Description of Available 3D Seismic Interpretation for Texas Inner Shelf

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Abstract

This document describes the licensable digital interpretation derived from 3D seismic data held by *Seismic Exchange, Inc*. Three-dimensional seismic data were licensed by the Bureau of Economic Geology (Gulf Coast Carbon Center) from SEI for regional interpretation that took place over the last decade between Corpus Christi and western Louisiana. Data primarily cover the Texas State waters (submerged lands) under the jurisdiction of the Texas General Land Office, but small portions extend further offshore into Federal jurisdictions, as well as onshore for areas around the Texas-Louisiana border. Digital interpretation has been completed over thousands of square miles for 8 seismic amplitude time horizons tied to key Miocene-age biostratigraphic markers and for all major (and most minor) faults in the data volumes (hundreds of fault trace polygon maps per horizon).

1. Introduction

The digital data described in this summary document constitute a primary regional structural and stratigraphic framework resource for considering subsurface geologic resource development in the Texas offshore State waters, including the recent interest in permanent geologic storage of carbon dioxide (CO_2, Carbon capture and storage - CCS). The data coverage for the available licensable interpretation is shown in **Figure 1**. While the interpretation derived from these seismic data is tied directly to the SEI seismic data (time domain, TWTT; can be visually rendered together) and is suitable for regional mapping, play, and prospect development, as well as initial reservoir modeling for simulation, the interpretations are likely not suitable for detailed local project work that would be needed to license and permit a CCS project. Depth conversions could be further developed utilizing SEI velocity products.

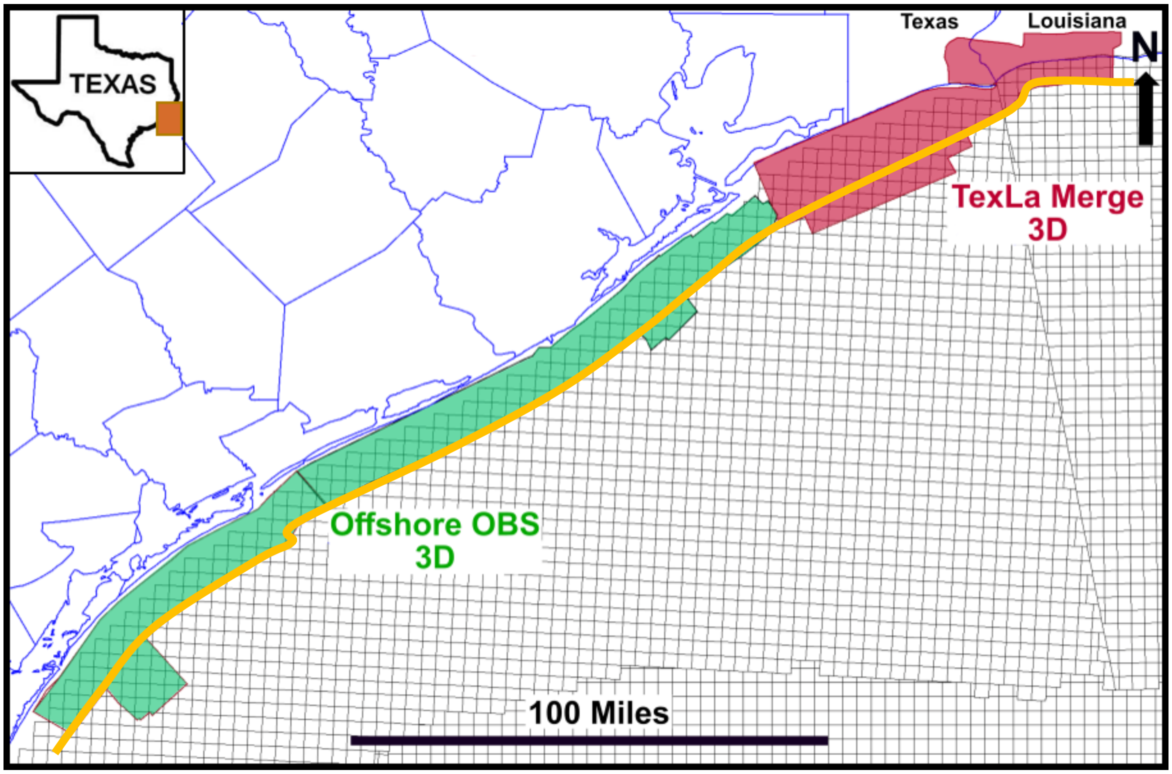

Figure 1. Location map of SEI's ***TXLA Merge*** (red) and ***Offshore OBS*** (green) 3D seismic data coverage area in southeastern Texas and southwestern Louisiana. The approximate offshore State-Federal boundary is indicated by the orange solid line. The Texas-Louisiana border is in the far upper right on the map. The footprint of these data cover 3,197 sq. mi.

2. Methods

2.1 Geologic Stratigraphy

The geology of this passive, progradational seaward-dipping dominantly clastic continental margin has been studied for decades and excellent summaries exist elsewhere (Galloway et al., 2000, Trevino and Meckel, 2017). Subsurface structural interpretations represented in the available licensable digital interpretation focus on the Miocene and upper Oligocene age stratigraphy that underlie thousands of square miles of integrated 3D seismic data covering predominantly the Texas state waters. Miocene age stratigraphy is considered to extend in depth over the most suitable range of prospective formations for CO_2 storage, being both below the depths for retaining CO_2 in supercritical dense phase, and above the natural geologic overpressure.

The geologic interpretations derived from the seismic dataset have utilized thousands of well logs with hundreds of bio-stratigraphic well top picks, and regional well log correlations, representing thousands of person-hours of work. Well-log and seismic correlations were used to construct a regional structural framework incorporating both seismic horizons and faults. An example of this is provided in DeAngelo et al. (2019). Key stratigraphic surfaces (sequence boundaries and maximum flooding surfaces (Mitchum et al., 1977) were identified using depth-converted seismic data and biostratigraphic picks in available wells. Biostratigraphic well tops are from an internal database at the Bureau of Economic Geology. Maximum flooding surfaces (MFS), characterized by both continuity and high amplitude, provide surfaces for mapping chronostratigraphic packages throughout the study area. In addition, sequence boundaries (SB) typically provide recognizable horizons that can be mapped throughout most of the seismic volume. An example of the biostratigraphic horizons tied to a type well log for a portion of the interpretation area is provided in **Figure 2**.

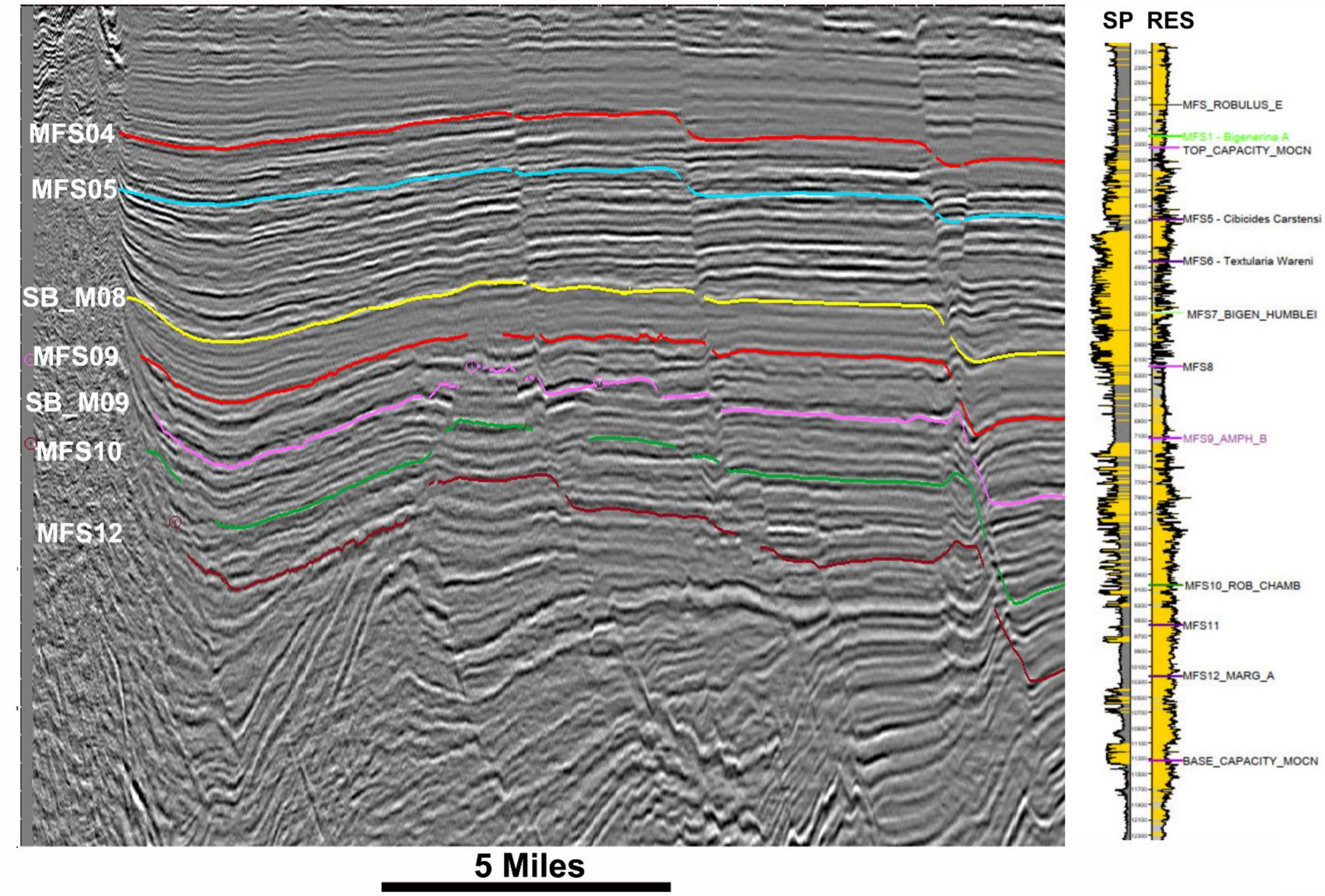

Figure 2. 3D-seismic vertical cross section (dip direction) with type log showing the seven key interpreted horizons. Seismic data owned or controlled by Seismic Exchange, Inc.; Interpretation done by the Bureau of Economic Geology.

2.2 Seismic Horizon Mapping

Shallow horizons in the TXLA Merge 3D-seismic volume were mapped initially, then deeper key horizons were systematically mapped. A total of eight horizons (**Table 1**) have been interpreted throughout the Offshore OBS and TXLA Merge 3D-seismic volumes (**Figure 2**). On a regional scale, the MFS05 horizon serves as a proxy for the shallowest depth for injecting CO_2 and retaining it is supercritical dense phase. Injecting CO_2 into permanent geologic storage sites typically take place at depths below 800 m (~2600 ft), where temperatures and ambient pressures usually convert CO_2 into a supercritical fluid state. The MFS05 horizon meets that criterion. The MFS12 horizon is another depth proxy, which demarcates the deepest (overpressure) depths suitable for supercritical injected CO_2 within the study area. These horizons set the vertical upper and lower boundaries of interest for CCS. It should be stated that this does not preclude CO_2 injection and storage above and below these top and bottom horizons, only that the intervening stratigraphy is considered optimal currently.

Initial "seed" horizons (**Figure 3**) were interpreted at regularly spaced intervals (typically 660 m), then further constrained by arbitrary lines that closely flanked the fault planes to ensure maximum surface correlations. The seed horizon was interpreted up to the fault plane, but did not cross it. This provided gaps in the interpreted seed horizons that were used to calculate fault heaves and subsequently used to create fault-polygon maps associated with each surface. When sufficient coverage was obtained, the seed horizons were interpolated using an 11 x 11 trace smoothing filter. The related fault-polygon files were then used to delete all interpolated picks within the lateral extent of the fault plane. **Figure 4** is an example resultant interpolated structure map with interpreted fault polygons for MFS09 throughout the 3D seismic data footprint.

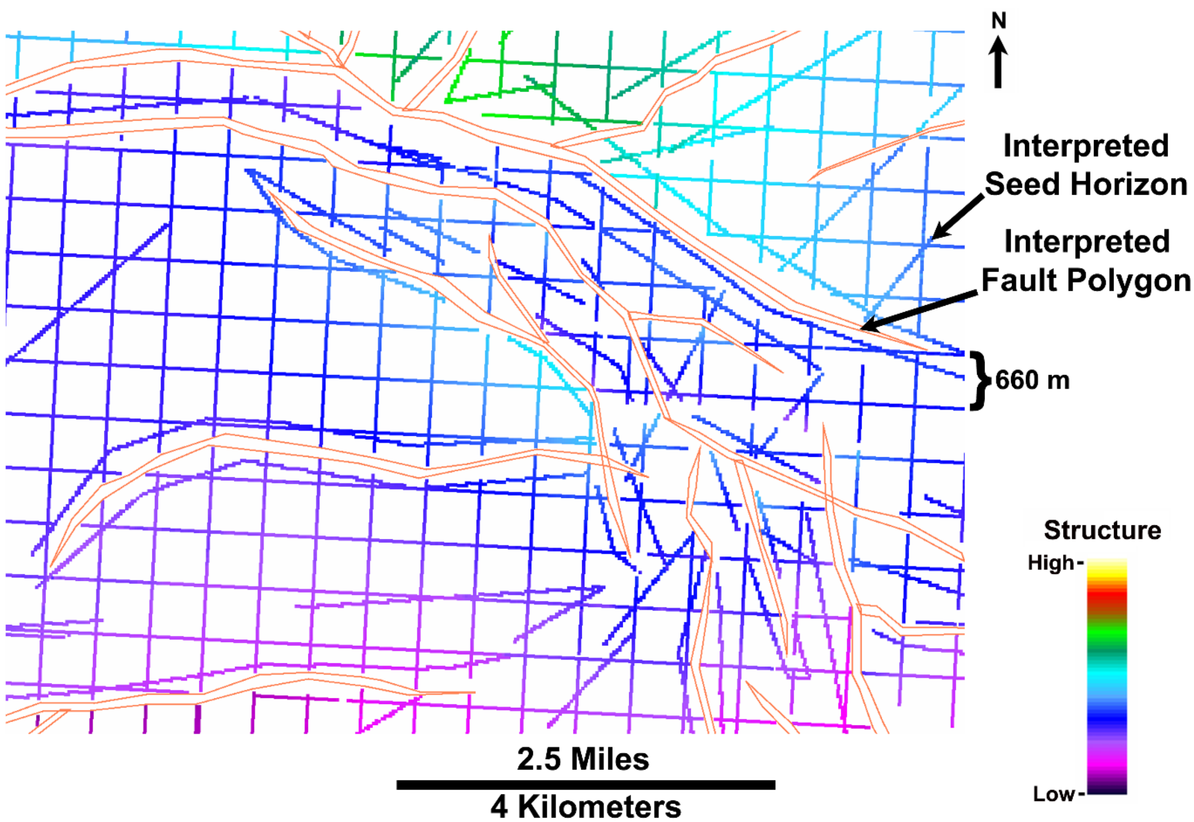

Figure 3. Example of seed interpretation of the MFS05 surface pick. Interpreted fault polygons are orange.

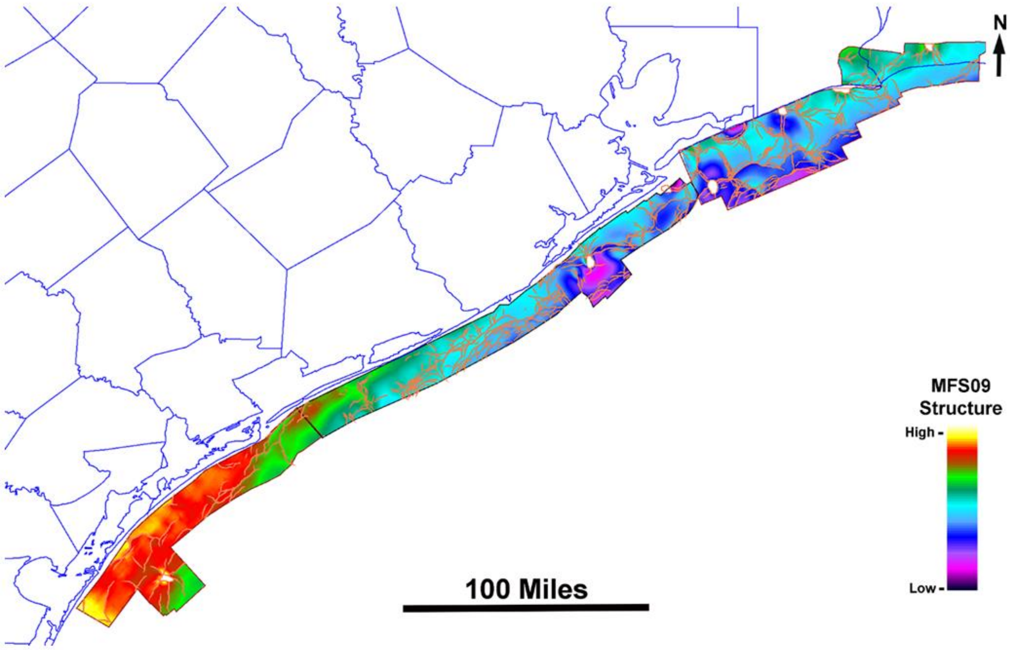

Figure 4. Interpolated structure map of the MFS09 surface pick. A total of 531 fault polygons penetrate the surface (orange lines).

2.2 Fault Mapping

Faults were mapped on the basis of seismic expression in vertical section and horizontal-slice views. Semblance-based coherency time slices, pioneered by Bahorich and Farmer (1995), were used in the initial structural interpretation phase, because this technique allows a mathematical assessment of the seismic data without being biased by previous interpretation. Semblance calculations compare waveform similarity between adjacent traces and can help image discontinuities such as faults and stratigraphic features. Traces within a specified time window

(40 ms) were cross-correlated with neighboring traces. The lowest correlation coefficient calculated will be assigned to the central sample. Semblance values range from +100 to -100. A value of +100 indicates a perfect match between adjacent traces. Semblance values near +100 indicate no lateral variations in stratigraphy or structure, designating zones of rock continuity. A value of -100 indicates a significant trace similarity if the phase of one of the waveforms is inverted. This condition could be an indicator of structural offset (faulting) within the reference window. In addition, low semblance values (negative) may indicate significant lateral changes in rock type, pore-fluid content, facies, or any geologic feature that can affect seismic reflection wave shapes (e.g., incised valleys, crevasse splays, fracturing, salt bodies, coal seams, etc.). Fault segments are more pronounced on semblance time slices relative to conventional amplitude time slices. Time slices of the semblance volume, starting at 0 ms, were generated at 4-ms intervals for the entire 3D-seismic volumes. Fault segments were interpreted across time slices at 100-ms intervals. The finer, detailed time slices (4 ms) were occasionally utilized to constrain fault-plane correlations in more complex areas.

Inline, crossline, and dip-direction vertical seismic sections were extracted from the 3D-seismic amplitude volume for further structural and stratigraphic analysis. Analysis of the 3D-seismic volume reveals numerous normal faults throughout the area.

First-order growth (i.e., syndepositional) faults are characterized by relative thickening of equivalent rock units on fault hanging-walls versus footwalls. The growth faults mapped typically having large offsets (>150 m). The faults extend from the near-seafloor to deeper portions of listric fault planes, which can flatten out into sub-horizontal decollements often seated on remnant salt or salt welds. Second-order faults can have growth or nongrowth geometries with less than 150 m of apparent offset. The number of fault polygons per horizon are shown in **Table 1** below. **Figure 5** Indicates which time seismic horizons and associated faults polygons are available in which portions of the SEI data.

Interpreted Seismic Horizon	Number of faults in shapefile
MFS_05	228
MFS_07	182
MFS_08	368
MFS_09	531
MFS_10	657
MFS_12	354
SB_08	208
SB_09	197

Table 1. Number of faults penetrating each of the interpreted seismic horizons that are in the individual shapefiles. Total number of fault traces for all horizons is 2,725

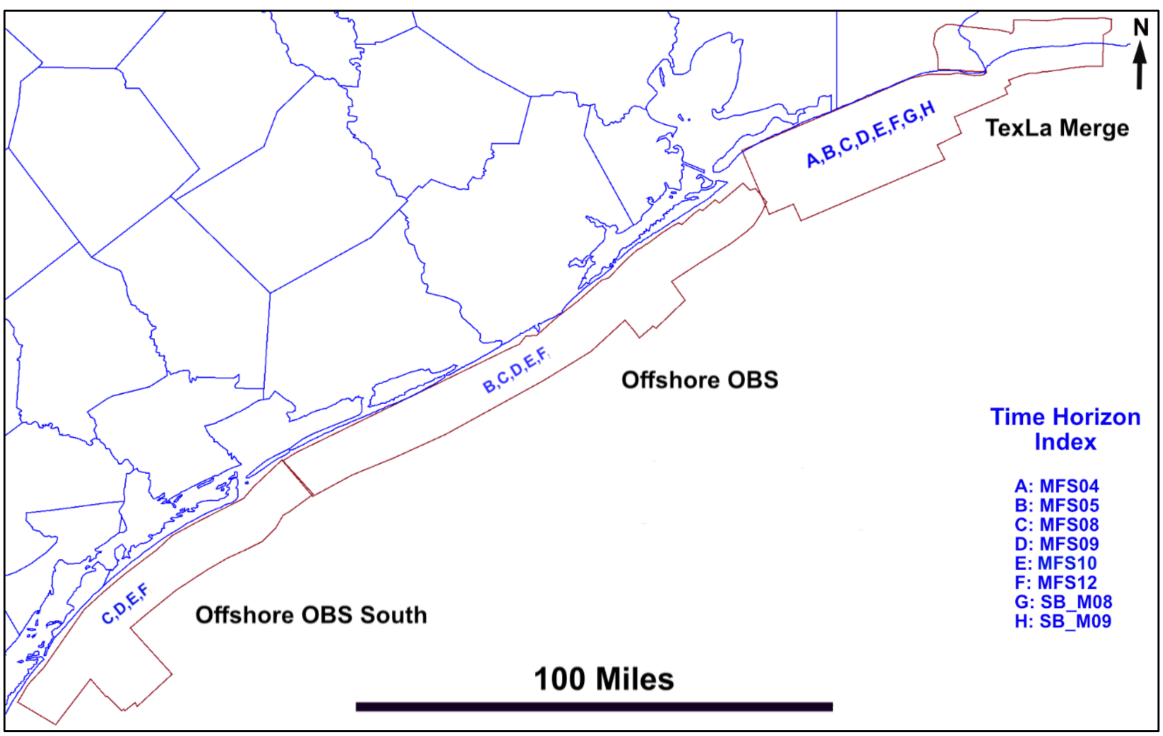

Figure 5. Map indicating which time structure horizons and fault polygons are available for each of the individual 3D seismic data volumes.

3. Summary

Digital data interpretations derived from 3D seismic data volumes are available for licensing within the *TXLA Merge* and *Offshore OBS 3D* seismic datasets. The interpretation products include:

- 8 seismic horizons (TWTT; Table 1) mapped continuously over approximately 3,200 square miles from Corpus Christi Bay, TX to western Louisiana.
- Hundreds fault polygon traces (shapefiles; lines representing the intersection of fault surface and interpreted seismic horizon surface) for each mapped seismic horizon (Table 1).

Acknowledgments

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APPENDIX

The following is a listing of the data in the June 2023 version of the data package:

Units are meters. Cartographic system is UTM-15US.

MFS = Maximum Flooding Surface, SB = Sequence Boundary

TWT = Two-way travel time (time domain data)

HORIZONS (TWT) – all seismic data volumes:

Data are formatted as .DAT files as inline/crossline/X/Y/Z.

Data example:

5033.0000000 6521.0000000 338012.676 3256423.785 743.9077759

1. SEI_UTA_MFS04_TWT_f
2. SEI_UTA_MFS05_TWT_f
3. SEI_UTA_MFS08_TWT_f
4. SEI_UTA_MFS09_TWT_f
5. SEI_UTA_MFS10_TWT_f
6. SEI_UTA_MFS12_TWT_f
7. SEI_UTA_SB_M08_TWT_f
8. SEI_UTA_SB_M09_TWT_f

HORIZONS (TWT) – individual seismic volumes

Data are formatted as .DAT files as inline/crossline/X/Y/Z.

Data example:

5033.0000000 6521.0000000 338012.676 3256423.785 743.9077759

1. SEI_UTA_MFS04_TWT
2. SEI_UTA_MFS05_TWT
3. SEI_UTA_MFS08_TWT
4. SEI_UTA_MFS09_TWT
5. SEI_UTA_MFS10_TWT
6. SEI_UTA_MFS12_TWT
7. SEI_UTA_SB_M08_TWT
8. SEI_UTA_SB_M09_TWT

FAULT POLYGON MAPS (shapefiles with supporting files; also XY .csv files)

1. SEI_UTA_MFS-04.shp
2. SEI_UTA_MFS-05.shp
3. SEI_UTA_MFS-07.shp
4. SEI_UTA_MFS-08.shp
5. SEI_UTA_MFS-09.shp
6. SEI_UTA_MFS-10.shp
7. SEI_UTA_MFS-12.shp
8. SEI_UTA_SB_M08.shp
9. SEI_UTA_SB_M09.shp