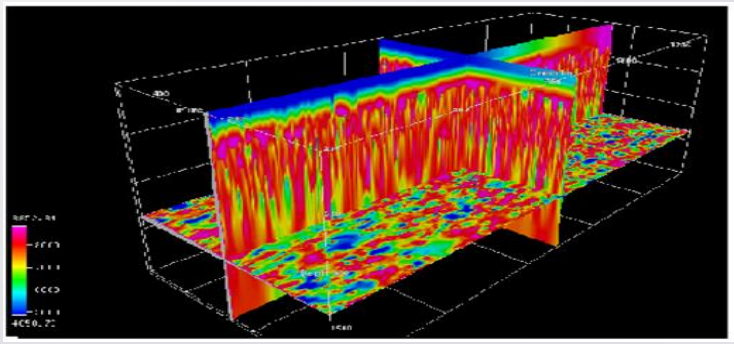
# How this new data type can aid reservoir characterization

- Lightning attribute maps identify lineaments related to faulting
- Lightning resistivity volumes provides an independent view of geology
- Lightning resistivity volumes can be created to match 3-D geometry
- We anticipate a merger of resistivity volumes and lithology predictions from velocity volumes via Archie's equation going forward







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# The Business Value of Lightning Analysis

**Scenario 1**

**Company A has a $2 million seismic budget**

- Where is the optimal location for new seismic?
- Which of the $2 million worth of spec seismic is best to purchase?

**Scenario 2**

**Company B has millions of acres of leases about to expire**

- How do they identify and **rank** the sweet spots?
- What leases need to be retained?

**ANSWER: Conduct a lightning analysis**


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# Summary

- Lighting Databases provide a new geophysical data type
- Data mining lightning databases is an example of innovation
- Lightning occurs everywhere, and databases are available
- Topography, vegetation, & infrastructure not primary location controls
- Lightning analysis works at regional, play fairway, & prospect scales
- Resistivity volumes are impacting 3D seismic interpretations
- This new data type aids reservoir characterization


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# See Lightning, Think DML

- Contact Information:
  - H. Roice Nelson, Jr.

    cell: 713.542.2207

    e-mail: roice@dynamicmeasurement.com
  - Dr. Jim Siebert

    cell: 832.423.2355

    e-mail: jim@dynamicmeasurement.com
  - Les R. Denham

    cell: 281.879.6010

    e-mail: les@dynamicmeasurement.com

- www.dynamicmeasurement.com
- 211 Baker Road #382

  Barker, TX 77413

  Office: 281.579.0172
- 2155 West 700 South #31

  Cedar City, UT 84720

  Fax: 435.267.2668

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