AN ASSESSMENT OF PROBLEM SOLVING AND WORKFLOW STRATEGIES EMPLOYED BY GEOSCIENTISTS IN SEISMIC INTERPRETATION

A Thesis

by

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ABSTRACT

This study was designed to advance understanding of the interactions, strategies, and techniques graduate geoscientists employ in the process of 2D seismic interpretation. This qualitative study was designed to record pre-professional, experienced participants in order to develop insights into emerging expert behavior in this task. Videos of participants were coded for co-occurrences of features that were identified by participants, the markings participants made, the order of common features among participants, physical interaction with the images, and time use between the different exercises resources provided to participants during interpretation. Information was also collected with a background survey and through interviews in order to gain insight into participant's experience with seismic interpretation. This information was used to place participants into different levels of experience and showed that participants have a limited ability to self-assess their experience. Trends in the data were searched among the different experience groups. Our results show that the lowest expertise group uses a less holistic approach with the available resources and is more hesitant to use written observations during their exercise. The high and medium-experience groups also employed techniques that the low experience group did not to help them asses the seismic data set. Additionally, this study was able to show and categorize the common elements among participants' interpretations, and offer a method to capture workflow strategies. Workflows were found to be variable and methods should be created to capture thought processes during interpretation. The insights from this study will help guide future research to probe the practice of seismic interpretation, with the hope to improve the efficiency of training geoscientists in seismic interpretation.

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TABLE OF CONTENTS

LIST OF FIGURES

LIST OF TABLES

1. INTRODUCTION

Geoscientists often investigate portions of the earth that lie underground to gain a better understanding of the geology or to locate resources such as water, hydrocarbons, and ores. One of the tools geoscientists commonly use to accomplish this is called reflection seismology, in which reflected seismic waves interact with the subsurface to collect an array of quantitative data. This data can be used to predict lithology, geological structures, sedimentological relationships, and other acoustical properties (Yilmaz, 2001). These predictions serve as interpretations of the data and must be supported through the use of observations, a process called seismic interpretation (Avseth et al., 2010; Herron, 2011). Seismic interpretation requires an individual to have an understanding of the geological and geophysical concepts of the science (Alcalde et al., 2017) . The outcomes of the interpretation process are often variable due to the differences in writing and annotations used to describe and indicate the significant features and boundaries contained within the data.

The skills needed to interpret seismic reflection data can be taught through formal training and coursework. The Society of Exploration Geophysicists, a professional organization, stresses the priority for geophysical education and need for geoscientists to amass expert ability (Hilterman, 2001). Expert ability in seismic interpretation, as with other domains, includes the knowledge, techniques, and strategies employed by those with a higher level of competence than their more novice counterparts (Ericsson, 2006b). Such high-level ability requires extensive experience in that domain (Ericsson, 2006a).

In order to delineate the role that an individual's experience plays in seismic interpretation, Bond et al. (2007) conducted a study that analyzed the completed interpretations of 412 geoscientists with varying backgrounds and experience. After each participant finished the interpretation exercise, the authors collected information from each participant on possible factors that they believed to influence interpretation (Bond et al., 2007). This included "the participant's educational level, length of experience, background expertise, and perception of his or her ability in structural geology and seismic interpretation" (Bond et al., 2007). Bond et al. (2007) compared this information with the finished seismic interpretations, and concluded that experience, along with expertise and interpretation technique ultimately influence and drive an individual's interpretation.

While Bond et al. (2007) analyzed a large amount of completed seismic interpretations looking for influential factors as well as expert practices, there has been limited research that observes participants engaged in a seismic interpretation exercise. Bond et al. (2011) observed undergraduates, graduate students, and professional geologists as they interpreted seismic, and found that the different cohorts approached interpretation differently (Bond et al., 2011). The less experienced groups had "a limited sense of how to construct arguments and thereby advocate their science", and showed more hesitation to begin the exercise and lacked confidence during interpretation (Bond et al., 2011, p. 20).

Similar to the work completed by Bond et al. (2011), the focus of this research is to investigate geoscientists engaged in a seismic interpretation exercise. However, in contrast to prior work this study will capture individual participants engaged in interpretation, as analysis by Riggs et al. (2009) found that there are different geoscience problem-solving methods and behaviors used in individual and group settings. As such, the methods of this study were designed to initially answer the following questions: (1) How do individual geoscientists work through and interact with a seismic data set? (2) What techniques, practices, and strategies do individual geoscientists employ during seismic interpretation? (3) What variations do participants display in their actions, workflows, and interpretations throughout the seismic interpretation process? Beyond answering the research questions, the methods described in this study will provide a framework to help guide future research also aimed at the seismic interpretation process. As this line of research continues to evolve, the goal, as with other geoscience education research, is for geoscience educators to consider their approach to improve the efficiency and impact of instruction.

2. METHODS

2.1 Theoretical Framework

A theoretical framework was utilized by the researcher to give structure throughout this study, by providing a foundation on which knowledge can be constructed (Grant & Osanloo, 2014). The selected theoretical framework helped the researcher to form the initial research questions, choose appropriate data collection methods, and allowed the researcher to justify the study (Grant & Osanloo, 2014).

The researcher ultimately chose to frame this study as an ethnography, as this qualitative approach attempts to understand and describe a culture or a group (Bodner & Orgill, 2007). In regards to an ethnographic study, McCurdy et al. (2004, p. 5) defines a culture as the “knowledge that is learned and shared and that people use to generate behavior and interpret experience”. This definition is intentionally left vague so it can encompass a variety of different research settings (Bhattacharrya, 2007). The definition also has implications in the research itself, as knowledge cannot directly be studied as it exists in the minds of people (McCurdy et al., 2004). Rather, the behavior and objects that an individual displays and produces are studied primarily through observation (Brewer, 2000). Detailed analysis of those observations allows the researcher to create meaning within that culture in order to understand the shared and learned knowledge between its members.

Whitehead (2005) further expands on the definition of culture to include those that share in a phenomenon of practice. In this study, the shared practice is seismic interpretation and the culture is individuals with a working knowledge of the science. This is a relatively limited group of individuals in the geosciences, who share a common vocabulary (language), strategies, and practices. Such geoscientists have obtained a unique understanding of the science, in that an outsider [someone without a background in geoscience] would struggle to understand the most basic aspects of seismic interpretation. Due to the underlying geological and geophysical concepts, it is necessary that the researcher in this study took an emic perspective, which means that the researcher identified within that culture (Morris et al., 1999). This perspective requires that the researcher of this study also has an understanding of the fundamentals of seismic interpretation.

A literature review and the ethnographic framework were utilized by the researcher in the formation of the initial research questions: (1) How do individual geoscientists work through and interact with a seismic data set? (2) What techniques, practices, and strategies do individual geoscientists employ during seismic interpretation? (3) What variations do participants display in their actions, workflows, and interpretations throughout the seismic interpretation process? An ethnography takes the position that such behavior can be analyzed and understood (Bhattacharrya, 2007).

However, Bhattacharrya (2007) states that in order to investigate a phenomena, the researcher needs to consider their perspective in regards to the study's data collection. Often, in ethnographic studies the perspective taken by the researcher is holistic in nature, in that the researcher aims to understand all aspects of a culture or group, but a more focused study can use a non-holistic approach to examine particular aspects of a culture (Boyle, 1994). The researcher adopted a non-holistic approach to focus operations and analysis on targeted aspects of seismic interpreters posed by the research questions.

The perspectives taken by the researcher in this study allowed the researcher to design an exercise to address the proposed research questions. This involved recording individuals engaged in the interpretation of a seismic data set [seismic exercise] and during the post-exercise interviews. The initial observations [codes] of the data were made to preserve that data's naturalistic style, meaning that the initial codes by the researcher were simply descriptive, so that future analysis of the same data would be able to capture any additional meaning (Wilson, 1977). From those observations, themes (patterns) were formed by the researcher through the process of thematic analysis [Methodology 2.6]. In order to ensure accurate interpretation, the themes were shared and discussed with the research group and member checks were performed. Member checks involve using an independent researcher to code the data using the same coding scheme as the primary researcher. This helps ensure accuracy in the results of the study. Member checks are necessary since an ethnographic study assumes that researcher bias is incorporated into both the data collection and data analysis processes. All of these steps are described in detail in the sections that follow.

2.2 Locating the Researcher

Qualitative research should be done in such a way as to minimally bias interpretations of the data (Gold, 1997). However as stated in 2.1 Theoretical Framework, an ethnography is founded on the idea that a study cannot be accomplished without some level of investigator bias and involvement (Bhattacharrya, 2007; Gold, 1997). Therefore, my experiences with reflection seismology inherently bias the data. In this section I will disclose my own experiences with seismic interpretation.

Prior to enrolling at Texas A&M University in the fall of 2014, I had little experience with seismic interpretation. I was aware of the broad concept from my undergraduate coursework. However, I never worked on interpretations of my own, or gained any true understanding of the science during this time.

In the spring semester of 2015, I participated on the Texas A&M Imperial Barrel Award [IBA] team. The IBA website describes it as a global competition where "university teams analyze a dataset [geology, geophysics, land, production infrastructure, and other relevant materials]" (*About the Imperial Barrel Award*, n.d.). The team analyzed a seismic reflection data set, incorporating the regional geology, to make decisions on potential oil and gas fields. In this competition, I did not perform make interpretations of the seismic data set, but I was required to have an overall understanding of its contents. In that same semester, I also attended a short course aimed at the basics of seismic interpretation.

In the spring of 2016, the data used in this study was collected. All ten of the participants took part in the thirty to forty-five minute seismic exercise which was followed by interviews. Coding of the data commenced in the fall semester of 2016. In the same fall semester, I enrolled in the graduate level course Seismic Interpretation at Texas A&M University. In this course, I gained a better understanding of the seismic interpretation process and terminology. I also gained valuable experience with interpretation software, and learned the science behind reflection seismology.

During the fall of 2016, I considered myself to have an insider perspective which was useful during analysis of this study. I still consider myself a novice to the science, but my experiences have given me a stronger understanding of the geological and geophysical concepts in seismic interpretation. These learnings have allowed me to understand and analyze the markings and terminology that participants were using in their interpretations, and allowed me to evaluate the actions and the behaviors that participants were displaying in context to seismic interpretation. Additionally, my training and experience has given me insight into the value of how participants may be using the provided resources and time.

Therefore, I do believe that the breadth of my experiences have helped improve my knowledge of seismic interpretation, and have subsequently affected my research.

2.3 Participants

Bond et al. (2012, p. 78) found that correlation between having a Master's degree or a Ph.D. and "significantly improved expert performance" in seismic interpretation. This correlation helped guide participant selection for this study. All of the participants in this study are working toward a graduate degree in geology or geophysics and were selected in part, because they are pre-professionals in the oil and gas industry and have some level of experience or training with seismic interpretation. The goal with this research is not to study those that lack a working knowledge or any training in seismic interpretation, so this ruled out collecting data from students who lacked the necessary knowledge or experience.

In order to find qualified participants for this study, a recruitment letter was drafted by the researcher and sent to graduate students in the in a geology department at a major research university. This invitation to participate was extended by the researcher to those that have experience interpreting seismic data. Further description of individual's experiences in seismic interpretation is located in 3.1 Theme 1: Experience.

Prior to the start of the exercise, background information from the participants was collected by the researcher using a survey, located in Appendix III. This information is displayed in Table 1 and Table 2. Ten individuals volunteered to participate. Eight are males and two are female, while six self-identified as geologists and four self-identified as geophysicists. One student was a Ph.D. candidate and the rest were pursuing a Master of Science degree at the time of their participation in this study. Eight have had internships or have worked in the oil and gas industry. On the survey, participants were given the option to self-evaluate their level of seismic experience. Participants were provided with the options to choose expert, proficient, novice, and none (as a level of experience). Three of students identify as proficient in seismic interpretation, and the rest identify as a novice.

	Participant	Gender	Education Level	Time worked in industry	Internship?	What company?
Geophysics	P1	F	M.S.	2 summers	Yes	Denbury, Exxon
	P2	M	M.S.		No	
	P3	M	M.S.	2 years	Yes	Precision Well Logging, BhpB
	P4	M	M.S.	2 years	Yes	EP Energy
Geology	P5	F	M.S.	3 years	Yes	Anadarko
	P6	M	M.S.	0.5 years	Yes	EOG & COP
	P7	M	PhD	1.5 years	Yes	Schlumberger
	P8	M	M.S.	3 summers	Yes	Southwestern, Statoil, SM
	P9	M	M.S.	2 summers	Yes	SM, Talisman
	P10	M	M.S.		No	

Table 1 - Information collected from the background survey This includes gender, education level, time worked in industry, internships.

	Participant	Thesis involves seismic interp.	Are you a structual geologist?	Are you a sedimentologist?	Dominant Expierence in	Self Assessment of Seismic Int. Experience (Expert, Proficient, Novice, None)
Geophysics	P1	Yes	No	Yes	Sedimentology	Proficient
	P2	No	No	No	Processing	Novice
	P3	Yes	Yes	No	Extension, Salt	Novice
	P4	No	No	No	Extension	Proficient
Geology	P5	No	No	Yes	Extension, Salt	Novice
	P6	No	Yes	n/a	Thrust, Strike Slip	Novice
	P7	Yes	No	Yes	Extension	Novice
	P8	No	No	Yes	Extension	Proficient
	P9	No	No	No	Extension	Novice
	P10	Yes	n/a	Yes	none	Novice

Table 2 - Additional Information collected from the background survey This information was collected using the document in Appendix III. It was done just prior to the participant taking part in the study.

2.4 Seismic Data

Seismic reflection data was interpreted by participants in this study. Two multi-channel seismic lines were used: line 2 and line 4 [External appendix files: Line-2, Line-4 (GeoPRISMS, 2015)]. Dr. Donna Shillington, through GeoPRISMS, provided the seismic lines to our research group. The seismic lines as well as processioning and acquisition information is also available to the public (GeoPRISMS, 2015). In a study, Bond et al. (2011) gave participants a synthetic seismic data set to interpret. The synthetic nature of that data set meant that it was created and a geological solution was known. The data used in this study is ‘real,’ meaning that the seismic profiles are real images of the subsurface Earth and no true geological solutions were known to the researcher. The data [seismic lines] was acquired as part of the Eastern North American Margin Seismic Experiment [ENAM] offshore North Carolina and Virginia. The goal of ENAM is to understand the full evolution of a rift margin and the post-rifting processes ("Eastern North American Margin," n.d.).

In this study, I did not provide the geographical location of the data until the post-exercise interview. Bond et al. (2007) found that seismic data sets are often taught with reference to a specific geographical location, and suggests that if a participant knows this location, they might bias their interpretations. This bias occurs when an interpreter applies a broad tectonic environment to their interpretation, and looks for features in the seismic data associated with that geographical location (Bond et al., 2007).

The data was provided to participants in two formats: computer images and paper seismic lines. The participants were allowed to use both, but asked to make their interpretations on the paper seismic lines. As noted by Bond et al. (2011), using paper lines removes the variable of learning and using a software package.

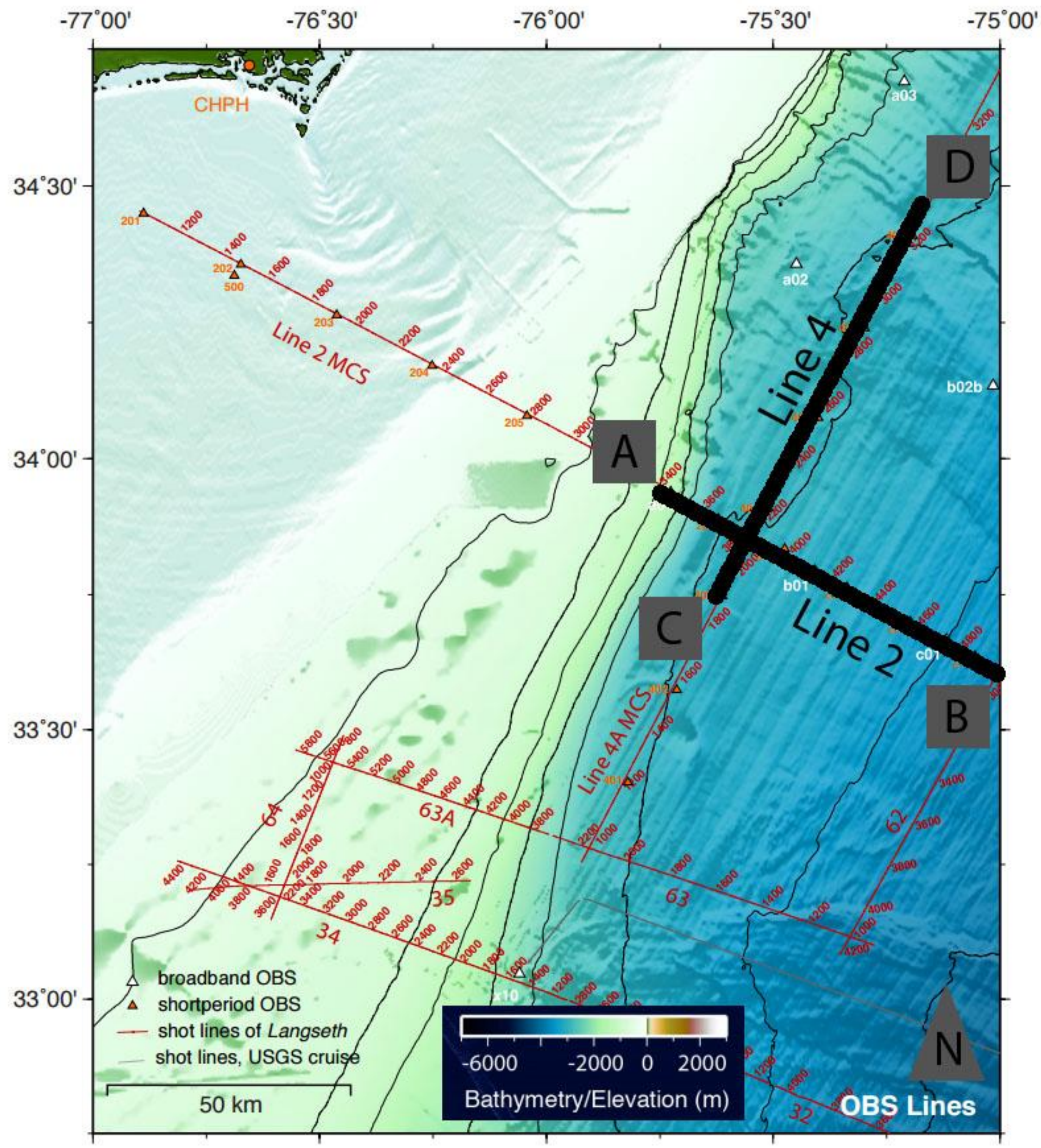

Figure 1 - Line Location Map Bathymetry Elevation map that shows the location of the two lines used in this study. The black lines represent the location and intersection of line-2 and line-4. This map was provided to participants during the exercise. The study area is off the coast of North Carolina, although this information was not provided to the participants until the interview. Reprinted from GeoPRISMS, 2015.

2.5 Data Collection

The experiment was conducted in the Halbouty building at Texas A&M University during the spring and fall 2016 semesters. Prior to the start of the exercise, participants were asked complete a consent form followed by a background survey [Appendix III]. The background survey collected information including gender, level of seismic experience, whether participants identified as a geologist or geophysicist, and information relating to any internship participants may have had. This information is summarized in Table 1 and Table 2.

At the start of the exercise, the researcher of this study explained the resources the participant had available to them as they worked on seismic data. Each participant was given a paper copy of seismic Line-2 and Line-4 [External appendix files: Line-2, Line-4], pencils, permanent markers, and an eraser. Participants were also given PDFs of each line on a dual-screen monitor, giving them the ability to zoom in and out on any feature in the data. Also, a map showing the relative locations [not the geographical location on the globe] and intersection of the lines was provided [Figure 1]. Participants were then given written and verbal instructions to interpret and write on the paper seismic lines. Participants were given thirty minutes to complete the exercise, but if they asked for more time ten more minutes were given.

In order to successfully capture interactions with the paper lines and the computer screens, one handheld camera and two GoPro cameras were placed in the room. The handheld camera [Camera-3] captured any use of the computer monitors, while one of the GoPros [Camera-1] captured work being done on the paper lines. Figure 2 is a screen capture from the point of view from Camera-1. The other GoPro [Camera-2] captured the entirety of the room, and served as a backup camera in case of a Camera-1 failure. Photos showing the experimental setup from the point of view of Camera-2 and Camera-3 are included as external appendices [external appendices: Camera-2 POV, Camera-3 POV].

Upon completion of the exercise, the researcher conducted an interview with each participant. The objective of the interview is to acquire a more detailed account of participant experience, as well as to gain more insight about the individual's thoughts and interaction with the seismic data. The interview is semi-structured meaning that the questions are standardized among the participants, but the interviewer may ask additional questions to further probe the individual (Harrell & Bradley, 2009). Interview questions and transcripts are detailed in Appendix VI.

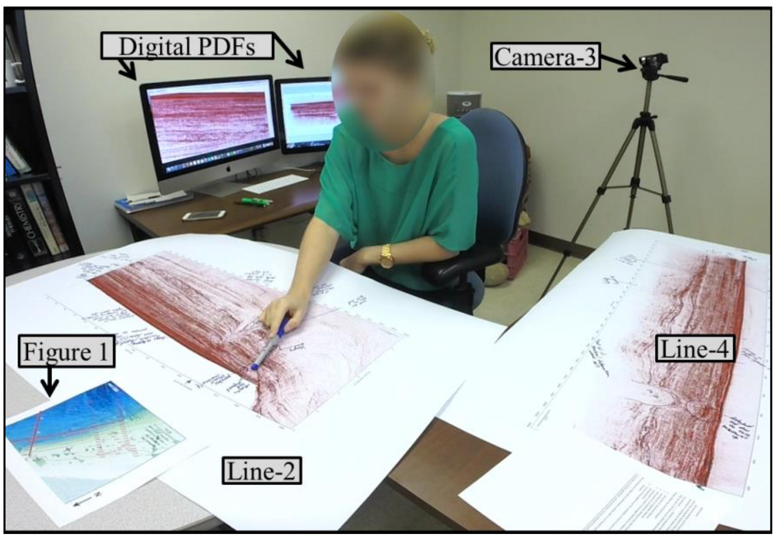

Figure 2 - Camera 1's Point of View of Experimental Setup This is a screen capture of participant 1 working on the seismic lines, and shows the point of view of camera 1. The paper lines Line-2 and Line-4 are labeled, and so are the digital PDFs of the aforementioned lines. The location of camera-3 and Figure 1 are also displayed.

2.6 Methodology

A methodology provides structure to a study giving the researcher direction on what data should be gathered, how to collect the data, and how to analyze it (Kothari, 2004). Ultimately, thematic analysis was chosen as the appropriate methodology for this study. Braun and Clarke (2006) explain that thematic analysis offers a more flexible approach than alternate methodologies, meaning that can be used with a range of theoretical frameworks. The authors state that when properly utilized, thematic analysis can provide a rich and descriptive account of the data in the study.

Due to its flexibility, thematic analysis allowed for the data to be transcribed and coded after all ten of the participants had completed the seismic exercise and all of the data had been collected. This was needed because the creation of a rubric was necessary to analyze participants' seismic interpretations, and the creation of this rubric could only be done through comparison of all twenty interpreted paper seismic lines [External appendix files: (P1–P10) Line-2, (P1–P10) Line-4].

The primary objective of thematic analysis is to search for patterns (themes) in the data (Braun & Clarke, 2006). The authors explain that themes can be described as any information that displays a pattern relevant to the research questions. While thematic analysis is a more flexible approach as it does not tie itself to any theoretical framework, there are steps one must follow. The steps of thematic analysis outlined by Braun and Clarke (2006) were utilized in this study: familiarizing yourself with the data, generating initial codes, searching for themes, reviewing themes, defining and naming themes, and producing the report.

Thematic analysis was utilized on both data sets collected in this research: video recordings of the individual working on the seismic exercise and video/audio of the interviews. The interview data was transcribed and used to further our understanding of how each individual interacted with the seismic data. All of the seismic exercise video recordings were uploaded into NVivo 10. This software allows for descriptive text to be written over a time-stamped interval in the video recordings. The initial codes serve as general descriptions of the actions, gestures, and workflows of the participants as he or she engages in the seismic exercise, with the purpose to capture as much information as possible, as any information may prove valuable in later phases (Braun & Clarke, 2006).

While watching the videos and making the initial codes, it became apparent that capturing the location of the markings was necessary. This involves using the shot number [X-Axis] and the two-way-travel time [Y-Axis] as a coordinate X-Y style system, information provided on the lines used in this study. To help search for patterns in the coded data, rubrics needed to be created to give names to commonly interpreted features and horizons on the seismic. The creation of these rubrics is described in 2.7 Seismic Line Rubrics.

Once patterns [themes] in the data were observed, they were rechecked against each other and the original data source. After themes were drawn out the seismic exercise data, the audio interview was used for triangulation to verify our results and seek completeness (Adami & Kiger, 2005). Then the themes underwent a deeper level analysis utilizing a literature review. These analyses are located in 4. DISCUSSION.

2.7 Seismic Line Rubrics

2.7.1 Seismic Line Rubrics and the Theoretical Framework

As mentioned in the methodology, keys [line rubrics] needed to be created to help analyze patterns in the data, by giving names to commonly identified features in the seismic data. The line rubrics were designed once all of the participants had been through the exercise and made their interpretations on the paper lines.

The decision to make the rubrics upon completion of participants' seismic exercises was intentional. An ethnographic study attempts to analyze a culture of practice in a naturalistic style (Bhattacharrya, 2007). The meant that the researcher did not want to impose his own importance of seismic data features during the creation of the line rubrics. Rather, participant's completed interpretations would be utilized to establish the features of interest and importance in the development of the rubrics. A rubric for both Line-2 and Line-4 was made utilizing this crowdsourcing technique [External Figures: Line-2 Rubric & Line-4 Rubric].

2.7.2 Design of the Seismic Line Rubrics

The rubrics were designed looking for commonality in interpretation elements among participants. The term, interpretation elements, refer to markings and written words participants leave on the paper seismic lines [3.2, Theme 2: Interpretation Elements]. The interpretation elements are used to highlight horizons, faults, sedimentary packages, growth strata, as well as other stratigraphic and structural features noticeable in the seismic images. However, while iterations of the same interpreted horizons or features in the seismic images exist across multiple individual's completed seismic exercises, variation in the marking and identification of features are evident.

This is particularly true of horizons. For example, horizon 4H-2 is drawn along in several participants' seismic exercises. The traced reflector of 4H-2 is relatively high amplitude and continuous, and there is less variation in the interpreted location of the drawn horizon. On the key, horizons that exhibit less variation are drawn with a solid line. This is contrary to horizon 2H-1 which all ten participants drew or identified. 2H-1 exhibits more fluctuation in its physical drawn location, as it does not appear to be a single horizon, but rather a change in reflector behavior. This makes picking a single horizon random to some degree. Horizons that have variation in their interpreted location are drawn with a dotted line on the key.

Faults interpreted by participants were widely variable by location and the amount. Rather than draw and label individual faults on the key, the researcher grouped faults into 'areas' by their location. This was done because of the variation between participant's seismic exercises. While some of the same interpreted faults were picked by multiple individuals, many of the faults were also unique to each participant. By using 'fault areas' the researcher is still able to describe where participants are interpreting faults and are also able to track participant's workflows during the exercise and make comparisons between participant's interpretations at useful level of precision. The research designated the locations of the fault areas using the proximity of all participant's interpreted faults and other prominent features in the data.

In the two seismic lines, there exist packages of reflectors that display the same characteristics. For example, the reflectors in package 4P-C are low amplitude and are bounded by higher amplitude reflectors [External Figures: Line-4 Rubric]. This similarity in amplitude was described by several participants. Six such packages were identified in participant’s seismic exercises. In some instances, individuals drew on horizons that outlined these packages, but provided no description of the reflector characteristics. A package of reflectors was only added to a participant’s frequency plot if they used observations to describe the package.

In addition to reflector packages, some individuals identified growth strata on line-2 along both sides of 2D-D in areas 2C and 2E. If a participant made this identification, it was added to their frequency plot. Twenty-three other features were also identified in the seismic images. The features are a mix of stratigraphic, structural, and geophysical artifacts. All but two of them were identified by at least two individuals. 4-F11 and 4-F6 were only identified by one participant. However, both of them appear to be geophysical artifacts, which may provide valuable insight into the difference interpretation strategies employed by geologists and geophysicists so they were included in the key. Four of these features are outlined in purple all share a similar low amplitude characteristic. They are named and colored differently from the rest of the features due to the frequency of identification among individuals. This helped see patterns more clearly.

2.8 Limitations of this Study

In order to discuss the limitations of this study, the researcher considered factors that have the potential to impact the findings discussed in this thesis. One of the major objectives of this study was to provide a methodological approach to how this type of data [studying individuals engaged in seismic interpretation] can be studied. The researcher developed these approaches through multiple levels of coding and many iterations of analysis. This also involved many internal discussions within the research group and consideration of approaches used in other studies. In order to perform a rich and detailed level of analysis, a decision was made to the limit the number of participants used in this study. My research group decided that ten participants would be an adequate number for this pilot study. In doing so, this does not guarantee that theoretical saturation has been reached, which occurs when new themes [patterns in the data] cease to develop as data is analyzed (Bryant & Charmaz, 2007). Applying these methods to a larger pool of participants will ensure that theoretical saturation has been reached. This may have an effect on how participants were sorted into the experience groups as well as differences in the actions, strategies, and techniques associated with those groups.

Another limitation in the study involves the seismic lines given to participants to interpret. Because the geological solutions to interpretations were not known to the researcher, it was not possible to make assessments of the best practices and strategies that led to most accurate interpretations. This means that those strategies and practices associated with the more experienced individuals are not necessarily the most efficient or effective way to interpret seismic data. If the goal of this study was to search for ‘best practices that lead to most accurate interpretations’, a panel of seismic interpretation experts could be assembled to make geological consensuses on features in the data.

The time constraint placed on participants may also have had an impact on this study. Participants were given 30-45 minutes to complete the exercise. However, interpretations of the seismic data could be extended for hours or days. This time limit in turn has an effect on how much seismic data participants were able to analyze and the actual interpretational outcomes. This could be mitigated by giving participants more time for their interpretations.

2.9 Reliability of Data

After coding, inter-rater reliability was performed in this study. The coding rubric for the data was written, shared and discussed with an independent researcher in our group, who is also geologically educated and who possesses basic knowledge of education research. Three of the ten interviews were recoded using the rubric by this second reviewer. The meaning of codes and format for recording this information was also discussed. Due to the complexity of the codes, percentage agreement was utilized and found 85.5% agreement between the researchers *(Run a Coding Comparison Query, 2012).*

2.10 Human Compliance and Biosafety

The Institutional Review Board at Texas A&M approved this study protocol IRB2015-0612D. This approval is located in APPENDIX 1, Institutional Review Board. Prior to analysis all data was removed of any identifiers or student names to ensure anonymity of the participants. Instead, individuals have been given a pseudonym used throughout this study. Participants were allowed to remove themselves from the study at any time. Only researcher and the researcher's group have access to the identifiable data.

3. RESULTS

The results have been produced through analyzing recorded video of participants working on the exercise, as well as utilizing their finished interpretations on the paper seismic lines. The interpreted paper seismic lines from each participant are included into this thesis as external files [see Appendix II for file descriptions].

3.1 Theme 1: Experience

The varying levels of experience that the participants have directed research efforts to in this study. This meant that the researcher wanted further understand the role of experience and its effect on an individual's interpretation. In order to do this, participants with more seismic interpretation experience must be distinguished from the lower experienced. The data used to distinguish different levels of experience came from two sources: the background survey and the interviews [Appendix VI]. The background survey had participants rank their own interpretation experience using the terms: expert, proficient, novice, none. It also asked the participants if their thesis involved seismic interpretation. After the background survey and exercise were completed, the interview was held. The first question in the interview asked participants to explain their experience with seismic interpretation.

Using the collected information, I separated participants into different experience-level groups. Participants who have had formal training in seismic interpretation [SI] through coursework and have a thesis project involving SI were placed in the high-experience group. Participants who had taken the SI class, but do not have a thesis involving SI were designated as medium or medium-high-experience. Finally participants that had not taken the class were labeled as low or medium-low experience depending on other experiences with seismic interpretation or processing of seismic data. These classifications will allow the researcher to look for co-occurrences of experience level with other themes in later sections in this study. The following descriptions of participants' experience with SI are summarized in Table 3.

3.1.1 Participant 1

Participant 1 [P1] is a geophysicist who is seeking a master's degree. P1 self-identified as '*proficient*' and P1's thesis involved seismic interpretation [SI]. P1 has had formal training in seismic interpretation through coursework. The interview provided additional information about P1's experience with SI. The response in the interview is as follows: "I am involved with seismic data processing, so I do sound geologic interpretations on our work but mainly looking at the acquisition and processing aspects of 2D seismic data … I had a few internships in industry looking at geophysical aspects of seismic data but mainly on the geology side. So I did a lot of interpreting data sets with that as well" [Appendix VI, Participant 1]. Given P1's experiences with SI, the researcher has placed P1 in the high-experience group.

3.1.2 Participant 2

Participant 2 [P2] is a geophysicist who is seeking a master's degree. P2 self-identified as '*novice'*. P2's thesis did not involve seismic interpretation [SI]. P2 has not had formal training in seismic interpretation, but has experience with interpretation through the Imperial Barrel Award team. P2 also has experience processing seismic data. The interview provided additional information about P2's experience with SI. The response in the interview is as follows: "I have limited interpretation. I've practiced more processing. I processed data, actually. I processed this same project. I also worked a seismic processing course here at A&M. We looked at a volcanic intrusion, so a lot of volcanic intrusions, I've been dealing with. I also did some interpretation at North Slope Alaska, working with the IBA team and interpreting a lot of stratigraphic features, up there in Alaska. Besides that, that would be about it. I haven't taken any courses, too much" [Appendix VI, Participant 2]. Given P2's experiences with SI, the researcher has placed P2 in the medium-low experience group.

3.1.3 Participant 3

Participant 3 [P3] is a geophysicist who is seeking a master's degree. P3 self-identified as "*novice"* and P3's thesis involved seismic interpretation [SI]. P3 has had formal training in seismic interpretation through coursework. The interview provided additional information about P3's experience with SI. The response in the interview is as follows: "Ok. The first time I actually interpreted was… the class was a basin analysis class and they wanted us to interpret the seismic using paper data ... So I learned to do it on black and white seismic data… The first 3d class that I took or virtual seismic interpretation was at UT… and that used seismic data that wasn't quite seismic data. It was data generated from a flume … Next I graduated from UT and I started working with Chevron for a year and a half, and I was on the seismic the interpretation earth model support team … I was the in-house expert of the software so whether they needed help on doing seismic interpretation or they didn't know how to do something … Then I came to A&M for my masters, the first semester I took a class with Dr. [name removed] it was his seismic interpretation class … That was somewhere in the gulf of Mexico field. 3d volume looking for what could be potential plays based on seismic response to hydrocarbons the edge of map field and then and analysis basin analysis why wanted you wanted to drill there for prospect analysis. Then I worked an internship over the summer with BHP Billiton, that was interpreting seismic data in petrel and that was interpreting the Hanesville shale play and I was looking at the salt beneath Hanesville and interpreting the salt and the salts movement. And my current research what I did with [name] was I shot a seismic survey using sparker source high resolution was the intent off the coast of Bonaire. Process that data and interpret it in paradigms interpretation suite" [Appendix VI, Participant 3]. Given P3's experiences with SI, the researcher has placed P3 in the high-experience group.

3.1.4 Participant 4

Participant 4 [P4] is a geophysicist who is seeking a master's degree. P4 self-identified as '*proficient*'. P4's thesis did not involve seismic interpretation [SI]. P4 has had formal training in seismic interpretation through coursework, and interpretation experience in the IBA program. The interview provided additional information about P4's experience with SI. The response in the interview is as follows: "Well i've taken seismic interpretation class here, did IBA [Imperial Barrel Award, see 2.2], I didn't do so much seismic interpretation during my internship but I dealt with a bunch of different seismic volumes, so im pretty familiar with it" [Appendix VI, Participant 4]. Given P4's experiences with SI, the researcher has placed P4 in the medium-experience group.

3.1.5 Participant 5

Participant 5 [P5) is a geologist who is seeking a master's degree. P5 self-identified as '*novice'*. P5's thesis did not involve seismic interpretation [SI]. P5 has not had formal training in seismic interpretation through coursework, and interpretation experience in the IBA program. The interview provided additional information about P5's experience with SI. The response in the interview is as follows: "I've done … basically some short courses and little bit with my internship" [Appendix VI, Participant 5]. Given P5's experiences with SI, the researcher has placed P5 in the low-experience group.

3.1.6 Participant 6

Participant 6 [P6] is a geologist who is seeking a master's degree. P6 self-identified as '*novice'*. P6's thesis did not involve seismic interpretation [SI]. P6 has had formal training in seismic interpretation through coursework, and interpretation experience in the IBA program. The interview provided additional information about P6's experience with SI. The response in the interview is as follows: "I have had experience with seismic lines from SI class geophys 629 and during the IBA class. I interpreted seismic in both cases. In the class we did seismic attributes and in the IBA was more ties to wells" [Appendix VI, Participant 6]. Given P6's experiences with SI, the researcher has placed P6 in the medium-experience group.

3.1.7 Participant 7

Participant 7 [P7] is a geologist who is seeking a Ph.D. P7 self-identified as '*novice*', and P6's thesis involves seismic interpretation. P7 has had formal training in seismic interpretation through coursework, and interpretation experience in the IBA program. The interview provided additional information about P7's experience with SI. The response in the interview is as follows: "For my dissertation I'm working on a seismic volume from Australia which is a prograding continent system, not much faulting result, not much tectonic activity in general, and it's relatively easy to follow. Other than that I took seismic interpretation.... [and know] some of the basics in general" [Appendix VI, Participant 7]. Given P7's experiences with SI, the researcher has placed P7 in the high-experience group.

3.1.8 Participant 8

Participant 8 [P8] is a geologist who is seeking a master's degree. P8 self-identified as '*proficient*'. P8's thesis did not involve seismic interpretation [SI]. P8 has had formal training in seismic interpretation through coursework, and interpretation experience in the IBA program. The interview provided additional information about P8's experience with SI. The response in the interview is as follows: "My experience is, I've taken coursework, such as seismic interpretation, graduate courses on seismic interpretation … short courses provided by Shell, AAPG, carbonate classes dealing with this. Multiple [inaudible] classes, Imperial Barrel Award Competition, 2014… and I dealt with it through my internships. And I've used software such as Seismic for GeoGraphix, I've used Schlumberger Software suite, Halliburton software*"* [Appendix VI, Participant 8]. Given P8's experiences with SI, the researcher has placed P8 in the medium-high-experience group.

3.1.9 Participant 9

Participant 9 [P9] is a geologist who is seeking a master's degree. P9 self-identified as '*novice'*. P9's thesis does involve seismic interpretation [SI], but had not spent any significant time on his project prior to the point in which the exercise occurred. P9 has not had formal training in seismic interpretation through coursework. P9 had some limited interpretation experience in the IBA program. The interview provided additional information about P9's experience with SI. The response in the interview is as follows: "I've dealt with it a little bit in some of my classes… There's still quite a bit of stuff that whenever I look at it, it takes me a while to figure out what it is. It's difficult to know. It's a lot easier to interpret stuff whenever you know where it's at. You didn't tell me where it's at, right? But, yeah, just in a couple of my classes. I haven't had seismic interpretation so that would definitely help. A lot of this and a ton of stuff is just because I'm unsure, just because I haven't had a formal class with it. There's a lot of stuff where I think I see it but it's hard for me to put it down" [Appendix VI, Participant 9]. Given P9's experiences with SI, the researcher has placed P9 in the low-experience group.

3.1.10 Participant 10

Participant 10 [P10] is a geologist who is seeking a master's degree. P10 self-identified as '*novice*'. P10's thesis does not involve seismic interpretation [SI]. P10 has not had formal training in seismic interpretation through coursework. P10 had some limited interpretation experience in the IBA program. The interview provided additional information about P10's experience with SI. The response in the interview is as follows: "Just in the IBA competition, [P2] and I worked [on seismic] pretty much. Just drew these seismic lines to finish doing this kind of stuff. It was not a very structurally inclined area. We were just tracing horizons" [Appendix VI, Participant 10]. Given P10's experiences with SI, the researcher has placed P10 in the low-experience group.

Participants	P1	P3	P7	P8	P4	P6	P2	P5	P9	P10
Experience Level - As designated by the Researcher	High	High	High	Medium-High	Medium	Medium	Medium-Low	Low	Low	Low
Self Assessment of Seismic Experience	Proficient	Novice	Novice	Proficient	Proficient	Novice	Novice	Novice	Novice	Novice
Thesis involves seismic interpretation	Yes	Yes	Yes	No	No	No	No	No	No	Yes*
Formal Training in Seismic Interpretation	Yes	Yes	Yes	Yes	Yes	Yes	No	No	No	No
IBA Seismic Interpretation	No	No	Yes	Yes	Yes	Yes	Yes	No	Yes**	Yes**
Additional Experience	Industry Processing	Industry		Industry			Processing	Short Courses, Industry		

Table 3 - Experience Groups This Table shows what experience groups participants were placed into with information collected from the background survey and interviews. The participants were placed into three groups based on academic qualifications. The high-experience group has seismic interpretation [SI] experience in their thesis projects and have had formal training in SI through coursework. The medium-experience group has all also had formal training, with the exception of P2 who has processing experience and SI experience through the IBA program. The low-experience group has not had any formal training, but have had related experience. Two participants from the medium-experience group and one from the high identified as proficient, and everyone else identified as novice. This suggests the inconsistency of self-assessment.

* P10's thesis involves seismic interpretation, but had not started on the project until after participation in this experiment

**In the interview, both participants admitted their limited seismic interpretation experience within the IBA program.

3.2 Theme 2: Interpretation Elements

Prior work done by Bond et al. (2012), identified six techniques commonly applied by geoscientists during seismic interpretation. These techniques refer to markings participants leave on the paper seismic lines: “[1] interpreting horizons, [2] drawing fault sticks [straight lines to represent fault locations], [3] identifying features, [4] annotations, [5] descriptive writing, and [6] thoughts about the geological evolution shown through sketches or writing” (Bond et al., 2012, p. 77).

This study found similar interpretation techniques applied, but in this study they are referred to as interpretation elements. This is because the term “techniques” is reserved for the steps and actions participants employ during the actual exercise. Due to the nature of this study, there are some differences in the interpretation elements from the work done by (Bond et al., 2012).

No participants provided any significant sketches or writing about the geological evolution of the provided lines, and I have combined descriptive writing and annotations into the same element category, writing. Therefore, the following element categories used in this study are drawn horizons [Figure 3a], drawn vertical lines [Figure 3b], identification of features [Figure 3c], which are circled or drawn to with an arrow usually accompanied with writing; and writing [Figure 3d].

The element writing was further broken into three sub-elements: observations, annotations, and labels. Observations refer to statements about seismic reflector characteristics, which is different from annotations and labels. Annotations are words associated with a specific feature in the seismic data. For example, a participant might use the word ‘salt’ to describe feature 2D-D [external appendix: Line-2 Rubric]. Because the

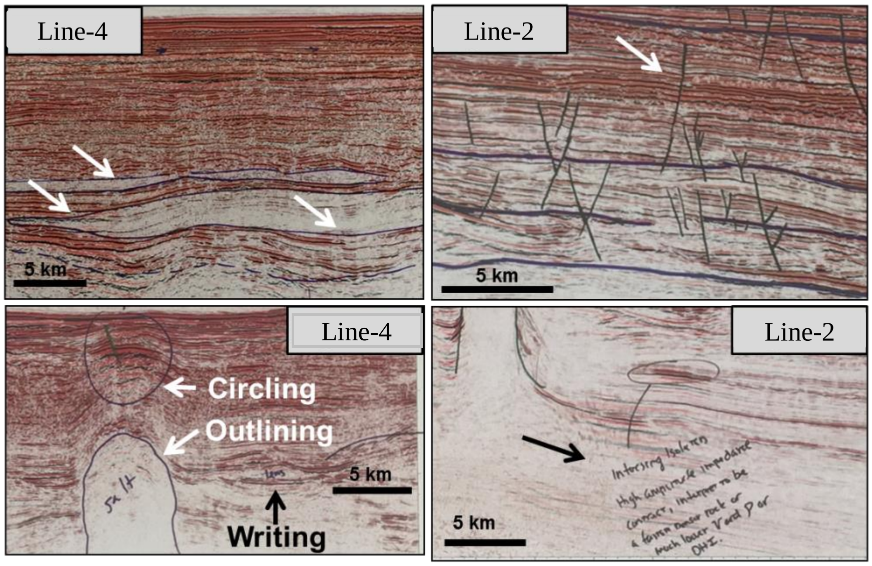

Figure 3 - Interpretation Elements (a) [Top Left] Interpreting Horizons – The arrows are pointing to drawn horizons on line-4, used in this instance to mark changes in reflector behavior. All participants but P2 (medium-low-experience group) and P5 (low-experience group) drew more than one horizon. (b) [Top Right] Interpreting Faults – The arrow are pointing to drawn vertical lines participants used to represent faults on Line-2. All participants drew these. (c) [Bottom left] Identifying Features – The labeled arrows show three different methods of feature identification: circling a feature, outlining [drawing on the border or on the feature], and writing. In this instance, the word ‘lens’ is written inside of the lens shaped featured. (d) [Bottom Right] Writing – The arrow is pointing to a written interpretation supported by an observation. In many instances, these elements are used together to identify the same feature. Reprinted from GeoPRISMS, 2015.

word ‘salt’ is referencing a feature without making observations about reflector characteristics, it is considered an annotation. Alternatively, labels are words that are not referring to anything specific in the image. For example, one participant wrote ‘sediment supply’ accompanied with an arrow. It seeks to describe the page as a whole and not a specific feature. The writing used by participants is further discussed in section 3.5 Theme 5: Writing in the Seismic Exercise.

3.2.1 Identified Features in Seismic Exercise

In the Methods, the need for a rubric that could assess interpretation frequency and the order in which interpretations occurred was described. The actual creation of the rubric was detailed in 2.7 Seismic Line Rubrics. With the aid of the rubrics I was able to generate a list of features and horizons that were commonly identified by participants. Identification can occur in a number of ways: it can be circled, outlined, or drawn to with an arrow or line [Figure 5.3]. The frequency of identification of features and horizons is located in Table 4.

3.2.1.1 Most Commonly Identified Features in the Seismic Exercise

Only one feature, 2D-D, and one horizon, 2H-1, were identified by all participants. Features 4D-D and 4D-F were both identified by nine individuals each. Similarly, 2E was the only fault area that had fault sticks drawn in it by every participant.

3.2.1.2 First Identified Feature in the Seismic Exercise

The video exercise data allowed the researcher to record which feature participants identified first. 7 out of 10 participants started on line-2, and 5 out 10 started on the low amplitude vertically oriented features 2D-D and 4D-D.

3.2.1.3 Hydrocarbons and Artifacts

Two participants identified what they believed to be DHIs [direct hydrocarbon indicators]: P2, P4. Both of these participants are geophysicists and from the medium-experience group. One other participant, P5, used the term 'organics' for the two high amplitude anticlines above features 2D-D and 4D-F. Three of four geophysicists identified what they believed to be geophysical artifacts in the data: P1, P2, P4. One of six geologists identified what they believe to be an artifact. According to Allmendinger (2015, p. 250), artifacts can be described as "misleading features that are easily misinterpreted as real geology" in the seismic data.

3.2.1.4 Reflector Packages

As noted in 2.7 Seismic Line Rubrics, a reflector package was added to a participant's frequency data [Table 4] if the participant used observations to describe the package. This behavior was only present in the high and medium-experience groups, with P7 and P1 [high-experience group] using extensive observations to explain many of the packages in the lines.

Line 2																										
Experience	Participant	2-F1	2-F2	2-F3	2-F4	2-F5	2-F6	2-F7	2F-8	Faults-2B	Faults-2C	Faults-2D	Faults-2E	Faults-2F	Faults-2G	2P-A	2P-B	2H-SF	2H-1	2H-2	2H-3	2H-SB	2-GS-1	2-GS-2	2D-B	2D-D
High	P7	X		X	X					1			6			X	X		X	X	X		X		X	X
	P1		X		X								7	2	12	X	X	X	X	X	X	X				X
	P3												14	6					X					X	X	X
Medium	P8						X	X		6		4	14					X	X	X	X	X	X			X
	P6	X			X			X	X			3	15		8			X	X	X	X	X	X			X
	P4	X	X		X	X	X		X	1			13				X		X		X				X	X
	P2	X				X	X	X	X				18		10	X	X		X							X
Low	P10									1		4	28	6					X	X	X					X
	P9							X					8						X						X	X
	P5	X	X	X	X					3		1	6	6	7		X		X							X

Line 4																															
Experience	Participant	4-F1	4-F2	4-F3	4-F 4	4-F5	4-F6	4-F7	4-F8	4-F9	4-F10	4-F11	Faults-4A	Faults-4B	Faults-4C	Faults-4D	Faults-4E	Faults-4F	Faults-4G	4-PA	4P-B	4P-C	4P-D	4H-1	4H-2	4H-3	4H-4	4H-5	4H-6	4H-7	4D-D	4D-F
High	P7	X		X		X							1							X	X	X	X				X	X	X	X	X	X
	P1	X	X	X				X		X	X		1					1						X	X				X	X	X	X
	P3	X	X							X	X																X	X	X	X		X
Medium	P8	X			X	X			X				1		3	3	1	12	1											X	X	X
	P6			X	X						X	X	1									X			X				X		X	X
	P4	X					X	X					1									X									X	X
	P2		X	X		X				X	X									X	X										X	X
Low	P10	X	X	X						X			6			6	5	8						X					X	X	X	
	P9												1					2													X	X
	P5	X		X	X				X	X																					X	X

Table 4 – Frequency of Identified Features This table shows what features [2-F#, 4-F#, 2-D#, 4D-#], horizons [2H-#, 4H-#], fault areas, packages [4-P & 2-P] were identified by which participant. Identification can occur through outlining, circling, or can use arrows/lines accompanied with writing. An X signifies identification by the participant, while the numbers signify how many faults were interpreted within that fault area. These feature names correspond to labeled features in the external appendices: Line-2 and Line-4. The fault areas are also labeled on the appendices.

Note that large vertically striking low amplitude features [4D-D, 4D-F, & 2D-D] were identified most frequently, along with horizon 2H-1, and faults in fault area 2E.

3.3 Theme 3: Interpretation Techniques

As stated in 3.2 Interpretation Elements, the term ‘techniques’ is reserved for the steps and actions participants employ during the actual exercise. These techniques were captured from the video of participants engaged in the exercise, rather than being derived from the finished interpreted paper seismic lines. The following information is summarized in Table 5.

3.3.1 Pencil Use

All of the participants were provided with a pencil and several colors of permanent markers. Participants were instructed to use the color permanent markers to make their ‘interpretation elements’. While all participants used the permanent markers, five students employed the use of pencil: P2. P3, P7, P8. P10. However, P2 and P3 only used the pencil twice and once respectively. P2 made an unidentified marking on both line-2 and line-4, while P3 drew a fault stick which was drawn over with permanent markers later in the exercise. P7, from the high-experience group, made nine markings in pencil ranging from faults, stratal terminations, to outlining features. P8, from the medium-high-experience group, used pencil ten times to draw horizons, faults, and outline several features. P10, from the low-experience group, used pencil to draw horizons. P7, P8, P10 all drew over the pencil markings in permanent marker later in the exercises.

While there appears to be a random distribution across the experience groups for those who used pencil during the exercises, there did appear to be a trend of when during the exercise participants used pencil. These results are shared in 3.6 Workflow and Timing.

3.3.2 Vertical Exaggeration

In some instances, participants make actions with the paper lines that do not involve drawing or writing. Two participants from the high-experience group created vertical exaggeration while looking at the paper lines. P7 accomplished this by positioning his head near the table and towards the end of a line [Figure 4], which from the perspective of the participant shorted the horizontal axis of the line creating vertical exaggeration. P3 also created vertical exaggeration by physically picking up each line to accomplish the same.

Figure 4 – Display of Vertical Exaggeration Participant 7 [P7] oriented his head near the paper to change the vertical to horizontal aspect ratio. This created vertical exaggeration, which the participant may be using to locate certain features in the seismic data. This behavior was only displayed by two members in the high-experience group, and may be an indicator of more experienced interpreters.

3.3.3 Three-Dimensional Model and Intersection

P3 also took each line and folded it at the intersection point [Figure 5]. With one line folded at the intersection, P3 put the lines together at the intersection line to create a 3D model of the intersection, and did this for both lines. While P1 did not make a physical model, at a time during the exercise P1 focused on the intersection, going back and forth between the two lines several times over. P6 and P3 use annotations at the intersection point, appearing to signify its importance.

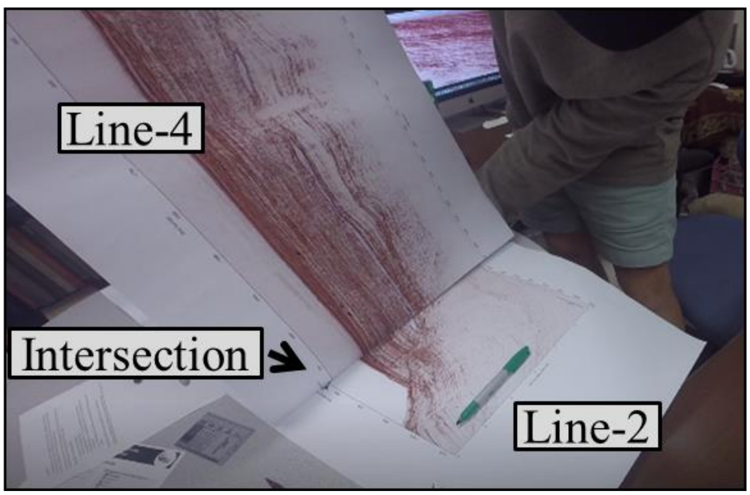

Figure 5 – Display of 3D Model and Use of Intersection Participant 3 [P3] created a three-dimensional mode**l** using line-2 and line-4. The lines are placed together at the intersection, which has the most data control.

3.3.4 Ghost Tracing

Six participants also used the 'ghost tracing' technique (Bond et al., 2011). This is where a student hovers above the paper with a writing utensil or finger appearing to draw a line "effectively rehearsing what might be a plausible interpretation" (Bond et al., 2011, pp. 8-9). The use of this technique does not appear to show a trend with experience level. One participant in the high, two in the medium, and one in the low-experience groups did not exhibit the ghost tracing technique.

Experience	High			Medium				Low		
Participant	P7	P1	P3	P8	P6	P4	P2	P5	P9	P10
Used Pencil	X		O	X			O			X
Vertical Exaggeration	X		X							
Creared 3D Model			X							
Intersection		X	X		X					
Ghost Tracing		X	X		X			X		X

Table 5 – Summary of Interpretation Techniques This is a summary of the techniques used by participants located in 3.4 Theme 3: Interpretation Techniques. An X indicates that this techniques was used by participants, but an O indicates it was only used once. Pencil use in the interpretations was predominantly used by three participants to make possible less permanent interpretations before they were drawn over in marker. The use of vertical exaggeration was used by two participants in the high-experience group, and two participants from the high-experience group and one from the medium-experience group seemed to place importance on the intersection. Ghost tracing was also used by half of the participants where they appear to draw a horizon without making markings on the lines.

3.4 Theme 4: Writing in the Seismic Exercise

The interpretation element of writing was already described in *3.2 Interpretation Elements*. It has three different styles: observations, annotations, and labels. Observations refer to statements about seismic reflector behavior and characteristics, annotations are words referencing a specific feature in the seismic data, and labels are words that describe the line as a whole.

3.4.1 Annotations and Labels

Even though participants were asked to write on the lines, P10 from the low-experience group did not use writing elements on either line. The other nine individuals did use writing in the form of annotations and observations. However, there was minimal writing used by both P9 and P3. Participants often use annotations to name features or to offer an explanation for the feature. For example, P5 annotates 2D-D as ‘salt post depositional”, but does not offer observations to support this interpretation. The naming of features and lack of supporting observations was done by all nine of the participants who used writing, but to the extent of which varied by the individual.

3.4.2 Observations

Observations refer to statements about seismic reflector behavior and characteristics. Eight of the participants made observations of the data. The two participants who did not write observations were P3 from the high-experience group and P10 from the low-experience group. The other eight participants all observed stratal terminations by writing the words onlap, toplap, terminations, or truncations.

Table 6 summarizes observations written by participants. The medium-experience group made the most observations on average. Both the medium and high-experience groups wrote more observations than the low-experience group, if you remove the two individuals that did not use observations. The low-experience group did not reference reflector amplitudes or geometries. P2 and P4, both geophysicists, used observations to support the presence of a geophysical artifact. Only one participant made numerous interpretations supported by observations: P4.

Experience	Participant	Onlap	Toplap	Terminations	Truncation	Thickening of Strata/Package	Relector Offset	Reflector Amplitude	Single Reflector Geometry	Mutiple Reflector Geometry	POR Amplitude	POR Geometry	Change in Reflector Character	Observation to support artifact	General Shape Description
High	P7	3		1	1			2			11	13	1		
	P1	1				1						4			
	P3														
Medium	P8	4			1			1			1				
	P6	2	2	1				4	1	2					1
	P4				12	1	5	1		4		1		1	4
	P2			5		1				3	1			2	2
Low	P10														
	P9			1											
	P5	1	1		2	1									2
POR = Package of Reflectors															

Table 6 – Observation Style This is a quantitative effort to categorize participants written observations on their paper seismic lines. The number in each box references the amount of times the participant used a word to make an observation. For example, P4 used the term ‘truncation’ twelve times. *Onlap, toplay, terminations,* and *truncation* were words participants used explicitly. *Thickening of Strata/Package* refers to observations that reference the changes in thickness between two reflectors horizontally. *Reflector Offset, Reflector Amplitude, and Single Reflector Geometry,* are observations that refer to single reflectors. *Multiple Reflector Geometry* refers to observations that describe the behavior of a set of reflectors. However, the reflectors do appear to be a part of any well-defined package of reflectors. *Package of Reflector [POR] Amplitude,* and *POR Geometry* refer to observations about a well-defined package of similar reflectors that share the same amplitude and/or geometry. Such packages are oriented horizontally, and 4P-C is an example. *Change in Reflector Character* refers to statements about changes in amplitude or geometry. *Observation to support artifact* refer to observations in that data the support the presence of geophysical artifacts. *General Shape Description* refers to broad statements about the shape of a feature and not to single or packages of reflectors.

3.5 Theme 5: Workflow and Timing

3.5.1 Workflow

Table 7 details the progression of each participant as they worked on features in the seismic exercise. It does not account for features that are not in the data rubrics. Features were only added to the chart if an interpretation element was applied during the exercise [Interpretation Elements 3.2]. The workflow data was investigated for patterns relating to experience groups, and trends between geologists and geophysics. Our data in Table 7 does not suggest any strong correlations. The data shows that participants have a tendency to start the exercise with the most commonly identified features. Five out of the ten participants identified features 2D-D, 4D-D, or 4D-F first, and two of the other five participants identified 2D-D second. Also, the commonly identified features often appear in participant's workflow more than once. For example, feature 2D-D appears at least twice in seven participants' workflows.

3.5.2 Pencil and Annotation Style

Five participants used pencil during the exercise. P2, P3, P7, and P8 only used pencil toward the beginning of the exercise, while P8 used the pencil throughout or even at later stages in the exercise. Similarly, some of the participants had the same approach with annotations. P7 and P8 make all of their writing toward the end of the exercise, while spending the rest of the exercise drawing interpretation elements.

P1	P2	P3	P4	P5	P6	P7	P8	P9	P10
Beginning of Exercise									
4H-2	F-2E	F-2E	4D-D	4D-F	2D-D	2D-D	2-F6	2D-D	2H-1
F-4A	2D-D	2H-1	4D-F	F-4F	F-2E	F-2E	2H-0	F-2E	2D-D
4H-1	4D-F	4-F1	2D-D	4D-D	2-F8	4D-F	2H-SB	F-2E	F-2D
4-F10	2H-1	4H-4	2H-1	4-F1	2H-1	4D-D	2H-3	2H-1	F-2E
4H-1	2P-B	4H-5	4-F1	4-F9	F-2D	4-F1	2D-D	F-2E	2H-1
4H-2	4-F5	F-2E	4D-D	F-4F	F-2E	4D-F	4-F1	2P-B	F-4A
4H-7	4P-A	F-4F	4D-F	4-F4	2D-D	4D-D	F-2D	4D-F	4H-1
4H-6	4-F2	2D-D	2-F2	F-4F	2-F1	2D-D	2D-D	F-4A	4H-1
4D-D	2-F8	4D-F	2D-D	4-F8	2-GS-1	F-2E	F-2E	F-4D	4-F3
4D-F	2-F6	2D-D	2-F8	4-F3	2D-D	F-2B	F-2B	4D-D	F-4E
4H-7	2-F1	F-4F	2F-1	2D-D	2H-SB	2H-1	F-2E	2D-D	F-4F
4H-6	2H-1	4H-6	2-F8	2-F3	2H-0	4-F1	F-2C	2P-B	F-2E
4-F3	2P-B	4H-7	F-2E	2F-2	2H-SB	4-F3	F-4A	2-F7	F-2F
4-F9	F-2E	4-F10	2-F5	2F-1	2-F7	4-F5	F-4F	F-2E	F-2E
4-F9	2D-D	4H-6	4-F7	F-2D	2H-3	2H-1	F-4G	2D-B	2H-3
4-F7	4D-F	4H-7	4-F6	2-F3	2H-2	2H-2	F-4D	2P-B	2H-3
F-4F	2H-1	2-GS-2	F-4A	F-2H	4-F10	2H-3	4-FC	2H-1	2H-2
4-F1	2-F7	2H-1	2H-3	2P-B	4-F3	2P-B	2-F6	F-2E	F-2F
2H-SB	4-F5		4P-C	2F-1	4D-D	2-F1	2H-1		2H-2
2H-SB	4-F3		2-F6	2P-B	4D-F	4H-6	2H-SB		F-2F
2D-D	4-F10		2P-B	F-2G	4-F10	4H-7	2D-D		4H-6
2H-0	4P-A		2P-B	2H-1	4H-6	4P-C	F-2D		4-F1
2-F2	4P-B		4-F7	F-2E	4H-6	4-F3	F-2E		4-F2
2H-SB	4-F9			F-2F	2H	4-F5	2-GS-1		4-F9
F-2E	4-F2			F-2E	4-F4	2-F1	2H-SB		4H-6
F-2G	4D-F			F-4C	4H-2	2-GS-1	F-2E		4H-7
2H-2	2-F5			4P-C	2H-1	2-F3	4D-F		4D-D
2H-3	2-F6			F-4G	F-4A	2-F4	4D-D		
F-2G	2-F8			4-F3	2H-0	2D-B	F-4F		
2H-1	2P-B			F-2F	F-4G	4H-4	2H-2		
F-2F	F-2G				4P-C	4H-5	4H-7		
2P-B						2P-B	4-F1		
						4P-D			
End of Exercise									

Table 7 – Workflow of Features This chart shows the progression of each participant as they worked on features in the seismic exercise. A feature was only added to this chart if it is located in the line rubrics and an interpretation element was applied. The most identified features have been colorized to enhance patterns in workflow. Eight out of the ten participants started on of those features in the table, and there is a clear pattern among the participants showing that they worked on many of the commonly identified features toward the beginning of the exercise. Participants P1 and P8 did not display this behavior; instead they appeared to start by drawing horizons on Line-4 and Line-2 respectively. The distribution of the most commonly interpreted features are more distributed in their exercises.

3.5.3 Ending Early and Extra Time

Two participants appeared to end the exercise before the thirty minute exercise was over: P3 and P5. The rest of the participants worked till the end of the thirty minutes, and P2, P8, and P10 all asked for extra time to complete their interpretations.

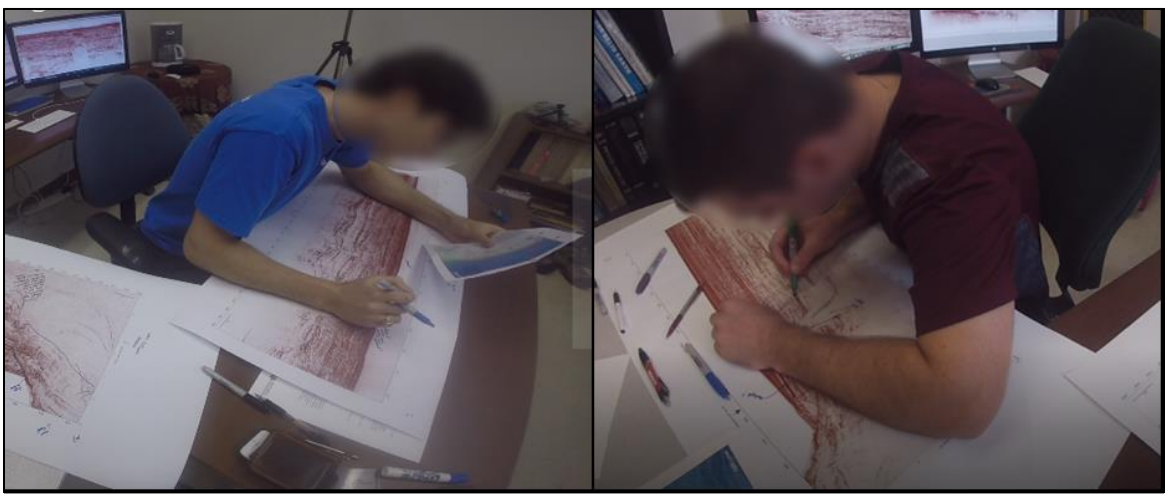

Figure 6 – Participant Engagement with Seismic Lines (a) **[**Left**]**Participant 6 [P6] looking at Figure 1, the map that shows the intersection of the two lines. (b) [Right] Participant 10 [P10] actively drawing a horizon on line-2. Both Figure 6.a and 6.b show participants engaged with the lines. The durations of time of these engagements with the different resources is played in Tables 8, 9, and 10.

3.5.4 Exercise Timings

Using the exercise video recordings, the duration of time each participant spent engaged with line-2, line-4, the computer images, the map that showed the intersection of the two lines [Figure 1], and the instructions was captured in intervals. This engagement with the different resources is shown in Table 8 and Table 9. This is displayed in Table 10. There is a trend in time spent on line-2 and line-4. In total, participants were engaged with line-2 for three hours and five minutes, while only spending an hour and forty-nine minutes on line-4. All participants spent more time on line-2. A ratio using the time from line-2 to line-4 was calculated. Eight of the participants' ratios fell between 1 and 2, while P9 and P10 from the low-experience group had ratios of 5.43 and 2.18 respectively.

The low-experience group also spent the least amount of time looking at the instructions and the map that showed the intersection of the two lines on average [see Table 10]. In Table 8 and 7.2, there is a pattern where the low-experience group spends all of their time on one line. At five minutes elapsed into the exercise, the low-experience group spends times of 4:56, 4:09, and 3:50 on a single line. In the medium and high-experience groups, the time was more evenly distributed. The time intervals of 5 and 10 minutes were selected as they are able to capture the behavior of the low-experience group's tendency to work on just one of these lines in those time frames.

Measured in Minutes:Seconds

First five minutes of exercise			Line 2	Line 4	Comp	Map	Instruc.
	High	P7	02:21.4	02:12.4	00:00.0	00:01.9	00:23.8
		P1	00:18.3	01:15.8	00:50.2	00:22.7	00:19.5
		P3	01:29.7	01:24.8	00:01.7	00:30.6	00:07.2
	Medium	P8	01:56.9	00:28.2	00:12.9	01:06.1	00:39.0
		P4	01:19.6	02:49.7	00:00.0	00:00.0	00:37.1
		P6	01:25.0	01:15.2	01:52.0	00:15.9	00:11.6
		P2	00:17.8	01:37.5	00:12.3	01:01.2	00:14.8
	Low	P5	00:00.0	04:56.1	00:00.0	00:00.0	00:03.1
		P9	04:09.7	00:09.2	00:00.0	00:00.0	00:00.0
		P10	03:50.4	00:02.0	00:48.1	00:17.6	00:01.9

Table 8 – Exercise Timings 5 Minutes The durations [measured in minutes and seconds] that each participant spent looking at or working on each line, the computer, the map containing the line locations, and the instructions [resources] at 5 minutes in to the exercise. Low, Medium, and High reference to the experience group each participant was placed in. The low-experience group exhibits longer durations spent engaged on a single line, and less time on the Map [Figure-1] and instructions.

Measured in Minutes:Seconds

First ten minutes of exercise			Line 2	Line 4	Comp	Map	Instruc.
	High	P7	05:45.3	03:31.6	00:00.0	00:11.1	00:31.5
		P1	00:18.3	05:50.7	01:10.5	00:22.7	00:24.3
		P3	05:09.8	02:00.8	00:33.2	00:43.7	00:07.2
	Medium	P8	05:44.8	01:40.3	00:12.9	01:06.1	00:39.0
		P4	04:18.9	04:28.2	00:00.0	00:22.3	00:37.1
		P6	06:19.0	01:15.2	01:58.0	00:15.9	00:11.6
		P2	03:16.5	01:59.7	01:46.2	01:44.4	00:26.1
	Low	P5	00:42.0	09:13.7	00:00.0	00:00.0	00:03.1
		P9	08:43.6	00:09.2	00:00.0	00:14.2	00:11.9
		P10	08:39.9	00:02.0	00:58.6	00:17.6	00:01.9

Table 9 – Exercise Timings 10 Minutes The durations (measured in minutes and seconds) that each participant spent looking at or working on each line, the computer, the map containing the line locations, and the instructions (resources) at 10 minutes in to the exercise. Table 8 and Table 9 both show a tendency of the low group spending most of their time on a single line, largely ignoring the other resources available to them. Low, Medium, and High reference to the experience group each participant was placed in. The low-experience group exhibits longer durations spent engaged on a single line, and less time on the Map [Figure-1] and instructions.

			Line 2	Line 4	Comp	Map	Instruc.	Line-2:Line-4
Whole exercise	High	P7	16:54.3	13:07.0	00:00.0	01:10.7	00:46.3	1.29
		P1	15:02.4	09:30.7	03:08.3	00:30.3	00:28.5	1.58
		P3	11:58.6	08:53.3	03:33.3	01:27.9	00:16.0	1.35
	Medium	P8	25:23.2	14:43.5	00:12.9	01:06.1	00:39.0	1.72
		P4	19:50.1	11:38.1	03:02.8	00:22.3	00:37.1	1.70
		P6	18:21.4	11:21.1	02:34.3	01:08.5	00:11.6	1.62
		P2	15:24.1	10:43.4	07:48.4	02:22.6	00:45.5	1.44
	Low	P5	17:17.3	14:42.6	00:09.2	00:00.0	00:12.4	1.18
		P9	22:58.0	04:13.8	02:25.5	00:31.9	00:16.0	5.43
		P10	22:00.8	10:06.8	00:58.6	00:17.6	00:01.9	2.18

Table 10 – Exercise Timings End of Exercise The durations [measured in minutes and seconds] that each participant spent looking at or working on each line, the computer, the map containing the line locations, and the instructions [resources] at the end of the exercise. Low, Medium, and High reference to the experience group each participant was placed in. All of the participants allocated more time to work on Line-2. Table 10 shows a ratio of the time participants dedicated to Line-2 versus Line-4. Eight of the participants' ratios fell between 1.18 and 1.72, while P9 and P10 from the low experience group had ratios of 5.43 and 2.18 respectively. The other member of the low-experience group, P5, had the most balanced ratio of all participants at 1.18. However, this balanced was achieved by the participant switching lines at the half way point in the exercise. With the exception of one member of the medium-experience group, P2, and one member in the low-experience group, P5, all of the members in the high-experience group had more balanced Line-2 Line-4 ratios when compared to the other six participants. This may suggests that the most experienced group is able to better allocate their time among the primary resources of Line-2 and Line-4.

4. DISCUSSION

4.1 Experience, Expertise, and the Assessment of an Interpreter

The participants in this study are graduate-degree seeking geoscientists, all with at least a working knowledge of seismic interpretation [SI] and on a track to the oil and gas industry. Much of their knowledge relating to SI has been acquired in graduate school. The learning and cognition that takes place in graduate school is critical, as they are transitioning into a professional role in an industry where the use of SI in an integral component. Although none of participants in this study have significant experience in SI over the course of a career, different amounts of experience relating to SI were apparent. The experience and knowledge that participants have acquired in SI during graduation school comes through a combination of formal training and other coursework, the Imperial Barrel Award program [2.2 Locating the Researcher], industry experience, and through their theses in some instances.

The theoretical framework [ethnography] utilized in this study claims that an individual's knowledge cannot be directly studied, and learnings must come through direct observation of the participant (McCurdy et al., 2004). As such, this study makes the assumption that individuals with more experience are more likely to exhibit observable expert like qualities, as a result of their expertise in SI. Expertise is defined as the "characteristics, skills, and knowledge that distinguish experts from novices and less experienced people" (Ericsson, 2006b, p. 3).

While more experience does not necessarily guarantee that an individual has more expertise, making this assumption allows this study to use an expertise driven approach. There are two general research approaches used to study expertise: absolute and relative.

Simonton (1977) explains that absolute expertise is used to study those at the top of their field, but who have acquired their ability innately. More appropriate for this study, relative expertise was used to differentiate participants into the more experienced and the less experienced .

This approach requires that participants are sorted into groups based on their experience level with seismic interpretation. Prior to participation in the exercise, individuals were asked to evaluate their own experience with seismic interpretation, and given the option to choose expert, proficient, novice, and none. The self-assessment data generated in this study was considered as a method to sort participants into lower and higher experience groups. However, similar studies have found that self-assessments are not reliable. For example, a study by Davis et al. (2006) found that health care physicians are limited in their ability to perform an accurate self-assessment, and suggests that external qualifications provide a more reliable method to evaluate an individual’s ability.

Therefore, this study attempted to use the background data [Appendix III] and interview data [Appendix VI] to establish external qualifications. Six of the participants had taken a seismic interpretation course at the graduate level. All of these participants were placed into the high or medium-experience groups, as they have had formal training in the science. In contrast, the four lowest experienced individuals had not any formal training in a seismic interpretation course. However, this ‘formal training’ qualification does not necessarily mean that participants from the higher experience groups will produce more accurate or better interpretations than those in the lower experience groups. Rather, it simply provides an objective method to help sort participants by their experience level. A similar qualification was used to separate the high and medium-experience group. All of the high-experience individuals had seismic interpretation as part of their thesis or dissertation.

The experience-established groups [utilizing external qualifications] were compared back to individual's self-assessments. This study found that participants' self-assessments did not provide a reliable method to evaluate an individual's seismic interpretation experience and supports the use of external qualifications or measures.

4.2 Observations of Experience in Seismic Interpretation

The original codes produced in this study served as general descriptions, in order to broadly capture the actions, techniques, and the markings [on the seismic lines] that participants made during interpretation. These codes were analyzed for co-occurrences between the participants utilizing the experience groups designated in 4.1 Experience, Expertise, and the Assessment of an Interpreter. The findings of this investigation are discussed in the following sections.

4.2.1 Experience, the Holistic use of Resources, and Time

Participants in this study were asked to interpret two intersecting seismic lines and given thirty to forty-five minutes to complete the exercise. They were not provided with the geographical location or any additional information on the source of the lines. Besides the two paper lines, participants were provided with additional resources to aid in their interpretations. This included a map showing the intersection of the two lines [Figure 1], instructions, and a dual screen monitor with each seismic line in a PDF format.

As participants were videotaped working on their interpretations, the times that participants utilized each resource were also recorded and are displayed in Table 8, 9, and 10. At ten minutes elapsed into the exercise, the low-experience group displayed a 'one line at time' behavior. This is a behavior where each of the low-experience participants started on either line-2 or line-4 and continued to spend the majority of their time interpreting that one line. In contrast, members of the medium-experience and high-experience groups had much more evenly distributed times among the resources during that time interval.

Due to the theoretical framework utilized in this research, the researcher cannot directly access knowledge to why participants from the low-experience group displayed this behavior, as observations are the primary research tool of an ethnographic study. However, previous studies have found similar findings. Gilhooly et al. (1997) found that individuals with more knowledge and experience had a more opportunistic approach than their more novice counterparts, meaning that experts will use all of the available resources to solve a problem in their domain, and the less experienced will not.

The durations that participants engaged with the two primary resources [paper line-2 and line-4] were also analyzed and compared. A ratio of the time spent on line-2 to line-4 was calculated for the entirety of the exercise [Table 10]. Most notably all of the participants spent more time on working on line-2 [ratio is higher than 1], perhaps due to the more structural nature of the line. With one exception in the low-experience and one in the medium-experience group, the three members of the high-experience group had the lowest line-2 to line-4 ratios and the members of the low-experience group had the highest ratios. This suggests that more experienced seismic interpreters are better able to manage their time between the available seismic data.

As this study is unable to assess the reason why low-experienced participants didn't engage more with the other resources at the beginning of the exercise, this study is also unable to explain why the high-experience group distributed their time more evenly among the primary resources. However, the findings presented in this section do provide context for future studies as it poses the following questions: Is a more holistic use of resources a trained or learned behavior that one acquires with experiences in seismic interpretation? Does a more holistic use of resources produce better interpretation results? Does time distribution among the available seismic data affect interpretation outcomes?

4.2.2 Experience and Problem Solving Techniques

Participants were asked to interpret two seismic lines in this study, but were not provided with any additional instruction on what they were to actually interpret. This also means they were not asked solve a specific problem within the data. This was deliberate, because the researcher felt that the need to capture problem solving techniques through the naturalistic style of an ethnographic study in seismic interpretation at its most elementary level. Analyzing the basic techniques that are broadly applied during seismic interpretation will provide the framework for more advanced studies in this line of research.

One technique was only present among the high-experience group. This involved manipulating the viewing orientation to the paper lines to create vertical exaggeration, essentially changing the vertical to horizontal aspect ratio of the images (Stewart, 2012). The author explains that altering this can provide advantages for interpreting different stratigraphic and sedimentological features. P3 and P7 were the only participants to do this, even though manipulating the vertical exaggeration is a basic function within seismic interpretation software. Although it was apparent they were applying this technique during the exercise, it is not clear specifically which features P3 and P7 were attempting to examine within the seismic data. However, Lesgold et al. (1988) found that individuals with more experience were able to identify features that the less experienced cannot, and I reason that these subjects were using this technique to aid in the identification of additional or subtle features.

Another unique strategy was found among three participants where they appeared to give attention to the intersection between Line-2 and Line-4, which was already labeled on each line for the participants. Given the nature of an intersection, it inherently has more data control as it allows a participant to view that point in space in multiple directions. The intersection between the lines is a basic feature of the data but attention given to it is significant. This is because uncertainty in seismic data sets results in discrepancy between participants' interpretations. If seismic interpretation instruction can train interpreters to use the points in the data that contain the most data control this could lead to less variation in interpretation.

One other strategy was observed from a member of the high experience group, P3. Participant-3 folded both of the lines at the intersection and placed them against each other to make a three-dimensional model as he scanned the entirety of the images. P3 was not prompted to use this technique, and may be demonstrating spatial reasoning in assessing the data set. However, it is not clear if this is a trained or an innate ability used for analysis, and it is unknown what specifically P3 was using this technique to accomplish. Future studies should be conducted to understand the role of spatial reasoning in seismic interpretation.

In this section we have detailed three different techniques that were prominent in the high-experience group. Chi (2006) explains that individuals that have acquired a higher level of expertise will use the most appropriate strategies and techniques to problem solve within a given domain. While these techniques are associated with that experience-group, their presence alone in interpretation does not necessarily guarantee better interpretation results.

However, this study suggests that the presence of these techniques may serve as indicators of individuals with more seismic interpretation experience.

4.2.3 Experience and Interpretational Elements

The intent of this section is to discuss patterns between the designated experience groups from 4.1 Experience, Expertise, and the Assessment of an Interpreter and interpretation elements. Interpretation elements refer to the markings and words participants leave on the paper seismic lines as they work on their interpretations [3.2 Theme 2: Interpretation Elements]. The interpretational elements found in this study are drawn horizons, drawn vertical lines [fault sticks], the identification of features [this is where features are circled or drawn to with an arrow usually accompanied with writing], and writing (modified from Bond et al., 2012).

Drawing horizons is fundamental to the seismic interpretation process, as it is used to establish changes in reflector character or used to identify prominent reflectors in the data. All of the participants drew horizons with the exception of one participant from the medium-low and low-experience groups. Rather than draw horizons, both participants focused primarily on circling or identifying features of interest in the data. Essentially, both participants seem to be looking for features they have seen before in the seismic data and labeled them as such.

The vertical lines [faults] drawn in participant’s interpretations were also analyzed. However in contrast to drawn horizons, all ten participants drew vertical lines to represent faults they interpreted to be in the data, but the number of faults drawn was variable among the participants. An individual from the low-experience group drew 64 faults, 19 more than the next highest amount drawn. It appeared as if this participant spent most of his time during the exercise looking for and interpreting faults. This participant expressed familiarity with interpreting faults during his interview, and appeared to default to that task in this exercise, even asking for extra time to continue to interpret faults. While this type of repetitive behavior does not necessarily imply that the participant has low experience, it may be an indication that the individual lacks the skills and knowledge necessary to provide additional analysis of the data.

The interpreted lines were highly individualized with interpretational elements between the experience groups, with the most significant differences present in the writing element. However, it cannot be assumed that participants felt expressing their thoughts through writing to be equally important to the interpretation process. If this assumption was made, this would imply that the more experienced would likely produce more robust writing, as a result of their knowledge and experiences. In reality, a member from the high-experience group and two members from the low-experience group produced minimal writing in their interpretations. However, the reasons for the lack of writing could have different explanations.

Participant-9 and participant-10, members from the low-experience group, produced zero and one observation respectively in their interpretations. This is consistent with the research by Bond et al. (2011), who found that less experienced interpreters to have a more limited ability "to construct arguments, and thereby advocate their science". This finding was supported during the post-exercise interviews, as both of these participants expressed confusion about features in the seismic images. In contrast, the member of the high-experience group [Participant-3, who produced limited writing] used a more expansive [geoscience] vocabulary during the interview to explain what he did and did not know about the data. Participant-3's lack of writing instead appeared to be due to a lack of interest in interpreting the lines, as he quit interpreting with five minutes left in the exercise. Rather, it seemed that participant-3 spent his time tacitly analyzing all of resources provided to him. However, the true nature of the lack of writing remains unclear, but could be probed in future exercises through interviewing.

With regards to the participants who used more extensive writing in their interpretations, this study analyzed and categorized their written observations in Table 6 [i.e. not participant-3 from the high-experience group; not participant-9 or participant-10 from the low-experience group]. The findings indicated that the high and medium-experience groups used more observations on average, and exclusively produced observations that described reflector amplitude or characteristics of reflector packagers. However, all participants used the word 'reflector(s)' in their interviews, which may suggest that the more experienced participants understand the value of describing reflectors to strengthen their interpretations. The style of observations lead the researcher of this study to ask the following question: are participants with more experience/expertise thinking about the geological nature of the reflectors as they interpret the data?

4.3 Attention and Workflow in Seismic Interpretation

In order to make comparisons between individuals written and drawn interpretations, two rubrics were created [see 2 .7 Seismic Line Rubrics**]**. The rubrics are copies of the lines given to participants during the exercise with an overlay that gives names to the commonly interpreted features, horizons, reflector packages, and faults. As such the rubrics could only be created once all of the participants had produced their finished interpretations.

This crowdsourcing method [i.e. using the entirety of the participant data to look for patterns in interpretation] allows the participants to establish what the most prominent features in the data are. If the participants had been given a more specific problem to address in their interpretations, this may have skewed the results ultimately biasing the interpretation of features. Although the researcher attempted to minimize such bias, there is evidence that participants displayed their own bias is in how the data was viewed. For example, the data rubrics capture all of the features that participants believed to be seismic artifacts [Artifacts can be described as “misleading features that are easily misinterpreted as real geology” in the seismic data (Allmendinger, 2015, p. 250)]. Three of four geophysicists identified what they believed to be geophysical artifacts in the data, while one of six geologists accomplished the same, suggesting the influence of participants’ backgrounds.

So although it is believe participants view the data uniquely based on their experiences and background in seismic interpretation, the data rubrics still allowed to establish commonality [interpretations] for the seismic interpretation exercise in in this study (Bond et al., 2007). The results of this study show that the large vertically oriented low amplitude features 4D-D, 4D-F, and 2D-D [see external appendices: Line-4 Rubric & Line-2 Rubric] were identified most frequently and given the most attention. This came as expected, because they are quite visually apparent upon inspection of Line-2 or Line-4. The number of times the rest of features were identified is displayed in Table 4.

When the features that participants identified were compared among their designated experience groups no significant patterns presented themselves. Instead participants’ interpretations are highly unique, but it allows the researcher to see which features are identified more and less in the data. The researcher believes that the examination of entire seismic data set and its features is an important step in seismic interpretation, as the recognition of certain features may control the order and time-use during interpretation (e.g. participants who interpreted a fault, often then spent time looking for other faults in the data set).

The seismic data rubrics were also used to establish the order in which feature were identified. Table 7 displays this order with the most common features colored to help highlight patterns within the data. Eight out of the ten participants started on of the most interpreted five features, and there is a clear pattern among the participants showing that they worked on many of the commonly identified features toward the beginning of the exercise. Participants P1 and P8 did not display this behavior; instead they appeared to start by drawing horizons on Line-4 and Line-2 respectively. The most commonly interpreted features are more distributed in P1 and P8's exercises. Although the workflows that participants display are highly variable, the two patterns presented here suggest that individuals do have preferences in the order to how they work through the data. Bond et al. (2012) and Macrae et al. (2016) have also shown the existence of workflows that effective interpreters employ.

Although this study cannot assess the effectiveness of workflows applied to the seismic data, using the rubrics created in this study will allow for a more systematic way to capture individuals' workflows in interpretation and should be applied to future studies. However, because interpretations are variable as expertise is subjective, methods need to be designed to capture thought processes to elicit the knowledge that participants are using to assess the data.

5. CONCLUSIONS

The need for improving the quality and impact of instruction remains a priority of the geoscience education research community. Ultimately, the role of geoscience educators is to provide the skills and knowledge individuals need to be successful for the workforce. One of the tools that geoscience students are often exposed to in the workforce is called reflection seismology, in which reflected seismic waves interact with the subsurface to collect an array of quantitative data. That data is used to make predictions about the subsurface in a process called seismic interpretation.

This qualitative study was designed with the intention to record graduate-level geoscientists engaged in the process of seismic interpretation. As common with qualitative studies, the research is driven by initial research questions. The initial research questions helped to design the data collection and data analysis methods used in this study. However, in the style of a qualitative study the data should be analyzed with minimum bias, meaning that the findings should emerge naturally during data analysis. This often results in findings that may diverge from the original research questions.

All of the data generated in this study was viewed and coded multiple times searching for themes (patterns) in the data. During analysis of the background surveys and interviews, differences in experience-level in SI became evident. Participants were asked to describe their backgrounds in SI and to self-evaluate their experience-level. This study found that participants were not able to effectively self-evaluate their experience in regards to the other participants. As such, this study recommends external measures to select participants for a future studies. External measures were employed in this study in the form of academic qualifications, which were used to place participants into three groups based on their experience with SI: low-experience, medium-experience, and high-experience. Additional analysis of the data was compared to these groups to search for experience related trends. The study found the following during analysis:

1) Participants in the low-experience group were found to display a ‘one line at time’ behavior, where participants that started on a line continued to spend the majority of their time interpreting that same one line largely ignoring the other provided resources at the beginning of the exercise.
2) Participants with more experience were found to have more even time distribution with the provided resources throughout the duration of the exercise, adopting a more holistic approach. They were found to have a more even distribution of time spent on interpretation of the two provided seismic lines.
3) Participants with higher experience displayed several problem solving techniques [creating vertical exaggeration, focus on the intersection, and creation of a three-dimensional model] that were not present in the low-experience group [only had one occurrence in the medium-experience group]. This suggests that certain techniques may be indicators of more experience in seismic interpretation.
4) Observations written by participants appear correlated to experience. The medium-experience and high-experience groups used more observations on average, and the observations that the more experienced used often described the characteristics of reflectors. This suggests to the researcher that the more experienced participants understand the value of describing reflectors to strengthen their interpretations and science.

The researcher of this study also attempted to search for patterns with regards to what features participants were paying attention to and the workflows that participants employed as they moved through the seismic lines. This study found that:

5) ‘Crowd sourcing’ of participants interpretations allows the participants to establish the most prominent features in the seismic data, and can be used to develop a rubric to establish commonly identified features useful for analysis.
6) The examination of a seismic data set and its features is an important step in seismic interpretation, as the recognition of certain features may control the order and time-use during interpretation (e.g. participants who interpreted a fault, often then spent time looking for other faults in the data set).
7) Workflows are individualized and variable, and do not simply track with experience level. Developing independent means to capture thought processes in their problem solving approaches may uncover expertise better than a log of steps.

5.1 Implications and Future Work

This study set out to answer the following research questions: (1) How do individual geoscientists work through and interact with a seismic data set? (2) What techniques, practices, and strategies do individual geoscientists employ during seismic interpretation? (3) What variations do participants display in their actions, workflows, and interpretations throughout the seismic interpretation process? Answering these questions is crucial to improving the effectiveness and quality of instruction in seismic interpretation.

However, the reality is that seismic interpretation is a complex skill deeply rooted in expertise and experiences. It is likely that there are many workflows, strategies, and practices that different individuals employ in their interpretation, but this study was able to show a possible relationship between an individual's experience and certain techniques, actions, written observations, and as well as the way an individual distributes their time. All of these patterns should be retested with a larger population, and future studies should be designed to see if these patterns affect the quality and accuracy of interpretation.

Seismic interpretation is a vastly technical domain with significant differences in experience existing even among a population of graduate students. In order to see trends at these different levels of experience, and due to the inconsistency of self-assessment found in this study, external measurement should be considered as a way to gauge a participant's experience or expertise. Expertise is subjective, often changing depending on the context (Clancey, 2006). As such any method that aims to elicit expert knowledge and practices may be more or less applicable depending on the setting and domain (Hoffman & Lintern, 2006). Designing research methods that are able to capture the full breadth of thought processes and knowledge incorporated into effective seismic interpretation remains a priority going forward. This may involve the use of a data rubric, similar to the one designed in this study to capture the order and exact features that participants are working on.

Data analysis needs to take a more opportunistic approach, so that all of the meaning is able to be extracted from participants. This may involve different stages of interviewing during or after the exercise or by having participants explain their thought processes and strategies as they watch themselves interpret seismic. Another potential data source may involve the use eye-tracking to capture the attention of participants, especially as this research transitions into studies using three-dimensional seismic interpretation. Considering the nature of expertise, multiple methods of intervention with the participant should be taken into account in any study focused on individuals engaged in seismic interpretation. Future research into the practice of seismic interpretation hopes to provide instructors with new teaching methods and software advancements to improve the efficiency of training geoscientists.

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APPENDIX I

INSTITUTIONAL REVIEW BOARD (IRB)

This is an outcome letter documenting the approval of our study through IRB.

DIVISION OF RESEARCH

TEXAS A&M UNIVERSITY

Submission Approval DATE: October 25, 2016

MEMORANDUM

TO: Eric M Riggs
TAMU - College Geosciences - Geology And Geophysics

FROM: Dr. David Martin
Chair, TAMU IRB

SUBJECT: Approval for IRB Continuing Review Form REF: 046152

Study Number: IRB2015-0612D

Title: Qualitative Analysis of Uncertainty in Geoscience Interpretation

Initial Application Approval Date: 12/17/2015

Continuing Review Due: 09/15/2017

Expiration Date: 10/15/2017

Documents Reviewed and Approved: Only IRB-stamped approved versions of study materials (e.g., consent forms, recruitment materials, and questionnaires) can be distributed to human participants. Please log into iRIS to download the stamped, approved version of all study materials. If you are unable to locate the stamped version in iRIS, please contact the iRIS Support Team at 979.845.4969 or the IRB liaison assigned to your area.

Submission Components			
Study Document			
Title	Version Number	Version Date	Outcome
Recruitment Script	Version 2.1	09/28/2015	Approved
Recruitment Script	Version 2.0	09/28/2015	Void
Observation Protocol	Version 1.1	null	Approved
Observation Protocol	Version 1.0	null	Void
Interview Protocol	Version 1.1	09/23/2015	Approved
Interview Protocol	Version 1.0	09/23/2015	Void
RecruitScript	Version 1.3	09/23/2015	Approved
RecruitScript	Version 1.2	09/23/2015	Void
RecruitScript	Version 1.1	09/23/2015	Void
Interview Protocol	Version 1.1	09/23/2015	Approved
Interview Protocol	Version 1.0	09/23/2015	Void
Study Consent Form			
Title	Version Number	Version Date	Outcome
2016-17 consent form	Version 1.1	10/20/2016	Approved
2016-17 consent form	Version 1.0	10/20/2016	Void

750 Agronomy Road, Suite 2701
1186 TAMU
College Station, TX 77843-1186
Tel. 979.458.1467 Fax. 979.862.3176
http://rcb.tamu.edu

Document of Consent: Written consent in accordance with 45 CF 46.116/ 21 CFR 50.27

Comments:	• This IRB study application has been reviewed and approved by the IRB. Research may begin on the approval date stated above. • Research is to be conducted according to the study application approved by the IRB prior to implementation. • Any future correspondence should include the IRB study number and the study title.

Investigators assume the following responsibilities:

1. **Continuing Review:** The study must be renewed by the expiration date in order to continue with the research. A Continuing Review application along with required documents must be submitted by the continuing review deadline. Failure to do so may result in processing delays, study expiration, and/or loss of funding.
2. **Completion Report:** Upon completion of the research study (including data collection and analysis), a Completion Report must be submitted to the IRB.
3. **Unanticipated Problems and Adverse Events:** Unanticipated problems and adverse events must be reported to the IRB immediately.
4. **Reports of Potential Non-compliance:** Potential non-compliance, including deviations from protocol and violations, must be reported to the IRB office immediately.
5. **Amendments:** Changes to the protocol and/or study documents must be requested by submitting an Amendment to the IRB for review. The Amendment must be approved by the IRB before being implemented.
6. **Consent Forms:** When using a consent form or information sheet, the IRB stamped approved version must be used. Please log into iRIS to download the stamped approved version of the consenting instruments. If you are unable to locate the stamped version in iRIS, please contact the iRIS Support Team at 979.845.4969 or the IRB liaison assigned to your area. Human participants are to receive a copy of the consent document, if appropriate.
7. **Post Approval Monitoring:** Expedited and full board studies may be subject to post approval monitoring. During the life of the study, please review and document study progress using the PI self-assessment found on the RCB website as a method of preparation for the potential review. Investigators are responsible for maintaining complete and accurate study records and making them available for post approval monitoring. Investigators are encouraged to request a pre-initiation site visit with the Post Approval Monitor. These visits are designed to help ensure that all necessary documents are approved and in order prior to initiating the study and to help investigators maintain compliance.
8. **Recruitment**: All approved recruitment materials will be stamped electronically by the HRPP staff and available for download from iRIS. These IRB-stamped approved documents from iRIS must be used for recruitment. For materials that are distributed to potential participants electronically and for which you can only feasibly use the approved text rather than the stamped document, the study's IRB Study Number, approval date, and expiration dates must be included in the following format: TAMU IRB#20XX-XXXX Approved: XX/XX/XXXX Expiration Date: XX/XX/XXXX.
9. **FERPA and PPRA:** Investigators conducting research with students must have appropriate approvals from the FERPA administrator at the institution where the research will be conducted in accordance with the Family Education Rights and Privacy Act (FERPA). The Protection of Pupil Rights Amendment (PPRA) protects the rights of parents in students ensuring that written parental consent is required for participation in surveys, analysis, or evaluation that ask questions falling into categories of protected information.
10. **Food:** Any use of food in the conduct of human research must follow Texas A&M University Standard Administrative Procedure 24.01.01.M4.02.
11. **Payments:** Any use of payments to human research participants must follow Texas A&M University Standard Administrative Procedure 21.01.99.M0.03.
12. **Records Retention**: Federal Regulations require records be retained for at least 3 years. Records of a study that collects protected health information are required to be retained for at least 6 years. Some sponsors require extended records retention. Texas A&M University rule 15.99.03.M1.03 Responsible Stewardship of Research Data requires that research records be retained on Texas A&M property.

This electronic document provides notification of the review results by the Institutional Review Board.

APPENDIX II

EXTERNAL FILES

File Name	File Type	Description of File
Line-2 *	PDF	This was provided to participants for the interpretation exercise in paper and digital format
Line-4 *	PDF	This was provided to participants for the interpretation exercise in paper and digital format
Line-2 Rubric *	PDF	Data Rubric for Line-2 (see 2.7 Seismic Line Rubrics)
Line-4 Rubric *	PDF	Data Rubric for Line-4 (see 2.7 Seismic Line Rubrics)
P1 Line-2 *	PDF	Participant 1's interpretation of Line-2
P1 Line-4 *	PDF	Participant 1's interpretation of Line-4
P2 Line-2 *	PDF	Participant 2's interpretation of Line-2
P2 Line-4 *	PDF	Participant 2's interpretation of Line-4
P3 Line-2 *	PDF	Participant 3's interpretation of Line-2
P3 Line-4 *	PDF	Participant 3's interpretation of Line-4
P4 Line-2 *	PDF	Participant 4's interpretation of Line-2
P4 Line-4 *	PDF	Participant 4's interpretation of Line-4
P5 Line-2 *	PDF	Participant 5's interpretation of Line-2
P5 Line-4 *	PDF	Participant 5's interpretation of Line-4
P6 Line-2 *	PDF	Participant 6's interpretation of Line-2
P6 Line-4 *	PDF	Participant 6's interpretation of Line-4
P7 Line-2 *	PDF	Participant 7's interpretation of Line-2
P7 Line-4 *	PDF	Participant 7's interpretation of Line-4
P8 Line-2 *	PDF	Participant 8's interpretation of Line-2
P8 Line-4 *	PDF	Participant 8's interpretation of Line-4
P9 Line-2 *	PDF	Participant 9's interpretation of Line-2
P9 Line-4 *	PDF	Participant 9's interpretation of Line-4
P10 Line-2 *	PDF	Participant 10's interpretation of Line-2
P10 Line-4 *	PDF	Participant 10's interpretation of Line-4
Camera-2 POV	PDF	Camera 2’s Point of View of Experimental Setup
Camera-3 POV	PDF	Camera 3’s Point of View of Experimental Setup
*Reprinted from GeoPRISMS, 2015. Seismic reflection data from the ENAM Community Stacks and post-stack time migrations of MCS data produced at sea. Retrieved from: http://geoprisms.org/listserv-01-26-15		

APPENDIX III

BACKGROUND SURVEY

This is the survey given to participants to fill out just prior to the start of the exercise that collects a variety of background information.

Your Profile

Your Name ______________________

Job Title ______________________

Technical Specialty:

- Geologist
- Geophysicist
- Other

Are you:

- Male
- Female

I have worked in:

- Industry years exp: ________
- Academia years exp: ________

Education level:

- Masters
- Doctorate
- Post-Doc
- Faculty

My experience is dominantly in (tick 1) :

- **Extension**
- Inversion
- Thrust
- Salt
- Strike Slip
- Other ______________________

Seismic Interpretation Experience:

- Expert
- Proficient
- Novice
- None

Do you consider yourself a:	**YES**	**NO**
Structural Geologist		
Sedimentologist		

Students only:	**YES**	**NO**
Thesis involve seismic interp?		
Have you had an internship?		

If so with what company?

____

Modified from : GSA Data Repository Item 2007280
Bond et al., GSA Today v. 17, no. 10, doi: 10.1130/GSAT01710A.1
What do you think this is? "Conceptual uncertainty" in geoscience interpretation.

APPENDIX IV

SEISMIC EXERCISE CODES

This is the coded information from the participant exercise video recordings utilizing NVivo Software. This was used to make the frequency and workflow charts. The column Nnvivo # shows the order of the codes. The pencil and comp (computer columns) refer to any code where participants used computers or pencils. The feature column designates which feature the participants are working on, utilizing the line rubrics. This column also may dictate which component of the exercise they working on, as well as labels being made, gesturing, and other miscellaneous actions. The line (area) column refers to which line or area (line rubrics) is being worked on. The 'if unique' column was used if a feature being worked was unique to the participant and uses the line, shot number, and time to locate the feature. If writing accompanied a feature or was it used, its transcribed into the writing elements column, and the research notes column were additional comments the research made for the code.

The chart below is used for the feature column in the exercise video recordings.

A	Action
G	Gesture
LM	Locator map
C	Comp
ST	Stratal terminations
U	Markings not on key
F	Draws Faults
2H/4H	Misc Horizon
INS	Instructions
VER	Vertical Exaggeration
?	Obstructed View/cant tell
L	Label
INTER	Intersection
(ADD)	Adds to previously drawn
(AN)	Adds annotation after being drawn
(M)	drawn in pencil lines with marker

A - misc action
G - anytime hands are being used not to draw
LM - anytime the locator map is used
C - identify which line is being looked at
ST - refers to any indicator of terminating horizons
UNI - needs the line, shot, time
F - faults need their respective area from key
2H/4H - not on key
INSTR - anytime instructions is read
VERT - anytime vertical exaggeration is made
? - Participant gets in the way of the line/cant see
L - writes something not connected to a location
INTER - places line at intersection point

P1 Seismic Exercise Codes										
Nvivo #	Pencil	Comp	Feature	Line (Area)	if unique [line,shot,time]			Writing Element	Researcher Notes
2	X		L						labels line name
3			LM						switched lines physical location using locator map
4		X	C						
5			LM						
6		X	C	4					zooms
7			A	4					moves line 4 next to comp
11	X		4-H2	4					pen, not pencil (just small portion)
12			F	4A				artifact/possible fault	circles it
13		X	C	4					
13		X	4H-1	4			4.25		pen.
15			INS						
16			4-F10	4A				possible channel fill	cirlced
17			4H-1 (ADD)	4					
18		X	4H-2	4					pen.
19			U	4-left					labels 4-4.25 seconds as youngest package
20			A						checks phone
21			G						points with pen
21			4H	4			5		
22			U	4				pkg 2	lables 4.5-5 seconds line 4A as package 2
23			4H-7	4					pen
25			4H-6	4					pen (outline the low amp pck)
26			INS						
27			4D-D	4D				salt	outline
27			4D-F	4F				salt	outline
28			4H-7 (ADD)	4					
28			4H-6 (ADD)	4					

29		X	C	4					
30			4-F3	4C					change in bedding from planar deposits
32			L	4-left				4 large pkgs	
34		X	4-F9	4C					
35			U	4H	4	2350	8.75	thickening of 4th pkg	
36			4-F9 (pre)	4C				lens	
37			4-F7	4G				possible channel	no outline
38			U	4F	4	3050	4.5	disturbed sed due to salt movement up	
39			A						checks phone
40			U	4G	4	3300	4	lapping sed structure	
41		X	C	4					
42			LM						
43			F	4F					
44		X	C	4G					
45			L	4H				not a lot of structural deformation around salt	
46			4-F1	4E				lens	outline
47		X	C	4					
48			A						moves line back to original Table
49		X	C	2A					
52			INS						
53			2H-SB	2					
55		X	C	2					
56			2H-SB (ADD)	2					
57			G						vertical up and down motion with pen
58		X	C	2					
59			2D-D	2D					solid line-smaller area
60		X	2D-D (ADD)	2D				salt height (?)	dotted line-larger area
64			2H	2					near cap on 2D-D
65			U	2-right				pk1 palanar dep	
66			U	2B	2	3700	4	chaotic sed deposit	
67			G						tracing

68			2H-0	2					
70			ST	2					arrows on 2H-1
70			U	2	2	4150	4.25	large onlapping surface	
71			G						tracing
72			?	2	2	4150	4.25	hard ground over 20km (?) seems too long? Possible SL transgr	not sure where this is referencing
73			L	2				not much structural def around salt sed disturbance	
74		X	C	2					
75			2-F2	2B				possible small channels	upper portion of 2-F2
76			C	2					
77	X		2H +2H-SB	2					misc. horizons + what appears to be the SB
77			G						tracing. Does this after starting horizon in pen
77			U	2				pkg #2 chaotic near shore then pplanar deposit (turbidite flow? fast sed transport)	second pack description
78		X	C	2					
80			F	2E					
82			F	2E					
83			U	2H				large faulted area w/in package 2&3 not extend into pck 1	refering to 2E faulted area
84		X	C	2					
85			F	2G					
86			2H-2	2				pkg 3	bottom of pkg 3
87			2H-3	2					slightly lower than key
88			2H	2C					highlights several reflectors in a small area
89			U	2-F4				slumping zone	outlines with a dotted line
90		X	C	2					
91			F	2G					
93			2H-1 (pre)	2					finishes it

94			G						tracing
95		X	C	2					
96	X		F	2F					
97			2P-B	2					draws on internal reflectors
98		X	C						
99			U	2		intersection		could be due to salt	
99			U	2-right				chanel/slump @ intersept ~6 seconds twt	
104			A						points at intersection of lines on line-2
105			U	4		intersection		line-4A same chanel/slump @ intersept ~6 seconds twt"	
107			checks time						
108			End of P1						

P2 Seismic Exercise Codes									
Nvivo #	Pencil	Comp	Feature	Line (Area)	if unique [line,shot,time]			Writing Element	Researcher Notes
2			LM						
3			A/LM						looks over at line 2, then looks back at line 4A and locator. This repeats and then he makes some marks on the locater map
4			LM						
5	X		?	4					
6	X			2					
7			INSTR						
4-13			A						spends time looking at both lines
14			A						stares at blank comp screen
18		X	Comp	2					
19		X	A	2					Moves image 2 in front of computer
20			A						phone

21		X	A						using the computer looks at line-2 then folds paper in half picks it up and looks at line-2
22			A						puts paper 2 back on Table
24			INSTR						
26		X	Comp	2					goes back to computer image-2 and repositions paper line-2 in front of computer again
27		X	Comp	2					
28			A	2					moves line 2 back to Table
29		X	A	4					moves line 4 in front of computer
30		X	A	4					Uses computer and paper line-4A together on the same Table, makes what appear to be some interpretations and moves the images around on the screen
31			A	4					puts line 4 back
32		X	Comp	2					
33			LM or INSTR						
34		X	Comp	4					
35		X	LM						brings LM to comp
37			G						interaction with monitor
38		X	Comp						
39			F	2E					
41			2D-D	2D					circles it
43			4D-F						
46			2H-1	2		3700-4100			circles portion of it
47			ST	2C-2D					circles terminating horizons
48			2P-B	2F					circles it
49			ST	2D					terminating

									reflectors, circles
51			INSTR						
52			ST (x2)	4F					circles two groups of terminating beds
54			U	4E	4	2800	4.25		
56			4-F5	4B					circles it
58		X	Comp	4					
59			LM						
64			4P-A	4A					circles it
64			U	4A	4	1900-2000	4-5		circles
70			U	4E					
71									
72									
73			4-F2	4G	4	3200	6		
75			ST	4G	4	3200	4.25		ST
76			U	4E	4	2800	4.25		
79			2-F8	2A					circles
80			2-F6 (add)	2A					
81			2-F1	2B					circles
83			2H-1 (add)	2					
85			2P-A	2				quite undesturbed beds	
87		X	comp	2					
88			F	2G					
89			label	2	2	4200	7	faults	
90			label	2	2	4700-5000	4.5	faults	
91			2D-D	2				some dome salt or volcanic intrusion	
93			4D-F	4				volcanic intrusion or salt intrusion	
95			ST (AN)	2				terminating beds into an intrusion	on both sets around diapir
96			2H-1 (AN)	2				cross bed where many bed terminate against it	
97			2-F7	2F				terminating bed	
99			#52 #75 (AN)	4G				terminating beds	
100			4-F5, 4-F3	4B,4C				possible debris flow/slump	channels is more likely

101			4-F10	4A				terminating beds	missed where he circled this
102			A						asks for more time
103			4P-A, #64 (AN)	4				hyperbolies tell me that there was some issues w/ migration	more likely real geology
104			U (AN)	4A	4	2100-2300	5	migration issues	
106			4P-B,	4				a bumpy reflector possibly	
106			4-F9	4E				a bumpy reflector possibly	
107			U	4				bumpy terrain	no idea why he circled these and annotated them
108			4-F2 (AN)	4G				bumpy terrain"	
109			4D-F	4F				bad amp. Here. Why?	
110			U	4	4	2350	6.5	section of seds gets thicker here	
114			2-F5	2E				possible DHI?	
115			U	2-right	2	4500-5000	5	interesting	
118			U	4G	4	3300	6	DHI?	
121			2-F6 (AN)	2A				reflectors going up showing migration issues	
122			2-F8 (AN)	2A				interesting reflectors	
124			2-PB	2				bumpy terrain	
125			F	2G					
126			END P2						

P3 Seismic Exercise Codes									
Nvivo #	Pencil	Comp	Feature	Line (Area)	if unique [line,shot,time]			Writing Element	Researcher Notes
1			VERT	2					picks up line 2, then looks "down the image" in both directions

2			VERT	4					picks up line 4, then looks "down the image" left to right while rolling image to see certain parts
3			LM						
3			G						pointing
4-5			A	2&4 intersection					folds both lines at intersection
6			INTER						overlays line 2 on top of line 4A at their intersection point (long side of line 2)
7			INTER						overlays line 2 on top of line 4A at their intersection point (long side of line 4A)
8			A						places line 2 back in its original position
9-11			A						examining lines
12			INS						
15		X	C	2E					
17	X		F	2E					
18			INS						
19			F (M)	2E					marker
20		X	comp	2E					
20			G	2E					draws them in a with a guesture against the screen
21			F (M)	2E					fault hunting
22			F	2E					permanently draws in faults
23			2H-1	2					
25			LM						
26			G	4					pointing
28			4-F1	4E					outline
31			INTER						line-4A on top of line-2 at intersection point (long side of line-2)
32			4H-4	4					
32			4H-5	4					

33			INTER						4A on top of line-2 at intersection point (long side of line-2)
33			A (important)						Transfer outline of low amplitude chaotic reflectors to line-2 from line-4A
34			F	2E					
35		X	INTER	2					
36			A						picks up blue marker (non structual) examins line, draws over a preexisting drawn line, then looks around image more
37			U	on 4-H1	4	2200-2400			stratal terminations I believe
38			F	4F					
40			G						tracing pointing
41			A				`		stands up to look at both lines
42			INTER						4A on top of line-2 at intersection point (long side of line-4A) then stands up line-4A perpendicular to line-2, then positions it flat on top of line-2
45			G						traces diapir 4F
46			2D-D	2D				possible salt body	no outline
46			4D-F	4F					outline
47			LM						
48			4D-F (AN)	4F				possible salt body (pause) but where is the source im not convinced	
48			2D-D (AN)	2D				not convinced though... where is the salt layer it flows from	
49			F	2E					

51			G						makes guesture with whole hand has hand out and turns his palm up (confusion?)
52			G						multiple tracing guestures
53			G	4					double tapping low amplitude package
53			4H-6	4					
53			4H-7	4					
56			4-F10	4A					
59		X	comp	4					whole line and zooms in on 4D-F
60			4H-6 (ADD)	4					continues outling
60			4H-7 (ADD)	4					continues outling
62			LM						plus looks at lines
64			VERT	2					
65			A						
67			G	2E					pointing guesture
67			2-GS-2	2E				package affected by growth of body	
68			A						breAK
70			?						
71			G						tracing guesture
71			2H-1						
73		X	A						seems unengaged, kind of looking around at computer and line-4A
74			?						
75			4H	4				basement	
76			A						gets on phone
78			A						looks unengaged.phone then looks at line-4A
79			LM						looks at locator map, then unfolds line-2, then keeps looking at the two
80			END P3						

P4 Seismic Exercise Codes									
Nvivo #	Pencil	Comp	Feature	Line (Area)	if unique [line,shot,time]			Writing Element	Researcher Notes
1			INS						
2			4D-D	4D				#1 salt dome, shadow zone, velocity pull up, abrupt terminations of layers -> could also be mud diapir	outlines
2			4D-F	4F				see #1	outlines
4			2D-D	2D					outlines
5			2D-D (AN)	2D				observe: truncation of layers, upward bending of layers that were originally horizontal, lack of reflectors below 6 TWT @ CMP interpret: mud diapir or salt diapir24500,	actual interpretation
6			2H-1					#2 "truncating layers/reflectors - interprets to be stratigraphic pinch outs"	doesn't draw horizon, just draws the stratal termination arrows
7			LM/INS						
8			4-F1	4E				this is interesting, reflectors on bottom are *concave-use image* while ontop are *convex-opposite relationship* lack of reflections on interior, possibly a paleo river channel, although it looks too large w/ respect to c-d *refering to line 4A*	
9			4D-D & 4D-F	4					extends both diapirs
11			2-F2	2B				this looks like a fault, offset (cant read) reflectors, thickening of reflectors on down thrown block - interprets to be a growth fault"	int it as fault with directional arrows
12			2D-D (ADD)	2D					extends

									diapir
13			G						both hands indicating size
14			2-F8	2A				#4 this makes no sense, reflectors crossing -> bad migration" also linear waves with posmue(?) slope are interpreted to be water column waves b/c their move out should be	outlines these reflectors in several other places as well
15			2F-1	2B				#2	outlines feature and stratal terminatio n in area
16			2-F8 (AN)	2A				see #4	
17			F	2E					
19			F	2E				"#5" 5= Faults, offset between continous reflectors, had to determine if thrust or normal w/o basin hsitory but my guess is normal faults	
21			2-F5	2E				interesting isolated high amplitude impedance contrast, interpreted to be a faster denser rock or a much lower V and P or DHI"	circles it
23			4-F7	4G				another possible paleo river channel that was infilled during a transgression	
24			4-F6	4A				migration issues, edge of survey	
25		X	C						tries to log on, cannot
27			F	4A				fault	
31			2H-3	2E				#2	doesn’t draw horizon just arrows
33			U-Package	2F	2	4400-5000	5-5.5	very chaotic reflectors nonhorizontal reflectors thtat are discontinous possibly igneous rock scattering energy, mobilized sand	

								bodies after depoistion or bed migration. later is probably not it b/c the layers above, below, and to the left are horizontal	
35			4P-C	4				lack of reflectors interpret to be lithologies that dont differ much b//c no contrast in impedance	
37		X	C	4 & 2					pans on both images
38			2-F6	2A				poor migration plus didnt clip enough off"	appears he focused here because of comp image
39			2P-B	2				i dont know whats going on here	draws another stratal terminatio n, then wavy portion of horizon
41			2P-B					something is here b/c reflectors become (shape of upside U) but if could be from intrusion of deformation from surrounding area	outlines
42		X	C	4 & 2					
43			4-F7	on 4-H1				possible paleo fluvial channel	
44			END P4						

P5 Seismic Exercise Codes									
Nvivo #	Pencil	Comp	Feature	Line (Area)	if unique [line,shot,time]			Writing Element	Researcher Notes
			INS						
2			Unique	4A	4	1975	4.25	truncation	stratal termination on 4-H1
4			4D-F	4F				salt	no outline
5			Faults	4F				reverse faults	faults have motion indicated

6			4D-D	4D				salt	no outline
7			4-F1	4E				Hummocky cross stratification? Storm or salt lens	
8			4-F9	4C				hummocky cross stratification	outline
10			Gesture						tracing horizon
11			Unique	4B	4	2275	4.5	truncation of strata	stratal termination
12			Faults	4F				deformation anticline via salt	
14			4-F4	4F				organic accumulation	
16			Unique	4G	4	3250	4.25	toplap	stratal termination
17			Faults	4F				normal faults	
19			Unique	4A	4	2125	5.25	ripples	
20			4-F8	4C				salt deformation	only label
22			Unique		4	2350	6.75	flooding surface	how did she arrive at this
24			4-F3	4C				channel / sed flow	
30			2D-D	2D				salt post depositional	no outline
32			Unique	2B	2	3725	4	foreland buldge or equivalent	
35			Unique	2B-2C	2	INT	4.25	onlap	stratal termination
38			2-F3	2D				organic accum	
39			2F-2 (fault)	2B				normal fault	not sure if fault is reasonable int
40			2F-1	2B	2	3600	4.4		
42			G						pointing
43			F	2D					indication of motion
46			2-F3	2D				def. anticline struc.	
48			U	2E-2F	2	4550	7	flood surf.	on a horizon
50			U	4C	4	2525	4.1	max flood surface	on a horizon
53			U	4B	4	2350	6.75	flooding surface	on a horizon
56			U	2E-2F	2	4425	4.25	flooding surface	on a horizon
58			F	on 4-H1				normal fault	
60			2P-B	2F				large scale ripples - storm setting	
62			U	2B	2	3725	4.7	organics	refering to bright spot
63			#19 (ADD)	2B	2	3725	4		draws labeled feature #19
65			2F-1 (AN)	2B	2	3675	4.4	turbidite/debris flow	adds location additional to #40 & label
67			2P-B	2F				large scale ripples - storm setting	added the "storm setting"
69			F	2G					
70			G						tracing G

72			2H-1	2-right				likely an unconformity	labels the CCH
74			F	2E					direction indicated
77			F	2F					
79			F	2E					
80			G						tracing
82			G						complex - pen
85			LM						
87			U	2A	2	3400	4.5	shelf	
88			U	2H				basinal	
90			F	4C					
91			4P-C	4				salt	
94			L	4-below					labels something, crosses it out
96			F	4G					
98			G						tracing
98			U	4	4	2450	4.75	channel	refering to package
101			4-F3 (ADD)	4C					
107			G						tracing
114			F	2F					
116			INS						break
117			END P5						

P6 Seismic Exercise Codes									
Nvivo #	Pencil	Comp	Feature	Line (Area)	if unique [line,shot,time]			Writing Element	Researcher Notes
1			LM						
2		X	C						looks at lines, computer images
7			LM						
*			A						has spent time looking at both lines
8			L	4-above				current sed source (.)	indicating direction of sediment source
9			L	2-above				current sed source ->	indicating direction of sediment source

10			2D-D	2D					outline
11			F	2E					
12		X	C	2					looking for faults?
13			2H	2	2	4600-5000	8	SF multiple	circled
14			L	2-right				~4s ~8s	labeling time on right of image
16			2-F8	2A				wave diffraction artifacts	draws several more beyond 2-F8
18			O	2					stratal terminations on 2H-1
19			2H-1	2					dots middle portion of horizon
20			F	2D					
21			F	2E				faults	
22			2D-D (AN)	2D				material absorbs acoustic signals shape resembles salt dome?	
24			2-F1	2B				?	
25			2-GS-1	2C				reflectors are not straight any more, since they had to be flat during deposition, either they have experieinced the effects of subsidence or they are growth strata"	
26			2D-D (AN)	2				mfs	adds label
27			2H	2				strong reflector	appears chose it bc it was a strong reflector
28			2H-SB	2					
29			L	2I				sea	
29			2H-0	2				seafloor	not drawn, identified
30			2H-SB (AN)	2				slope break	
31			U	2A	2	3450	3	cont shelf	

32			U	2					connects slope break to previous horizon
34			U	2F	2	4700-5000	6-7s		circles several vertical low amp features
35			2H	2				acoustic basement	
36			2H #13 (ANN)	2E					circles #13
37			U	on 4-H1	2	4200	6	?	horizontal line along reflector (similar to below)
37			2-F7	2G				?	(above)
39			2H-3	2				strong reflector	
40			2H-2	2				why is this wavy?	
42			L					alay	????? Don't know what this is
43			A	4					switches to line 4A for first time
45		X	C	4					pans
46			4-F10	4A				onlap channel	
47			4-F3	4C				channel?	
48			U	4F	4	3025	4.25	wedging of strata mark time of salt movement?	
49			4D-D	4D				into the page salt diapir	
50			A						picks up line 4A while looking at 2. then puts it down looks at locator map, then draws on locator map. do not have this data for locator map on paper
51			4D-F	4F					outlines, identified all other similar structures as

									salt. why not this one?
52			4-F10	4A				channel	
53			G						tracing
54			4H-6	4					does this in 3 segments, starting with the most contrasted portion in the middle
55			4H	4				basement	
56			4H-6 (AN)					strong reflector	
57			2H (AN)	2				strong reflector	does this for two lines
58			4-F4	4F					just highlights the cap
59			4H-2	4					related to #58
60			A	Intersection					seems to be looking at intersection points on both lines
61			2H-1	2-Intersection	2	INTER	4.25		at the intesection point, annotates "horizon w/ channel on line D-C
62			A						
63			F	4A					
64			L	4-above					* faults are indicated by lateral terminations of seis. reflectors
65			U	4F	4	3000	4.25	toplap -> unconformity	break
66			U	4A	4	2150	4.25		draws more arrows indicating truncations near surface
67			2H-0	4					a couple reflectors down from the true sea bottom

68			U	4J	4	3300	3.5	poor filtering?	
71			U	4 & 2					draws wavy line (not following reflectors" on line-4A, then immediately on line-2. doesnt explain this, and its not possible to tell if they are related
72			L	2-above				very few faults… relatively passiv margin?	
73			F	2G					
74			#34 (AN)	2F				gas chimneys	on vertical circled features
75			4P-C	4				? & why such poor reflections here?	
76			G						
77			END P6						

P7 Seismic Exercise Codes									
Nvivo #	Pencil	Comp	Feature	Line (Area)	if unique [line,shot,time]			Writing Element	Researcher Notes
1			instructions						
2	X		2D-D	2D					
2	X		F	2E					
3			VERT	2					positions his head near the Table looking east west line-2 (to see vertical ex)

4	X		stratal term	on 2H-1					
5			VERT	2					positions his head near the Table looking east west
6	X		stratal term	on 2H-1					
7			VERT						positions his head near the Table looking east west
9			locator map						looks at lines while looking at it
10	X		4D-F	4F					outline
10	X		4D-D	4D					outline
11			G						hand
12	X		stratal term	on 2H-1					
14	X		4-F1	4E					outline
15	X		stratal term	4					
18			VERT						he puts his head near the paper looking south north to see vertical ex. Twice
19			instructions						
21			4D-F (pre)	4F					marker
21			4D-D (pre)	4D					marker
22			locator map						
23			2D-D (pre)	2D					marker
24			F	2E					
24			fault	2B					
25			instructions						
26			ST (pre)	on 2H-1					marker
27			INSTR/LM						
28			2H-1	2					draws along the cross cutting horizon for a small portion stops, then focus on the right of the CCH. Then draws in the rest slowly.
30			ST	4F					
31			ST	4A on 4-H1					

32			G						guesture- hand for confusion?
33			INSTR	on 4-H1					
34			4-F1 (pre)	4E					
35			4-F3	4C					
35			4-F5	4B-4C					
36			ST	4F					
37			LM						
38			U	2-right	2	4500-5000	5.5	chaotic ref package	label for package
40			VERT	2					creates vertical Ex by looking down image east-west
40			2H-1 (pre)	2					finishes line
41			2H	2				more cont, parallel, high amp	draws horizon above CCH serperating reflector behavior
42			L	2-right				less amp, some chaotic	
43			2H-2	2					
43			2H-3	2					
44			L	2-right				med-lo amp to chaotic	
45			2P-B	2				med amp undulating"	
46			LM						
46			L	2-above				~90km	
47			2-F1	2B					
49			L	4-left				chaotic ref	to the right of an outlined package
50			4-H6	4					
50			4-H7	4					
50			4P-C	4				Lo amp	
51			4-F3	4B-4C				chaotic	
51			4-F5	4C				truncations some chaotic channel	
52			U	4F	4	3050	5	hi amp" & "low amp/chaotic "chimneys	outlines vertical low amp features
53			L	4				onlap	3x for arrows drawn earlier
54			INSTR						break
55			2-F1 (pre)	2B				chaotic hedge	
56			2-GS-1	2C				growth strata	
57			2-F3	2D				hi amp cap	outlines whole feature

58			A						checks time
59			2-F4	2B				abrupt reflector termination	draws vertical line here
61			2D-B	2B					outline
62			U	2F	2	4850	6.5	?	outlines two vertical features
63			L (add)	2-right				package wedges out	add refering to #38
64			U	2E	2	4000	5	lateral amp loss	circles area next to diapir
66			4H-4	4					
66			4H-5	4					
66			2P-B	4				low-amp chaotic zone	
67			VERT	4					looks down image 4A to see vertical ex.
68			4P-D	4				lo amp chaotic	outlines
69			END P7						

P8 Seismic Exercise Codes									
Nvivo #	Pencil	Comp	Feature	Line (Area)	if unique [line,shot,time]			Writing Element	Researcher Notes
1			INSTR						
2			LM						
4			L						labels orientations on both lines
5			LM						
5			G						tapping
6		X	C						
7			LM						
8			2-F6	2A					outlines curved feature
9			G						tracing
10			2H-0	2					
10		X	C						
12	X		U	2	2	3850	4.5		tracing reflector pattern
13	X		2H-SB	2					
14	X		2H-3	2					
18			2H	2					hard to tell what horizon

19	X		2D-D	2D					
20	X		4-F1	4F					
22	X		F	2D					
23	X		2D-D (ADD)	2D					reoutlines???
26	X		F	2E					
26	X		F	2B					
26	X		F	2E					
29			A						switches to line-4A, then does more pencil guesturing or marking switches to line-4A, then does more pencil guesturing or marking … randomly stops, picks up maker, and then switches to line-2
30			F	2E					marker
30			F	2C					marker
31			F	4A					marker
33			F	4F					
33			F	4G					
34			F	4D					
36			F	4C					
37			2-F6 (M)	on 4-H1					curved features outlined in marker
44			2H						tracing
38			2H-1	2					
39			2H	2					above 2H-1
40			2H	2					above 2H-1
41			ST	on #39	2			onlap	
42			L	on 2H-0				water bottom large impedance	
43			2H-SB	2A					marker dotted line on angled portion
44			2H	2A					runs 200 shots in length
45			2D-D	2D					marker, partial outline is dotted
46			F	2D					
46			F	2E					
47			2-GS-1	2C				growth strata	highlights two reflectors to show GS
48			2H	2					

48			ST	2				onlap	drawns on #48
49			2H-SB (ADD)	2					draws it across the line
50			2H	2					intersects faults
50			F	2E					
51			2H	2					partial horizon
53			4D-F	4F					
53			4D-D	4D					
54			F	4F					
56			F (ADD)	4				(draws arrows on fautls)	
57									
58									
59									
60			2-H2						break
62			ST	4				onlap	
63			U	4					two vertical lines. Faults?
64			U	4G			4.25		series of 45 degree lines. Clinoforms?
65									
66			L	4F				salt? volcanics? no internal contrast of density?	lables 4D-F
67			L	4D				salt?	labels 4D-D
68			L	2D				salt? volcanics	labels 2D-D
69			4-H7	4					uses dotted lines in portion where its not clear…..he pauses before he does this (IMPORTANT)
70			U	2	2	4400	5	clinoforms	
77			L	on 2-F6				channels? erosional features"	
72			L	on 4-F1				MTD?	
73			2H						
74			G						
75			A	4				speaks "this doesnt make sense"	while pointing to low amplitude feature
69				4E				MTD?	not sure when he did this
70			END P8						

P9 Seismic Exercise Codes									
Nvivo #	Pencil	Comp	Feature	Line (Area)	if unique [line,shot,time]			Writing Element	Researcher Notes
1			INS						
4			2D-D	2D				salt diapir	outline
5			F	2E					
6			F	2E					
7			2H-1	2				multipe	wrongly annotated, not a multiple
8			F	2E					
9			G						frustration? Then speaks into camera
12			LM						
14		X	C	2E					examining computer
15			2P-B	2E					draws on one wavy reflector
17			LM	4					
18			4D-F	4F					outline
19			F	4A					
20			F	4F					
21			4D-D	4D					
24			2D-D (add)	2D				gas chimney or salt attenuation?	arrow points to top of the feature
26			2P-B (add)	2E					draws on more wavy shaped horizons
28			2-F7	2F				unconformity? Termination of beds	his only actual interpretation supported by observation
30			F	2E					
31			2D-B	2B					outline
32			2P-B (add)	2E					draws on one wavy reflector
36		X	C	2					zooming panning, back and forth
37			2H-1 (add)	2					adds more to CCH
39		X	C	2					
41			F	2E					
42			END P9						

P10 Seismic Exercise Codes									
Nvivo #	Pencil	Comp	Feature	Line (Area)	if unique [line,shot,time]			Writing Element	Researcher Notes
3			LM						
4			L						labels A-B on line 2 using locator map
6	X	X	2H-1	2					does this in segments
7			G						tracing guesture on horizon
8			2H-1 (M)	2					marker
9	X	X	2H-1 (ADD)	2					
10	X		2H-1 (ADD)	2					starts in pencil. Finishes in marker
11			2D-D	2D					outlines
12			F	2D					
13			F	2E					
14			2H-1 (ADD)	2					
15			U	2B-2C	2	3900	4.25		line (probably indicating termination)
19			F	4A					
20	X		4H-1	4					pause
21			4H-1 (M)	4					marker
22			4-F3	4C					larger than the key's 4-F3
23			?	4E					appears to first box off somes areas
23			F	4E					
24			F	4F					
29	X		H-U	2					trying to sort out how a horizon goes across line
31			F	2E					
32			F	2F					
34			G						tracing guesture with pencil
35	X		?	2					pencil marks but cant sort out where
36			F	2E					
37			U	2B-2C	2	3900	4.25		line (probably indicating termination)
38	X		2H-3	2					
39			2H-3 (M)	2					marker

41			A						aks for more time
42	X		2H-2	2					pencil then marker
43			F	on 4-H1					
44			2H-2 (M)	2					markers over pencil, finishes with marker
45	X		2H	2					horizon unique his interperation
46			F	2F					to the right of the other 2F cluster
47	X		2H #45 (M)	2					continues with #45 in pencil, then markers it
48	X		4H-6	4					
49			4-F1						outline
50			4-F2						outline
51			4-F9						outline
52			4H-6 (M)	4					marker
52			4H-7						
53			END						
53			4D-D						outlined after interview starts
54			END P10						

APPENDIX V

TIMING CHARTS

The duration of times participants spent engaged with the different exercise components are recorded in the following charts. (minutes:seconds)

P1 Exercise Timings							
Start	End	Duration	Line-2	Line-4	Comp	Map	Instructions
00:00.0	00:37.5	00:37.5					
00:37.0	00:49.0	00:12.0					00:12.0
00:49.0	01:23.6	00:34.6					
01:23.6	01:32.4	00:08.8				00:08.8	
01:32.4	01:35.1	00:02.7		00:02.7			
01:35.1	01:43.6	00:08.5	00:08.5				
01:43.6	02:06.1	00:22.5					
02:06.1	02:09.1	00:03.0			00:03.0		
02:09.1	02:10.1	00:01.0	00:01.0				
02:10.1	02:13.1	00:03.0				00:03.0	
02:13.1	02:43.6	00:30.5			00:30.5		
02:43.6	02:50.0	00:06.4				00:06.4	
02:50.0	02:54.5	00:04.5		00:04.5			
02:54.5	02:59.0	00:04.5				00:04.5	
02:59.0	03:08.4	00:09.4		00:09.4			
03:08.4	03:17.2	00:08.8	00:08.8				
03:17.2	03:53.7	00:36.5					
03:53.7	04:01.7	00:08.0			00:08.0		
04:01.7	04:21.6	00:19.9					
04:21.6	04:32.5	00:10.9		00:10.9			
04:32.5	04:33.5	00:01.0			00:01.0		
04:33.5	04:57.5	00:24.0		00:24.0			
04:57.5	05:03.7	00:06.2			00:06.2		
05:03.7	05:25.7	00:22.0		00:22.0			
05:25.7	05:27.2	00:01.5			00:01.5		
05:27.2	05:34.7	00:07.5					00:07.5
05:34.7	07:56.4	02:21.7		02:21.7			
07:56.4	08:01.2	00:04.8					00:04.8
08:01.2	08:43.2	00:42.0		00:42.0			
08:43.2	09:03.5	00:20.3			00:20.3		
09:03.5	12:19.3	03:15.8		03:15.8			
12:19.3	12:29.2	00:09.9			00:09.9		
12:29.2	12:32.0	00:02.8				00:02.8	

12:32.0	12:39.4	00:07.4		00:07.4			
12:39.4	12:46.6	00:07.2			00:07.2		
12:46.6	13:22.0	00:35.4		00:35.4			
13:22.0	13:32.5	00:10.5			00:10.5		
13:32.5	13:40.2	00:07.7	00:07.7				
13:40.2	13:58.1	00:17.9			00:17.9		
13:58.1	13:59.0	00:00.9	00:00.9				
13:59.0	13:59.9	00:00.9			00:00.9		
13:59.9	14:09.3	00:09.4	00:09.4				
14:09.3	14:14.1	00:04.8				00:04.8	
14:14.1	14:50.1	00:36.0	00:36.0				
14:50.1	14:53.3	00:03.2			00:03.2		
14:53.3	15:17.1	00:23.8	00:23.8				
15:17.1	15:18.7	00:01.6			00:01.6		
15:18.7	15:44.6	00:25.9	00:25.9				
15:44.6	15:46.9	00:02.3		00:02.3			
15:46.9	17:38.5	01:51.6	01:51.6				
17:38.5	17:42.7	00:04.2					00:04.2
17:42.7	19:12.4	01:29.7	01:29.7				
19:12.4	19:15.1	00:02.7			00:02.7		
19:15.1	19:28.1	00:13.0	00:13.0				
19:28.1	19:38.4	00:10.3			00:10.3		
19:38.4	21:03.1	01:24.7	01:24.7				
21:03.1	21:12.4	00:09.3			00:09.3		
21:12.4	21:15.4	00:03.0	00:03.0				
21:15.4	21:16.0	00:00.6			00:00.6		
21:16.0	21:35.2	00:19.2	00:19.2				
21:35.2	21:37.9	00:02.7			00:02.7		
21:37.9	21:38.5	00:00.6	00:00.6				
21:38.5	21:41.9	00:03.4			00:03.4		
21:41.9	22:32.7	00:50.8	00:50.8				
22:32.7	22:42.9	00:10.2			00:10.2		
22:42.9	25:21.0	02:38.1	02:38.1				
25:21.0	25:30.9	00:09.9			00:09.9		
25:30.9	26:26.7	00:55.8	00:55.8				
26:26.7	26:29.9	00:03.2			00:03.2		
26:29.9	26:31.1	00:01.2	00:01.2				
26:31.1	26:37.8	00:06.7			00:06.7		
26:37.8	26:42.3	00:04.5	00:04.5				
26:42.3	26:45.4	00:03.1			00:03.1		
26:45.4	26:48.6	00:03.2	00:03.2				

26:48.6	26:49.3	00:00.7			00:00.7		
26:49.3	26:59.0	00:09.7	00:09.7				
26:59.0	27:01.6	00:02.6			00:02.6		
27:01.6	27:38.1	00:36.5	00:36.5				
27:38.1	27:39.3	00:01.2			00:01.2		
27:39.3	29:04.7	01:25.4	01:25.4				
29:04.7	29:33.0	00:28.3		00:28.3			
29:33.0	29:36.0	00:03.0	00:03.0				
29:36.0	29:39.6	00:03.6		00:03.6			
29:39.6	29:45.7	00:06.1	00:06.1				
29:45.7	29:52.7	00:07.0		00:07.0			
29:52.7	29:54.0	00:01.3	00:01.3				
29:54.0	29:57.5	00:03.5		00:03.5			
29:57.5	29:59.3	00:01.8	00:01.8				
29:59.3	30:23.1	00:23.8		00:23.8			
30:23.2	30:29.5	00:06.3	00:06.3				
30:29.5	30:31.7	00:02.2		00:02.2			
30:31.7	30:34.9	00:03.2	00:03.2				
30:34.9	30:35.9	00:01.0		00:01.0			
30:35.9	30:57.0	00:21.1	00:21.1				
30:57.0	31:06.1	00:09.1					
31:06.1	31:09.3	00:03.2		00:03.2			
31:09.3	31:19.9	00:10.6	00:10.6				
31:19.9	31:31.0	00:11.1					

P2 Exercise Timings							
Start	End	Duration	Line-2	Line-4	Comp	Map	Instructions
00:00.0	00:36.3	00:36.3				00:36.3	
00:36.3	02:45.6	02:09.3					
02:45.6	02:52.7	00:07.1			00:07.1		
02:52.7	02:56.3	00:03.6	00:03.6				
02:56.3	03:01.5	00:05.2			00:05.2		
03:01.7	04:37.4	01:35.7					
04:37.4	05:21.6	00:44.2		00:44.2			
05:21.6	05:26.1	00:04.5				00:04.5	
05:26.1	05:34.3	00:08.2		00:08.2			
05:34.2	05:56.1	00:21.9				00:21.9	
05:56.1	05:57.5	00:01.4	00:01.4				
05:57.5	06:00.6	00:03.1				00:03.1	
06:00.6	06:05.0	00:04.4	00:04.4				
06:05.0	06:07.4	00:02.4				00:02.4	

06:07.4	06:09.0	00:01.6	00:01.6				
06:09.0	06:19.7	00:10.7				00:10.7	
06:19.7	06:21.6	00:01.9		00:01.9			
06:21.6	06:31.0	00:09.4				00:09.4	
06:31.0	06:34.3	00:03.3		00:03.3			
06:34.3	06:43.5	00:09.2				00:09.2	
06:43.5	06:58.7	00:15.2		00:15.2			
06:58.7	07:04.4	00:05.7	00:05.7				
07:04.4	07:19.2	00:14.8					00:14.8
07:19.2	07:38.8	00:19.6		00:19.6			
07:38.8	07:39.9	00:01.1	00:01.1				
07:39.9	08:01.2	00:21.3		00:21.3			
08:01.2	08:03.8	00:02.6				00:02.6	
08:03.8	08:08.7	00:04.9	00:04.9				
08:08.7	08:13.0	00:04.3				00:04.3	
08:13.0	08:16.9	00:03.9					00:03.9
08:16.9	08:18.2	00:01.3		00:01.3			
08:18.2	08:25.6	00:07.4					00:07.4
08:25.6	08:29.4	00:03.8		00:03.8			
08:39.5	08:56.1	00:16.6					
08:56.1	09:15.5	00:19.4	00:19.4				
09:15.5	09:16.4	00:00.9		00:00.9			
09:16.4	10:00.1	00:43.7	00:43.7				
10:00.1	11:03.7	01:03.6			01:03.6		
11:03.7	11:15.3	00:11.6	00:11.6				
11:15.3	11:26.9	00:11.6			00:11.6		
11:26.9	11:35.4	00:08.5	00:08.5				
11:35.4	11:48.0	00:12.6					
11:48.0	12:06.7	00:18.7			00:18.7		
12:06.7	13:37.3	01:30.6	01:30.6				
13:37.3	13:37.4	00:00.1					
13:37.3	13:48.2	00:10.9					00:10.9
13:48.2	13:58.4	00:10.2	00:10.2				
13:58.4	13:59.2	00:00.8			00:00.8		
13:59.2	14:06.2	00:07.0	00:07.0				
14:06.2	14:18.4	00:12.2			00:12.2		
14:18.4	14:21.9	00:03.5	00:03.5				
14:21.9	14:24.6	00:02.7			00:02.7		
14:24.6	14:36.7	00:12.1	00:12.1				
14:36.7	14:38.2	00:01.5			00:01.5		
14:38.2	14:54.8	00:16.6	00:16.6				

14:54.8	14:58.2	00:03.4			00:03.4		
14:58.2	15:23.7	00:25.5	00:25.5				
15:23.7	15:25.8	00:02.1			00:02.1		
15:25.8	15:39.7	00:13.9	00:13.9				
15:39.7	15:45.8	00:06.1			00:06.1		
15:45.8	16:26.9	00:41.1	00:41.1				
16:26.9	16:39.3	00:12.4					
16:39.3	16:56.3	00:17.0			00:17.0		
16:56.3	17:09.1	00:12.8	00:12.8				
17:09.1	17:20.1	00:11.0			00:11.0		
17:20.1	17:29.5	00:09.4	00:09.4				
17:31.5	18:11.5	00:40.0			00:40.0		
18:11.5	18:24.4	00:12.9					
18:24.4	19:53.9	01:29.5			01:29.5		
19:53.9	19:55.1	00:01.2		00:01.2			
19:55.1	20:28.1	00:33.0			00:33.0		
20:28.1	20:36.1	00:08.0					
20:36.1	20:50.0	00:13.9			00:13.9		
20:50.1	20:55.4	00:05.3					00:05.3
20:55.4	20:56.8	00:01.4				00:01.4	
20:56.8	21:21.6	00:24.8			00:24.8		
21:21.6	21:26.8	00:05.2				00:05.2	
21:26.8	21:53.7	00:26.9			00:26.9		
21:54.2	22:55.5	01:01.3					
22:55.5	23:17.4	00:21.9			00:21.9		
23:17.4	23:18.2	00:00.8		00:00.8			
23:18.2	23:21.1	00:02.9			00:02.9		
23:21.1	23:21.2	00:00.1					
23:21.1	23:24.2	00:03.1			00:03.1		
23:24.2	23:26.1	00:01.9				00:01.9	
23:26.1	23:34.2	00:08.1			00:08.1		
23:34.2	23:35.7	00:01.5	00:01.5				
23:35.7	24:00.1	00:24.4			00:24.4		
24:00.1	24:34.8	00:34.7	00:34.7				
24:34.8	24:35.9	00:01.1					00:01.1
24:35.9	25:01.3	00:25.4	00:25.4				
25:01.3	25:39.8	00:38.5		00:38.5			
25:39.8	26:56.9	01:17.1	01:17.1				
26:56.9	28:15.7	01:18.8		01:18.8			
28:15.7	28:19.5	00:03.8			00:03.8		
28:19.5	28:22.6	00:03.1				00:03.1	

28:22.6	28:33.1	00:10.5				00:10.5	
28:33.1	28:36.8	00:03.7				00:03.7	
28:36.8	28:42.2	00:05.4		00:05.4			
28:42.2	28:54.6	00:12.4				00:12.4	
28:54.6	29:05.7	00:11.1		00:11.1			
29:05.7	29:22.6	00:16.9	00:16.9				
29:22.6	30:49.9	01:27.3		01:27.3			
30:49.9	31:24.7	00:34.8	00:34.8				
31:24.7	31:26.8	00:02.1					00:02.1
31:26.8	32:02.1	00:35.3	00:35.3				
32:02.1	32:15.2	00:13.1			00:13.1		
32:15.2	33:19.6	01:04.4	01:04.4				
33:19.6	33:43.3	00:23.7		00:23.7			
33:43.3	35:11.3	01:28.0	01:28.0				
35:10.8	36:33.0	01:22.2		01:22.2			
36:33.0	36:41.2	00:08.2					
36:41.2	39:25.7	02:44.5		02:44.5			
39:25.7	40:46.0	01:20.3	01:20.3				
40:46.0	41:16.1	00:30.1		00:30.1			
41:15.9	43:12.9	01:57.0	01:57.0				

P3 Exercise Timings							
Start	End	Duration	Line-2	Line-4	Comp	Map	Instructions
00:00.0	00:20.2	00:20.2					
00:20.2	00:51.1	00:30.9	00:30.9				
00:51.1	01:27.3	00:36.2		00:36.2			
01:27.3	01:38.5	00:11.2				00:11.2	
01:38.5	01:39.8	00:01.3		00:01.3			
01:39.8	01:41.8	00:02.0				00:02.0	
01:41.8	01:45.7	00:03.9	00:03.9				
01:45.7	02:01.4	00:15.7				00:15.7	
02:01.4	02:04.4	00:03.0		00:03.0			
02:04.4	02:06.1	00:01.7				00:01.7	
02:06.1	02:45.2	00:39.1	00:39.1				
02:45.2	03:17.5	00:32.3		00:32.3			
03:17.5	04:43.3	01:25.8					
04:43.3	04:47.0	00:03.7	00:03.7				
04:47.0	04:52.1	00:05.1		00:05.1			
04:52.1	04:52.7	00:00.6	00:00.6				
04:52.7	04:56.7	00:04.0		00:04.0			
04:56.7	04:59.9	00:03.2	00:03.2				

04:59.9	05:07.1	00:07.2					00:07.2
05:07.1	05:15.4	00:08.3	00:08.3				
05:15.4	05:18.3	00:02.9		00:02.9			
05:18.3	05:34.5	00:16.2			00:16.2		
05:33.8	07:47.4	02:13.6	02:13.6				
07:47.4	08:04.4	00:17.0			00:17.0		
08:04.4	09:15.8	01:11.4	01:11.4				
09:15.8	09:31.4	00:15.6		00:15.6			
09:31.4	09:44.5	00:13.1				00:13.1	
09:44.5	09:58.4	00:13.9	00:13.9				
09:58.4	10:17.3	00:18.9		00:18.9			
10:17.3	10:18.5	00:01.2	00:01.2				
10:18.5	10:24.2	00:05.7		00:05.7			
10:24.2	10:38.6	00:14.4					
10:38.6	11:28.2	00:49.6		00:49.6			
11:28.2	11:43.3	00:15.1					
11:43.3	11:59.5	00:16.2	00:16.2				
11:59.5	12:04.0	00:04.5			00:04.5		
12:04.0	12:05.2	00:01.2	00:01.2				
12:05.2	12:12.7	00:07.5			00:07.5		
12:12.7	12:39.0	00:26.3	00:26.3				
12:39.0	13:34.8	00:55.8		00:55.8			
13:34.8	13:36.6	00:01.8	00:01.8				
13:36.6	13:43.8	00:07.2		00:07.2			
13:43.8	13:51.3	00:07.5	00:07.5				
13:51.2	14:29.1	00:37.9					
14:29.1	14:46.3	00:17.2		00:17.2			
14:46.3	15:13.3	00:27.0	00:27.0				
15:13.3	15:27.3	00:14.0		00:14.0			
15:27.2	15:46.1	00:18.9	00:18.9				
15:46.1	15:52.0	00:05.9		00:05.9			
15:52.0	15:57.0	00:05.0				00:05.0	
15:57.0	15:59.4	00:02.4					00:02.4
15:59.4	16:19.0	00:19.6		00:19.6			
16:19.0	16:19.9	00:00.9	00:00.9				
16:19.9	16:30.3	00:10.4		00:10.4			
16:30.3	17:31.4	01:01.1	01:01.1				
17:31.4	17:41.8	00:10.4				00:10.4	
17:41.8	18:03.6	00:21.8	00:21.8				

18:03.6	18:56.8	00:53.2		00:53.2			
18:56.8	19:03.4	00:06.6	00:06.6				
19:03.4	19:31.6	00:28.2		00:28.2			
19:31.6	19:39.3	00:07.7	00:07.7				
19:39.3	21:08.1	01:28.8			01:28.8		
21:08.1	21:38.2	00:30.1		00:30.1			
21:38.2	21:45.9	00:07.7				00:07.7	
21:45.9	21:52.3	00:06.4					00:06.4
21:52.3	22:00.8	00:08.5				00:08.5	
22:00.8	22:08.2	00:07.4		00:07.4			
22:08.2	22:55.7	00:47.5	00:47.5				
22:55.7	23:06.9	00:11.2			00:11.2		
23:06.9	24:38.3	01:31.4	01:31.4				
24:38.3	24:48.4	00:10.1					
24:48.4	25:24.1	00:35.7		00:35.7			
25:24.1	26:00.2	00:36.1	00:36.1				
26:00.2	26:10.9	00:10.7		00:10.7			
26:10.9	26:35.9	00:25.0			00:25.0		
26:37.3	27:36.8	00:59.5		00:59.5			
27:36.8	28:22.5	00:45.7					
28:22.5	28:26.4	00:03.9	00:03.9				
28:26.4	28:58.1	00:31.7					
28:58.1	29:17.3	00:19.2					
29:17.3	29:27.3	00:10.0				00:10.0	
29:27.3	29:33.9	00:06.6	00:06.6				
29:33.9	29:36.4	00:02.5				00:02.5	
29:36.4	29:52.3	00:15.9	00:15.9				
29:52.3	29:52.4	00:00.1					
29:52.4	29:58.9	00:06.5	00:06.5				
29:58.9	30:02.7	00:03.8		00:03.8			
30:02.7	30:06.7	00:04.0			00:04.0		
30:09.2	30:44.5	00:35.3					
30:43.9	31:23.0	00:39.1			00:39.1		
31:23.0	31:39.9	00:16.9					
31:39.9	31:43.8	00:03.9	00:03.9				
31:43.8	32:28.5	00:44.7					

P4 Exercise Timings

Start	End	Duration	Line-2	Line-4	Comp	Map	Instructions
00:00.0	00:06.5	00:06.5					
00:06.5	00:10.7	00:04.2					
00:10.7	00:16.0	00:05.3					
00:16.0	00:53.1	00:37.1					00:37.1
00:53.1	01:24.8	00:31.7		00:31.7			
01:22.4	01:38.2	00:15.8					
01:38.2	02:57.2	01:19.0		01:19.0			
02:57.2	03:00.1	00:02.9	00:02.9				
03:00.1	03:02.0	00:01.9		00:01.9			
03:02.0	03:07.4	00:05.4	00:05.4				
03:07.4	03:11.1	00:03.7		00:03.7			
03:11.1	03:14.8	00:03.7	00:03.7				
03:14.8	03:55.9	00:41.1		00:41.1			
03:55.8	04:15.6	00:19.8	00:19.8				
04:15.6	04:27.9	00:12.3		00:12.3			
04:28.2	08:01.7	03:33.5	03:33.5				
08:01.7	08:09.9	00:08.2		00:08.2			
08:09.9	08:15.2	00:05.3	00:05.3				
08:15.2	08:30.1	00:14.9				00:14.9	
08:30.1	08:30.2	00:00.1					
08:30.1	08:37.5	00:07.4				00:07.4	
08:37.5	08:44.3	00:06.8	00:06.8				
08:44.3	08:45.6	00:01.3		00:01.3			
08:45.6	08:47.1	00:01.5	00:01.5				
08:47.1	11:35.3	02:48.2		02:48.2			
11:35.3	11:56.6	00:21.3	00:21.3				
11:56.6	11:58.7	00:02.1		00:02.1			
11:58.7	13:35.9	01:37.2	01:37.2				
13:35.9	13:36.0	00:00.1					
13:35.9	13:37.6	00:01.7	00:01.7				
13:37.6	13:37.7	00:00.1					
13:38.8	16:36.5	02:57.7	02:57.7				
16:36.5	16:37.8	00:01.3		00:01.3			
16:37.8	17:28.3	00:50.5	00:50.5				
17:28.3	17:42.7	00:14.4					
17:42.9	18:02.3	00:19.4	00:19.4				
18:02.3	18:09.8	00:07.5					
18:09.8	21:20.6	03:10.8	03:10.8				
21:20.6	21:30.5	00:09.9		00:09.9			
21:30.5	21:32.3	00:01.8	00:01.8				

21:32.3	22:54.7	01:22.4		01:22.4			
22:54.7	23:02.4	00:07.7	00:07.7				
23:02.4	23:09.6	00:07.2			00:07.2		
23:09.6	23:27.2	00:17.6					
23:27.2	23:37.7	00:10.5		00:10.5			
23:37.7	23:58.9	00:21.2			00:21.2		
24:00.4	24:58.0	00:57.6		00:57.6			
24:58.0	28:10.9	03:12.9	03:12.9				
28:10.9	29:49.0	01:38.1		01:38.1			
29:49.0	29:49.9	00:00.9	00:00.9				
29:49.9	30:27.0	00:37.1		00:37.1			
30:27.0	31:28.6	01:01.6			01:01.6		
31:28.6	31:28.7	00:00.1					
31:28.6	31:49.5	00:20.9			00:20.9		
31:49.5	34:35.2	02:45.7	02:45.7				
34:35.2	34:38.0	00:02.8			00:02.8		
34:38.0	34:38.9	00:00.9	00:00.9				
34:38.9	34:52.0	00:13.1			00:13.1		
34:52.0	34:54.6	00:02.6	00:02.6				
34:54.6	35:50.6	00:56.0			00:56.0		
35:50.6	36:22.4	00:31.8		00:31.8			
36:22.4	36:27.6	00:05.2					
36:27.6	36:47.2	00:19.6		00:19.6			
36:47.2	36:59.4	00:12.2					

P5 Exercise Timings							
Start	End	Duration	Line-2	Line-4	Comp	Map	Instructions
00:00.0	00:19.8	00:19.8					
00:19.8	00:53.9	00:34.1		00:34.1			
00:53.9	00:54.7	00:00.8					00:00.8
00:54.7	02:45.1	01:50.4		01:50.4			
02:45.1	02:47.4	00:02.3					00:02.3
02:47.4	09:36.6	06:49.2		06:49.2			
09:36.6	12:32.1	02:55.5	02:55.5				
12:32.1	12:32.3	00:00.2					
12:32.3	13:18.2	00:45.9	00:45.9				
13:18.2	13:26.8	00:08.6		00:08.6			
13:26.8	13:28.3	00:01.5	00:01.5				
13:28.3	14:05.9	00:37.6		00:37.6			
14:05.9	15:56.5	01:50.6	01:50.6				
15:56.5	15:56.6	00:00.1					
15:56.5	20:47.8	04:51.3	04:51.3				

20:47.8	20:47.9	00:00.1					
20:47.8	24:01.5	03:13.7	03:13.7				
24:01.5	24:15.0	00:13.5					
24:15.0	24:30.5	00:15.5	00:15.5				
24:30.5	25:01.6	00:31.1		00:31.1			
25:01.6	25:04.0	00:02.4	00:02.4				
25:04.0	29:15.2	04:11.2		04:11.2			
29:15.2	31:06.8	01:51.6	01:51.6				
31:06.8	31:16.0	00:09.2			00:09.2		
31:16.0	32:29.1	01:13.1	01:13.1				
32:29.1	32:38.4	00:09.3					00:09.3
32:38.4	32:54.6	00:16.2	00:16.2				
32:54.6	33:01.9	00:07.3					

P6 Exercise Timings							
Start	End	Duration	Line-2	Line-4	Comp	Map	Instructions
00:00.0	00:08.1	00:08.1				00:08.1	
00:08.1	01:25.5	01:17.4			01:17.4		
01:25.5	01:52.3	00:26.8		00:26.8			
01:52.3	02:03.8	00:11.5					00:11.5
02:03.8	02:26.1	00:22.3		00:22.3			
02:26.1	02:33.9	00:07.8				00:07.8	
02:33.9	03:00.0	00:26.1		00:26.1			
03:00.3	03:17.3	00:17.0	00:17.0				
03:17.3	03:17.4	00:00.1					
03:17.3	04:25.2	01:07.9	01:07.9				
04:25.2	04:48.5	00:23.3			00:23.3		
04:48.5	04:48.6	00:00.1					
04:48.7	05:06.0	00:17.3			00:17.3		
05:06.0	18:05.9	12:59.9	12:59.9				
18:05.9	18:16.8	00:10.9		00:10.9			
18:16.8	18:53.1	00:36.3			00:36.3		
18:53.1	20:45.0	01:51.9		01:51.9			
20:43.3	20:47.1	00:03.8				00:03.8	
20:47.1	20:51.9	00:04.8	00:04.8				
20:51.9	20:52.0	00:00.1					
20:51.9	20:53.0	00:01.1	00:01.1				
20:53.0	20:56.4	00:03.4		00:03.4			
20:56.4	21:06.5	00:10.1				00:10.1	
21:06.5	21:06.6	00:00.1					
21:06.5	21:11.1	00:04.6				00:04.6	
21:11.1	21:13.5	00:02.4		00:02.4			

21:13.5	21:14.6	00:01.1				00:01.1		
21:14.6	21:15.5	00:00.9		00:00.9				
21:15.5	21:17.4	00:01.9				00:01.9		
21:17.4	21:19.9	00:02.5		00:02.5				
21:17.4	21:31.2	00:13.8				00:13.8		
21:31.2	21:32.5	00:01.3	00:01.3					
21:32.5	21:34.8	00:02.3				00:02.3		
21:34.8	21:37.4	00:02.6		00:02.6				
21:37.4	21:37.7	00:00.3						
21:37.7	21:38.8	00:01.1		00:01.1				
21:38.8	21:39.4	00:00.6				00:00.6		
21:39.4	21:43.2	00:03.8		00:03.8				
21:43.2	21:48.1	00:04.9				00:04.9		
21:48.1	21:49.7	00:01.6	00:01.6					
21:49.7	21:51.0	00:01.3				00:01.3		
21:51.0	22:00.8	00:09.8		00:09.8				
22:00.8	22:03.3	00:02.5	00:02.5					
22:02.5	22:10.4	00:07.9				00:07.9		
22:10.4	24:16.6	02:06.2		02:06.2				
24:16.6	24:29.9	00:13.3	00:13.3					
24:29.9	24:33.0	00:03.1		00:03.1				
24:33.0	24:34.6	00:01.6	00:01.6					
24:34.6	25:06.1	00:31.5		00:31.5				
25:06.1	25:08.0	00:01.9	00:01.9					
25:08.0	25:12.9	00:04.9		00:04.9				
25:12.9	25:15.7	00:02.8	00:02.8					
25:15.7	25:17.3	00:01.6		00:01.6				
25:17.3	25:35.4	00:18.1	00:18.1					
25:35.4	25:40.5	00:05.1		00:05.1				
25:40.5	25:44.2	00:03.7	00:03.7					
25:44.2	25:49.0	00:04.8		00:04.8				
25:49.0	25:50.1	00:01.1	00:01.1					
25:50.1	25:52.7	00:02.6		00:02.6				
25:52.7	25:53.0	00:00.3						
25:53.1	29:07.9	03:14.8		03:14.8				
29:07.9	29:09.3	00:01.4	00:01.4					
29:09.3	29:29.2	00:19.9		00:19.9				
29:29.2	29:45.2	00:16.0	00:16.0					
29:45.2	29:45.3	00:00.1						
29:45.2	29:48.1	00:02.9	00:02.9					
29:48.1	29:52.3	00:04.2		00:04.2				

29:52.3	32:32.0	02:39.7	02:39.7				
32:32.0	32:35.8	00:03.8		00:03.8			
32:35.8	32:38.2	00:02.4	00:02.4				
32:38.2	33:32.0	00:53.8		00:53.8			

P7 Exercise Timings							
Start	End	Duration	Line-2	Line-4	Comp	Map	Instructions
00:00.0	00:30.2	00:30.2					
00:30.2	00:54.0	00:23.8					00:23.8
00:54.0	03:03.7	02:09.7	02:09.7				
03:03.7	03:05.4	00:01.7				00:01.7	
03:05.4	03:09.1	00:03.7		00:03.7			
03:09.1	03:10.8	00:01.7	00:01.7				
03:10.8	03:10.9	00:00.1					
03:10.8	03:13.7	00:02.9		00:02.9			
03:13.7	03:13.8	00:00.1					
03:14.2	04:07.4	00:53.2		00:53.2			
04:07.4	04:17.4	00:10.0	00:10.0				
04:17.4	05:50.4	01:33.0		01:33.0			
05:50.4	05:53.0	00:02.6					00:02.6
05:53.0	06:46.7	00:53.7		00:53.7			
06:46.7	06:50.2	00:03.5				00:03.5	
06:50.2	06:55.3	00:05.1		00:05.1			
06:55.3	08:40.1	01:44.8	01:44.8				
08:40.1	08:45.2	00:05.1					00:05.1
08:45.2	09:28.0	00:42.8	00:42.8				
09:28.0	09:33.7	00:05.7				00:05.7	
09:33.7	10:43.8	01:10.1	01:10.1				
10:43.8	12:23.3	01:39.5		01:39.5			
12:25.8	12:27.2	00:01.4					00:01.4
12:27.2	14:36.0	02:08.8		02:08.8			
14:36.0	14:36.1	00:00.1					
14:36.0	14:36.9	00:00.9	00:00.9				
14:36.9	14:38.9	00:02.0		00:02.0			
14:38.9	18:47.3	04:08.4	04:08.4				
18:47.4	19:46.9	00:59.5				00:59.5	
19:46.9	20:23.6	00:36.7	00:36.7				
20:23.6	24:39.8	04:16.2		04:16.2			
24:39.8	24:45.6	00:05.8	00:05.8				
24:45.6	24:59.0	00:13.4					00:13.4
24:59.0	27:31.6	02:32.6	02:32.6				
27:31.6	27:32.9	00:01.3					

27:32.9	31:03.7	03:30.8	03:30.8				
31:03.7	32:32.6	01:28.9		01:28.9			
32:32.6	32:40.3	00:07.7					

P8 Exercise Timings							
Start	End	Duration	Line-2	Line-4	Comp	Map	Instructions
00:00.0	00:39.0	00:39.0					00:39.0
00:39.0	00:59.3	00:20.3				00:20.3	
00:59.3	01:09.7	00:10.4					
01:09.7	01:36.2	00:26.5					
01:36.2	01:38.8	00:02.6	00:02.6				
01:38.8	01:44.9	00:06.1		00:06.1			
01:44.9	01:51.0	00:06.1				00:06.1	
01:51.0	02:03.9	00:12.9			00:12.9		
02:03.9	02:43.6	00:39.7				00:39.7	
02:43.6	03:15.8	00:32.2	00:32.2				
03:15.8	03:37.9	00:22.1		00:22.1			
03:37.9	05:42.0	02:04.1	02:04.1				
05:42.0	06:09.9	00:27.9		00:27.9			
06:09.9	06:40.4	00:30.5	00:30.5				
06:40.4	06:53.9	00:13.5		00:13.5			
06:53.9	09:29.3	02:35.4	02:35.4				
09:29.3	11:23.6	01:54.3		01:54.3			
11:23.6	13:00.0	01:36.4	01:36.4				
13:00.0	13:07.2	00:07.2		00:07.2			
13:07.2	16:28.3	03:21.1	03:21.1				
16:28.3	17:02.7	00:34.4		00:34.4			
17:02.7	17:49.9	00:47.2	00:47.2				
17:49.9	19:51.3	02:01.4		02:01.4			
19:51.3	31:31.9	11:40.6	11:40.6				
31:31.9	31:34.1	00:02.2		00:02.2			
31:34.1	31:46.7	00:12.6	00:12.6				
31:46.7	39:25.7	07:39.0		07:39.0			
39:25.7	39:38.3	00:12.6	00:12.6				
39:38.3	40:11.0	00:32.7		00:32.7			
40:11.0	40:58.9	00:47.9	00:47.9				
40:58.9	41:41.6	00:42.7		00:42.7			
41:41.6	42:41.6	01:00.0	01:00.0				
42:41.6	42:55.5	00:13.9					

P9 Exercise Timings							
Start	End	Duration	Line-2	Line-4	Comp	Map	Instructions
00:00.0	00:48.3	00:48.3					
00:48.3	00:57.5	00:09.2		00:09.2			
00:59.5	01:28.2	00:28.7					
01:28.2	01:38.3	00:10.1					
01:38.3	08:34.4	06:56.1	06:56.1				
08:34.4	08:46.3	00:11.9					00:11.9
08:46.3	09:38.2	00:51.9	00:51.9				
09:38.2	09:52.4	00:14.2				00:14.2	
09:52.4	11:30.1	01:37.7	01:37.7				
11:30.1	11:56.3	00:26.2			00:26.2		
11:56.3	11:58.0	00:01.7	00:01.7				
11:58.0	12:18.8	00:20.8			00:20.8		
12:18.8	14:32.7	02:13.9	02:13.9				
14:32.7	14:42.3	00:09.6		00:09.6			
14:42.3	14:54.9	00:12.6				00:12.6	
14:54.9	17:56.4	03:01.5		03:01.5			
17:56.4	17:58.2	00:01.8				00:01.8	
17:58.2	17:58.9	00:00.7		00:00.7			
17:58.9	18:01.1	00:02.2	00:02.2				
18:01.1	18:46.9	00:45.8		00:45.8			
18:46.9	18:49.9	00:03.0	00:03.0				
18:49.9	18:51.7	00:01.8		00:01.8			
18:51.7	18:53.8	00:02.1				00:02.1	
18:53.8	18:59.0	00:05.2		00:05.2			
18:59.0	23:51.8	04:52.8	04:52.8				
23:51.8	23:55.6	00:03.8					
23:55.6	25:29.3	01:33.7	01:33.7				
25:29.3	25:30.5	00:01.2				00:01.2	
25:30.5	27:40.4	02:09.9	02:09.9				
27:40.4	27:44.5	00:04.1					00:04.1
27:44.5	27:48.9	00:04.4	00:04.4				
27:48.9	28:08.3	00:19.4			00:19.4		
28:08.3	28:09.6	00:01.3	00:01.3				
28:09.6	29:04.4	00:54.8			00:54.8		
29:04.4	29:38.0	00:33.6	00:33.6				
29:38.0	30:02.3	00:24.3			00:24.3		
30:02.3	31:58.1	01:55.8	01:55.8				
31:58.1	32:15.4	00:17.3					

P10 Exercise Timings							
Start	End	Duration	Line-2	Line-4	Comp	Map	Instructions
	00:52.2	00:52.2	00:52.2				
00:52.2	00:58.8	00:06.6				00:06.6	
00:58.8	01:06.8	00:08.0	00:08.0				
01:06.8	01:17.8	00:11.0				00:11.0	
01:17.8	01:19.8	00:02.0		00:02.0			
01:19.8	03:16.9	01:57.1	01:57.1				
03:16.9	03:18.8	00:01.9					00:01.9
03:18.8	04:11.9	00:53.1	00:53.1				
04:11.9	05:10.5	00:58.6			00:58.6		
05:10.5	11:49.1	06:38.6	06:38.6				
11:49.1	11:52.3	00:03.2		00:03.2			
11:52.3	11:52.4	00:00.1					
11:52.6	12:06.9	00:14.3		00:14.3			
12:06.9	12:07.7	00:00.8	00:00.8				
12:07.7	12:41.8	00:34.1		00:34.1			
12:41.8	12:46.5	00:04.7	00:04.7				
12:46.5	18:56.7	06:10.2		06:10.2			
18:56.7	18:59.5	00:02.8	00:02.8				
18:59.5	18:59.6	00:00.1					
18:59.5	19:03.2	00:03.7	00:03.7				
19:03.2	19:05.3	00:02.1		00:02.1			
19:05.3	19:09.2	00:03.9	00:03.9				
19:09.2	21:33.2	02:24.0		02:24.0			
21:33.2	32:34.4	11:01.2	11:01.2				
32:32.6	32:41.9	00:09.3		00:09.3			
32:41.9	32:45.1	00:03.2	00:03.2				
32:45.1	32:46.7	00:01.6		00:01.6			
32:46.7	32:51.8	00:05.1	00:05.1				
32:51.8	33:17.7	00:25.9		00:25.9			
33:17.7	33:24.0	00:06.3	00:06.3				
33:24.0	33:38.0	00:14.0					

APPENDIX VI

INTERVIEWS

P1 Interview

Interviewer: Start off with a question that is unrelated, just get talking, and make it a little less awkward. Alright so just tell me a little bit more about the work that you do here.

P1: So I am involved with seismic data processing, so I do sound geologic interpretations on our work but mainly looking at the acquisition and processing aspects of ___ seismic data.

I: And I know youre going into the more academic side of things now, but how .. did you want to do that similar type of work in industry when you were thinking about going that way

P1: Yea I had a few internships in industry looking at geophysical aspects of seismic data but mainly on the geology side. So I did a lot of interpreting data sets with that as well.

I: Alright well I guess we can talk about the exercise. So how did you decide to start where to start on your interpretation, did you pick out a place?

P1: So I kind of looked for… larger features id say. So in like these images you can tell that first or youngest package is very planar in both of the images. So kind of like with my eye could you know map out some of these in both of the lines, and say like ok this is pretty definitive I know this is one solid package of the same material. So im looking for like larger things, so that was something that drew my eye. The salt features, anything that's different or unique about the images that's kind of where im looking first.

I: Okay great. And you can start just sort of walking through some of the things that you saw?

P1: Yea, so I mentioned the packages coming up first thing so very planar, young package at the seafloor in both of those. Interpreting the salt there is not a lot deformation around the salt, which sometimes you get a lot of faulting and structural deformation. And then I didn't see much of that in either of the 3 diapiers I interpreted. A lot of what I was looking was sed features, so in this image you have a lot of very chaotic deposition or what im calling chaotic deposition near the shore here. And then also in this what im calling package 4, this lower package, some emulations some lens type features that I saw here in package 4 and then also a little higher in section kind of similar lens features on line 4a as well.

I: So lets talk about. Im really interested in what you think is going on in here. Do you have an explanation for that?

P1: Yea, you know im not really sure. I was kind of something I was a little bit stumped on. So higher in the package you have really like planar features some sed variances. You do you see these these wave type features and they are about 2-5 km long and then about half a kilometer thick, so they are pretty significant. So they could possibly be sea level change when sea level was fluctuating down and you have offshore in this region at the time. I don't know where we are so I can't really speak to the curve. There were sea level was where this continent was but my guess would be due to sea level variances. The other possibility that if the sea level was higher closer to where current day or present day that you had some sort of like really strong turbidity currents that were being deposited down here. But again, this is really far off the shelf, but with this kind of sharp feature that we see here it could have created some sort of like quick flow and then these chaotic deposits.

I: And so clearly you had some different hypotheses about that area but is there any other places in the data that you kind of struggled to interpret.

P1: Yes, so within this the dip line here as well, kind of a similar thing I don't know there is some features here this is maybe possibly a processing error. But the horizons aren't uniformly connected so it could be something with processing. But if you look closer you can almost kind of tell that some of these can line up and then again down here you get some like large possibly channel features, some curves in the reflectors. So I called it a slumping zone so if you have or you're coming off the shelf and you get justa very quick slump here. And your sediment again chaotic is going down quickly off the shelf and youre not getting really strong reflectors and then you know you see these reflectors kind of all pretty planar coming up to it and it just goes away. So I had a hard time connecting these reflectors. Um and im not really sure you know 100% why and then again right here there seems to be pretty hard surface coming down but chaotic sediment deposits here as well. For me I think that that's probably a… some sort of quick sediment.. chaotic like deposition right there

I: And is there any other spots on any of the two images?

P1: Yea, so I didn't see very much structure in my line 4A. maybe above the salt here, then again like im saying there isn't a lot of deformation, structural deformation around the salt. There is a lot of sediment deformation but because of this bending or kind of the pushing upwards here of the salt the movement of these sublayers, there is possibly some small faults like right above the salt there. And then I saw a lot of faulting in this region, more zooming in on the computer. And you can see that there is a difference in ____ offset in your reflectors on those and that's pretty ____ sigh of faulting there and then also what I call hard surface here. There is a lot of possible splayed faults like kind of coming off of that so that could be. It could be artifacts in the data, but there is a little bit of outset for _____ discrepancy in some of the horizon so I interpreted those as faults.

I: Would you say that these faults are showing a similar environment of stress?

P1: Yea well there _______ for what I can see I wouldn't say this is a very high stress area depositionally. I don't see a lot of tectonic you know large tectonic activity, you see some with the faults. But I would say maybe that you know sediment loading is causing some of these faults like some of the small faults and in this area possibly salt movement plate movement, but pretty minor. This was the largest fault that I interpreted. The offset was still very small on this scale at least.

I: So where would you say in the data did you. Were you most confident with like I know what this ive seen this before. You know. I didn't have to spend too much time. I felt really confident about it.

P1: Yea two things. The salt diapiers I felt like pretty confident that that's what that was. But not necessarily like 100% confident in where the boundaries of the salt and sediment were. So in this one I kind of drew two interpretations, my dotted line which is what I think is probably the least likely and then my salt line which im pretty confident like this is salt because youre not seeing reflectors under that. But you're getting some discoloration here as well.

I: How would you explain with if the salt is up that high and there is those….

P1: Well you're pretty shallow. You're at about 5 seconds two way travel time there, which isn't super shallow but you might just with your equipment you might be able to image through some of that a little more. But there aren't any, I mean you're not going to see any structure within in salt. So it might be areas where salt seeped has a little bit but youre kind of maybe… make sure or the most likely case would be this is the salt interpretation and this is just a disturbance because of that salt moving up into already deposited sediments

I: Sure

P1: And then another area I would say I was probably pretty confident in is the youngest package. its very planar like features that go kind of all the way across the seafloor on both of the images.

I: With the exception of the chaotic

P1: With the exception of the yea chaotic feature right there at the shelf edge

I: So If I could provide you with any data to go along what you have here, what would you think would be most useful.

P1: Probably a geologic background, just to know whats going on because you know you might be able to explain some of these areas that I don't really understand whats going on. You see some differences in structures and the reflectors are telling a different kind of story there but being able to relate that to with to with actually kind of happened in geological time in this area.

I: Let's go one step further than that.

P1: O**P1: I:** Lets say if were. Lets say were at a place lets go real out there. Lets go real out there, lets say we are on mars. And were we have these seismic line and showing you it to you and I need you to get one other piece of data but you can lets you cant have the background **_______________**.

P1: Ok. I would definitely say cores. I would probably drill you know if you could do however many you wanted. My idea would be to put one here, one right over the faulted area, and then one here. So that you would know like that you want to look deeper into this. Is this a problem with the seismic data? What's actually happening here? This area is very complex and being able to look at the actual rock would be nice. Maybe cutting through some of these faults, the sediment is pretty planar but you could tell some more about the structure. And then definitely in here, is this sediment. Is this. You don't really know, so being to have a core of the rock there would be nice.

I: If I could provide you with a seismic line intersecting both of these? Where would you put it?

P1: Another seismic line

I: Yea

P1: Probably through the faulted region, like another one here, because you can see like in with this **_________** intersection of these two lines, you can see similar channel features and kind of sediment features. I highlighted both of those. Im assuming that you could probably see these features but I would be curious to see the extent of the faulting. So is it just in this small area? Is it just around kind of salt regions? And if yea, I could a line here I could look in the strike direction and see if they extended there as well

I: Ok. Is there any other, any other areas on here that you found particularly interesting that we haven't really talked about, any other ones.

P1: Yea. This line is pretty simple. You had again a little bit of structure around the top of the salt here. Oh this was interesting. Both of the lines in package 1, I said they were pretty planar except right here. You get some chaotic features. But that

I: How would you explain that?

P1: That might actually be another good place actually to have an intersecting dip line. Because in you know here this line you know is lining up right here right. I know what's happening on the shelf at this intersection, but I don't know what is happening here, so maybe having a strike line going right through here would be nice. But it looks like maybe there is channel that's creating the you know chaotic sediment deposition again. But there is some sort of change within this like kind of 5-10 kilometers. I would really interested in that to look at to have more information on. I saw some lens features here kind of throughout this line again which I would probably assume would be a channel coming down off of the shelf. You get thicker packages if these were channels and they have been filled with sediment there.

I: And let's say _____ from a petroleum standpoint, and obviously there is going to be some traps around some obvious areas. Where else besides. I mean just point out somethings where you think is a chance for some petroleum element.

P1: Yea. I mean it always around salt you can get some you have that can create a trap. as well there is not a lot of faulting there so it could be holding some sort of petroleum. Lets see, possibly in these channels these would be like any sort of channel river system that hard to ______ but they could get no like be carrying some sort of some sort of gas. They are pretty blurred out, youre not seeing any reflectors in there which is also can be an indicator of some sort of petroleum presence. So anywhere like that that ive interpreted that youre getting this almost like wedge trapped type of shape and nothing coherent in between that's probably I would say. Youre not you don't really have many structural traps. Maybe along this larger fault here but that would probably be one of the only structural traps that I would say. And then in this interpretation I also have like have interpreted pretty like hard ground. So if you have any sort of like seepage up, then laterally I don't know how you would be trapping but you could be trapping horizontally because I don't think there is much. This looks like a pretty hard surface here. So you probably are looking at two very distinct rock types.

P2 Interview

Interviewer: First off, we're going to just start off with just what we talked about, the actual activity. We're just going to talk a little more about your background, so briefly, tell me about your past experiences with seismic interpretation, any projects you've worked on, and the kind of setting, were the passive margin you saw, that kind of stuff.

P2: I have limited interpretation. I've practiced more processing. I processed Indian data, actually. I processed this same project. I also worked a seismic processing course here at

A&M. We looked at a volcanic intrusion, so a lot of volcanic intrusions, I've been dealing with.

I also did some interpretation at North Slope Alaska, working with the IVA team and interpreting a lot of stratigraphic features, up there in Alaska. Besides that, that would be about it. I haven't taken any courses, too much.

I: Might I encourage you to take 30 seconds to now review what you've done, just so that when we talk about all this, it's really fresh in your mind, so just go ahead and check things out.

P2: Just tell you?

I: No, what I'm asking you to do is, there's stuff you did 30 minutes ago, it's probably not fresh in your mind. Just take a look at everything you did, so when we do talk everything is super fresh.

P2: You want me to take 30 seconds?

I: Yeah. Just take 30 seconds, check over everything, just to make sure you remember all that you did.

[pause]

P2: Ready.

[pause]

I: OK?

P2: Mm-hmm.

I: How did you decide to start your interpretation? Where did you start your interpretation?

P2: I started by not really making too many interpretations, just looking at it.

I: Where, specifically?

P2: Obviously, these two big features drew my attention on these two maps.

I: Did you look for the bigger features first and work your way down to the smaller things?

P2: I actually started with the smallest things. I spent the most time with the smallest things, specifically these faults. Well, I interpreted as faults over here. I looked at those and try to get as many as I thought were there.

I: Just go ahead and start walking me through some of the things that you saw, explaining them, and then I'll ask questions when I need to.

P2: Awesome. I started here to the left, just over here. I like this because it makes sense to me, since this is higher and this is closer to land, based on the map here. You notice that we're going down the shelf, so that's why it's really high over here, a little shallower over here.

I didn't know what these were, so I just circled them with the purple. Then over here I noticed these reflectors, and they're not flat, and this isn't real. The layers are not going upwards, so this is a migration issue in the processing of the data, so you notice that.

Let's see, I'll move it down here. That brought me to this right here, when I think of two really strong terminating beds here. A lot of beds terminate into right here and right here, so I thought that's pretty interesting.

I also noted that all these sediments here are very flat line, quite undisturbed for the most part. Moving back over here a little bit. Here, we have this intrusion of some sort. I didn't know if it was a volcanic or salt intrusion. I'm not too sure, but then I also noticed these...

[crosstalk]

I: Why are you not too sure?

P2: I'm not sure what salt tectonics look like. I don't have any background in it. I don't know if it has a specific signature, or if volcanic are different, unfortunately. I noticed the terminating beds, then we came across all this faults over here. I determined they were faults.

I: Do you think that they're from the same stress?

P2: Of this?

I: Well, I don't know. I'm saying, all these faults, you think they're all related?

P2: I was thinking about that. I'm not sure. I would think some of them are, but I have them oriented in different directions, so I'm not too sure exactly how faults and the whole fault systems work too well, unfortunately.

There's a possible direct hydrocarbon indicator due to it being a very high amplitude. Coming over here, I noticed these things. I looked at the bottom and I saw over there another line, as well. I think this is layered, somewhat, so this is not very wavy.

I didn't know what caused that or what that would be from, but something to note. Another direct hydrocarbon indicator over here. It's, again, a high amplitude anomaly, out of nowhere.

I: What about the feature? How would you think it was traveling?

P2: When I was looking for it traveling...

I: This one.

P2: It would probably. I'm honestly not sure, because I'm not sure what the lithologies are.

I: That's perfectly accepTable. If you don't know, just say you don't know. OK. Is that on this one?

P2: I just see some faults [inaudible 6:39] .

I: This one, it's like...

P2: I don't know, it's very interesting. It's not very smooth, very chaotic over there. I didn't know what was causing that, but something is causing it.

I: If we can go over here. Is it the same kind of thing?

P2: Yes. This is the bumpy terrain. That's on the side, you just see bumps throughout. Again, there's a really big intrusion here of some sort. I'm not sure if it is salt or volcanic.

Terminating beds, again, at the top. Something different that I noticed was here. I'm not sure about this one, but I'm pretty confident that maybe that's possibly the re-flow or a slump, due to the fact you have all these nice [inaudible 7:29] sediments, then all starting right here, which is very chaotic.

I'm not sure what would cause that. Something's causing it. I thought that of it as a slump, because to me, it seemed like this is all turned downwards, so [inaudible 7:44] . You just see [inaudible 7:50], really [inaudible 7:51] there.

Again, there's a lot of uncollapsed little bowties here, so might be a migration issue. Another thing that I noticed was right about here, this package of sediment, gets really thick right here. That [inaudible 8:12] the images there.

I: You don't know what it could be?

P2: No, I don't know. [inaudible 8:17] . I'm not sure what this is, either. Something's happening here that's causing the amplitudes just to [inaudible 8:25], right in this inception. Not sure what's causing that. [inaudible 8:32].

I: Having us take a step back, what parts of the data were you most comforTable or most confident interpreting?

P2: I'd say these. All I know, it's some sort of intrusion, but I don't know if it's salt or volcanic. Real proud of those, and then I like the migration aspects of it. Understanding that. Looking at stratigraphic [inaudible 9:05] , so different trapping beds.

I: What do you think is going on in here?

[pause]

I: You just don't know?

P2: No, it seems like this is going on here, but it seems this is coming up to another bump and then it goes back down. I'm not sure what that would be. I'm not sure, it's something that's very interesting.

I: Mostly just stratigraphic set for you, is what you felt most confident with?

P2: I think so.

I: What about the opposite? What parts in the data, maybe something you didn't get to, but things that you struggled to interpret the most?

P2: Probably most of the stuff in the purple. This is something going on here, I'm not sure. This should be purple, I'm not sure what's going on there. This whole bumpiness of that. Maybe it's random, but that's pretty interesting to see it on two different cross lines.

I: Let's say I could give you any extra data, any data to go along with these two lines, what would you want me to give you?

P2: It would be nice to have a strat column here or a Wilcox, at least. I like Wilcox with a strat column, correlating them together, so I could see it, so I could maybe drill a hole somewhere.

I: Where, specifically, would you want me to drill the hole? Or, maybe two places. Whatever you think is necessary.

P2: I'd like to drill, if possibly, over by this slump that I've got over here and probably through here.

I: Why those two locations?

P2: I like this slump over here because I still think it'd be a good trapping mechanism or maybe it's not even a slump put some sort of a hydrocarbon accumulation right there causing weird type of feeds. That's why I'd be interested in that.

But, then, specifically here, if you drill down lower, you'll start to see a little bit of a dome there. Maybe that could be used as a trapping mechanism. Just looking at this, I would guess that this is probably some sort of sandstone lithology. Maybe that's why it changes pretty rapidly and goes away.

It possibly would be a good reservoir that contain hydrocarbons and hopefully have that be some sort of [inaudible 11:51] trap. If you do that, maybe you could ID the lithologies. Then, over here, as well, maybe you'd get some trapping from faulting if their quality [inaudible 12:07] . I'll just be interested to see what's going on.

I: Let's say I could give you a seismic line to intersect this data. Where would you want that line to be? You can draw it on there, too, if you want to. Or, you can show me.

P2: It's a little bit confusing. I didn't really understand what these numbers meant on the line.

I: The shot numbers?

P2: These are shot numbers then? This 2,400?

I: Yes.

P2: Then, they don't quite line up, so I don't know.

I: You might be looking at just a portion of the line. I don't know if it's a perfect replica or not.

P2: OK, more or less, you just want to use this to know how they cross near those, where they cross. It's more just a locator map than it is...OK, but then...I'm sorry. I'm guessing this is not a part of it. This is a little bit confusing because you have D over here as the highest number here, maybe shot number. Then, C, over here, should be your lowest but it's actually the highest and D...

I: Maybe I just flipped them on accident. Let's go.

P2: But, I'm not sure though because you have this intersecting over here...

I: I'll look into that after we finish this interview but...

P2: ...it's just kind of hard for me to...

I: Then, don't worry about the shot...

P2: I would come over here, just over here, open up beside the line, crossing this, because I'm pretty confident about this is something. This, I'd like to see that, if anything.

Then, this is somewhat of a slump, in there, hydrocarbon accumulation. I'd like to get another line going this way to get some volume metrics on it to see if it continues down some because it just like slice [inaudible 14:11] .

I: You're looking at that from a petroleum standpoint?

P2: Yeah.

I: Where, specifically? You mentioned there. May have mentioned a different place but where else do you think there's potential for petroleum significance?

P2: Probably, right across in these as well, these two intrusions because of the [inaudible 14:35] , the hydrocarbons can accumulate underneath them, so that would be great to drill over here. Also, a good thing about getting seismic over here, if this does end up being a reservoir and a seal, you could get more volume metrics again, on this side of the body, this feature.

I: These lines were actually shot offshore, near the Carolinas. This is a salt, place with a lot of salt, diapirs and it's in this land site and creeps that are really prevalent under water here. This change [inaudible 15:18] about any of the features that you see.

P2: Then, they told me about the salt that we saw, salt then. The [inaudible 15:28] zones going to be a definite [inaudible 15:29] on there, under it, if underneath that, possibly, depending on if this is what's going on around it. If there's even oil, there or whatever.

That just compels me to feel better about this being a possible slump, but a creep, though. I guess, maybe that it's a possible creep but I thought debris flow, specifically, because it's very chaotic there. I thought slumps generally won't be as chaotic. But, slump, debris flow, mass...

I: Col, all those things are direct.

P2: ...similar. Maybe a particular comment about that. I didn't see too many...maybe call this one a possible because it's kind of chaotic over here, for some reason. Possibly it's something there, but I don't think I see any other. I was looking for some sort of mass wasting event. I didn't see one. Just the ones that I pointed out over here because even over on this.

I: Did you get a chance to use the computer images?

P2: Yeah. I used the computer images to help me with the faults, specifically. That is about it.

I: That's cool. Were there any other portions of the data, things that you saw that were interesting, that you didn't get a chance to mention? You already talked about this area. Anything you were like, "I wish I could have gotten to that."?

P2: I didn't really even know but it seems pretty interesting to me. I didn't really know how to interpret it, so I just thought, I see these flip buttons crossing a lot of stuff and right here again, as well. I don't know if that's a fault. I didn't really know how to even interpret it during the IVA.

I: Anything else? Or, is that about it?

P2: Yeah. That's about it. I just circled all this stuff that I thought was interesting at the least.

I: Very cool. All right. Well, I think we're good then.

P2: Awesome.

I: Well, thanks for doing this for me.

P2: Yeah.

I: Awesome. Yeah, it's interesting how everybody has different interpretations, notices different things.

P2: I think so.

I: Which is what you would expect, but some things are totally different. Some people interpret things that just don't make sense, but this is why we're doing this. Any other questions about any of this? Things that you were like, "Oh, what is this?"

P3 Interview

Interviewer: Alright, so just go ahead before we start talking the actual activity. Just tell me a little more about your past experience with seismic and maybe even about your project.

P3: Ok. The first time I actually interpreted was. It sits in the 3D virtual world, but the class was a basin analysis class and they wanted us to interpret the seismic using paper data so it printed off you know every certain of cross and every number of inlines and then gave us a certain of number of arbitrary lines that cut through the 3d volume and then a couple of wells we had to tie. So I learned to do it on black and white seismic data in the maddog field. That was at UT. I took a first 3d. The first 3d class that I took or virtual seismic interpretation was at UT as well about a year later using kingdom suite and that used seismic data that wasn't quite seismic data. It was data generated from a flume. And they didn't cut it and then imaged it. So we had to interpret what the sediments were doing in this lab, and there were some 3D data sets there. Next I graduated from UT and I started working with chevron for a year and a half, and I was on the seismic the interpretation earth model support team at chevron in the energy technology company and I supported seismic interpretation in _____ in the seisearth module of paradigm so 3d canvas 2d canvas section windows and all of those projects were whatever the business unit had so Africa, deep water gulf of mexico, shelf gulf of mexico, latin America and so I was the inhouse expert of the software so whether they needed help on sdoing eismic interpretation or they didn't know how to do something. I did that. Then I came to A&M for my masters, the first semester I took a class with Dr. (*name removed*) it was his seismic interpretation class using landmark. That was somewhere in the gulf of mexico field. 3d volume looking for what could be potential plays based on seismic response to hydrocarbons the edge of map field and then and analysis basin analysis why wanted you wanted to drill there for prospect analysis. Then I worked an internship over the summer with BHP billiton, that was interpreting seismic data in petrel and that was interpreting the hanesville shale play and I was looking at the salt beneath hanesville and interpreting the salt and the salts movement. And my current research what I did with bobby was I shot a seismic survey using sparker source high resolution was the intent off the coast of Bonaire. Process that data and interpret it in paradigms interpretation suite.

I: Ok. So did you need more time?

P3: No I quit after a while

I: So take like a quick 20 seconds kind of look over what you did just so when we are talking you have it fresh on your mind

P3: Mmhm

I: So I mean if you're ready let's just talk about the exercise. How did you decide where you started your interpretation or started looking at the data.

P3: Well I first looked at both of them first glance, then I looked at them on the sheet on here and saw where they were before I actually folded the lines together. I looked down the page to see if I could see anything that stuck out. Drop it down here. And then after I did that I brought the two lines together and just wanted to orient myself. To see what was going on. I think the next thing I did was after that just noticing what stuck out first. And then I first jumped into these green faults right here or what I thought were faults and then started interpreting some and then I kind of pulled back because I zoomed in on the image and a lot do like faults some of them might be image quality so interpreted a few. I think the next thing interpreted was just marking this package right here and how it separate from this one.

Onlaps on the whatever package this is. I went over here the same package but then I was picking you know where the onlapping off lapping reflectors were and then I was just going with what stuck out to me since there were no directions on what I was supposed to interpret. I just started picking things that I saw. I didn't actually pick these images or what could have been bodies of sorts. I thought maybe salt bodies but then I put I wasn't convinced. So I used purple for those guys. Because I didn't know where the source or the salt was or where I am in the world. But you know I marked them on all of them. On this line here, I marked this package because you have relatively resolvable stratigraphy. And then all of a sudden you go into a hot mess static-y and then you come back to resolvable stratigraphy.

I: So how would you explain that geologically? How would you explain that chaotic package?

P3: You know Depending on where we were I would have gone with salt. That is what my initial thought was. I didn't call it anything. From my work this summer, that is what the salt took shape as. And then just underneath it you get another package thing, where you don't get the same resolution as well. And then you have those structures, its possible salt. But you know I don't know enough on what causes data loss between the two. And then here when I put them together I got that same little package as well. But then I wasn't able to you know bring it over just cause whatever is going on here. I did mark here though that if this some sort of body, I did mark a possible growth period for it. Whatever you got going on here, its thin it thickens. Whatever is going on there you have a growth period here. And then I pretty much said well I don't know what im looking at, so im gonna stop.

I: Ok. So lets talk about, what specifically what parts that you interpreted were you most confident with? What were you like ive done this before, or maybe you have seen this before.

P3: The most confident would be faults. You know the offset in the reflectors.

I: What kind of environment do those faults show? Or what do you think they were caused from?

P3: Well its you know it by this body here. They don't extend all the way up. I don't know 100% how many of them are all faults or not, but you know its possible its related to whatever is going on here. You don't have them in the top surface or this general area. I didn't see faults here and I really didn't see faults in here except whatever is going with this body or this structure. You have faulting at the top of it as well. So if I had to pick I would pick whatever is going on with those things. that would be the most confident just cause the interpretation of seismic reflector offset for me. And then you know clearly the way these sediment packages are laid down onto this, you know its laid down at a different time. It comes onto it. So that would be my second most confident.

I: What about areas that you struggled to interpret? Or maybe an area you didn't get time to or bc it looked too complicated.

P3: Yea, the bodies. Not necessarily, well picking out if those are salt bodies if they were where did they flow from? Where is their source? But yea I just focused on what I was most familiar with. I didn't go into… you know I didn't know what direction I supposed to interpret so I just interpreted what I saw.

I: Ok based on prior experiences?

P3: Yea prior experiences or stuff that looks interesting.

I: Ok

P3: You know Layer cake stuff, you look at it and there is nothing going on so you move onto the next area.

I: Specifically I am interested in this in this area. I don't know if you really got a chance to look at it.

P3: Well yea I noticed it on my sheet of paper, that as we go toward A we are going up in topography, topographical elevation. Yea I saw you know these sediments are coming onto I guess maybe the shelf or the continent. Yea I didn't put too much into because yea who knows what is going on there. I just dint focus there.

I: Ok. So if I could provide you with any data, what do you wish you could know. What would help you the most?

P3: Good. I would like to have maybe a well, well log, or core sample?

I: Maybe multiple?

P3: Well if I could get multiple, I would want to put one that would go through here that shot number 2600. If I could hit this package and this package you know see what is going on there. Maybe something through here. Yea I mean it would depend, if my employer was a an oil and gas company I would probably be looking you know for stuff you know hydrocarbon traps hydrocarbon specific you know layers that indicated you know geologically though my own curiosity. I would curious about the packages, first and foremost you know that would be way later on in my concern. I would focus on putting a well maybe through here somewhere in here I could intersect it.

I: Similarly, if I could provide you with an extra seismic line that would intersect the data where would you want it to be? You can show it on that map so you make sure the camera can see it. Draw it to if you want to.

P3: Yea. You know what, I would like one where I could I get I don't know if I can draw it on the map. 4000

I: You can just explain

P3: 4000. One that would intersect at 4000 here, and then try to hit one these of two structures here to see if there are related. I don't know where those are 2700 and 3100

I: What would hope that that would show?

P3: To see if those structures are related

I: Related how?

P3: Sesimically, if you had the hot mess going into whatever the structure youre doing?

I: Ok.

P3: ____ up. Yea if I didn't have well data, that is what I would want.

I: Are there any features to you that are significant from a petroleum standpoint.

P3: You know wherever you have trapping. Structural traps stratigraphic straps, you have the stratigraphic traps in certain areas with the erosion with the offlapping and onlapping. Yea if these were salt bodies or whatever these structures are you know accumulation points on the salt. Maybe here. I see a bright reflector going into this body. Maybe the area in between this layer and this layer. Yea maybe its. Salts got interesting properties I think underneath it I don't know. Temperature it does something with temperature. and I cant remember off the top of my head, but you know maybe stuff near viscous salt. But petroleum wise, yea I would want to know where were in the world first.

I: Ok, well lets let me tell you that. This is near the offshore Carolinas, which is an area really prone to salt and as well as land slides. So knowing that now do you look at any of these features and jump to any conclusions.

P3: Yea I would more certain that this was salt, if you told me that. I still don't see in this image where my salt is coming from. At least with this one. This one I've said its moved in this way I'm more confident that this is the salt body ____ maybe you have another salt body up there. Landslides yes I guess if this is the coast, I would look over here for the landslide.

Possible over there somewhere I don't know. I don't I'm not really familiar with landslides in seismic.

I: Ok

P3: yea but since its off the coast of the Carolinas, I know you know it's a big future play. People want to get into it, the Jurassic I think. Yea, so definitely.

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Were you able to use the computer images?

P3: Yea I used them a little bit.

I: And what features, you can just point to them on here?

P3: The faults, really the ______ just zooming in.

I: Just cause you see the offset?

P3: Yea, its kind of hard to be sure if they are faults.

I: Is that the only place you used it?

P3: Yea really for the interpretation.

I: Ok were there any other features, maybe things you noticed, maybe not necessarily an interpretation, or things you notice don't have an explanation for or maybe you do have an explanation for? Its just not something were able to get done.

P3: Yea I noticed this area right here. I didn't put anything down, but you know its just kind of hummocky pattern. Wavy in this one layer right here. I didn't comment on it though or mark it. I just thought that was interesting, I saw that on the way in. Yea

P4 Interview

Interviewer: We'll just start with the easy questions. Tell me a little bit more about your past experiences with seismic interpretation.

P4: Well, I've taken seismic interpretation class here, and did IBA. I didn't do so much interpretation during my internship, but I dealt with a bunch of different seismic forms, so I'm pretty familiar with it.

I: If you could be a little more specific like, "We were working with passive margin stuff," did you see salt things, suspension, processing?

P4: In seismic interpretation class, we dealt with salt domes and mud diapirs. In IBA, we dealt with [inaudible 0:40] environment that was heavily faulted, but no salt or anything that was mobilized, except for near-surface sand bodies.

For seismic processing, I've taken a processing class. Even though this stuff is probably processed very well, you can still tell there's evidence of bad migration and stuff like that in parts of the data set that I've outlined.

I: What I will encourage you during this, is that when I ask you a question, don't feel like you need to answer right away because you've written a lot of things, so just take time to make sure you're reviewing all of what you have here. Let's talk about the exercise. How did you decide where you started your interpretation?

P4: I started on this guy because I was sitting right in front of it. I picked out the most obvious features first, which I interpreted to be salt domes or mud diapirs, something along those lines.

I looked at big features first, and then I came onto this guy, and did the same thing with the big features, and then after that I tried to get into more of the detail and the interesting stuff.

I: Is that typically how you start any kind of interpretation you've done?

P4: Yeah, definitely. For seismic volume, you'd scan through the whole thing multiple times, looking for the big, obvious features, and then get a better idea of the entire picture, the deformation history, everything it's undergone, and then after that you get into the details. Understand the big picture before you understand the small one.

I: All right, let's talk about the big picture. Can you start walking through what you saw throughout the volume, and we'll ask a few questions about [inaudible 2:20]?

P4: AB looks like it's going up the coast in a perpendicular direction, so as I expected, I found a lot of what appear to be stratigraphic pinch-outs. There's also a lot of faulting in this section relative to the other section, I think. That's what I interpreted. Some bad areas of poor migration and bad processing, those [inaudible 2:44] are crossing, which doesn't make any sense at all.

I interpreted a large growth fault right here. There's an interesting isolated high amplitude reflector right here, that's not really seen anywhere else. Something very complex going on right here. I'm not really sure what it is, but I did label that there's something interesting here.

I also noticed a lot of chaotic reflectors right here that are bounded by continuous reflectors on the top and the bottom, which could indicate scattering of energy from the seismic wavefront, or some sort of mobilized body. I couldn't interpret exactly what it was, but it's bounded by continuous reflectors, so I don't think it's a migration issue.

I: I'm interested in this feature, specifically how it pinches out. I think that's what you're trying to show. The lack of reflectors in there, is that something that you can explain?

P4: I think a better one is over here. There's a big body of lack of reflections that's bounded by continuous reflectors, and I interpret that to mean, the lithology, here it's a little more complicated because you have obvious truncation, but here I interpret it to be that the lithology doesn't change much in this packet because there's no acoustic impedance contrast in that two-wave travel time.

Here, it's a lot more complex, because obviously you have different layers with different impedance contrasting, that seem to begin to truncate right here. Maybe there's a fault. I'm not sure, but the lack of reflections in here is either poor processing, or just an absence of impedance contrast because that's what we're looking at in seismic data.

I: What did you have written next to...Was it lenses? That one line in the middle?

P4: This guy?

I: Yeah. What did you have that as?

P4: I put "This is interesting. Reflectors on the bottom are concave down, while on the top are concave up. Lack of reflections on the interior, possibly a paleo river channel, although it looks too large with respect to how big the line CD is." I'm not sure how many total kilometers this is. It looks like maybe two.

I: Yeah, that's a scale.

P4: That's 10 kilometers wide, which seems a little large. But it is diagnostic of maybe some erosion with [inaudible 5:12], but I think this might be a better example, where it's definitely concave down and it looks like a spot reflected on top, at least for a paleo channel.

I: Of the places we've talked about, or maybe places we didn't talk about, what parts did you struggle to make interpretations about?

P4: Definitely these two sections that are outlined in purple, and then this guy traced with a black marker.

I: Is that just because you have a lack of experience working with this type of sediments?

P4: Without knowing where this is, or anything like that, I don't know what the sediments are, so it's hard to make an interpretation. When you have complex deformation like this, you're basically guessing unless you have some more background.

I: Let's flip that. What parts of the data you think were, to you, you were most confident with? You knew what this was, you'd seen it before.

P4: These guys are pretty diagnostic for some kind of salt dome or mud diapir. The reflectors on the edges are bent up from something becoming mobilized and buoyant inside. This is definitely a pretty heavily faulted section in the middle because there's offset between reflectors.

As far as if there are normal faults or river faults, I lean toward normal faults, but it...

I: Why is that?

P4: I'm just assuming that this is an extensional environment. Because there's nothing with a huge throw on it, and this looks like a big growth fault here, so it would have to be a normal fault for it to be able to have a growth fault, to grow from the foot wall.

I'm assuming if this is a normal fault, all of these are probably normal faults too, because they've all gotten the same deformation history. Those are faults are high confidence. These stratigraphic pinch-outs are high confidence.

There's a fault over there. It's not that big of a deal. This looks like...That's more low confidence. The big features, I'm definitely confident about, whatever these mobilized sediments are. I'm also confident that there's some bad migration going on.

I: If I could provide you with any extra data, what do you think would be most useful to you?

P4: Where is this? What's been done to the seismic, and lithologies, and basin history? I'll take as much as you can give me, but critical would be probably be basin history and location.

I: Another similar question, if I could provide you with a seismic line, maybe two seismic lines that would intersect either one of these lines, where would you want them and why?

P4: Is there anything in particular I'm looking for?

I: It's up to you.

P4: If you're looking for an exploration question, if that was the case, then you'd use wherever these possible salt domes are.

I: Sure, let's talk geologically. Just want to know more about the area.

[pause]

P4: It's hard to say, because I don't know what exactly, geologically, we're looking at, but if we were going to get one, it would definitely have to cross that other line somewhere so that we could have a better full picture. You wouldn't take a random line out here. That makes absolutely no sense. You can't tie it to anything.

I: Let's say we shot these lines. No one's ever looked at the rocks here before. They would just provide you with these two lines, and they're like, "[inaudible 9:05]. We need to pick another line so we can learn the most we can from having another line."

P4: Then I would intersect it right here. Something along that, where you can tie up the CD and you can tie it to AB. That gives you the most tie control. These are both nice because they'd be longer lines, but at least here you can constrain this smaller...

I: Would you try to intersect any specific features while you're doing that?

[pause]

P4: The obvious features you'd want to intersect are possibly these salt domes. For me, I'm more interested in this stuff that I can't interpret what's going on.

Now, as far as that making economic sense, I don't know if someone would choose to shoot a line here just so they could see what these interesting chaotic features are. I think they'd be more interested...

The salt domes or these diapirs, they would also give a little bit more information on the history of...

I: I think you mentioned this a little bit, but what features in here specifically are interesting from a petroleum standpoint?

P4: Definitely the salt domes or mud diapirs, whichever these are, because they connect these tracks on the sides of them, although it's quite difficult to image them seismically.

As well as this big old growth fault here. That's another guy with the thickening, the sediment patches on the downthrown side. Definitely stratigraphic pinch-outs where you can have a sand body that pinches out with maybe a shale on top, bounded by a shale, so the hydrocarbons can migrate up dip and then they become trapped in the pinch-out. All of those would be of interest.

Fluvial channels possibly, but I think to begin with I'd definitely focus on these salt domes with the traps being on the flanks, as well as the stratigraphic pinch-outs. In fact, if it was really me, I'd probably put a well right here so I could hit this pinch-out and I could hit the salt dome.

I: Great. I'm going to tell you where the lines were. They were offshore Carolinas, so just offshore of North Carolina, where the shelf, that margin. I don't know if you have any experience there, but would this alter your interpretations or change the way you thought about any of the data?

P4: I don't have any experience there, so...

I: Need to know more?

P4: You said offshore where?

I: Near the Carolinas.

[pause]

P4: I just don't have much...

[crosstalk]

I: That's OK. That's not a problem. Did you actually get a chance to use the computer on this?

P4: Yeah, I did. After I kind of looked at these big guys, and the obvious pinch-outs, and I came back in through here.

I: Where specifically do you think you used it at?

I have it on video, I just want to...

[crosstalk]

P4: I kind of just scrolled through everything. I zoomed way in and just looked for anything. I think I didn't notice this fault before. I spent most of my time on this guy, because I found this one more interesting. I looked at these guys a little bit, and I think I went through this some, but definitely fine details, not look at this huge thing.

I: Was there any other part of the data that we didn't really talk about, that you found interesting, that we didn't bring up at all, maybe a smaller feature, or something you didn't understand, or just any kind of last, second, thoughts?

P4: Definitely interesting, deformation going on. From a geophysical standpoint it would have been nice to know how was this data processed?

For instance, this definitely looks like it's gained somehow. Depending on the gain you used, you can't compare reflections to reflections, based on the window size and a variety of other parameters, so that's big for looking at the impedance contrast. They might be. They might be fake, they might be real.

You can definitely tell it's migrated. I think other than that, the biggest thing would be the impedance contrast, or however it is being done.

P5 Interview

Interviewer: So just start by telling me a little bit about your past experiences with seismic interpretation.

P5: I've done an intro class, and basically some short courses and little bit with my internship

I: How many how long have you been working on seismic stuff? … No I mean since…

P5: I don't know, probably two years three or two years

I: So, just take like seconds and kind of look over what you have done because I know some of it you did minutes ago and its not fresh. Just take a quick look over things… Good?

P5: Yea

I: So just start walking through. lets just start here actually. How did you decide to start your interpretation. Where did you start it at?

P5: Um. I just started basically what the easiest feature is where to see umm

I:

Which is what?

P5: Salt domes and salt diapirs and then I looked for um stratigraphic changes around those. And I worked on the mega features. Um then tried to look at what other geological features were associated with those and then kind of worked my way up from the seismic lines from there.

I: Great and so start walking through some of things that you saw.

P5: Do you want structurally or…

I: That is up to you. And ill ask some questions as we go through the (cant hear)

P5: Sure, ok. Um. So associated with the salt domes you see a lot of faulting both reverse and normal faulting depending where you were on the dome. You also probably get organic accumulations in the anticlines that are on top of your salt diapirs. Um.

I: Why is that ?

P5: Why well your cuz of hydrocarbon migration so your its um its lower buoyancy it moves up further into the rocks till the point where you have a structure that will trap it and prevent migration. So like at the top of these two, also it's a brighter spot on the seismic usually indicates your looking at. Um what else do I want to say? Um there is these weird I don't know if they are sort of like I don't know ripples of if they are salt deformation but you see them in the bottom closer to the bottom of the seismic lines. So they are either large scale ripples which could be storm setting or they could just be formations from the salt. Some of these look like hummocks which would indicate that you are within or just below the storm wave base so you get them deposited when you get large storm activities. You can see the strata that start to thin on top of these different um hummocks as you move across. It just could be a salt lens that's what's throwing off um the reflections in the seismic. Um uh. For this one there was if your near the shelf or there is indications of debris flows and turbidities being deposited down here. And you also get almost like a foreland bulge in the equivalent when youre moving down into more basinal setting. And then your sediments are fairly continuous after that just disruptions from small faulting and from some salt (cant hear).

I: In this area right here I find it particularly interesting. So you think that's a fault?

P5: Or its slumping. So I put both

I: Ok

P5: Yea um so either youre just in transition from the topography so you had preexisting topographical low here or you could have some faulting down uh or you're just transitioning further from your shelf. And then you have some flooding surfaces throughout um you definitely have indications of onlaps. Youre indicating you see the whole thing increasing as you get towards the top of the section. Um. Onlap and toplap you have both of those. Um this one looks like you have some channels uh.

I: What is indicating that?

P5: You get truncation of two sides um thickening towards the middle of your strata. And then and then channels on the sides in two different locations.

I: The scale of these maps. Is that something you dealt with before?

P5: Not really. I usually get them instead of time I get them in…

I: Well just in terms in the latter or um.

P5: Yea, no they are fine

I: Yea some of these are like are like - kms across.

P5: Yea They are huge. No that really wasn't a problem. Its just kind of hard to focus on them when you have so much to look at eventually. You just kind of think about…

I: Ok so what parts of the data do you think were most were easiest for you to like understand like whats going on. Was it structural was it sediments stuff.

P5: For me it was the sedimentology

I: And where specifically, was like stuff you felt really confident you knew that's what it was. It couldn't be anything else.

P5: Probably when youre just looking at like flooding surfaces where you have truncations and laminations where there is like evidence of your strata changing thickness and pinching out.

I: That's just because you had experience doing it?

P5: Yea.

I: Ok. And what about the opposite. What for you was the most difficult thing to understand in this data.

P5: Um. Probably the strength of the reflections in the seismic so when youre looking at different strata why I may interpret something as you know being a sedimentologist so im looking at ripples though where it could be you know salt deformation or someone who has looked a lot more seismic may see more reasons why the reflectors may look like that.

I: Anywhere else at all or other things…

P5: I mean it really wasn't too bad.

I: Were there things you had multiple interpretations for that you were like it could be this maybe maybe this.

P5: Not really.

I: Ok. So if I could give you any additional data what would you want to know what you want to know right now.

P5: So these are the positions of the lines right?

I: Yes.

P5: So…

I: It doesn’t have to be lines I could be anything.

P5: I wrote parallel to shoreface I didn’t even look at this. That’s funny. Um… I think another line maybe closer to the shelf parallel so parallel to C & D.

I: Where?

P5: Closer to A

I: Closer to A and why

P5: I just want to know how continuous like these features are. And are they debris flows where they are continuous along that line. Just for interest sake. But also you know a well would be sweet. Depends on what im looking for. If its just general geological knowledge or if im working for industry.

I: Yea so, that’s actually my second question was where youd put a seismic line since you already kind of answered that. And you said that lets say past that, what other kind of data would really useful to you.

P5: A well

I: Where? Where would you put it?

P5: Probably does it matter what line? Um

I: You can pick a few places.

P5: If I was going to go for organics, Id put one basically on the one of the hinges of these anticlines or just on the side of the hinge or one of the anticlines of the salt domes. And then um. There are some other places. Uh probably also, if maybe in the channels. Depending on what the sediments really look like. You need to do an exploratory um exploratory well. And see what the strata look like cuz I don’t really know what the rocks are.

I: Right

P5: You can also drill through the onlaps and those are flooding surfaces so you probably have like a source.

I: So the faults especially, you know you have some faults over here some faults over here. And you said some of them are from salt.

P5: Some of them are extensional

I: Which ones?

P5: The normal the normal faults

I: Which uh which faults do you think are showing that?

P5: Here is extensional, these are probably all um extensional here because you have (inaudible)

I: There is not significant offset on any of these.

P5: No, so then it's probably just not too many extension just be from salt movement below and you have some collapse and that's why youre having some normal faulting.

I: Ok alright um. Was there any other features that you found interesting stuff we didn't mention?

P5: Um.

I:Up in here. What you thinks going on up in here?

P5: Well, you can just have its probably just like a small basin that's filling. Right? Because you correlate your strata all the way across, across here. So you have this buldge so this probably like a small basin here infilling sediment as your increasing your sea-level and depositing out.

I: So like lets talk about the salt right here. What would cause these continuous reflectors toward the top of the.

P5: Well its post-depositional right? For the most part. Um so you have these beds deposited then you have salt migration pulling your strata up as it goes so

I: How far do you think the salt extends upwards?

P5: Like meter wise kilometer wise?

I: No. Just kind of show me with your finger where you like think the salt stops

P5: So probably until you can start seeing probably like this one here. Where you get you have more continuous reflectors because they are just bending around the top part. Where you have an influence from your salt because of the decrease in strength of your reflectors and it's probably all the way up here.

I: So that's you kind of already mentioned this but let's talk about it a little bit more. Are there any areas on here you find significant from a petroleum standpoint.

P5: Yea, I mean well what youre looking for is youre looking for areas where you would have a trap. Right? And so anything that is going to give you um a pinch out whether um somewhere where you have room to accumulate whether its an anticline or you have faulting or you have something like a channel where youre getting restriction of your sediments um could be possible for hydrocarbon accumulation. So those are of interest and there is a few of these in the lines.

I: Point them out to the camera.

P5:Here. You could have onlap accumulation here. You could have some in your channels. Along sides of your domes as well as on top. Top of your anticline from your deformation structure. Um there is some also areas of pinchouts that you could have them. Depending on um what youre sealing is like for your traps.

I: So these lines were shot um primarily well actually for a bunch of different reasons. But they actually have never been looked at or interpreted like this. And so um, these are actually offshore near the Carolinas. Would that make you knowing that would that change your idea about anything that's going on so like maybe depth of?

P5: Depth and how recent they are.

I: Well I mean.

P5: What age of the rocks

I: (unaudible) this strata here. (inaudible)

P5: But I mean from surface its pretty deep. It might be too mature in some of these places for your hydrocarbons. But the shallower you go the less maturation you have so maybe I don't know. Youd have to do an exploratory well to see cuz it depends on how long its been cooking and what the depth is and whether you had a lot of organics to start with in the first place. And um whether you

I: If we are doing petroleum?

P5: Yea if we are doing petroleum.

I: Yea Absolutely.

P6 Interview

Interviewer: Alright, so before we get started I wanted to ask you a quick question. Could you tell me more a little or tell me about your past experiences and projects that you've done with seismic interpretation. And just like the regimes that they are like maybe for example like is it passive margin, salt extension, processing?

P6: I have had experience with seismic lines from SI class geophys 629 and during the IBA class. I interpreted uhh seismic in both cases. In the class we did seismic attributes and in the IBA was more ties to wells which was during seismograms. yea ____seismograms from check shots to type wells to the seismic.

I: Great

P6: _____?

I: Gotcha. So so when I ask you questions feel free to take youre time especially because there is a lot of things you looked at and probably made notes of and some things aren't exactly fresh in your mind as much as other parts are, so take your time in answering the questions and make sure youre looking at everthing before we before you answer

So let's talk about the exercise, how did you decide where to start your interpretation?

P6: I started where we left off ha , we left off of this Table so

I: So you just decided that this is where… where specifically in the image?

P6: The most prominent feature

I: Is this typically how you would start interpretation, looking for the bigger features?

P6: Yea look at the … look at it from far away and see where the first thing that come that are prominent and start with those and then get into details later

I: Ok. Just start walking through some of your interpretations and things that you saw and marks that you made. Just start giving me a brief overview.

P6: Sure. I see that the seismic reflectors are discontinuous across this feature and that the seismic reflectors have less amplitude than the surrounding strata so this effect usually happens with salt because it absorbs sounds so just by its shape I think it is a salt dome. Then after that I looked at areas that were lacking reflectors. Kind of like this area and over here. I starting seeing these shapes are artifacts of seismic refractors are not even filtered out and then I decided we were below acoustic basement. And then I kind of extrapolated that line over and then I saw the strong reflector which is seafloor multiple. ______________? and its pretty strong. Then I started looking for faults, because they were kind of obvious. So I found as many as I could. Then I started with striatal terminations. I saw onlaps to this surface. I also saw top laps onto a surface over here. I confirm that by looking over there, but that was later. So I made an interpretation that this was the maximum flooding surface, but im not for sure. I looked at this and I had no clue whats going on. I thought it was really strange. There was this very strong drooping reflector that connected here and the reflector had the same ____ as that?

I: So what lets talk about this feature a little bit more. I mean it is really interesting. What are your observations about it?

P6: These seismic reflectors don't continue as they get closer to the dipping reflector. The reflectors here are kind of like bulging. The reflectors seem to terminate against this surface and yea I have no clue what is it.

I: Ok, so this whole area to you is yea a little bit of a mystery? This whole feature here

P6: Yea this area, and what's underneath this. I don't know. I don't know what this is. I don't know how this part relates to this. I know that this is the slope break.

I: What would help you? What would help you figure out what is going on that area?

P6: First of all, first of all. I would like to figure out whats happening in that area if I knew it was important for my evaluation

I: Sure

P6: If I knew if there was no reservoir or source here then I wouldn't care about it.

I: If we are talking about it from a conventional standpoint, but if we are just talking about it from a geological

P6: So you want to understand just the history of the position in this area

I: Ok

P6: Is that it?

I: That works. What about the other image?

P6: So since I saw this salt feature, I just started just looking for things that were similar to that. It has some very sharp images here. Maybe it's the same thing. I mapped them to see if they had any correlation. Then I saw this. I was like the signature is the same, but the reflectors are kind of like strong underneath. Maybe ______________. I saw channels are not straight anymore. I also saw top lap onto surface. That usually happens when you have erosion ___too quiet___. Its pretty close to the surface. ___________. And then this is the point where I move to ____ comparing stuff. So I want to see if I can see top lap on that surface. So I did. And I thought that I was looking more at the same feature. ___________. And I looked at the next stronger reflector that go across the sesismic. Kind of like this one and across the acoustic barriers ___________. And I saw some features that were similar and I correlated interpreting the same reflectors on both. This lines _____. Not in the same the area.

I: Well geologically what do you do think those might be? Those areas.

P6: Well they are discontinuous reflectors and they might reflect chaotic strata. Kind of like landslide underwater that has carried sediment and has not deposited it in a slow manner like all of the other deposits. So maybe like a turbidite

I: Okay. So a few lets. That's pretty good for that, and we will come back to some more things. What areas you think in here obviously i think this area is one of them, but where else in here do you think did you come with not observations but struggled with interpretations of what they could be?

P6: This area here. I think I saw that these reflectors pinch and swell kind of like this. And I just **___** I just have no idea what this is.

I: Ok

P6: I struggled. Well. Parts that are not continuous reflectors, I tend to leave that at the end. I tend to stick to what I know and to what I don't know ______. ______.

I: Ok. Any other spots in either one of the two images.

D.

Yea this stuff

I: This stuff right in here

P6: Yea, I don't think

I: Or this right here

P6: The purple

I: Ok

P6: I don't think this has. This doesn't look like this. I don't think so. Or maybe it does.

I: Do you need a second to get back **____**?

P6: No, I don't know about the sediments or since this is like parallel to the shelf. So also be coming this way. The shape that this has is symmetric. But the fact that this is like over half a second in time might be like a pretty huge turbidite. So **___________**? Yea

I: Ok, so you talked about where you struggled. Where about areas you think you just most confident with?

P6: Faults. For sure. And onlap terminations. And strong reflectors and find multiples.

I: And what about lets talk about the faults. What do you suspect was the source of the stress or why do you think they are there? _________

P6: Mhm. Pretty discontinuous, not big, they are not thrust faults so they are not reverse faults. They are more like normal faults bc the reflectors on the hanging wall are lower than the reflectors on the footwall. So they are extensional features, and _____ are. They are similar to. They are what normal faults look like. I don't know about the ______________.

I: So lets say I could provide with some data to go along with these lines. Any type of data. What would be most useful to you and why?

P6: What is the objective?

I: To understand the geology of the area?

P6: Is there anything specific about the geology I want to understand?

I: What do you think would give you.. what data would give you the most if you were going ahead and you wanted to know more about this area what would give you the most. The best idea of whats going on

P6: Mhm. Good core.

I: Where would you put it at?

P6: I would put it in a section that is representative of the whole picture. For example, I wouldn't drill the salt dome. I wouldn't drill through here bc I don't know whats going on. I would probably drill somewhere here.

I: Ok. And this is a similar type of question. If I could provide you with a seismic line maybe two in reference to these, where it would be most useful for you to make this same kind geologic

P6: Mhm. I think the salt features are very interesting. I would like all of the lines to be connected so I would put one here, one here, and then one here.

I: Interesecting the salt?

P6: Yea kind of. Yea

I: ____. Ok. Why would you pick those? Just because you want them to be connected?

P6: Yea

I: But thats what you would be most interested in ________

P6: Yea. I would like. I would. I have no wells. so if I had my seismic lines and they are not connected to the ones I already interpreted I do know if I am interpreting the same things. Again, if I was trying to interoperate the stratigraphy than I would rather cover more area but if I was trying to understand the structure I would try to put them closer together. You know?

I: Yea awesome. So I were tell these lines were shot offshore near the Carolinas, so atlantic, passive margins. And mostly a lot of what they were doing here was actually looking at slumps looking at giant flows?

P6: Debris flows underwater?

I: Yea so would that alter any interpretations or data that you would want?

D

We were looking at slumps?

I: Yea

P6: Ok I would say that

I: Massive underwater landslides

P6: Yea I would. I was thinking that these could be turbidites, and so what a turbidite is is an underwater landslide. What you say? Something. Now that I know that what would change? My interpretation

I: Yea, what. Maybe you would change where you would put the lines. Maybe you think about this area a little bit differently

P6: In terms of observations I wouldn't change anything but interpretations yea I would think that most of the discontinuous reflectors could have dealt with debris flow like maybe all of these maybe these uh maybe these as well especially these. We're next to the slope break. Um this is a very prominent reflector and its very. Sediments might have fallen from the slope, yea do that.

I: Cool. So it just gives you a little more confidence maybe

P6: Yea

I: Knowing that those might be what youre looking at

P6: Well I assume that they had some reason for picking this area. So yea it gives me a little more confidence maybe

I: Ok. And did you get a chance to use the computer images at all?

P6: Yea

I: And where what were you looking at? Or was it just like an overview of

P6: I wanted to look at the zoomed version of like this area and this area to look for faults. Some of these have very little offset, so I just wanted to make sure that they were faults

I: Sure

P6: Since the computer has more resolution

I: And that's pretty much where you used it specifically?

P6: Yea

I: Ok

P6: For nothing else

I: And was there was any other areas that or last thoughts that you had or anything that we didn't get a chance to talk about? Areas or just general things about the images themselves?

P6: Yea. So when I was trying to put these in the map, I noticed that the shot numbers matched this line but the shot numbers don't match this map. Haha. I noticed that. Haha.

I: Good to know. Good to know.

P6: Something that is not in the image, uh ______

I: Well you were the first person to notice. So there you go.

P6: Yea

I: Ok I think that is about what I needed from you. Cool alright thank you sir.

P7 Interview

Interviewer: I know a little bit of this, but for the camera sake tell me a little bit more about your experience with seismic interpretations until this point?

P7: [inaudible 00:10] .

I: I know.

P7: For my dissertation I'm working [inaudible 00:15] seismic volume from Australia which is a [inaudible 0:23] system, not much faulting result, not much tectonic activity in general, and it's relatively easy to follow.

Other than that I took seismic interpretation [inaudible 00:43] some of the basics in general.

I: OK, so I guess let's talk about the exercise. How did you decide where you started your interpretation at? If you remember correctly.

P7: I began the dip line. I looked at the overview sheet, and looked at the contours and saw that the AB line and the dip line roughly, and just went for the big obvious features that popped in there, structural features, then [inaudible 01:25] features.

It started with folds or what I interpret to be folds. Then those, whatever those may be. They're pretty big.

I: What were you referring to?

P7: Those, dome.

I: Yes, OK, yeah.

P7: I don't have enough experience to say yet to [inaudible 01:51] up to a seven seconds to way travel time now. I interpret the obvious or the funny looking things.

I: Is that what you thought this was as well? Maybe?

P7: Yeah it could also be a bunch of diffractions.

I: Sure.

P7: Folds, those would be features. Then I went to stratigraphy, looked and saw that there were a bunch of [inaudible 02:24] features identifiable.

I: What do you think about this area where it's...

P7: I saw that there's...

I: Two of those.

P7: Yeah. That one was pretty obvious. It's a package of chaotic reflectors that wedges out, more towards.

I: What do you think is the cause of that, looking at the overall line, geologically?

P7: Chaotic reflectors, down dip, some mass transport of pulses. That would be my guess.

I: You'd say the same thing about this area, or is it a little bit different?

P7: No. Up here, the amplitude was relatively OK. Medium amplitude, but reflectors were chaotic. Down here, amplitude is also medium to low and the reflector is undulate.

Could be some huge channels, maybe. They're definitely different. I would not lump them together, same origin.

I: The faults that you see in here, can you talk about those a little bit?

P7: I looked for reflector packages that were offset vertically. That's where I just drew lines. Some of them are relatively obvious.

[laughter]

P7: I think this one and this guy were pretty obvious. There are a bunch of smaller ones in here with less offset.

I: In your own words, what do you think is the source of these faults, based on what you can see?

P7: Based on what I can see, I wouldn't say that this guy, this feature, has something to do with the fault. Maybe it causes some...

I've seen some [inaudible 04:59] strata, which means that, at least in this part, this feature was active, but that's almost posited. It's also a fault cutting through those.

I: What about up in this area, here?

P7: The question mark?

I: Yes.

I: OK. Then what about up in this area here?

P7: OK, the question mark?

I: Yes.

P7: I can see that coming from the basing reflectors, or that's terminated against nothing. Or just terminated, and they were not really offset.

Maybe this package could be related to this guy, but up here, the reflectors just terminate, they're not offset. They transition laterally into a chaotic wedge, as I call it, which is then overlaid by some medium amplitude reflectors in there. Hence for this all.

I: You don't know what [inaudible 06:18] could be geologically?

P7: We have a topographic high there, so that might be some material being transported basing forward. Then I wouldn't know what would terminate so promptly. Hence...

I: We can talk about that more in a minute. I want to move on to the other one. Some of the other things that you saw, just go ahead and then describe them. Then I'll ask a couple of questions.

P7: Same thing looking for obvious features. There's another [inaudible 07:05] similar to this guy over here. There is some interesting chaotic wedge-like feature that pinches out laterally, and then transitions.

[inaudible 07:21] again. There's some truncating reflectors that form something like a channel, or composite channel made out of more smaller channels. Vertically, there are zones.

Then medium amplitude, transitioning into a lower amplitude to chaotic zone, going back into sub-parallel leading to high amplitude, and then transitioning back into lower amplitude, so between those two highs.

Of this guy, I saw that the reflector amplitude decreased with almost chaotic, and there was [inaudible 08:17] by really high amplitude reflectors.

I: Which tells you what?

P7: That's the observation. Seeing that combination of structure and amplitudes, I could imagine that that might be gas or either problems, leaking vertically upward, and then terminating here, creating an amplitude norm.

I: Great. My next question is, of the data, I think we're already talking about this, at least with interpretation.

If you're thinking about this geologically, not so much just the description of what you're seeing. What do you think for you, was the hardest thing you struggled with? Also in terms of coming up with a geological reason to why it's there?

P7: OK. Looking at those features, I would say is some kind of [inaudible 09:15] here, at first hunch. Then I'll look at the two-way travel time, and see that it's gone down oversight in sight.

It's deep, and I don't have enough experience to know if that's really visible or if it would look like that if we put it down there.

This side, I definitely have no idea what that is, or how that could have been formed. Some material must have eroded, deposited down there.

That would be my best guess, but then there's some open questions about that. What else? Geologically...

I: Well, we can go on to the next part. And, that's pretty good. What parts of the data do you think you're most confident with? You know you've seen this before. This is something that you really recognize.

P7: I'm really quite confident over here where reflectors just [inaudible 10:27] into bigger reflectors. I'm confident with the growth strata over there.

The bounds of that feature are, they're not definitive but obviously, there's some that cause other reflectors to warp up and terminate against. That's what I can say for sure.

I: We didn't really talk about this feature. What do you think, this feature, maybe we did but I didn't hear it?

P7: Yeah, I didn't talk about that, so that is in between those two features and it causes reflectors to bend upward.

Actually, it's pretty interesting. It's naturally, discontinues, terminates to up and right and it's internally chaotic. [inaudible 11:35] wedge or something?

I: Why do you say that? Just because of where it is?

P7: Yeah and I don't think that fault up there very nice resolution below, so it would reflect everything way more. I wouldn't say that because one feature that causes this [inaudible 12:19] a fault.

I: Let's take a step back and just say if I could provide you with any additional data, what would be most helpful to you right now? What do you wish you could know right now? What would help you with this interpretation to be a little more confident?

P7: If you were able to tell me in which geographic region.

I: Why?

P7: Then I would have a better idea of the regional geology where I am in relation to favored geological features.

I: Similar question. If I could provide you with a seismic line that intersects either one of these two lines, where would you want it to be? Even multiples [inaudible 13:10] . You can mark it on the [inaudible 13:18] one of these next, as well.

P7: I think most helpful would be maybe some lines parallel to the AB line. That would be helpful to see what those features, how continuous they are.

I: Do you want one just stepped over a few kilometers or we talking maybe the middle of the line? Or, talking towards the end?

P7: That would depend on what we're trying to figure out. That's about almost a hundred kilometers, maybe 130 kilometers, so then, relatively large area. We're not looking for one [inaudible 14:21] as well, at this point.

I: We're just looking at the geology as a whole. We're trying to learn.

P7: If we want to figure out what's happening, I would like to have one right there.

I: Did you end up using any of the computer images?

P7: No.

I: Why not?

P7: I felt that I don't need to zoom in anymore because we're looking at some big [inaudible 14:49] features...

I: We are.

P7: I didn't get the urge to zoom in further to look at one tiny little thing.

I: If you had more time, do you think you might have put it on here or possibly any of these places where...

P7: Yeah, I had a look into either this or this [inaudible 15:22] .

I: Let's ask this question. You touched on it already. Actually, I like this one first. Any other parts of the data or things that you wanted to interpret that we didn't get a chance to talk about? Just general observations about these areas, as a whole?

P7: I think the main, general observation is that [inaudible 15:48] there are packages of reflectors that are continuous medium to high altitude.

Then there are packages below or above that shear, are really quiet at that altitude. Then there's stuff with higher altitudes below again, and that's not normal. That's very obvious.

I: Are any of these features, you touched on this a little bit, but are they significant to you from a petroleum standpoint? Where, specifically? Why?

P7: Yes. From a petroleum perspective, I would, first of all, look for geometries or anticline features and for altitude nominally and for [inaudible 16:57] .

This guy and those two over here, they create anticlinal features. They bend natural reflectors upward and make them terminate, so there would be one way of trapping potential hydrocarbons.

Looking over here, on top of this guy, there's our geometry and altitude nominally on top of that with some chaotic reflectors. Channel-wise, chaotic reflectors below, so that that jumped right into my eye, as being potential hydrocarbon accumulation.

I: My last question. So, I'm going to tell you where these lines were shot. They were shot off shore, near the Carolinas, on the Eastern seaboard. Does that alter anything that you saw? I don't know if you're familiar with the area.

P7: I'm not familiar with the area. Yeah, I don't know anything about them.

I: You already mentioned that's where you would start. You'd want to know where and why. Then...

P7: Right.

I: Great, I think we got what we wanted...

I: I know a little bit of this, but for the camera sake tell me a little bit more about your experience with seismic interpretations until this point?

P7: [inaudible 00:10] .

I: I know.

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P7: No.

I: Why not?

P7: I felt that I don't need to zoom in anymore because we're looking at some big [inaudible 14:49] features...

I: We are.

P7: I didn't get the urge to zoom in further to look at one tiny little thing.

I: If you had more time, do you think you might have put it on here or possibly any of these places where...

P7: Yeah, I had a look into either this or this [inaudible 15:22] .

I: Let's ask this question. You touched on it already. Actually, I like this one first. Any other parts of the data or things that you wanted to interpret that we didn't get a chance to talk about? Just general observations about these areas, as a whole?

P7: I think the main, general observation is that [inaudible 15:48] there are packages of reflectors that are continuous medium to high altitude.

Then there are packages below or above that shear, are really quiet at that altitude. Then there's stuff with higher altitudes below again, and that's not normal. That's very obvious.

I: Are any of these features, you touched on this a little bit, but are they significant to you from a petroleum standpoint? Where, specifically? Why?

P7: Yes. From a petroleum perspective, I would, first of all, look for geometries or anticline features and for altitude nominally and for [inaudible 16:57] .

This guy and those two over here, they create anticlinal features. They bend natural reflectors upward and make them terminate, so there would be one way of trapping potential hydrocarbons.

Looking over here, on top of this guy, there's our geometry and altitude nominally on top of that with some chaotic reflectors. Channel-wise, chaotic reflectors below, so that that jumped right into my eye, as being potential hydrocarbon accumulation.

I: My last question. So, I'm going to tell you where these lines were shot. They were shot off shore, near the Carolinas, on the Eastern seaboard. Does that alter anything that you saw? I don't know if you're familiar with the area.

P7: I'm not familiar with the area. Yeah, I don't know anything about them.

I: You already mentioned that's where you would start. You'd want to know where and why. Then...

P7: Right.

I: Great, I think we got what we wanted...

P8 Interview

Interviewer: Before we start talking about the exercise, can you tell me a little bit, just a brief introduction, or rather just talk a little bit about your experiences with projects, with seismic interpretation in the past?

P8: My experience is, I've taken coursework, such as seismic interpretation, graduate courses on seismic interpretation, R dominance [inaudible 0:31] class, short courses provided by Shell, AAPG, carbonate classes dealing with this. Multiple [inaudible 0:51] classes, Imperial Barrel Award Competition, 2014, I believe, using several monoseismic, and I dealt with it through my internships.

I've used software such as Seismic for GeoGraphix, I've used Schlumberger Software suite, Halliburton software, that's all for what I used for seismic. Then I taught the ICG Seismic course.

I:: Before we start talking about this stuff, just because you've been spending about 40 minutes on it, look over everything that you did, so when I bring up questions that you know that each of these features still exist, if that makes sense. Give an overview and check everything out.

[pause]

P8: What do you want me to do?

I:: The things you did most recently are freshest on your mind. Make sure that you try and check out everything that you've done, so you're not only talking about the most recent.

[pause]

I:: How did you decide where to start your interpretation?

P8: Great question. First thing I did was look at where I am on the map. First thing I did was look at my location map. I am assuming these are contour maps. I'm assuming that from going off here into deeper water.

I:: Based on the color configuration?

P8: Also, look at my scale. Scale's important to determine what kind of features you're looking at. Are you looking at something that's only a mile long, or you can tell here this is five kilometers right here, or are you looking at several hundred long, each way?

When you orient it, if you make the assumption that this is going into deeper water, am I looking at a cross-sectional view from shelf to basin, or am I looking at a lateral transect view along shore? That was how I initially got oriented.

I:: You did that before you did any kind of...?

P8: Before I did any interpretation. What I did was first make observations, before you make interpretations.

I:: Talk to me about those observations.

P8: The first thing I always do is I step back and look at it from afar. I don't try to look at it close as I can, and I try to get a big picture perspective, big picture view. Something that I had to get my bearings around is this seismic interpretation which is perpendicular to this one, is this one's reversed, as it's listed here.

I had to visualize that as how I'm looking at that. When I made a big picture observations here, I noticed that you have many dipping beds and many horizontal beds. I see convergence of dipping beds.

I also saw that there's a contrast between basically less resolution or color on the lower portions and you see more contrast, more horizons to the top. You see that in both images, which makes sense, as deep go deeper, you can see less resolution, less reflection.

With that, first thing I noticed was there's these large obvious features that are difficult to resolve. You don't see any internal reflection, or limited internal reflection, which means that there's not going to be large enough of density contrast between the two, probably not, you can't resolve them well.

I noticed these features, that was a large observation, and what I did was I looked also for type of horizon truncations -- onlap, downlap, toplap, baselap, erosional truncations, erosional features. Do I see the type of growth strata, etc.? I looked for features like that.

I:: Why were those important for you to identify?

P8: Those are very important because to me, those observations give me a timeline picture. I know certain things that are deposited on top, but if I see onlap, then I can build a perspective and get an image of what's happening with regards to its space and time.

Is maybe sea level rising or could sea level be falling? How are these deposited on it? If you see a truncation feature, you know that either it's erosion or for instance, a salt deformation structure. Something happened that caused a disturbance in the natural deposition, and those features ring in to what you're looking for.

I:: What other features did you see in here that [inaudible 6:49] talk about?

P8: You want me to talk about interpretations?

I:: Interpretations of things that you've seen.

P8: I saw discontinuous horizons, which I interpreted as false. I went through, and I marked, "Interpreted false," which based on these discontinuous reflectors. If I was using the interpretation that this large structure right here would be salt or volcanic or something, if it were salt it would make sense that if you have deformation, you would be having stress creating movement.

I identified salt, I also noticed that you can see several areas that have a lot of discontinuous reflectors but they're overlaid in a lens-type shape.

I:: What do you think that is?

P8: I interpreted it as the possibility of a mass-transport deposit, and another thing I interpreted it as was possibly an unresolved carbonate structure, but I don't know too much about this area where I am, so I don't know, it could be carbonate or carbonate-type structure.

Up here, you also see something similar, they could be channels, they could be turbidites, or mass-transport deposits, or they could be little carbonates, etc. I noticed especially up here, you have very clean truncation erosional features, and then deposition within it are layers that look like typical scour feature.

I interpreted those as channels. I interpreted this down here as growth strata, to a certain point, because what I notice is as you move towards the structure, you can see more sediment being deposited, same with this, so you have that lag for sediment deposition.

I:: What does that tell you about the timing?

P8: It tells you it's the same depositional with the structure to a certain point. I didn't really spend too much time on that. [inaudible 9:40] moved on.

As there are a couple lenses over here also, you see a lot of places have abrupt terminations and bright reflectors, which could be indication of hydrocarbons, but I didn't want to make too much interpretations about observations in that time.

Then you see this fuzzy stuff throughout here where you have these wavy type beddings, which could be clinoforms or they could be etc., you name it. I thought they might be little, small clinoforms because we're talking about five kilometers here so I don't exactly know about that.

Especially over here, if this is a giant, salt structure, it makes sense that you have...Especially if it forced things up and it occurred after, then...Especially if it was salt evacuation structure where salt was removed by a fault, faulting, then all this faulting above it makes sense.

Also you have a lag here which is moving along this. It makes sense how it goes out and comes back. You can see that ancient topography. I'm rambling here. Where am I supposed on this?

I:: That's fine. What about faults? Let's talk about those. How would you explain those faults? Why do you think they're there?

P8: Great question.

I:: I don't know if...

[crosstalk]

P8: My hypothesis would be that this may be an extensional type basin, where you have a lot of faults, majority of the orientations which would be low. Maybe it was under tensile stress at that point.

I:: Did we talk about this area at all? Did you get a chance to look at it? I know it's not something you probably looked at.

P8: I didn't really...

I:: That's OK.

P8: I noticed these little wavy things but I didn't [inaudible 11:43] .

I:: What about in this area, especially? Pick a moment. Tell me at least what you're seeing. It goes on. This whole area is really interesting. I was just thinking you could make some observations and maybe...

P8: What's really interesting is the type of processing they use, as you can see, the circular, processing sphere for that. That's interesting.

You see how you have your almost like a giant syncline, anticline type structure. Maybe it's slope to basin. Then you have truncation. This could have been a large bowl but I didn't want to make that assumption.

I:: Why not?

P8: I was too busy running around.

I:: How did you resolve that? If you wanted a clinoform, how would you resolve that? What would you do at least to figure out what's going on in there?

P8: One way is to look for similar patterns, similar reflector patterns. You can see there are certain areas where they're more horizontal and they get faded, faded packages, and then all of a sudden you get these wavy packages. You look for similar packages on both sides to see if it does go through.

If you wanted to make the interpretation that there is a fault here, you need to look for similar reflector patterns on both sides.

If you're assuming that this is a giant, a very large, fault and that this whole side has been dropped down or vice versa, this whole side has been moved up, then you can make the hypothesis that this erosional feature right here, if it's not an artifact of just resolution from up here then maybe this is a long shore channel that could have had secondary deposition.

No idea what this is. I'm going to be honest. Maybe it's ancient carbonates.

I:: What parts of this data do you think were easiest for you to interpret geologically?

P8: Breaking apart from the larger packages, reflection packages, looking at where your truncation onlap.

I:: Is that because you have a lot of experience drawing that?

P8: Yeah, that's what I've done.

I:: What about the opposite? What about things you really struggled to interpret?

P8: Maybe some of the larger structural features like I stayed away from this because I don't really know what it is. Also this stuff scared me because I wasn't sure how much of this is real, how much of this is artifact.

I:: What else too?

P8: I didn't get to this so I don't know what went over here.

I:: What about another image?

P8: One major goal is, when you're timed here, you focus. You're focused and your attention goes to what catches your eye, what you think would be important.

Just looking at it my first hypothesis is I see these are going to be important and so you have probably 30, 40 kilometers over here that I didn't even hardly look at because I was so focused on the structures here. Jarring your attention is important, sure, time management too.

I:: If I were to provide you with any data right now, what would be most helpful to you to go on with these two lines?

P8: A well would be nice.

I:: Where would you put it?

[pause]

P8: I'd maybe put it somewhere like right here to get as much of a full section as possible and maybe apply some restraints on what's going on in here, or maybe right here, or right here if I wanted to constrain, if I'm looking for oil and I think these are hydrocarbon indicators.

[inaudible 18:43] but I'd want to get as much section as possible to get [inaudible 18:49] .

I:: One more thing real quick. If I could provide you with an extra seismic line that would intersect the data, where would you want it to be? This [inaudible 19:05] you can see it.

P8: This is split, right?

I:: Yeah.

[pause]

P8: Maybe like another one...

I:: You don't have to draw it right here. You can just show it on [inaudible 19:38] if that makes it easier.

P8: [inaudible 19:41] another seismic line, if there's another one out here you get more indication about what's going on out here, or if you're feeling crazy you can have another one that kind of goes across to get the best of both worlds and apply some restraints on what you're looking at, or go more along shore, not on shore but...

I:: That's how you would do it strictly from a geological approach and just trying to learn [inaudible 20:18] more information, but what if we were doing it from an oil standpoint?

P8: I definitely would want probably as much as possible right along here. Basically, I'd want as much information about probably this area as possible. I'd want to be able to constrain what's going on.

Like with these, what the lateral extent is of these, how large these type of features are. Where are my hydrocarbons going to migrate? What's the structural makeup of [inaudible 21:07] ?

I:: What else is interesting in here besides these structures? What else is interesting to you from a petroleum standpoint?

P8: A lot of these fault features, I saw rock tarnation. You see these bright spots, especially like something like this over here, some of these features maybe. Up here there's a little thickness after the structures.

I:: That's fine. [inaudible 21:44] that's fine.

P8: It's [inaudible 21:56] so we don't really know, but it's about 2000 milliseconds per kilometer. Maybe [inaudible 22:19] methane hydrate right around here that escapes right through there. These features could be interesting. This could be interesting, especially right here.

I:: Because you said there were channels earlier, right?

P8: Yeah, if they were channels, yeah absolutely. Like especially these [inaudible 22:43] channels. Again, I didn't really look around over here but there definitely could be some potential out here.

I:: These lines were actually shot offshore near the Carolina's. This is an area prone to salt, and landslides, and creeks. Does this change any of what you thought about any of these lines?

P8: No. You've got your mass transport deposits, turbidities, salt, salt deformation.

I:: Did you get a chance to use the computer images at all?

P8: Didn't look at it at all.

I:: Not a problem. Were there any other parts of the data that we can talk about that you found interesting, we need to talk about that now or if there's any other thing that you wanted to?

P8: Yeah, these guys right here, this kind of wavy bedding. Do you have any information on them?

I:: I don't.

P8: Yeah, these definitely were interesting over here. Also, now that I look over here, this is interesting. What is this thing? Just onshore sharp feature or is at a...?

I:: No one has ever looked at these lines really, so there is really not a lot. You guys are literally the first people who have looked at these lines, so your guess is as good as mine.

P8: The resolution of this stuff right here is what drove [inaudible 24:39] . You can see it's done with a circular spinning, so maybe if you could resolve this a little more. Maybe you can't. Maybe you can't get down [inaudible 24:51] this is all basement. I didn't put a basement line because I didn't...

P9 Interview

P9: Here's some stuff for Fred. I'd have to stare at it or I'd have to look at it for a while to figure out some of the different systems tracks in the seismic down here and parts.

Interviewer: Talk about other stuff.

P9: Yeah.

I: Still good on battery. Yes. Before we start talking about the exercise, just tell me about experiences that you've had with seismic.

P9: I've dealt with it a little bit in some of my classes. Also, [inaudible 0:33] that we did together so I've looked at it a little bit. There's still quite a bit of stuff that whenever I look at it, it takes me a while to figure out what it is.

It's difficult to know. It's a lot easier to interpret stuff whenever you know where it's at. You didn't tell me where it's at, right? But, yeah, just in a couple of my classes. I haven't had seismic interpretation so that would definitely help.

A lot of this and a ton of stuff is just because I'm unsure, just because I haven't had a formal class with it. There's a lot of stuff where I think I see it but it's hard for me to put it down.

I: We'll talk about this.

P9: Yeah.

I: When you're looking at these lines, how did you decide where to start with interpretation?

P9: I started with the dip section just because it's probably where you're going to see most of the features. Not to say that this drag section doesn't help but it's where you're going to see a lot of the extensional features, the faulting and all the different stratigraphic features that are going out into the basin.

I: Where specifically that one in the section?

P9: In the line. Let's see. The first thing that jumps out is just the structural stuff. Notice the salt that appeared out of the bed. It's where I started. I was looking at big structural features. I look from that till looking at faults.

Basically, I look at the structural features first before I look at any of the stratigraphic stuff. Also, I even set in the camera thing. I flip the colors.

I: [inaudible 2:23] structure [inaudible 2:24] stratigraphic. Let's talk about why did you pick these structural stuff first. Is that something that you had just more experience with?

P9: It stands out a little bit more. It's less ambiguous and the structure a lot of the times affects your stratigraphy. As a starting point, you notice the structural features.

I: They pop out at you better.

P9: Yeah, for sure. You'll notice the faults, the salt, the salt movement and things like that.

I: So you felt pretty confident with separating those?

P9: Yes. Something like that.

I: You were pretty sure it was salt? Just curious, what tells you that?

P9: Just the way your seismic's being pulled up like this. It's usually a good indicator of salt and it's coming up through your geology. Essentially, it's just the speed of your seismic, it's going so fast that it actually just warps your seismic data.

I: Is there anything else that could do that, or could explain?

P9: The only thing is it's either, it could be salt, it could be some sort of gas chimney, but I feel like that's [inaudible 3:53] .

I: You could spend some time on this. Let's talk about some of those features that you saw, that maybe you didn't have answers for? You were just starting to, you had some ideas, just start talking about some of the things you saw?

P9: Mostly, down in this section as you get further in. You can see pro-grating type systems. At least that's what it looks like to me. Just looking at it just for 20 minutes, it's hard to figure out different systems track or whatnot. You can definitely see different types of sediment patterns.

As far as it pro-grating out and actually some that are trying to come back.

This looks like it's some form where you're not going to have [inaudible 4:51] against this. There is just some stuff where if you looked at it a lot longer you could figure out some of the fine details. You could definitely see different packages in there.

I: You would spend some time looking at packages. What about, let's say down in here? The factor is not very continuous. Kind of bumpy? Do you have any ideas?

P9: I'm just trying to go through either. It doesn't look like they're stacked on top of each other. They could be some turbidite systems. I wasn't really sure just as far as how...they look like they're continuous but they're just wavy, just kind of interesting, but I wasn't really sure exactly.

I: Let's talk about this area right here. Start with this part and then move down into here. What do you see? Before we talk about what you think it might be.

P9: Let's see. Just looking at this, it looks like you have some big, major faulting but that's what I was a little bit unsure about was if it was faulting going on here or if it was more salt coming up through there that's making that look like that.

A lot of times, from what I know, is whenever you get closer to sediments worse, this is going to be a lot more convoluted. But yeah, I honestly wasn't exactly sure.

I: What about in the other image? First off, let me just take you back. Do you think there's more faults in here?

P9: For sure. Definitely.

I: Did you get a chance to use the screens?

P9: Yeah, I did. You can definitely see the faults much, much easier on the computer images.

I: That's what you used it for?

P9: Yeah and a lot of these, you can just notice them, the bigger ones. But whenever you zoom in and see some of the features on the image, it definitely makes it easier to see. You can even see some of these packages a lot more defined in the images, also.

I: Let's talk about the other line. What you're seeing. Just talk about it.

P9: I didn't look at this one that much.

I: Why not?

P9: Just because it's going to be difficult to see a lot of some of the same structures and features when you're going along strike like that. Not to say that this isn't useful but as far as stratigraphy goes, it's going to be difficult to pick out any sort of...

As far as doing sequence, it's going to be difficult to pick out any packages going along strike like that. It's going to be a lot easier to do it in the dip section. You can see some of these structures. These look like salt domes as well.

Maybe a fault in there but I didn't have time to really give this one that much.

I: What do you think that these lenses in here could be?

P9: They could be possible channels coming out. Looking at it from this direction, you could have maybe some channels that are coming out into the basin at one point or another.

I: If you have more to say, go ahead.

P9: I didn't mark it down but that's what I was thinking. These channels that were coming out towards the unit of the basin.

I: What about this area in here? The clear reflectors are here and here. Why would that...?

P9: I would say some of the stratigraphy above it is absorbing that energy, not allowing it to get to the reflectors below it. That's probably one reason why, just because you have some features, some geologic features taking up a lot of the energy, not allowing it to go through into the layers just below it.

Kind of like in [inaudible 9:31] had that big unconformity on the cretaceous, it made the seismic just below it not very clear because it took up a lot of that energy.

I: Let's look at my list of questions here.

P9: Have you had somebody interpret this quite a bit?

I: Nine other people have interpreted it. There's no answers yet. Do you see anything else that catches your eye in this image? Take your time. Just observations.

P9: I think whatever...I thought you'd expect to see the salt over here, at the intersection. You don't see it at all. Right at this intersection, I thought just looking at it -- maybe I was just thinking wrong but I thought you should've seen salt in this general area, but you didn't.

I don't know. Or is there something glaringly obvious? I'm not sure.

I: That's OK. I'm just asking. Let's just back it up a second and ask you something different. If I could provide you with any data to go along with these two lines, what would you want?

P9: Has all this been migrated? Has it been processed? For the most part, it's all...

I: It's been done.

P9: Let's see.

I: You'd want to know what was done?

P9: Yeah. Do you know what has been done?

I: It's written down but I'd have to look it up. Why is that important to you?

P9: Because whatever processing it went through, whatever it's been put through is going to...it could possibly change some of the different layers going through and it could change your interpretation a little bit, especially for faults.

I: Back it up though. Let's say, neglecting that just for now, what data would be really helpful for you to have, to make a better interpretation of this whole area?

P9: More lines.

I: Where would you want them?

P9: Let's see. Going across this, probably just more dip section lines. I know that's vague but a 3D cube would be awesome.

I: Let's say a line going perpendicular to the coast. Why would that be helpful for you?

P9: This?

I: Yeah. Why?

P9: It would just confirm maybe some of these different features. You could see laterally how some of these packages might come. And see more towards the south, I guess. If some of these channels in here...

It might also help to get some that are along strike two to see if you could find more of these channels. Maybe distributor channels of the delta [inaudible 14:09] system or something like that.

I: Any other data that you would find useful to have?

P9: I don't know, just for interpreting seismic...?

I: For helping you understand the geology.

P9: Well logs would be awesome. Well logs.

I: Where would you want well logs? I give you one well log to put somewhere, where would you put it? Why? Take your time.

P9: I would say, one well log...Not too far out of the basin but towards the middle, just because you're looking at more stratigraphy from younger sediments but also getting a lot of the older stuff.

I: What about on the other line?

P9: A well log right here going through that channel. See if that is a channel, see if there's any fluvial sands in there, for oil and gas especially.

I: Let's talk about that. Where do you see in this image, places that would be really interesting from a petroleum standpoint?

P9: Anywhere along the salt domes. You have structural traps. Anywhere along the faults where you have juxtaposition of your reservoir source or whatnot. Some of these packages, if you had more time to map these out, you could figure out where you have low [inaudible 15:55] systems tracks for good sands for reservoirs.

Same thing for transgressive. Sorry. Same thing for an acredational type system where you could have source rocks that are further out. It just depends. Along the faults for traps, up against the salt domes for traps. Over here in the strike section, you could have possible fluvial tide reservoirs in here.

Anything within these channels that are going [inaudible 16:36] . If that's a channel. Maybe just whatever.

I: These images, I'm going to tell you where they are. These images are shot offshore near the Carolinas. This is an area prone to a lot of slumping, a lot of creeps and a lot of underwater landslides. Does that change your opinion of any of these features?

P9: Yeah. It changes it for that. It makes sense that you have the bumpy type hill and that might not be a channel anymore. Let's see. Makes me wonder if that's salt anymore. It makes more sense as far as the bumpiness of some of the stratigraphy, I would say. I figured it was in the Gulf of Mexico or somewhere.

I: These are lines that no one's really looked at before other than the handful of people in this study. Any other features or any other observations before we call it a day? Anything else you noticed? Observations? If not, that's OK.

P9: Not really. Like I said, it had a ton of seismic, so it's...wish I could say more about it. That's probably about it.

I: I think that's all I need from you, so thanks for doing this because now I can wrap up my data.

P9: Sorry if it's not enough. I feel like I didn't interpret that much.

I: No, it's totally fine. That's the whole deal.

P9: Yeah, everybody else...

I: Depends on the per...

P10 Interview

Interviewer: All right. Before we talk about the exercise, just go ahead and tell me about your experience with seismic [inaudible 0:09] .

P10: Just in the IBA competition, ‘P2’and I work [inaudible 0:18] pretty much. Just drew these seismic lines to finish doing this kind of stuff. It was not a very structurally inclined area. We were just tracing horizons.

I: Just go ahead, and you've been working on this stuff for a while that you're probably OK, but just make sure that everything, you've looked at everything before we start talking about all of the different areas. Just so you know, when we start talking that you know these things out.

P10: Yeah.

I: Good?

P10: Yeah.

I: How did you decide where you started your interpretation? Where did you start?

P10: The top.

I: Which line?

P10: From this one, I guess. This, sitting right here.

I: How did you decide what feature to start with?

P10: The clearest ones.

I: Which were what?

P10: Which is this onlapping surface right here, and then these secondary onlapping surfaces in this upper section right here.

I: OK. Go ahead and start talking me through what you saw throughout this. Piece together your interpretations [inaudible 1:32] .

P10: It looks like some kind of composite salt withdrawal. You can see another structure like that on this line as well. Corroborate that structural style operating this area. I saw multiple different sedimentary sections with different characteristics within them as well. This bottom section goes way deep. One particular looking thing down here...

I: An explanation for that?

P10: It might be channel bodies, perhaps. Possibly deep channel bodies or, I don't know, what's the vertical exaggeration on this? There's no...

I: Honestly, I couldn't tell you off-hand. They have it somewhere, but don't worry about it.

P10: Yeah, that would make a difference, if it's like some kind of clinoform progradation going into and out of the pane. There's not really a line of one of those on here so you can't really tell. It kind of looks either like channel bodies or clinoforms prograded into or out of the plane it kind of looks like to me.

We have a fissure right here with a lot of vertical fractures above it, so it kind of separates it and makes it difficult to trace between each side of it. [inaudible 3:10] resolution I guess and escaping gas I think that's what that is or [inaudible 3:17] .

Then this kind of middle-ish package determines just based off of whatever was down there I think surface was up here, and then to the top of this really seismically washed out area. It could be a separate lithology change right there, should be distracting. [inaudible 3:43] lithology from here to here could be carbonate or something like that.

I: How would you define this package?

P10: That one?

I: Yeah.

P10: It's pretty chaotic. A lot of really completely traceable seismic reflectors. You can kind of draw and trace them I guess.

I: What do you think the source of those features might be?

P10: Are they heterogeneous sediments maybe?

I: What would help you in figuring out what that actually is...?

[crosstalk]

I: Where else did you see some things?

P10: Right here, is interesting. It's a mushed up zone but it's really close to the top of your [inaudible 4:45] . It's like some kind of debris collection there. I don't know. It's kind of interesting. I was just going to like circle it, but...

I: Point out whatever you didn't get a chance to circle something, just point it out.

P10: Yeah, it's kind of interesting why it's so shallow but there's no resolution out there, so it might be really mushed up, messed up, something like that, just a bunch of stuff all mixed together. Yeah, a lot of it looks like normal faulting, perhaps, which is due to subsidence from this salt uplift. I don't think there's much over here.

I: Did you get a chance to look at this area, at all?

P10: Yeah, they look like there might be...This is interesting, why it's so sharp, right there. Might even be something like this, a basement or something like that, because you have these diffractions coming here. It's hard to tell if these are [inaudible 5:55] with those, or if they're...

[crosstalk]

I: What would help you?

P10: Maybe another line right there, because I can't really see that part.

I: OK. We'll touch on that in a few minutes. What about the other image?

P10: Right here, you have another uplift zone with the same kind of faulting on the crest of the uplifts. These faults extending all the way up until the uppermost underformed sediment. Kind of like how it is in here with some of these deformed section sediments.

There's this interesting little section right here, up on this topmost horizontal folds that kind of outline starts and ends here properly. I don't know, I haven't really worked with carbonates ever, so maybe that's like a reef, I don't know.

I'm not sure what those look like or I've never worked on that. I have no experience of those either. Then you have these lens-shaped bodies that are [inaudible 7:05] . It doesn't look like there's intersections.

I: Is it possibly sourced to that hydro-carbons, maybe? Hydrocarbon [inaudible 7:20] ?

P10: I don't know.

I: That's up to you.

P10: I don't know. I said I don't [inaudible 7:27] sediments. It's kind of tracing stuff out. I'm trying to take that out some sequences as well. This boundary, you might correlate it with this boundary, and then this boundary probably correlates with this boundary, as well.

I guess, just based on the seismic nature, you kind of washed out here and washed out here. That's a [inaudible 7:59] , as well. It wouldn't make sense where the lines [inaudible 8:04] that you dip is kind of this geometry that you can't really see it, where the cross is. This is DMC, right? This page is DMC?

I: Yeah, I'm going to write that down.

P10: I don't think that would be visible there. The fault geometry's very interesting. Hard to pick out. A lot harder to pick out on this line. Maybe that's just because you're on the opposite side to the subsidence. This big feature right here.

Also, you're going over here, from this direction. If this is the crossline, didn't really see any really obvious faults in this section right here, so it wouldn't make any sense why you'd have it [inaudible 8:57] .

I: We'll come back to this in other things. What parts of the data were you most comforTable with interpreting?

P10: Just the on-offing and down-offing surfaces. I don't really know where you can draw those lines, because you have terminations [inaudible 9:20] don't happen. This will pop up and you'll on-up there [inaudible 9:30] sedentary features.

I: Is that because you've had experience with that?

P10: Yeah. That'd be my background in sedentary geology.

I: What about places in the data, specific features, that you can point out that you had a hard time with interpretation?

P10: This area here. I'm not really sure what's going on there. It looks like a large escarpment, and then this was just sedimentary inflow of like a steep basin wall. If there's possibly uplift in a large, deeply extending fault through this area, it might make sense. That might be a good option. Maybe what's...

[crosstalk]

I: Any other places?

P10: Yeah, it's kind of hard to tell where this is, not knowing the environment and definition, if its terrestrial or marine, that would make a big difference. Then right here, too. Lithology would help a lot on knowing what features those are, because you have some kind of geometry that...

These look like they are somewhat parallel to each other and they just kind of go away. It's weird. Then the same nature is also building that middle section. It's just all fuzzy.

I: I think you touched on this already but doesn't hurt to ask again. If I could provide you with any extra data, what do you wish you could know right now? What would help you the most?

P10: Lithology.

I: More specifically.

P10: I guess from the crossline. [inaudible 11:34] constraints from both of these lines.

I: Say I give you a well for each.

P10: A well for each one. I would put this line...Can I have two wells?

I: Sure. Tell me where you'd want...

[crosstalk]

P10: Maybe on the side of this right here.

I: Why there?

P10: On this side of it. You can see the nature and the lithology a lot in the salt, as well. Then you could use this to correlate to whatever they want to know. It's probably out in this middle area. It seems like the thickest and most diverse section of this unit.

Also, you would characterize all of these as well and you could correlate that with whatever you see on the opposite side courses to this, whatever this is. Then over here, I probably would want it...that means there's a well behind this line up here. That should be all the same lithology.

Maybe through here, through this little [inaudible 12:58] . I would do it right here because you can get this interesting feature.

I: Try to maximize...?

P10: Yeah, try to dig out all that good stuff.

I: The areas where you can identify. If I could provide you with an additional seismic line, where would you want to have it?

[crosstalk]

I: ...there.

P10: Depends on what you're trying to figure out. Are you...

[crosstalk]

P10: ...for oil? Or are you just trying to figure out the nature of the salt in the area?

P10: Let's go with just geologically.

P10: Geologic comprehension?

I: Yes. What would help you the most? Where would we put some lines that'd be like, "If I put one here, this'll tell me..."

P10: This is out over here. [inaudible 14:17] , you can see it, right?

I: Yeah.

P10: I would put one line through that, through this little dome feature here, so that would probably be [inaudible 14:36] .

I: Those lines on the map.

P10: Over here.

I: Point out where on that line.

P10: Through this feature here so I can [inaudible 14:53] through here.

I: Why there?

P10: Because it would near the same tectonic activity and if you're trying to just go for a good understanding of the whole area then there's this same thing, this withdrawal and faulting and subsidence. Is that really going on? Because if it is going on, you would expect it to be the same up here. That would be [inaudible 15:21] .

I: Where in this data is interesting to you from a petroleum standpoint?

P10: Anywhere you have these terminations. It also depends on lithologies. Like, if you have these stratal terminations and it's all just sand, it doesn't matter but say this is one continuous shell unit and this is a sand unit, then that would be interesting.

This are right here, any of these faults, depending on what these lithologies are, they all depend on lithology. Against all the terminations. Against the salt or whatever this type here is. It's kind of shell-like. Maybe against this uplift area, perhaps, if that is uplift.

Over here, these things through there. You don't really see any termination on this uplift very much. [inaudible 16:32] . I don't think this would be a very [inaudible 16:37]. These faults continue all the way up onto the surface.

Maybe right up here, you could have [inaudible 16:49] in this area. Perpendicular to [inaudible 16:56] Maybe up here. Something.

I: These lines were actually shot offshore near the Carolinas. There's a lot of salt here. There's also landslides and creeps. Does that change your opinion or interpretation about any of these features that you see?

P10: Depends on how old this stuff is. Maybe this area's more landslide. Creep-like uplift or...

I: Slow-moving sediment down the slope.

P10: Oh, OK. Yeah, that's probably what's resulting in all this stuff, I would guess. Just kind of crinkling up [inaudible 18:07] sediments [inaudible 18:08] . If it's marine then yeah I would say that's some mass movement type facies on here, large blocks moving together in some kind of heel, in some kind of movement.

Then that would also determine if this is like how far -- not only into the continental shelf here. I don't know if this is bedrock or what's going on here.

I: OK. [inaudible 18:43] feature, the one that looks kind of like a smudge in the middle of the page.

P10: Yeah, this right here?

I: Yeah, what do you think that is?

P10: It looked kind of like some gas feature. Isn't that similar to the top of this uplift domes or something. From what I've been told, gas can sooner or later, sign your signal...

I: Yeah, that's very kind of biodiverse.

P10: Right. It is pretty weird, just kind of right there in the middle -- not volcanics -- [inaudible 19:27] really intrusive body...

I: OK.

P10: ...kind of like a person [inaudible 19:42] .

I: All right. Did you get a chance to use the computer at all?

P10: Yeah. It wasn't very helpful.

I: OK. Why not?

P10: It was just difficult to move around in it.

I: OK. Is there any other area we didn't talk about? Or something you found interesting you didn't have an explanation for? Just something you'd like to know, any last comments or words?

P10: Yeah, walking tour would be really good.

I: Really helpful?

P10: Yeah. Knowing what the revulsions are, and if there's carbonate, or...

[crosstalk]

I: I agree with you. Let's say I think it's about...I'm going to guess. This is about a kilometer. I think it's like 2,000 seconds to the kilometer, that's what I was told. Let's say this is two kilometers of core. How would you use that information? You just well that or do you want to look at the actual rocks?

P10: What?

I: Do you want to look at the actual rocks? Do you want to look at well data?

P10: Yeah, definitely -- the rocks.

I: Two kilometers of it?

P10: Yeah, unless there's some [inaudible 21:00] . You got the choice [inaudible 21:03]. I mean, you would obviously look at your well data first, and find your intervals that you want to go for.

I: All right.

P10: It's a lot easier to look at a long piece of paper than one piece of actual rock.

I: Absolutely. Awesome. I think I got what I needed.

P10: Cool.