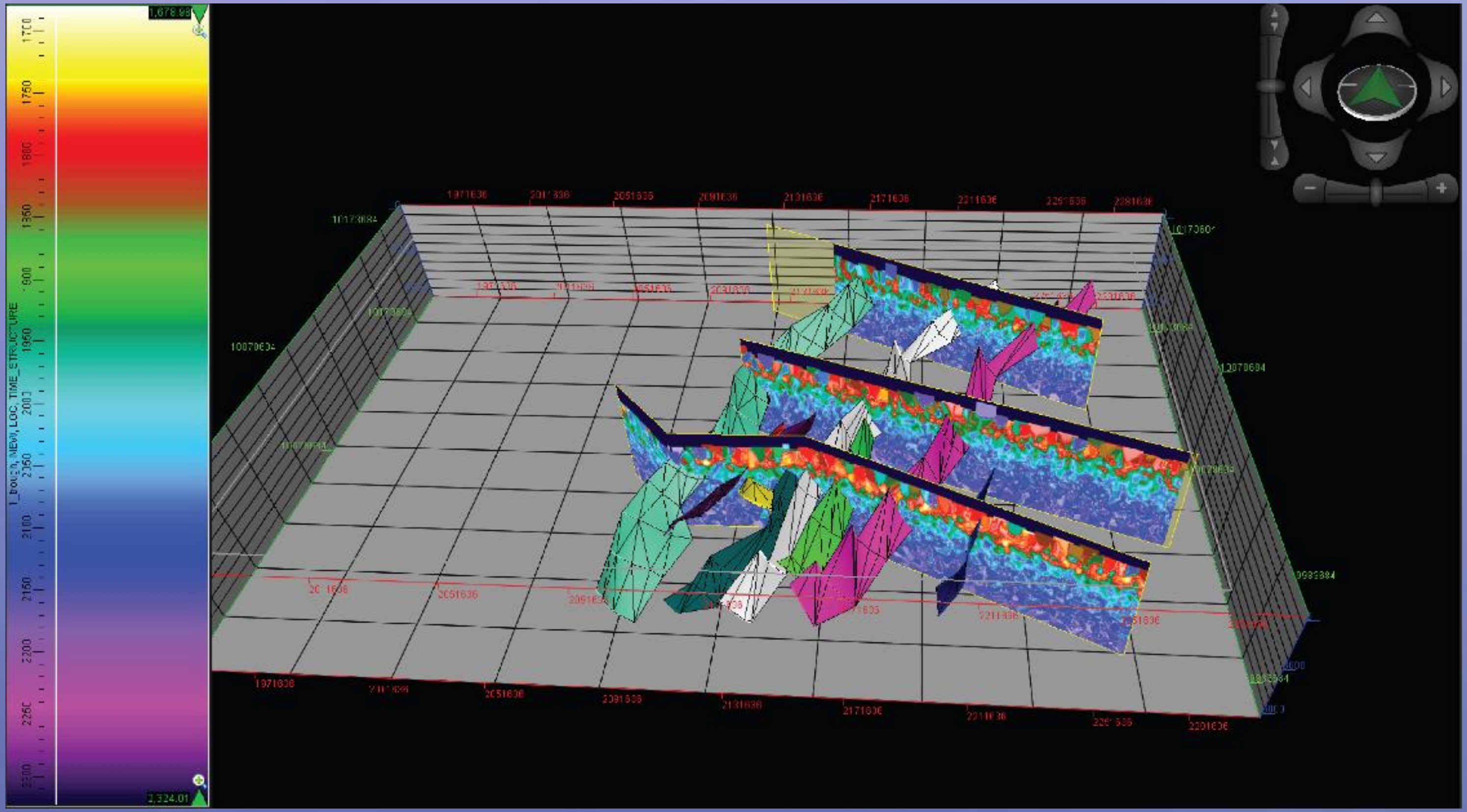
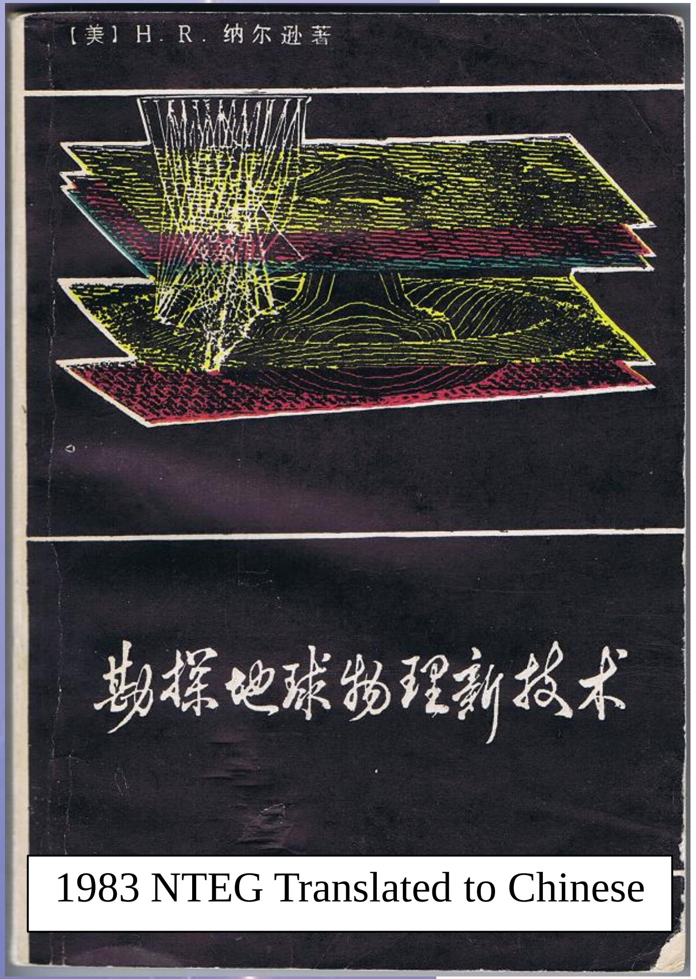
Lightning Analysis: creating geo-frameworks



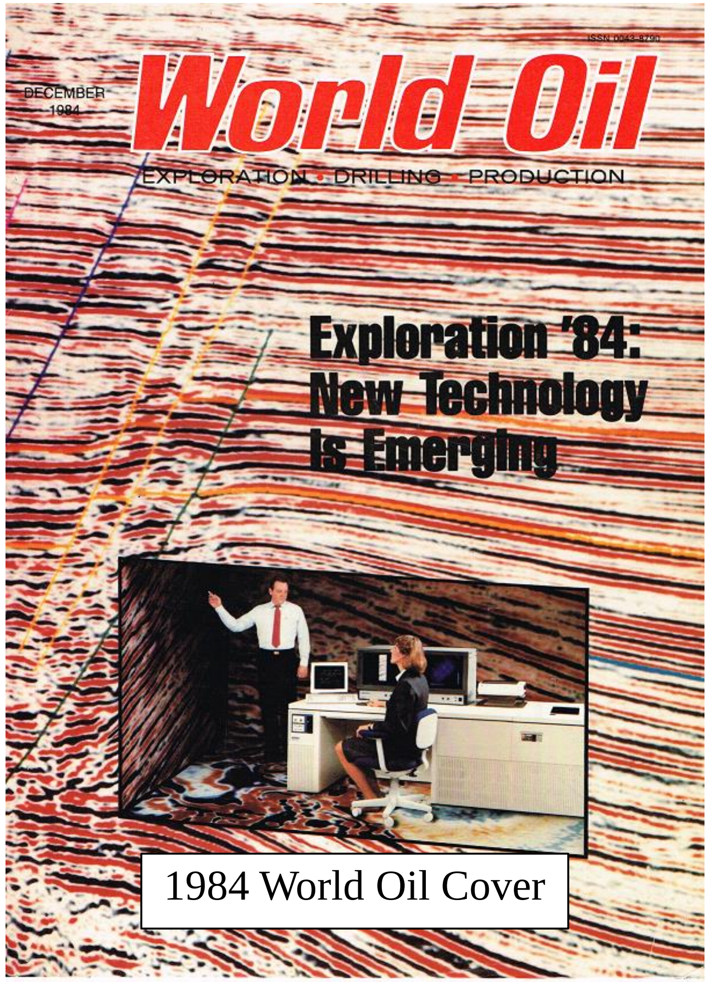
Southern Utah Rock Club
02 March 2017

H. Roice Nelson, Jr.
Dynamic Measurement LLC

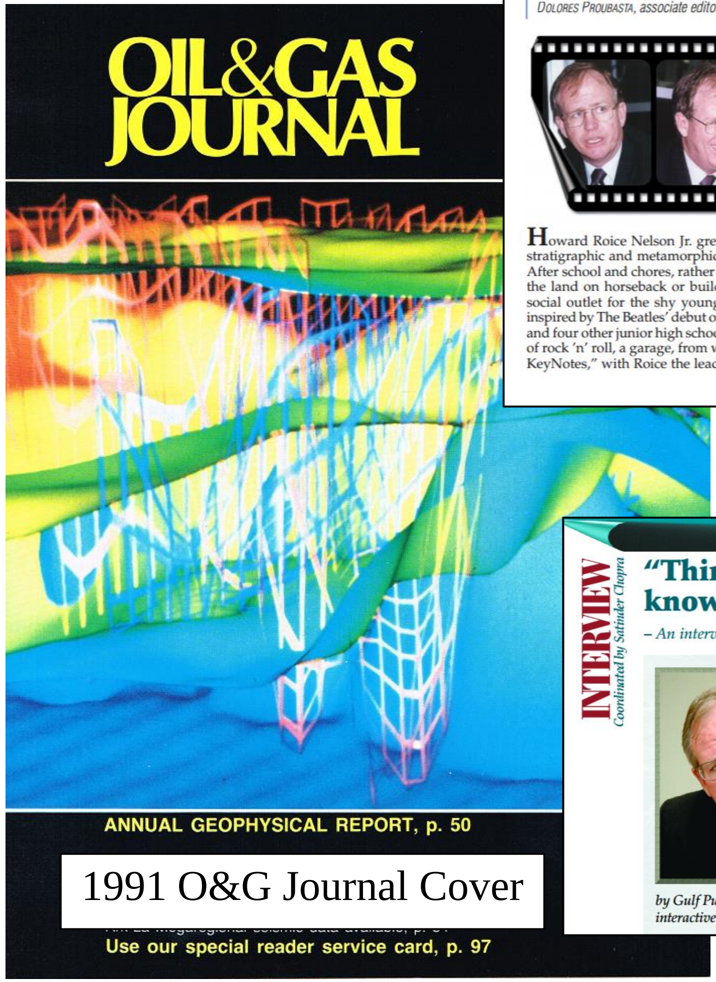
Career as geophysicist spent looking underneath the surface of the ground



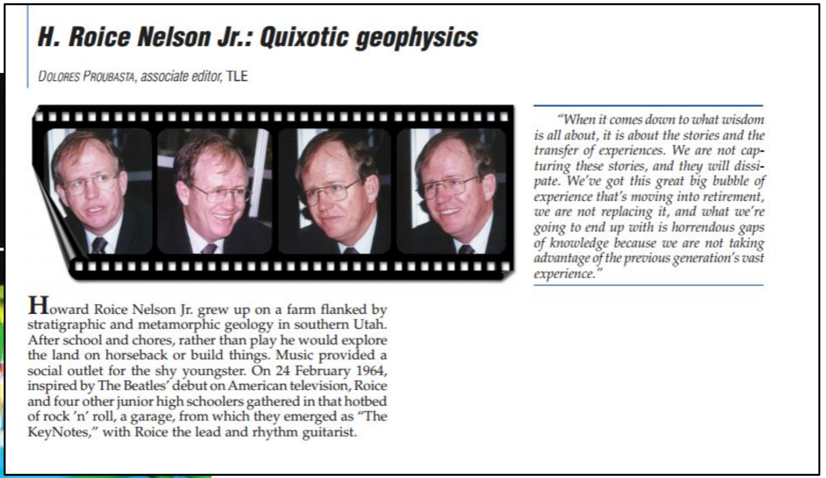
1983 NTEG Translated to Chinese



1984 World Oil Cover



1991 O&G Journal Cover



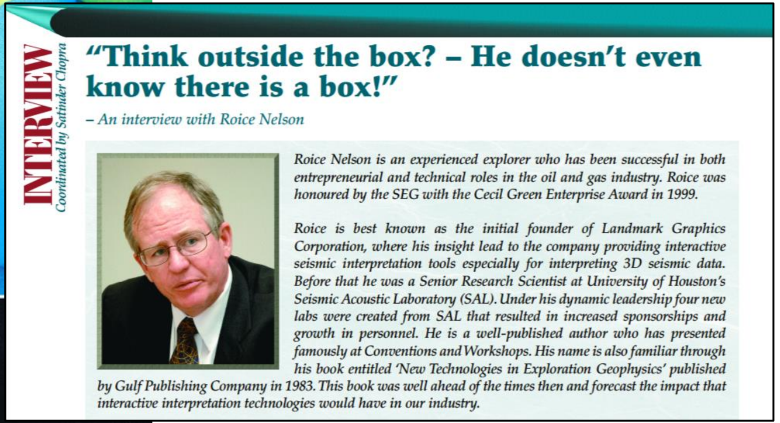
H. Roice Nelson Jr.: Quixotic geophysics

Dolores Proubasta, associate editor, TLE

"When it comes down to what wisdom is all about, it is about the stories and the transfer of experiences. We are not capturing these stories, and they will dissipate. We've got this great big bubble of experience that's moving into retirement, we are not replacing it, and what we're going to end up with is horrendous gaps of knowledge because we are not taking advantage of the previous generation's vast experience."

Howard Roice Nelson Jr. grew up on a farm flanked by stratigraphic and metamorphic geology in southern Utah. After school and chores, rather than play he would explore the land on horseback or build things. Music provided a social outlet for the shy youngster. On 24 February 1964, inspired by The Beatles' debut on American television, Roice and four other junior high schoolers gathered in that hotbed of rock 'n' roll, a garage, from which they emerged as "The KeyNotes," with Roice the lead and rhythm guitarist.

2003 The Leading Edge



INTERVIEW

Coordinated by Satinder Chopra

"Think outside the box? – He doesn't even know there is a box!"

– An interview with Roice Nelson

Roice Nelson is an experienced explorer who has been successful in both entrepreneurial and technical roles in the oil and gas industry. Roice was honoured by the SEG with the Cecil Green Enterprise Award in 1999.

Roice is best known as the initial founder of Landmark Graphics Corporation, where his insight lead to the company providing interactive seismic interpretation tools especially for interpreting 3D seismic data. Before that he was a Senior Research Scientist at University of Houston's Seismic Acoustic Laboratory (SAL). Under his dynamic leadership four new labs were created from SAL that resulted in increased sponsorships and growth in personnel. He is a well-published author who has presented famously at Conventions and Workshops. His name is also familiar through his book entitled 'New Technologies in Exploration Geophysics' published by Gulf Publishing Company in 1983. This book was well ahead of the times then and forecast the impact that interactive interpretation technologies would have in our industry.

2008 CSEG Recorder

DML Started with 2 Questions:

1. Can lightning hit twice at the same place?

2. Does this mean there is oil on my property?

Strikes from 1 storm (colors Peak Current) 27 Sep 2011, Hockley Dome, Harris County, TX

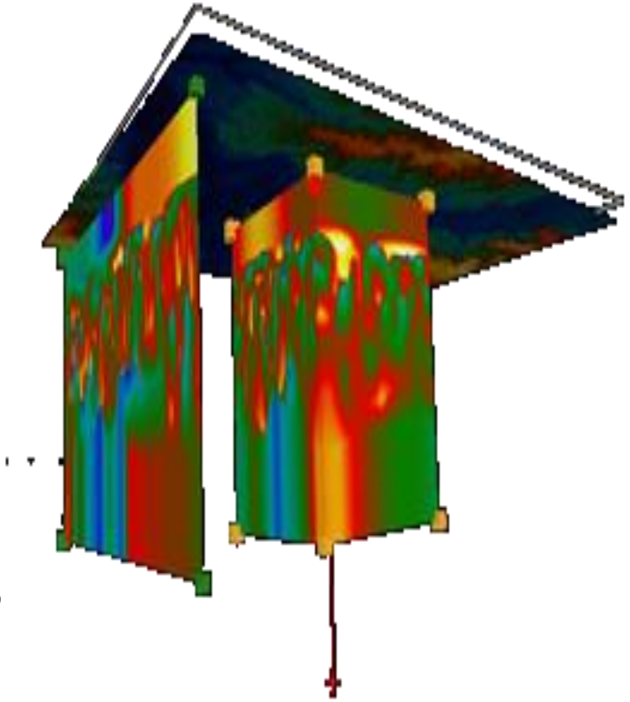
The Answer to Both Questions is Yes!

The answer to the first question is “yes,” lightning strikes cluster and the clusters are consistent over time.

The answer the second question is “there is oil here,” as shown by the tanks now at the location of the lightning strikes raising the questions.

Presentation Outline

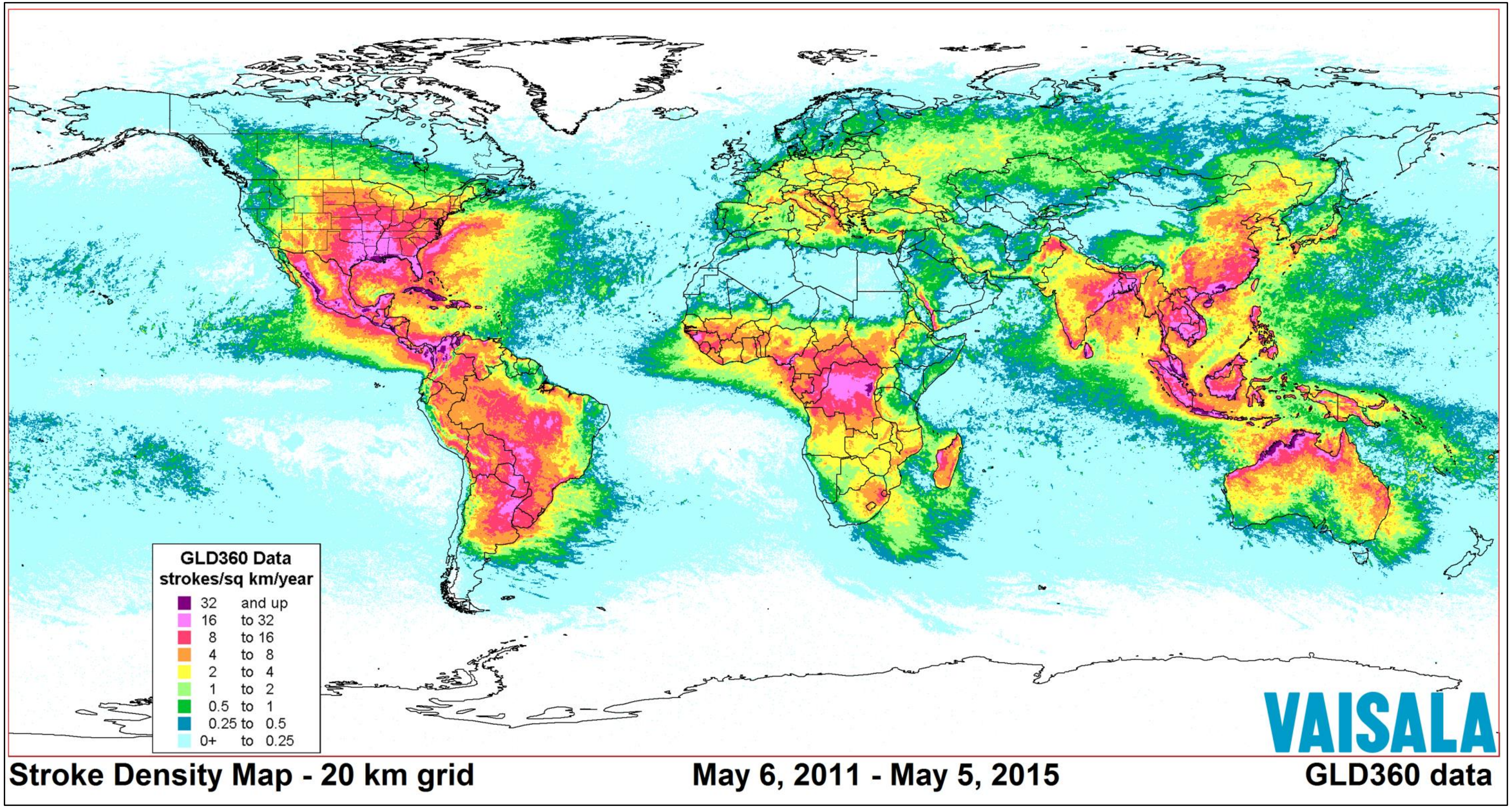
Milam County Texas apparent-resistivity Volume



1. Lightning Occurs Everywhere
2. Lightning Database Analytics
3. Lightning Analysis & Attributes
4. Rock Property & Attribute Maps & Volumes
5. Arizona, Louisiana, Michigan, & Texas Examples

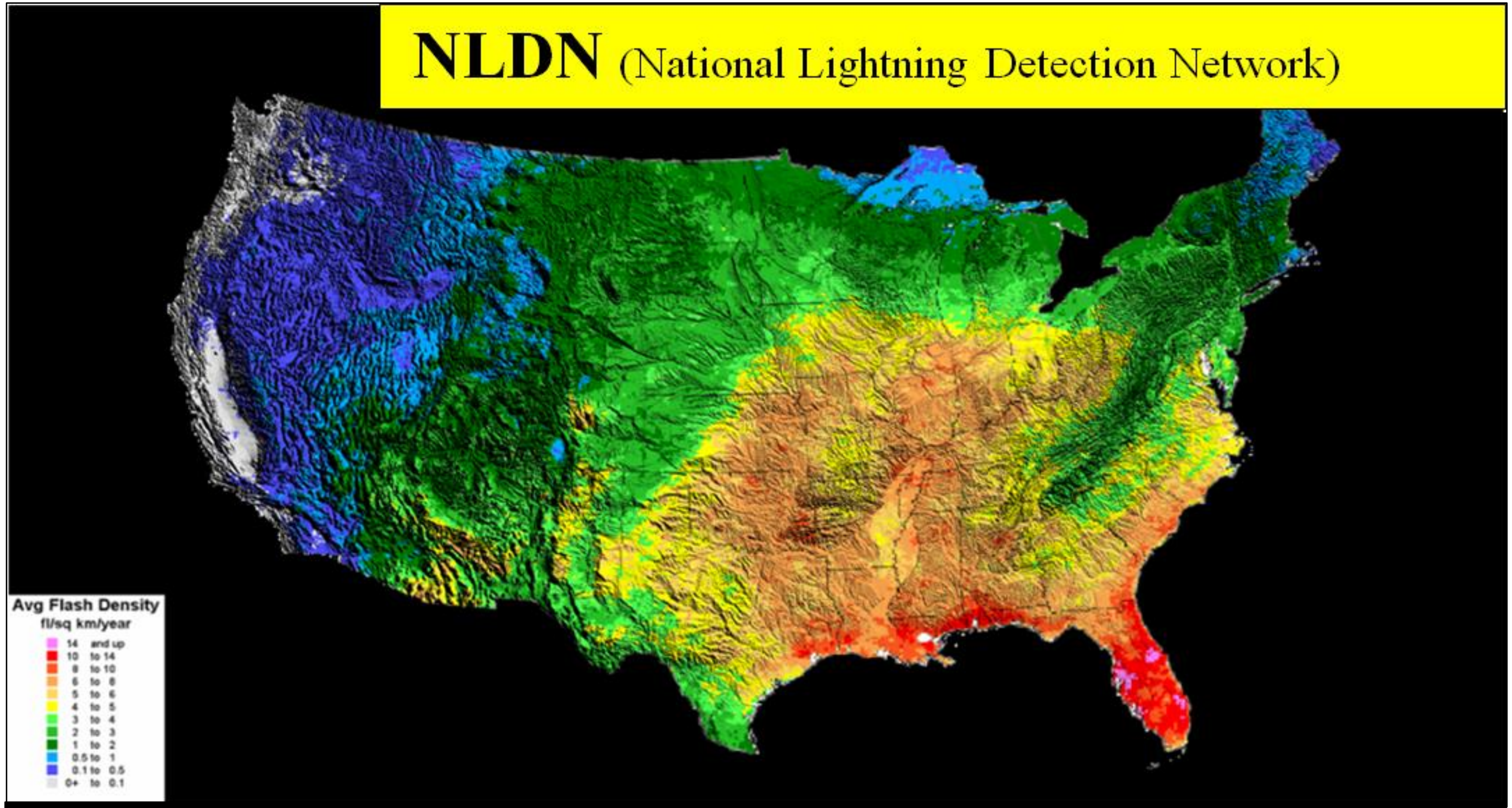
1. Lightning Occurs Everywhere

5+ years of data in GLD-360 database



The U.S. has the most complete database

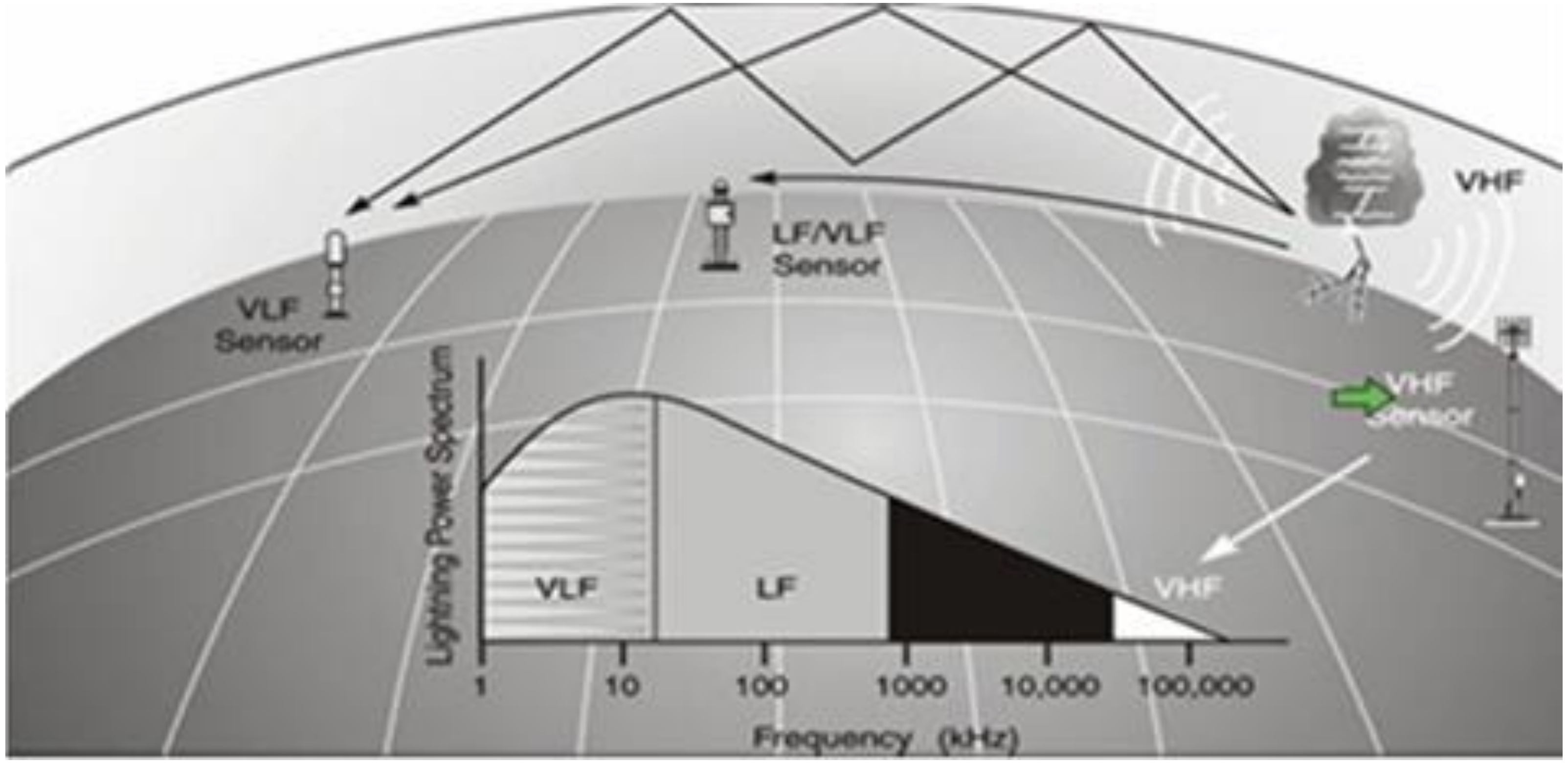
18+ Years of Data in the NLDN Data Base



Originally Collected for Insurance, Meteorology, and Safety Reasons

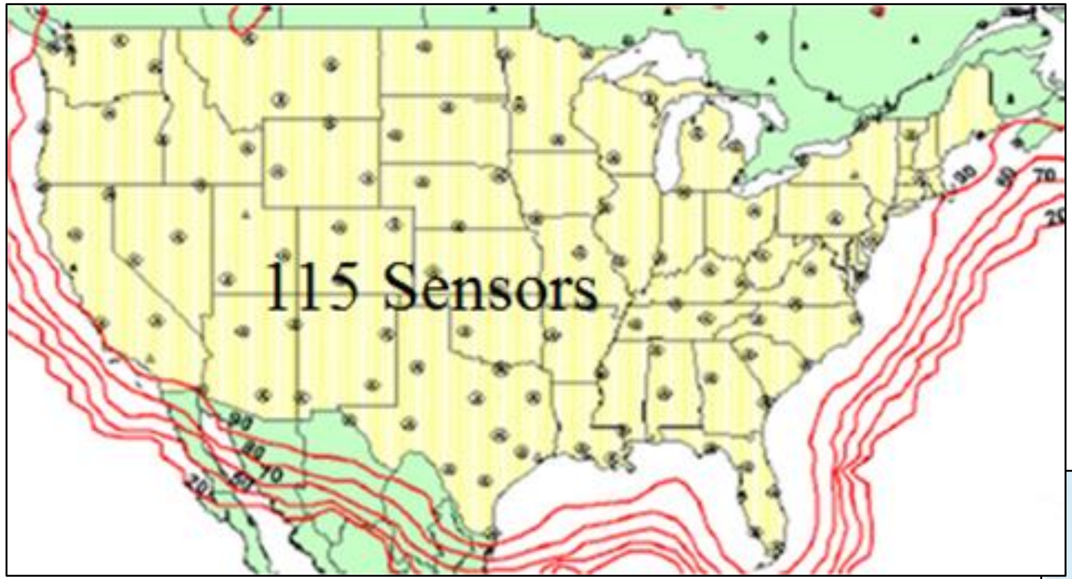
Sensors Measure Direction to Strike & Lightning Attributes

Strike Triangulated & Measurements Reconciled



Vaisala: Martin Murphy
2016 Webinar used with permission

Vaisala's NLDN Lightning Detection Network

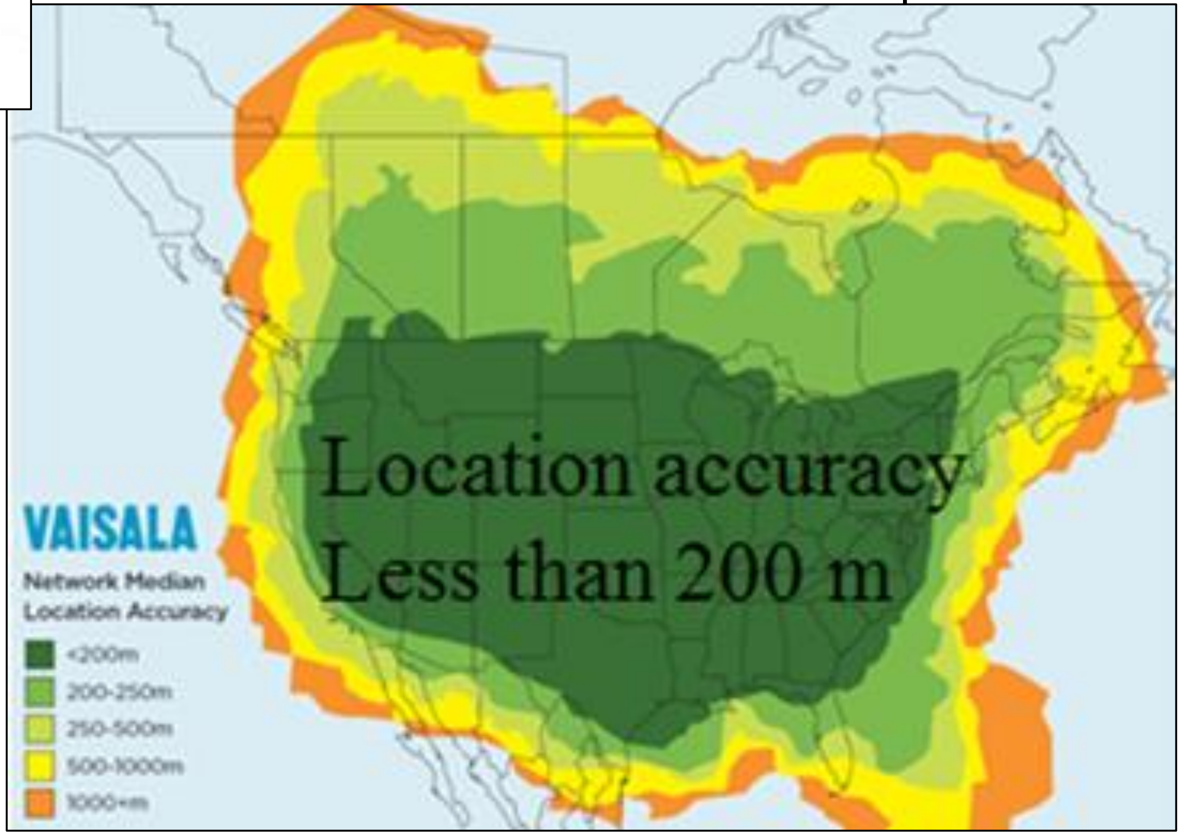


In Texas 12-24 sensors record each lightning strike

Location Accuracy:
150-600 feet

Lineament Accuracy:
10-100 feet

From 2016 Vaisala Webinar: Martin Murphy, used with permission



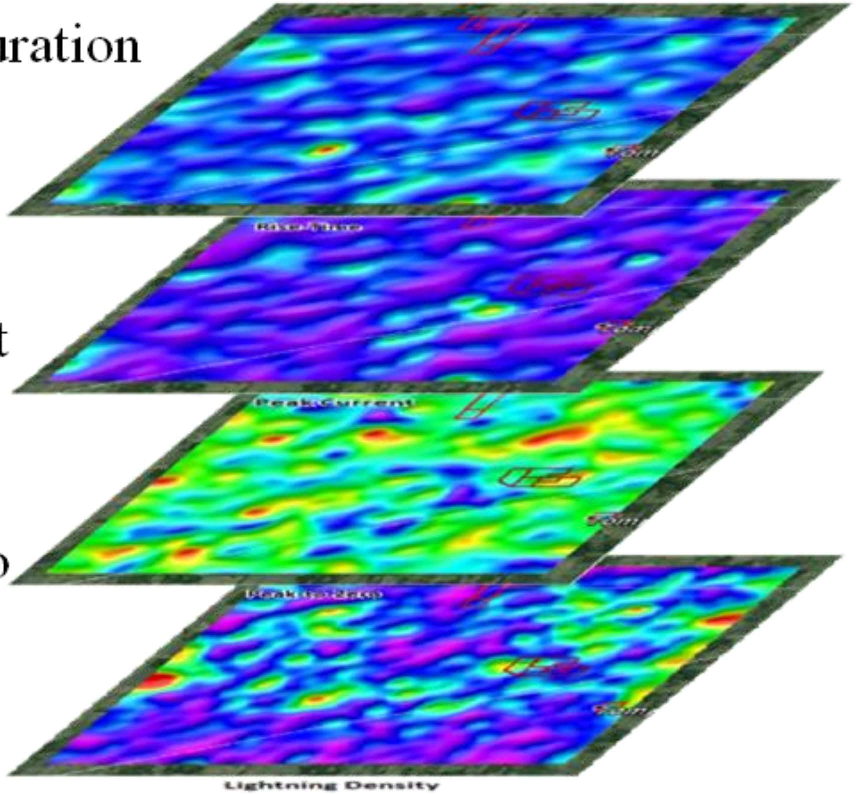
Geophysicists have used passive gravity, magnetic, and seismic measurements to understand the subsurface of the earth for decades. Using existing lightning strike databases expands this work.

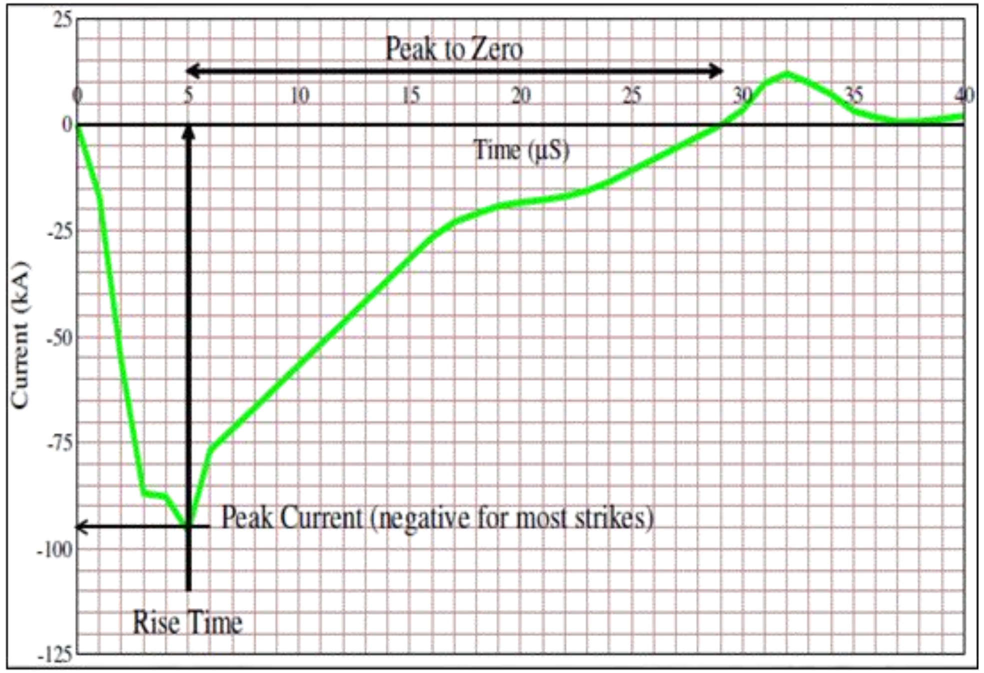
2. Lightning Database Analytics

- Typical projects have millions of lightning strikes.
- To date all projects have tied subsurface control.
- Attributes are measured or calculated for lightning strike locations, then contoured or gridded.
- Lightning strike density and attribute values cluster, and these clusters are somewhat consistent over time, allowing the data to be stacked.
- Lineaments, like fault scarps, have been mapped with 30 foot horizontal location accuracy.

Lightning Measurements

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

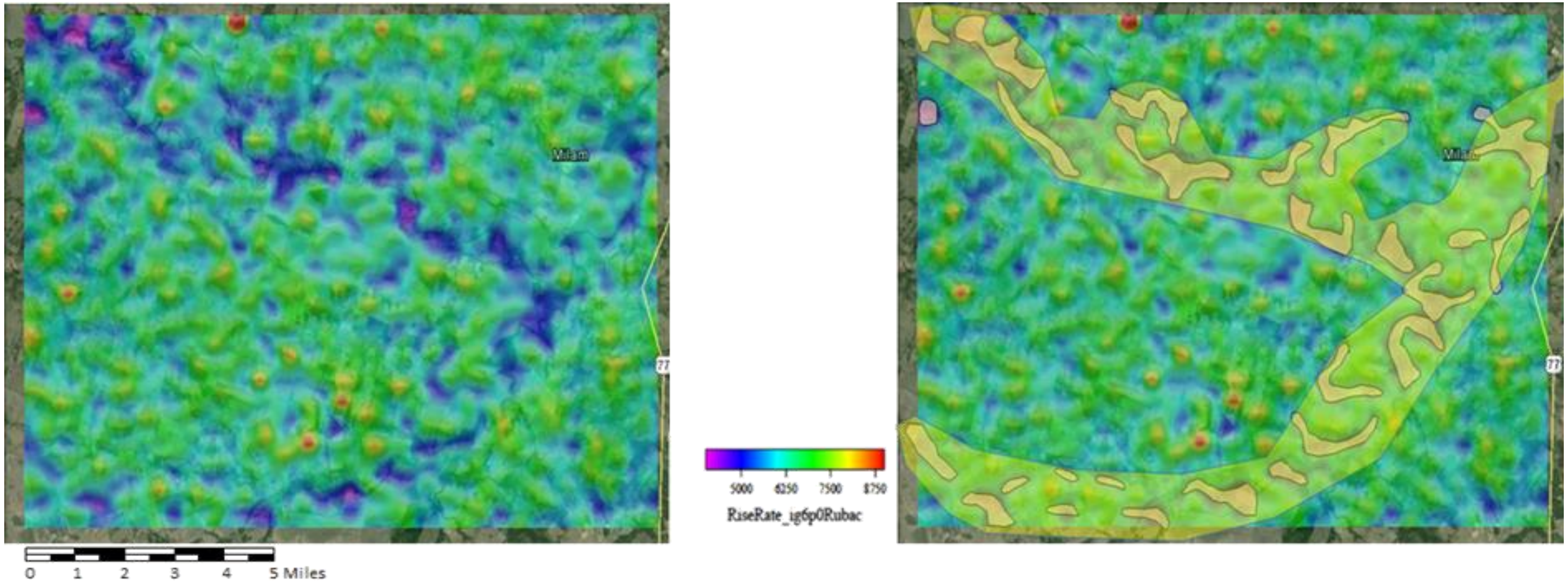




- Other attributes calculated from these measurements.
- The time of the lightning strike is correlated with solar and lunar tides.
- Measurements separated by time.

3. 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

Dynamic Measurement LLC Patent 1

Method for locating sub-surface natural resources

DYNAMIC MEASUREMENT

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)

(73) Assignee: **Vaisala Oyj**, Helsinki (FI)

(*) Notice: Subject to any disclaimer, the term of this patent is extended or adjusted under 35 U.S.C. 154(b) by 391 days.

(21) Appl. No.: **12/655,810**

(22) Filed: **Jan. 7, 2010**

(65) **Prior Publication Data**

US 2011/0163733 A1 Jul. 7, 2011

(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

5,417,282 A *	5/1995	Nix	....	166/248
2010/0023267 A1 *	1/2010	Karabin et al.	....	702/4

* cited by examiner

Primary Examiner — Amy He
(74) *Attorney, Agent, or Firm* — Portland Intellectual Property, LLC

(57) **ABSTRACT**

A method for locating sub-surface natural resources. The method utilizes lightning data to discern relatively likely locations for finding the sub-surface natural resources.

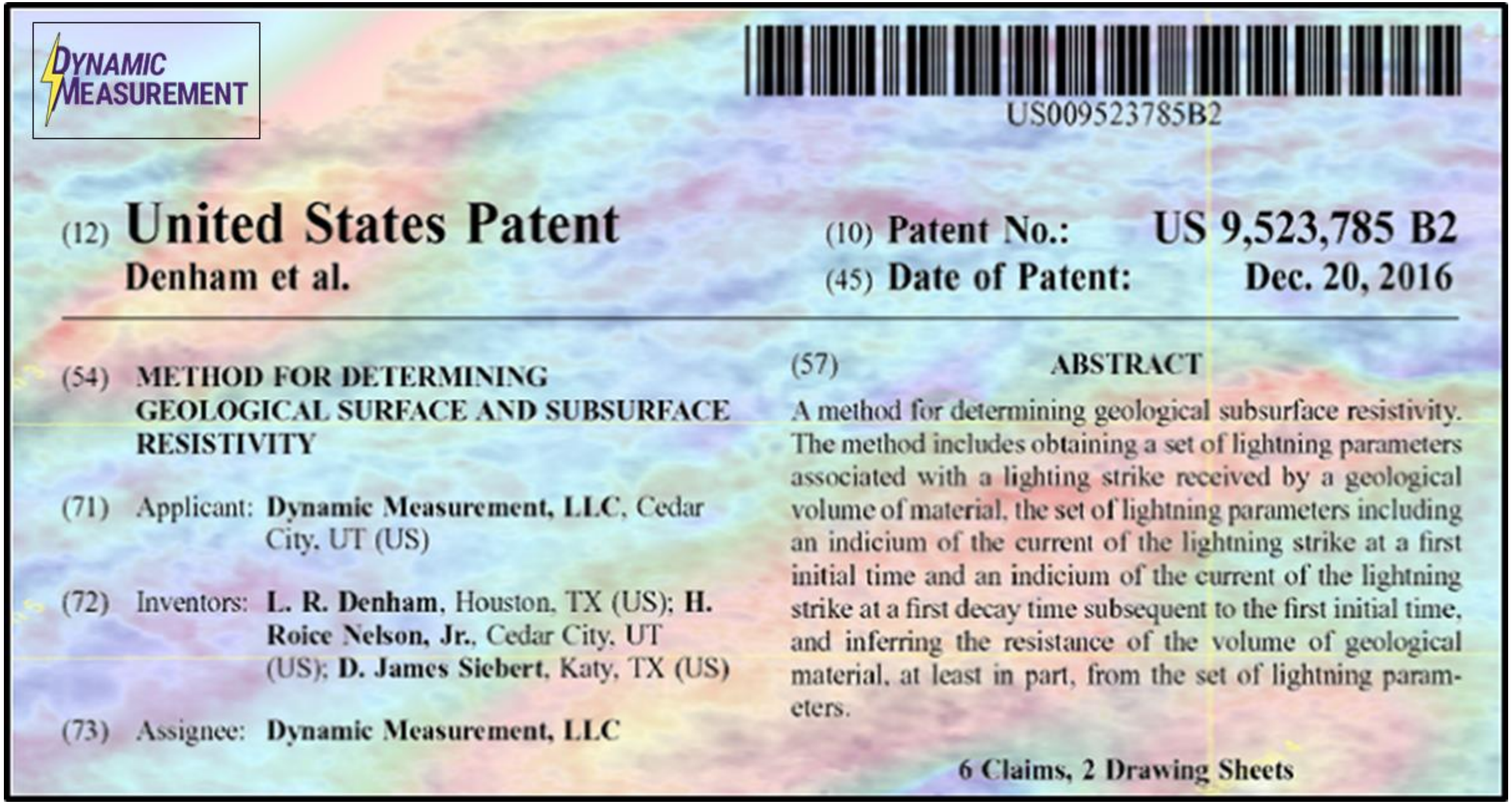
16 Claims, 8 Drawing Sheets

Natural Resources defined as:

- Diamonds;
- Other Gemstones;
- Gold;
- Silver;
- Copper;
- Other Minerals;
- Geothermal Deposits;
- Oil;
- Gas;
- Water; &
- Other sub-surface natural resources sharing inherent similarities.

Dynamic Measurement LLC Patent 2

Method for determining geological surface and subsurface resistivity



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

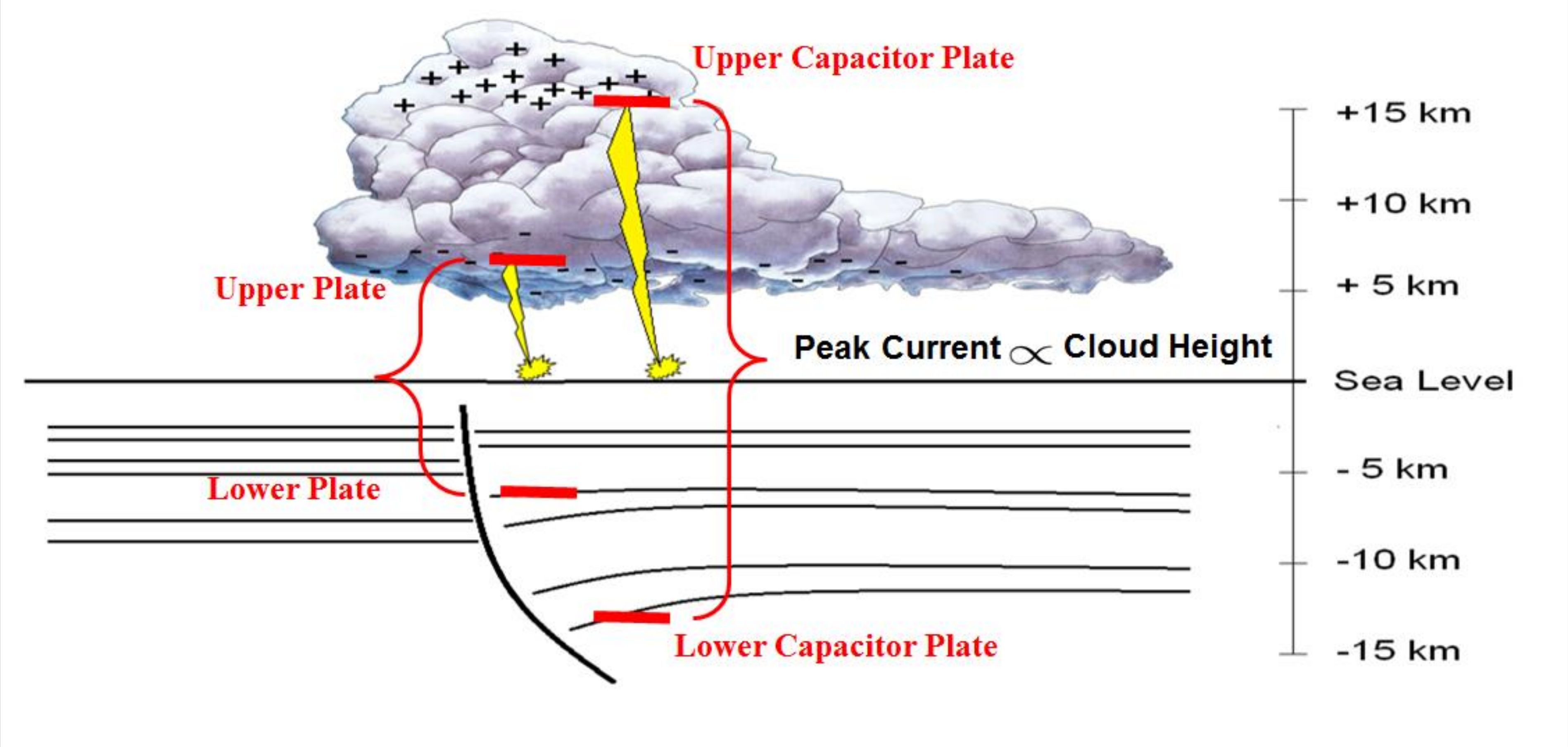
A method for determining geological subsurface resistivity. The method includes obtaining a set of lightning parameters associated with a lighting strike received by a geological volume of material, the set of lightning parameters including an indicium of the current of the lightning strike at a first 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

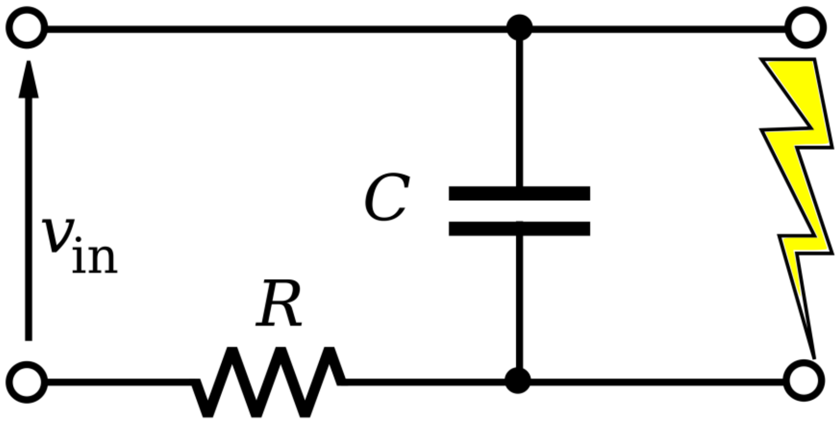
4. Rock Property & Attribute Maps & Volumes

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

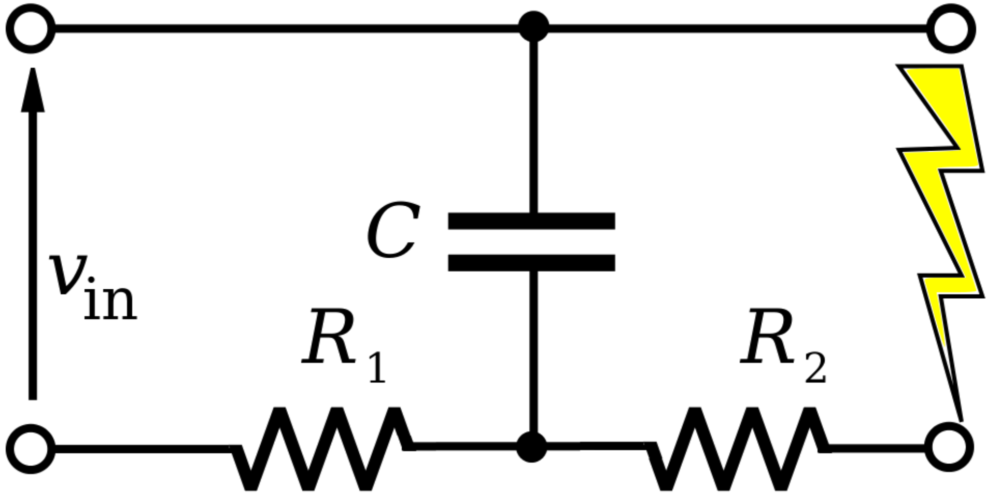


Relaxation Oscillator Physics and Lightning (a giant neon tube)

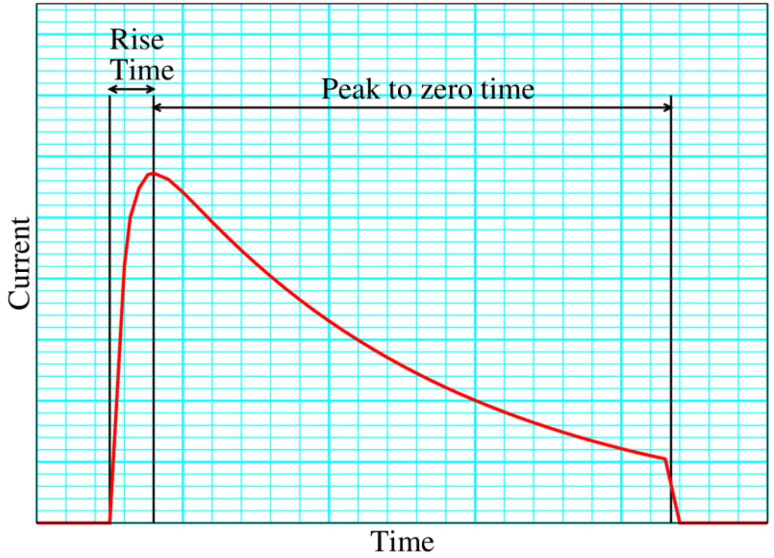


- The atmospheric capacitor is like a relaxation oscillator
- Just an additional resistance (R_2) limiting the current

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

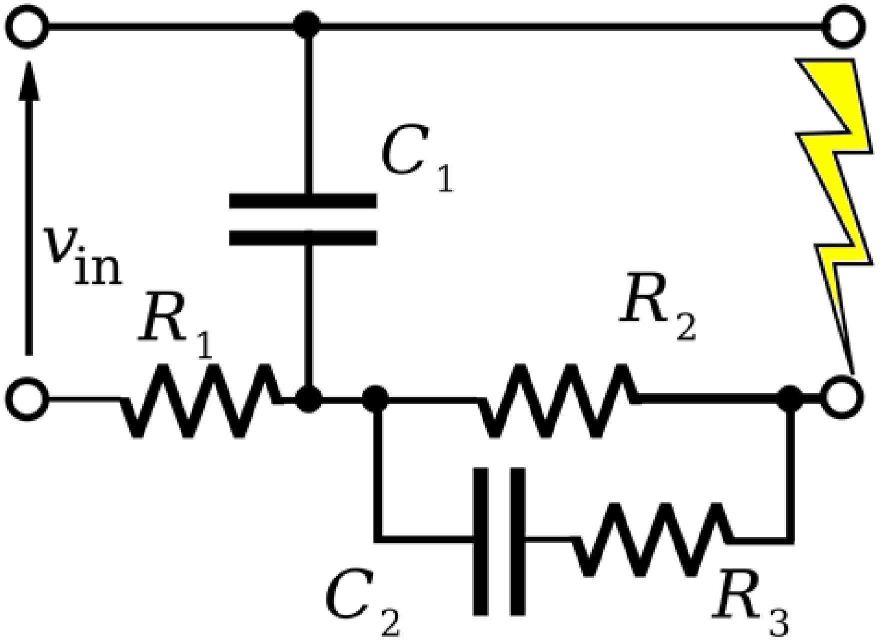


Lightning and the Induced Polarization Effect

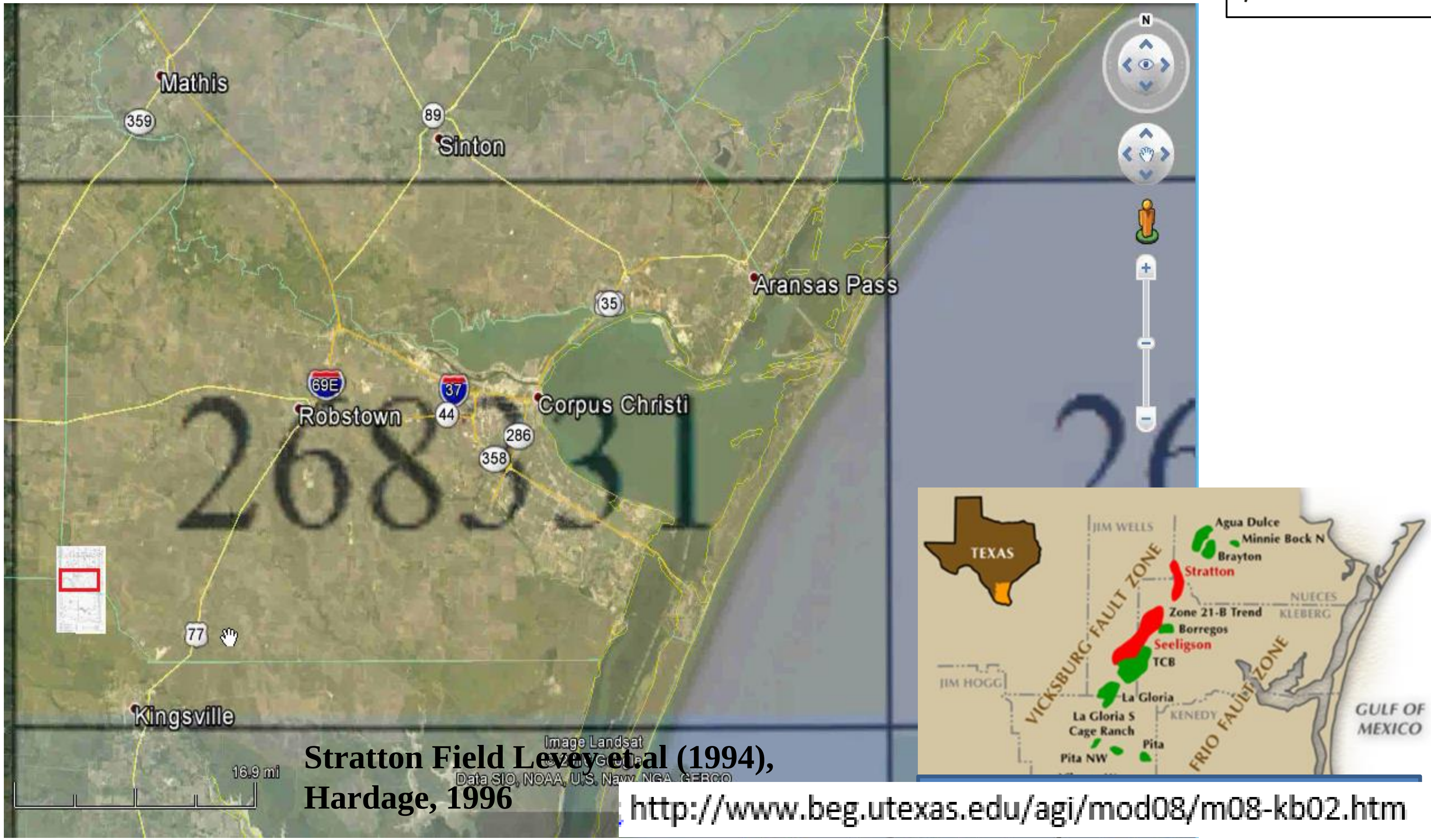


- Lightning does not have a square waveform
- But it does have a very steep onset
- Variations in the onset as measured (rise-time) show the IP Effect

- 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 apparent permittivity can be calculated



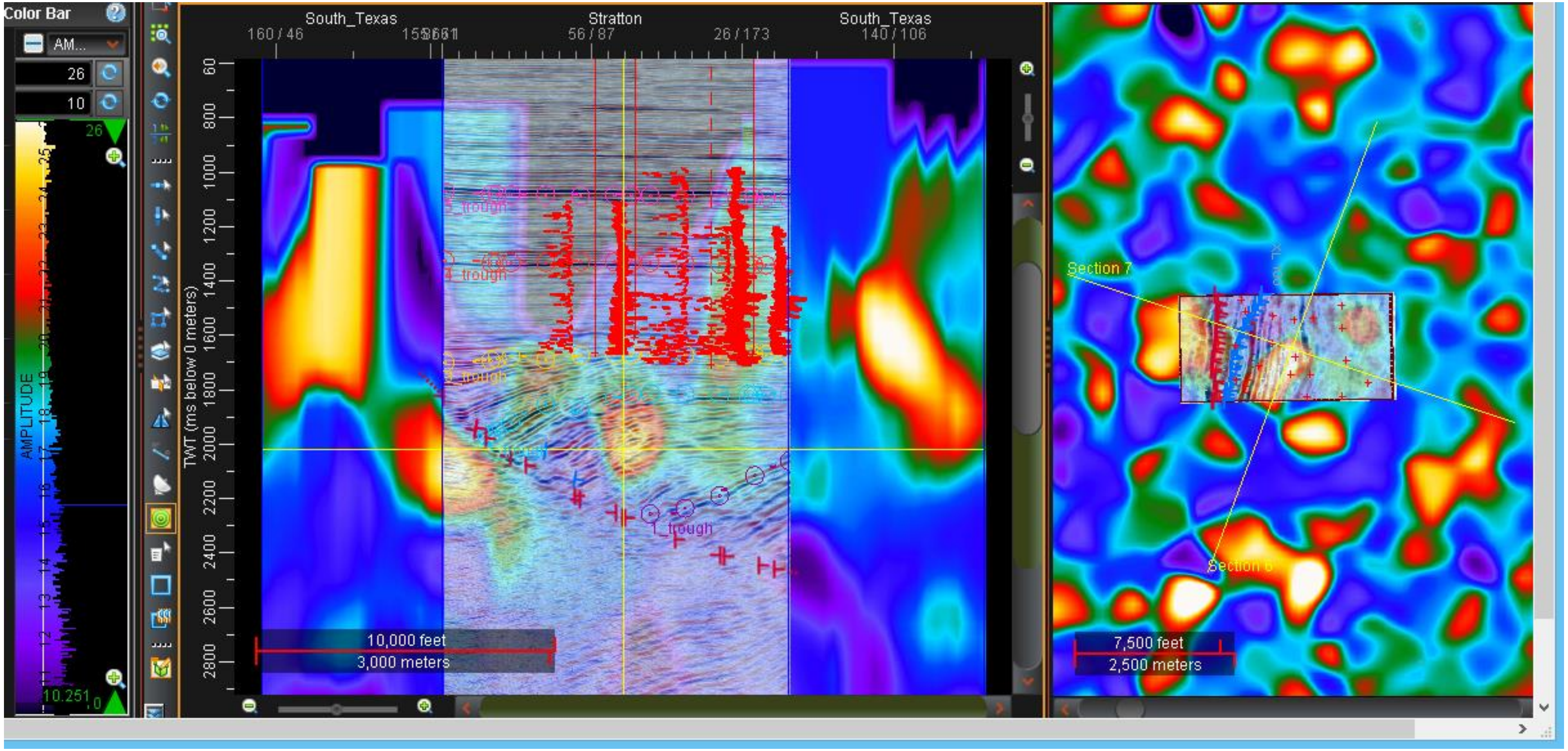
5. Study Area around Corpus Christi, Texas



Stratton Field Levey et.al (1994), Hardage, 1996

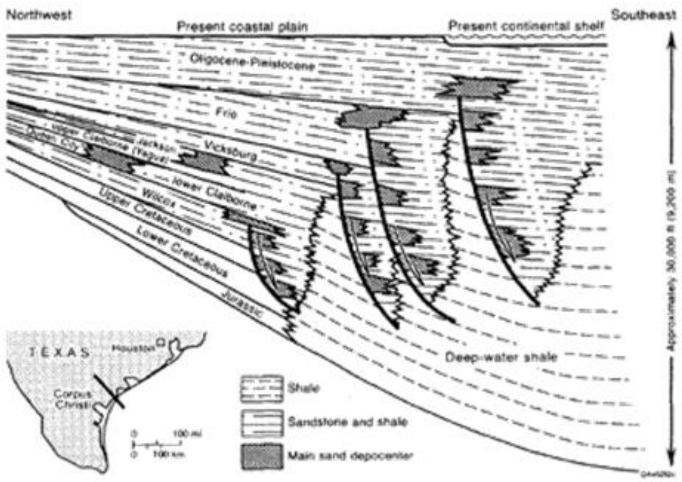
http://www.beg.utexas.edu/agi/mod08/m08-kb02.htm

Stratton Apparent-Resistivity Sections

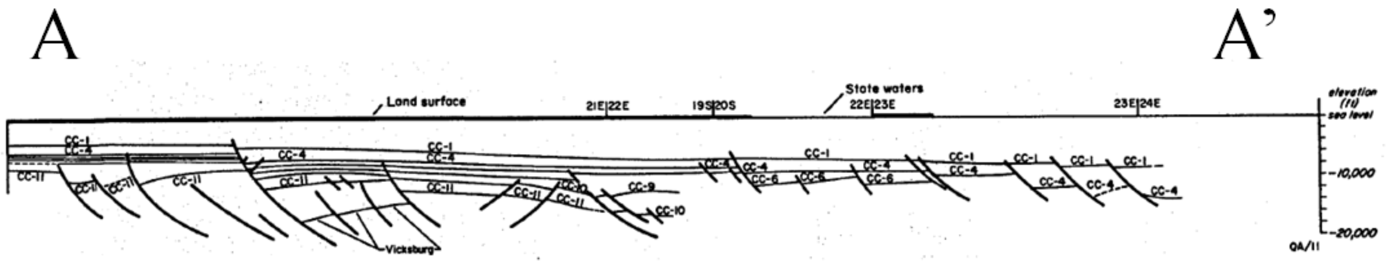


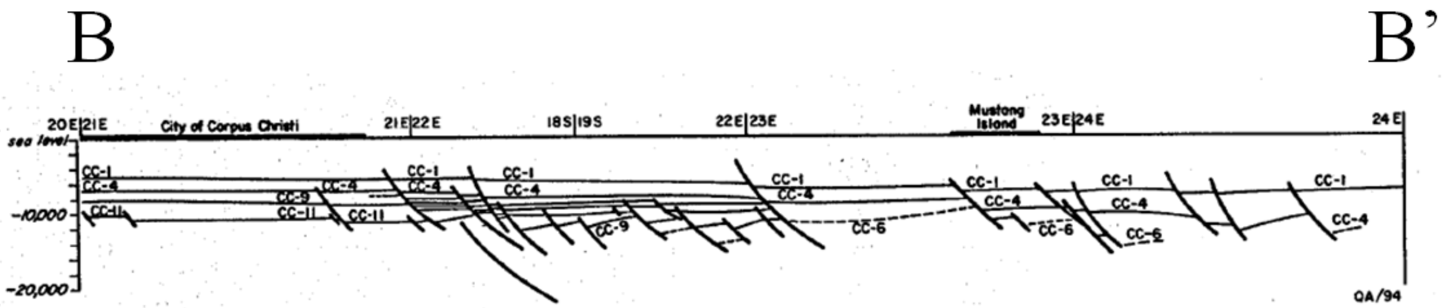
Working on calibrating depth and calculated vs. measured resistivity

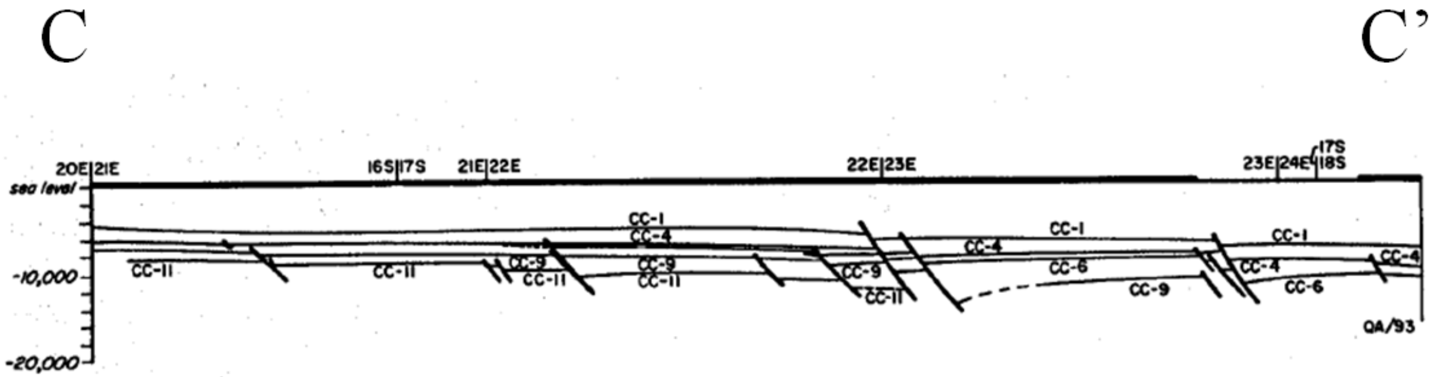
Study Area - Geology and Structure Corpus Christi from Ewing (1986)



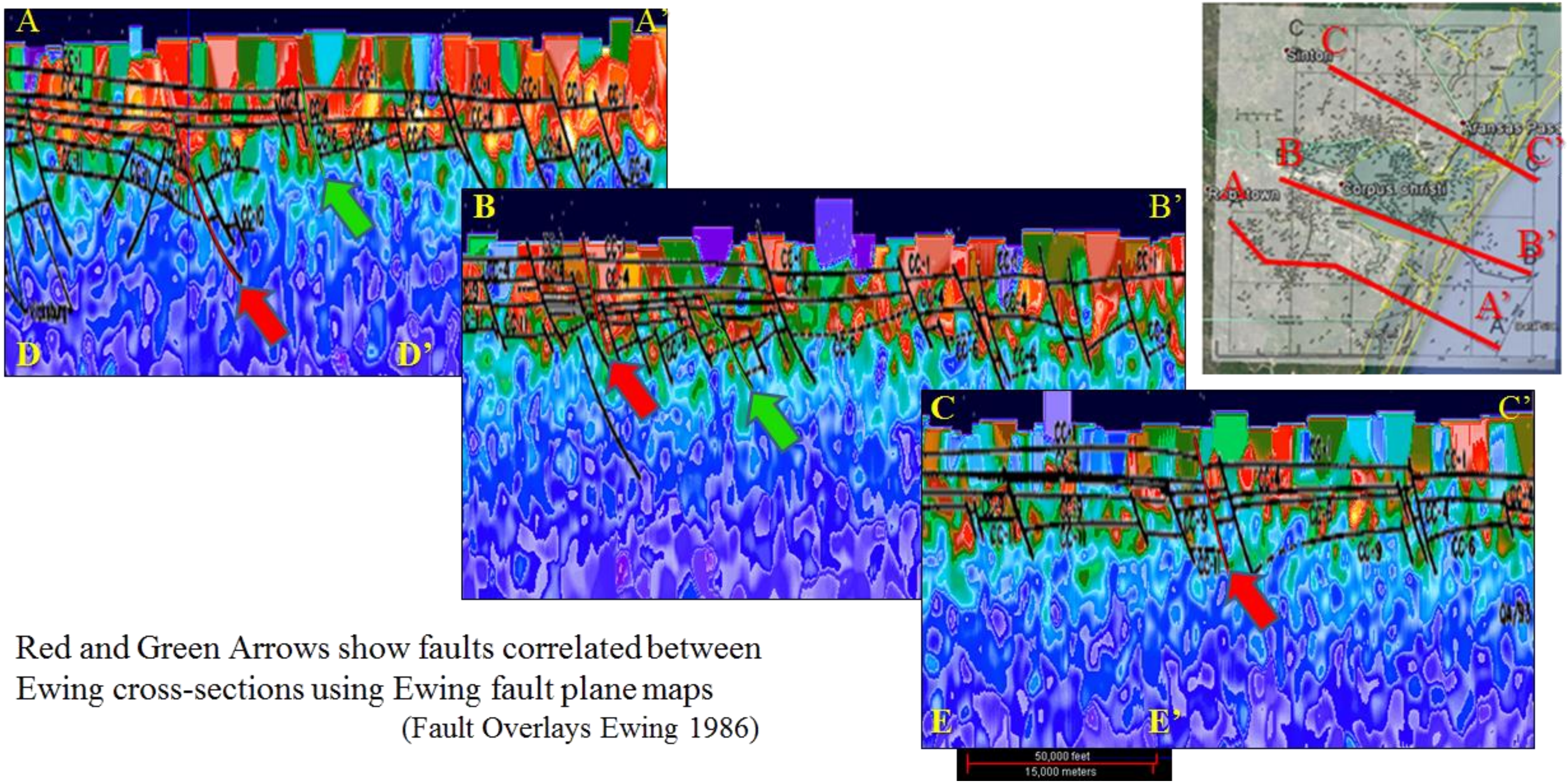
From Levey, et al,1994
Bebout and others,1982







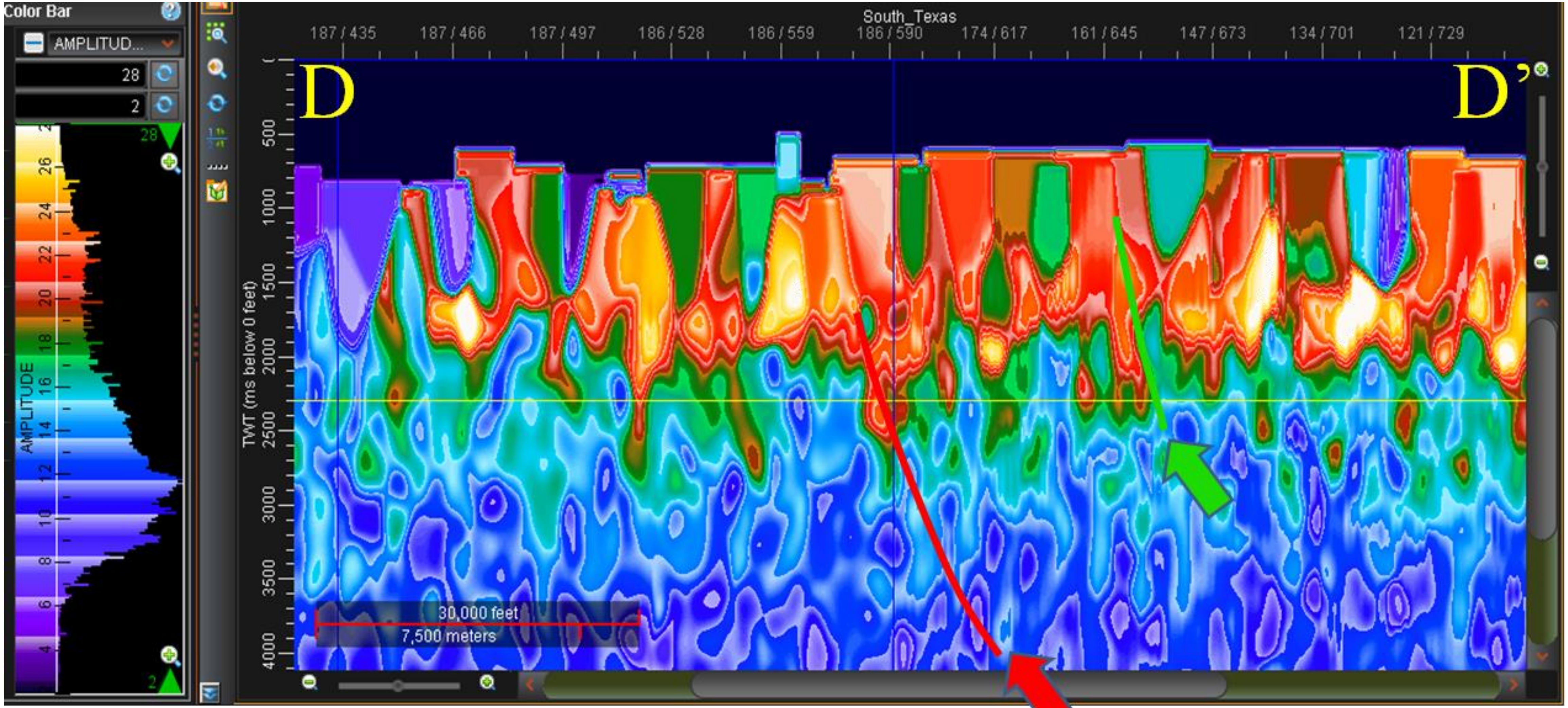
2016 Lightning-Derived Resistivity Cross-Sections Match Geology on 1986 Ewing Interpretation Overlay



Red and Green Arrows show faults correlated between Ewing cross-sections using Ewing fault plane maps

(Fault Overlays Ewing 1986)

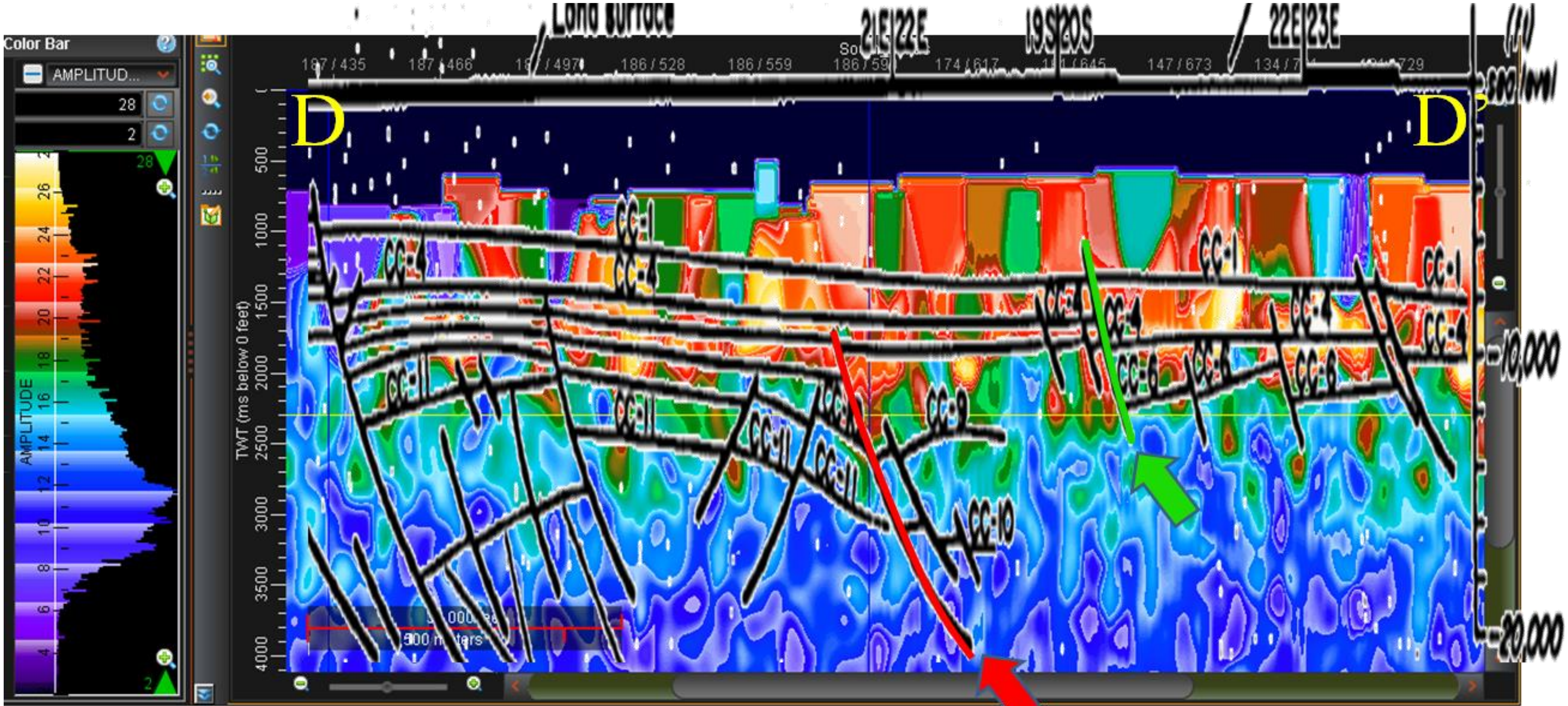
D-D’ Close-Up on Graben on A-A’ without overlay



Red and Green Faults were major faults on Ewing’s maps. Note high apparent-resistivity events (bright) appear to have plumes above these faults.

D-D’ Close-Up on west Graben

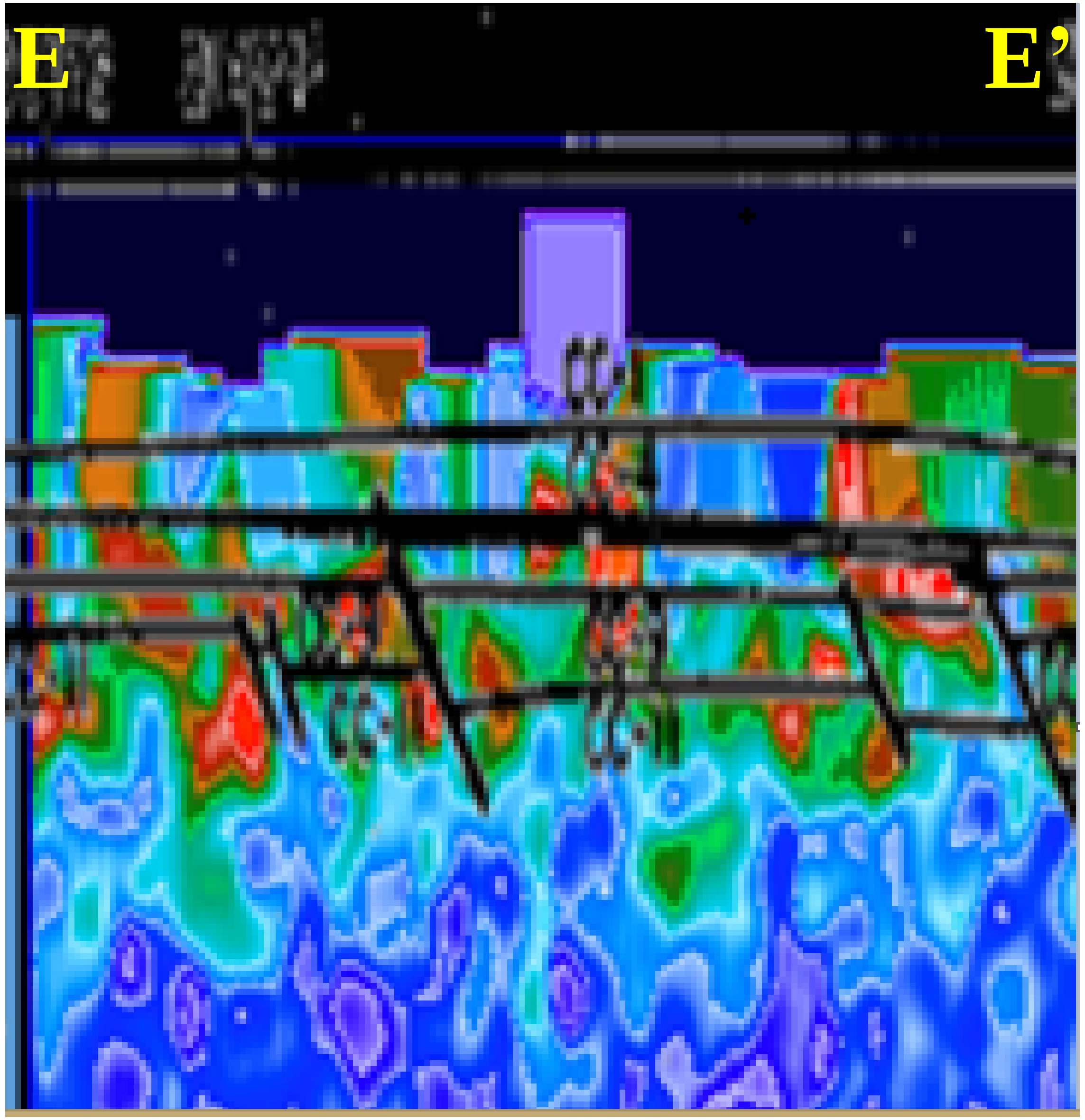
Interpretation 1986 by Tom Ewing, Apparent Resistivity 2016 from Lightning Databases



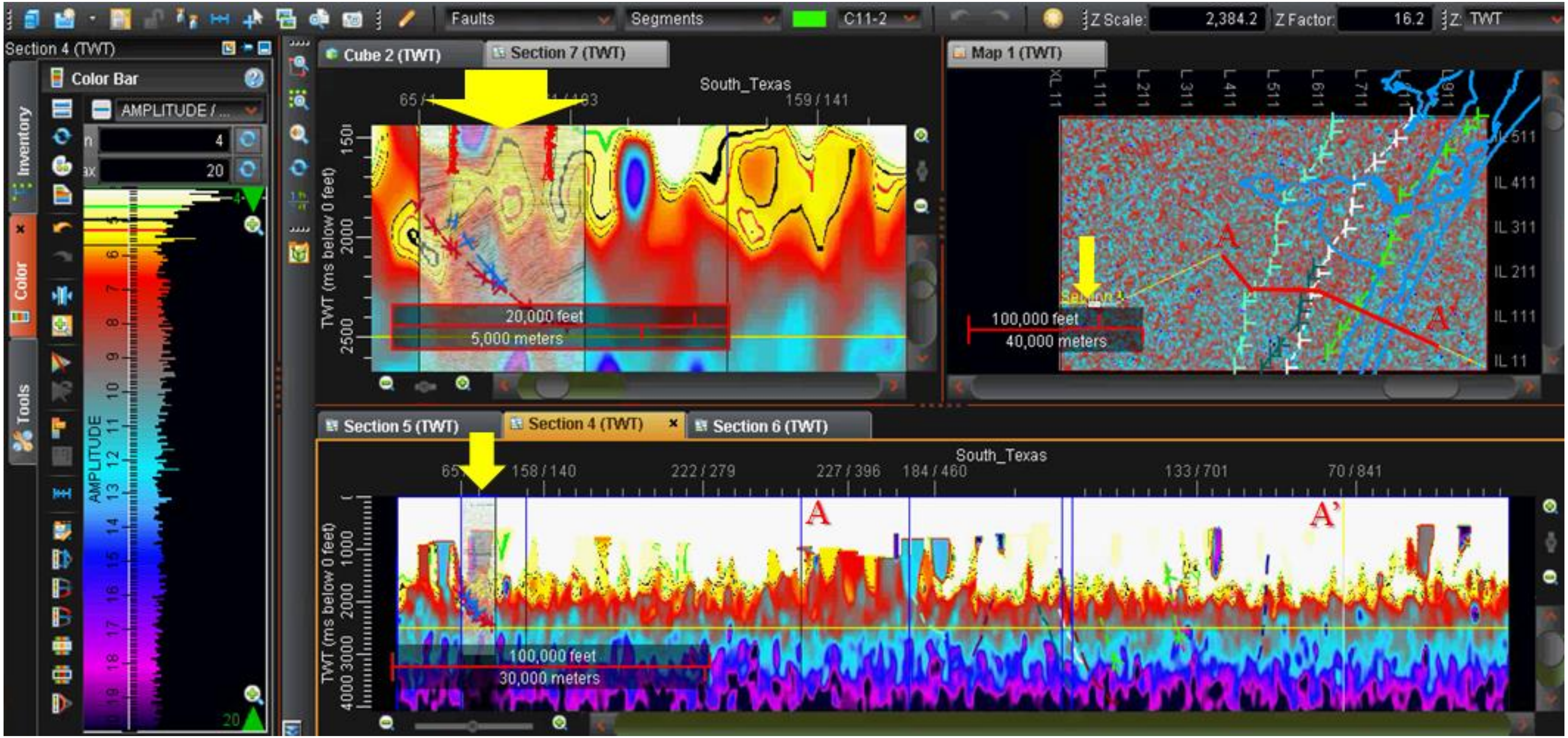
Note: interpretation by Tom Ewing in 1986. The resistivity section calculated from lightning in 2016.
Co-located sections show breaks where faults were interpreted. There are resistivity plumes tied to faults.

E-E' on the Northwest End of Ewing's C-C'

Note offsets in adjacent "Packages" of Higher Values of Apparent Resistivity

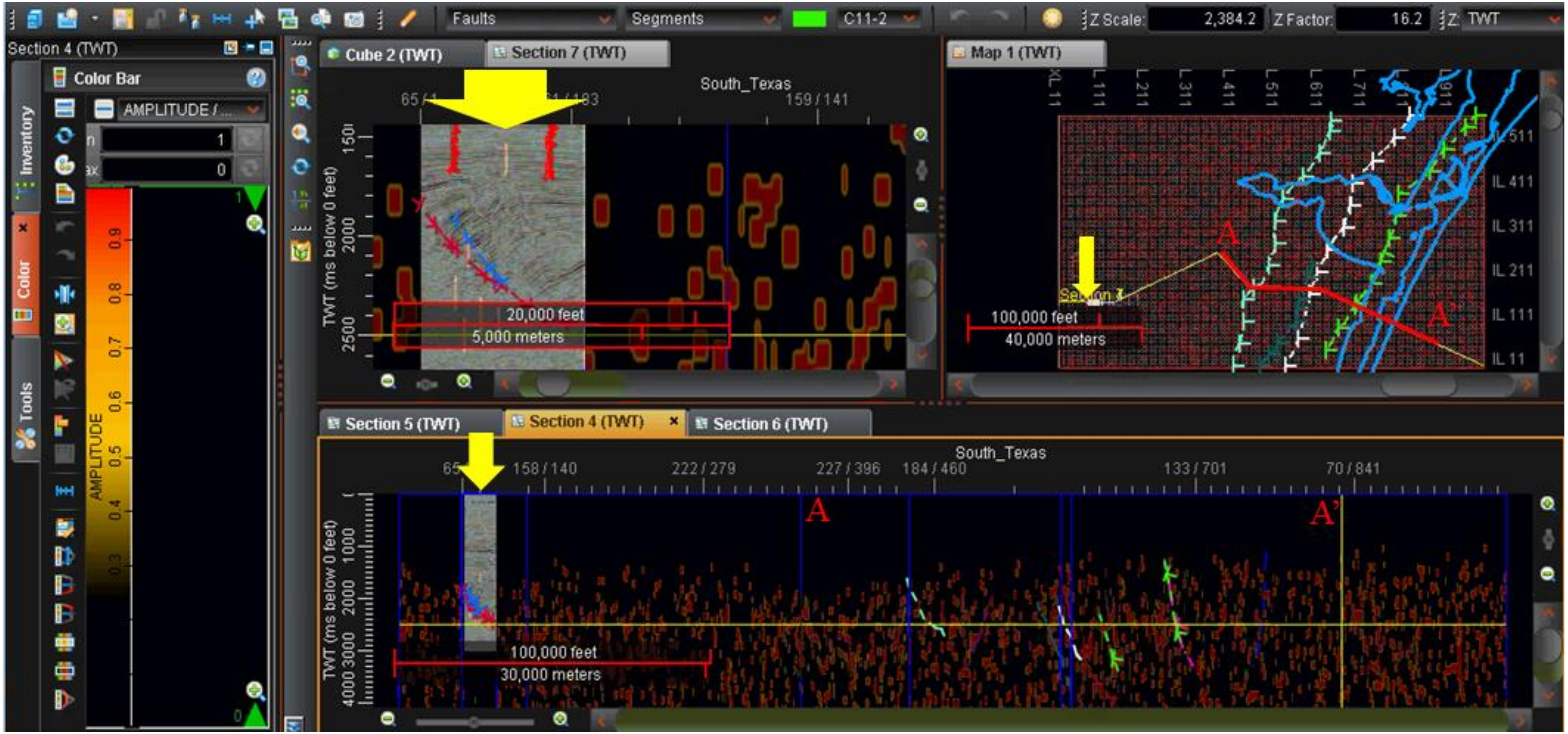


Lightning Attributes - Peak Current – 3 of 20+



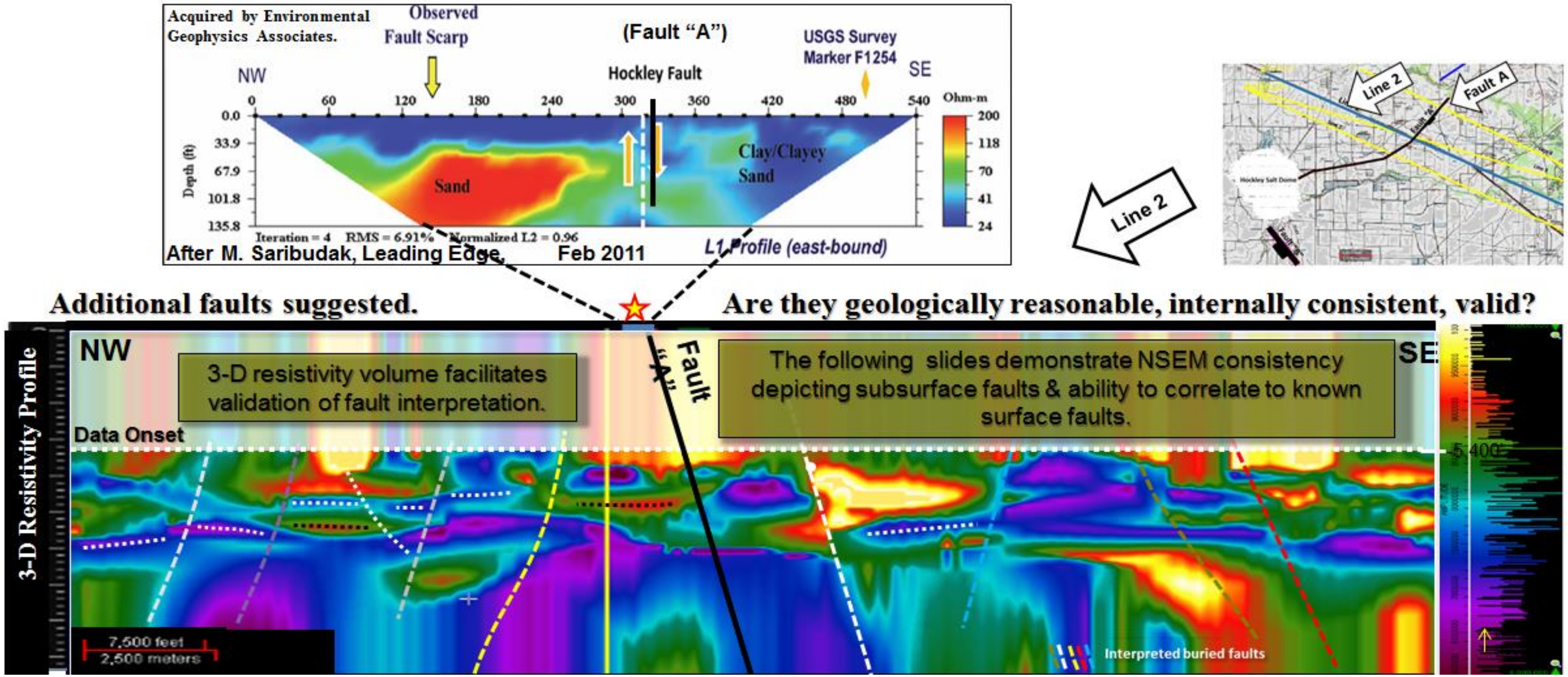
(kiloamperes)

Lightning Attributes - Spike - 2 of 20+ Attributes



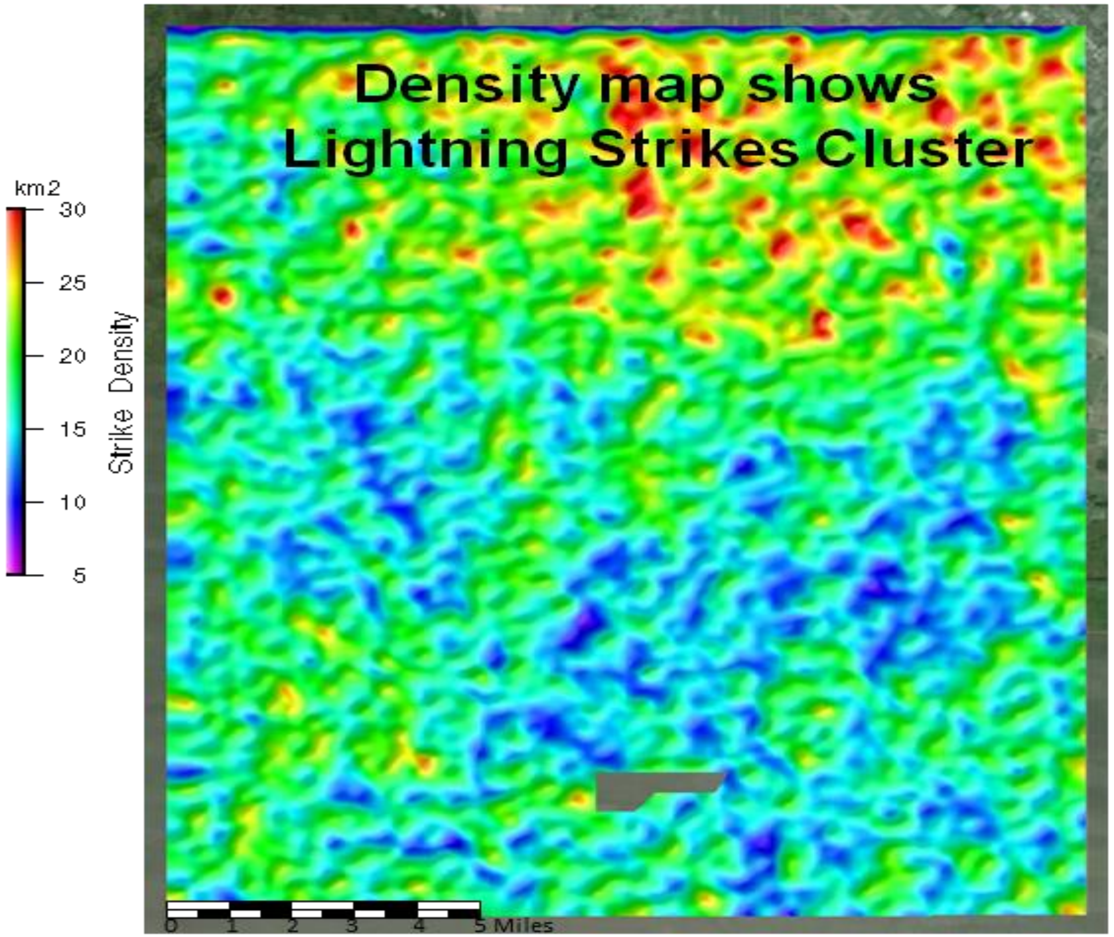
(position of strike)

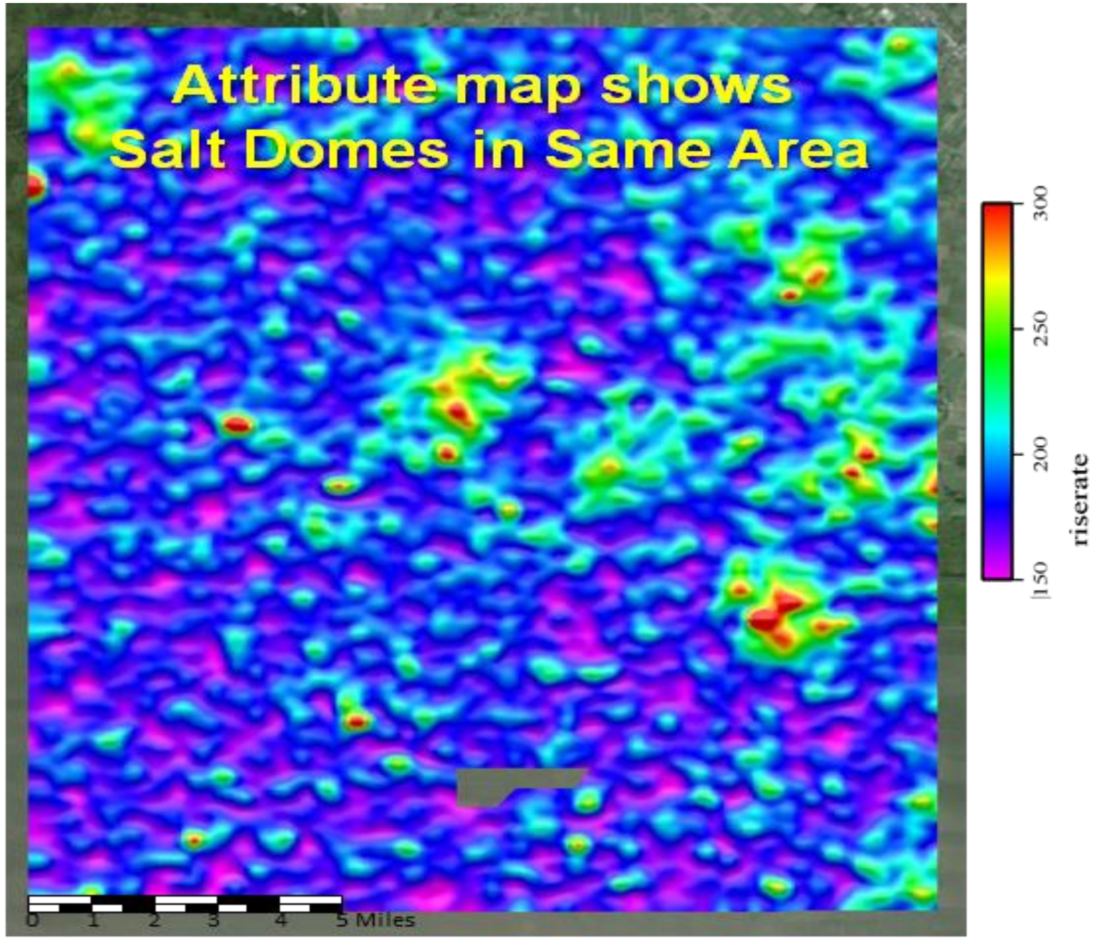
5. One Last Texas Example



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

5. Louisiana Example

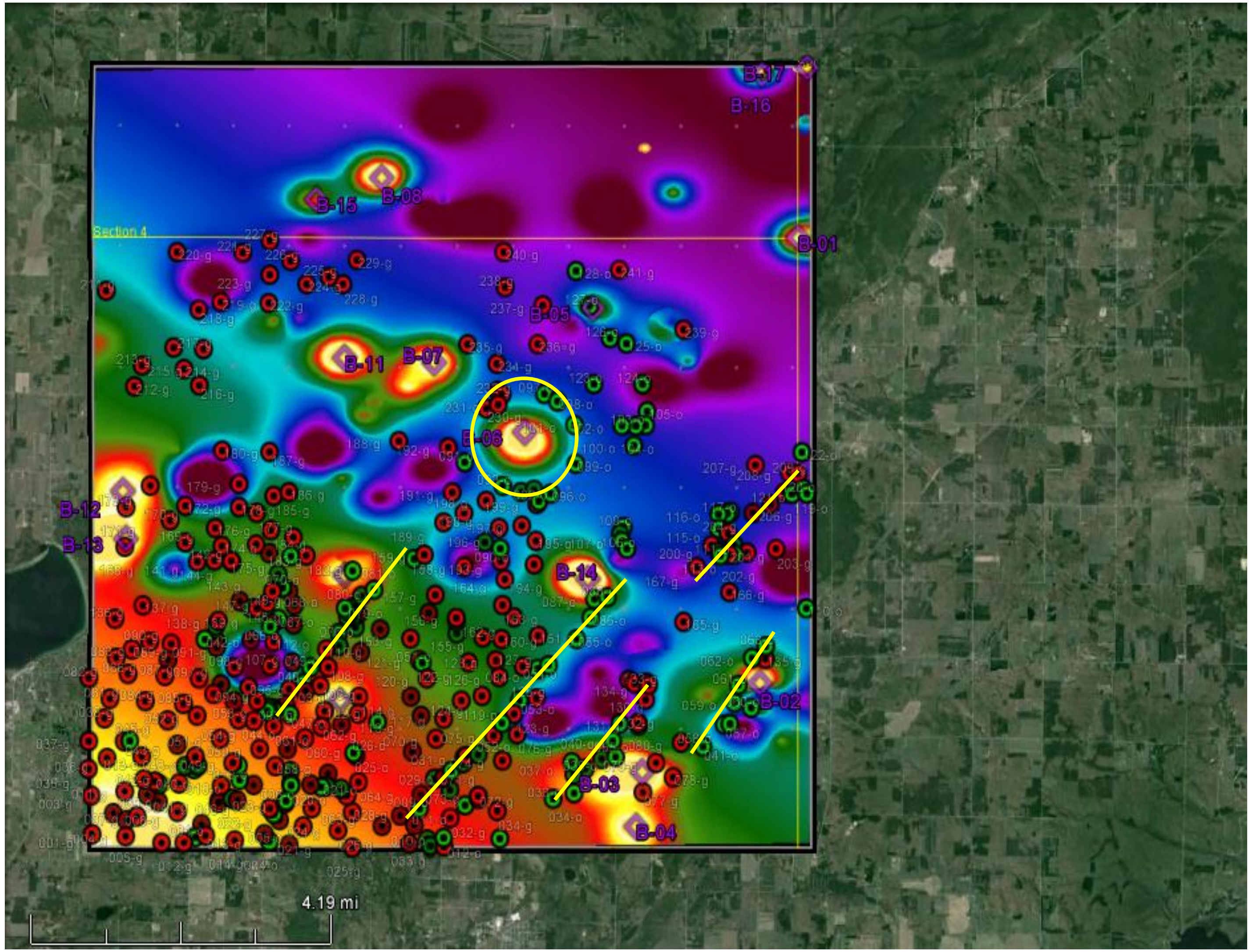




Density Map & Rate-of-Rise-Time Map

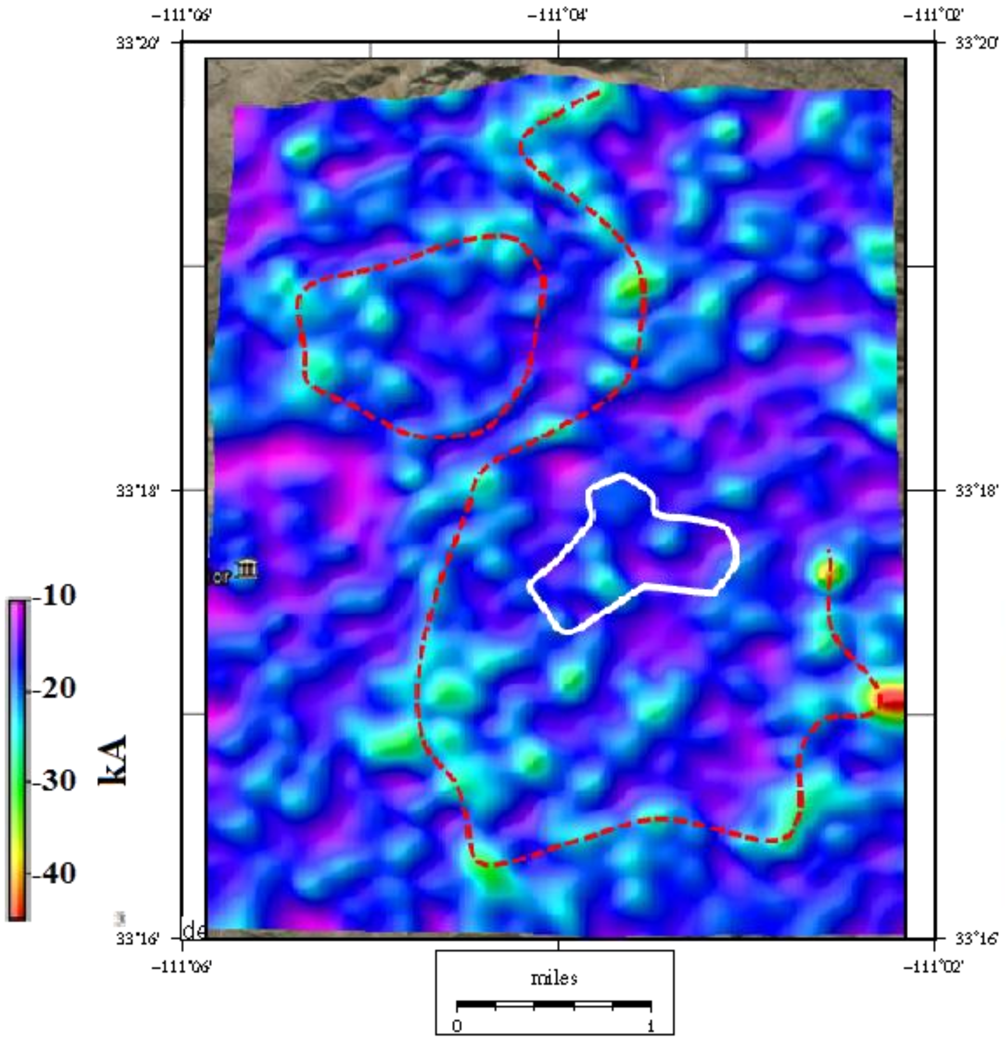
5. Michigan Example
High Resistivity to SW on B-2 Horizontal-Slice

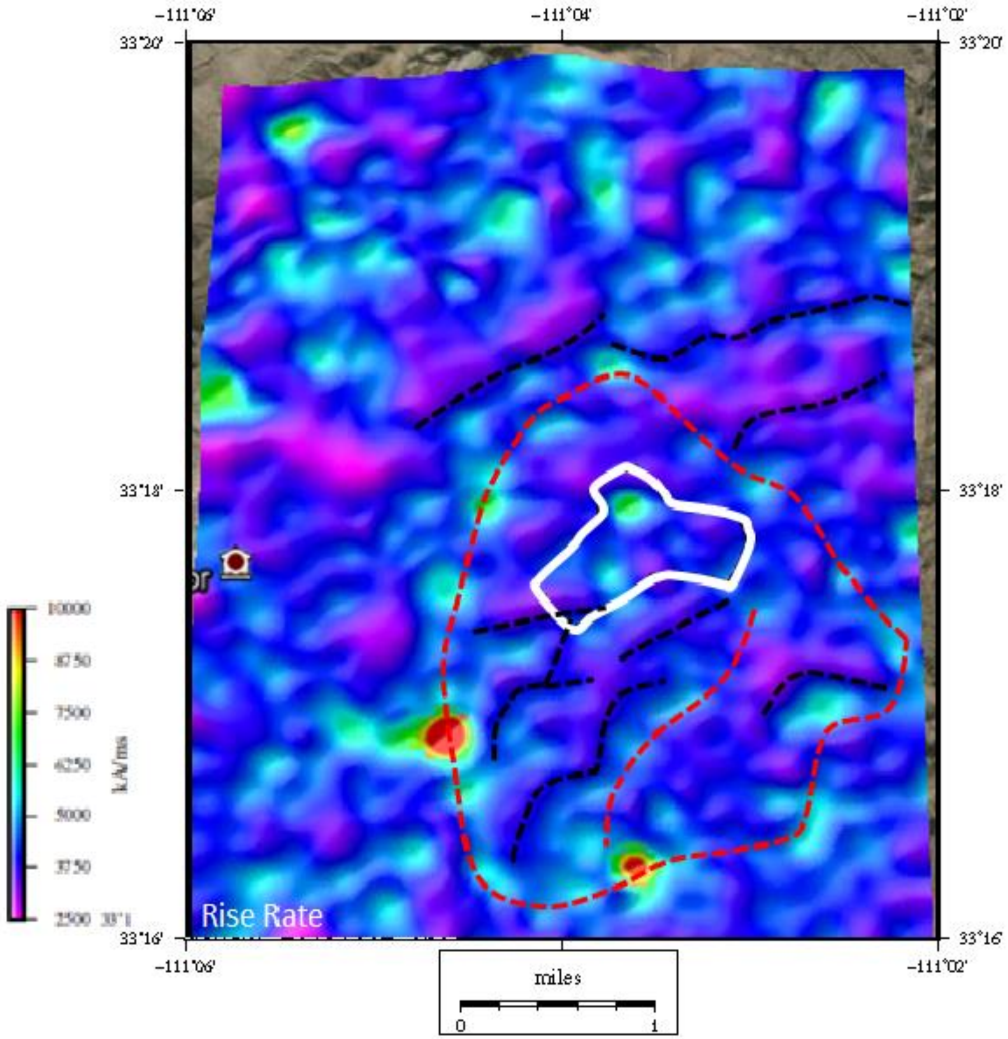
with Oil & Gas Wells in Analysis Area posted (note lineaments)



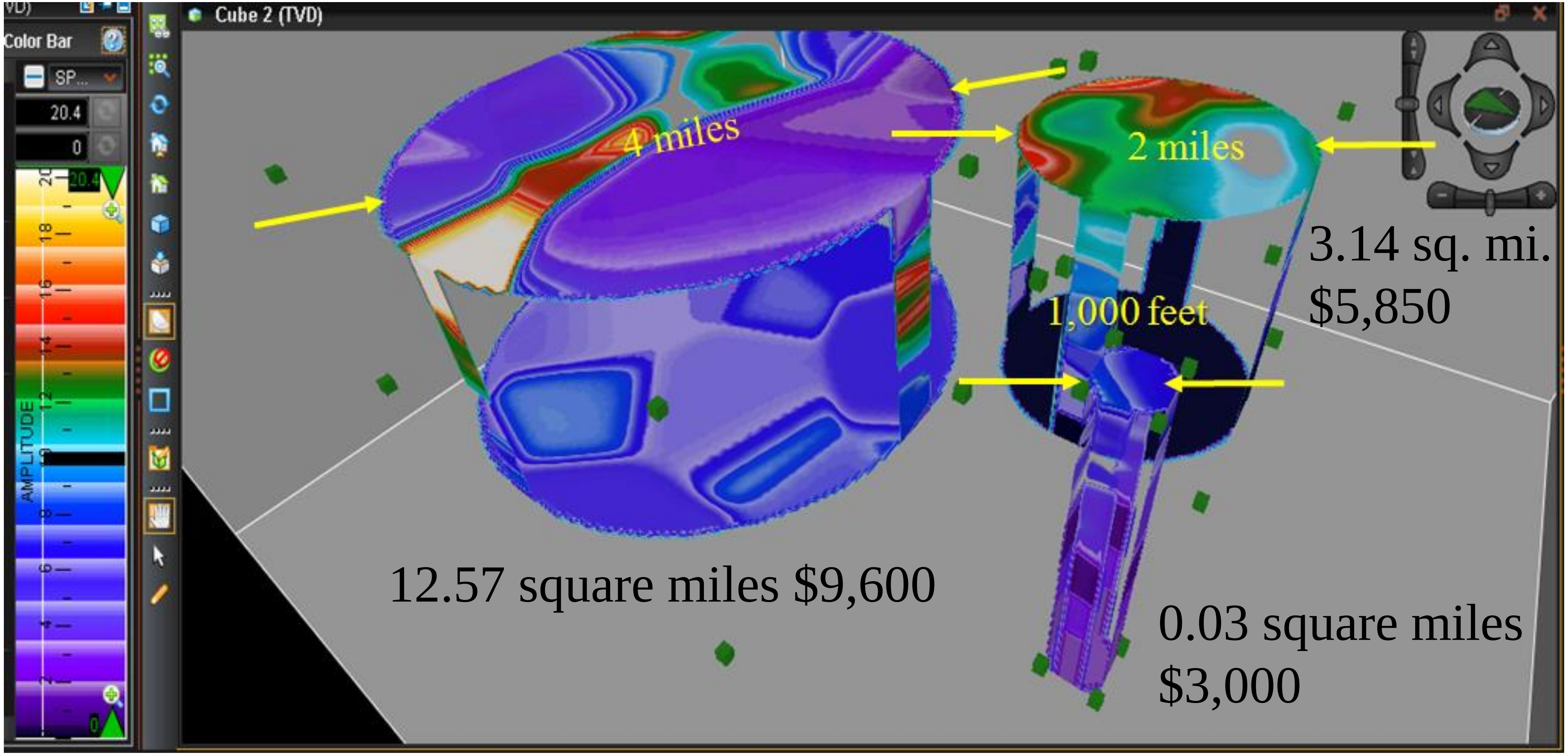
5. Arizona Examples: Resolution Copper

NLDN Peak Current & Rise-Rate

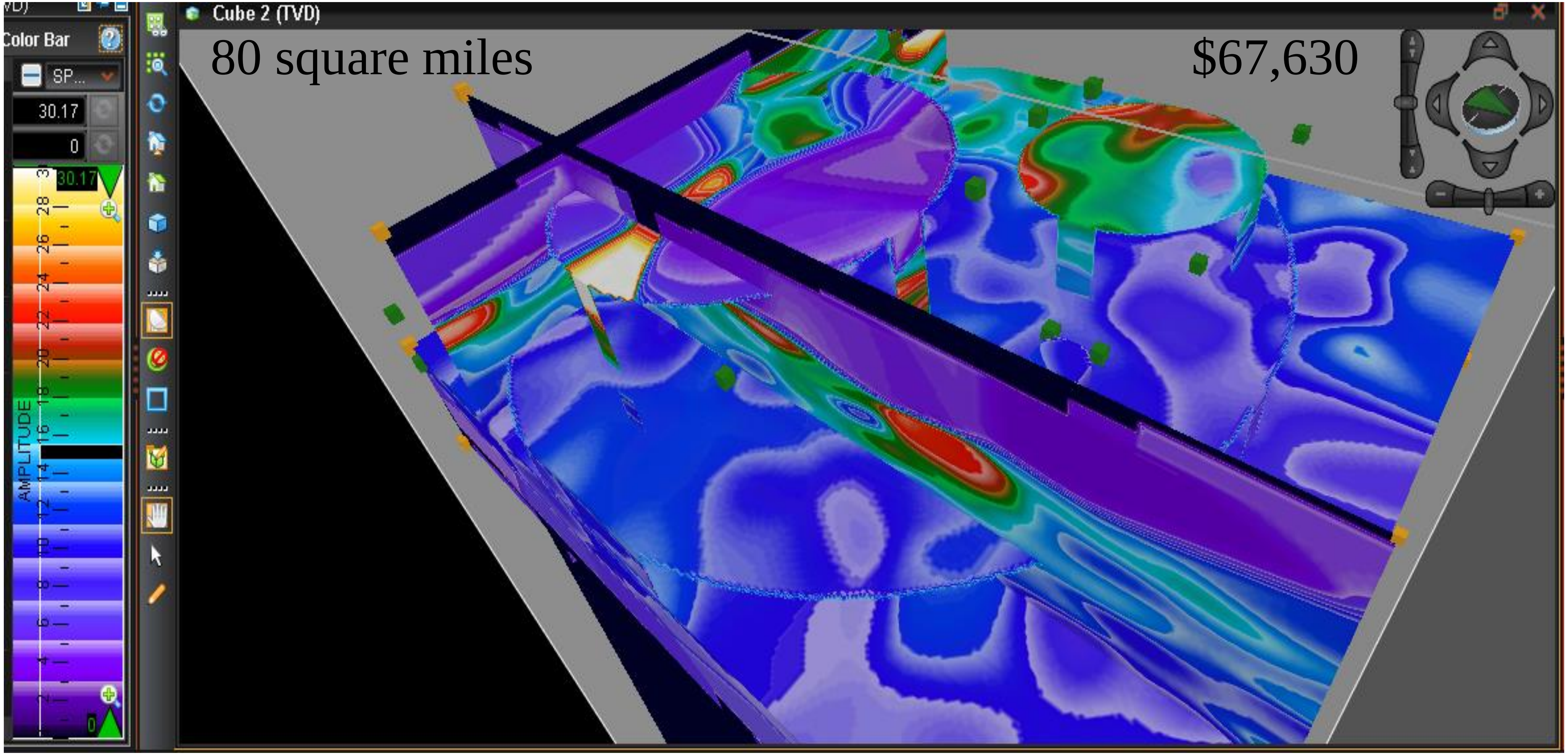




Three Example SPOT℠ Apparent-Resistivity Cylinders

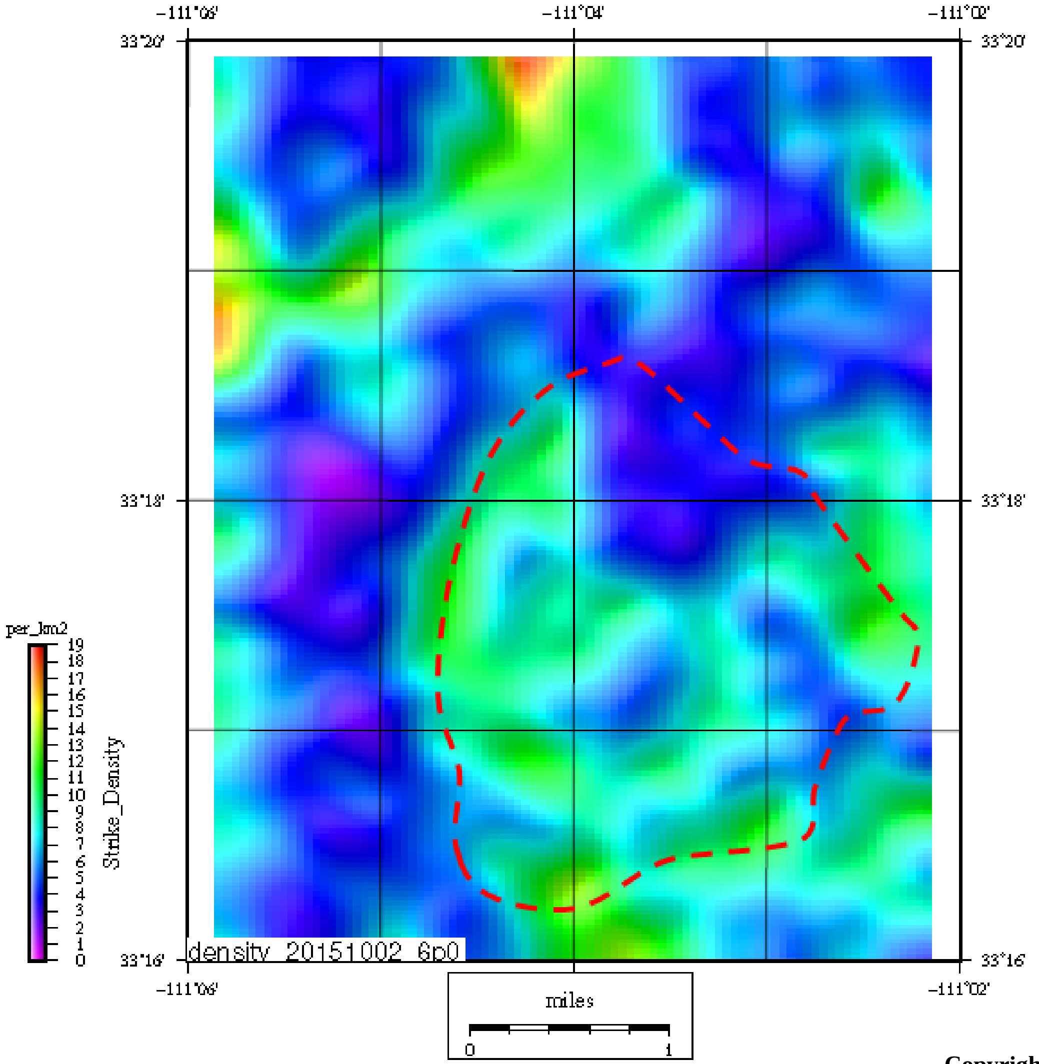


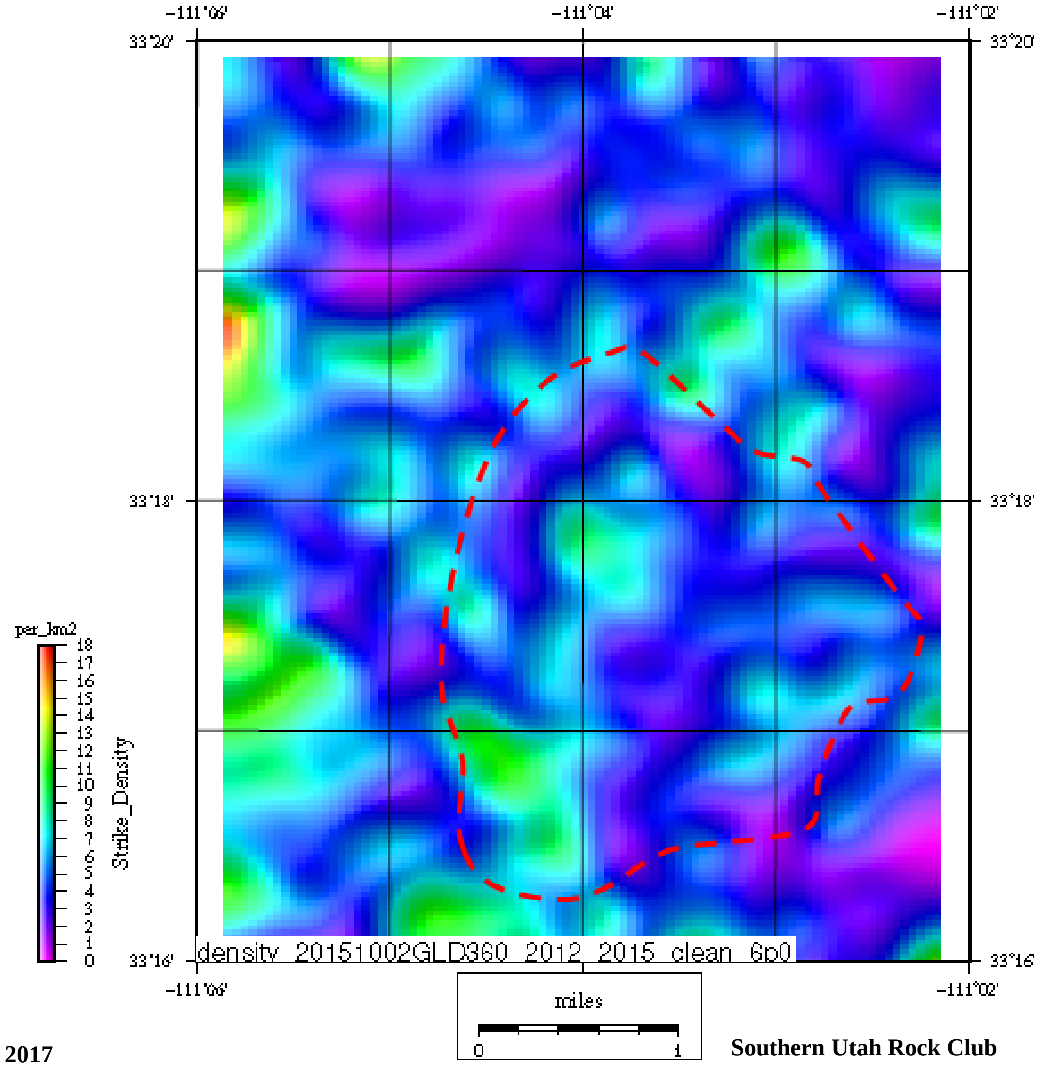
Integrating Resistivity in Three-Dimensions



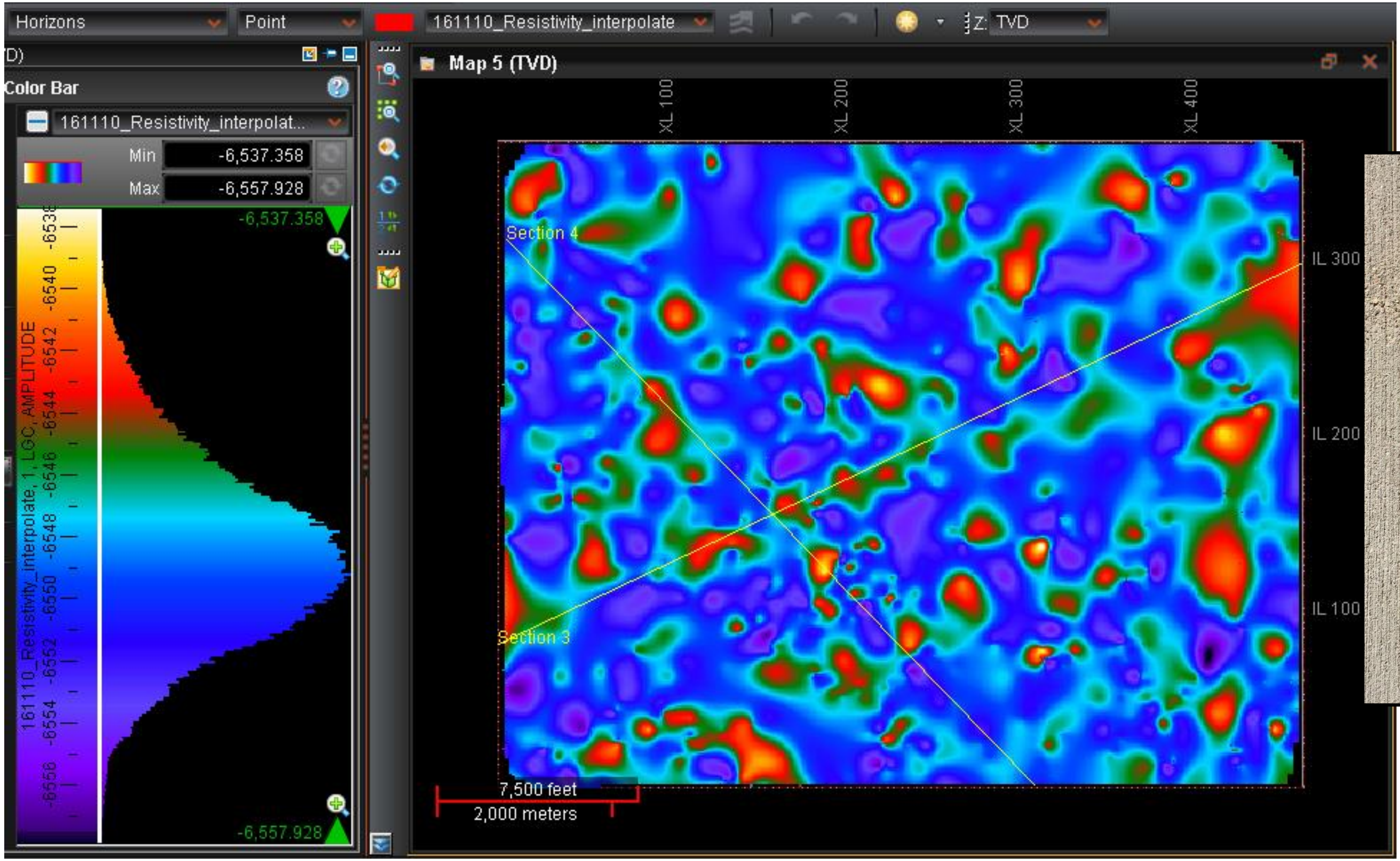
Comparing NLDN and GLD-360 data

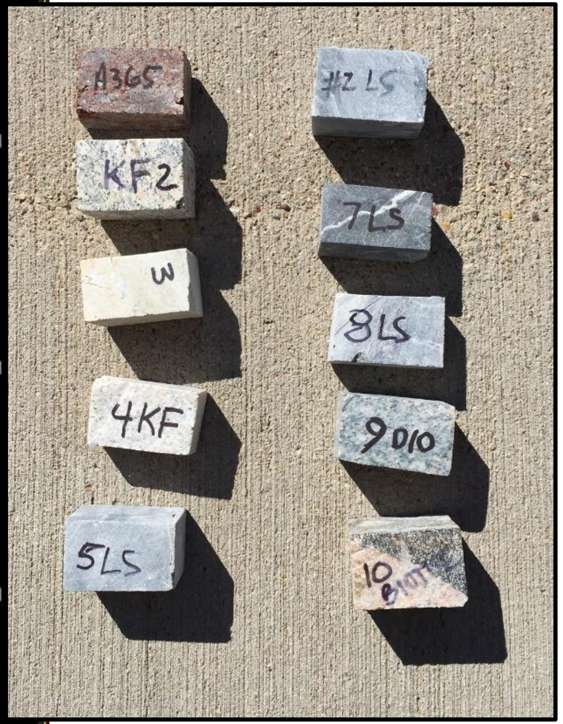
NLDN Density 1998-2015 & GLD-360 Density 2012-2015



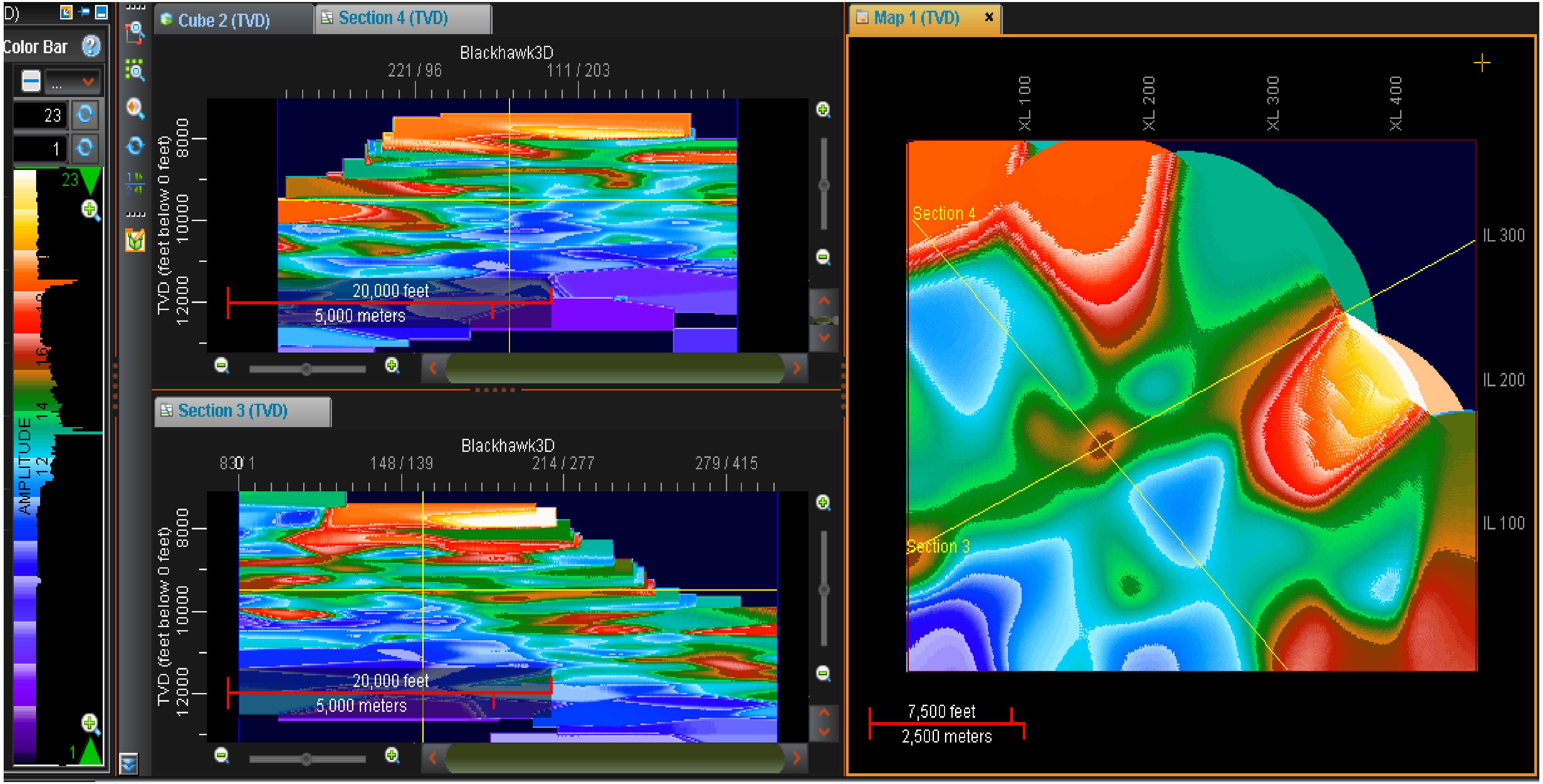


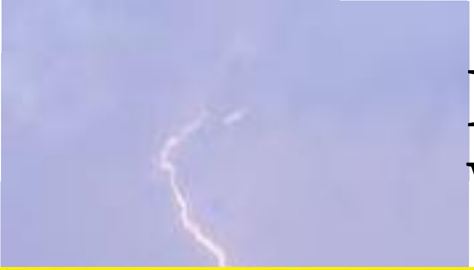
California – Apparent Resistivity Map





5. California – Apparent Resistivity Sections





Imagine August Parties when there is a rain storm Watching Lightning over the Cedar Iron Mines

Not-Yet-Initiated Southern Utah Plans to use this technology (because of cash flow):

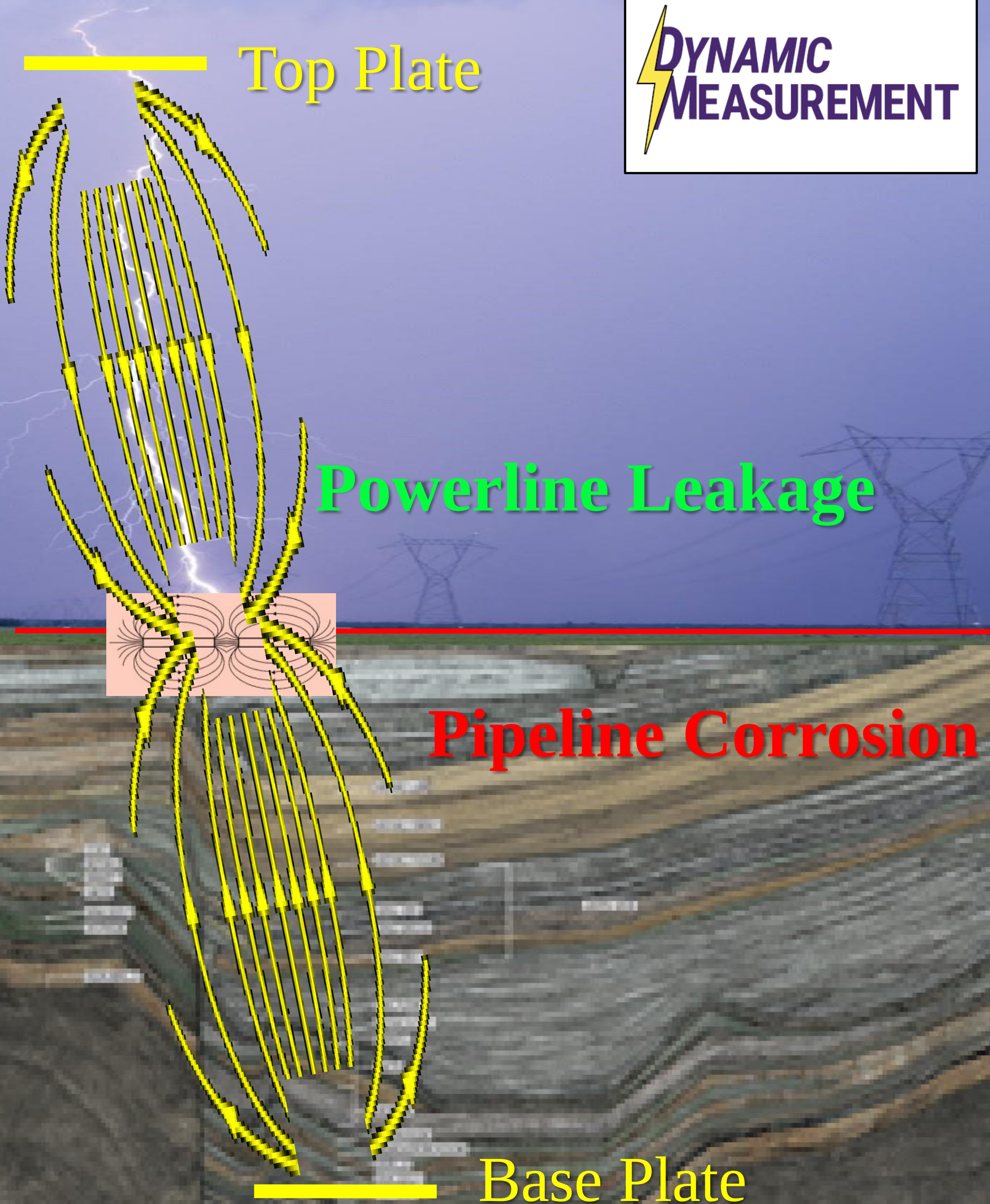
Define aquifers;
Explore for undiscovered mineral deposits;
Map potential new geothermal deposits;
Predict where lightning strikes could start a forest fire among all of the dead trees on Cedar Mountain;
Optimize real estate development to avoid lightning strike concentrations;
Find areas needing cathodic protection along natural gas pipelines;
Identify areas where telluric and terralevis (shallow earth) currents are bleeding electricity off of high power transmission lines;
Locate places to look for unique rocks;
Etc.

Lightning is tied to all aspects of the Earth's Electrical System

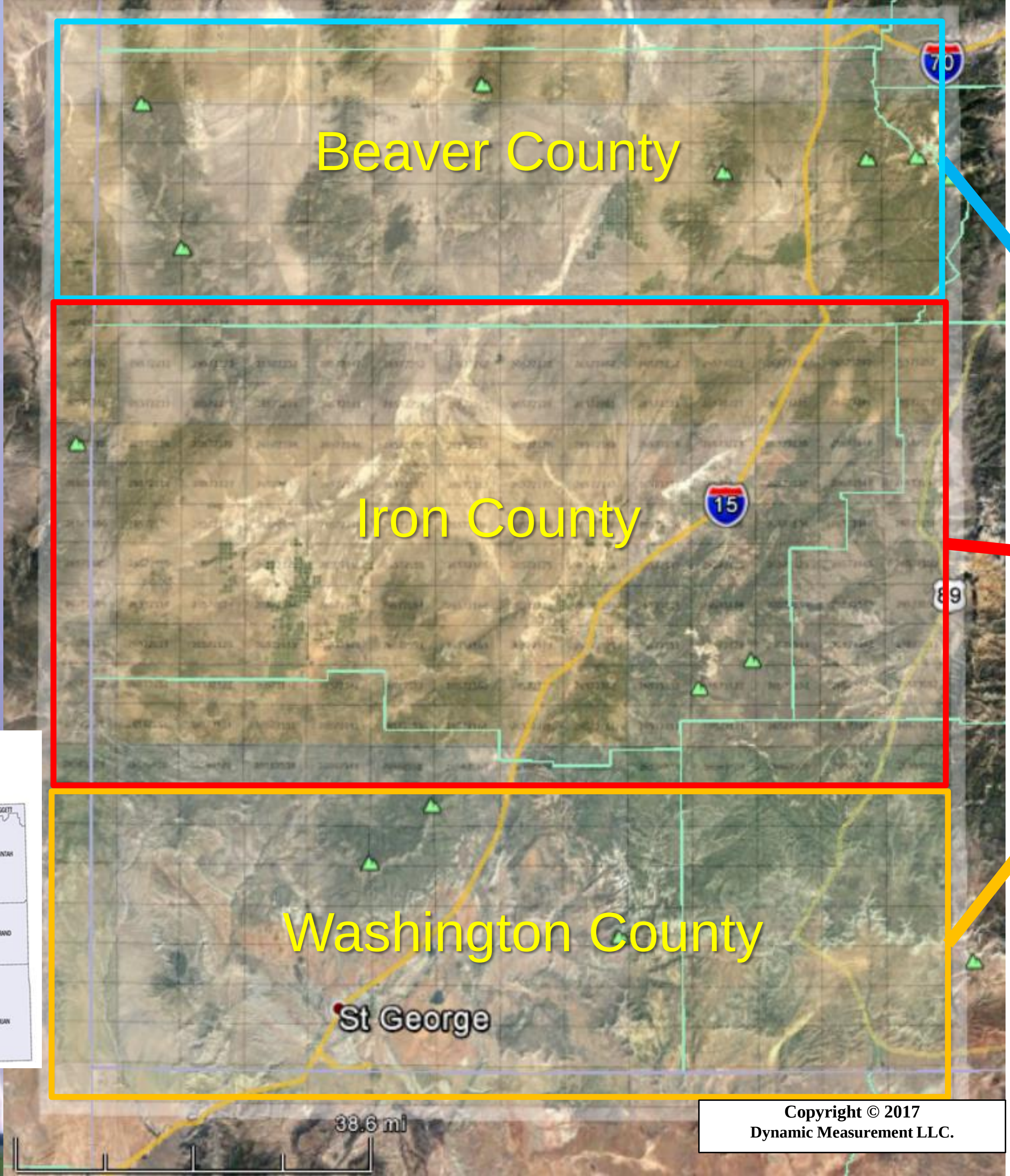
DYNAMIC MEASUREMENT

Just as Geo-Magnetic-Hot-Zones attract more lightning strikes, they pull on electrical current during power transmission, which leads to Leakage

Geo-Magnetic-Hot-Zones are where concentrated sub-surface currents interact with pipelines speeding up corrosion and impacting integrity.



D.NSEM Prices



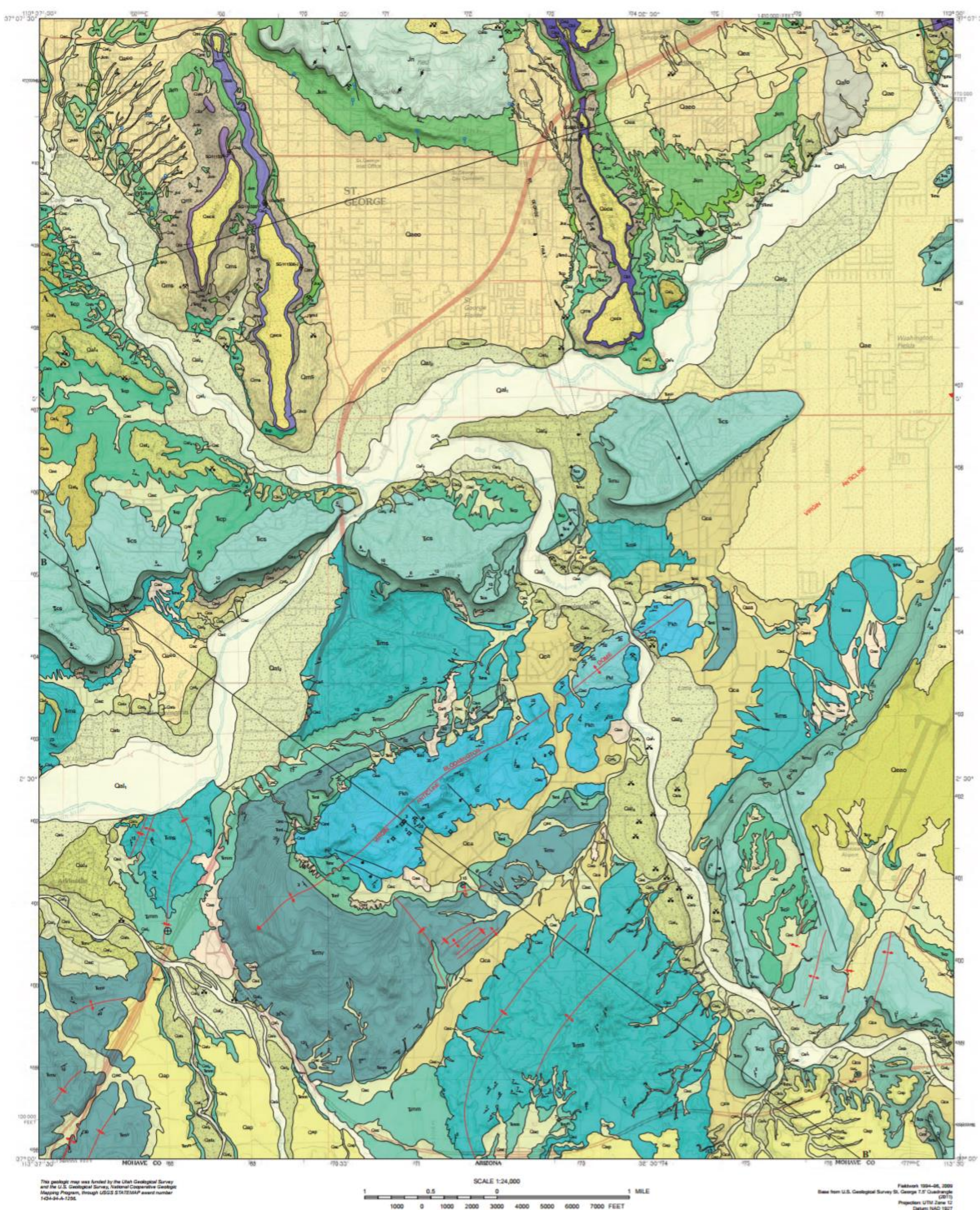
Beaver	Area	Price	Per Unit
Acres	1,805,485	$232,350	$0.13
Sq.Km.	7,306		$31.80
Sq.Mi.	2,821		$82.36

Iron	Area	Price	Per Unit
Acres	3,093,510	$280,000	$0.09
Sq.Km.	12,519		$22.37
Sq.Mi.	4,834		$57.93

Wash.	Area	Price	Per Unit
Acres	2,102,048	$244,920	$0.12
Sq.Km.	8,507		$28.79
Sq.Mi.	3,284		$74.57

TOTAL	Area	Price	Per Unit
Acres	7,000,614	$371,560	$0.05
Sq.Km.	28,331		$13.12
Sq.Mi.	10,938		$33.97

02 March 2017



Identifying Places to Collect Unique Rocks, A Suggested Process:

1. Start with existing state geologic quads (this is the St. George Quad);
2. Purchase lightning data maps and volumes;
3. Map faults with potential hydrothermal alteration;
4. Integrate data types and local knowledge;
5. Go exploring in the field.

Lightning Density Maps show where to look for Lodestone

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

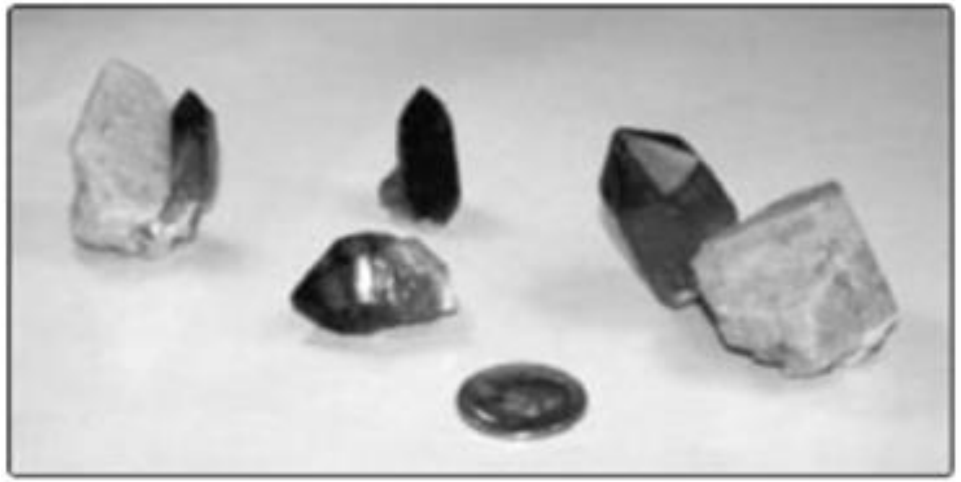
Sand fulgurites found on the top of Mount Raymond. U.S. quarter for scale. 1 / 2

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

Smoky Quartz vugs tie hydrothermal alteration

Geologic information:

The Mineral Mountains, located in Beaver County, make up the largest exposed plutonic body in Utah. Rock compositions range from quartz monzonite in the northern half of the pluton to granite around Rock Corral Canyon in the south. Excellent crystals of smoky quartz and feldspar are found in vugs or cavities in the granite. They formed when cooling fractures in the granite were filled by late-stage pegmatites consisting of quartz, microcline, and plagioclase. Quartz occurs as clear to smoky, euhedral crystals up to three inches long while microcline is commonly found as euhedral, equidimensional crystals averaging approximately 0.75 inches in width. Occasionally, large pseudomorphs of limonite after pyrite can be found in these areas as well.



Sunstones and Topaz deposits are associated with lightning mappable underground geologic processes

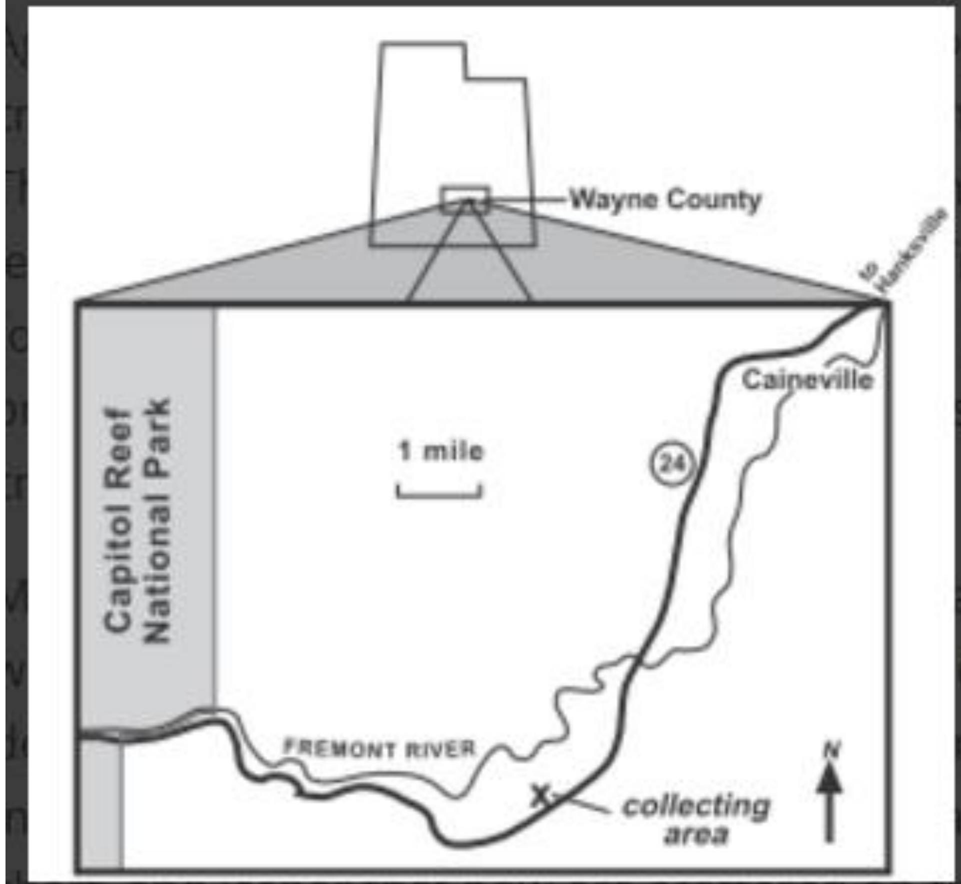
Sunstones collected at Sunstone Knoll, Millard County. 1 / 4

Topaz crystals. 1 / 7

One of the numerous pits that collectors excavated in their search for topaz and other minerals. 6 / 7

Predicting sites of volcanics, mineralization, & alteration

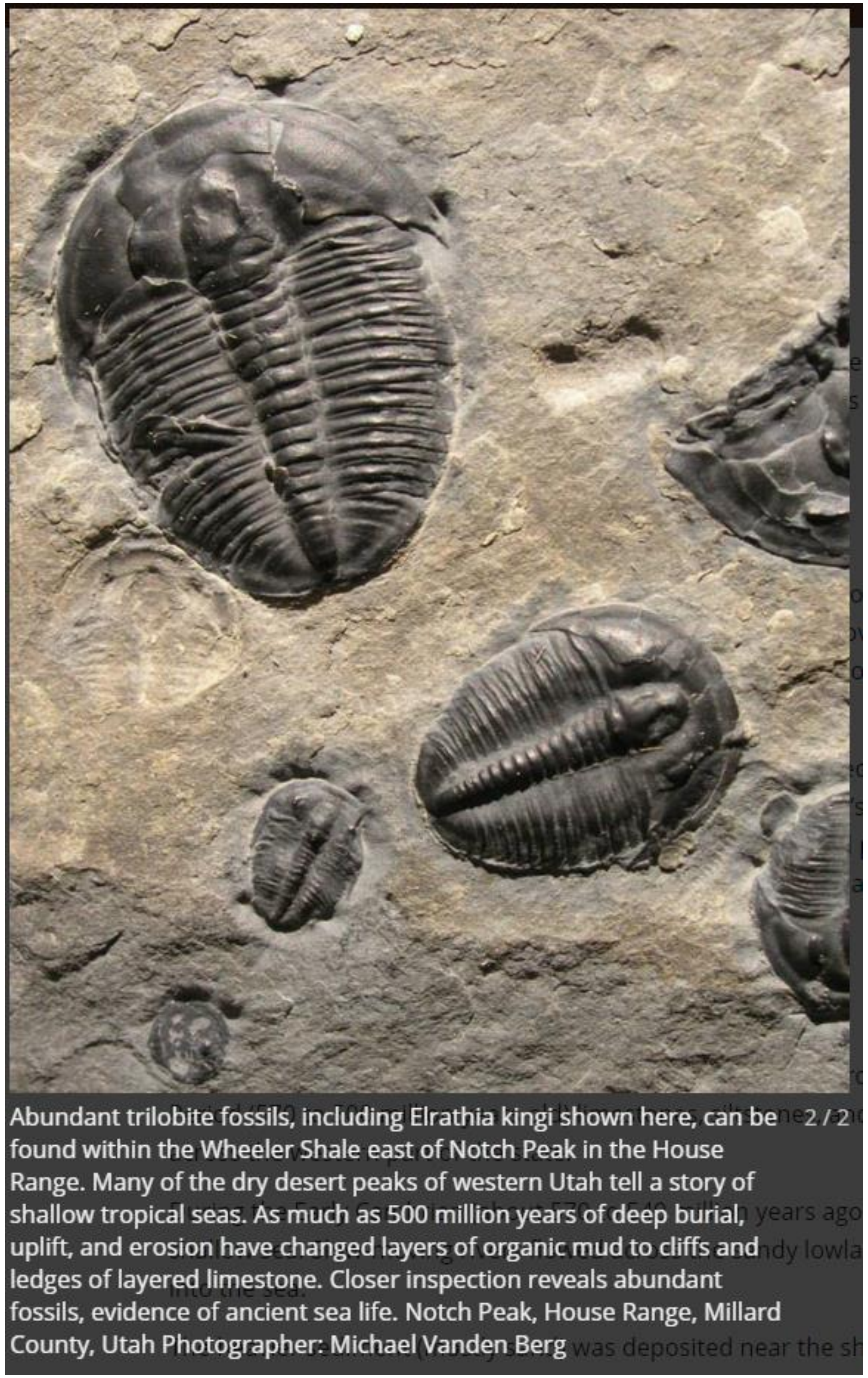
minerals: Bixbyite with amethyst found in rhyolite. 1 / 3



How to get to agate, chert, jasper, and petrified wood collection site near Caineville, Wayne County, Utah. 3 / 3

Snowflake obsidian collected in the Black Spring area, Black Rock Desert, Millard County. 1 / 3

Where sedimentary rocks with fossils outcrop can be predicted from lightning volumes



Red & Green Beryl
are a direct result of hydrothermal alteration

Specimen of red beryl from the Ruby-Violet claims in the Wah Wah Mountains. U.S. quarter for scale.

THE GEOLOGY OF... Emeralds

Green Gold

Oh, what a little hot water can do to boring old shale

BY ROBERT KUNZIG

Before the Spanish conquest of what is now Colombia, people in the mountains north of Bogotá are said to have thrown emeralds into Lake Guatavita. Once a year the Indian ruler would cover himself with honey and gold dust and at daybreak have his men row him out into the lake. As he plunged into the water, offering the gold to his god, the crowd on shore would throw in their own offerings. The rich ones chucked in emeralds.

When the Spaniards finally found the Indian emerald mines after decades of bloody searching, the Old World went crazy for the New World's gems. Although the Egyptians had begun mining emeralds near the Red Sea as early as 1650 B.C.—and emeralds had long been symbols of immortality, cures for dysentery, and preservers of chastity—the new Colombian gems were the clearest, biggest, and greenest anyone in Europe had ever seen. They still are: the same mines remain in operation, accounting for 60 percent of the world's production.

Emeralds are valuable because they are rare, rarer than diamonds. They are rare, says geologist Alain Cheilletz of the Center for Petrographic and Geochemical Research in Nancy, France, because they are a mixture of elements that

For centuries emeralds were thought to cure dysentery and even preserve chastity

don't ordinarily get a chance to mix: "They are a mineral that shouldn't exist at all."

An emerald is a type of beryl, a mineral made of beryllium, aluminum, silicon, and oxygen. All those elements are common in the continental crust, so beryls are not rare. But whereas ordinary beryls are colorless, emeralds are green because a few of the aluminum atoms in their crystal structure have been replaced by atoms of chromium or vanadium. Neither of those elements has any reason to meet up with beryllium; they and it belong to two different chemical families that drifted apart billions of years ago.

Soon after Earth was born, when it was young and mostly molten, a lot of silicon and aluminum rose to the surface, like a kind of scum, then cooled, forming the first continents. Most of the iron stayed behind in the mantle or sank into the planet's core. Other elements chose one of those two fates, too, based on their weight and size.

Because of this parting of the elements, Earth's surface rocks are segregated into two realms, like yang and yin: light and dark, crust and mantle, continent and ocean bottom. Geologists call the light minerals felsic and the dark ones mafic. The paradox of the emeralds, as Cheilletz calls it, is that beryllium belongs to the light, felsic, continental side, whereas chromium and vanadium are from the dark, mafic, oceanic side. Emeralds, in other words, are yin and yang in a single crystal. "The whole problem in our research," says Cheilletz, "was to figure out the geologic conditions that could permit these two elements to meet at the same time and place."

A sparkling Colombian emerald born of the drabbest black shale.

The answer, they discovered, has to do with plate tectonics, the ceaseless shifting of Earth's crust that smashes continents together to build mountains. Every now and then, when an ocean disappears between two colliding continents, a chain of volcanic islands or a slab of seafloor gets beached on land. As a result, the continental crust has over the eons lost its original purity; it has become a patchwork that includes oceanic rocks, and thus traces of chromium and vanadium, along with the continental rocks that are laced with beryllium.

To make an emerald, though, those elements have to come together in a single hot liquid. The most common place for it to happen is underneath a young mountain range. Where the edges of two colliding plates stack up, continental rocks can get dunked so deep into Earth that they melt again, liberating a great balloon of magma that rises back through the crust. At a depth of around six miles, the magma reaches its level of neutral buoyancy, stops, and begins to cool and solidify as granite. From the top of this cooling mass, streams of superhot, mineral-laden water—granite juice—migrate upward into fissures in the surrounding rock and begin to leach out elements.

Ninety-five times out of a hundred that surrounding rock is some ordinary bit of continent, and nothing terribly novel happens. "But if by chance the granite happens to hit a zone of mafic rock incorporated in the continental crust, then the chemistry will be completely different," says Cheilletz. "It will include iron, magnesium, and calcium—and traces of chromium and vanadium." When the felsic-mafic mixture finally freezes, the fissure will be filled with biotite, a kind of mica—black, flaky, and useless. But scattered through the mica, like green snowflakes, may be emeralds.

Most of the world's known emerald deposits, from the 3-billion-year-old ones in South Africa to the 9-million-year-old ones in Pakistan, were formed by granite intrusions. In the 1980s, Cheilletz and his colleague Gaston Giuliani studied deposits like that in Brazil. Then they went on to Colombia to have a look at the most renowned emerald mines—and soon saw that they didn't fit the standard picture. "In Colombia, geologists had been looking for granites but not finding them," Giuliani says. "When I arrived, I saw right away that the rocks were not the same."

Instead of granites intruding from below, in Colombia there are black shales laid down from above—sedimentary rocks deposited on the floor of a shallow inland sea during the Cretaceous Period, 100 million years ago. The sea must have been shallow, because the shales are sandwiched among layers of salt, which precipitated out of the water at times when it had all but evaporated. Black shales, besides being progenitors of oil fields (of which Colombia has a few), also contain everything that washed off the various rocks that made up the neighboring land. The Colombian shales contain, in dispersed form, all the ingredients of emeralds.

According to Giuliani and Cheilletz, those ingredients came together on two distinct occasions, 65 million and 38 million years ago. Surges in plate motions—the Atlantic Ocean was getting wider, pushing South America against the Pacific and raising the Andes—caused the thick stack of sediments under the shallow sea to buckle. Large sloping faults formed several miles down in the sediments, and hot water was squeezed out of them, escaping upward along the faults. Rising through layers of salt, the 570-degree water became extremely corrosive. Continuing through layers of shale, it dissolved out the emerald ingredients. Finally it pooled under a layer of especially impermeable shale until the pressure became great enough to shatter that layer explosively.

Then the hot solution shot up through empty cracks in the rock. As its temperature and pressure plummeted, emerald crystals snowed out of it immediately. It all happened so fast, says Giuliani, that the emeralds had no time to grow around grains in the surrounding shale. They grew unconstrained and pure, without the minerals that often cloud emeralds found in other parts of the world. That is why Europeans were so enraptured with the Colombian stones when they first laid eyes on them in the sixteenth century.

Like other emeralds, those from Colombia contain tiny pockets of fluid, typically no more than a hundredth of an inch across—gardens, as they're called in the gem trade. If you look at one of the Colombian gardens under a microscope, says Giuliani, you will see that it contains a crystal of salt, ordinary sodium chloride. The crystal is a trapped fossil of the brine from which the emerald itself crystallized, tens of millions of years ago.

Inside each emerald is a small pocket of fluid, called a garden. In the fluid is a crystal of salt. Often that microscopic evidence is the only way to tell a fake

Except for those inclusions, emerald manufacturers today are able to mimic natural processes so well that it can be difficult for a layman to tell synthetics from the real thing. Perhaps that's one reason emeralds don't pack the same emotive resonance for us that they did for bygone Indians and kings. We no longer see links to divinity or immortality in an emerald's limpid green depths. What we might imagine swirling around in the stones is history: the entire history of the planet distilled into a single miraculous (scientifically speaking) crystal. That's resonance enough for a rock.

Photo Researchers

Courtesy Tiffany & Company

Acknowledgements:

- Les Denham, DML Chief Geophysicist.
- Kathy Haggar, DML Geologist.
- Louie Berent, DML Geophysicist.
- BYU Interns Dustin Northrop and R. Corbin Lewis.
- Tom Ewing (BEG) for regional South Texas geology.
- Bob Hardage (BEG) for Stratton seismic survey.
- Andrea Nelson, for enduring the startup phase.

Thank You!

http://www.dynamicmeasurement.com/TAMU/170302_Lightning_Analysis_creating_geo-frameworks.pdf

- H. Roice Nelson, Jr., Geophysicist

  cell: 713.542.2207

  e-mail: roice@dynamicmeasurement.com

www.dynamicmeasurement.com

www.dynamicmeasurement.com/TAMU

www.dynamicmeasurement.com/LI

- 211 Baker Road #382

  Barker, TX 77413

  – Office: 281.579.0172
- 2155 West 700 South #31

  Cedar City, UT 84720

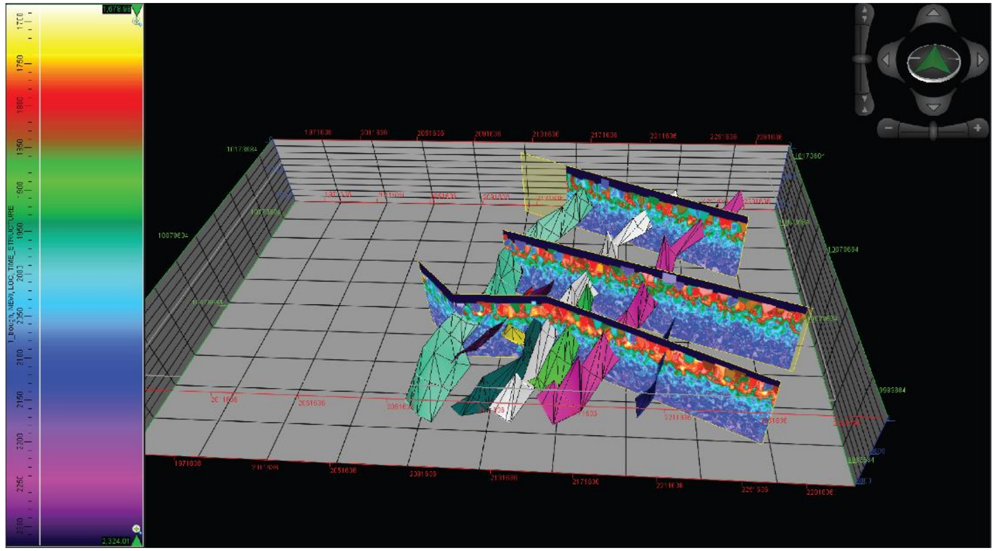
  – Fax: 435.267.2668

Abstract – Lightning Analysis: creating geo-frameworks

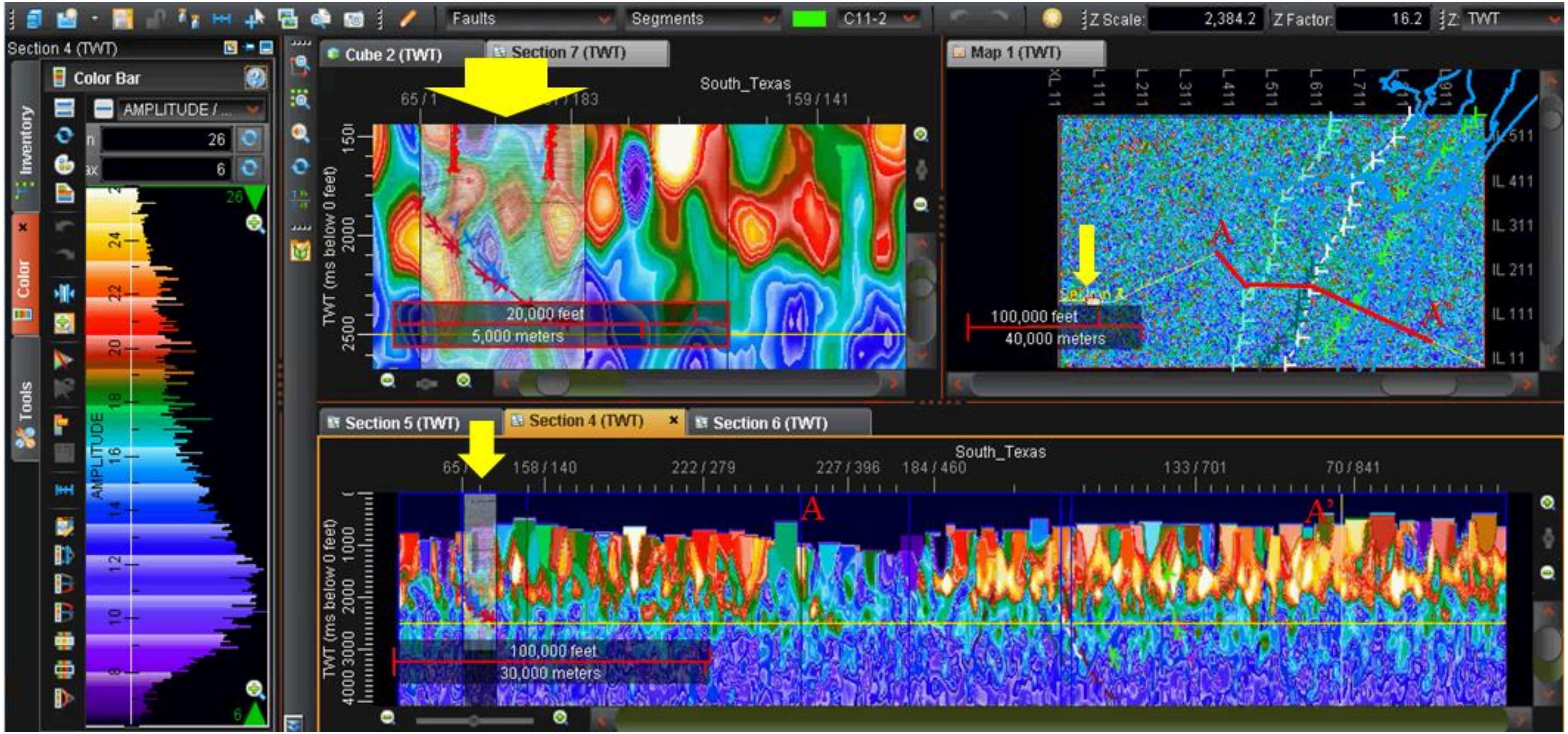
02 March 2017, 6:15, at the Cedar City Recreation Center on the Hill, H. Roice Nelson, Jr., a geophysicist from Cedar, B.S. Geophysics 1974 University of Utah, with over 45 years working in oil, gas, & mineral exploration, will speak at the Southern Utah Rock Club Meeting.

Geophysicists have used passive gravity, magnetic, and seismic measurements to understand the subsurface of the earth for decades. Dynamic Measurement has expanded these capabilities, developing and patenting ways to data mine electrical information in existing lightning strike databases in order to map faults, creating geo-frameworks of subsurface geology anyplace onshore and out to at least 100 meter (330 foot) water depths.

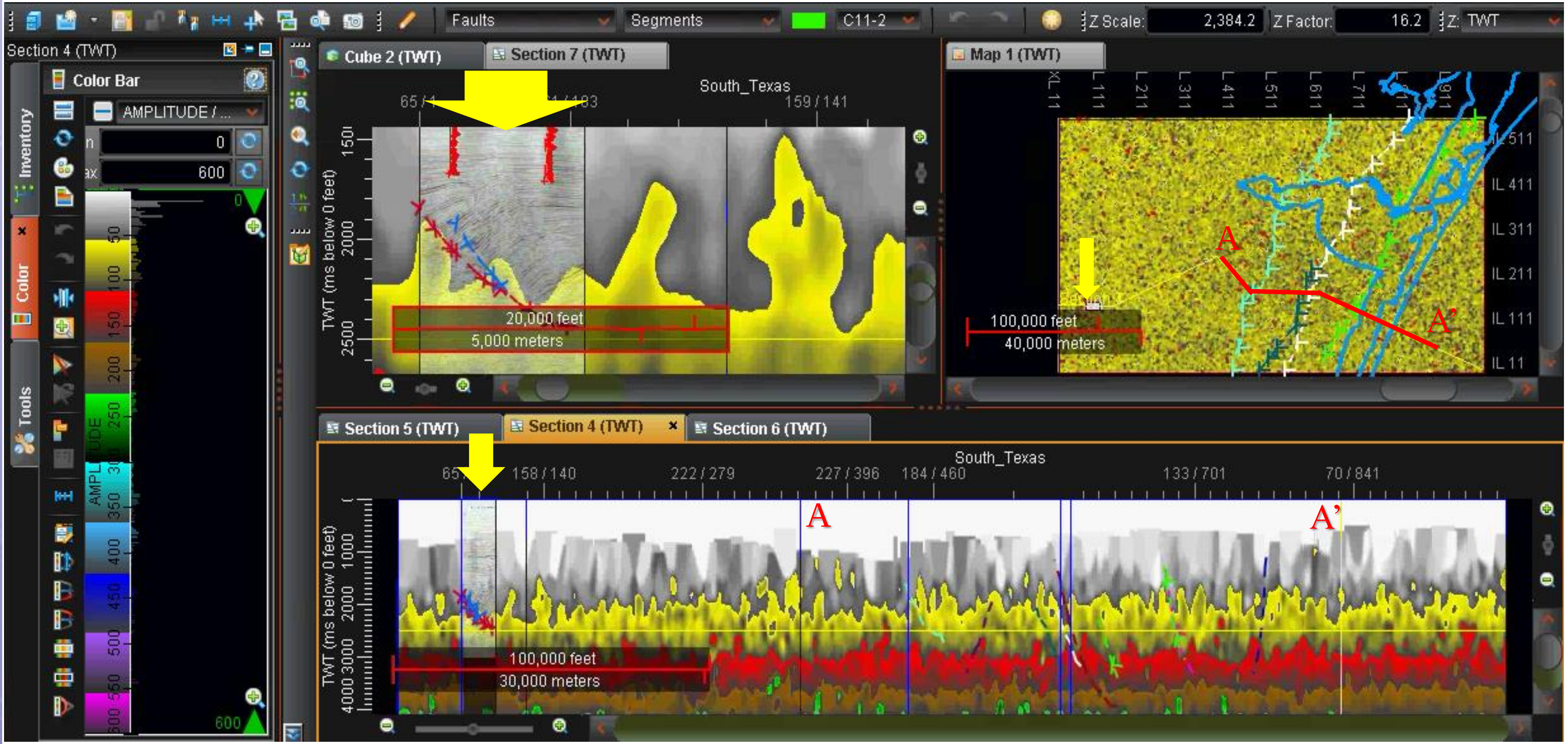
This presentation will review Dynamic's lightning technologies, and show examples from lightning analysis projects in Texas, Louisiana, Michigan, Arizona, and California. Because Roice and Andrea moved back to Cedar City a couple of years ago, there will also be a review of plans to use this technology in Southern Utah to map mineral deposits, define aquifers, predict where lightning strikes could start a forest fire among all of the dead trees on Cedar Mountain, optimize real estate development to avoid concentrations of lightning strikes, predict areas needing additional cathodic protection along natural gas pipelines, identify areas where telluric and terralevis (shallow earth) currents are bleeding electricity off of high power transmission lines, and, most importantly, identify new places to collect unique rocks.



Apparent-Resistivity extension of Ewing (1986) A-A' through Stratton seismic data

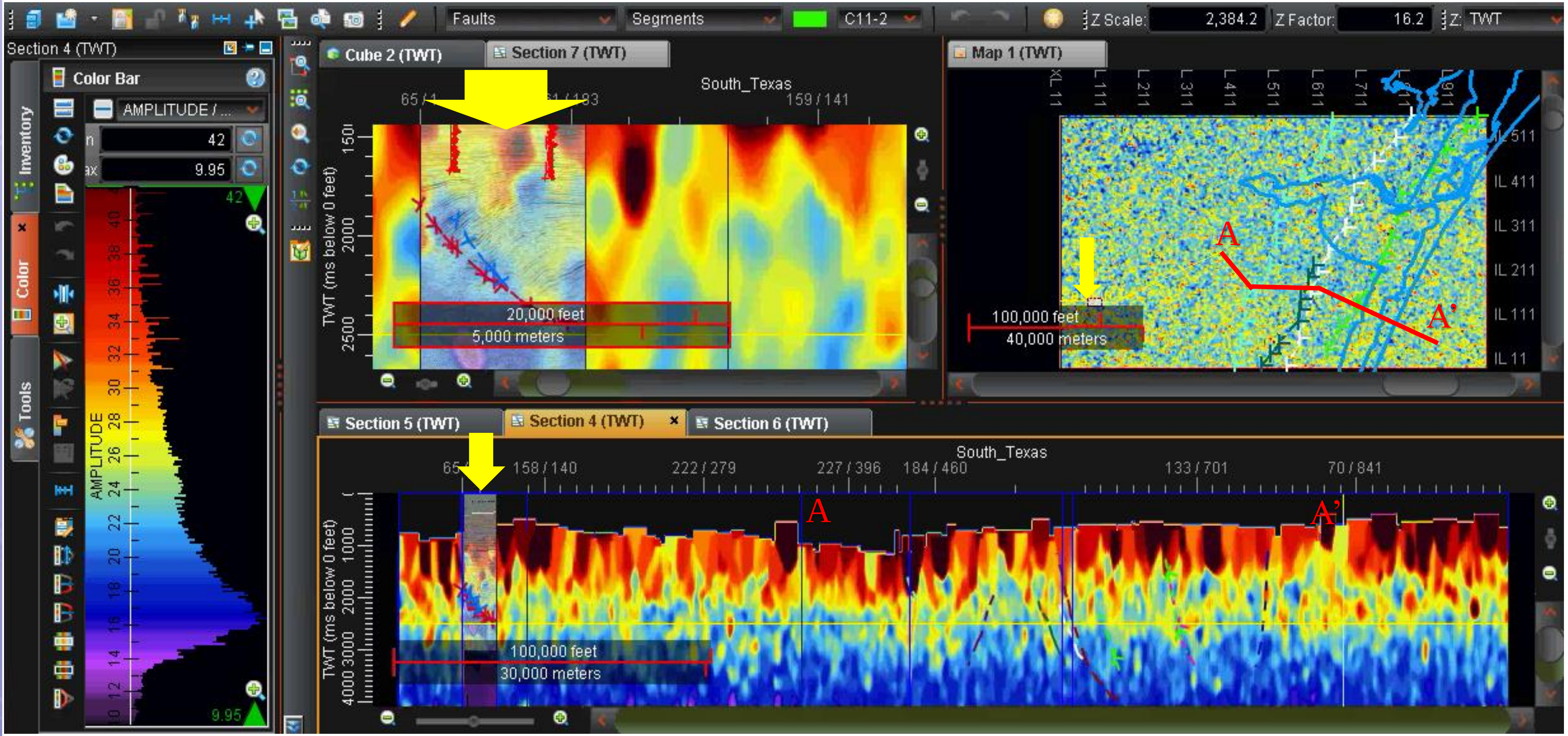


3 of 18 Lightning Attributes - Energy



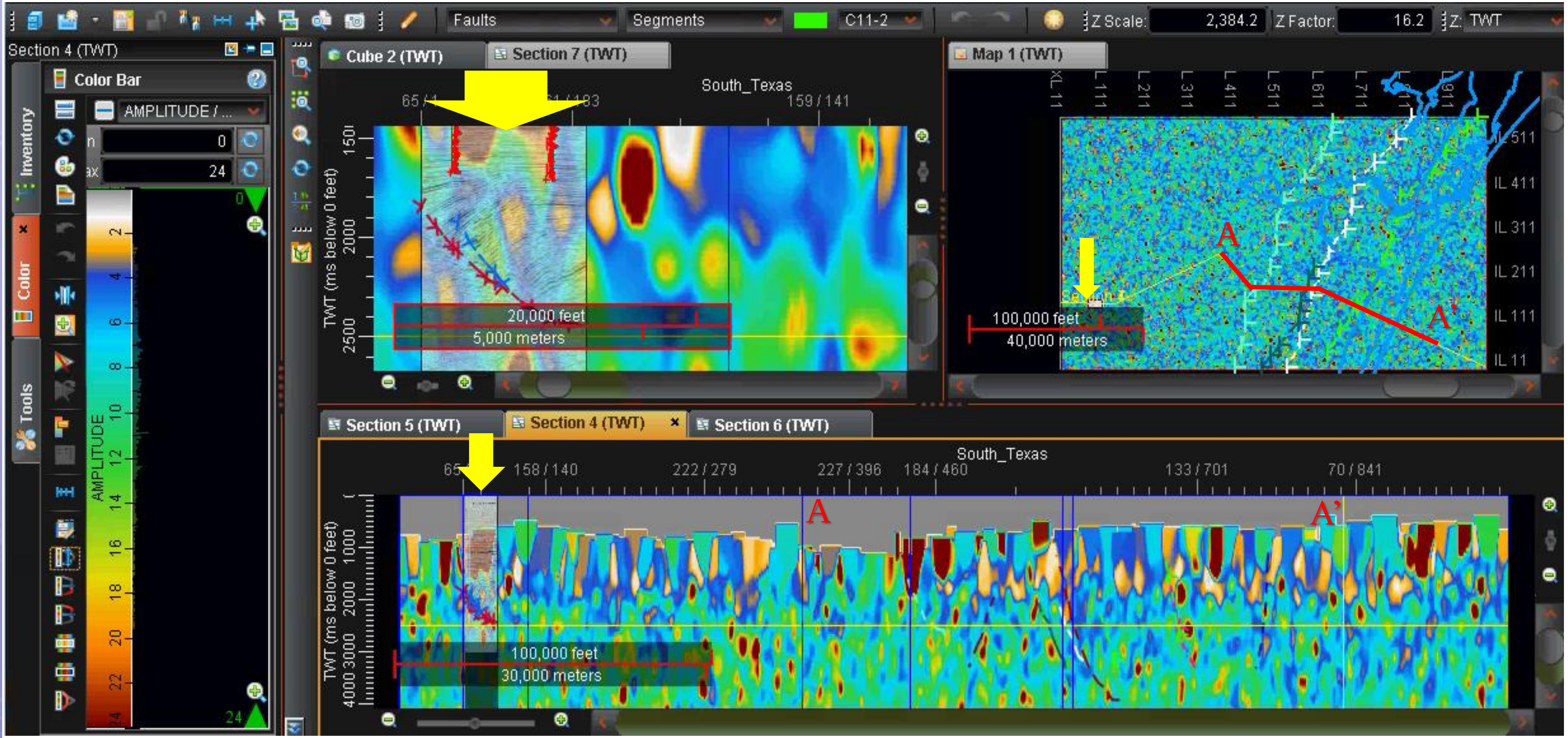
(milliampere-seconds)

4 of 18 Lightning Attributes - Frequency



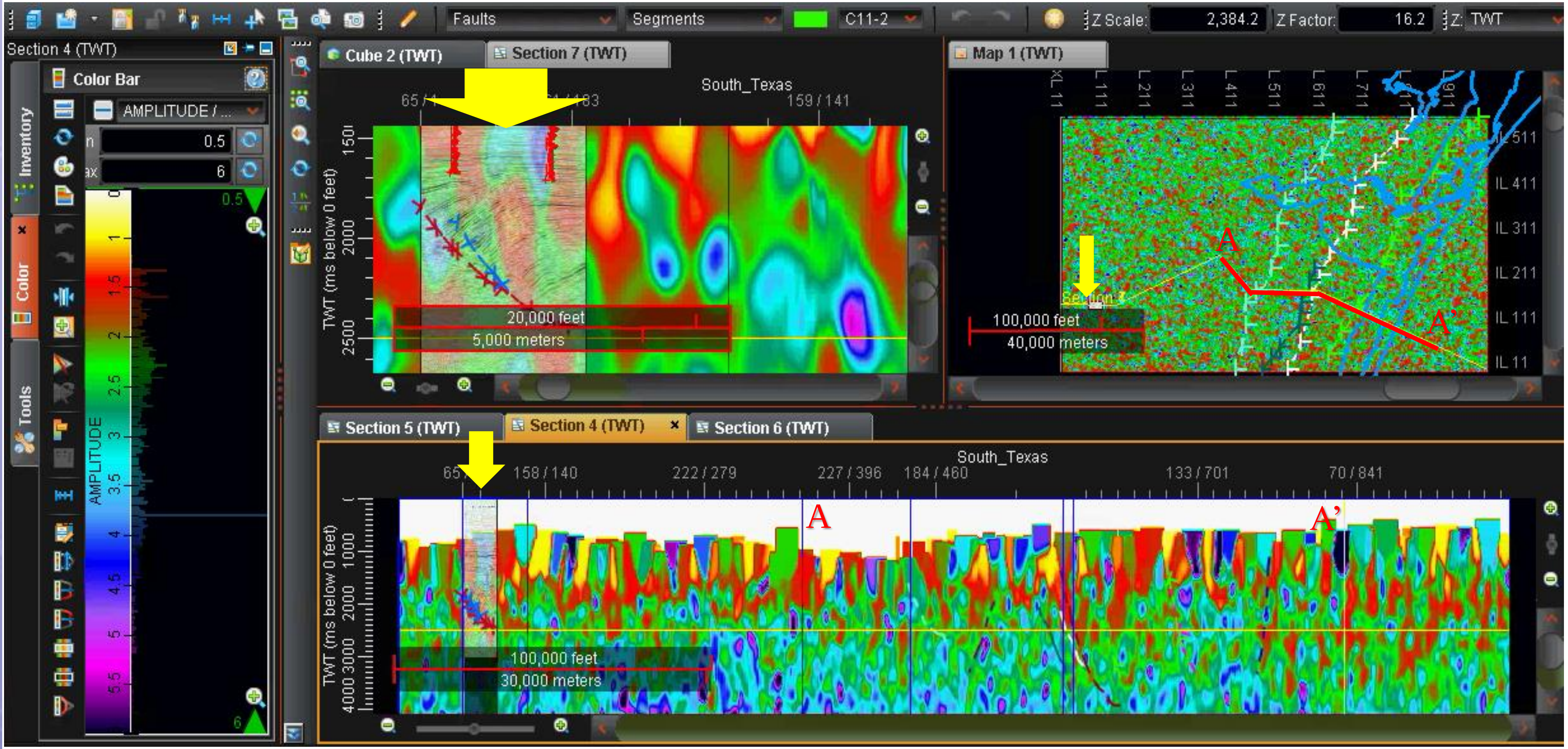
(kilohertz)

9 of 18 Lightning Attributes - Apparent Permittivity



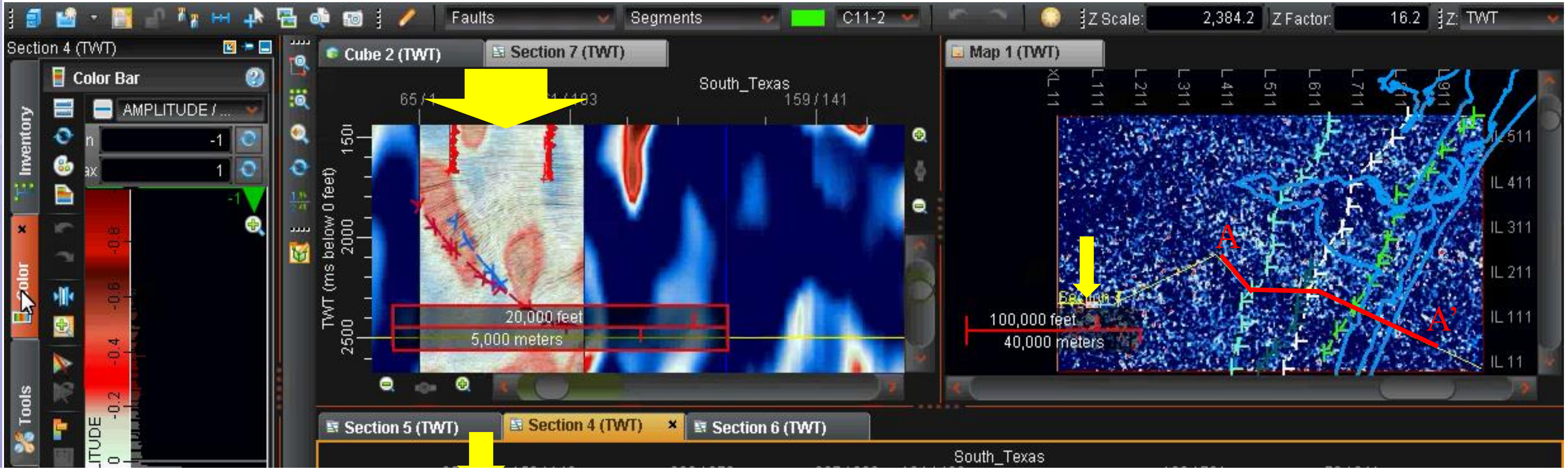
(microfarads per meter)

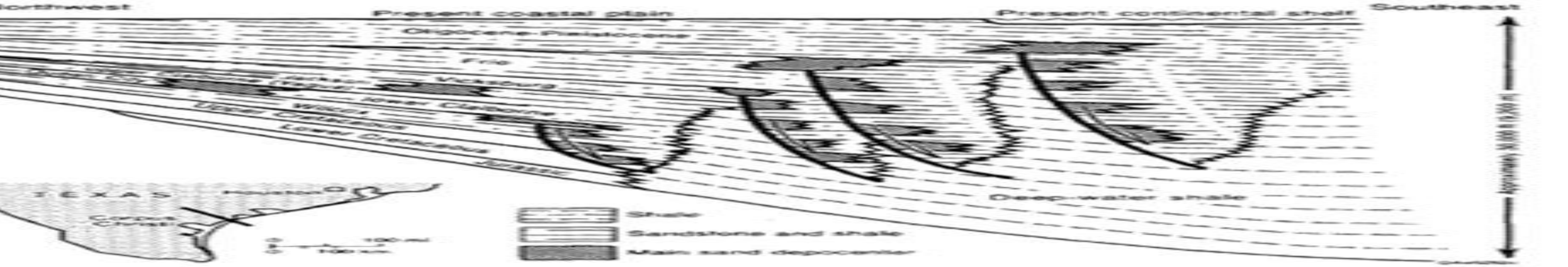
11 of 18 Lightning Attributes - Rise Time



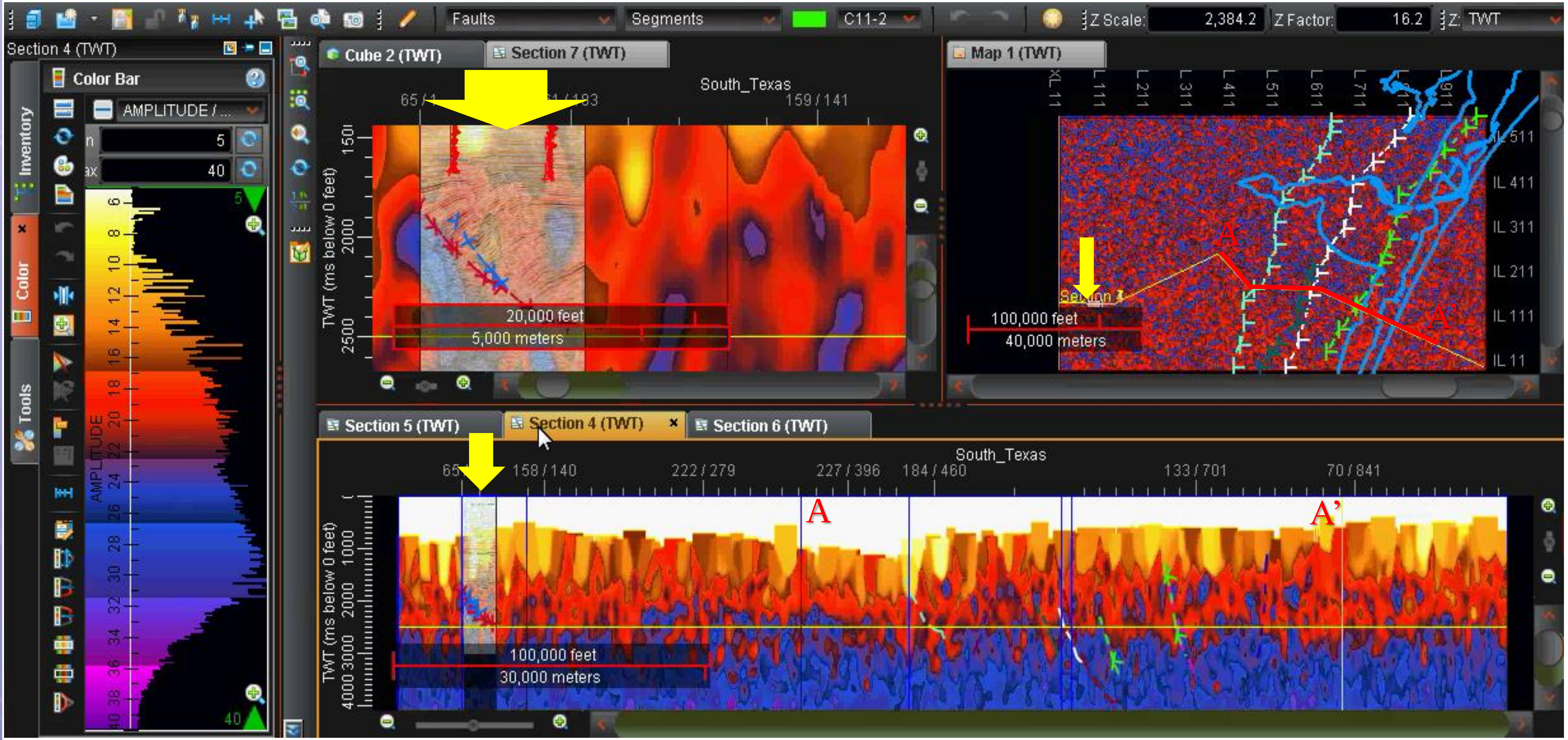
(microseconds)

17 of 18 Lightning Attributes - Tide Gradient





18 of 18 Lightning Attributes - Total-Wavelet Time



(microseconds)

Southern Utah has some of the best "rock hounding" available on planet Earth

Igneous

Quartz Monzonite: Quartz monzonite, a very close relative of, and locally known as "granite", is a gray, "salt and pepper" igneous rock exposed in the lower reaches of Little Cottonwood Canyon. It is exposed on the Temple Quarry Nature Trail on the south side of Little Cottonwood Road (SR 209) near the mouth of Little Cottonwood Canyon. The quartz monzonite intruded into the Wasatch Range between 24 and 31 million years ago (Hintze, 1988).

Metamorphic

Slate and Quartzite: Slates and quartzites are exposed in lower Big Cottonwood canyon at the geologic road sign "Storm Mountain Quartzites", about 3 miles from the mouth of the canyon. The black slates and "rusted"quartzites are part of the Big Cottonwood Formation, and are about 900 million years old (Hintze, 1988).

Marble: Seven miles from the mouth of the canyon, white marble intruded by dark diorite exposed in a road cut on the north side of the canyon. The geologic road signs, "Blind Miner", "Mississippian Marble", "Big Cottonwood Mining District", are in the turnoff area across from the outcrop. The sign indicates that the marble is a metamorphosed Mississippian-age (360-320 million years) limestone. The diorite is 72.4 million years old (James, 1979).

Gneiss: A gneiss that may be as much as 3 billion years old is exposed at the north end of the bridge, where 300 East becomes Skyline Drive in northern Farmington City. The gneiss has dark schistose (lots of mica) and light gneissose (quartz and feldspars) layers. The gneiss is part of the Farmington Canyon Complex.

27,270 year old volcanic flows in Santa Clara

In the fall of 2005, we finally found the charcoal we had been looking for – a short woody branch preserved in loose sand just below the lava flow that appeared to have been burned by the advancing lava. The lab (Beta Analytic, Inc.) struggled with the sample, probably because of the high temperature to which it had been subjected, but finally obtained an age of 27,270 ± 250 radiocarbon years before present. We feel confident that this age is reliable, but we hope we can someday confirm or refute the results by finding another sample and using another dating method.

Is the Santa Clara flow the youngest lava flow in Utah, as some have suggested? No – not even close. Though other young flows are poorly dated for similar reasons, we are confident that some flows in the Fillmore-Black Rock Desert area in central Utah, and on the Markagunt Plateau north of Zion National Park, are much younger. The Ice Springs flow near Fillmore may be less than 1000 years old (C.G. Oviatt, UGS Special Studies 73).

geology.utah.gov/map-pub/survey-notes/new-age-for-the-santa-clara-basalt-flow/

There are all types of rock waiting to be found

Sedimentary

Limestone, Sandstone, Siltstone, and Shale: A short (just less than one mile) walk on uneven but level ground that used to be the I-80/Foothill Drive off-ramp leads to an outcrop of limestone, sandstone, siltstone, and shale on the north side of the mouth of Parleys Canyon. Walking south, the rocks appear in sequence as gray limestone, orange sandstone, and red siltstone and red shale. The limestone is part of the Jurassic (208-163 million years) Twin Creek Limestone Formation, the sandstone is the Jurassic Nugget Sandstone Formation, and the siltstone and shale make up the upper member of the Triassic (245 – 208 million years) Ankareh Formation.

Conglomerate: A beautiful red conglomerate with clasts up to cobble size crops out near the junction of the Emigration Canyon road and the road to Pinecrest in Emigration Canyon. The conglomerate is the Cretaceous (144-66.4 million years) Kelvin Formation.

References

Hintze, L.F., 1988, Geologic history of Utah: Brigham Young University Geology Studies Special Publication 7, 202 p.

James, L.P., 1979, Geology, ore deposits, and history of the Big Cottonwood Mining District, Salt Lake County, Utah: Utah Geological and Mineral Survey Bulletin 114, 4 pl., 98 p.