South Texas
Lightning Calibration with Ewing Faults

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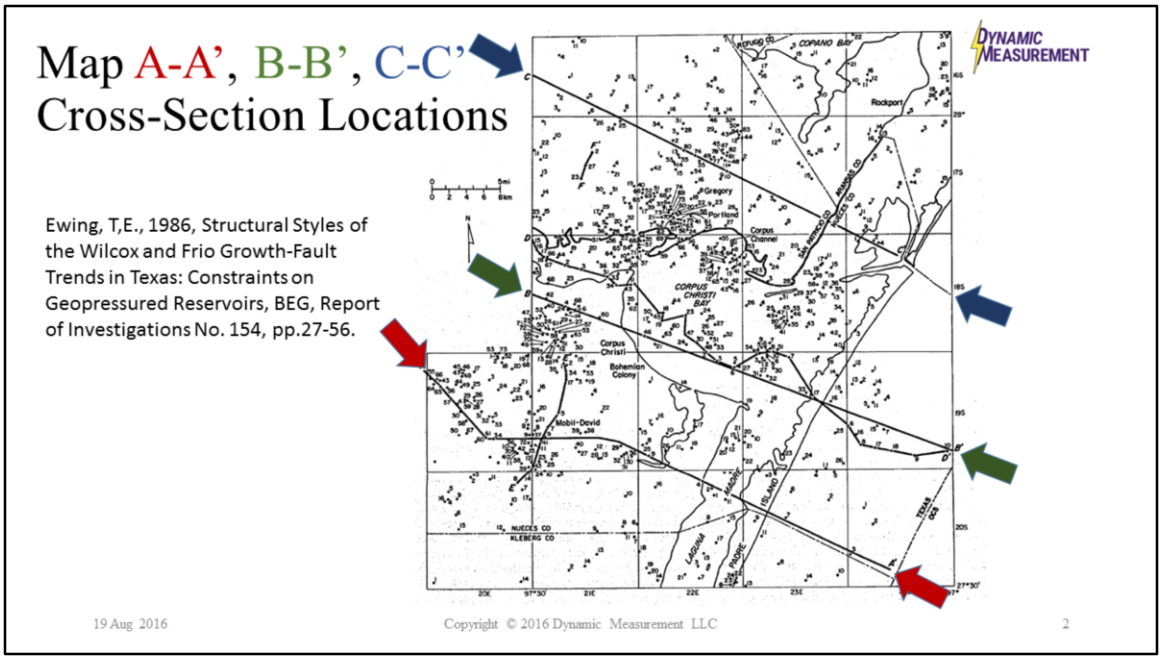
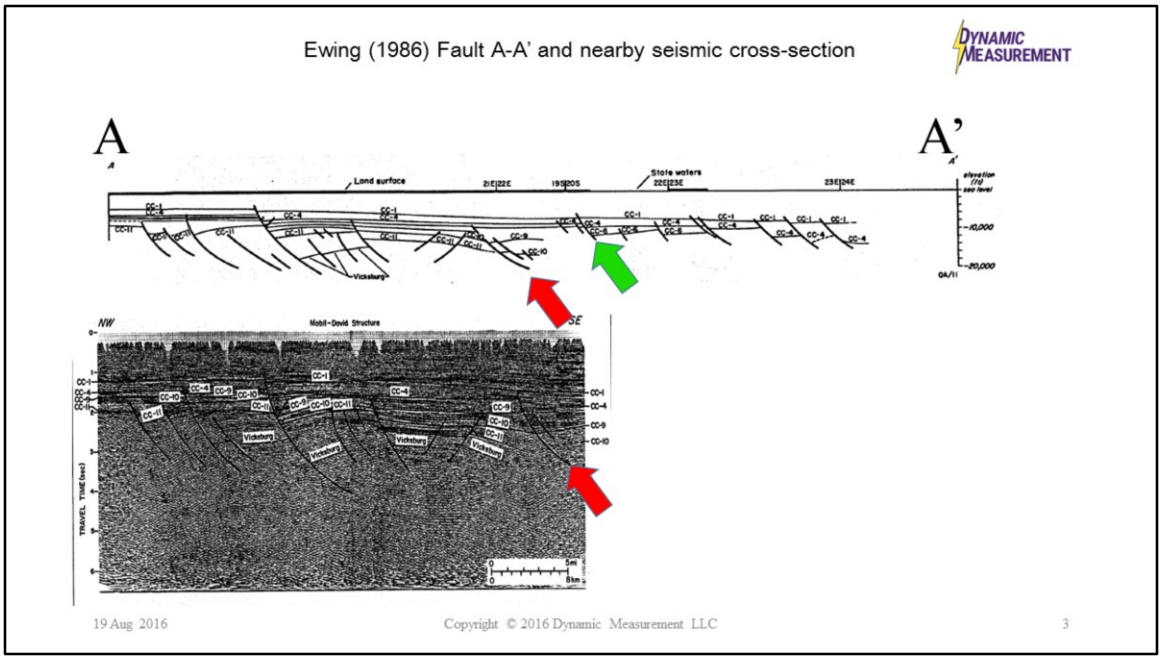
This set of slides is part of an on-going study in South Texas originally tied to the seismic data released by the University of Texas' Bureau of Economic Geology (UT BEG) over the Stratton Field.

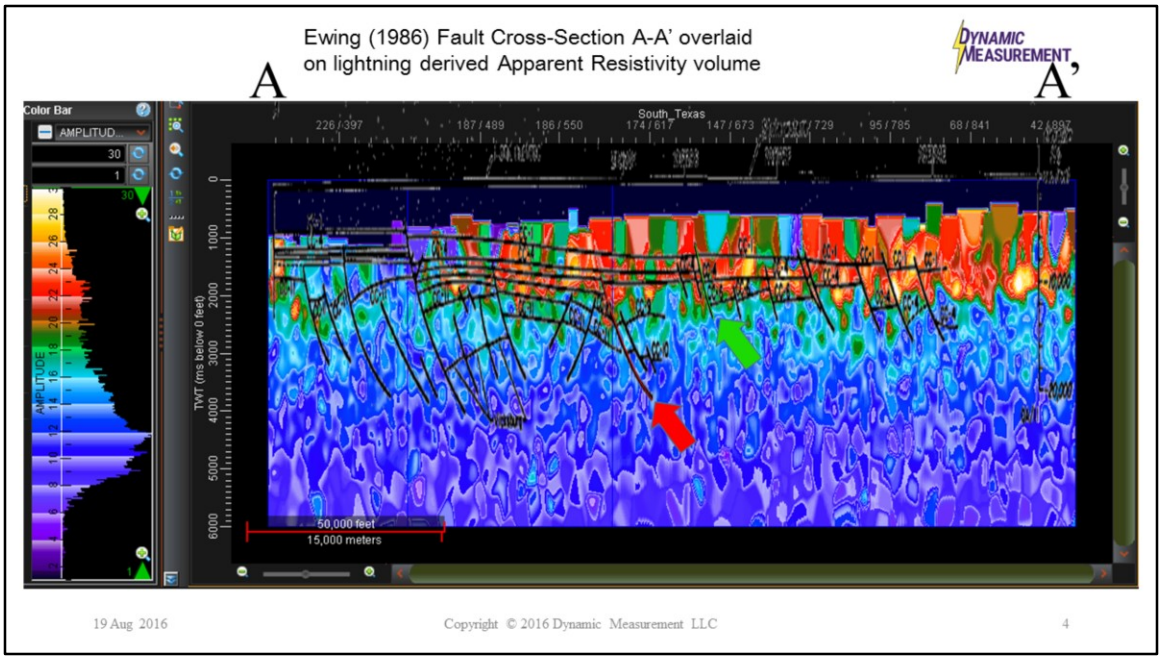


One of the key issues with introducing a new geophysical data type is convincing potential clients and other scientists the new type of geophysical data actually relates to geology. Dynamic Measurement has done over 20 projects, and so far every project has results which tie back to local geology and the control available for the specific area.

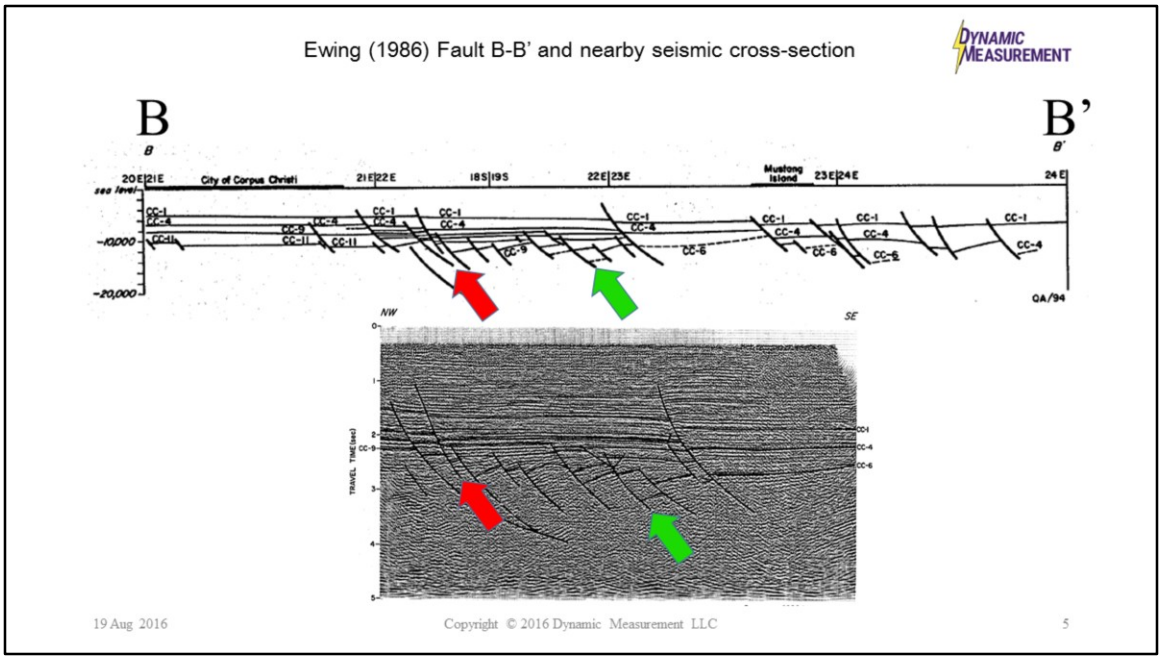
Dynamic has over 21,000 square miles of lightning data in South Texas, which we use for testing and product development. An article written by Tom Ewing in 1986 describes faults in the 2,100 square mile area we recently reprocessed. The above map shows the location of three cross-sections, A-A', B-B', and C-C', through the eastern portion of this area around Corpus Christi, Texas.



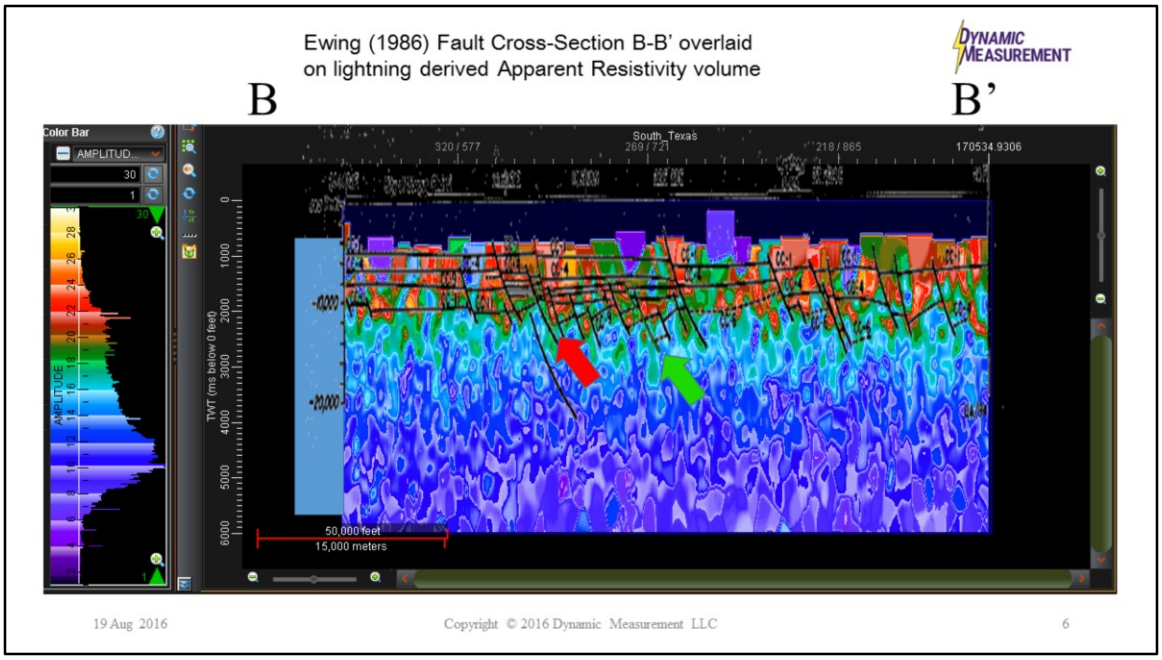
This is the southern most of these three cross-section, A-A'. The seismic used to define the northwestern portion of this cross section is also included. Two regional faults referred to later, named Red and Green, are also noted on this display.



Dynamic creates maps and volumes of rock properties and lightning attributes from the lightning databases. One of the key volumes is a resistivity volume. A description of creation of these volumes is at http://www.dynamicmeasurement.com/TAMU/150115_GSH_Potential_Fields_SIG.pdf. Overlaying the Ewing faults on the lighting derived resistivity cross-section A-A' shows an excellent correlation. Reds are higher resistivity, and blues are higher conductivity. The isolation of higher resistivity areas against downthrown sand wedges across this section is evident. The higher resistivity anomalies go much higher than the published Ewing faults. It appears this is because of vertical gas migration and geochemical alteration of shallower sediments. The red and the green fault locations are noted on the integrated cross-section.

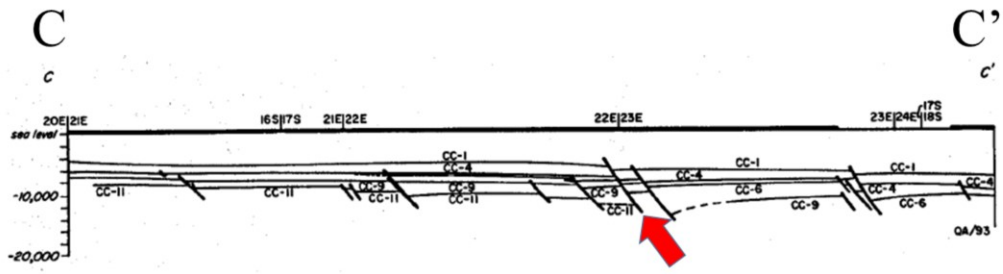


The central Ewing cross-section, B-B', shows the same red and green faults on both the fault cross-section and the shorter seismic cross-section. The CC-1 horizon is the Frio at the top of the cross-section, and the CC-11 horizon is at the base of the two different types of cross-sections shown here.



Overlaying the fault cross-section B-B' on the equivalent lightning derived resistivity cross-section shows the same kind of correlation at this scale. Note the key assumptions made in calculating resistivity volumes is that the earth's surface acts as an electromagnetic half-space, and the height of the cloud where the lightning originates is related to the depth in the earth telluric currents which control where the lightning strike occurs. The second key assumption is that the Peak Current recorded for each lightning strike is proportional to the height of the clouds and the origin of the stroke. The idea is a higher Peak Current is required to cross a larger distance through the very resistive atmospheric dielectric. A lightning bolt is like a wire carrying current, which creates a strong circular magnetic field, inducing and interacting with telluric currents at depth.

Ewing (1986) Fault Cross-Section C-C'



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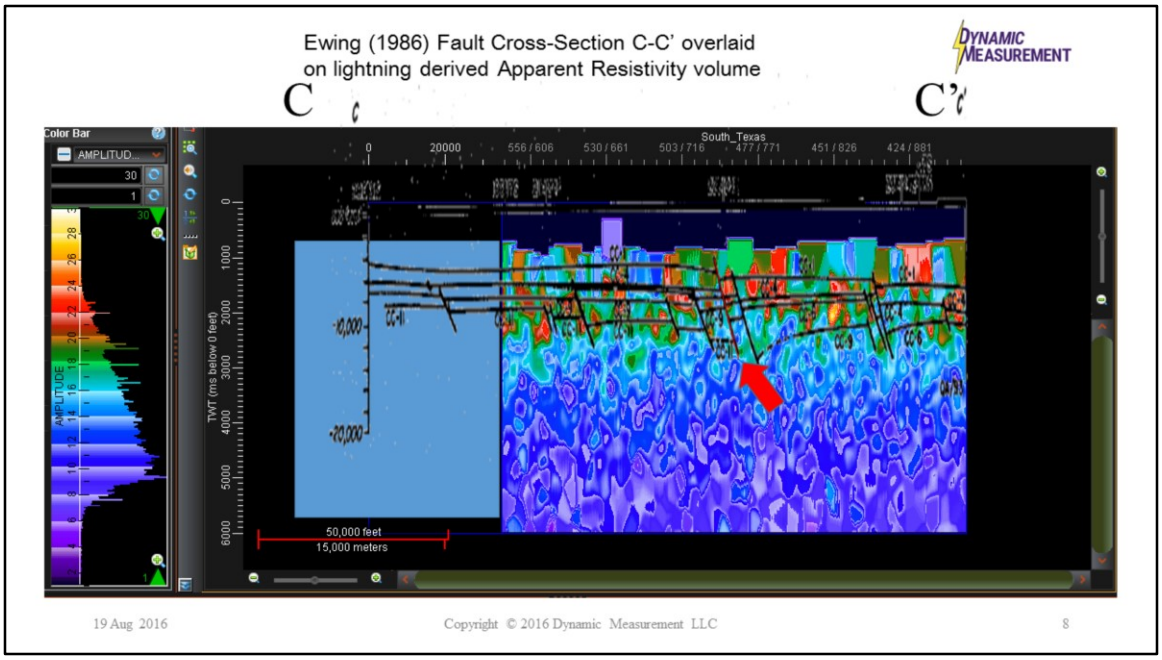
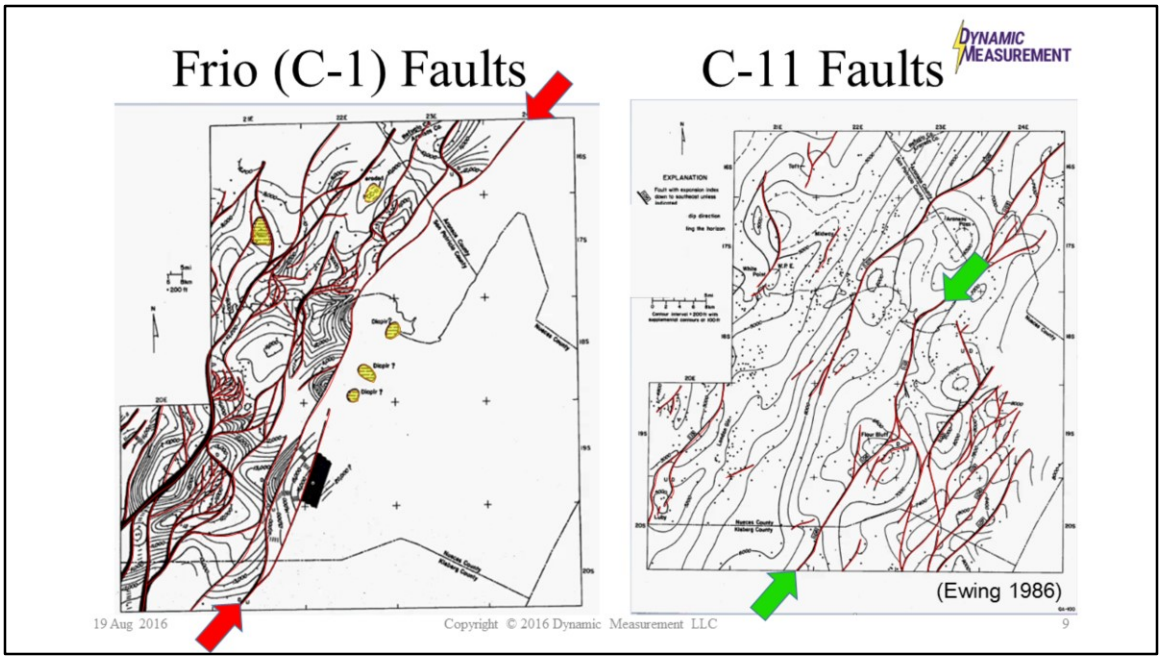
Ewing's fault section C-C' does not include seismic control. It also appears that the regional green fault does not go this far to the north. However, the red fault appears to continue this far to the north, as noted above.

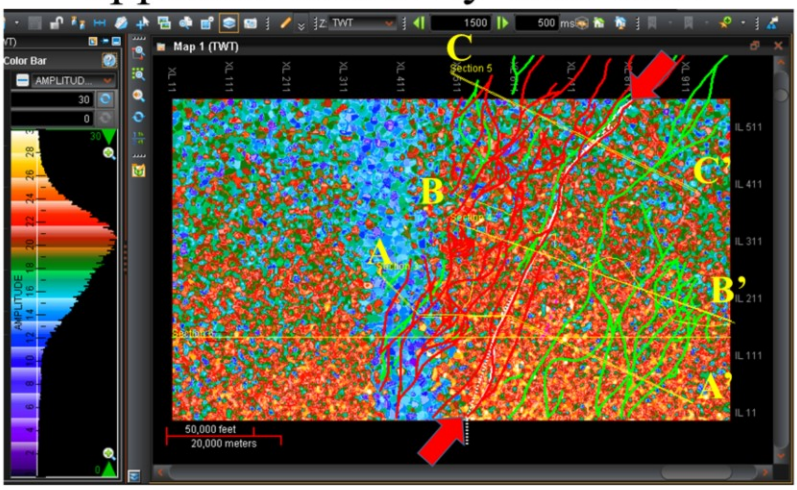


This is an overlay of the Ewing fault cross-section C-C' on the resistivity within the area reprocessed. Note the processed lightning data does not go as far as the northwest corner of this cross-section. It is a compelling result to see how well the resistivity anomalies are captured within fault blocks on this first pass correlation between the Ewing fault cross-section and the lightning derived resistivity sections.



The Ewing paper included maps of the C-1 (Frio) faults at about 1500 ms and the C-11 faults at about 3000 ms depth. A regional fault was identified from each map, as noted above, for a first pass correlation between the three published fault cross-sections in the analysis area.

Frio Faults (red) over 1500 ms apparent resistivity time-slice



(Fault Overlays Ewing 1986)

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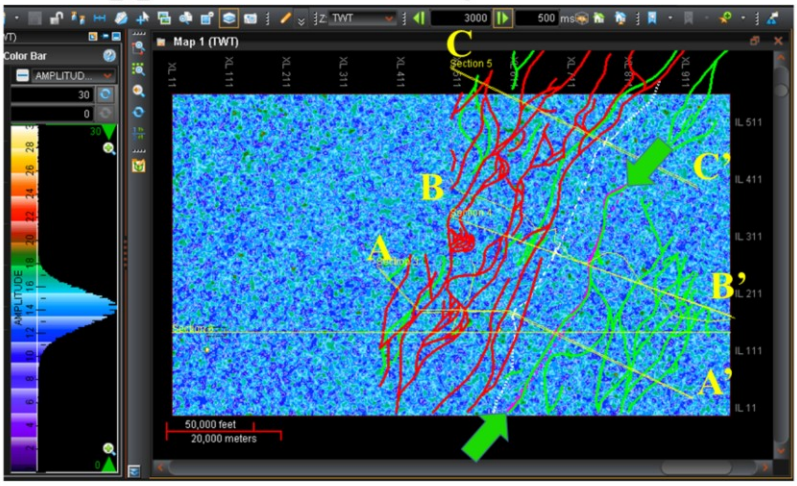
This is a 1500 ms time-slice through the reprocessed area with the two maps from the previous slide digitized and overlaid. The displays are done using Landmark Graphic's DecisionSpace™ (DSG) software. This time-slice is at about the level of the Frio or C-1 faults, and a fault was interpreted on this time-slice, which means it comes up on any cross-section across this location. The location of cross-sections A-A', B-B', and C-C' are shown on his time-slice display. The blue stripe on the time-slice is explained below.

C-11 Faults (green) over 3000 ms apparent resistivity time-slice



(Fault Overlays Ewing 1986)

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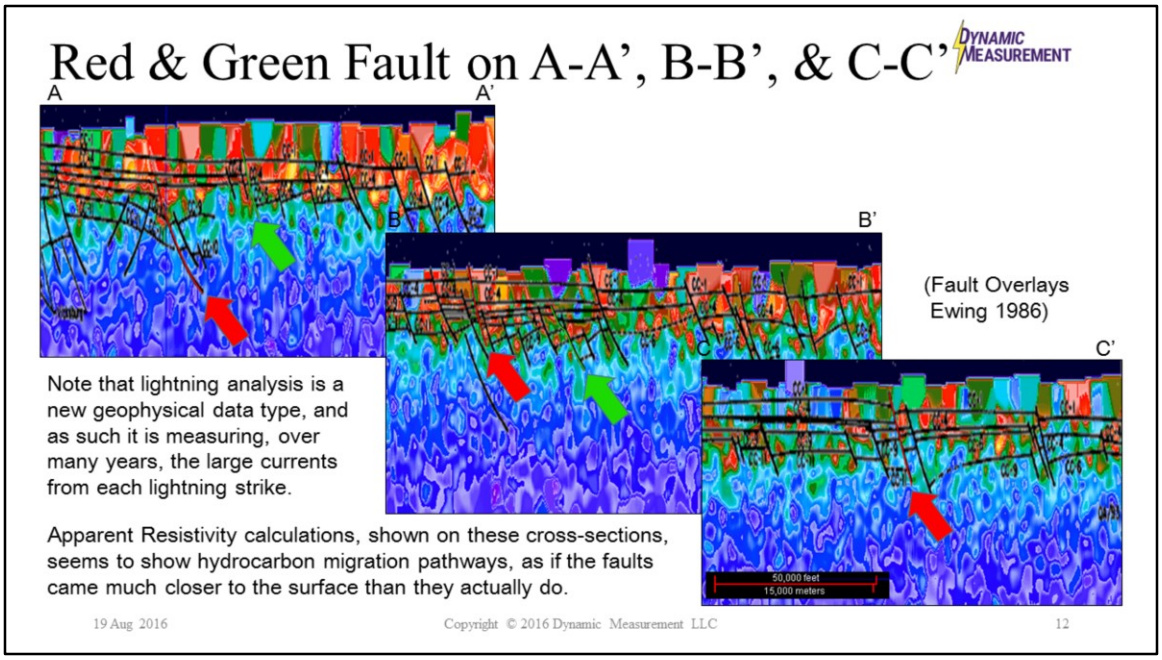
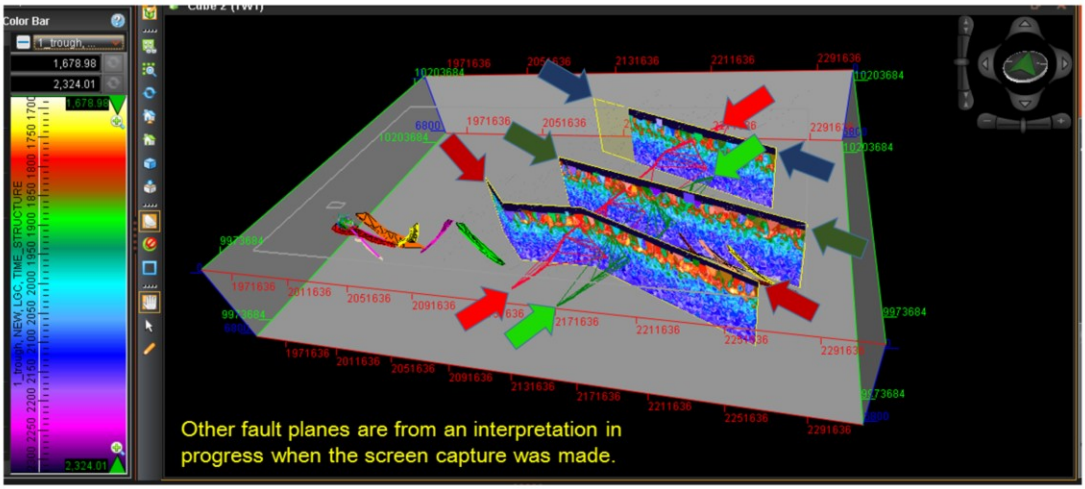
This is a time-slice at 3000 ms, which is close to the depth of the C-11 Fault Plane Map. Again, a fault was interpreted in DSG which is along one of the regional faults as shown above.



This composite zoom on cross-sections A-A', B-B', and C-C' shows a comparison of the red and green fault correlation across the analysis area. Zooming in on the cross-sections also shows how the resistivity anomalies appear to rise above the various fault blocks and why Dynamic came to the conclusion this new geophysical data type appears to show hydrocarbon migration pathways. Dynamic predicts that further calibration and validation work will confirm this. These volumes have tremendous potential to help with regional and play fairway exploration analysis and the identification of sweetspots.

A-A', B-B', C-C' Cube Display



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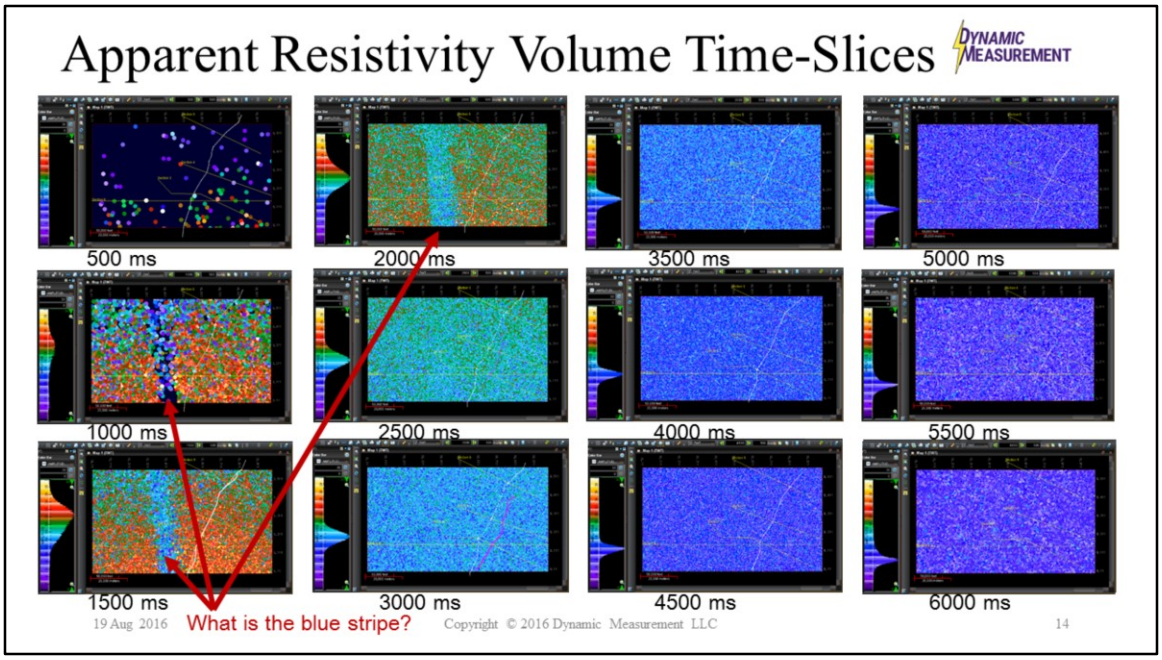
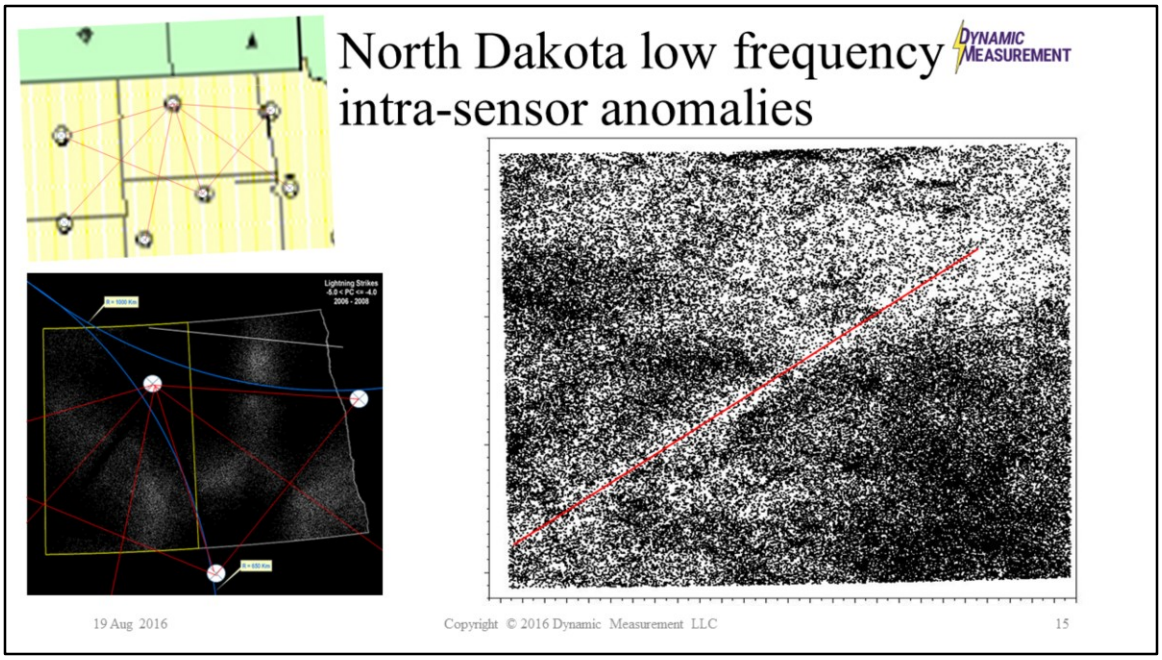
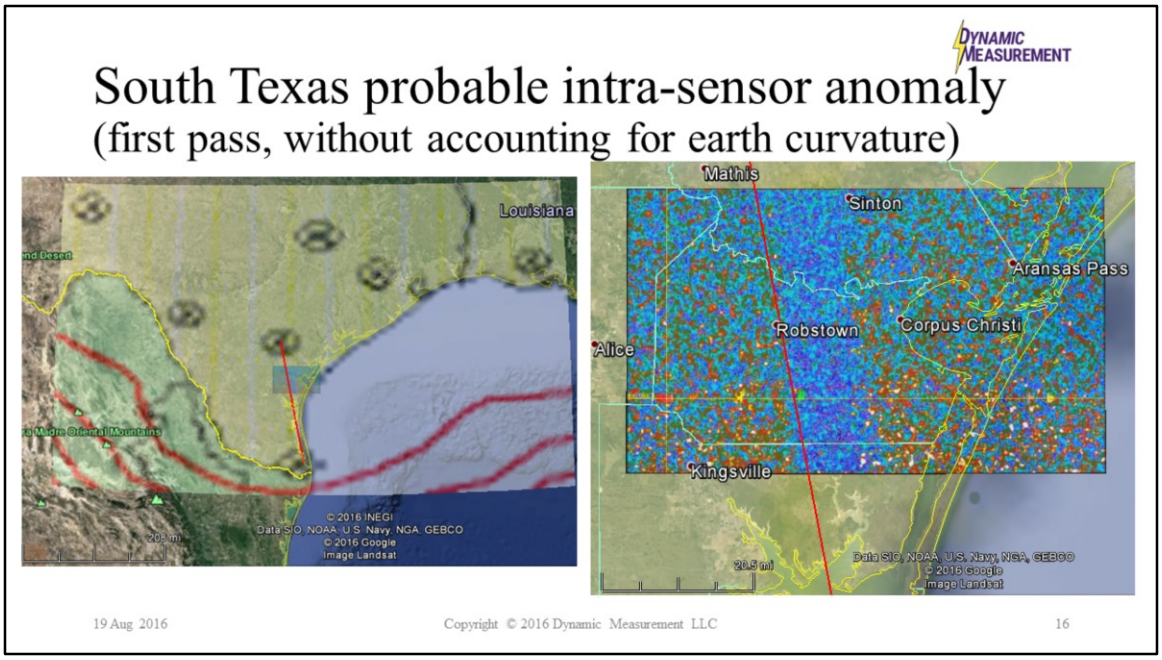
Because DecisionSpace™ keeps track of all of the data in the analysis area, it is easy to generate this type of display showing the spatial relationship between cross-sections A-A', B-B', and C-C' as well as the two initially picked fault planes through the area. There are additional preliminary fault interpretations to the west and between cross-sections A-A' and B-B' which were not turned off when this screen capture was made.



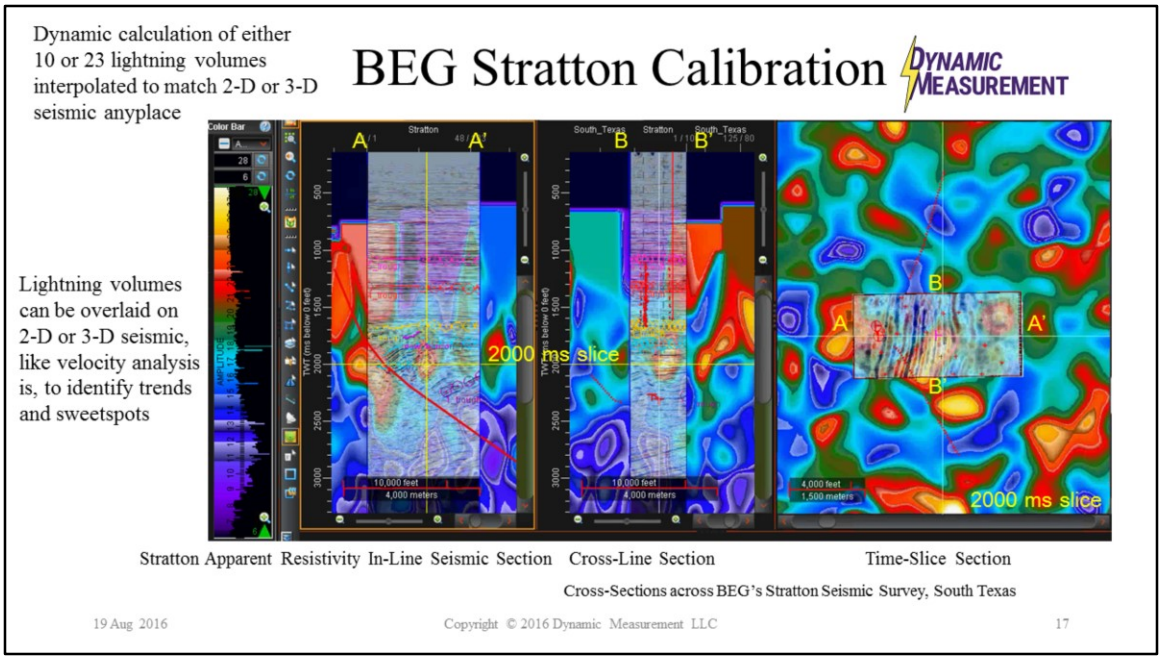
These 12 time-slice sections are through the reprocessed resistivity volume from 500 ms depth to 6000 ms depth. There is a linear anomaly on time-slices 1000 ms, 1500 ms, and 2000 ms for which a first past explanation is given on the next two slides. At this scale, the time-slices just look like a blob of color. However, when zoomed in on there are lineaments and trends which relate to geology and which become part of the interpretation process.



The first project Dynamic Measurement did, in the North Dakota, saw similar linear anomalies. These anomalies appear to be a feedback which removes a lot of the high frequency data directly between lightning recording stations, as is shown on the maps above. This type of bias is an area of active review and research at Dynamic Measurement.

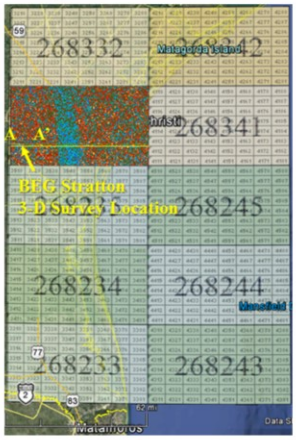


There are not lightning sensors in Mexico. So the southern tip of Texas does not have the redundancy of sensors surrounding the southern most sensor. It appears the line between the two southernmost sensors in Texas is close to the blue stripe seen on time-slices 1000 ms, 1500 ms, and 2000 ms. We expect this will be a better correlation when we take into account the curvature of the earth.

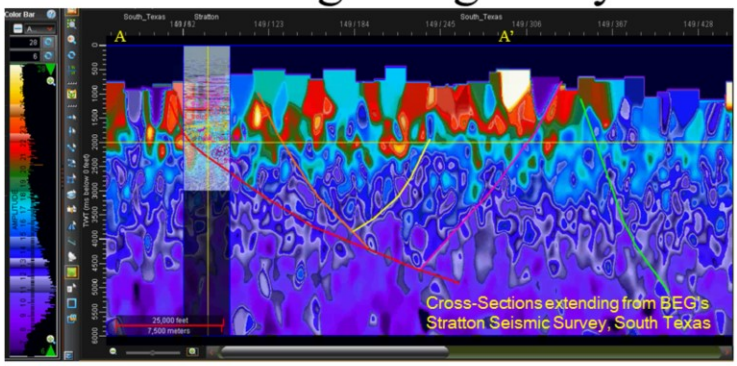


As mentioned at the beginning, this analysis area was selected because it covers BEG's Stratton seismic survey. These cross-sections show an in-line, cross-line, and at 2000 ms time-slice section through the Stratton seismic survey with a resistivity volume at the same line and trace spacing overlaid, and a regional resistivity volume in the background filling the gaps. Dynamic routinely creates a set of regional lightning analysis volumes, like this resistivity volume, covering client areas of interest. Then we interpolate additional volumes at the same line, trace, and sample spacing as an existing seismic survey within the analysis area. DSG, and most geophysical workstations, allow the resistivity volume to be overlaid on the seismic volume as if it were a velocity analysis volume. This type of visual integration has a positive impact on interpretation results.

Map showing area where initial multi-client lightning analyses available



Multi-Client Lightning Analysis



Select any 5 of 640 ~33 square mile IG4 cells in this area and receive Basic (5 maps and volumes), Standard (15), or Advanced (23) lightning analysis maps and volumes over the entire cell plus (1) set of lightning analysis maps and volumes matching a 3-D seismic survey geometry within each cell, for 10% of the standard Lightning Analysis price.

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The processed data covers one of 10 cells DML already has lightning data from, as shown on the map above. These 10 cells cover the same as the 640 smaller cells shown. Dynamic uses these cells and subsets of these cells to organize and process lightning data for customers. Since Dynamic has the data in this area, this area is being used to test the concept of multi-client lightning analysis projects. Clients can select any 5 of the 640 cells in this area, and provide line and trace and sample spacing for 1 geophysical survey within each IG4 cell (aeromagnetic data or seismic data), and Dynamic will create lightning derived rock property and lightning attribute volumes covering the IG4 cell and matching existing geophysical survey geometries. Because this data is available in databases worldwide, we can do this for any equivalent area anyplace on the planet and deliver maps and volumes within 2 months of a data order.

Thank You

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Thank you for your interest. Kathy's house in Baton Rouge has been flooded, and so feel free to contact Roice Nelson or Michael Reed if she is not available to answer your call. Michael Reed is Dynamic's Chief Operating Officer in Houston, Texas, and can be reached at 281.300.8049.