Dynamic Measurement White Paper
Field to Regional Lightning Analysis Projects Results and Opportunities

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INTRODUCTION

This white paper was prepared to show interpretation results of field and regional scale lightning analysis projects, and then to suggest two specific areas where regional lightning analysis could have significant economic benefit. The outline of the White Paper is as follows:

- Lightning analysis works well to define field sized areas like the Stratton Field in South Texas.
  - There is good correlation with seismic and well control.
- Lightning analysis works well to define regional faulting in South Texas.
  - There is good correlation with interpretations, and mapping of migration pathways.
  - There is also correlation between lightning density and known oil and gas fields.
- Lightning analysis continues offshore, and so regional interpretations can continue offshore.
  - It makes a lot of sense to do lightning analysis offshore the East Coast, where the BOEM is going to hold Federal Lease Sales starting in 2020.
- Regional Studies can also be done onshore. A significant opportunity is the Great Basin.
  - Lightning analysis has shown correlation at the Covenant overthrust oil field.
  - Lightning analysis could be correlated with Alan Chamberlain's work in Nevada overthrust areas to find more fields like the Railroad Valley fields.
  - Lightning might be key to see beneath volcanics in Southern Idaho.
  - Lightning has identified anomalies which could be replicas of the Sleeper Gold Mine.
  - Lighting analysis can be used for identifying geothermal anomalies.

The South Texas Stratton Field and Regional lightning analysis to the west demonstrate the value of lightning analysis. Lightning derived geophysical analysis can be done anyplace, out to at least 1,000-foot water depths, with no notices to anyone, no permits, no boots on the ground, and these projects are quicker, safer, and less expensive than any other geophysical data type.

Since lightning analysis provides useful results in South Texas, it will provide useful results anyplace else the technology is applied. Two specific areas where lightning analysis could have a significant economic advantage are offshore the East Coast and The Great Basin of the Rocky Mountains in the western United States. The opportunities for each area are introduced below.

The Federal Government has committed to hold Federal mineral lease sales offshore the East Coast and California starting in 2020 and to continue to hold regular lease sales in the Gulf of Mexico, the next being on August 21, 2019. Prior to these lease sales the BOEM (Bureau of Ocean Energy Management), formerly MMS (Mineral Management Services), has to do a technical and economic analysis of the areas to be put up for lease, to make sure accepted lease bids reflect the value of the minerals being bid on. The issue with offshore California, and specifically offshore the East Coast, is that there have not been modern geophysical surveys run in these areas, specifically there are no regional 3-D seismic surveys. These surveys typically have a 50-meter (164-foot) trace spacing, and provide a picture of geological structure and stratigraphy under the sea floor. BOEM is also charged with issuing permits for this type of data to be collected. These surveys cost at least $85,000 per square mile. There are about 479,524 square miles of area theoretically available for lease. This means it would cost over $40 billion to cover the entire area with 3-D seismic. Lightning analysis creates 50-meter trace spacing 3-D apparent resistivity and lightning attribute volumes, and for this same area will cost $3,836,190 or $10,000^{+}$ times less that 3-D seismic. There is certainly less vertical resolution, and yet this White Paper is intended to demonstrate the value to use this data to create geological frameworks, and to come up with initial estimates of economic value, as well as sweet spot areas.

If a regional lightning analysis can be done offshore, one can also be done onshore. The Great Basis of the Rocky Mountains in the western United States is an ideal second candidate for a regional lightning analysis. There are proven oil fields; gold, silver, lead, zinc, copper, and other mineral mines; as well as most of the geothermal opportunities in the continental United States in this proposed analysis area. There are also example projects here.

Stratton Field

In 1994, the Bureau of Economic Geology, W. L. Fisher, Director, released a 3-D Seismic and Well Log Data Set over the Fluvial Reservoir Systems at the Stratton Field, South Texas. The publication was by Raymond A. Levey, Bob A. Hardage, Rick Edson, and Virginia Pendleton. It included figures describing regional geological control (BEG Figure 1 below), and an example seismic section (see BEG Figure 5 below). Particularly note the Vicksburg and Frio growth fault packages at both a regional and oil field scale:

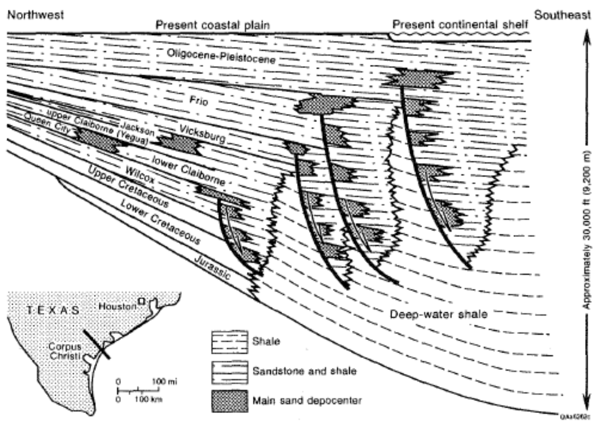


Figure 1. Depositional dip-oriented cross section through the Texas Gulf Coast Basin illustrating the relative position of major sand depocenters (from Bebout and others, 1982).

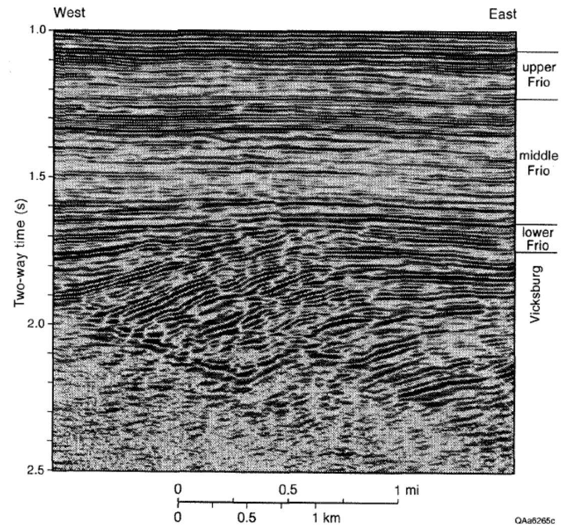


Figure 5. Subregional dip-oriented reflection seismic line through Stratton field showing the rotation of fault blocks in the lower Frio and Vicksburg Formations. This faulting contrasts sharply with the lack of faulting in the middle and upper Frio Formation.

In 2016 Dynamic Measurement did a regional proof-of-concept lightning analysis project across this same area. Figures 2 and 3 below shows results. In this case, there is a northwest-to-southeast lightning data derived apparent resistivity cross-section overlaid on a seismic section along with well logs from the BEG Stratton data volume. The color scale shows calculated apparent resistivities range from 11 to 26 ohm-meters. On Figure 2 a horizontal slice, at just over 2.000 seconds, is shown to the right, with a Stratton seismic time-slice at the equivalent depth.

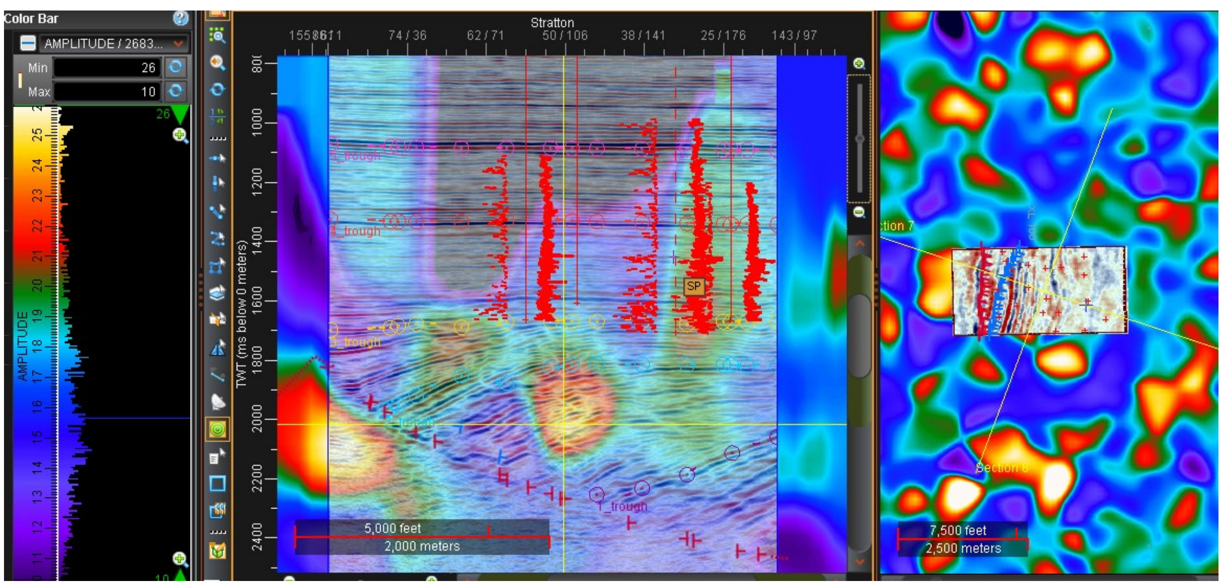


Figure 2. U.S. Patent Protected lightning derived apparent resistivity volume over the Stratton Field faulted data.

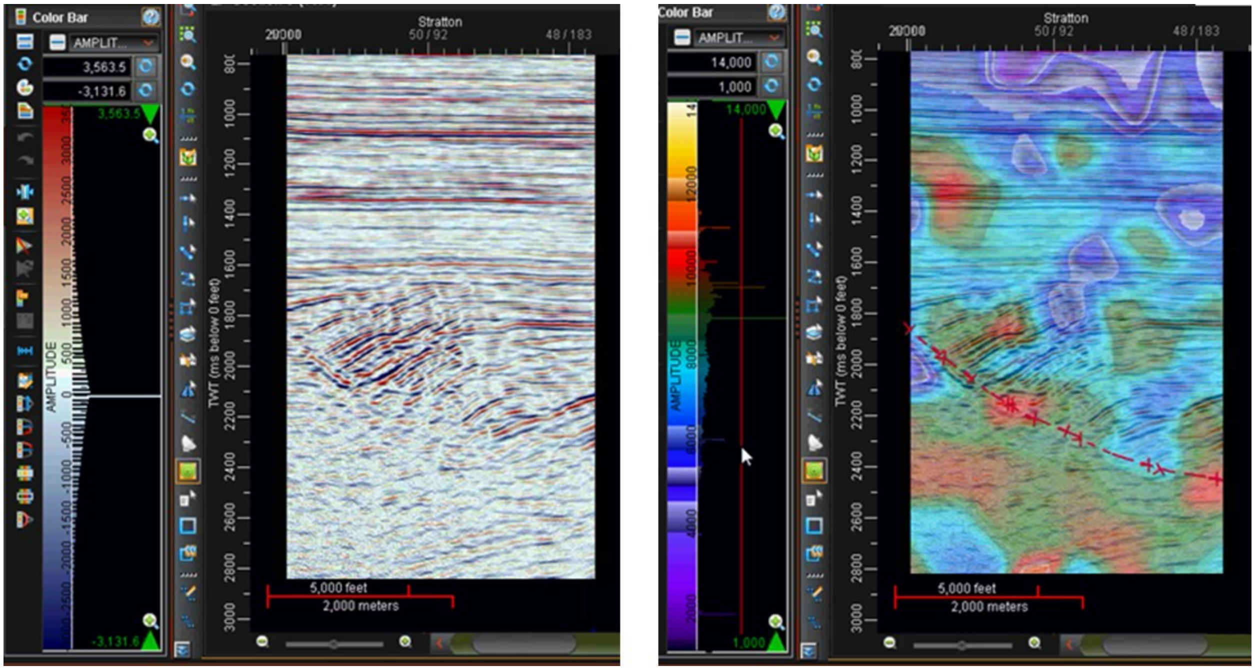


Figure 3. Direct comparison between Stratton seismic section and apparent resistivity overlaid on the same section.

Dynamic Measurement has grown, or not, by cash flow. A downside of this approach is not having cash to purchase seismic, log, and other existing geologic and geophysical control. We did obtain two resistivity well logs in the Stratton Field area. Figure 4 below shows correlation between two resistivity well logs along lightning derived apparent resistivity section B-B'. The highest 20 ohm-meter log measurement is just south of the 23 ohm-meter highest lightning derived apparent resistivity measurement. A key result was how well extension of seismic derived fault interpretations tie lightning volume fault interpretations. This work was done in September of 2017. Lightning occurs everywhere. This lightning derived apparent resistivity volumes are not limited to being with a few inches of a logged well bore. The vertical resolution, more so than the horizontal resolution, is at a much lower frequency than the vertical sampling resolution on either well logs or seismic sections. This is to be expected with this new potential fields geophysical data type. Potential Fields data has lower resolution than logs or seismic data. However, lightning occurs everywhere. Lightning derived volumes are not limited to well or seismic line locations.

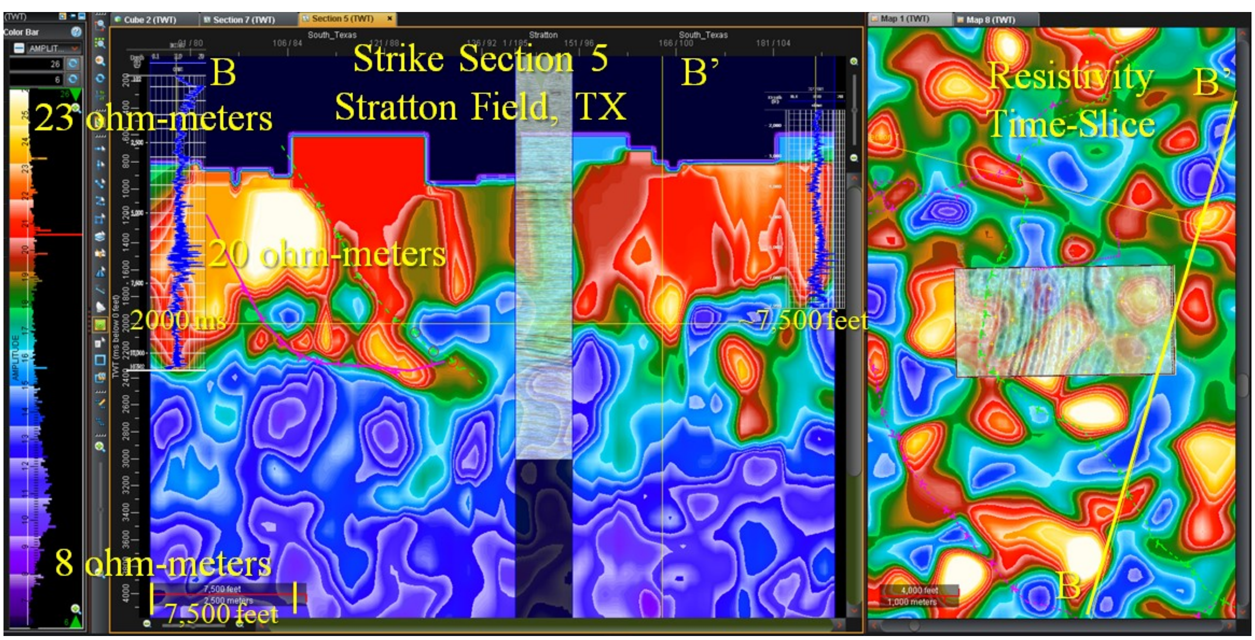
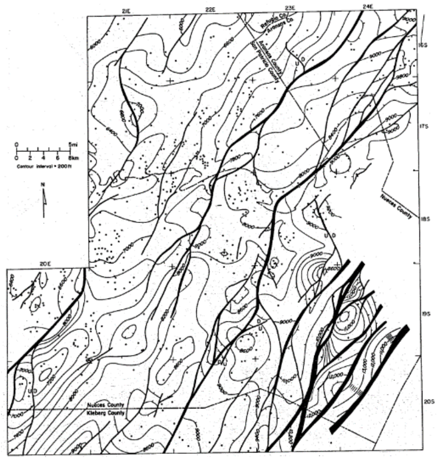


Figure 4. Two resistivity well logs from Drilling Info showing correlation with lightning derived apparent resistivity.

Regional Faulting South Texas

In 1982 Tom Ewing, also at BEG, published a regional study of South Texas faulting. This study included maps (see BEG Figure 24 Frio map labeled as Figure 5 below), and three regional cross-sections (see Figure 6 below).

Note this work was done in 1982, and of course the results tied the work done at the Stratton Field six years later, some of which is shown above. Geology does not change over human time scales. Fluid content and pressure from water reinjection can change over a few years, but not the basic geology and not the fault framework. Lightning derived geophysical analysis can be done anyplace, out to at least 1,000-foot water depths, with no notices to anyone, no permits, no boots on the ground, and these projects are quicker, safer, and less expensive than any other geophysical data type. Lightning analysis will tie other geophysical work done before or after or in 1982 or 1994.



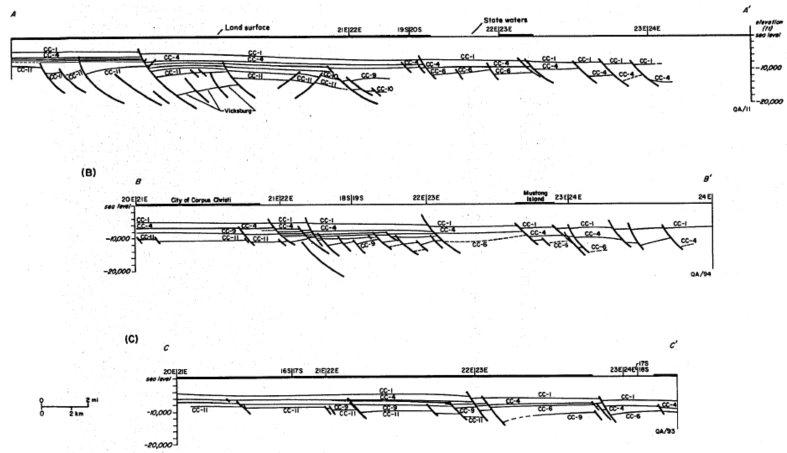


Figure 5. Map of Frio with faulting. Figure 6. Ewing TVD sections A, B, and C in South Texas fault study.

Figure 7 below shows the location of the three cross-sections shown in Figure 6, along with well control used to create the maps. Figures 8, 9, and 10 below, respectively show apparent resistivity cross-sections A-A', B-B', and C-C' without and with the Ewing fault interpretation overlain on the apparent resistivity cross-sections. Note how well the 2016 lightning derived apparent resistivity cross-sections match the 1982 fault interpretations. The red and green faults and arrows are respectively from faults on the Frio and C-11 maps as shown in Figure 11 below.

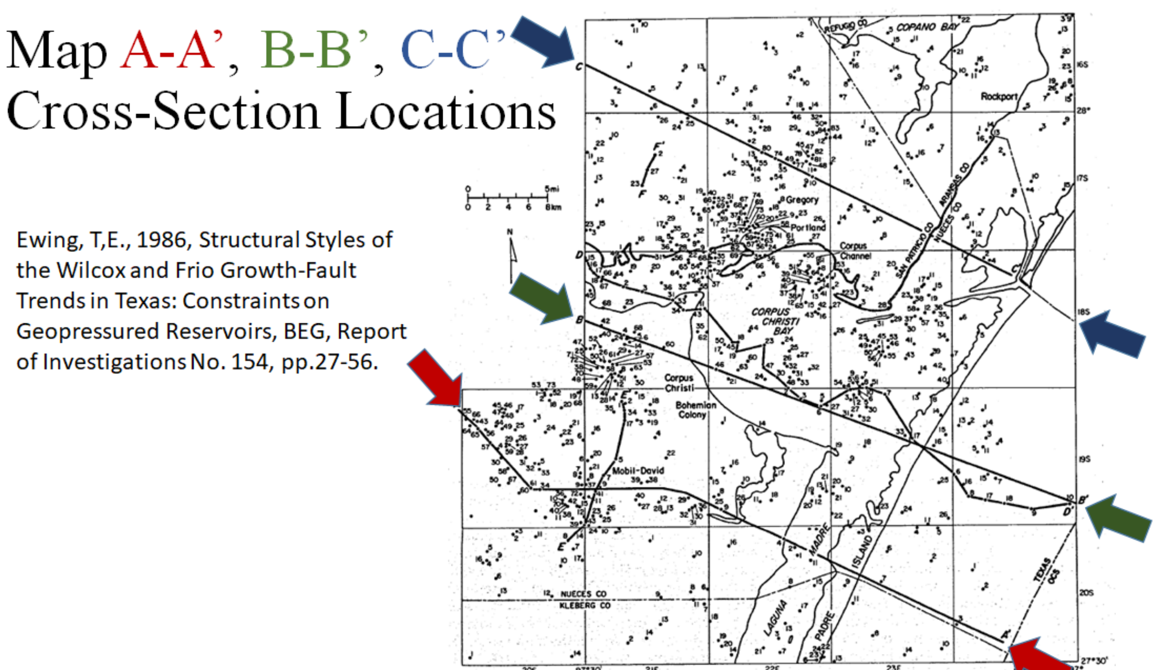


Figure 7, Locations of 3 Ewing cross sections, along with well control used in creating the maps.

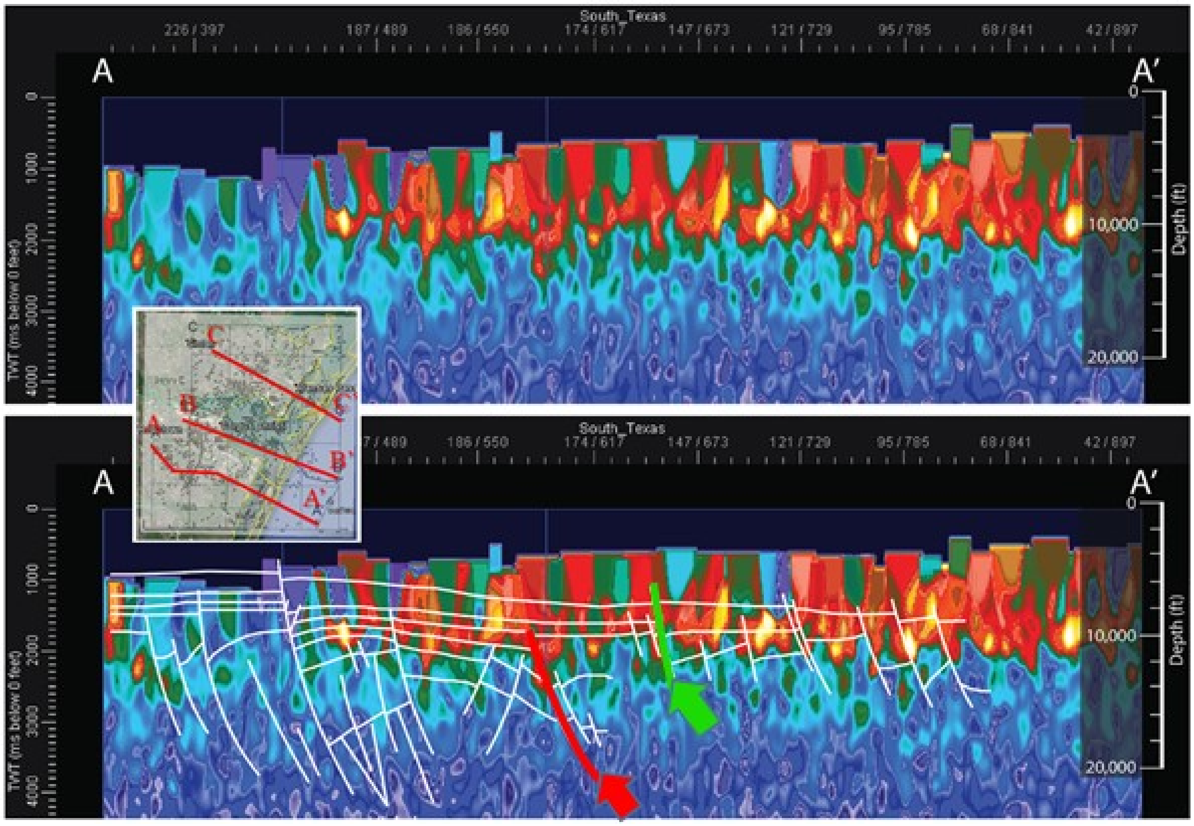


Figure 8. Apparent Resistivity Cross-Section A-A’ without and with Ewing Interpretation.

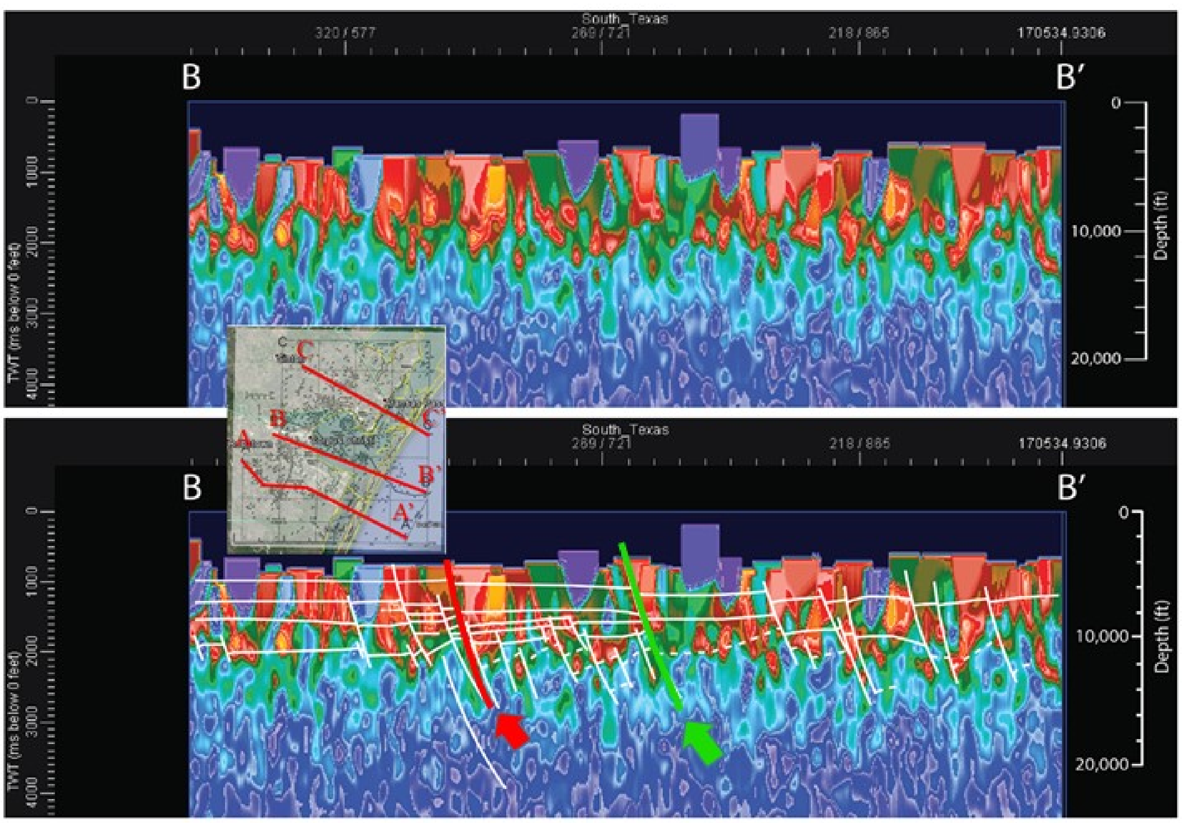


Figure 9. Apparent Resistivity Cross-Section B-B’ without and with Ewing Interpretation.

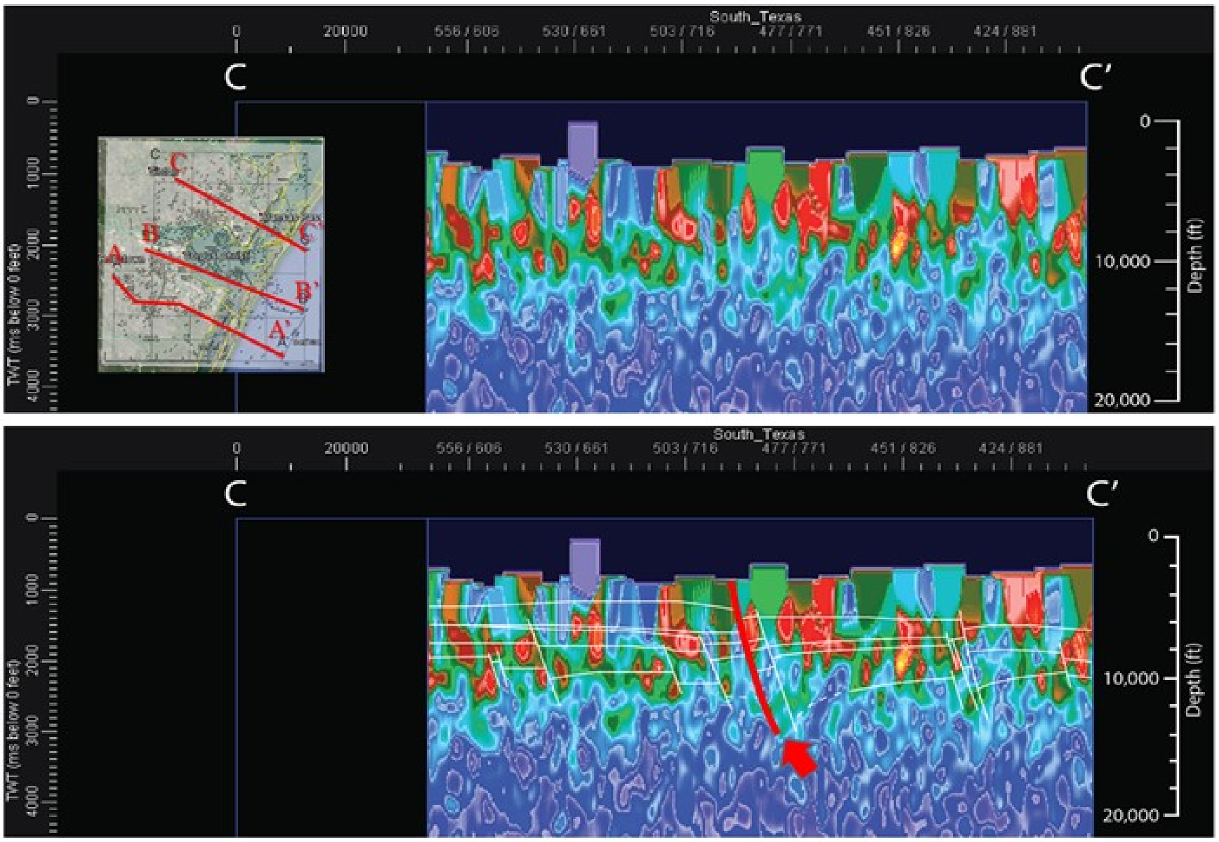


Figure 10. Apparent Resistivity Cross-Section C-C' without and with Ewing Interpretation.

An interesting follow-up study with this data will be to define active oil migration pathways from well and production and fault control, and then compare these faults to the apparent high resistivity calculations in the lightning derived apparent resistivity volume. First glance at the above sections, appears to show the high resistivity anomalies calculated near the surface follow along the same fault plane. If so, lightning analysis will have a major role, when combined with regional geochemical and basin analysis studies, to define migration pathways and traps.

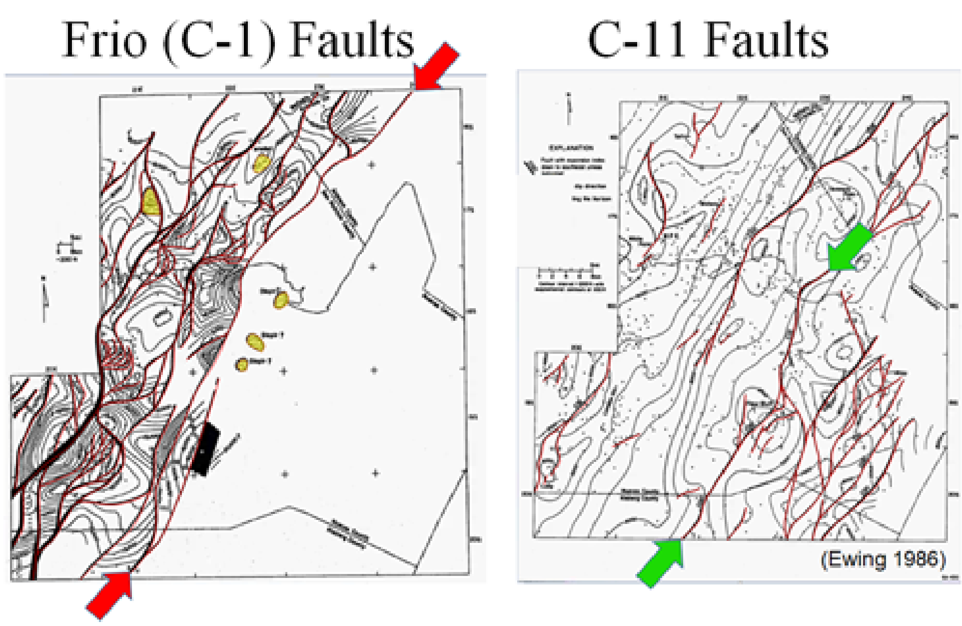
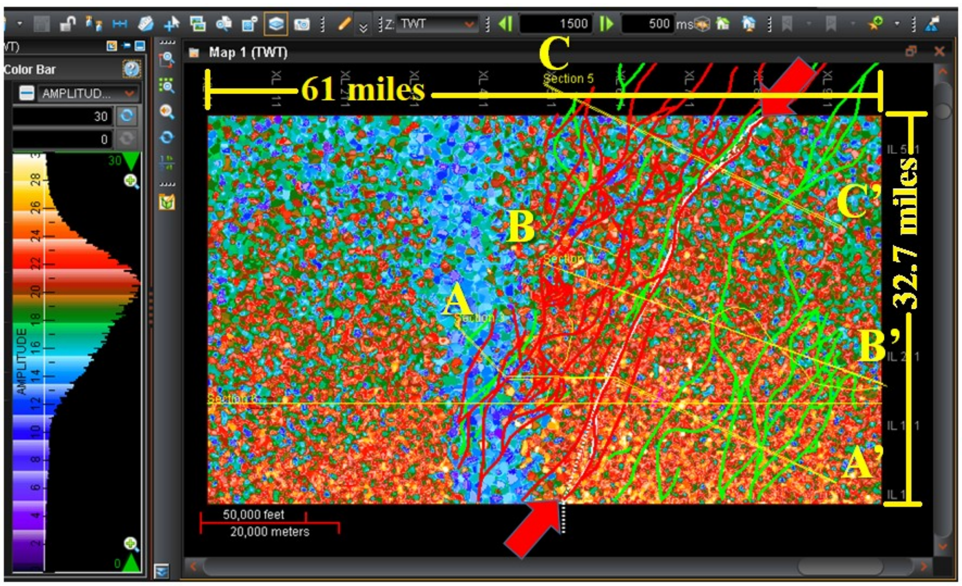


Figure 11. Frio and C-11 Faults from Ewing regional interpretation.

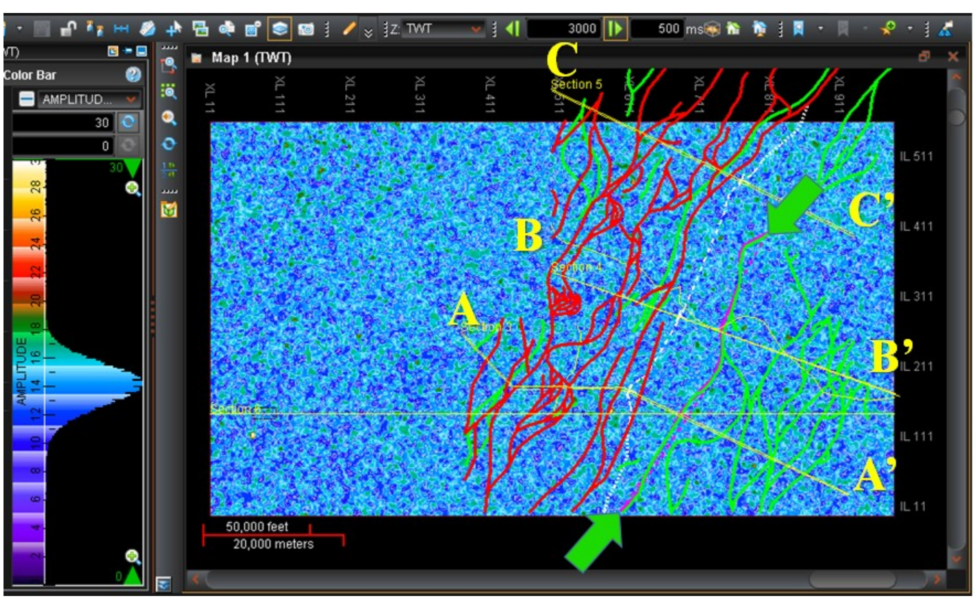
The fact regional fault maps can be tied to faults interpreted in lightning derived attribute and apparent resistivity volumes has several implications. First, it demonstrates the lightning analysis processing is creating volumes which are tied to the geology. Second, since lightning analysis generates volumes, it allows generation of 25-meter separated cross-sections perpendicular to and along the strike of each fault. These cross-sections allow detailed interpretation of the fault plane between 2-D seismic or other geologic control. If the only control is surface fault expression, it allows detailed fault plane interpretation in alluvial filled valleys where there is not surface fault expression. State Geological Surveys can use this approach to create a 3-D version, with throw direction, of existing stick maps showing more details of faults across their state. Third, these fault planes provide a new geophysical based approach to predict hydrocarbon migration pathways. This can provide a step change in Basin Analysis.

Figures 12 and 13 below show two regional lightning derived apparent resistivity time-slices. Tom Ewing's Frio and C-11 fault maps have been overlain on these apparent resistivity horizontal-slices. The location of the three cross-sections described above are shown on each horizontal-slice. Figure 14 below shows the three apparent-resistivity cross-sections in a cube display. Most geophysical workstations can do this, and these displays were created using Landmark Graphics DecisionSpace™. Figure 15 below shows time-slices every 500 ms from 500ms. to 6000 ms.



(Fault Overlays Ewing 1986)

Figure 12. Frio & C-11 Faults, Ewing regional interpretation, overlaid on 1500 ms. apparent resistivity time-slice.



(Fault Overlays Ewing 1986)

Figure 13. Frio & C-11 Faults, Ewing regional interpretation, overlaid on 1500 ms. apparent resistivity time-slice.

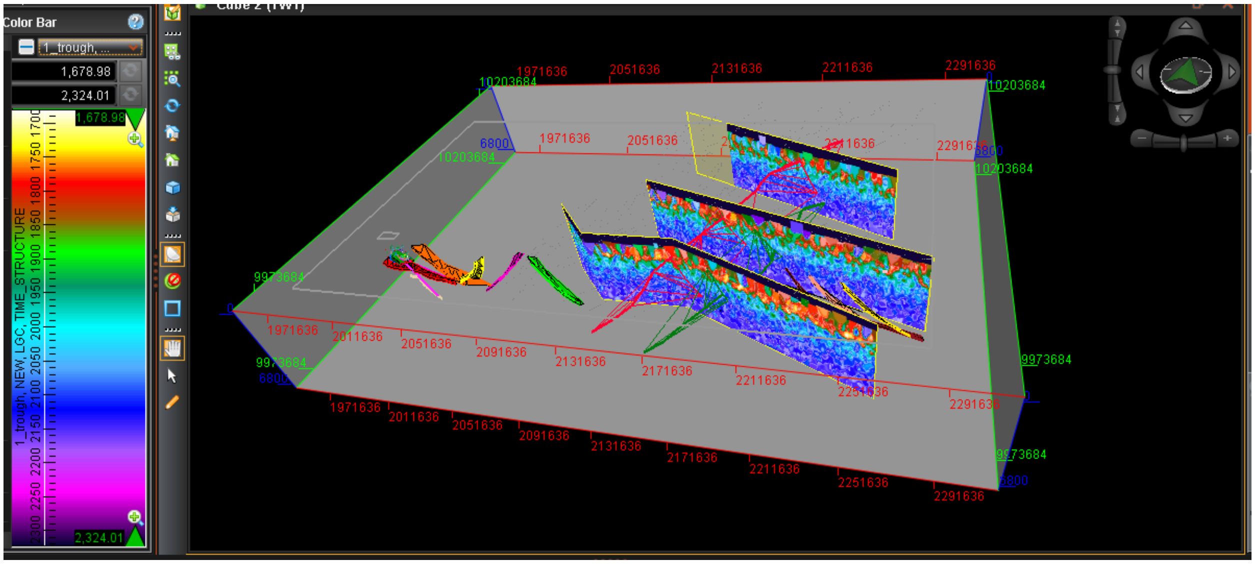


Figure 14. Cross-Sections A-A’, B-B’, and C-C’ in a cube display with the Frio & C-11 red and green fault planes.

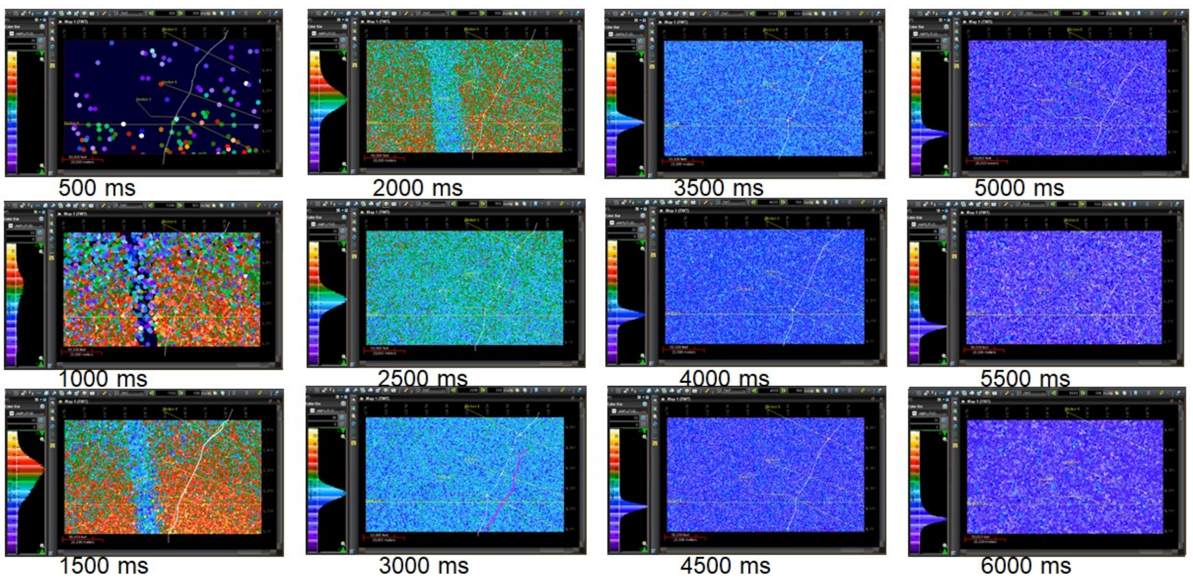


Figure 15. Cross-Sections A-A’, B-B’, and C-C’ in a cube display with the Frio & C-11 red and green fault planes.

This analysis area was about 61 miles by 32.7 miles. The analysis area could have been 610 miles by 327 miles, and the processing of this much more data would not have taken appreciably more time. It costs more, because we have to get lightning strike data from the larger area. Dynamic’s lightning vendor provides a nice discount for larger project areas, and this is reflected in Dynamic’s pricing. The 1000 ms, 1500 ms, and 2000 ms time-slice have a blue north-south lightning data artifact. This artifact appears to be tied to feedback between lightning sensors. Dynamic now understands these effects as probably intra-sensor anomalies (see Figure 16 below), and can remove most of these effects during processing. These artifacts have only been noticed on regional projects.

Note, this South Texas lightning analysis projects continues offshore, which is shown in the right image in Figure 16 below. The results on various time-slices and arbitrary cross-section displays on the workstation appear consistent from on-shore to offshore. We know in deep water there are not as many lightning storms as on land. One possible explanation is conductive salt water is not allowing a connection between atmospheric and telluric currents in deep water. If this is the case, there will be a drop-off in the effectiveness of lightning analysis as projects go into deeper water. However, based on this project, lightning analysis is certainly viable out to 100-meters water depths. Projecting, Dynamic anticipates projects will be viable at 300-meter water depths (1000-feet water depths), or where the shelf starts to break into the slope in the Gulf of Mexico, on the East Coast, and offshore California.

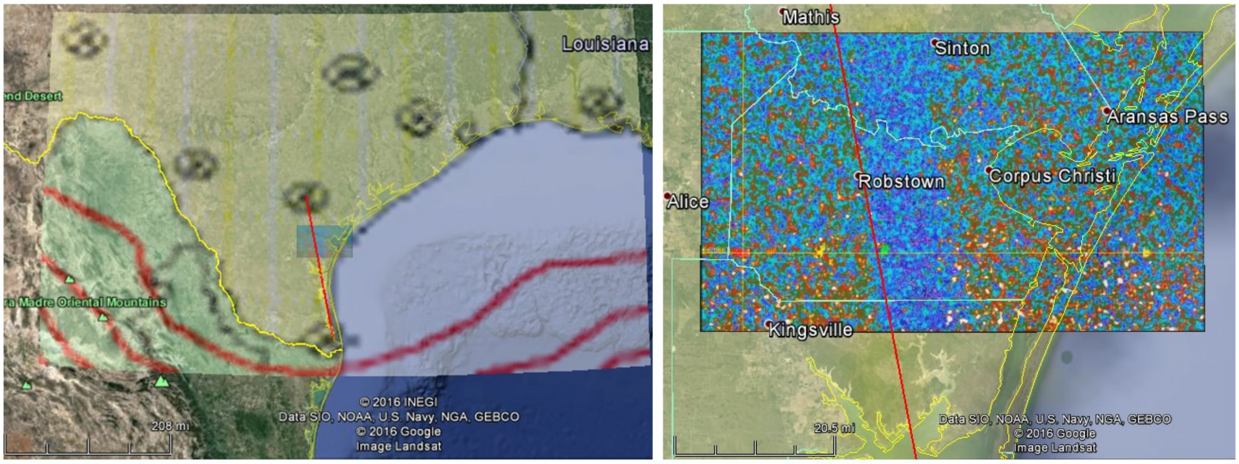


Figure 16. The probable intra-sensor anomaly, where there is feed back between lightning detection sensors, shown at two scales, without accounting for earth curvature.

One of the first test projects Dynamic did was to contour lightning density. This was done for a larger area along the Texas Coast, as shown in Figure 17 below. This map was looked at in some detail by Louis J. Berent, an interpreter who spent the first part of his career at Amoco. Louie found correlation between lightning density and known fields and faults. These results are shown in Figure 18.

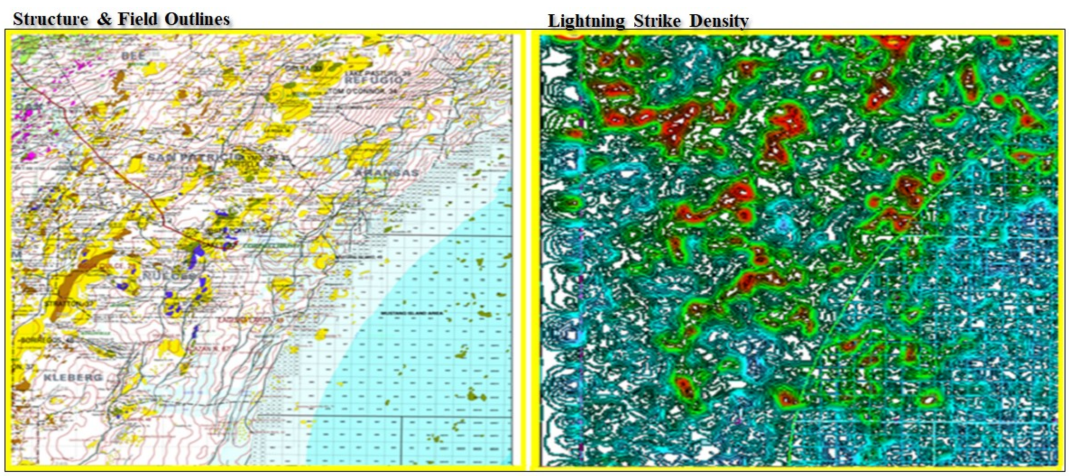


Figure 17. Note the similar trends in the GeoMap display of fields, and the lightning density contour map.

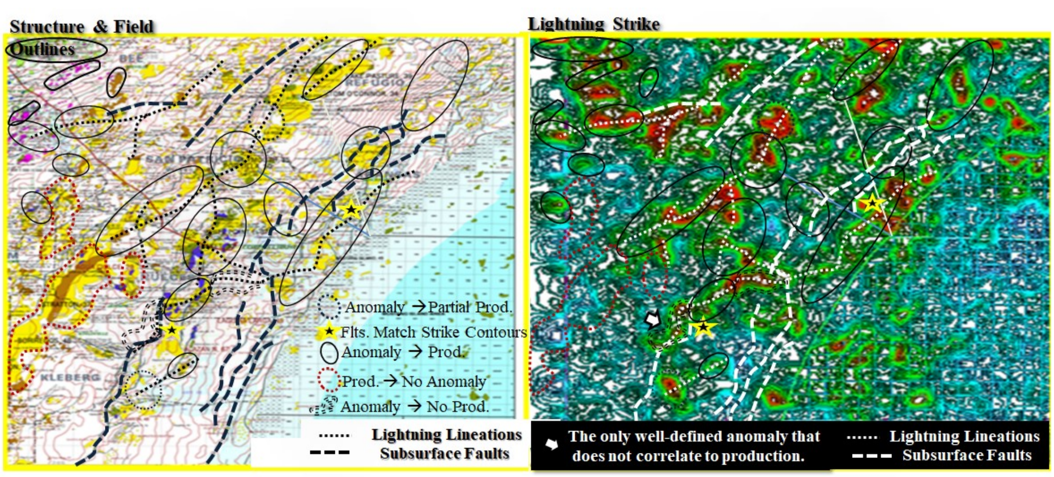


Figure 18. Note the correlation between fault patterns and hydrocarbon accumulations, as derived by Louis Berent.

Back in about 2012 an initial attempt was made to compare the highest lightning density with known fields over a larger area, all along the South Texas Coast. The results are shown in Figure 19 below. It turns out 68% of the fields had higher lightning density. Dynamic does not believe this higher lightning density is related to iron in the ground tied to production facilities. In a project in North Dakota, which went across the Nesson Anticline in western North Dakota, a comparison was made between lightning density over the most densely drilled Beaver Lodge Field and non-drilled areas 50-miles to the west and 50-miles to the east. There were no significant differences between the three areas in terms of lightning density and clustering. Lightning is a meteorological event, and is tied to electrical currents in the atmosphere, while lightning strike locations are tied to telluric currents in the subsurface. Telluric currents in the 3-D matrix, which makes up the subsurface, dominates over any currents along 2-D drill pipe or other manmade infrastructure. A key takeaway of this figure is that there is a bigger impact on lightning density based on the number of sensors, than there is based on water depth. As you get down to the south tip of Texas, there are only a few sensors picking up lightning strikes. This is because there is not an equivalent lightning detection network in Mexico like there is in the United States and Canada. The map on the right in Figure 19 shows there are fewer lightning strikes in the south, where there is less lightning sensor coverage. Certainly, in the Gulf of Mexico, the offshore data can be improved by placing lightning sensors on some of the many oil and gas offshore platforms.

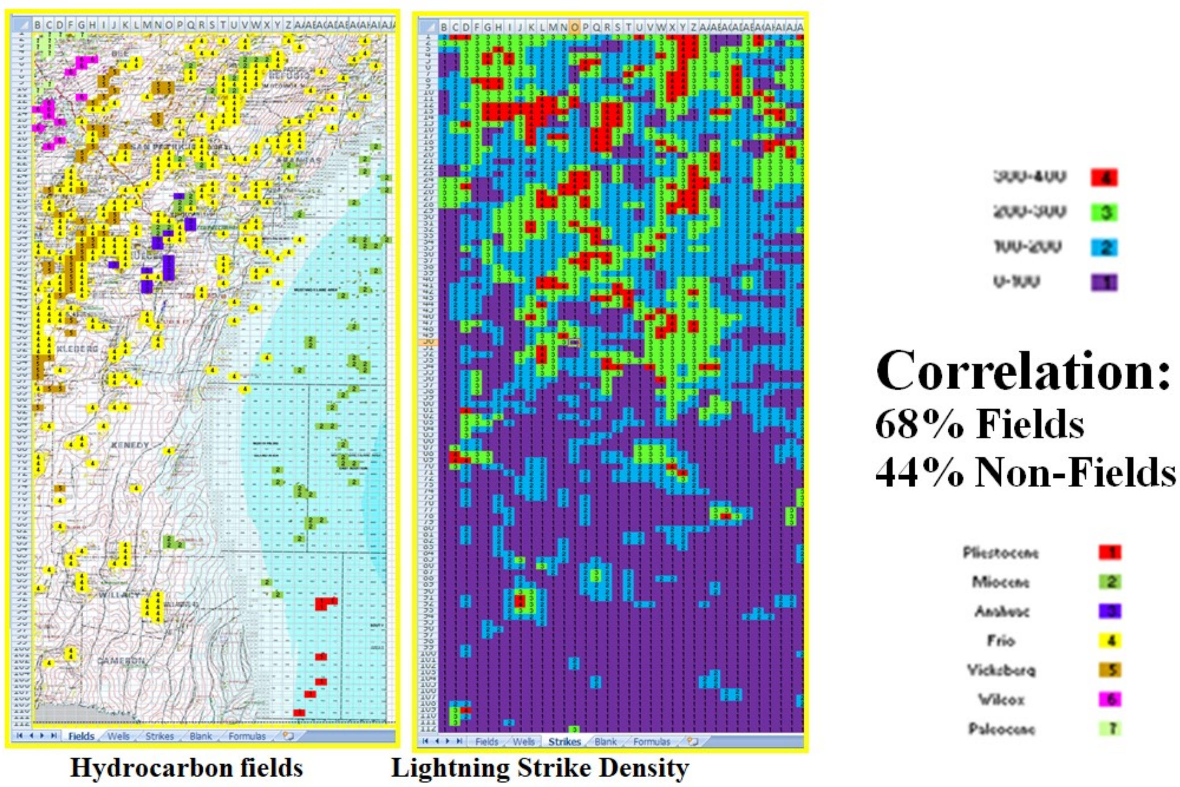


Figure 19. First pass gridded correlation between high lightning density and field locations was 68%.

Offshore and East Coast

Dynamic did another test with this offshore data in June of 2018. We used the above lightning data to create a series of maps for a standard 4-mile diameter SPOTsm lightning analysis (price $9,600 for 25 lightning attribute maps and volumes). Figure 20 below shows 14 different lightning attribute maps. These maps look just like the same lightning attributes mapped onshore. The different lightning attribute maps each have fairly consistent characteristics. A SPOTsm analysis can be sampled with 25-meter trace spacing (a grid of about 275 x 275 traces for a 4-mile diameter SPOTsm. Volumes this size show fault distributions, as well as the dip of beds at various depths. It seems reasonable the time will come when no new well is approved or drilled unless there is a lighting SPOTsm analysis for review and correlation with other geological and geophysical data. This would be limited to where the equivalent of NLDN (National Lightning Detection Network) quality and quantity of data is available, which currently is in the continental U.S. and Canada. Statista reports and predicts about 20,000 wells drilled in the US each year from 2014 to 2022. If 50% of these wells had SPOTsm analysis, about $10 million in annual income would be generated for Dynamic. Key is showing this work improves well success. Improving a few wells will easily save over $10 million.

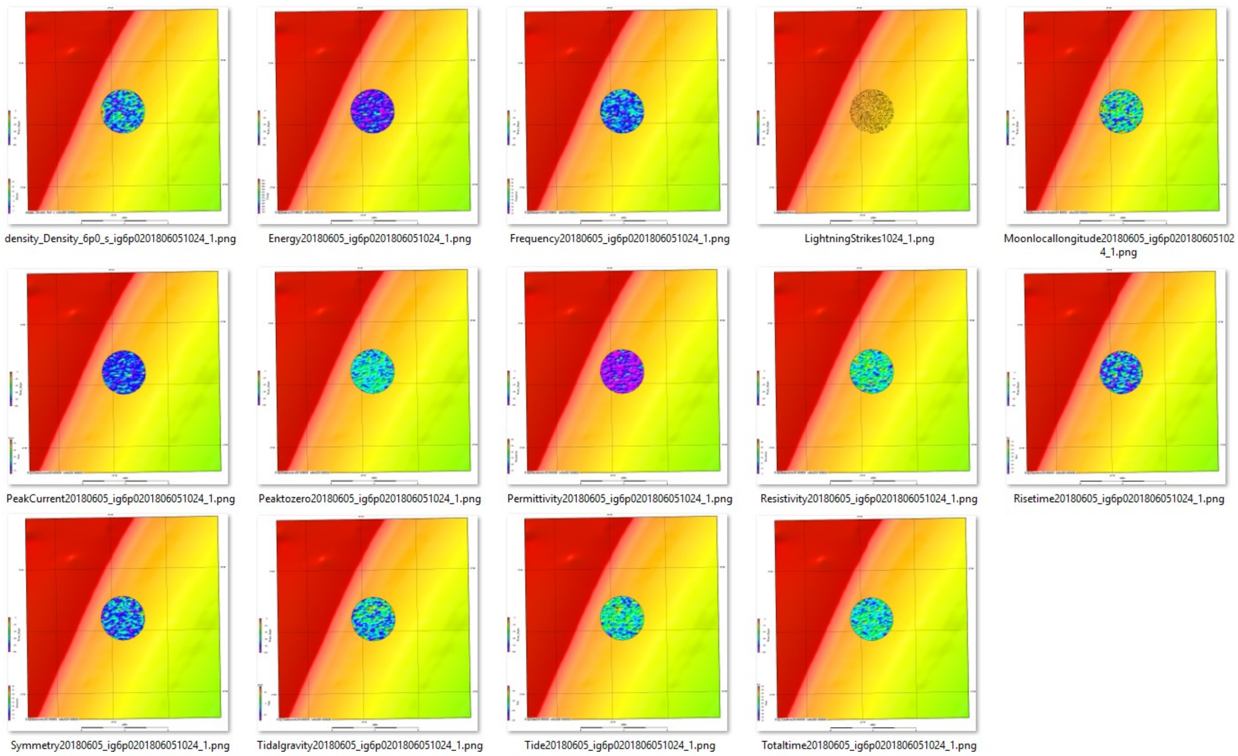


Figure 20. 14 Different Lightning Derived Attribute SPOT^{sm} Maps offshore Corpus Christi in State Waters.

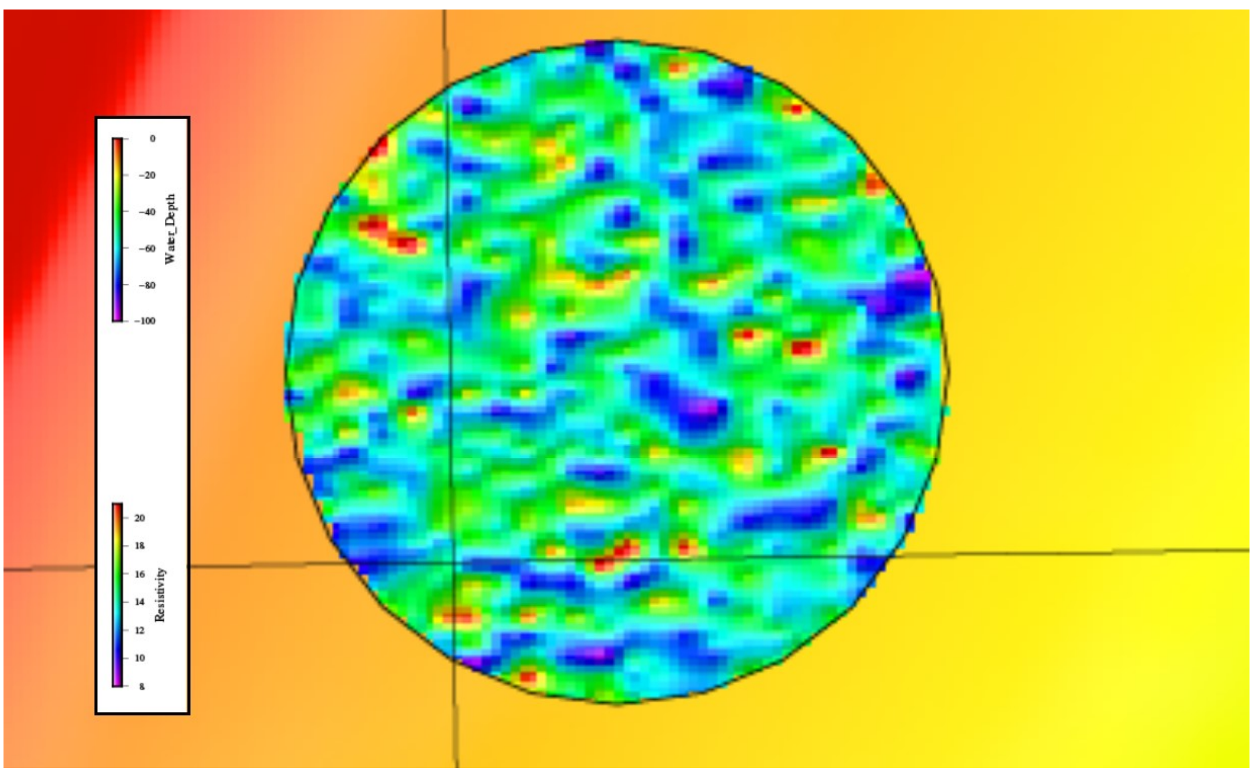


Figure 21. Zoom on an Apparent Resistivity SPOT^{sm} Map offshore Corpus Christi in Texas State Waters.

To expand the concept of regional lightning analysis programs beyond Texas and the Texas Shelf, Figure 22 below shows lightning stroke density in the western hemisphere. Particularly note the East Coast of the U.S. and Southern Brazil. The prevailing winds blow storms deep into the Atlantic, so there are plenty of lightning strikes to do a lightning analysis in those areas where deep water exploration will occur off of the East Coast of the USA. This data comes from Vaisala's worldwide lightning detection network, GLD-360. This white paper does not go into the basis for calculating lightning attribute maps and volumes, as there are other publications where this information is available, including: Does Lightning Strike Twice?, GEO ExPro volume 15 number 5, 22 Oct 2018; Lightning Analysis – A Remote Imaging Exploration Tool, SEG Remote Imaging Workshop, Anaheim, CA, 19 Oct 2018; and Lightning Analysis for mapping Faults and Identifying Exploration Sweetspots, Rocky Mountain and Pacific Coast AAPG Meeting, Las Vegas, NV, 04 Oct 2016.

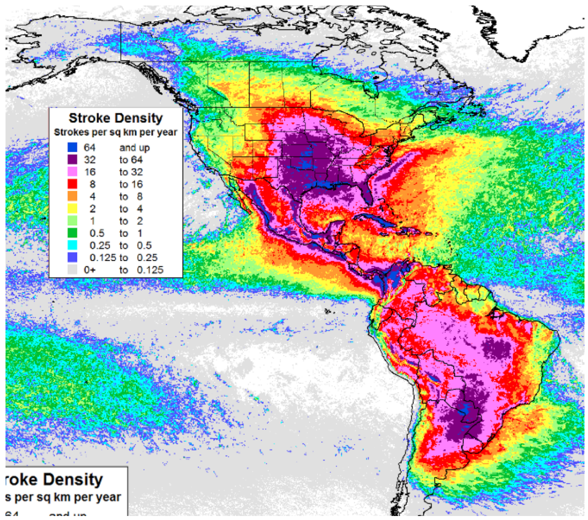


Figure 22. Lightning density in the Western Hemisphere from the GLD-360 database. re

The Bureau of Offshore Energy Management (BOEM) has prepared a Draft Proposed Program for 2019-2024 National Outer Continental Shelf Oil and Gas Leasing (see https://www.boem.gov/NP-Draft-Proposed-Program-2019-2024/). A summary of proposed lease sales is shown in their Figure 2 on page nine of this report, which is replicated below as Figure 23. Note this proposal includes Federal Lease Sales all along the East Coast and off of Southern California in 2020. The rest of the West Coast would come up for sale in 2021, and there would be Federal Lease Sales in each area every 2 years following the initial Lease Sale. Economic drivers will likely overcome environmental concerns, and some of these Federal Lease Sales will happen, even if there are temporary delays.

An issue with any of these lease sales is there has only been limited geophysical data collection in these areas, especially new modern surveys, and there has been almost no new geophysical data collected for decades. In order to set minimum bids, and for oil companies to bid on any newly made available lease blocks, there must be a scientific basis for economic potential. Lightning analysis provides a new geophysical data type which can provide an initial scientific basis quicker and at less expense than any other available geophysical service. Consider:

- Lighting strike locations and attributes are impacted by geology.
- Lightning strike clusters are predictable from historical data.
- Cross-plotting randomized lightning strike locations vs. recorded locations shows there is a geologic effect on lightning strike locations.
- Skin depth of lightning electrical energy s tied to the build-up of storms and charges and interacts with telluric currents at exploration depths.
- Rock properties, apparent resistivity and apparent permittivity, can be calculated from lightning databases.
- Rock properties and lightning attribute distributions, displayed as maps, volumes, and interpolated to match other existing or planned geophysical surveys, allows filling-the-gap between control.
- Lightning maps and volumes allow creation of geotechnical frameworks – faulting, bed dip, apparent resistivity anomalies, & sweetspots – quicker, safer, & less expensive than any other geophysical data type.
- A passive lightning energy source has more power than any other geophysical service, with unique results.
- No permitting, no notification, no boots on the ground, and easy integration allows quick, safe, and inexpensive geophysical analysis of a new large area like the East Coast of the United States.

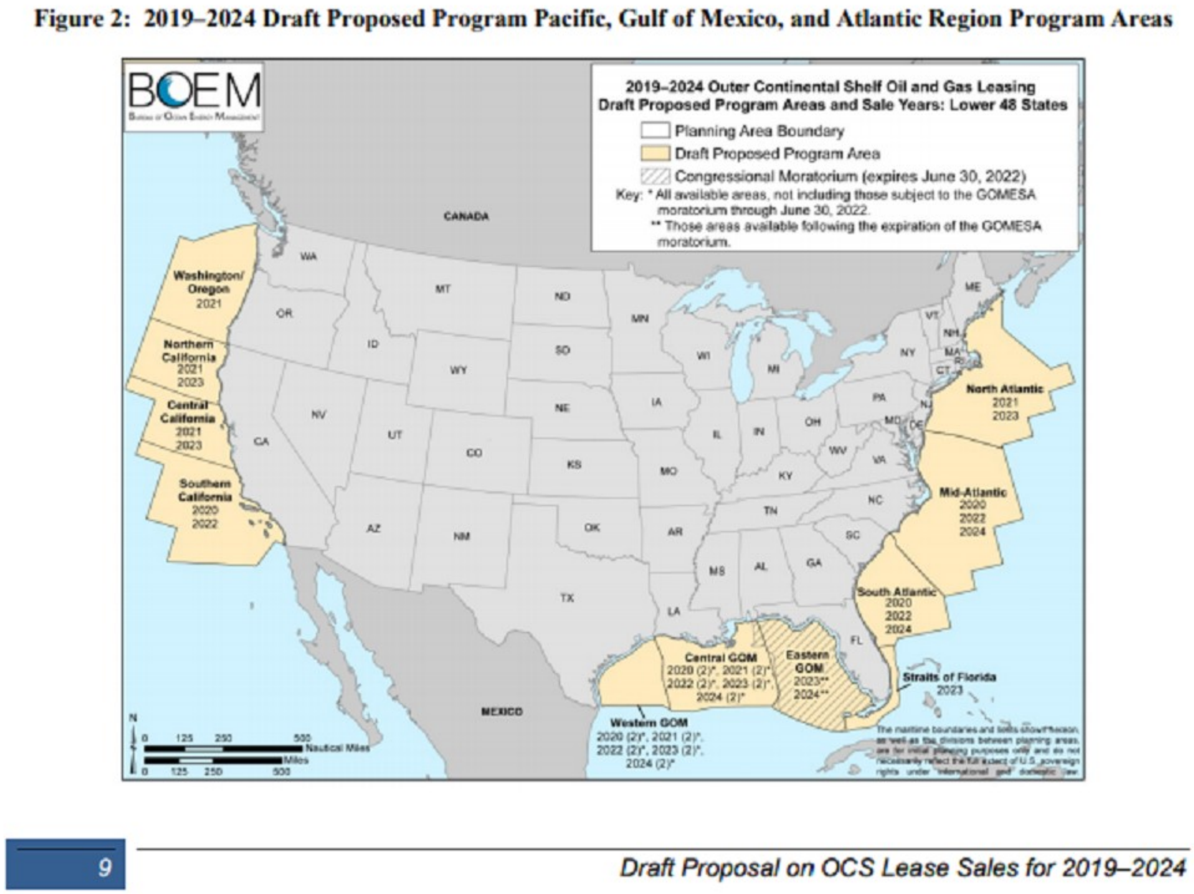


Figure 23. BOEM draft proposed program for Pacific, Gulf of Mexico, and Atlantic Region Program Areas.

Figure 24 below shows an alternative way to break up the East Coast, based on available public 2-D seismic data and different geologic areas. One group, DMIGEO, whom Dynamic has worked with, has collected all of this 2-D seismic data, velocity data, and pore pressure information. Tom Sherman, a principal of this company, died earlier this year, and so there will be some work putting this data together for delivery, though it can probably be accomplished within a couple of months for any company interested.

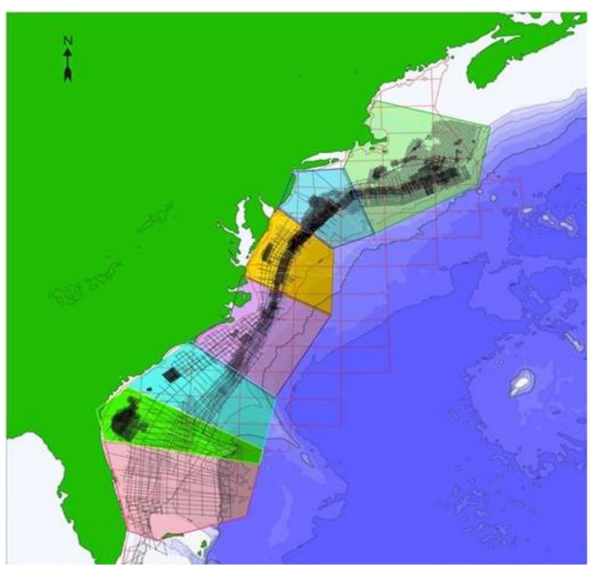
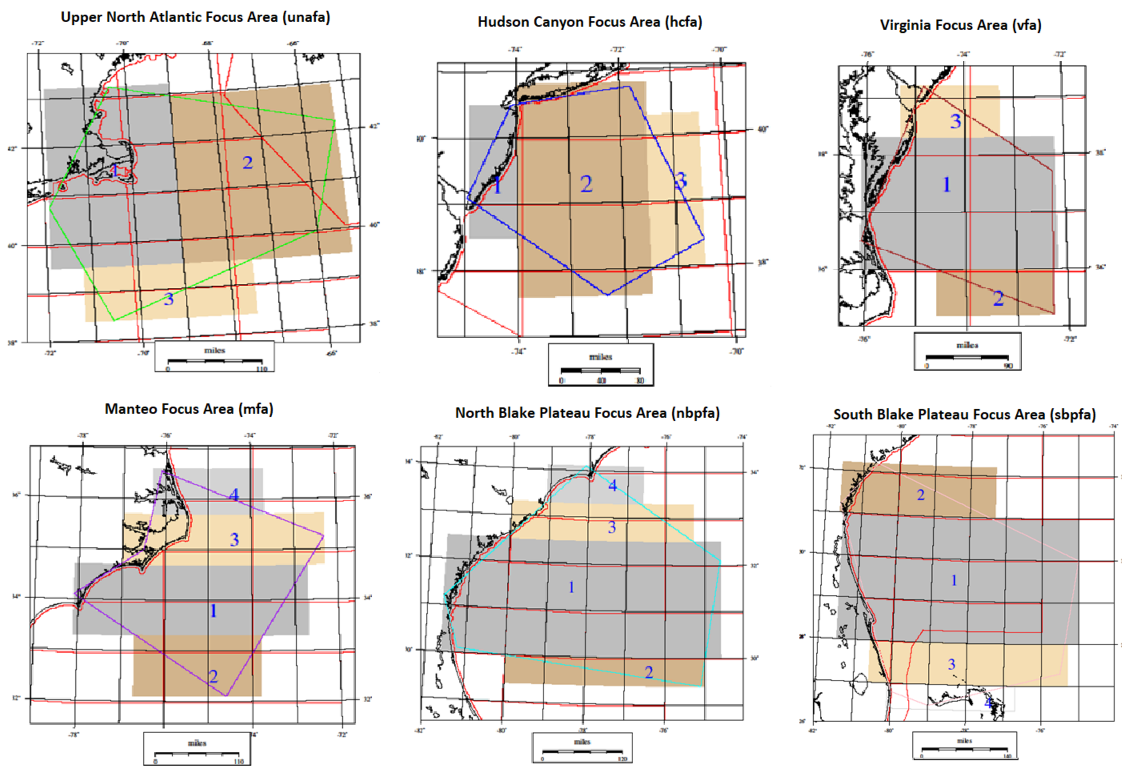


Figure 24. One subdivision of exploration areas off of the East Coast, showing available public 2-D seismic data.

A regional lightning analysis can be accomplished over any sub-area, or over the entire East Coast. Creation of 25 different lightning derived maps and volumes within a couple of months of receipt of an order. The SEG-Y volumes will have a 25-meter (or client specified) trace spacing, and can be easily loaded into any of the different available geophysical workstations for interpretation. There will be so much data, it will probably take a couple of years to interpret all of the data, building a fault framework, and specifying layering dip at various depths. This work is simply an extension of the South Texas examples, shown at the beginning of this white paper.



Area	Acreage	Square Miles	Price ($8/sq. mi.)
unafa	45,549,786	71,172	$569,372
hcfa	28,593,342	44,677	$357,417
vfa	27,858,127	45,528	$364,224
mfa	45,549,786	77,172	$617,376
nbpfa	68,313,035	106,739	$1,073,888
sbpfa	85,911,003	134,236	$853,913
Total	**301,775,079**	**479,524**	**$3,836,190**

Figure 25. East Coast broken into six areas, with price for lightning analysis for each area, at $8 per square mile.

As mentioned in the South Texas discussion above, one concern is how good the results will be as water depth increases. Figure 22 above shows there are plenty of lightning strikes offshore the East Coast of the U.S.A. However, it does make sense to do some testing to see what kind of response there is at various water depths. Dynamic has three basic products: SPOT^{sm}, LINE^{sm}, and d.NSEM^{sm}. The above analysis, assumes rectangular areas defined by longitude and latitude and a regular defined grid spacing. This is a d.NSEM^{sm} analysis.

It makes sense to do a series of SPOT^{sm} Analyses as you go into deeper water. The four images on Figure 26 below show 4, 6, and 8 possible SPOT^{sm} locations. The standard SPOT^{sm} Analysis covers a circle with a 2-mile radius, and the prices for 4 projects would be $38,400, for 6 would be $57,600, and for 8 would be $76,800. This is a minimal cost compared to other geophysical surveys or compared to just the cost of preparing a BOEM lease application. Alternatively, the SPOT^{sm} Analysis could be 4-mile radius, which increases the area from 12.57 square miles per project to 50.27 square mile per project with a proportional increase in price.

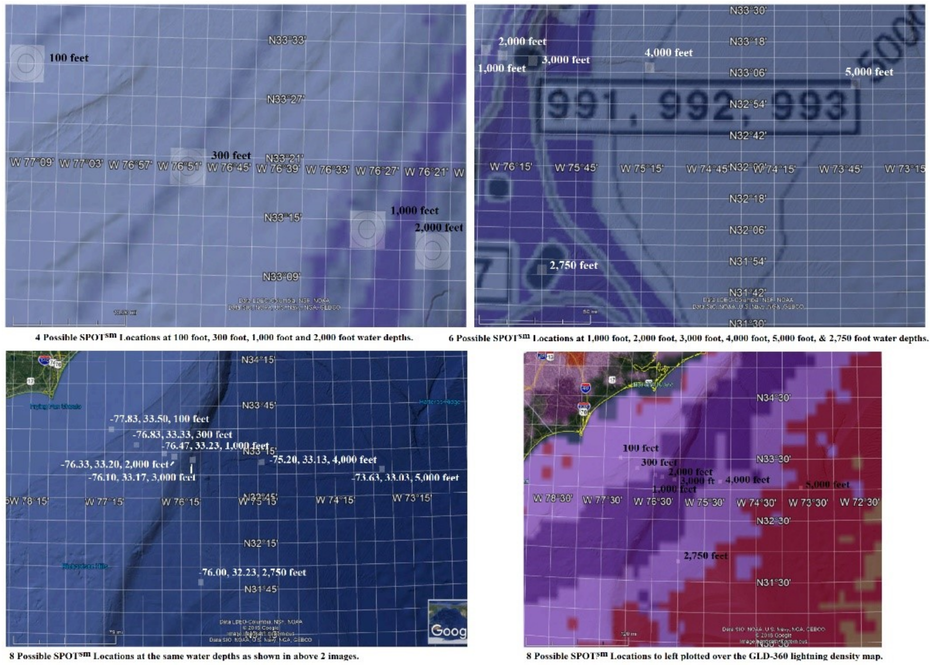


Figure 26. Possible locations for SPOT^{sm} Analysis Projects on the East Coast based on available university data.

Alternatively, a LINE^{sm} Analysis project would show gradational changes in lightning analysis results as the water depth increases. This analysis could be run along an existing 2-D seismic line to allow calibration, and hopefully show dip information for some of the seismic reflectors. The proposed test on the maps in Figure 27 below would be about 65-miles long. Given the test is 1-mile wide, there would be about 65-square-miles of data ordered, which is priced at less than $60,000. It takes less than 2-months from the time of a lightning data order to delivered maps and volumes. The process over this time interval is to order data, receive data, clean data, process data, package, and deliver results to the client. On all projects to date Dynamic Measurement geophysicists helped with interpretation.

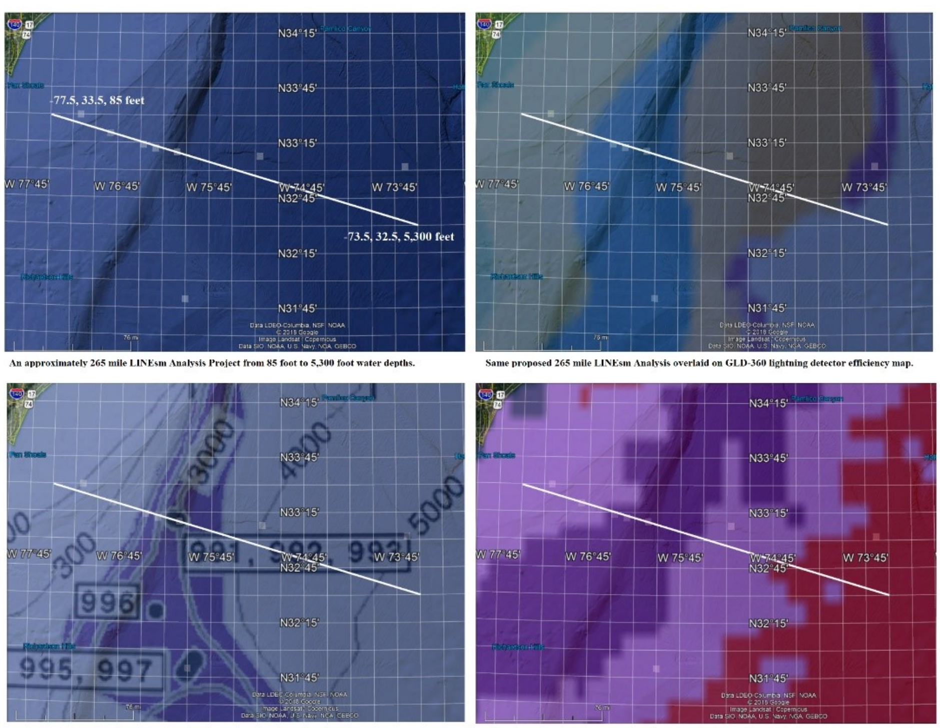


Figure 27. Possible location for LINE^{sm} Analysis Project on the East Coast based on available university data.

To close out this section on the East Coast, Figure 28 below shows a seismic section from the East Coast. Figure 29 below shows an apparent resistivity lightning derived cross-section from South Texas, without and with an interpretation. Based on over 36 lightning analysis projects, we anticipate the same kind of interpretation done in South Texas can be done on the East Coast, or anyplace within the U.S. and Canada. This is where 20-years of NLDN (National Lightning Detection Network) and CLDN (Canadian Lightning Detection Network) data are available. Worldwide there is 6-year worth of GLD-360 data available. As described in some of the other papers referenced above, there are 6-years of available GLD-360 data. GLD-360 data does not include Rise-Time and Peak-to-Zero Time as a standard part of the delivered data. The horizontal resolution can be an order of magnitude poorer. And so, we recommend using U.S. and Canadian data for initial lightning analysis projects. We anticipate being able to set up a private network anyplace in the world and collect useful NLDN quality data within 2-to-3 years. We also anticipate being able to enhance processing of the GLD-360 data over what we can do now.

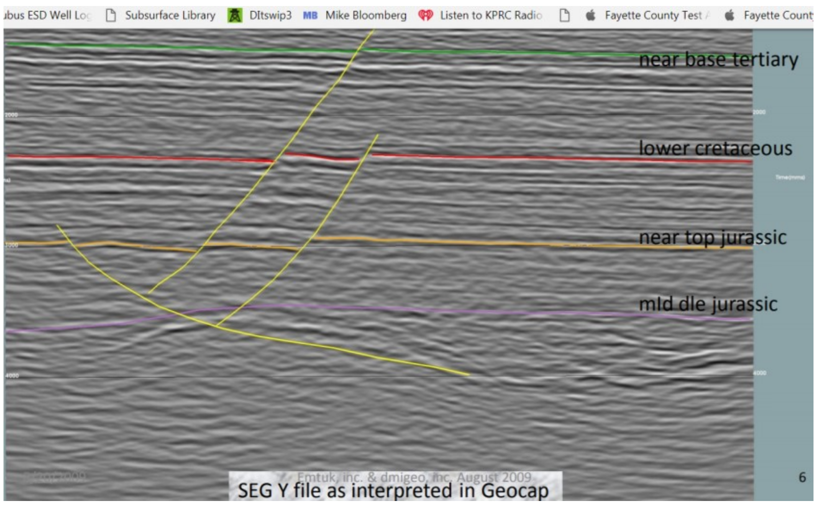


Figure 28. Seismic data off the East Coast from DMIGEO.

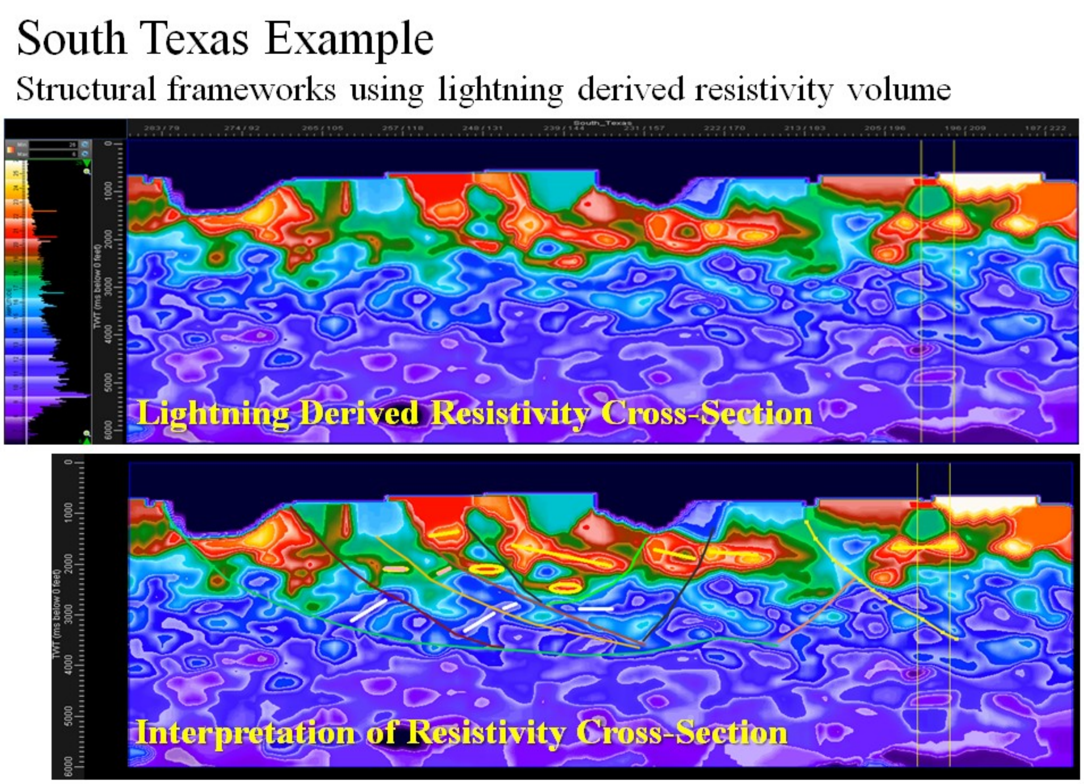


Figure 29. South Texas seismic data, showing how lightning analysis can be used to build geotechnical frameworks.

Great Basin

Lastly, the type of regional lightning analysis which has been proposed, based on work in South Texas, along the East Coast of the United States can be done anyplace. For instance, consider a Great Basin Regional Lightning Analysis. Figure 30 below shows a proposed analysis area covering the Great Basin. We have done 2 lightning analysis projects in the south-east portion of the Great Basin, and 1 lightning analysis project in the west-central portion of the Great Basin. There are oil & gas, mineral, and geothermal exploration projects in this area. The price for creating the lightning analysis maps and volumes for this large of an area is less than $2 million, as shown on Figure 30. To illustrate the value of putting this type of regional analysis together, below there is a description of:

1. the Covenant Field in the southeastern area,
2. oil discoveries in Railroad Valley Nevada,
3. Alta Mesa oil discoveries in Payette County Idaho,
4. the Sleeper God Mine in Humboldt County Nevada,
5. a geothermal analysis in South Utah,
6. the Escalante Silver Mine,
7. the Blundell Geothermal Power Plant, and
8. the Stillwater Geothermal Plant.

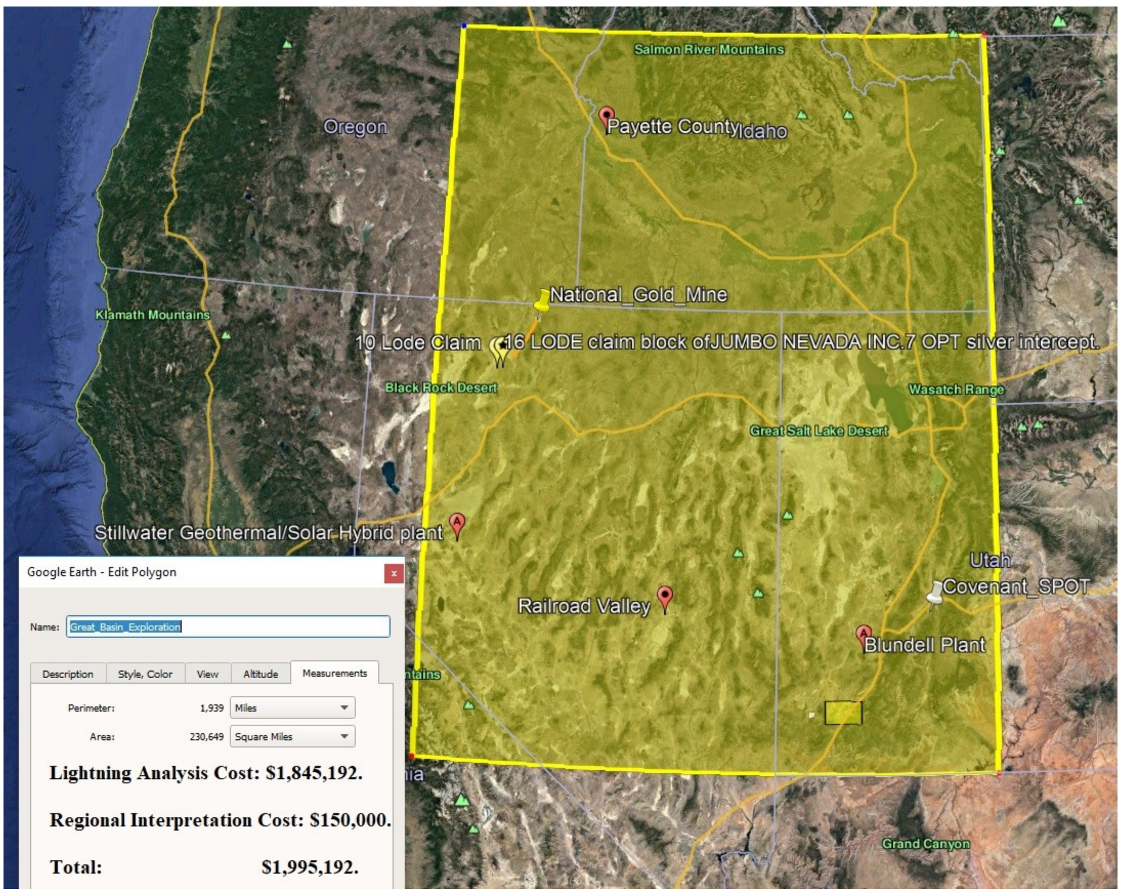


Figure 30. Proposed extent of a 230,000 square mile regional lightning analysis project over the Great Basin.

1. **The Covenant Field in the southeastern area**

The Covenant field, located in Sevier County, Utah as shown in Figure 31, produces oil and water (about 5%), and essentially no gas. Cumulative production as of October 1, 2006 was 2,611,688 barrels of oil and 434,629 barrels of water. The original oil in place reserves are estimated at 100 million barrels, and a 40-50% recovery is anticipated. West Texas Intermediate Crude is selling for $59 per barrel on 01 July 2019, which gives a recovery value of $2.950 billion over 20 or 30 years. There are potentially 100 oil fields this size within the proposed Great Basin Exploration area, each fed by the very thick Chainman Shale source rock, equivalent to the Bakken Shale in North Dakota.

The average porosity for the Navajo Sandstone at Covenant field it is 12%; the average grain density is 2.651 g/cm^3; gross pay thickness is 487 feet, and net pay thickness is 424 feet, with a net-to-gross ratio of 0.87; reservoir temperature is 188º F; average water saturation is 38%; average produced water resistivity (R_w) is 0.279 ohm-m at 77º F; initial reservoir pressures of 2,630 pounds per square inch; reservoir drive mechanism is an strong active water drive; API gravity of the oil is 40.5º; specific gravity is 0.8280 at 60º F; viscosity of the crude oil is 4.0 centistokes at 77º F and the pour point is 2.2º F; average weight percent sulfur is 0.48; and nitrogen content is 474 parts per million.

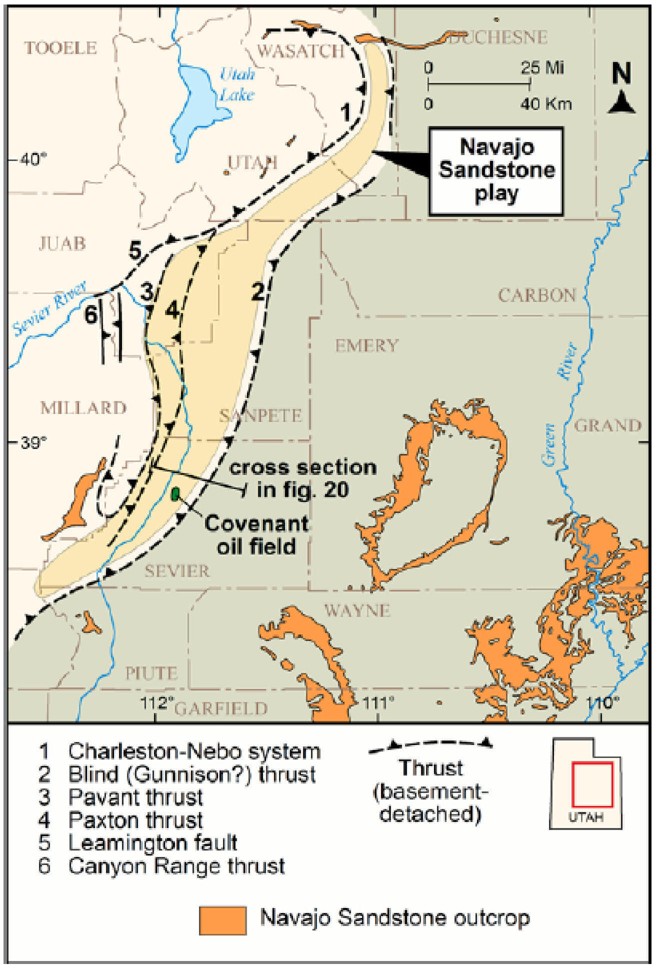


Figure 3. Location of Covenant oil field, uplifts, and selected thrust systems in the central Utah thrust belt province. Numbers and sawteeth are on the hanging wall of the corresponding thrust system. Colored (light orange) area shows present and potential extent of the Jurassic Navajo Sandstone Hingeline play. Modified from Hintze (1980), Sprinkel and Chidsey (1993), and Peterson (2001).

Figure 31. Location of the Covenant Oil Field along the Navajo Sandstone Play along the Utah Hingeline.

A test SPOT^{sm} analysis was performed over the Covenant Field. Preliminary results from this test are shown in Figures 32 and 33 below. Dynamic's process produced good data, even though there are not as many lightning strikes in the Great Basin as South Texas. We noticed was there is an anomaly which appears to be bounded by the mapped oil/water contact of the Covenant Field (blue outline and blue vertical cross-section bars in Figure 32).

Of even more interest was an interpretation Louie Berent of Dynamic Measurement did on a key cross-section across the field. This interpretation is shown in Figure 33. It is along a published cross-section across the field. Dynamic has not been able to get well log data yet, and so there are still questions about the vertical calibration. However, the fact we are mapping the same basic forms, on an equivalent cross-section is significant.

This example provides a basis for believing similar structures can be identified on apparent resistivity volumes from a regional lightning analysis across the entire Great Basin. Of course, one of the first steps would be to take public domain data from the Railroad Valley Fields in Nevada and integrate it with lightning attribute and rock property volumes, to create a calibration or type of what to look for in new exploration areas.

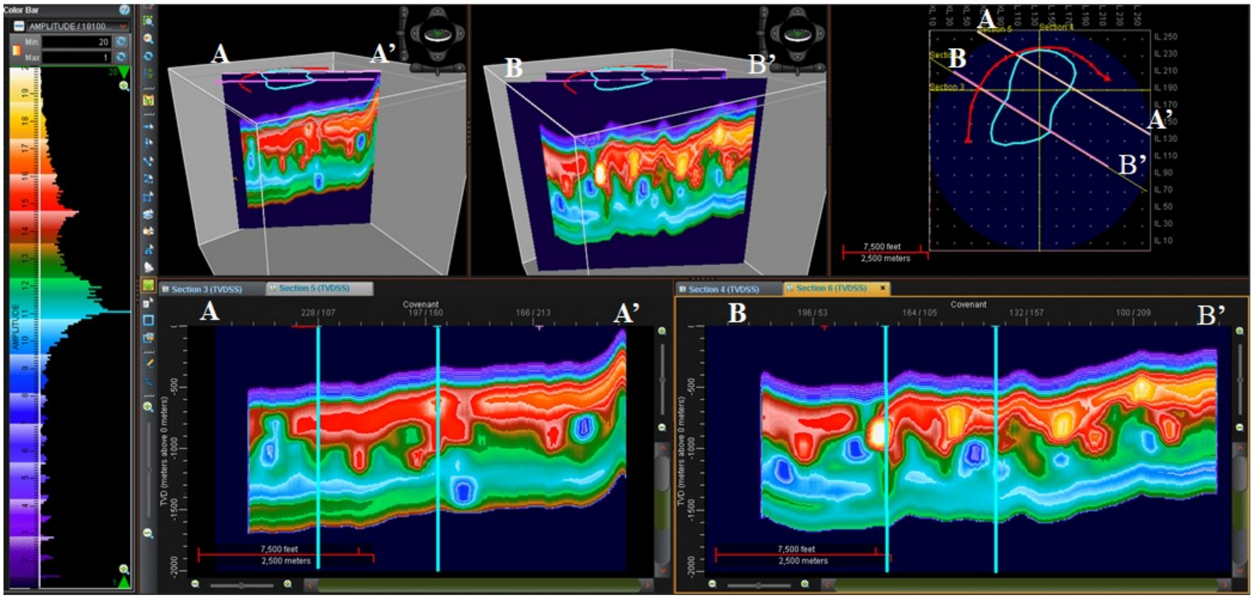


Figure 32. Map of thrust fault and oil water contact (upper right), perspective views of cross-sections upper right, cross-sections A-A' & B-B' bottom. Bright colors are high apparent resistivity, blue colors are high conductivity.

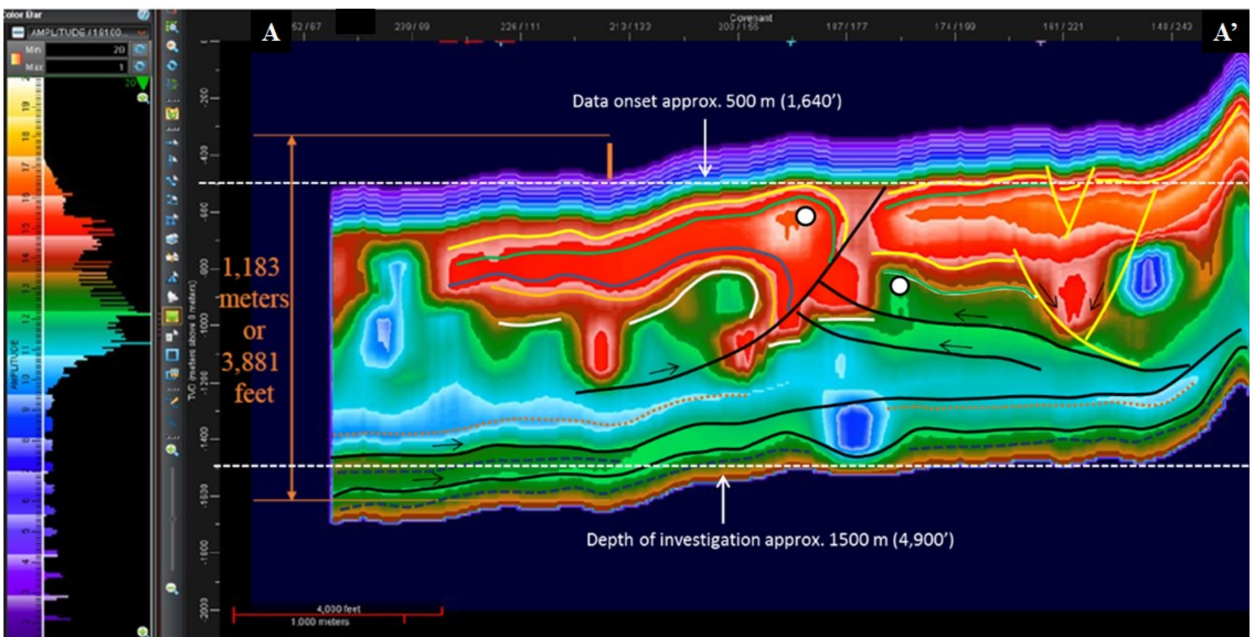


Figure 33. Overthrust interpretation of cross-section A-A'.

2. **<u>Oil discoveries in Railroad Valley Nevada</u>**

Nevada's first oil field, Eagle Springs, was discovered by Shell Oil in 1954. What led Shell Oil to explore for oil and gas in a remote valley in east-central Nevada? Possibly, because some droplets of live oil were found in goniatites in 1946 by Walt Youngquist in the Mississippian Chainman shale, 30 miles northwest of the Eagle Springs field. Since 1954, nine oil fields have been discovered in Railroad Valley, and to-date have produced a total of 47,000,000 barrels of oil (at $59/barrel $2.773 billion). Production is from Oligocene volcanics, Eocene lacustrine limestones and Paleozoic carbonates. Case histories of three fields are available (Eagle Springs, Trap Spring and Grant Canyon-Bacon Flat). Future exploration will be for both conventional and unconventional fields. The proposed regional lightning analysis can be calibrated against historical data on these 9 fields. The following is an article about "Great Basin Oil Giant" opportunities by Alan K. Chamberlain.

Most of the giant oil fields on earth are found in passive margin shelves like the Paleozoic passive margin shelf of the Great Basin of western Utah and eastern Nevada.

These shelf Paleozoic sediments thicken from several thousand feet from the Utah Hingeline in central Utah to more than forty thousand feet in central Nevada (Figure A). Many age-equivalent North American producing oil shales were deposited in this stratigraphic wedge. However, the Great Basin shales are not just as organically rich as the other shales but they are many times thicker. The eastern Great Basin, covering 71 million acres, most of which is available for leasing, is the last underexplored onshore basin in North America likely containing giant oil and gas fields.

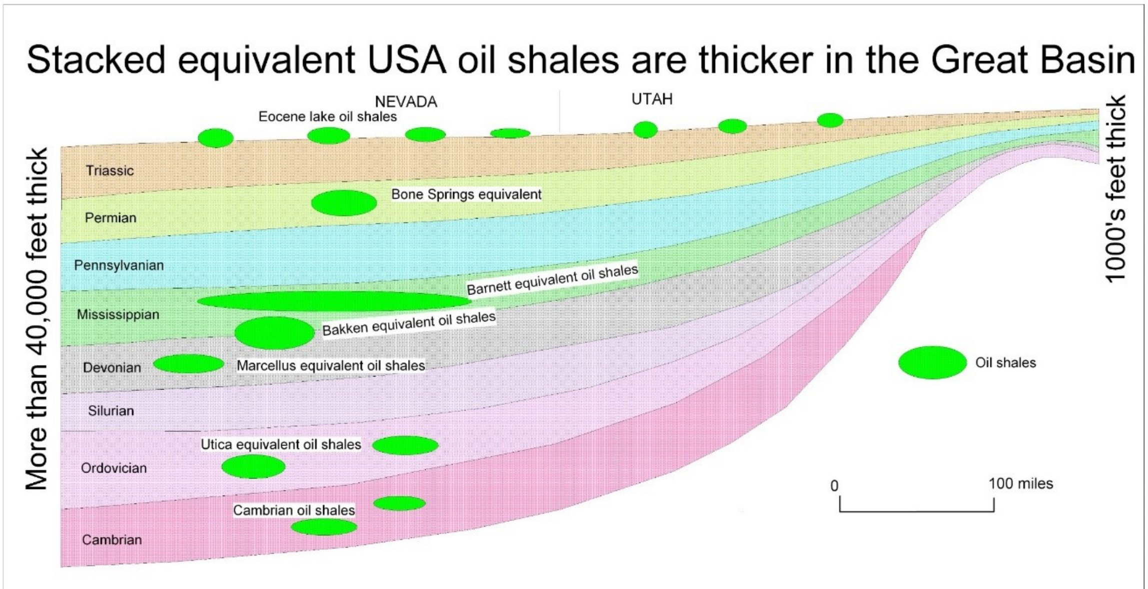


Figure A. Thickening of oil shale source rocks in the Great Basin.

Bakken age-equivalent Mississippian-Devonian Pilot oil shale is up to 900 feet thick in the Great Basin, in contrast with only 150 feet or less in parts of North Dakota. One of the favorite stops on Cedar Strat's helicopter-supported fieldtrips is an outcrop of tight Pilot sandstone that bleeds oil when it is freshly broken (Figure B). Oil seeps from organic-rich Marcellus age-equivalent Middle Devonian shales in some Nevada outcrops. One well, with gas shows, cut eight thousand feet of Utica age-equivalent Ordovician Vinini shale and was still in Vinini at Total Depth. Oil shales in these Ordovician strata are so organic rich in some outcrops that they have been retorted for oil.

Figure B. Keystone Thrust showing a helicopter on a Cedar Strat field trip.

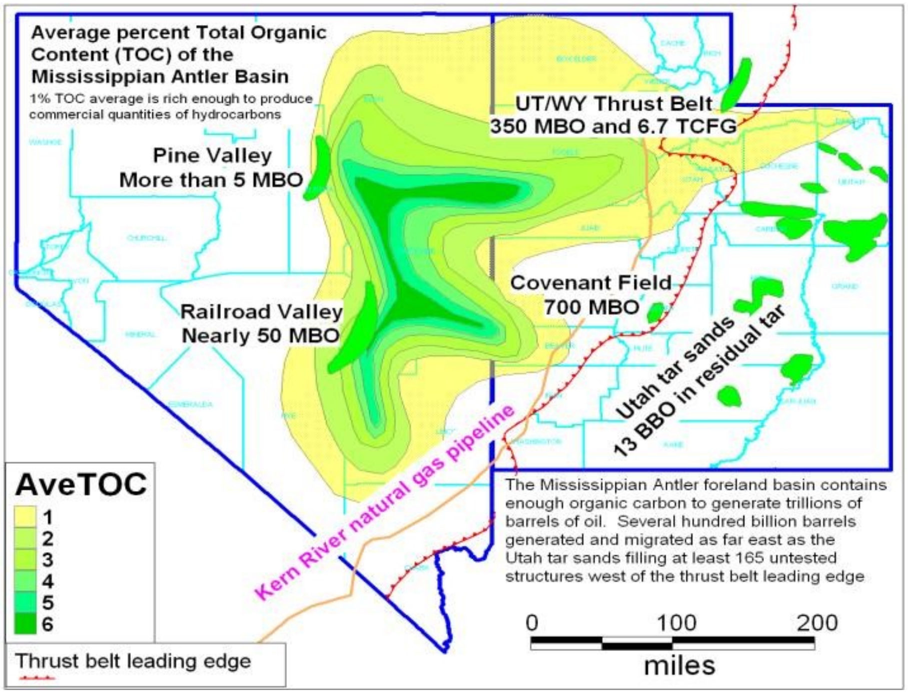


Figure C. Total Organic Content of the Mississippian Antler Foreland Basin, Nevada.

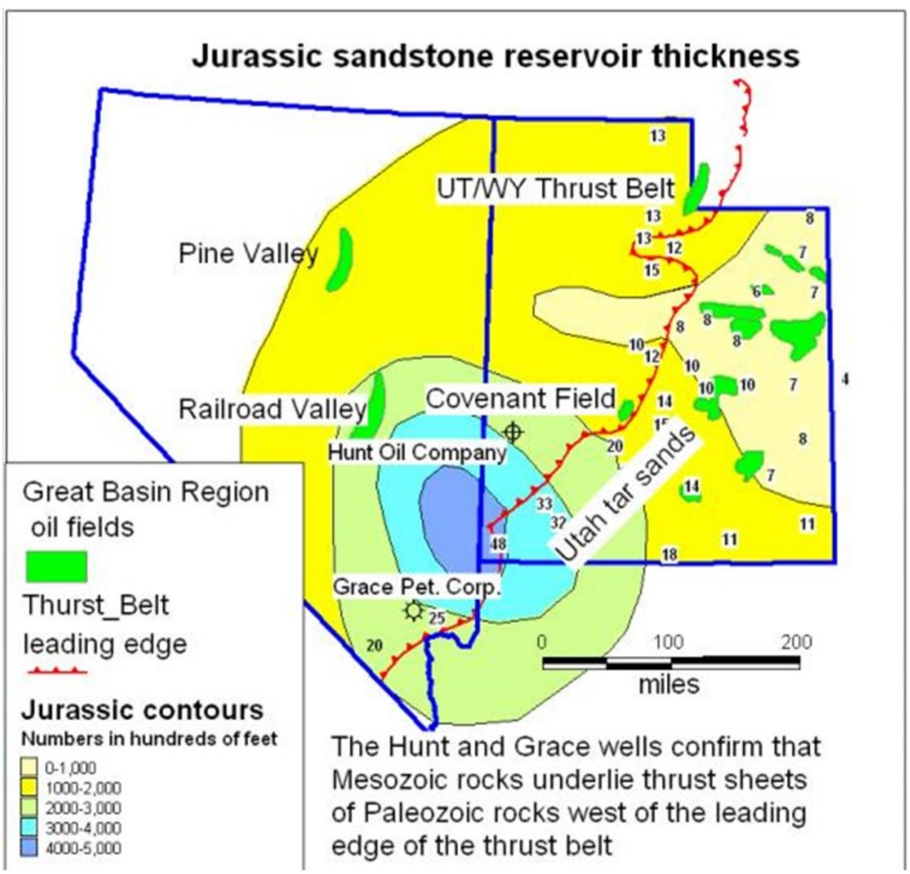


Figure D. Location of the Utah tar sands east of leading edge of the western North American Cordillera Thrust Belt.

Cedar Strat, using its proprietary geological survey created a structural contour map on the top of the Mississippian Joana Limestone (Figure E). This map combines stratigraphic field measurements and gravity data to create a structural contour map parallel to the Pilot Shale source rock. Cedar Strat has been creating the geological survey ever since several major oil companies gave Dr. Alan Chamberlain the financial incentive to leave Placid Oil Company and initiate the first Great Basin geological survey in 1984. The reason they encouraged Dr. Chamberlain to conduct the survey is because the State of Nevada has never authorized a geological survey and much of the mapping of western Utah is composed of compilations of student summer field camps. Dr. Chamberlain chose to make the contour map on the top of the Joana because the Joana forms a prominent cliff above a strike valley in the Pilot Shale below and a strike valley in the Mississippian Antler basin shales above, it is easily distinguished on surface and subsurface gamma ray logs, and because it is extensively distributed.

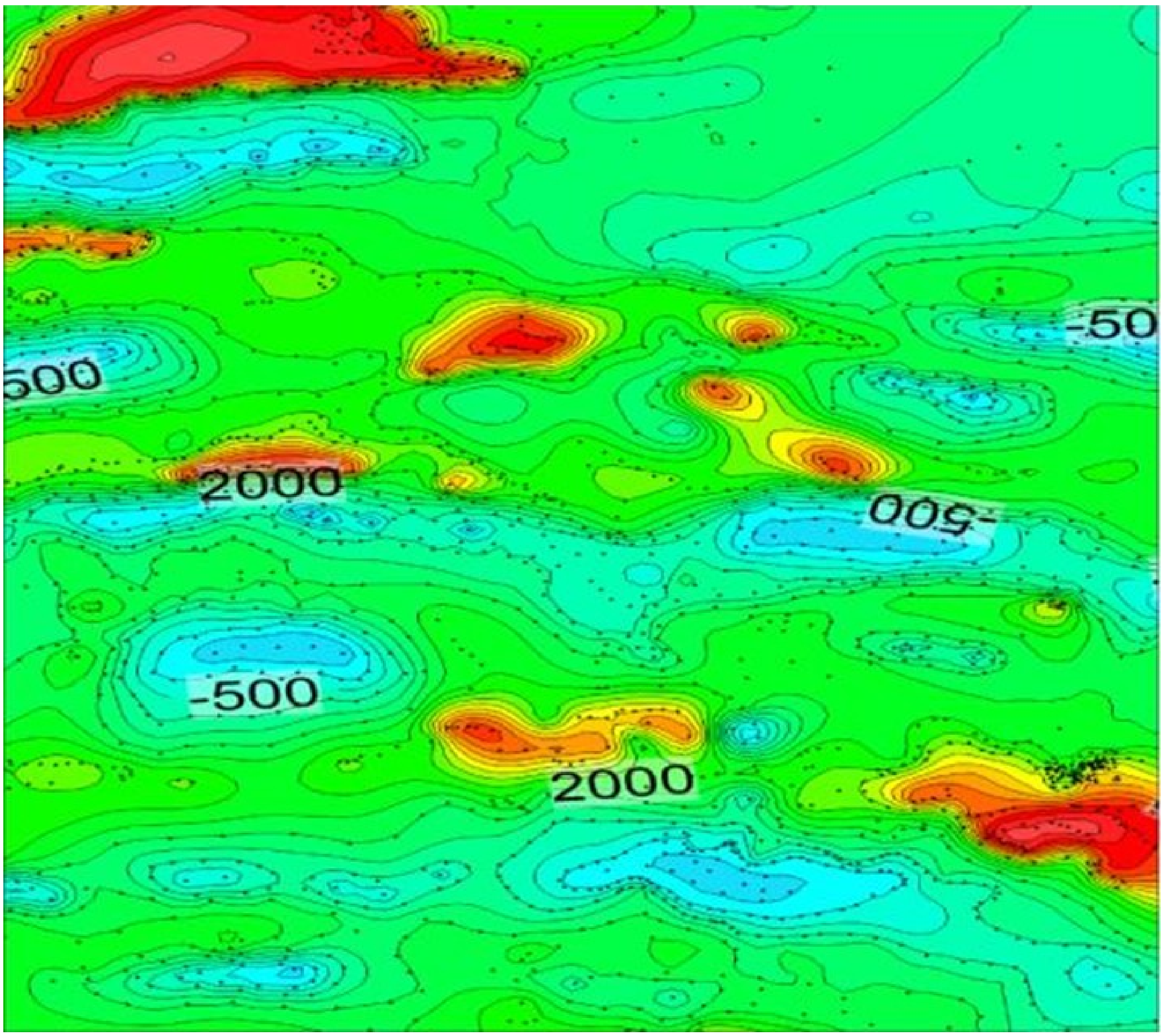


Figure E. A small part of a proprietary treasure map of the top of the Joana Limestone.

The structural contour map literally became a treasure map as it identifies at least 165 untested structures possibly full of oil and gas covering twenty million acres between the Antler Basin oil generating kitchen and the leading edge of the Cordillera thrust belt. As oil migrated from central Nevada to Utah it filled up each fold to spill point before flowing over to the next structure to the east (Figure F). Each of the structures could contain a billion or more barrels of oil or oil equivalent. Fortunately, erosion by the Colorado River has exposed thousands of feet of subthrust Jurassic sandstone that forms the cores of mountains in the Las Vegas area. Cedar Strat typically begins its helicopter-supported field trips in Las Vegas where mountain roots are exposed and then moves northward where only tips of hanging wall thrust duplexes are exposed. Two wells, penetrating thousands of feet of Precambrian and/or Early Paleozoic rocks confirm that subthrust Mesozoic rocks occur below the thrust sheets west of the leading edge of the thrust belt (Figure D). These evidences suggest that thick subthrust Mesozoic sandstones may also core some, if not many, of the 165 untested structures north of the Colorado River basin. Not only are the subthrust sandstones the conduit for oil migration but, also, they are the reservoir rock that has already produced trillions of cubic feet of gas and hundreds of millions of barrels of oil along the leading edge of the thrust belt (Figure C).

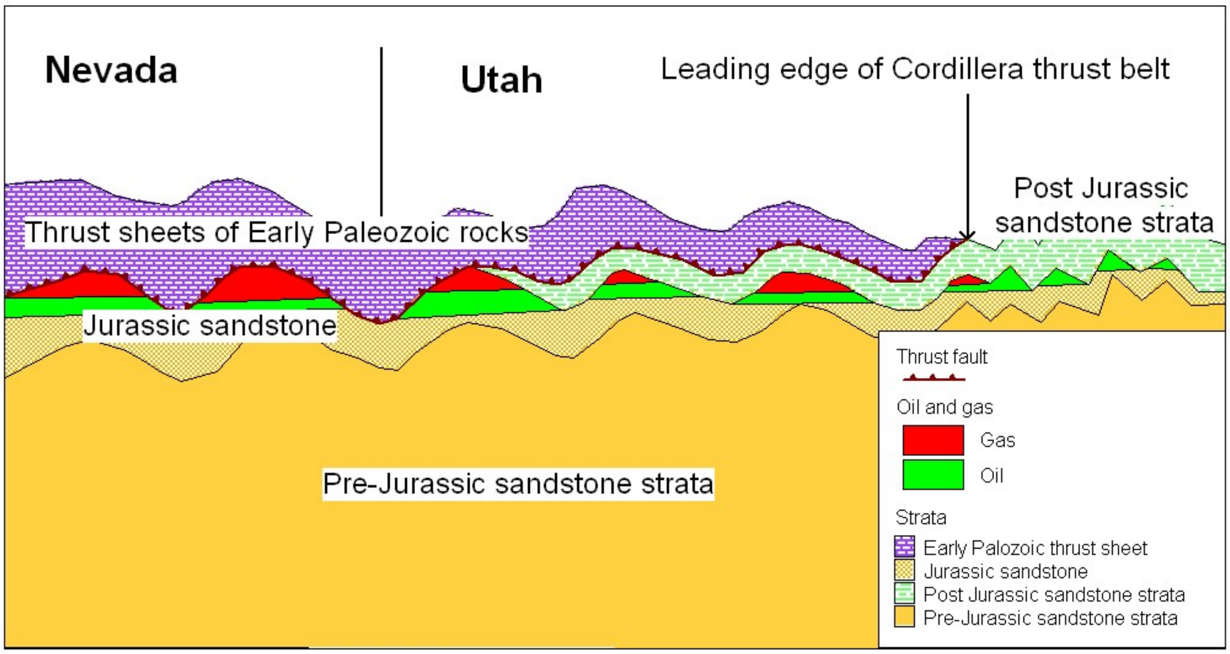


Figure F. Cartoon of how Jurassic sandstone structures, deeper than existing well tests, could have filled as hydrocarbons migrated to the east.

During the downturn of oil prices in the 1980's the principals at XTO raised $35M, hired experience geologists, acquired key leases, and developed technology and data to explore the Barnett Shale in the Ft. Worth Basin. Several years later Exxon bought XTO for $36B because XTO had the leases, technology and data and expertise that Exxon needed. Cedar Strat believes that by investing $100/acre in the 165 structures to acquire leases, expertise, and technology and data the leases could be sold to industry for at least $300/acre, similar to XTO. Investors are likely to see their investments at least double within two or three years. Note, discoveries at Pineview and Covenant fields caused the value of trend leases to increase to more than $10K/acre.

The opportunity is to control the leases, data, and expertise that exploration companies will need when oil prices spike again. In addition to its helicopter-supported field trips to show the prospective areas, Cedar Strat also provides briefing sessions in Las Vegas to reveal aspects of the proprietary Great Basin geological survey. Cedar Strat presents Great Basin petroleum geology—including the history of oil exploration in the Great Basin and explains how the survey datasets were acquired from which the treasure map was created.

The profit from acquiring, developing, and selling Great Basin leases will not only cause an army of geologists to be hired and trained but it will also provide the resources to complete the Great Basin geological survey, develop new technology and data and ultimately create a private technical research institute to replace the company research centers that were dismantled in the 1980's. The goal of the new institute is to capture expertise before it goes to the grave and train up new generations of scientists and engineers to help solve the world's energy problems.

3. Alta Mesa oil discoveries in Payette County Idaho

June 28, 2016: Alta Mesa Idaho confirmed Tuesday that one of its well in the Willow Creek field seven miles north of New Plymouth is producing both oil and natural gas. The deeper zone produces crude oil, while the upper zone produces natural gas and condensates, which are liquid hydrocarbons similar to jet fuel. That material condenses as a liquid out of the natural gas as it is brought to the surface. The well, called the Kauffman 1-9 LT, was drilled and tested during 2014. Alta Mesa has 16 wells drilled in Idaho, with seven of them producing natural gas, condensate, oil and other liquids. Alta Mesa has two wells permitted but not drilled and nine listed as waiting for connecting pipelines. Alta Mesa Idaho Spokesman John Foster said the discovery does not significantly change the nature of the industry in Idaho. Both products are collected at Willow Creek and shipped to a railroad yard in Ontario, then shipped to Salt Lake and other destinations. Most of Alta Mesa's natural gas is used in Idaho Power's Langley Gulch natural gas electric generation plant. It flows into the Williams pipeline near I-84 south of New Plymouth, where Alta Mesa has a plant that removes water from the gas. It was six years ago this month that Idaho Gov. Butch Otter announced that Bridge Resources, which was bought out by Alta Mesa, had discovered natural gas in Idaho. In 2010, Bridge found gas and condensate in seven wells it drilled, showing the state can produce natural gas commercially. Before that, the last well drilled in the state was in 2007 near Grays Lake in Bonneville County. Drillers have applied for permits to drill in that area again, Schultz said Tuesday. There was a flurry of interest in Eastern Idaho from the early 1970s until the late 1980s, in part of an area known as the Overthrust Belt, a 250 million- to 500 million-year-old rock formation that runs from Alaska to Mexico. This belt produced large oil and gas fields in Wyoming, Utah and Colorado. The geology in the western Treasure Valley is significantly younger. The Tertiary Period sediments that underlie the area range from 15 million to 20 million years old. That's when a series of lakes formed Lake Idaho, which drained out through Hells Canyon. Geologists say the climate was wetter and more like Southern California's at the time. That humid climate allowed more organic material to grow, decay and be captured in the sediments where gas and oil explorers look today.

Seismic cannot see through the volcanic cover on the snake river plains. Lightning most likely can, and based on the Humboldt County lightning analysis project below, there is sufficient data to get good results. My friend who told me about this opportunity, Dr. Norman Neidell, also told me Mr. Burke in Midland made $600 million and has committed to build a pipeline though Idaho. My friend pointed out there is a unique opportunity to explore Southern Idaho with lightning analysis over the next 2 years. Then selling the identified anomalies to a leasing company, would allow them to obtain the best leases before oil and gas transportation becomes available through the state.

4. The Sleeper Gold Mine in Humboldt County Nevada

The Jumbo deposit was discovered in 1936, and total production from adularia-quartz veins through 1963 was slightly less than $1,000,000. The Sleeper prospect was located in 1982 during an aerial reconnaissance program which identified a scarp stained with iron oxides. Locally, gold content averages more than 20 oz/ton, and ranges to more than 170 oz/ton. The USGS report suggests silica and gold were transported and deposited as colloids. Structure is one of the most important controls on ore formation at district, deposit, and meter scales. Miocene extensional tectonism created the local volcanic field and ore-bearing structures. The USGS suspects ancestral fracture-zones controlled emplacement of one or more rhyolite domes and pre-vein silicification. Brittle rocks were required for ore formation. The majority of the high-grade veins are within the rhyolite dome or related flows.

The Sleeper deposit is a low sulfidation, bonanza gold vein ore body enveloped by bulk tonnage, low grade disseminated gold ore. It was a shallow, Nevada range-front, pediment discovery drilled by Amax in 1984. Open pit mining took place from 1986 to 1996, originally centered on the Sleeper Vein itself. Successful exploration lead to the discoveries of the Wood, Office, and West Wood veins and the open pit was expanded to mine those ore bodies. Figure 34 below is a recent photo of the open pit mine. Recorded mine production was 1.682 M oz Au, and 2.8 M oz Ag. At $1,393 per ounce for gold and 15.13 per ounce silver, today prices, it places the value of equivalent discoveries at $2.343 billion for gold and $42 million for silver.

Two overlapping SPOT^{sm} Analysis were undertaken on Claims just south of the Sleeper mine, over properties where minerals are owned by friends who are willing to deal. This is at the northwest corner of the Great Basin. Five resistivity anomalies were identified, each about the same size as the Sleeper mine. We proposed drilling 5-8 $50,000-$80,000 test wells, based on identified anomalies from the lightning analysis, in order to quantify the in-place deposits. Figure 35 shows four down to the basin faults, invisible at the surface because of alluvial fill, and one of the anomalies that has friendly Claims over it. The intrusive rhyolite containing the gold ore is believed to have come up equivalent to or extensions of these faults. Figure 36 below shows the progression of the interpreted faults across the northern portion of the analysis area. The lightning analysis provides a new geophysical methodology for mapping faults and building a geotechnical framework. The business model is to sell the combined block of CLAIMS. The two groups who funded this work are looking to sell 75% of their ownership in the lightning analysis work in exchange for $75,000 cash and written commitment to drill 5-8 test wells. This fee will pay for two additional SPOT^{sm} surveys in order to tie current work to the Sleeper mine. We will help negotiate a deal with the current Lode Claim owners. In the best-case scenario, the opportunity within the 2 existing SPOT^{sm} analysis areas is worth over $10 billion. The Genesis fault appears to go north to the National Gold Mine. An upside is being able file for Claims along this trend. Regional analysis allows detailed interpretation covering hundreds and thousands of miles, providing a significant multiple on the potential upside.

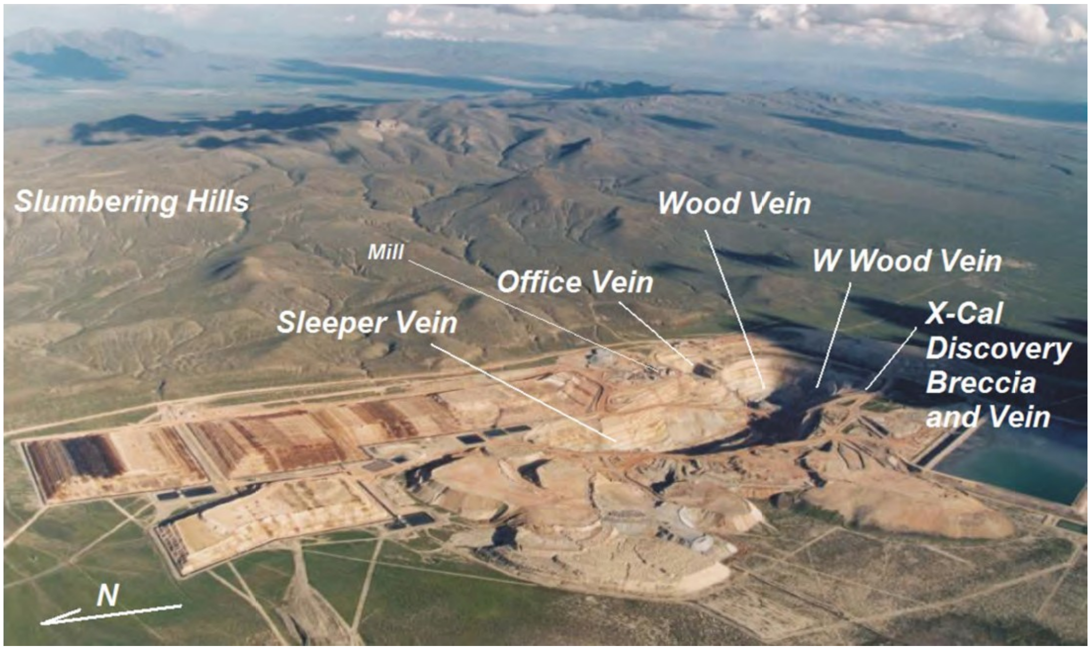


Figure 34. Aerial view of the Sleeper open pit looking SE along the Cortez Gold trend of Nevada, U.S.A.

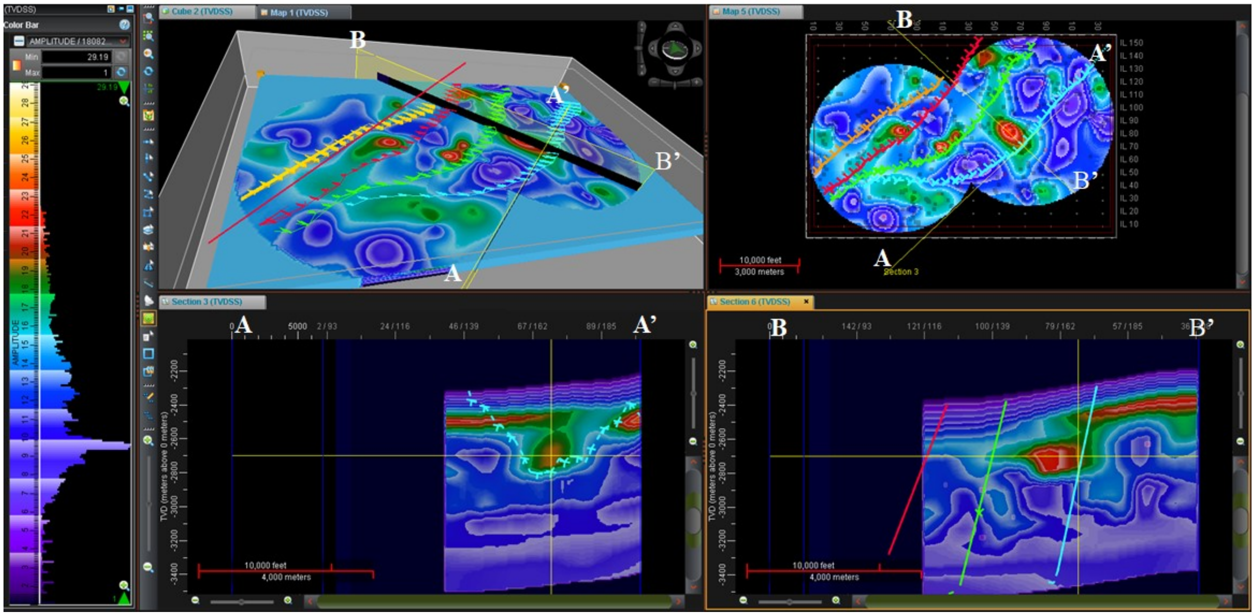


Figure 35. Apparent Resistivity volume displays highlighting an anomaly covered by friendly Claims.

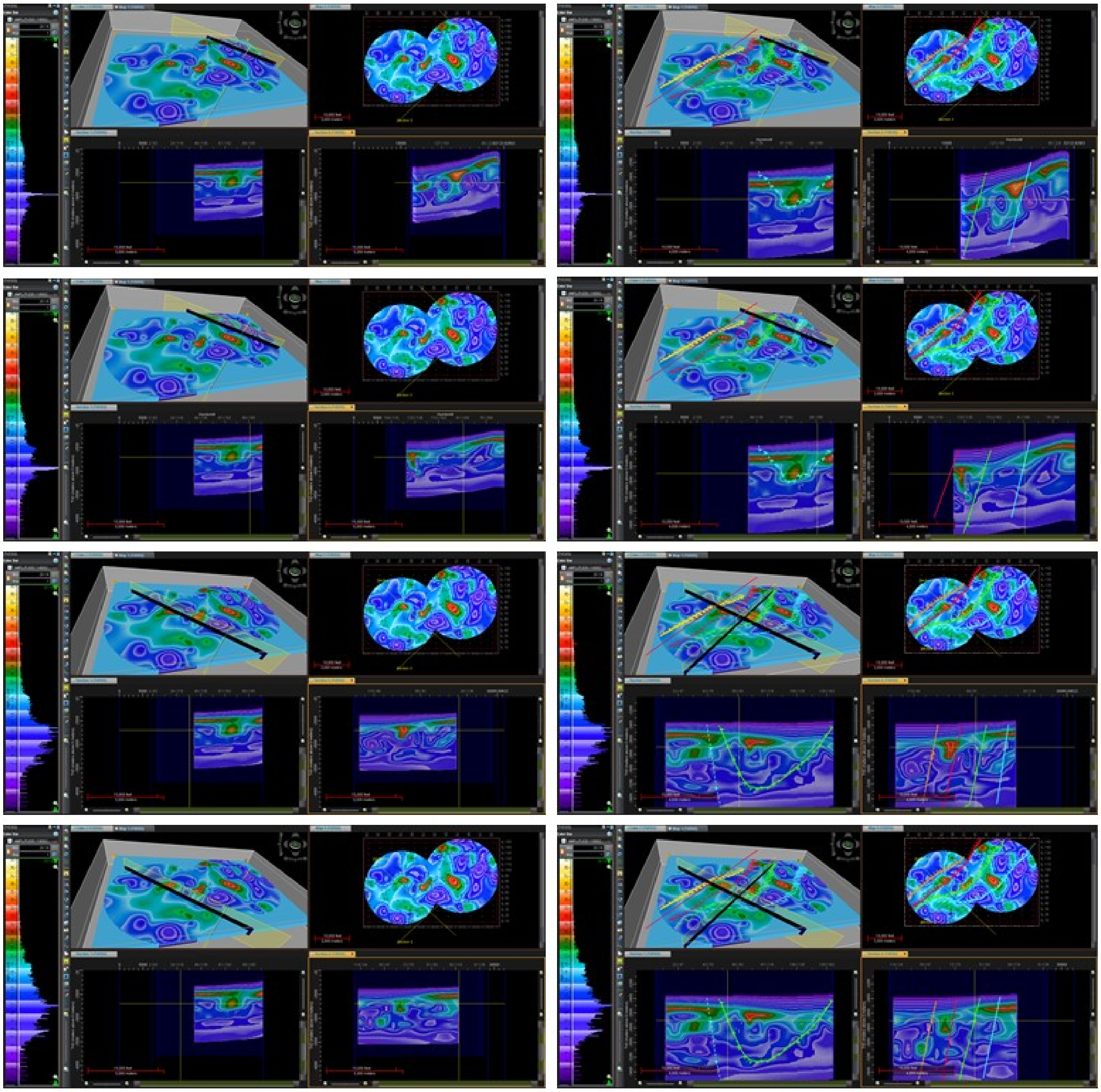


Figure 36. Four dip sections, uninterpreted and interpreted, showing progression of the down-to-the-basin faults.

5. A geothermal analysis in South Utah

Dynamic Measurement did a Lightning Analysis project in South Utah for a company with geothermal leases. The confidential report for the company became the basis for BLM renewing and extending their leases for another 5 years. Figures 37A-G below are released images from this report. Figure 37A shows strike locations over 20 years, as well as the locations of Risk Points, where at least 1 strike per year is predicted. Figure 37 B is a statistical plot which shows lightning strike locations are primarily controlled by geology. This graph shows there is a significant difference between randomized locations of lightning strikes and raw data. The difference is the impact of geology on strike locations. The next 5 figures (Figure 37C - Figure 37G) show how well lightning derived apparent resistivity cross-sections match seismic interpreted cross-sections, where the first section comes from the USGS (United States Geological Survey) and the other four are from the UGS (Utah Geological Survey).

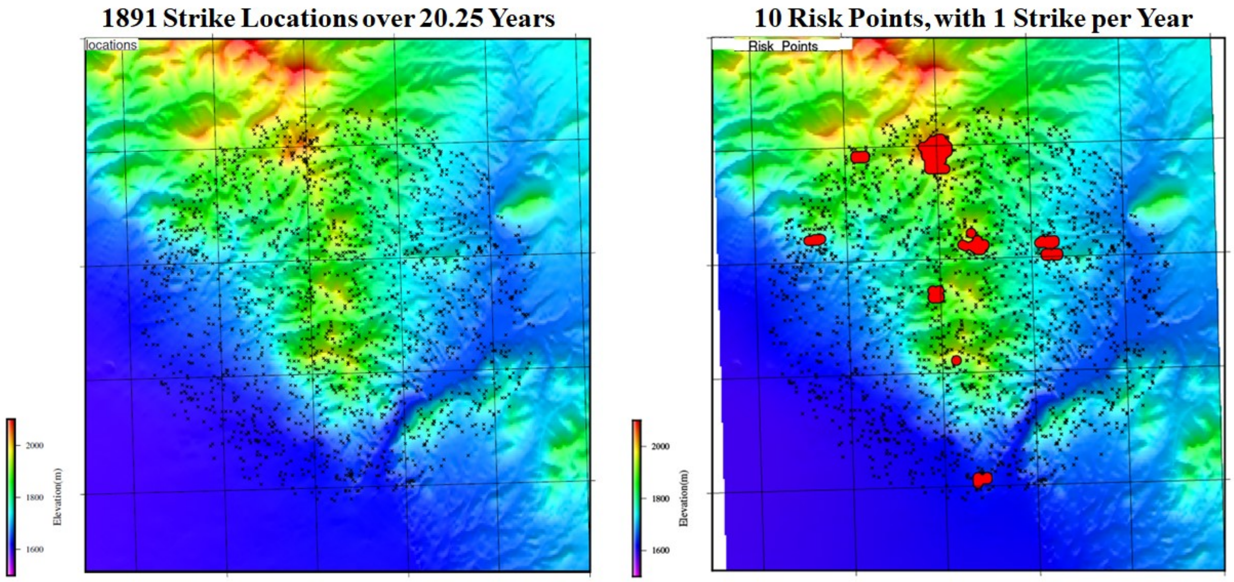
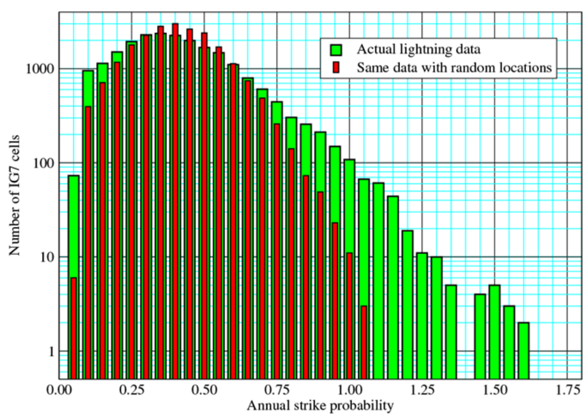


Figure 37A. Strike Locations (left) and Risk Points (red on right image), where 1 strike per year is predicted.



- Green Bar Chart shows number of 30 m x 50 m cells which receive between 0.1and 1.65 strikes per year.
- Red Bar Chard is same data, with randomized locations. Note the Risk Points, greater than 1 strike per year, do not occur in randomized data.
- Risk Point locations on previous slide.

Figure 37B. This figure shows lightning strike locations are primarily controlled by geology. The difference between the randomized locations (red bars) and the raw data (green bars), is the impact on strike location due to geology.

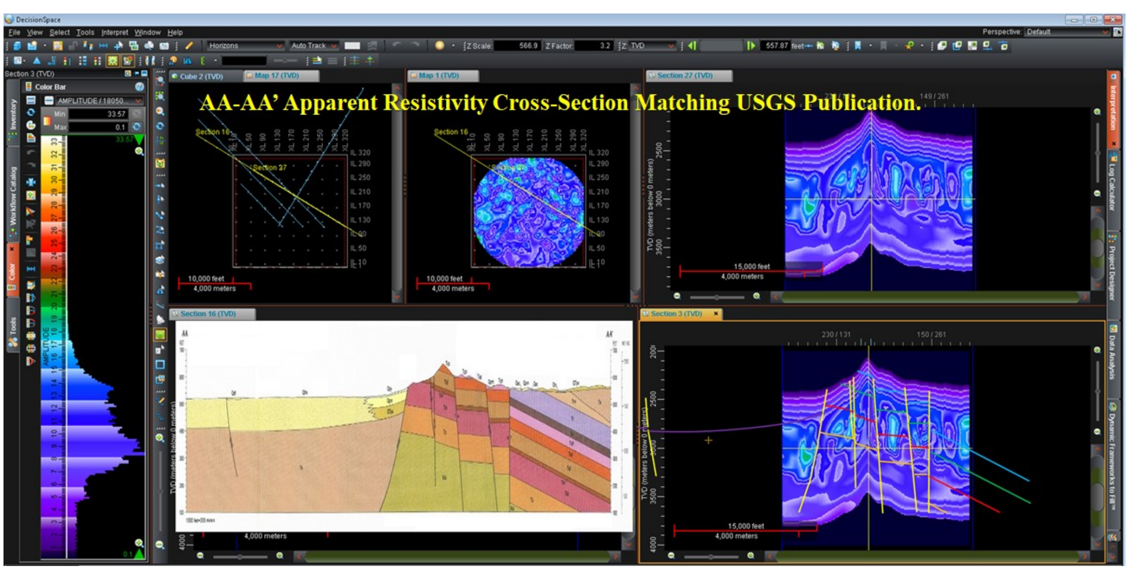


Figure 37C. USGS seismic derived cross-section, and with apparent resistivity raw and with seismic interpretation.

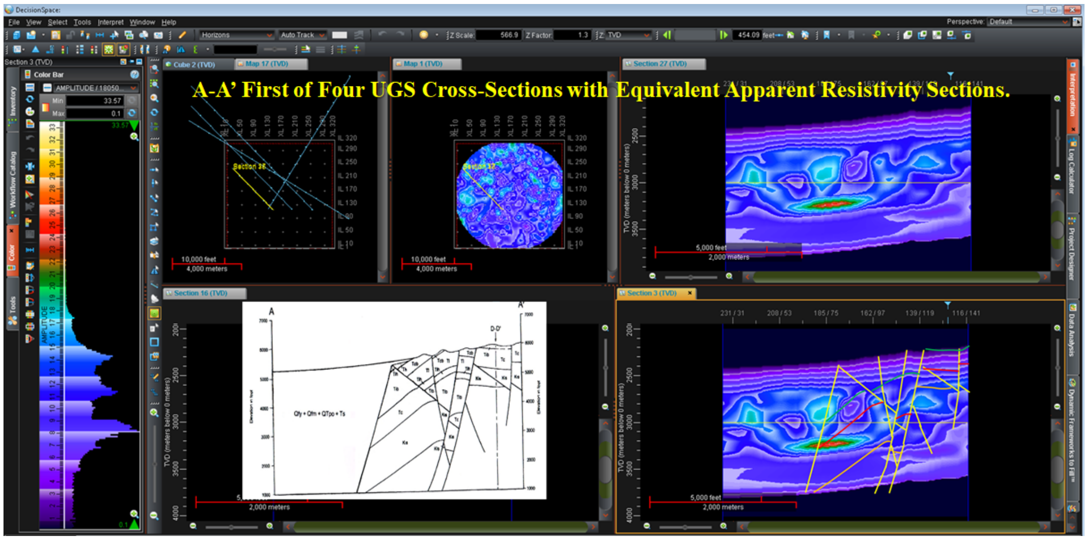


Figure 37D. UGS seismic derived cross-section A, and with apparent resistivity raw and with seismic interpretation.

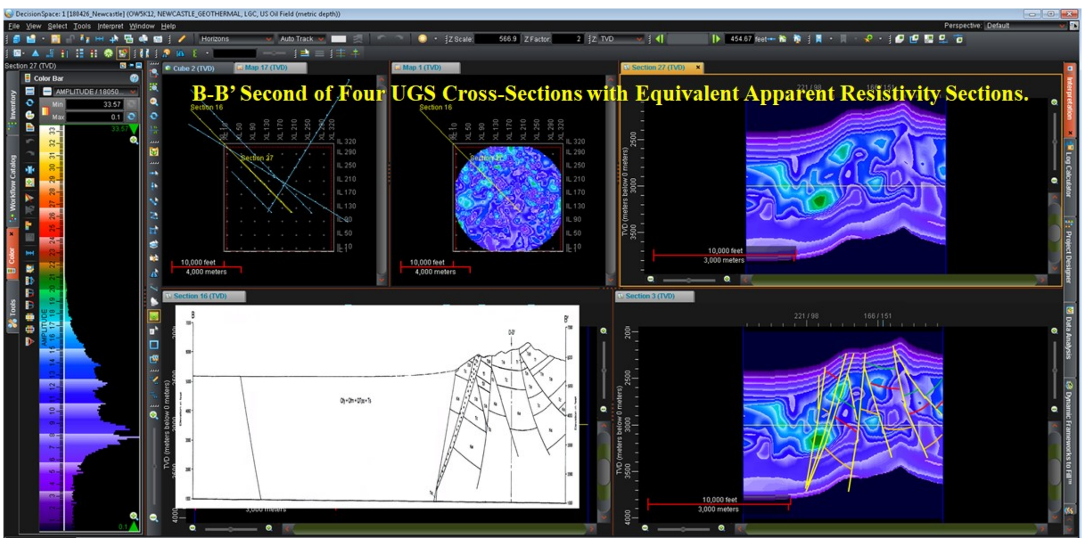


Figure 37E. UGS seismic derived cross-section B, and with apparent resistivity raw and with seismic interpretation.

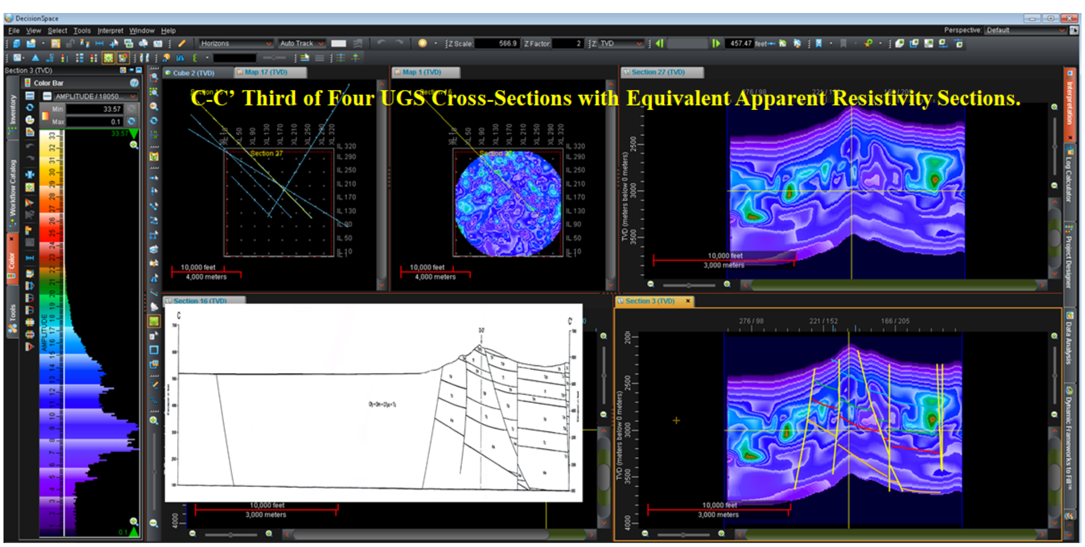


Figure 37F. UGS seismic derived cross-section C, and with apparent resistivity raw and with seismic interpretation.

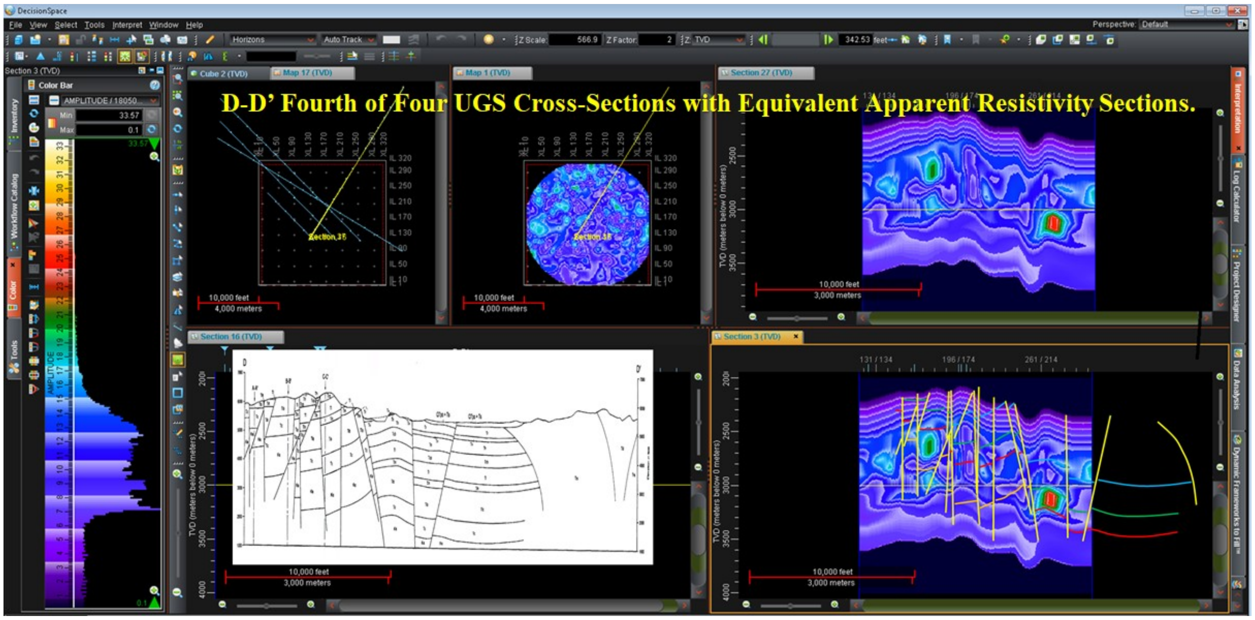


Figure 37G. UGS seismic derived cross-section D, and with apparent resistivity raw and with seismic interpretation.

The next 5 figures, Figure 38A – Figure 38E below, show an alternative structural interpretation derived from the lightning analysis. These sections, as shown on the map on the left side of each figure, are orthogonal to the major down to the basin fault. The geologic literature for the area implies faults in the valley should be down-to-the valley growth faults. However, each of some 25 parallel apparent resistivity cross-sections shows faults going back towards the mountains. The interpretation is that these represent a flower structure, and were caused by a strike-slip fault parallel to the mountain front. There is a significant high resistivity anomaly at the base of this flower structure, which could be related to granitic intrusion or even silver.

There was a significant silver mine paralleling this potential strike-slip fault possibly related to this analysis project. Lightning analysis should be able to map where the silver-producing strike slip fault went after the vein terminated against another fault.

The last example from this project is Figure 39 below, a perspective display of interpretation showing the probabe strike-slip fault, with the centered resistivity anomaly.

Thermal gradient wells are currently being drilled, and locations were influenced by lightning analysis (think field trip). The goal is to find 6,000 gallons per minute of 300° F water to produce 15 MW of power with a binary system. Wells will also provide calibration on lightning analysis depth predictions. Ownership in this opportunity is available for sale, if this becomes a best ranked exploration opportunity within the Great Basin Exploration area.

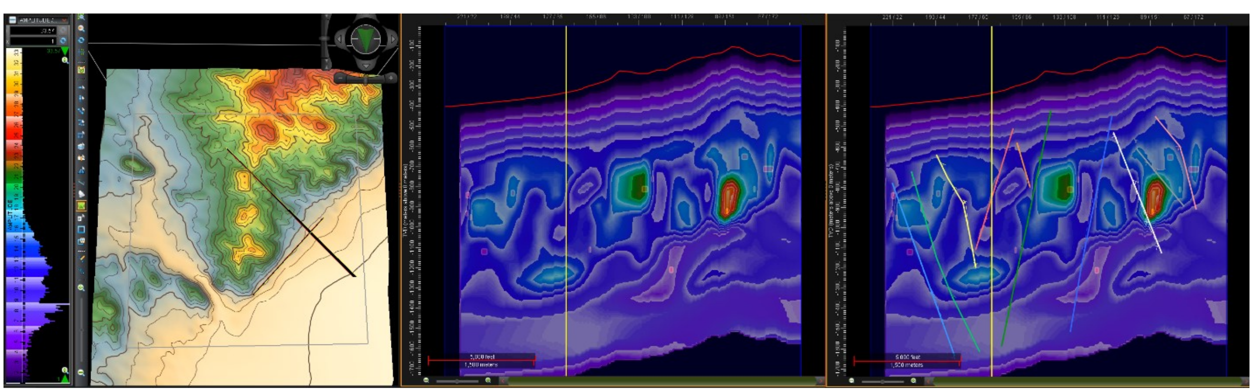


Figure 38A. 1 of 5 cross-sections raw and with interpretation showing “flower structure” strike-slip faulting.

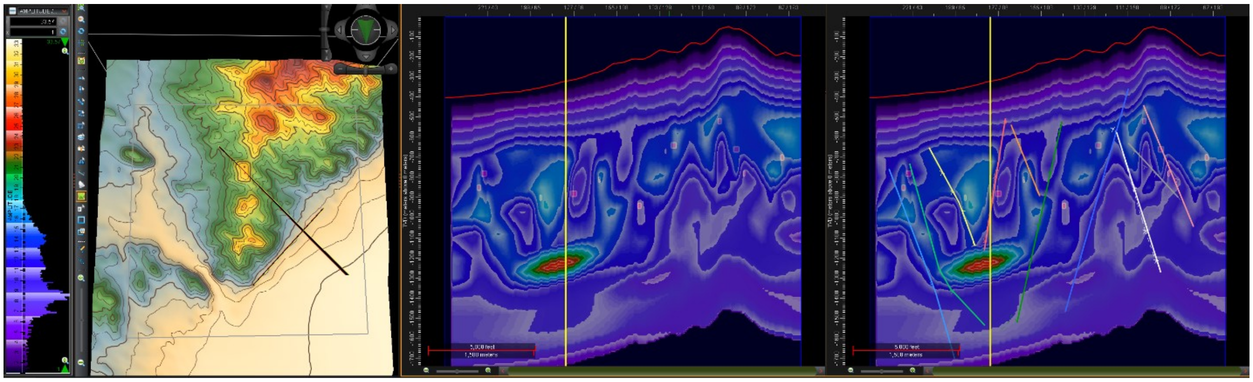


Figure 38B. 2 of 5 cross-sections raw and with interpretation showing “flower structure” strike-slip faulting.

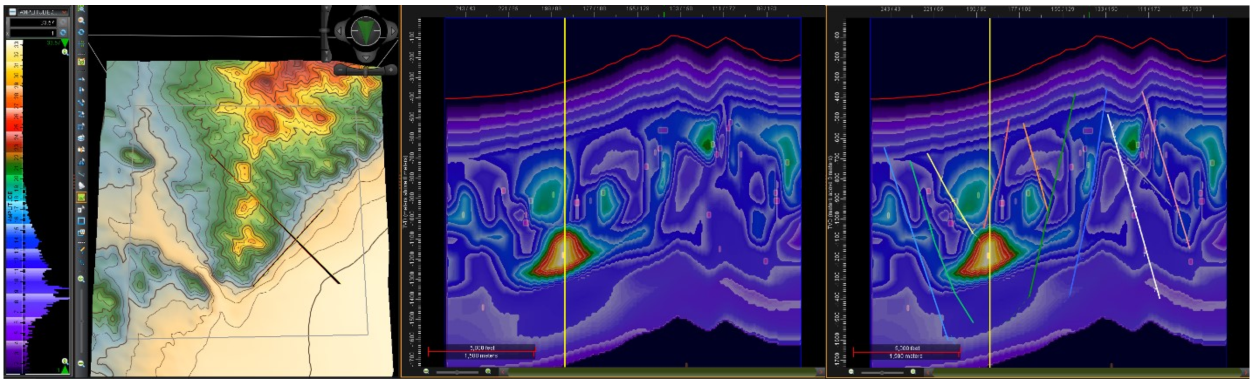


Figure 38C. 3 of 5 cross-sections raw and with interpretation showing “flower structure” strike-slip faulting.

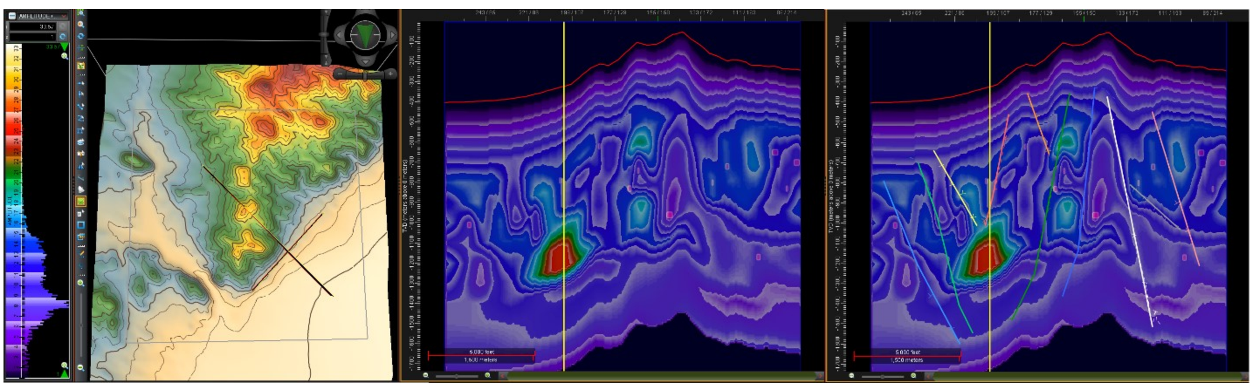


Figure 38D. 4 of 5 cross-sections raw and with interpretation showing “flower structure” strike-slip faulting.

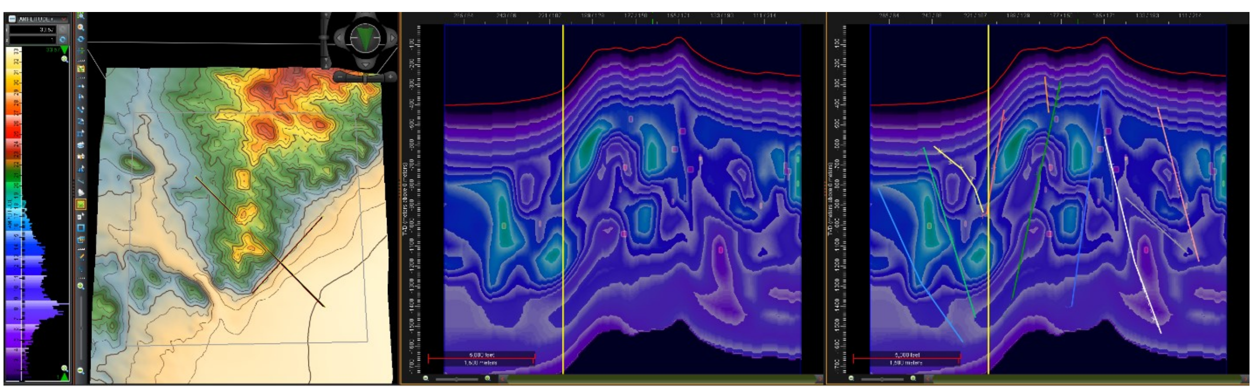


Figure 38E. 5 of 5 cross-sections raw and with interpretation showing “flower structure” strike-slip faulting.

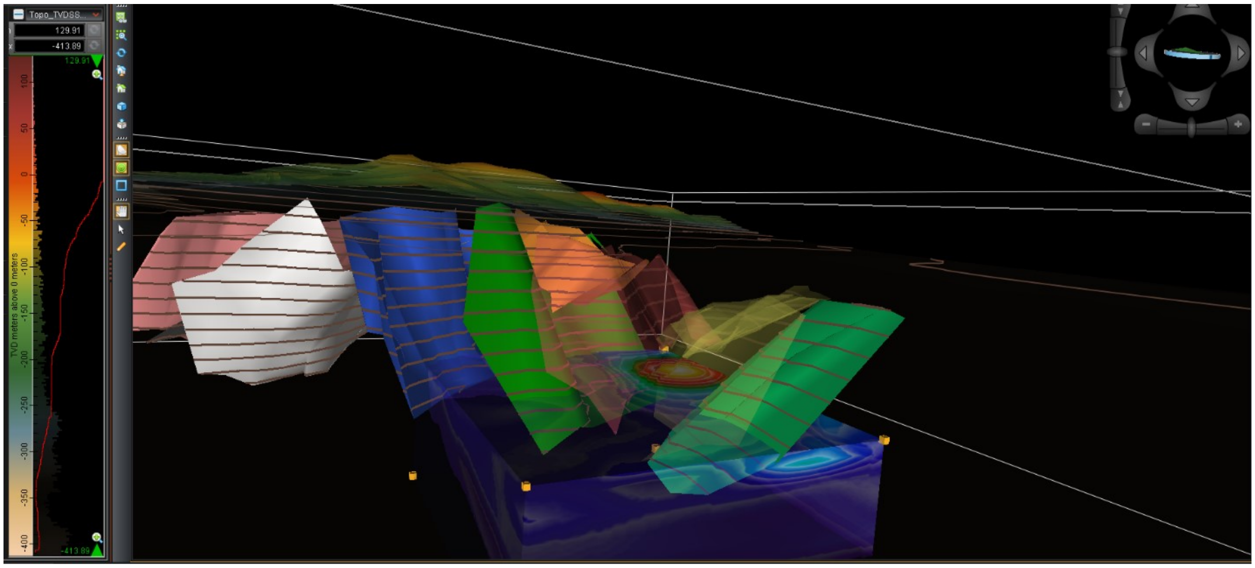


Figure 39. Perspective display of interpretation showing probably strike-slip fault with centered resistivity anomaly.

6. <u>The Escalante Silver Mine</u>

"Escalante Silver Mine" is a producer vein deposit site discovered in 1896 in the Intermontane Plateaus of Utah, The United States. It is a medium deposit, located in the Escalante District mining district and is not considered to be of world-class significance. Silver, lead, and gold deposits are documented at "Escalante Silver Mine." Silver is present at a grade sufficient to have a strong effect on the economics of an excavation project. It may even be viable as the only commodity mined. Lead can be economically recovered from this site but would have little effect on the viability of the mining project. The gold at this site is economically interesting but not currently recoverable. At the time this deposit was surveyed, there was a medium scale production. Mining operations could be year-round, intermittent, or seasonal. Heber Holt Enterprise Utah was most closely involved in the discovery of this deposit. The most important method or feature used in the discovery of economic minerals at this site was ore-mineral in place. Production at "Escalante Silver Mine" began in 1934.

Line - Category - Comment

1. Deposit - THE DEPOSIT OCCUPIES A CONTINOUS ZONE WITHIN THE ESCALANTE VEIN. THE VEIN AVERAGES 19 FEET WIDE AND MINERALIZATION OCCURS OVER THE ENTIRE WIDTH. VEIN IS MARKED BY CRUSTIFORM BANDING WITH BANDS OF FINE-GRAINED CRYSTALLINE QUARTZ AND QUARTZ WITH HEMATITE, CALCITE, OR FLUORITE, INCLUSIONS. SILVER IS ASSOCIATED WITH QUARTZ - HEMATITE BANDS. BRECCIATION AND REPEATED VEINING IS COMMON - TENTATIVE PARAGENESIS IS (1) EARLY BARREN-CALCITE PHASE, (2) LATER QUARTZ-FLUORITE PHASE, (3) EPISODIC DEPOSITION OF QUARTZ-SULFIDE, SILVER AND HEMATITE MINERALS, AND (4) A LATE QUARTZ-CALCITE PERIOD.
2. Workings - MAIN ACCESS IS VIA A FIGURE-EIGHT SPIRAL DECLINE WITH CROSSCUTS AT PERIODIC INTERVALS DRIVEN TO THE VEIN. DECLINE IS USED FOR REMOVAL OF ORE VIA DUMP TRUCKS. DECLINE WILL ULTIMATELY BE AT LEAST 5100-FOOT-LONG. MINING METHOD IS END-SLICING, A VARIATION OF VERTICAL CRATER RETREAT MINING.
3. Location - AREA OF MINING AND MINING CLAIMS COVERS MUCH OF THE SOUTHEAST QUARTER OF SECTION 2 ; INFO FROM LAND.ST :(1975)
4. Development - ORIGINAL CLAIMS STAKED IN 1896 BY HEBER HOLT OF ENTERPRISE UTAH. CLAIMS WERE PATENTED IN 1910. LIMITED EXPLORATION AND MINING WAS CONDUCTED ON THE PROPERTY UNTIL 1957. SYSTEMATIC EXPLORATION BEGUN IN 1958 BY SAMUEL S. ARENTZ, BUT PROPERTY STILL UNECONOMIC. RANCHERS EXPLORATION TOOK CONTROL OF THE PROPERTY IN 1975. DRILLING AND TEST MINING BEGAN IN 1979. FULL MINE DEVELOPMENT BEGAN IN 1980. ORE FIRST FED TO THE MILL ON AUGUST 29, 1981. MINING ACTIVE TO PRESENT - MAY 1985 - AND IS EXPECTED TO CONTINUE FOR THE NEXT 10 YEARS. HECLA MINING COMPANY BOUGHT RANCHERS EXPLORATION IN LATE 1984 AND NOW OWN AND OPERATE MINE

5. Production - ESTIMATES BASED ON PROJECTED FIGURES IN 1982. MINING AND PRODUCTION IS CURRENTLY IN PROGRESS
6. Geology - VOLCANICLASTIC HOST ROCK IS POST-MIDDLE MIOCENE IN AGE AND FILLS EAST-NORTH EAST TRENDING GRABEN STRUCTURE
7. Deposit - MINING CURRENTLY IN PROGRESS; INFO.SRC : 1 PUB LIT; 2 UNPUB REPT

This mine is at about the same strike as the probable transform fault identified in the South Utah lightning analysis project, N 22º E. I anticipate a lightning analysis will allow us to map these transform faults, and to look for geothermal and possibly mineralization anomalies along these faults, similar to the South Utah and Humboldt County work. There is also a relationship with Thermal Hot Springs to the northeast, still in Escalante Valley, discovered by Fathers Escalante and Dominguez in 1776. These hot springs are on trend with Roosevelt Hot Springs, which is where the Blundell geothermal plant is now.

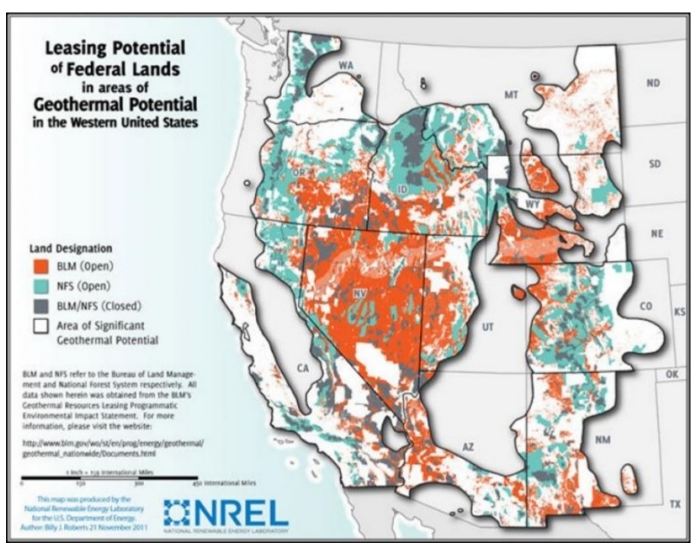
7. <u>The Blundell Geothermal Power Plant</u>

Blundell is a 34-megawatt geothermal facility near Milford, Utah. The plant was completed in 1984, becoming the first geothermal electric plant outside of California. In a geothermal electric generating plant, the source of energy is ground water thousands of feet below the surface, heated by nearby magma. The hydro thermal reservoir at Blundell lies 3,000 feet below the Earth's surface and contains water at more than 500°F and a pressure of 500 pounds per square inch. A well brings the high-pressure, heated water to the surface, where it "flashes" to steam, then is used to power a steam turbine and generator. Blundell is a fully renewable, zero-discharge facility. No fossil fuels are used to generate electricity; rather it is renewed and generated by heat in the ground. There is also no pollution of the atmosphere because of the absence of combustion by-products.

DOE is spending $160 million in research on the FORGE Project a few miles from Blundell (https://utahforge.com/). Utah FORGE is a dedicated underground field laboratory sponsored by DOE for developing, testing, and accelerating breakthroughs in EGS technologies to advance the uptake of geothermal resources around the world. It is located near the town of Milford in Beaver County, Utah, on the western flank of the Mineral Mountains. Investigations will commence in 2020 as the facility is being constructed and continue through 2024. Competitive funding rounds will be open for public application to attract outstanding programs of innovative research and development in geothermal engineering and science. Near term goals are aimed at perfecting drilling, stimulation, injection-production, and subsurface imaging technologies required to establish and sustain continuous fluid flow and energy transfer from an EGS reservoir. There is currently no plan to commercialize the results of this work. I believe the regional lightning analysis I am proposing can result in a way to commercialize the wells they drill at FORGE for pennies on the dollar.

8. <u>The Stillwater Geothermal Plant</u>

On the other side of the Great Basin is the Stillwater Geothermal Plant Site, which includes a 26 MW solar photovoltaic plant, a 2 MW solar thermal plant, and a 33 MW geothermal plant. This proposed regional lightning analysis across the Great Basin covers over 90% of potential geothermal sites in the Rockies.



<u>SUMMARY</u>

Lightning analysis provides a new geophysical data type. Lightning analysis projects can be located anyplace. Since the results are database driven, there is no need for new field work or new data collection. Resulting maps and cross-sections can be tied to historical geophysical data in the area. The lightning analysis fills gaps between control, and allows building a geotechnical framework. Results from field scale studies tie regional studies, and this White Paper is proposing viability of new regional analysis in the Gulf Coast, off of the East Coast, and in the Great Basin.

