Seismically Incorrect: How Errors in Geophysical Data Affect Exploration Success

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Introduction

Exploration organizations are beginning to recognize seismic data as a corporate asset. This means it must be managed and protected in the same way as financial or human resources. An important step toward this goal is data validation, insuring that data which is used to support critical business decisions is correct. Seismic data as it is stored and used by exploration and production business units is prone to several common types of errors which can diminish its value, or even lead to financial losses. This paper presents case histories with examples of several of these errors which have been encountered during data management projects.

Is the data in the right place?

Seismic data can exist in an exploration organization in a multitude of datastores and formats, and accounts for a large percentage of the volume of data that these organizations are charged with managing. Yet in very few organizations can a working geophysicist call up a map view of the location of all of this data, regardless of the format, application, or storage media it may reside in. Tools are now available to create such a map view, and the exercise of using these tools can lead to important revelations about errors in geophysical data storage. In the case of a global organization, this view must be worldwide, and the best way to uniquely position a data point on the earth's surface is by latitude and longitude. Yet seismic data is stored in most interpretation applications in a variety of projected x and y coordinates, and these are also the coordinates stored in orignial format (SEGY) digital seismic files. Errors in interpreting, documenting, or changing the datum and projection used to convert between latitude/longitude and x and y coordinates can lead to erroneous placement of data. A map based Geographic Information System (GIS) can be used to discover these errors. First, applications are queried for a combination of spheroid and datum and projection system used in individual loaded projects. This combination is cataloged as a unique coordinate reference system (CRS). Then the x and y coordinates are transformed to latitude and longitude using this system and stored in a relational database. This database is used to project the location of the data onto a world map using a single standard coordinate reference system selected by the organization. This technique will visually show errors or inconsistencies in data location. Analysis of data loaded into application environments for several large multi-national oil and gas exploration companies has shown that in some areas or business units up to 30% of data may have locational errors. For example, one company's database when projected onto a world view showed a large 2d dataset on the Antarctic Peninsula (Figure 1). The x and y locations were correct within the local coordinate reference system, but the projection system had been identified as Universal Tranverse Mercator (UTM) zone 18 south by a data loader who noted that the survey was in South America. Actually the data was north of the equator in Venezuala and the projection should have been UTM zone 18 North, which would place the data correctly around Lake Maracaibo. Since all cultural and well data in the application project would have also been referenced by x and y, this error was not apparent in the local interpretation project and was not discovered until the transormation to latitude and longitude was performed.

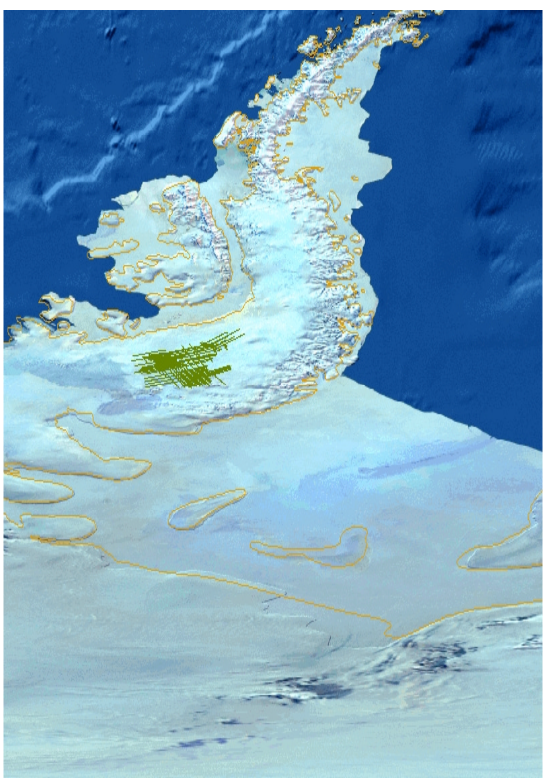

Figure 1: Seismic survey incorrectly positioned in Antarctica

Other errors can be generated by using different coordinate reference systems when loading the same x and y coordinates into different applications, which can lead to mis-positioning of up to 200 meters depending on the area of the globe involved (Figure 2). Again, these errors become visually apparent when data is projected onto a global view. An example is shown from a large national oil company where the exploration and development teams working on a project used different interpretation software to analyze the same 2d lines. The postioning error was not noted until software was used to collect the x and y coordinates and coordinate reference systems from both operational datastores and then project them together onto a single map view of the projects. Obviously, this could lead to a well being located in a different location from the seismic data used to evaluate the potential of the subsurface reservoir.

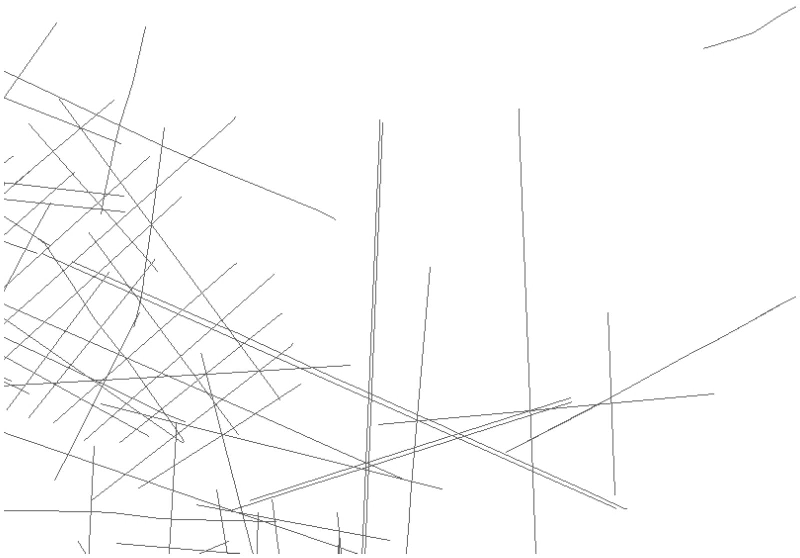

Figure 2: A documented 200 meter error in position of 2d seismic lines produced by using different datums in multiple applications (actual map references deleted to protect client confidentiality).

A more bizzare result occurs when additional data is added to an existing line navigation in interpretation software, and then original format (SEGY) digital data files are extracted for transfer to another application or corporate archiving. Some interpretation applications allow the creation of a set of shotpoint locations for a 2d seismic line, and then the loading of more traces than are defined in the navigation. Map displays in the interpretation package simply extrapolate the locations from the last defined point. However, if SEGY data is exported from this application, the additional traces are assigned x and y values of zero and zero in the trace headers. The GIS system will convert these values to latitude and longitude at the origin point of the projection system, which for UTM zones is the equator and the central meridian of the zone. Thus a SEGY file entered into this system will appear to detour to the equator for its last few traces (Figure 3). The example here was caused by the inclusion of a single trace beyond the defined set of shotpoints in the navigation. Other incorrect default values generated by software such as 9999 can cause latitude and longitude plots of surveys to crisscross the globe several times.

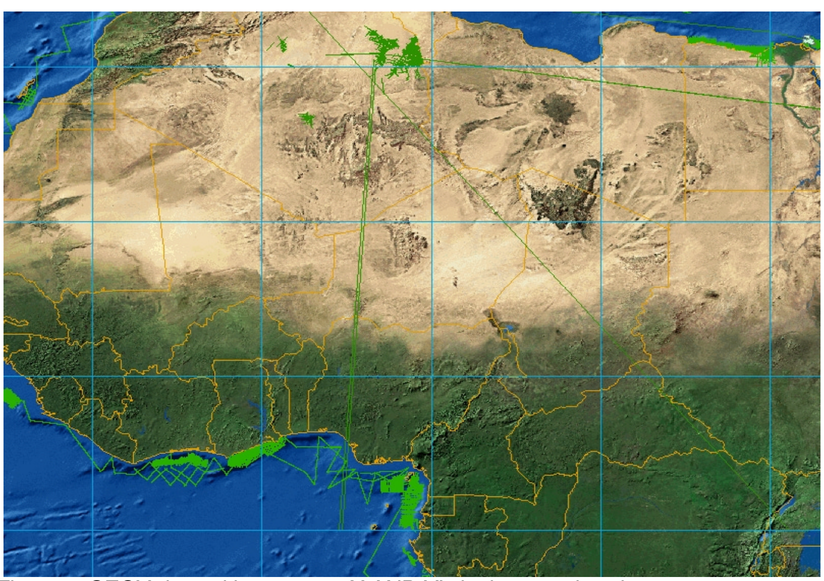

Figure 3: SEGY data with zero,zero X AND Y's in the trace headers

The internal x and y coordinate reference systems used by some interpretation applications fail to account for the fact that the latitude and longitude of a survey can change from positive to negative if it crosses the equator or prime meridian. This situation occurs frequently in exploration regions that straddle these lines, most importantly the North Sea, Indonesia, some South American and Equatorial African basins. Again, this problem will not cause a visual problem in the map displays referenced to x and y within the application. But if coordinate information is requested for output in latitude and longitude and there is no digital byte position assigned for the positve or negative sign, then the plotting of this output in a global GIS will cause it to “bounce” off either of the arbitrary quadrant boundaries (Figure 4). The example shown is from long regional lines off the west coast of Africa where the locations crossed both the equator and the prime meridian in the same survey.

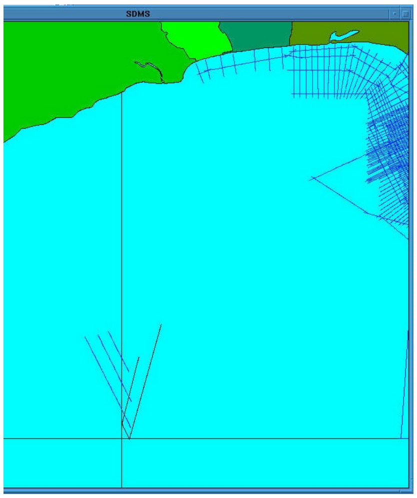

Figure 4: Shotpoint locations arbitrarily constrained to the northeast quadrant of the globe

While these examples should be enough to demonstrate the possible locational errors in applications and how they could severely impact the exploration success of an oil and gas organization, they are only a subset of the multitude of errors and inconsistencies that only come to light when application datastores are subjected to analysis and display in a robust, global map viewing tool. This step should be a required part of an overall data management and validation scheme for any seismic data used by explorationists.

Conclusion

Drilling decisions with large associated costs are routinely made based on the location of seismic data. Analysis of datasets from several large companies shows that while this locational information may appear to be correct in the native application to which it was loaded, it should be carefully compared with other datasets using a global map view before drilling decisions are made.

References

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