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Development of Expertise in Seismic Interpretation In Petroleum and Scientific Exploration

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About this Project

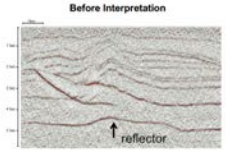
Seismic reflection data interpretation has been a key tool in geological subsurface exploration for the last several decades. Despite the central significance of this exploration tool in the petroleum and minerals industries and in scientific investigations of tectonics and sedimentary systems, the characteristics of expert skill in this area remain unevenly documented and the educational pathway to expertise is poorly understood. This project proposes to optimize university graduate-level education in seismic interpretation through analysis of expert behavior development in formal classroom and live research settings. The key objectives of this project are to: 1) Replicate threshold and transformative experiences internal and external to graduate curricula based on a unifying framework of learning sciences theory and prior research by this team; 2) Pioneer more effective and efficient paths to create competence, expert behaviors, and identity in this skill area.

What is Reflection Seismology?

Artificial or natural energy waves move through the ground. Their interaction with the subsurface is used to collect an array of quantitative data

Used to locate resources, as well as gain a better understanding of the subsurface

(Yilmaz, 2001)



What is Seismic Interpretation?

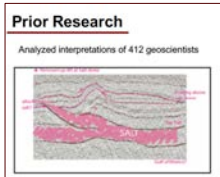
They are predications based on observations of reflection seismology data

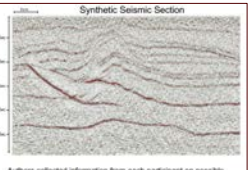
This may include lithology, geological structures, sedimentological relationships, and pore fluid type

(Yilmaz, 2001)

Prior Research

Analyzed interpretations of 412 geoscientists





Factors influencing interpretation included:
- tectonic expertise
- breadth of expertise,
- the length of experience,

Bond, Gibbs, Shipton, and Jones (2007)

Problem Statement- Methodology

The focus of this study was to characterize individual seismic interpretation workflows employed among graduate geoscientists among diverse educational and experiential backgrounds

- Authentic data involving two seismic lines
- Interpretations completed individually
- Incorporation of eye tracking data collection

Methods of this study were designed to address the following questions:

(1) How geoscientists work through and interact with seismic data sets
(2) Techniques, strategies, and practices individual geoscientists employ during seismic interpretation

Participants in this study

- Pre-professional graduate students in G&G department
- Experience with seismic interpretation
- No significant vision hindrances, including far-sightedness

Who are they?

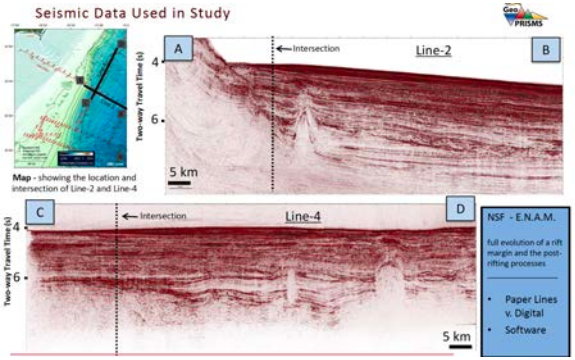
Eye Tracking Study:

Geologists: P1 Ph.D., P2 M.S., P5 M.S., P6 M.S.
Geophysicists: P3 M.S., P4 Ph.D.

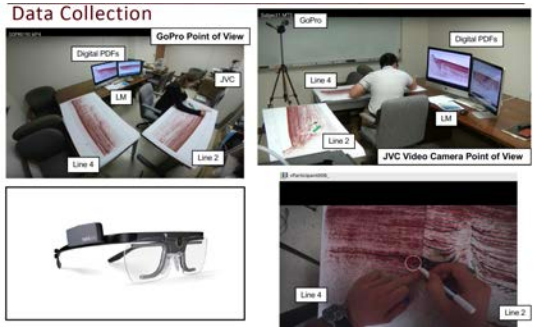
Jackson 2017 Study:

Geologists: P5 M.S., P6 M.S., P7 Ph.D., P8 M.S., P9 M.S., P10 M.S.
Geophysicists: P1 M.S., P2 M.S., P3 M.S., P4 M.S.

Seismic Data Used in Study



Data Collection

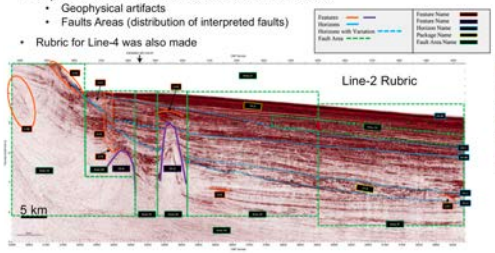


Participants were provided fresh printed 2D seismic lines and the same lines on monitors arranged with the same geometry. They were provided up to 60 minutes to interpret the geologic structures revealed in the images and were recorded by video cameras while working. Six participants also wore a TobiPro Glasses II eye tracking unit to record gaze and attention. All participants were interviewed about their workflow and interpretations immediately afterwards.

Crowdsourced Map of Attention and Significant Areas

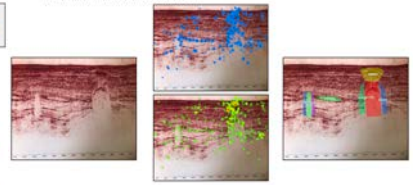
We used participants' markings, gestures, physical dwell locations and gaze data to identify areas of attention (AOI) to focus further analysis with eye track data. This graphical rubric:

- Captures and names co-occurrences features and horizons
  - Geophysical artifacts
  - Faults Areas (distribution of interpreted faults)
- Rubric for Line-4 was also made



Data Analysis

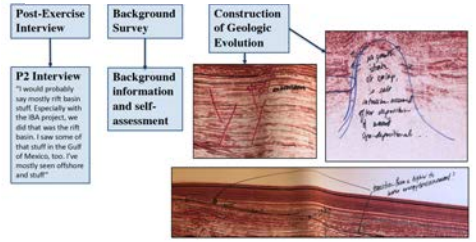
- Eye tracking video analysis with and without Tobii software
- Pre-exercise background survey
- Post-exercise interview transcripts

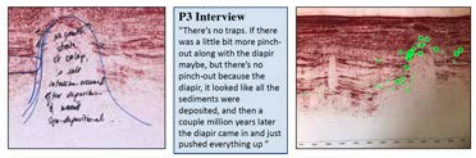


Key Findings

- We document that behaviors consistent with high quality interpretations are associated with participants who construct a narrative of the geologic evolution of packages of features and structures. This process is shown by:
  - The interpreter contextualizing events through geologic time as (shown in the figures on the right).
  - Identifying structural setting and constructing sequence stratigraphic framework
  - Assessing the dataset on regional scale by focusing on the intersection of lines, thinking in 3D, and correlating packages of strata (shown below)
- We have documented behaviors that are consistent with higher levels of expertise. These include:
  - Holistic thinking, broad use of resources and time
  - Application of specific appropriate and successful visualization and process strategies
  - Making more written notes to support their interpretation and decision-making processes.

Expert behaviors

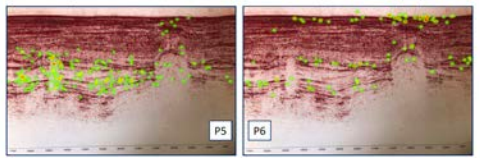




Workflow Characterization

P5: Fixations cluster near diapir and lower amplitude zones. Little evidence of tracking horizons

P6: Fixations cluster in strata overlying diapir, patterns of horizon tracking, little focus on larger features (diapirs)



relative novice subject *relative expert subject*

Conclusions

- Coding data and workflows using a "crowd sourcing" technique developed in this study allows the use of participant data to indicate prominent and subtle yet potentially important features.
- Eye tracking allows for detailed modeling of participant attention and gaze paths throughout seismic interpretation.
- We can capture the full breadth of thought processes associated with completing effective and higher quality interpretations with our mixed-methods suite of data collection and analysis approaches.

Future Research Directions

- Analyze current data set for pupillometry signals
- Once pandemic-related delays and restrictions with in-person instruction and industry office occupancy ease, expand expand the participant pool to include higher levels of experience and expertise.
- Adapt methodology to conduct similarly structured study for software 3D seismic interpretation.
- Isolate tasks and interpretation actions to better document successful problems solving and embed in curricula for testing
- Work with industry partners to build more effective training strategies and workflows for students and current practitioners