PUBLIC VERSION

IN THE MATTER OF AN ARBITRATION UNDER CHAPTER ELEVEN OF THE NORTH AMERICAN FREE TRADE AGREEMENT AND THE 1976 UNCITRAL ARBITRATION RULES

between

THEODORE DAVID EINARSSON, HAROLD PAUL EINARSSON, RUSSELL JOHN EINARSSON, GEOPHYSICAL SERVICE INCORPORATED (GSI)

(the "Claimants")

-and-

GOVERNMENT OF CANADA

(the "Respondent", and together with the Claimants, the "Disputing Parties")

(ICSID Case No. UNCT/20/6)

Expert Opinion Report

by Doug Uffen (P. Geoph (APEGA), P. Geo (APEGBC)

President / Director of Reflection Peak Enterprises Limited

January 13, 2023

REFLECTION PEAK

I. BACKGROUND AND QUALIFICATIONS

1. I, J. Douglas Uffen, of Calgary Alberta Canada, am registered as a professional geophysicist with the Association of Professional Engineers and Geoscientists of Alberta (APEGA) and as a professional geoscientist with the Association of Professional Engineers and Geoscientists of British Columbia (APEGBC). My consultancy, Reflection Peak Enterprises Limited (RPEL) possesses a Permit to Practice from both APEGA and APEGBC. I offer services to the oil and gas industry as a consultant through RPEL.

2. I graduated with an Honours Bachelor of Science (HBSc) degree in Geophysics with a Geology minor from the University of Western Ontario in London, Ontario in 1982. I have over 40 years of industry experience in the oil and gas industry, working with and interpreting seismic data.

3. I am also the creator and sole author of a course entitled, The Rights, Privileges, Responsibilities and Obligations of Seismic Data Ownership, which I have delivered on numerous occasions to educate individuals and companies about the rules associated with seismic data ownership. As a member of an APEGA Practice Standards Committee, I participated in the preparation of a guideline document for professional members entitled, the Guideline for Ethical Use of Geophysical Data.

4. I am a current member and a Past President of the Canadian Society of Exploration Geophysicists (CSEG). I served on the Past President's Advisory Council for ten (10) years and as a Board Member for the CSEG Foundation for two (2) years. I have also served one year as Vice President of the Canadian Federation of Earth Scientists (CFES). I served two multi-year terms as a Board Member for the Calgary Geoscience Data Manager Society (CGDMS) and was one of the Founding Members of that Board. In addition, I am a member of the Calgary Petroleum Club.

5. In my career, I have been involved as a team member in property valuations, National Instrument (NI) 51-101 reserve audits in accordance with mandatory regulatory reporting of oil and gas reserves and valuing properties associated with corporate mergers and acquisitions. I have also assessed the value of seismic databases in corporate merger situations in addition to independent seismic data licenses in legal disputes.

6. I have provided expert opinion evidence in a couple of legal cases before, authoring reports that assess the value of geophysical seismic data. I was accepted as an expert witness to the Court of Queen's Bench in Alberta (ABQB) on behalf of Total E&P Canada Ltd. and Total S.A (Total) in a litigation initiated by GSI,[1] which is involved in this arbitration. In the ABQB proceeding, I provided, based upon my knowledge and experience, information about seismic data, oil and gas industry practices associated with seismic data and a market valuation assessment for a license of specific GSI seismic materials obtained by Total from the Canada-Newfoundland and Labrador Offshore Petroleum Board (CNLOPB). I have also been involved in two National Energy Board (NEB) hearings, acting as a witness in one of them.

7. My curriculum vitae is attached as Part X of this Report.

II. PURPOSE OF THIS REPORT

8. I was engaged by the Government of Canada as an independent expert in this arbitration to provide insight about the appropriate methodology that an objective third party would adopt in order to establish a fair market value of GSI's seismic data library. In this Report, I describe and comment upon various practices within the seismic industry, as well as oil and gas industry practices as they relate to seismic data.

9. I note that GSI did not provide a valuation of its seismic data library in the Claimants' Memorial, filed in this arbitration on September 27, 2022. Nor have any past valuations of GSI's seismic library been submitted as evidence in this arbitration. Thus, I am unable to comment on whether any such valuations would be reasonable or not. As described further below, in my opinion, the only proper means of determining the value of GSI's seismic data library is to conduct a data quality inspection of GSI's seismic data, storage tapes, files and records. I understand from Mr. Paul Einarsson's witness statement (paragraph 44) that these materials are kept at a storage facility in Alberta, Canada. It would be necessary to account for the factors I describe below in such an appraisal. In the absence of an actual data quality inspection, this Report describes the methodology

[1] **R-011**, *Geophysical Service Incorporated v Total S.A.*, 2020 ABQB 730, Reasons for Judgment, 25 November 2020.

that an objective third party would use in an appraisal of GSI's seismic data library and makes observations based on information that is currently available.

10. The following list of materials (referred to together as the "Claimants' Memorial") were provided and reviewed in preparation of this Report:

a) Claimants' Memorial, September 27th, 2022
b) Expert Report of Paul Sharp of Pricewaterhouse Coopers LLP, September 26th, 2022
c) Expert Report of "Chip" Gordon C. Gill, September 13th, 2022
d) Witness Statement of Theodore David Einarsson, December 2nd, 2019
e) Witness Statement of Ralph Maitland, August 24th, 2022
f) Witness Statement of Russell John Einarsson, August 4th, 2022
g) Witness Statement of Harold Paul Einarsson, September 27th, 2022

11. I am providing my opinions in this Report based upon the above and other sources cited herein and based upon my expertise, knowledge and experience gained from over forty years in the seismic industry.

III. GEOPHYSICS AND THE SEISMIC METHOD

12. Geophysics is the science of the Earth, which is a science based upon measurement. The breadth of the science spans the composition of the Earth, its core, the mantle and lithosphere, its oceans and currents known as the hydrosphere, and the atmosphere. Exploration geophysicists try to measure mathematically the physical differences in compositional, acoustic, electrical and magnetic properties associated with rocks. In the case of seismic data, acoustic impedance contrasts associated with changes in density and velocity between rock types are measured. Collecting seismic data is a remote sensing geophysical technique used extensively in the oil and gas industry and to a lesser extent in the mining industry.

13. For the seismic method to be deployed, artificial seismic energy is created using many different source types. Air guns, water-guns, vibrator trucks, weight drop machines and dynamite are all sources utilized by industry with dynamite and vibrator trucks being the most commonly used sources for onshore seismic data acquisition.

14. For marine seismic applications, which are the focus of this Report, air gun arrays are the most common source. The resultant seismic waves generated by these artificial sources reflect and refract from subsurface rock formations according to variations in rock density and acoustic velocity. They reflect and travel back to the surface and the signal is received by pressure sensors or hydrophones in marine applications (see Figure A). These "listening" devices receive the signals and send them to the recording center.

15. The travel times associated with these reflections are sorted and processed to provide geophysicists the ability to image subsurface structures that might be favourable to trap hydrocarbons. Working alongside geologists, geophysicists can assist with delineating more subtle subsurface stratigraphy (variations in rock properties, pore space content, and lithofacies) that may prove favourable to finding and producing hydrocarbons. It is in this manner that seismic data is used to increase the chance of success when drilling for potential oil and gas reserves.

16. Seismic data can be acquired for numerous reasons throughout the exploration, exploitation and development of a hydrocarbon reserve. As discussed in further detail below, seismic data is particularly valuable at the initial exploration phase to delineate structural features favourable to the accumulation of hydrocarbons. 2-dimensional (2D), 3-dimensional (3D) and even 4-dimensional (4D) seismic data can provide information of different degrees and varying qualities needed for delineating hydrocarbon development in a particular area. For mature oil and gas deposits, seismic data can provide insight to assist with developing a hydrocarbon reserve through a Field Development Plan (FDP). Whether a 2D, 3D or 4D survey is best suited at a particular phase of exploration, exploitation or development depends upon numerous factors, some of which I describe below.

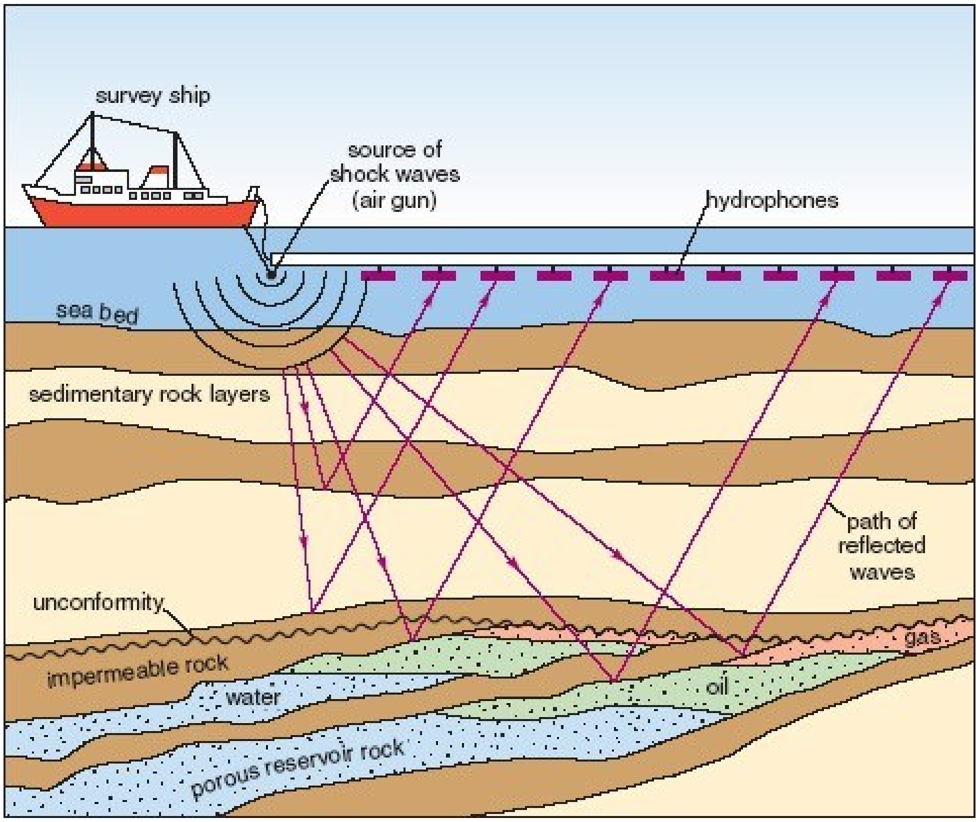


Figure A: Schematic drawing of a marine 2-dimensional (2D) seismic data acquisition.[2]

IV. DIFFERENTIATION BETWEEN TYPES OF SEISMIC DATA

A. 2D, 3D and 4D Data / 3C P-Wave and S-Wave Data

17. The seismic industry uses dimensions to describe the mode in which the subsurface is measured. 2-dimensional (2D) seismic data is essentially a vertical profile or cross-sectional view of the subsurface directly underneath the surface position of the 2D line. In 2D applications, the source points and receiver points are typically located in a straight line to produce an acoustic impedance cross-section of the subsurface beneath the surface position. To use an analogy, it is like cutting a multi-layered cake with a knife, the knife being the position of the 2D seismic line. When the cut portion of cake is pulled aside, the various layers of the cake are exposed in a cross-sectional view. This is what is produced with 2D seismic applications.

[2] Schematic drawing of a marine 2-dimensional (2D) seismic data acquisition, available at: http://geologylearn.blogspot.com/2015/06/marine-and-land-seismic-aquisition.html.

18. For 3-dimensional (3D) seismic data, imagine this cake being sliced many times in the same direction, and even in the orthogonal direction, leaving the cake with the opportunity to see vertical profiles at any point, in either of the directions. Hence, with 3D seismic data, the "cake" is a 3D volume of data that can be "sliced" in many orientations to provide multiple 2D profile images along the width or length of the 3D volume of data. Whereas 2D seismic data permits us to create a vertical profile image underneath the surface position of the 2D seismic line, 3D seismic data is essentially a series of 2D seismic lines beside each other. An offshore 3D survey is created by towing numerous streamers behind a ship (see Figure B).

19. What differentiates 3D seismic data is its enhanced spatial resolution. Out of plane reflections, ones which are off to the side, away from the 2D seismic line position in a flanking position, can contaminate 2D seismic profile sections. It is easier to track faults in the subsurface, buried pinnacle reefs and even old river channels on 3D seismic data than on 2D seismic data. For this reason, while 3D seismic data is more expensive to acquire, 3D seismic data is generally preferred over 2D seismic data as it provides greater spatial information about the subsurface.

20. 4-dimensional (4D) seismic is more commonly deployed onshore, particularly in Canada's oil sands, but it is much less common in offshore environments. 4D seismic data is essentially time-lapsed 3D seismic data: a baseline 3D seismic survey is acquired and several years later, another 3D seismic data set is acquired over the exact same area to show the differences in acoustic impedance over time. These differences can be used, for example, to measure changes in various rock properties and lithology associated with steam injection for enhanced oil recovery.

21. Most historical marine seismic data recording is comprised of single component or primary wave reflective energy, created by compressional waves emulating from the source. Figure C shows the motions propagated by primary and shear waves. With more modern marine data, 3-component (3C) geophone receivers can be used to record primary wave (P-wave) and shear wave (S-wave) data in shallow water situations (<100m or so water depth). 3C seismic data is acquired when additional information specific to certain rock properties that relate to stress and strain are required. To acquire 3C seismic data in a marine environment, the receivers need to be attached to the sea floor, as shear waves do not travel through fluids such as ocean water. As such, 2D or 3D 3-component seismic data

acquisition in a marine environment is rare, expensive and time consuming. For these reasons, it is much less common.

22. In today's context of oil and gas exploration, 2D seismic data is used more commonly to obtain regional control and information over vast geographical areas, although some oil and gas companies still make use of a finer grid of 2D seismic lines to determine a prospective drilling location for an exploratory well. 3D data is typically acquired once a significant discovery of hydrocarbons has been declared as it is the preferred choice today for developing a subsurface image of a potential hydrocarbon field. As 3D is more expensive to acquire, many operators will wait to deploy this level of seismic technology until they know that there is a resource to be developed in the area.

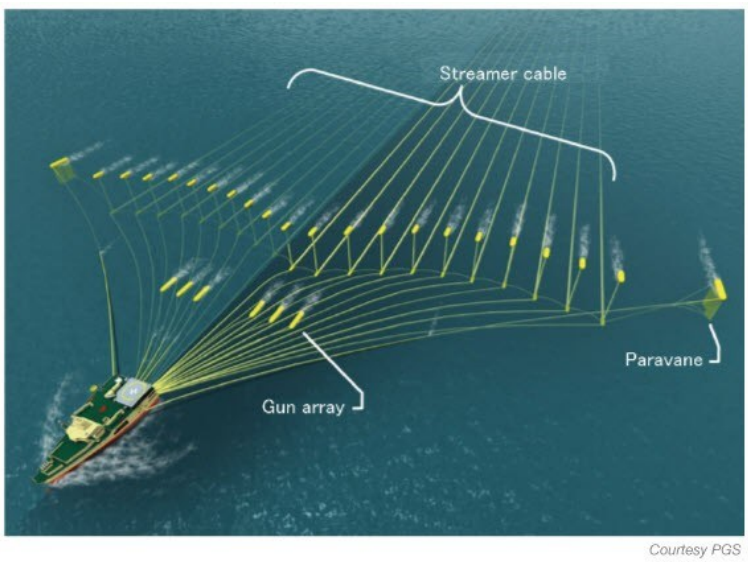


Figure B: Schematic diagram showing multiple streamers behind a ship for 3D data acquisition.[3]

[3] Schematic diagram showing multiple streamers behind a ship for 3D data acquisition, available at: https://twitter.com/ihrdctraining/status/1519757353834352640?lang=cs.

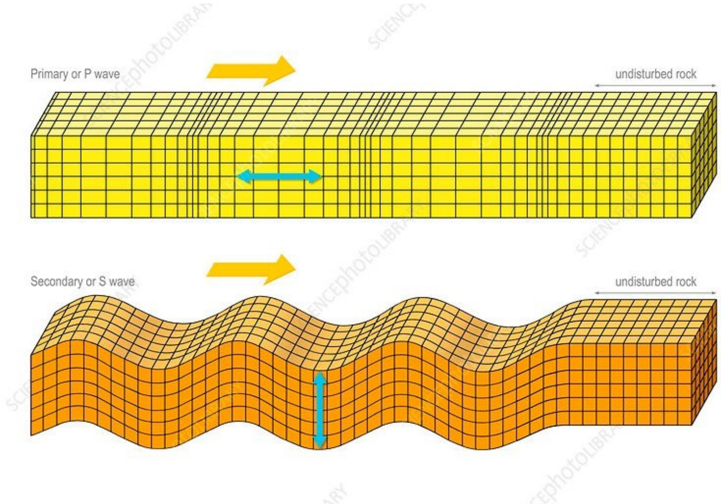


Figure C: Schematic diagram showing the difference between P-waves and S-waves. [4]

B. Field Data Versus Processed Data

23. Seismic Field Data (Field Data) consists of some key components: (1) the digital raw seismic response recordings for each source point for which the artificial energy was activated, (2) the navigational data that denotes the location of the sources and receivers for each activated source point, and (3) the Observer's Notes which denotes which source points were activated when and which receivers were actively recording and the recording conditions. Marine applications also may take note of cable feathering which occurs when ocean currents cause the recording streamers to not follow directly behind the boat. They may also record the depth of the streamers towed behind the vessel. Processed Data refers to seismic data that has been re-sorted and summed into a stacked section that provides a cross-sectional profile view of the subsurface (see Figure D).

24. Field Data can be stored on a variety of storage mediums. If the Field Data is stored on magnetic tape (which was typical of data collected in the 1970s and 1980s), the tapes need to be spun once every few years as part of a tensioning program to prevent stiction. Stiction occurs when the backing on the magnetic tape peels off and results in data loss. To mitigate this, a climate-controlled storage

[4] Schematic diagram showing the difference between P-waves and S-waves, available at: https://www.sciencephoto.com/media/167086/view/p-and-s-seismic-body-waves-artwork.

facility is preferred and a scheduled “spinning of the tapes” is required to help maintain data storage integrity. Hence the medium for Field Data storage and even Processed Data storage can become an issue for older datasets if not conveyed and transferred to more modern, longer life storage medium.

25. Over the years, seismic technology has evolved and matured. Field Data digital formats such as SEGA, SEGB and SEGD have their association with various types of field recording instruments of different eras. Historically, SEGY digital format, first introduced in 1975 by the Society of Exploration Geophysicists (SEG), was an exchange format for transferring processed seismic data. It has undergone revisions and updates since first introduced. Nowadays, SEGY data, despite its intentions to be a standardized digital format for processed data, is anything but a standardized format. Just as languages of the world can have different dialects, so does SEGY digital format. The SEGY digital format specifies that data should be stored using an IBM 370 encoding scheme with a certain byte order; however, most computers use an IEEE floating point encoding system for application speed. Due to this desire to offer programming speed and ease of use, many programmers ignored the strict specifications associated with SEGY digital formats. Hence, numerous dialects of SEGY digital formats ensued in industry.

26. Once acquired, Field Data needs to be processed in a processing center to create a profile of the subsurface structure. To do this, the data first needs to be re-sorted. Scaling functions are then applied to the deeper reflectors to enhance them and make them comparable to the strength of shallower reflections. Velocity analysis is conducted to properly image reflective events. The frequency content of the data gets enhanced through the processing sequence using a process called deconvolution. Spurious noise or unwanted, contaminated signal within the data can be removed by filtering to enhance reflective signal energy. For example, water-bottom multiples are a problem with marine data acquired in shallow waters but there are methods which can be used to remove this unwanted “noise”.

27. The data is then summed together to create a stacked section which is the cross-sectional profile. Migration is a post-stacking process typically, by which reflective signal is re-positioned for dipping reflective events, putting it back to its proper spatial position. There are many types of migration algorithms that range from post-stack time migrations and post-stack depth migrations to

pre-stack time migration algorithms of today. Throughout data processing, algorithms are applied to enhance reflective signal while reducing noise. The final product from data processing is the vertical profile or cross-section of the subsurface, filtered and enhanced to provide the best image of the subsurface. Cross-sectional examples of processed 2D and 3D seismic data are shown in Figure D. Typically, SEGY digital format is used to describe processed seismic stacked data files whereas paper prints, mylar sections and film are mediums used to hardcopy processed seismic data.

28. Processed seismic data permits the geophysicist to interpret geologic horizons and make maps of the subsurface. When assessing the quality of seismic data to attract a potential license sale, it is industry standard practice to provide processed stacked section for data quality inspection. The processing maturity of the stacked section can often affect data quality.

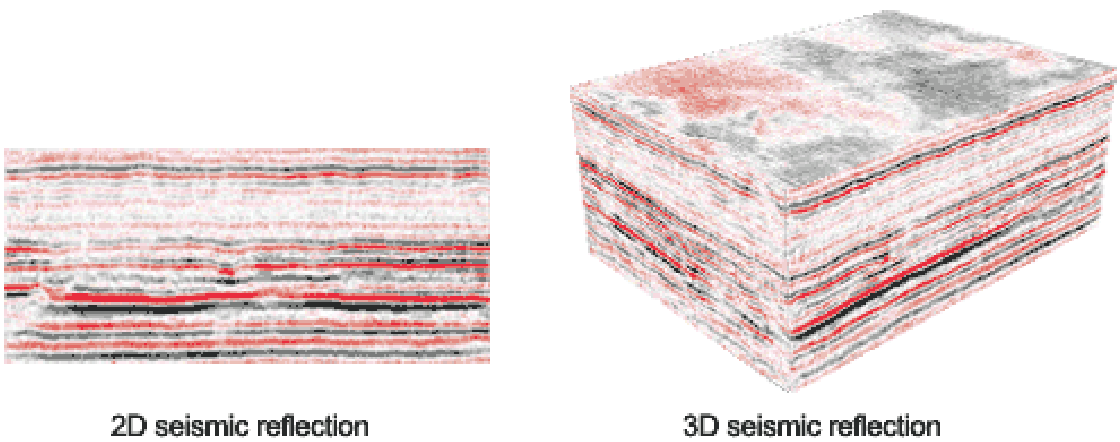


Figure D: Example of a stacked 2D seismic line and a 3D seismic volume in cross-sectional view.[5]

C. Seismic Data Reprocessing

29. Seismic data quality can often be enhanced by reprocessing: various improvements in statics corrections, better deconvolution processes to enhance the frequency content of the signal and other algorithms that reduce unwanted signal or noise, can make a difference. However, reprocessing seismic data requires access to the raw digital Field Data. To facilitate reprocessing a seismic line or

[5] Stacked 2D seismic line and a 3D seismic volume in cross-sectional view, available at: https://www-ig.unil.ch/geophysa/sis1a.htm.

survey, the field tapes, the Observer's Notes, and the navigational data are required. Survey information is necessary for every shot point to ensure proper global positioning.

30. Seismic data cannot be fully reprocessed without access to this raw Field Data. While it is possible to improve the quality of an already-processed seismic profile through reprocessing, the acquisition parameters used for recording could restrict how much improvement can actually be made. In particular, there are real limits to reprocessing data collected from the 1970s and 1980s because of the limitations related to the acquisition technology and instrumentation of the day.

31. Seismic data acquisition techniques and equipment have evolved considerably over the years. Geophysicists can record data with more channels that in turn permits higher fold data to be acquired, resulting in data that has less noise and better subsurface sampling. Data that was acquired with high fold and lots of recording channels provides the best opportunities for improvement for a reprocessing effort. Data acquired with dated acquisition technology may be improved upon somewhat with a reprocessing effort, but there are limits to the algorithms and processes which can be used to fix or repair problems within the data related to the dated acquisition parameters.

32. In view of the additional challenges associated with reprocessing older data, and with the benefits that modern seismic data offer for a comparable cost, geophysicists tend to prefer newer datasets to older ones as the data quality is typically better.

D. Difference Between Seismic Data Reprocessing and Post-Stack Enhancement

33. There is a significant difference between reprocessing seismic data and post-stack enhancement of a hard copy image of a stacked seismic section. As noted above, reprocessing seismic data requires access to raw digital Field Data.

34. In contrast, seismic data materials submitted to the various regulatory boards in Canada (specifically, the NEB, CNLOPB and Canada-Nova Scotia Offshore Petroleum Board (CNSOPB), together referred to as the "Boards") typically consists of a paper, mylar or film copy of a stacked section. In my experience, the hardcopies submitted to the Boards come from a variety of stacked processed sections of varying quality maturity, such as Brute stack sections, unfiltered migrated

sections and even filtered stacked migrated sections (see Figure E). A Brute stack section is essentially stacked data in its least mature processed form with a minimal amount of noise attenuation applied. Operators may submit Filtered Unmigrated data or Filtered Migrated data without noise attenuation and signal enhancement processes. In some cases, even pre-stack migrated sections, a more mature processed version, may have been submitted. In other words, knowing that the data was to be released to the public after the expiry of the confidentiality period, operators often submit a less mature, poorer displayed and even a poorer quality stacked section than what they retain for themselves for data interpretation and/or licensing.

35. To summarize, the seismic materials submitted to the Boards are different than having access to the raw digital Field Data, which can be reprocessed. While publically-available materials may be used for post-stack enhancements, their quality and utility can vary significantly depending on what was actually submitted to and released by the Boards.

V. LIMITATIONS ASSOCIATED WITH POST-STACK ENHANCEMENT

36. Once seismic data is stacked and committed to hardcopy paper or mylar form, it is not possible to change any of the processes used to create that stacked section without access to the Field Data. As such, the options to improve the quality of the data accessed from the Boards are limited to post-stack enhancements only, since any processes that were applied to the data are essentially “locked in” by the stacked hardcopy image (see Figure E). Thus, the amount of improvement possible through a post-stack enhancement process is much less than a full reprocessing effort utilizing the raw digital Field Data. Reprocessing seismic data infers that you are starting from scratch with the raw digital Field Data elements. One cannot truly reprocess an already stacked seismic section, only post-stack enhancements can be undertaken.

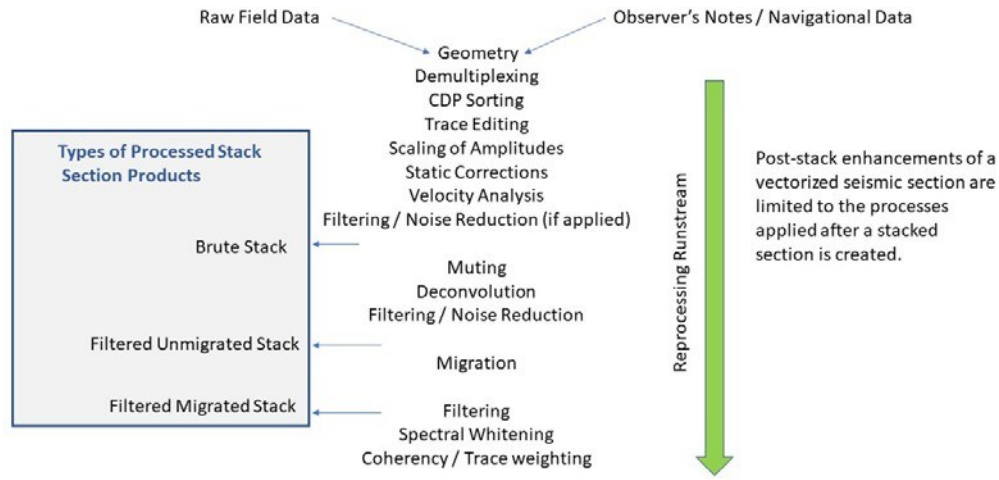


Figure E: A standardized processing / reprocessing run-stream sequence that shows the maturity of various types of stacked sections. Filtered Migrated stacked sections are likely of better data quality than Brute stacked data.

37. Vectorization is a process similar to scanning but the image captured possesses additional fidelity. Scanning an image creates a rasterized image. A scanned, rasterized image of a photograph becomes pixelated and fuzzy when it is expanded. Vectorized images do not. Vectorized images are composed of mathematical shapes and lines, which can be expanded or contracted thousands of times without running into the pixelation problem associated with scanned rasterized images. However, just as scanning a photograph on your home computer often results in a fuzzier and sometimes darker image, even vectorized images are not perfectly identical to the original image.

38. As explained above, knowing that the data was going to be released by the Boards at some point in the future, many operators submitted to the Boards their least mature processed version. Sometimes companies would submit "squashed" plot sections with a tight trace spacing, making it more difficult for vectorizing routines to capture the data. Similarly, tightening the vertical scale, often expressed in inches per second, could make it more difficult for vectorizing routines to capture the full fidelity and detail of the original image. Other operators rendered the data they were submitting in variable density display mode, using a gray colour scale instead of wiggle traces to display the data, thereby making it even more difficult to vectorize the data. Despite the potential perfection of the vectorizing routines and algorithms to capture the hardcopy image to the best of

their ability, these display methods would challenge even the best of the vectorizing routines. As a result, the vectorized image is typically inferior to what is available directly from the operator if the data were to be licensed.

VI. COMMERCIAL CONSIDERATIONS ASSOCIATED WITH THE LICENSING OF SEISMIC DATA

A. Distinction Between Seismic Materials Disclosed by the Boards and Licensed Data

39. Pursuant to various laws and regulations, companies acquiring seismic data in the Canadian offshore are required to submit certain materials to the regulatory Boards as a condition of their authorization to access the offshore. Those laws and regulations permit the Boards to release certain materials after the expiry of a set confidentiality period. This period can vary depending on whether the data is exclusive (to a specific oil and gas company) or non-exclusive (to a speculative survey company), which a company undertakes on its own to market to multiple customers, if it can. While it is well-known and accepted in the industry that the information submitted to the Boards is made public by the Boards after the expiry of the confidentiality period, I take no position on matters such as copyright or the appropriate length of the confidentiality period.

40. As noted above, the seismic data materials released by the Boards comprised hardcopies of the paper print, mylar or film version of the processed stacked seismic section that was submitted to the Boards. The stacked image accessed may not have been the best quality image that a processing effort could muster in its day; or it might have not been displayed optimally. Hence, it is important to understand that the material released by the Boards ***is not*** the same as what remains in the exclusive possession of the company. While the copies released by the Boards may be of utility, even with the highest calibre of vectorization, it is not possible to reverse engineer the hardcopies available from the Board to be a direct substitute for the data materials available by license from the company. This lack of quality is compounded by the fact that most companies' submissions to the Boards are often of the lowest possible quality. Furthermore, survey information submitted to the Boards typically consist of an "ENDS & BENDS" file that only indicates the positioning of the beginning of the seismic line and its termination point, and any bends along the way, which is much less accurate than obtaining the original data source. Even if the survey is supplied as a paper-based shotpoint base map,

it would still have to be copied and then digitized with all the inherent potential inaccuracies. Hence the material released by the various Boards is not the same product that an entity receives when a company licenses exclusive data, or speculative data from a seismic company.

41. As it is common industry practice to interpret seismic data in a digital workstation, the seismic profile sections have to be vectorized and placed into a digital SEGY processed file format to facilitate data loading. Survey data either had to be digitized, if supplied as a paper based shotpoint map, or the ENDS & BENDS file had to be interpolated to approximate the actual position of the various source point locations. While these processes make it possible to interpret the data in a workstation environment, it is not optimal. By whatever means the locational data is derived, it is not as accurate as the survey information received when purchasing a license from a company like GSI. Proper coordinates for every shotpoint are provided when a license is purchased. A company who purchases a license to the data would also receive the Field Data and be able to reprocess the data from scratch, if it so wished.

B. Seismic Data to Evaluate Potential Acreage

42. Government regulators will issue a call for bids for petroleum exploration licenses on a semi-regular basis (yearly in some jurisdictions and less frequently in others) and seismic data can assist companies to decide whether to bid on a parcel for tenure.

43. The successful bidder is allowed to hold the Exploration license (EL) for an initial 6-year period. Pending the various financial commitments towards the proposed winning work bonus commitment bid, the license can be extended up to another 3 years. Hence, seismic data has its value throughout this process to delineate and prioritize various prospects.

44. While geophysical remote sensing techniques such as gravity and magnetic data are less expensive way to define the outline of sedimentary basins and to look for large scale structures, seismic data provides a more detailed approach with much more information about the subsurface which can influence a decision on whether to make a bid and for how much. For regional reconnaissance purposes, 2D seismic data is most popular as a large area can be covered with a grid of seismic lines (see Figure G) at a relatively low cost.

45. However, once something of interest has been identified, additional information to better delineate prospects of interest would be required. At this time, some companies may opt to purchase or acquire 3D seismic data to pinpoint a drilling location. This way, capital costs are kept to a minimum while developing insight about the exploration or development opportunity. 3D seismic might be used to position the discovery well or be acquired shortly after a Significant Discovery License (SDL) is declared. Once a declaration of commercial discovery is made, the operator can apply for a Production License (PL), additional 3D seismic may be acquired thereafter. As it takes several years of technical study to delineate the optimum drilling location, seismic data sales revenue can be generated along the way. The greatest level of industry engagement is always around the timing of bid round land tenure announcements.

46. The more frequent the license bid rounds, the more in demand seismic data is likely to be. Of course, this also means that in areas of high exploration activity, there will likely be more seismic data available from which companies can choose. As operators can have up to several years to drill a well under a work bonus commitment scheme for land tenure, using a drilling metric as a proxy for estimating periods of peak seismic purchasing activity is inappropriate. An offshore drilling prospect typically has had many years of technical study associated with its identification and delineation before it is drilled.

C. Seismic Data and Bidding Consortiums

47. Offshore exploration and development of hydrocarbons is an expensive exercise. Individual wells can cost $50-$100 million dollars each today. Hence many companies wish to limit their financial exposure by having partners or consortiums. It is not uncommon for certain companies to share the risk in thirds or quarters. These partners or consortiums will meet and discuss which parcels of land possess the best opportunity to find hydrocarbons.

D. The Data Quality Inspection Process and Potential Sale of a License

48. In some cases, companies will choose to contract a seismic company to conduct a field operation and acquire proprietary seismic data. This is known as an exclusive survey whereby the operator collecting the data keeps ownership and the ability to license the data collected. However, it

is often much cheaper for oil and gas companies to purchase a license from a multi-client or speculative survey company (also known as non-exclusive) for a particular set of 2D or 3D seismic data to build up technical knowledge about a parcel of land. Companies will often contact a seismic data broker to see what data might be available for sale in a prescribed area. If the company knows in advance of a data set held by a speculative survey company, they might reach out directly to that company. If a company wants to license a set of seismic data, a data quality inspection process would take place.

49. In the data quality inspection process, data brokers will show a “stick-map” that would indicate the position of the data and some of the Field Data acquisition parameters. The asking price for a license would also be disclosed. The broker would then show a paper print as an example of data quality. Nowadays, this is often done via a computer and showing a digital image of the seismic line. Most datasets will also provide some information about the processing run-stream, offering the person who is inspecting the data to discern if it would be worthwhile to reprocess the data. No interpretation or measurements of any kind from the data are permitted. Volume discount pricing as well as licensing terms and conditions can be negotiated. These agreements have matured over the decades and vary from one company to another.

VII. METHODOLOGY FOR VALUATION OF SEISMIC DATA LIBRARY

A. Overview of Aspects of Data Quality Assessment

50. In my opinion, the fair market value of a multiclient seismic data company cannot be assessed without an actual valuation of its seismic data library – that is its most valuable asset. In the Claimants’ Memorial, no attempt is made to value GSI’s seismic data library. In my view, this is problematic. There is objective and available information by which a value can be assigned to GSI’s seismic data library. Given the absence of any such assessment by the Claimants and without access to GSI’s seismic data library, the following section of my Report is limited to describing the methodology for a data quality assessment and all the factors that would go into it.

51. The first step would be to conduct an inspection of the actual data at the storage facility, including an inspection of the storage medium and the maintenance records. As noted above, older

data is particularly susceptible to degradation if stored on tape and not properly maintained. Once the integrity of the data is confirmed, an appraisal of key data acquisition parameters and the processing algorithms is undertaken with a goal of assigning an overall data quality rating (often expressed in a quartile scheme of Excellent, Good, Fair and Poor).

52. Once an overall data quality rating is assigned, a valuation based on various factors can be undertaken using technical assessments and industry knowledge. The following are what I would consider to be among the most important factors to take into account.

1. **Geographic Location**

53. With respect to the geographic location of any seismic data, seismic data acquisition costs can vary appreciably depending upon the geographic location. Land seismic data acquisition costs are appreciably higher than marine seismic acquisition costs, as additional costs are associated with permitting, clearing cutlines, testing water wells, avoiding man-made infrastructure and other topographic obstacles. Of course, marine data acquisition is not without its own obstacles associated with fishing boats, offshore platforms, marine life and storms. Acquiring seismic data in environmentally sensitive areas can also appreciably impact costs.

54. Seismic data that costs more per kilometer or per square kilometer to acquire will usually be more expensive proportionately to purchase under a seismic data license and therefore, more valuable in terms of standalone library value. <u>However</u>, data acquired in remote areas that may cost more to acquire may not result in future sales unless industry is active in the region. Furthermore, moratoriums for exploration or environmentally protected regions reduce access to a resource and hence negatively impact industry activity levels. The only market for data acquired in an area under current moratorium or an environmentally restricted area would be for non-exploratory or alternative purposes. For example, the Canadian Arctic, where the former GSI acquired data in the 1970s and 1980s, is under an oil and gas exploration moratorium, which would impact the demand for, and hence, the value of such seismic data.

55. In this regard, considerations regarding the land sale bid round activity in the geographic location of the seismic data are important. As explained earlier in this Report, licensing bid rounds

create a flurry of activity to evaluate various parcels of land that might be of interest. The greatest level of industry engagement is always around the timing of bid round land tenure announcements. In areas of low activity where licensing rounds are infrequent (for example, the Arctic or Labrador North and South – see Figure F),[6] demand for seismic data is lower and hence less valuable.

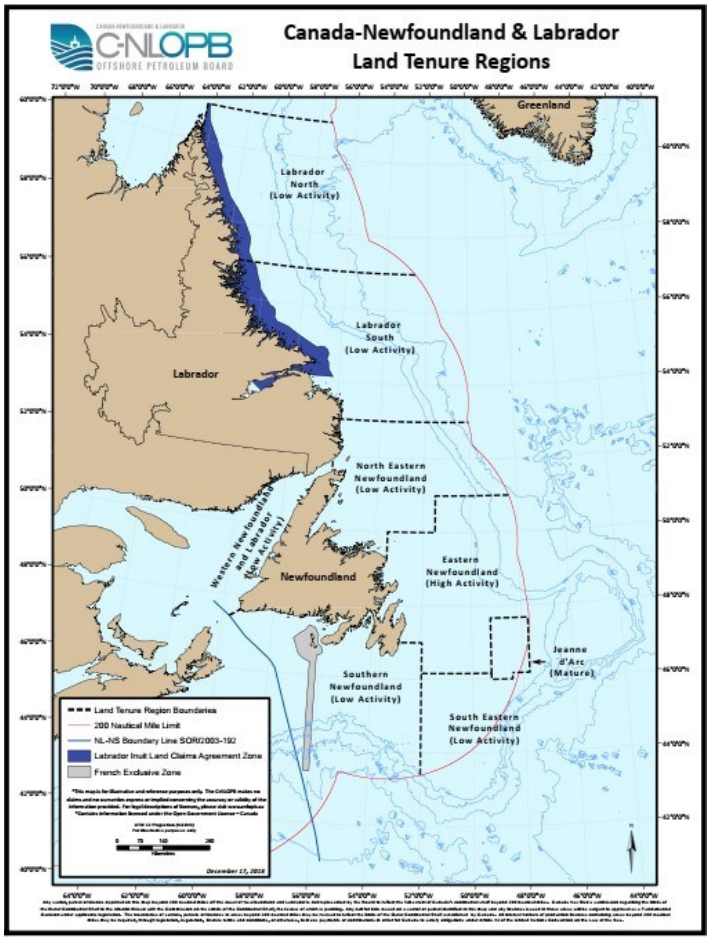


Figure F: Map showing Canada-Newfoundland & Labrador Land Tenure Regions

56. On the other hand, in areas of high activity where there are regular licensing bid rounds, demand for seismic data is higher. However, in these areas of high activity the availability of seismic data may also be more prolific; hence, the availability of competitor data in the same geographic area –

[6] **RWS-02**, Witness Statement of Trevor Bennett, Annex I, CNLOPB Jurisdiction and Land Tenure Map.

especially if non-confidential and available from the Boards – must be taken into account when establishing a value of seismic data in regions of high activity (e.g., Jeanne D'Arc basin, Figure F).

57. Maps published on GSI's website purport to indicate where its Canadian seismic data are located: High Arctic, Beaufort Sea/Mackenzie Delta, Offshore Labrador/Baffin Island and East Coast (Newfoundland and Labrador).[7] Maps from the CNLOPB and CNSOPB also indicate GSI's seismic data in their jurisdictions, as well as other publically available seismic data that may compete with that of GSI (see e.g., Figures G, H and I).

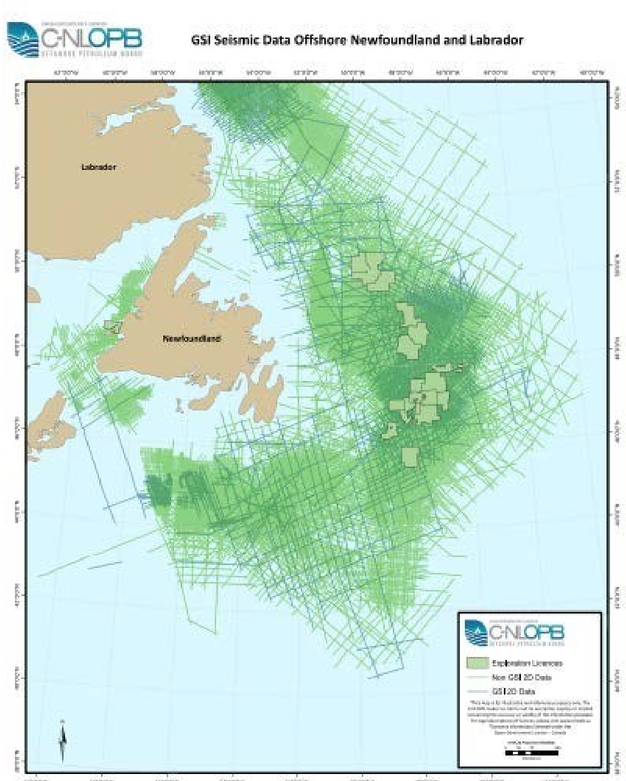


Figure G: Map showing 2D seismic data available in Offshore Newfoundland and Labrador[8]

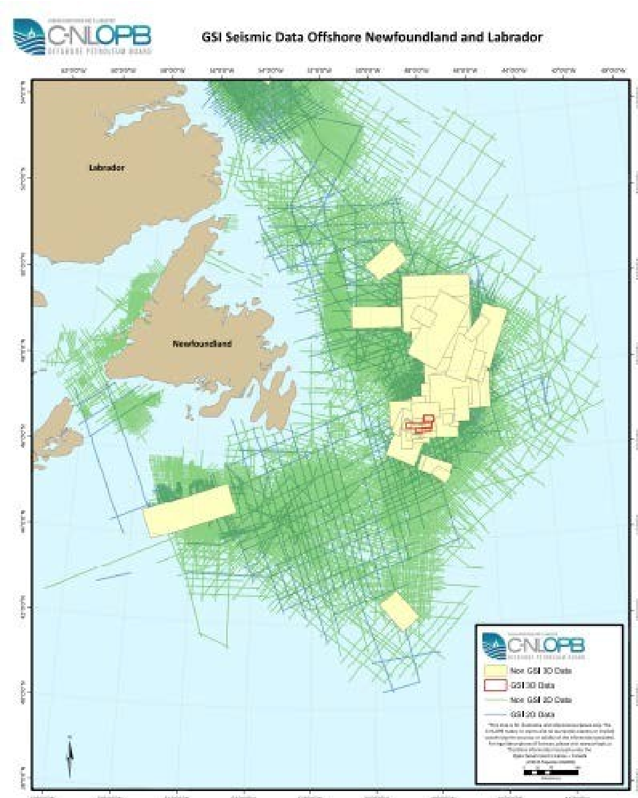


Figure H: Map showing 2D and non-GSI 3D seismic data available in Offshore Newfoundland and Labrador[9]

[7] **R-158**, Geophysical Service Incorporated, Offshore Canada Maps, available at: http://www.geophysicalservice.com/index.php?mode=webpage&id=621

[8] **RWS-02**, Witness Statement of Trevor Bennett, Annex II, p. 4.

[9] **RWS-02**, Witness Statement of Trevor Bennett, Annex II, p. 5.

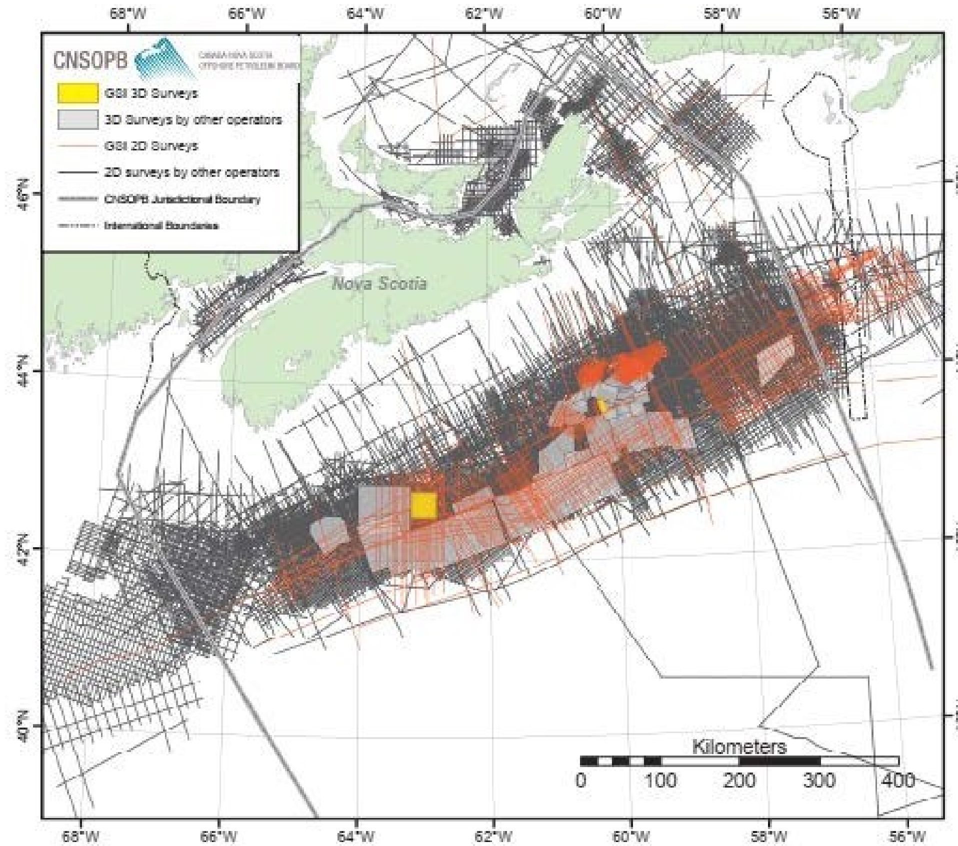
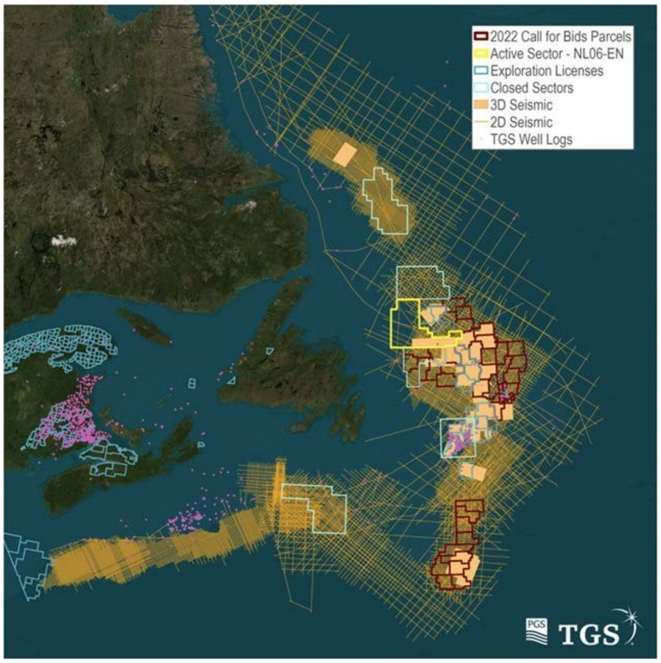


Figure I: Map showing seismic data available in Offshore Nova Scotia[10]

58. It is apparent from these maps that much of GSI's data is located in current low activity regions, which may affect future data licensing sales revenue (see Figure F). As for GSI's data in higher activity regions like Eastern Newfoundland, its value would be impacted by the availability of competing data in the same area (see e.g., Figure J).

[10] **RWS-03**, Witness Statement of Carl Makrides, Annex VI.



TGS holds 2D and 3D seismic data, interpretation studies, and well data in and around the area covered by the Call for Bids in the Labrador South (NL16-CFB03) regions.

Figure J: Map showing available TGS speculative seismic data as related to upcoming bid round parcels and historical licenses offshore Newfoundland and Labrador[11]

59. In summary, an objective third-party buyer contemplating the purchase of GSI's seismic data library would carefully consider the geographic location of each survey, including whether it is in an area of high or low activity, the frequency of licensing rounds and the availability of competitor data in the same area. Each of these factors can significantly affect the value of a seismic data library.

2. Type of Data (2D / 3D)

60. As noted in a previous section of my Report, for reconnaissance purposes, 2D seismic data may be used in preliminary phases of exploration to develop a regional perspective for an area. Vast amounts of an area can be covered by a grid of 2D seismic lines – the tighter the grid, the more useful it is. As areas of interest evolve with ensuing technical study, additional 2D seismic lines can be used to delineate prospects for future drilling. However, as companies prepare to drill a prospect, 3D

[11] TGS, Map of speculative seismic data as related to upcoming bid round parcels and historical licenses offshore Newfoundland and Labrador available at: https://www.tgs.com/our-data/north-america/offshore-canada/bid-rounds.

seismic is preferred. As a field is being delineated in terms of areal extent, 3D data provides the most detailed information for FDPs. Hence 3D seismic data is typically more targeted in its approach and is either land, field or prospect specific.

61. Since 3D seismic is more expensive to acquire, it can carry a higher premium. Furthermore, if 3D data is available overtop of 2D seismic data, unless there is a significant price difference, 3D data will generally be preferred because of its spatial coverage advantages.

62. It appears that most of GSI's seismic data library consists of 2D seismic data, although it does have a few 3D programs.[12] While GSI's 3D data may be more valuable in principle, whether it still retains any value depends on the other factors outlined in this Report. For example, GSI's 3D data in Eastern Newfoundland and Labrador appears to overlap with other available 3D data (see Figure H). Again, this is a factor that an objective third-party buyer would take into account when considering the value of GSI's library.

3. **Acquisition Parameters**

63. Seismic acquisition parameters are also often reflective of the technology available at the time and are an objective means by which to assist with the assessment of value. The number of recording channels used for seismic data recording, the group interval and the source interval all factor into the determination of seismic "fold". Fold is the number of independent repetitions for sampling of any point in the sub-surface. Generally, the higher the fold, the higher the data quality. As technology has progressed, it has become possible to acquire seismic data with many more recording channels. This increase in the number of channels available, permits group intervals to decrease and resultant fold to increase, both of which improve data quality. The source type and source size can also affect data quality as these parameters provide insight about the quality of the artificial input signal. A larger source array can provide better signal propagation. The record length and sample rate to record the reflective energy can also affect data quality. Due to these sorts of technological constraints, older seismic data is typically valued less than more modern or recent seismic data.

[12] **R-159**, Geophysical Service Incorporated, Acquired Data website, available at: http://www.geophysicalservice.com/index.php?mode=webpage&id=620

4. **Vintage or Age of the Data**

64. The date of data acquisition is a good proxy for data quality, as advances in data acquisition techniques are often specific to the era in which the data was acquired. More modern datasets will take advantage of better instrumentation, better navigational methods, and more recording channels with longer streamer lengths. This typically results in better quality data. Newer datasets can often be used for structural and stratigraphic interpretation. Older datasets, especially prior to the 1990s may be only able to offer gross structural imaging that may lack more detailed information such as faulting. As a result, the commercial applications for older data are more limited as there comes a point where the data no longer attracts any data sales. At some point, the age of the data makes it no longer of any economic value for resale.

65. I note that GSI purchased a large portion of its seismic data library from Halliburton in 1993 for US$450,000.[13] This modest price may have been to reflect the limits as to how much value can be derived from reprocessed data from the 1970s and 1980s, especially given the likelihood that there may be newer data available in the more commercially active areas offshore. The newer seismic data that GSI shot between 1997 to 2008 would likely have some value, but even that cannot be assumed without an assessment based on the factors I outline in this Report.

5. **Processing Date / Contractor**

66. As seismic data can be reprocessed and data quality can be potentially enhanced through that process, noting the date that a dataset was last processed or reprocessed is important. If a decade or two has elapsed since the data was last processed, it is likely that an improvement can be obtained by reprocessing the data. It is also important to keep in mind that only so much can be done with older data as the acquisition parameters used to collect the data are pre-determined. Some algorithms require a certain threshold of data quality in order to improve the data. If that threshold for data quality is not met, then some of these algorithms and processes may actually make the data appear worse and result in lower data quality. Depending upon when a dataset was processed and what types

[13] **C-049**, Seismic Data Purchase Agreement, 20 February 1993, Section 2 (Consideration to be Paid to Seller).

of algorithms were applied at the time, it is possible to ascertain what technological advances might be best suited to enhancing the data in a reprocessing effort with more modern algorithms.

67. My understanding is that GSI may have reprocessed the seismic data that it acquired from Halliburton.[14] However, additional details have not been provided as to what datasets may have been reprocessed, when they were reprocessed and what key algorithms may have been applied. This would be part of the data quality inspection process.

6. Assessment of Processing Run-stream

68. If the seismic data has already been reprocessed, additional consideration would need to be given to the reprocessing methods applied. Seismic data processing technology has progressed appreciably over the years. Some modern-day processing algorithms such as pre-stack time migration did not exist when some of GSI's data was first recorded. Reprocessed data may be of more value than the original processed data because improved algorithms can enhance signal to noise ratios. Noise is essentially unwanted signal, potentially caused by the recording conditions (weather, wave height, ocean currents, etc.), the recording instruments themselves (cable length, internal electronics, etc.) and spurious signals from other sources such as other nearby ships or fishing boats. Noise may be reduced by utilizing more modern processing algorithms, hence improving the signal to noise ratio.

69. While a reprocessed version is typically better than the original data processing, older reprocessing efforts may still leave room for improvement with more modern techniques and algorithms, assuming that data quality is sufficient for the algorithms involved. It is less likely to improve much upon a dataset that was reprocessed perhaps 3 years ago versus one that was reprocessed 20 years ago. Technology must be allowed the time to mature and advance. Typically, the second reprocessing effort reaps a more marginal improvement than the first reprocessing effort, unless a totally different approach is being undertaken.

[14] **C-125**, CSEG, Recorder Interview of Davey Einarsson, May 2008.

7. Processed Data Quality Assessment

70. Data quality is a significant factor that affects data valuations. While the acquisition parameters and the processing algorithms applied are an objective way to describe the context associated with data quality, assessing the data quality involves a more subjective consideration of seismic data acquisition. The consistency of reflectors both in the deeper and shallower sections, the frequency content of the data, (often best described by the proxies of the final bandpass processing filters), the abundance of source generated noise or ambient noise levels, and the presence or absence of reflective water-bottom multiples, are all factors affecting data quality. Visual inspection of the processed stacked seismic data allows for these factors to be considered when assessing the quality of the data.

B. Other Considerations Affecting the Value of Seismic Data

71. After conducting a data quality assessment of the seismic data itself, other market factors must be taken into account to value a seismic data library. In this section, I have identified some other considerations which would need to be taken into account in assessing the value of a seismic data library.

1. Benchmarking GSI Data to Other Industry Data Sets for Quality and List Price

72. While a review of sales history under historical licensing agreements is important, past sales may not be a suitable benchmark in areas where other oil and gas companies or speculative survey companies have acquired seismic data proximal to the position of pre-existing data. This may be done with more modern seismic data acquisition techniques and may also benefit from more modern processing algorithms. The value of data must be reviewed commensurately with other available datasets that are available for license in the market. As such, older vintage datasets may be rendered less valuable and may not promote future data sales. Should some 3D data be acquired over some older 2D data, the 2D data may also become less valuable to a potential licensor. In any given locale, competitive options to license other industry data exists.

73. Benchmarking data essentially refers to a comparison of certain seismic data to other data potentially available in the same geographic region. Datasets are compared based upon some key acquisition parameters, the processing run-stream and license asking price. More recent datasets,

based upon their acquisition parameters and vintage, are more likely to be of better data quality and may possess a higher asking price for the purchase of a license. The presence of more modern datasets proximal to GSI data might affect the value of their datasets.

74. The list price or asking price to license any GSI data for a given area should be comparable to other industry datasets in a region with somewhat similar data acquisition and processing parameters. Data sets which are over-priced will not attract much interest from potential licensors. It is important to keep in mind that for any large-scale licensing transaction, large pricing discounts are typically offered, which means the list price is often much higher than the transactional price for a volume discount licensing deal.

2. Company-Specific Valuation Factors

75. Apart from the valuation of seismic data itself, other company-specific considerations would likely be taken into account in the appraisal and purchase of a seismic data library.

(a) Seismic Data Licensing Agreements

76. Typically, the purchase of a seismic data library would include all existing licensing agreements. Therefore, consideration would need to be given to the terms and conditions of those agreements.

77. Seismic data licensing agreements vary between licensors. These agreements have also changed and matured over time, becoming more voluminous and complex. While some basic consistencies exist for most agreements, finer details can vary appreciably. Seismic data licensed from an oil company will not possess any transfer fee clauses upon a change of control of the licensee. Speculative survey companies now almost always have clauses to address transfer fees upon a change of control. Transfer fee clauses have become a significant part of the future revenue stream for speculative survey companies. The definition of what comprises a change of control varies between agreements. The timelines under which a company can return unwanted data to avoid a transfer fee can be as short as a couple of weeks and up to a couple of months. Both of these timelines can be tight for large scale change of control transactions. This is done deliberately by speculative survey

companies as transfer fee revenue has become a lucrative way to make money in the active merger and acquisition aspects of the oil and gas industry.

78. In sum, an objective third-party buyer would examine GSI's existing licensing agreements carefully to determine any potential future revenues.

(b) Pricing and Sales History

79. To value a seismic data library, it is important to review historical price lists, previous sales history and volume discounts and to ascertain if the data is still being licensed on the open market.

80. By analyzing historical GSI price lists, it is possible to surmise if the license price for the data was being depreciated according to its age or vintage. It is also possible to determine if any reprocessed data value was reflected in GSI's pricing. For most companies that sell seismic data, the field tapes are made available at current copy or reproduction costs.

81. Data licensing sales can be used as a barometer or guidance to future data sales forecasts. Many licensors offer volume discount pricing for their 2D and 3D seismic data. For marine data, discounts can be applied for larger volume purchases but also for full line or full 3D surveys. Creating a subset of data from a 3D survey is possible but not without some effort and associated cost. Providing a partial of a 2D line is less cumbersome and less difficult. It is not uncommon for larger purchases of offshore seismic data, that discounts for licensure can be 50% or more. Industry expected large discounts for potential future large data purchases can limit the upside sales revenue associated with future licensing.

82. It is also important to note who the data was licensed to in the past as there are only a dozen or so companies with the financial resources to be able to afford to explore for hydrocarbons in an offshore environment. Knowing if there are some key companies that might still license the data is another factor to consider. As many of these surveys are underwritten at the onset by the early participants, it is worth noting if any other companies have licensed the data since and whether there is potential to do so in the future.

83. I understand that the Claimants have attempted to compare GSI's maintainable earnings before interest, taxes, depreciation and amortization (EBITDA) to that of Pulse Seismic Inc. (Pulse), another speculative seismic survey company in Calgary, Alberta.[15] However, unlike GSI, Pulse has a large onshore seismic database that is concentrated in western Canada. While both companies acquire data and license it on a multi-client basis, the costs associated with offshore exploration in Canada restrict the number of companies that can afford to participate. Pulse has access to hundreds of companies when they market their data to industry. Land sale activity in western Canada varies by jurisdiction but it typically occurs either monthly or every two weeks. In contrast, the Boards conduct land tenure bid rounds for offshore areas once every year or so. While Pulse may sell proportionately smaller amounts of data at a time, multi-client offshore seismic companies such as GSI may sell large swaths of data periodically. While both companies are in the multi-client licensing business for seismic data, their business models are quite different and I do not consider Pulse, an onshore speculative seismic survey company, to be an appropriate comparator to GSI, an offshore speculative seismic survey company.

VIII. SUMMARY AND CONCLUSIONS

84. In this Report, I have described the nature of seismic data, including the distinction between different types and quality factors associated with seismic data. I have also described the difference between the seismic data materials that are submitted to the Boards and released to the public with seismic materials that are retained by the multiclient company, and from which it can reprocess and license access to Field Data. This Report further described the limitations for using post-stack enhancements and vectorization of the materials available from the Boards once the applicable confidentiality period is over.

85. I have also described how an objective third-party would go about assigning a value to GSI's seismic data library. Once a quality inspection and an appraisal of the condition of the data is undertaken, consideration of various factors such as geographic location, age and vintage, acquisition parameters and the availability of competitor data must be made.

[15] **CWS-06**, Witness Statement of Paul Einarsson, para. 171(j).

J. Douglas Uffen, P. Geoph (APEGA), P. Geoph. (APEGBC)
President / Director
Reflection Peak Enterprises Limited

Dated this 13th day of January 2023

PERMIT TO PRACTICE
REFLECTION PEAK ENTERPRISES LIMITED

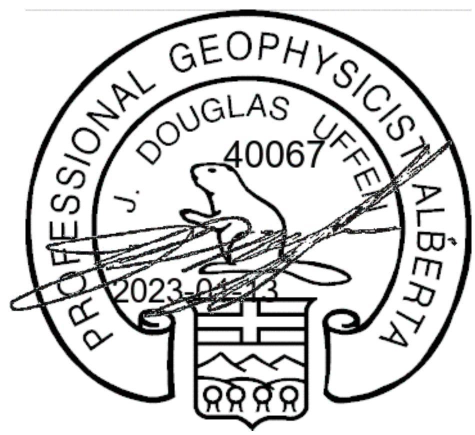
RM SIGNATURE: ____________

RM APEGA ID #: 40067

DATE: 2023-01-13

PERMIT NUMBER: P008041

The Association of Professional Engineers and Geoscientists of Alberta (APEGA)



IX. GLOSSARY

Acquisition Parameters: This encompasses the various aspects of laying out a seismic acquisition program resulting from a program design. It includes specifying the number of channels used, source and group intervals, recording lengths, recording spreads and all aspects required to successfully record seismic data.

Channels: The number of hydrophone sensors used in the streamer (cable) towed behind the ship.

Field Data: The seismic data recordings as acquired by conducting a seismic survey along with the navigational data, the Observer's Notes and any ancillary data that may be recorded while recording the data such as cable feathering, etc.

Fold: The number of repetitions that any point in the subsurface is sampled by an independent measurement. Fold is calculated using the number of channels and the source and group intervals. Higher fold data makes use of the power associated with stacking the data, to improve signal to noise ratios.

Frequency Content: The bandwidth in Hertz contained in a signal is referred to as the frequency content. Higher frequencies are desired as it aids vertical resolution of various rock layers.

Gathers: An interim processing product resulting from the re-sorting of data from a field record format to a common depth point perspective. Gathers are used to create a stacked seismic section.

Group Interval: The distance between hydrophones sensors in the recording streamer.

Hydrophones: The seismic sensor in the recording streamer that responds to pressure changes to record the reflective seismic signal.

Migrated: The process by which seismic reflective events that are not flat are geometrically re-located in either space or time to the actual location where the event occurred in the subsurface.

Multiples: Any event that has incurred more than one reflection from a subsurface layer is deemed to be a multiple. An example of a water bottom reflective event would be the raypath from the source, down to the reflective event at the ocean floor and back to the hydrophones in the recording streamer. A water-bottom multiple constitutes doing this raypath twice (reverberating), creating a ghost-like image or multiple.

Processed Data: Data which has been sorted, enhanced by various computer algorithms and stacked to show a cross-sectional image of the subsurface is considered to be processed data.

Post-stack: Once the seismic data is summed for every common depth point and compiled into a stacked form, any process applied thereafter is applied in a post-stack sense.

Reflectors: A reflector in the subsurface is created by a difference in the density and velocity associated with the seismic signal passing through the medium. Stronger reflectors will have a greater contrast in these rock properties on either side of the reflective boundary.

Receiver: The actual sensor used to record the signal. In a marine survey, hydrophones which respond to pressure differences are used.

Sample Rate: How often the reflective signal is sampled when recorded.

Shotpoint: The distance between group intervals.

Source Interval: The distance between the activation of the air gun source.

Stacking: The processing step by which the interim gathers are summed for each common depth point and amalgamated into a seismic profile image.

Stratigraphy: The branch of geology concerned with the study of rock layers and layering.

Streamer: The cable towed behind the ship that contains the hydrophone sensors.

Trace: A seismic trace represents a spatial position from which seismic reflective signal was recorded.

X. CURRICULUM VITAE

J. Douglas Uffen, P. Geoph. (APEGA) P. Geo (APEGBC)

An honest, passionate, and highly creative geophysicist / executive that integrates his technical knowledge, business acumen, strong communication skills and strategic vision to successfully add value, utilizing communication across multi-disciplinary teams to mitigate drilling risk for new exploration opportunities and optimizing production development.

Work Experience

Reflection Peak Enterprises Limited (RPEL) **Calgary, Alberta** 2002 - 2007
Title: President 2010 – present

Responsible for all financial reporting, licence to practice, and all technical aspects

Accomplishments

- Providing executive and technical level interpretational expertise to several international junior start-ups.
- Proved the value of geophysics to define geologic lithologic edges in a conventional play and geo-steered over 62 wells with 7 of the original 10 wells being top 10 IP30 oil producers in Alberta that year.
- Proved the value of geophysics to define compressional structuring in Upper and Lower Montney, selected drill locations and pad locations, and combined it with coherence, curvature and a Poisson Ratio interpretation depicting stratigraphic variance, while also acquiring micro-seismic data to gain insight for selecting frac ports and affecting well completion design.
- Performed a Reservoir Characterization study including a petrophysical classification of rock lithology to define and high-grade 10 new drilling locations for a client in India.
- Conducted a waveform classification study and neural net study for lithologic discrimination.
- Conducted a 2D interpretation in Algeria resulting in the recommendation to drill a wildcat exploration well which was economically successful.
- Post a corporate merger for a major oil company, conducted an asset property review interpretation consisting of 4 3D surveys and approximately 3,000 kilometers of 2D data in a five-month period, resulting in a catalogue listing of opportunities and several proposed drilling locations.
- While a co-owner of a subsidiary firm, Petrel Robertson Consulting Ltd., performed due diligence assignments for NI51-101 reserve audits, Reserve Assessments, Initial Placement Offerings (IPOs) and share financings, performed interpretive projects for a variety of junior oil companies within the Western Canadian Sedimentary Basin as part of an exploration team for hire.

- Performed technical interpretation for a domestic client that resulted in 29 of 30 exploratory / appraisal wells being cased for future completion.
- Created Geo-Reservoir as a wholly owned subsidiary of RPEL and practiced through this entity for 3 years, then shut down due to oil price collapse in Q1 2015.
- Expert party third witness for 3 legal cases, including two other National Energy Board (NEB) hearings.

Canoro Resources Limited Calgary, Alberta 2007 - 2010
Title: VP Geoscience, Officer of the Company

Responsible for all aspects of geology and geophysics, play generation, strategic planning, third party opportunities evaluations, exploration drilling program design, regulatory consultations and compliance, partner and investor presentations, Board presentations, press releases and supervised up to 8 staff members domestically and internationally.

Accomplishments

- Drilled 2 successful Barail wells, re-established production from a shallower zone and added a newer deeper producing zone, resulting in production additions from 500 bbls/d to 1100bbl/d.
- Recommended investing in compression to raise reservoir pressure of a retrograde gas condensate field above dewpoint and to strive for positive corporate cash-flow.
- Conducted a post-mortem of drilling results and performed two Pre-Stack Depth Migrations and additional reservoir characterization to revise the geologic model accurately depict reserves to mitigate future drilling risk.
- Co-authored a Plan of Development document and identified key targets for another round of drilling activity.

Conoco Canada Limited / Conoco Canada Resources Limited / ConocoPhillips Canada Limited Calgary, Alberta 2001 - 2002
Titles: Chief Geophysicist , April 2001 - August 2001
Exploration Manager, Western Canada New Ventures, August 2001 - March 2002
Chief Geophysicist, March 2001 - October 2002

As Chief Geophysicist, lead a community of 40+ professional staff, reviewed plays and economic evaluations to provide consistent risking, made technical and economic recommendations and influenced exploration strategic planning.

As Exploration Manager, started a New Ventures Exploration group that reviewed the Western Canadian Sedimentary Basin for potential, high graded opportunities, and initiated a “Big E” exploration program.

Accomplishments

- Initiated the G&G mapping of four play trends within the WCSB and initiated prospect generation along those play trends that met corporate criteria for reserve additions and economic criteria.
- Served on a rotational basis as Deputy Incident Commander for the Emergency Response Team.
- Possessed a $ 5M signing authority by Conoco Canada, $ 1M by ConocoPhillips.
- Undertook a forensic accounting exercise to correct the corporation's exploration accounting records after the merger, to facilitate more accurate reporting, budgetary management and forecasting.
- Chaired a Software / Database Rationalization Committee which recommended a methodology and approach for streamlining geological and geophysical workflows and reducing overhead costs by $1M dollars.
- Initiated and negotiated the contract terms for the purchase and acquisition of $20M worth of Foothills 3D seismic data.
- Instituted monthly geophysical meetings to share knowledge amongst the community.

Canadian Forest Oil Ltd. **Calgary, Alberta** 1997-2001
Title: Chief Geophysicist

Conducted seismic interpretations and geophysical operations, responsible for seismic budgets, AFE accruals, departmental computer planning, data management, pathfinding new plays and participating in corporate evaluations. In addition, supervised a group of professional full-time employees and part-time consultants with support staff.

Accomplishments

- Recommended whipping the P-66A well in Fort Liard which was press released as flowing after stimulation at 24 mmcf / day.
- Recommended the drilling of N-01 in Fort Liard which was press released as flowing from three Mattson zones at 49.7 mmcf / day.
- Assisted with numerous third party play evaluations, one being Cutpick (Grande Cache), which became a core property for the company, netting 30 mmcf / day production by the end of 2001.
- Recommended and assisted with numerous corporate evaluations and acquisitions, resulting in the purchase of Saxon Petroleum, Anschutz Canada and the N.W.T. assets of Unocal.
- Orchestrated and initiated a seismic database clean-up which streamlined operations, resulting in a one-year cost recovery through a 250% increase in data sales.
- Upgraded computer software and hardware, coupled with a Y2K plan, to further maximize data workflows and data management.

Boyd PetroSearch   Calgary, Alberta 1995 - 1997
Title: Senior Geophysicist

Performed seismic interpretation and play evaluations for domestic and international clients and provided technical training for international clients.

Accomplishments

- Performed a commercial interpretation of the Blackfoot multi-component 3C-3D survey on behalf of 22 sponsoring companies and the CREWES consortium at the University of Calgary and received Honorable Mention for Best Paper at the SEG in 1997.
- Working alongside Chinese Nationals, conducted a 2D data interpretation and regional basin analysis of two regions within the State Province of Jiangsu

Home Oil Company Limited   Calgary, Alberta 1986 - 1995
Titles: Geophysicist, Senior Geophysicist, Staff Geophysicist

As an Exploratory Geophysicist, conducted play and prospect generation along with making recommendations for data acquisition, data processing, data purchases and land sale purchases. As a Production Geophysicist, conducted development and exploitation geophysics for 28 core production properties.

As an Exploration Advisor, acted as an internal resource person / consultant / instructor, kept abreast of geophysical technology, evaluated new methods and performed advanced interpretations in AVO, VSPs and electro-magnetics.

Accomplishments

- As a Production Geophysicist, fourteen operated locations drilled (12 successful) from 51 mapped and recommended drilling locations, fifteen non-operated locations endorsed, 8 of 9 were drilled successfully.
- As a Development Geophysicist, recommended drilling three wells (one vertical and two horizontal wells) at Swan Hills Unit #1 with an initial cumulative gross production of 2600 bbls / day, resulting in an initial 10% unit production increase and received two Best Paper awards at industry forums.
- Recommended drilling four exploration wells at Umbach with initial cumulative gross production of 150 bbls / day oil and 9.5 mmcf / day gas, making it a new core property for the company.
- Was instrumental in the corporation maximizing value at Caroline which was sold for a 40% return.
- Recommended drilling a well that tested 36 mmcf / day from the Swan Hills formation at Caroline.
- Drilled the discovery well in Caribou Hills which tested 1.5 mmcf / day from the Grosmont.
- Developed a new Performance and Development process and form that was more responsive to performance management and aligned with corporate values.

- As a member of a "Skunk Works" group, recommended a strategy to exploit reserves about core properties which later became my mandate, culminating in a transfer to the production department.
- Chaired a committee that guided the development and data clean-up of a digital shotpoint database.
- Drilled a Jean-Marie discovery gas well in Shekelie and scoped the potential at Peggo / Pesh that initiated the corporation's aggressive development program.

General American Oils Limited (Phillips Petroleum) 1984 - 1986
Titles: Geophysicist, Staff Geophysicist

Performed structural and stratigraphic seismic data interpretation, prospect generation and made recommendations for land purchases and drilling locations

Accomplishments
- Drilled a successful Gilwood oil well on the Peace River Arch that spurred further exploration activity.
- Drilled a successful Sulphur Point oil well near the Shekelie basin.

Texaco Canada Resources Limited **Calgary, Alberta** 1982 - 1984
Titles: Geophysicist I-II

Interpreted seismic data, performed seismic modeling, initiated seismic acquisition programs, and made recommendations to management.

Accomplishments
- Interpreted, mapped and recommended 14 drilling locations for Glauconite oil and gas in Southern Alberta.
- Recommended half a dozen locations at Blueberry for gas potential just prior to deep rights reversion.
- Interpreted, mapped and drilled my most expensive dry-hole of my career in the Gulf of St. Lawrence and learned how to deal with failure.

Education

1978 - 1982 B. Sc. (Hon) Geophysics with a Geology minor
The University of Western Ontario
London, Ontario, Canada

Affiliations

Canadian Society of Exploration Geophysicists (CSEG)
Canadian Society of Petroleum Geologists (CSPG)
Association of Professional Engineers and Geoscientists of Alberta (APEGA)
Association of Professional Engineers and Geoscientists of British Columbia (AAPEGBC)
Calgary Petroleum Club (CPC)
Canadian Prairies Jaguar Club (CPJC)

Awards

Received the Best Geophysical Paper Award at the 1994 CSPG / CSEG joint convention for the oral paper, "Swan Hills Unit #1 : Adding Value with Seismic Through Reservoir Delineation and Characterization".

Received the CSEG Best Paper Award in 1995 for a co-authored, co-presented version of this paper.

Received from the SEG, Honorable Mention for Best Paper in 1997 as a co-author of an oral paper presented by Don Lawton, "Using 3C-3D Seismic Data to Delineate a Sandstone Reservoir, Alberta, Canada".

Received a Meritorious Service Award from the CSEG in 1999 for his dedication to the science of geophysics.

Volunteer of the Year Award from the Calgary Geoscience Data Managers Society in 2020.

Work Experience

International Exposure
China, India, Algeria, Egypt, Kuwait, Tunisia, Tanzania, Senegal, Italy, France, Australia, New Zealand, Argentina, & Gulf of Mexico (USA).

Canada's Frontier Structural Regions
Fort Liard, NWT - Chinkeh, Mattson, Flett, Nahanni,
Central MacKenzie, NWT - Indian River, Kee Scarp and Cambrian.
Beaufort Sea, NWT - Tertiary Section
Southeast Yukon - Mattson, Flett, and Nahanni
East Coast - Jurassic and Paleozoic Sections

Canadian Foothills
Cardium, Cadomin, Gething, Cadotte, Baldonnel, Triassic, Mississippian, Wabamun, Slave Point,

Northeast British Columbia
Bluesky, Gething, Baldonnel, Charlie Lake, Halfway, Doig, Nikanassin, Artex, Kiskatinaw, Montney, Belloy, Debolt, Wabamun, Slave Point, Keg River, and Pine Point.

Northwestern Alberta
Grosmont, Rycroft, Kiskatinaw, Jean-Marie, Slave Point, Sulphur Point, Muskeg and Keg River.

Northeastern Alberta
Grand Rapids, Viking, Clearwater, Wabiskaw, McMurray and Keg River.

Central Alberta
Gething, Viking, Cardium, Mannville, Montney, Mississippian, Nisku, Wabamun, Leduc, Swan Hills, Gilwood,

Peace River Arch
Slave Point, Keg River, Gilwood, Granite Wash.

Deep Basin
Cardium, Gething, Cadomin, Fahler, Notikewan, Wabamun, Leduc, Swan Hills.

Southern Alberta
Viking, Mannville, Glauconite, Sawtooth, Sunburst, Basal Quartz, Elkton, Pekisko, Shunda, Turner Valley, the Paleozoic unconformity, Nisku, Leduc, Swan Hills and Granite Wash.

Saskatchewan
Birdbear, Winnipegosis, Red River, Torquay, Bakken and Grand Rapids.

Written Papers

Data, Information and Knowledge Management: A Practical Perspective
Published in the April 2017 edition of the CGDMS Newsletter

Reliable Geophysics
Published in the April 2015 Edition of the CSEG Recorder, Marian Hanna co-author

Value of Integrated Geophysics
Published in the February 2014 edition of the CSEG Recorder, Marian Hanna co-author

Geophysics and a Reserve Audit Perspective
Published in the March 2011 edition of the CSEG Recorder

Are You Managing Your IT Solutions or is IT Managing You?
Published in the September 2004 edition of the CSEG Recorder

The Industry Today and the Road Ahead
• CSPG/CSEG Joint Convention, June 2003
• Co-author, Doug Pruden, GEDCO

Executive Report
Published in the March 2003 edition of the CSEG Recorder

Your Society Today
A President's message which was published in the April 2002 edition of the CSEG Recorder

A Personal Biography
Published in the May 2001 edition of the CSEG Recorder

A Message from the CSEG Vice-President
Published in the May 2001 edition of the CSEG Recorder

The Great Seismic Round-Up: A Database Clean-Up and Management Case Study
Published in the September 2000 edition of the CSEG Recorder

GeoTriad '98; A More Relaxed Perspective
Published in the November 1998 edition of the CSEG Recorder

Swan Hills Unit #1 : Adding Value with Seismic through Reservoir Delineation and Characterization
• Applications of 3-D Seismic Data to Exploration and Production as Chapter 19, the AAPG and the SEG, P. Weimer and T.L. Davis, editors, chapter 19.
• Published an abbreviated version of the paper in the January 1996 edition of the SPE Newsletter.

Oral Papers

Reservoir Characterization Using 3D Seismic Attribute Volumes: Adding Value By Providing The Opportunity for Better Drill Outcomes
Presented as a guest speaker at the 2014 CSEG symposium, March 2014

How to Set Up a Dataroom
Presented at the CSEG / CSPG Joint Convention, May 2012
Presented at the CSEG Lunchbox Theatre session, October 2012

Ethical Use of Geophysical Data
Presented at GeoCanada 2010 convention, May 2010

Byte Me! How Geoscience Data Architecture Can Help You
Presented at the joint CSPG / CSEG convention, June 2005

Applied Data Architecture: A Geo-Science Perspective
Presented at the PPDM Conference in Calgary, November 2004

The Industry Today and the Road Ahead
• Presented at the 2003 CSEG Convention, March 2005
• Presented at the University of Alberta, March 2005
• Invited Keynote Speaker at the 2003 PPDM Conference in Calgary, contributing presenter at the 2004 PPDM conference

How to Maximize Seismic Data Asset Value
Presented at the Centrum conference, May 2001.

Using 3C-3D Seismic Data to Delineate a Sandstone Reservoir, Alberta, Canada
Presented by Don Lawton at the 1997 SEG convention.

The Application of Geophysical Reservoir Technology within a Business Perspective
Presented at the 1996 CSEG convention as an invited reservoir geophysics workshop guest panelist.

Swan Hills Unit #1: Adding Value with Seismic Through Reservoir Delineation and Characterization
• Presented at the joint 1994 CSPG/CSEG convention.
• Co-authored and co-presented an expanded version of the paper with Rick Wallace of Ulterra Geoscience Ltd. at the January 1995 CSEG luncheon.
• Presented at the 1995 SEG convention in Houston and received outstanding contribution recognition by the SEG.
• Presented at the University of Calgary in March 1996.
• Presented to the Canadian Institute of Mining, Metallurgy & Petroleum Technology technical luncheon in Calgary at the Westin Hotel.
• Presented to the Society of Exploration Geophysicists, Beijing Section, September 1996, Beijing, China.
• Presented to the Society of Petroleum Engineers at the Integrated Reservoir Characterization workshop in October 1996, Calgary.

Do We Really Know How to Think?
The Process of Diagnosis in Exploration and Development
Presented at the 1994 CSPG/CSEG joint convention.

AVO and the Practical Geophysicist
Presented at the 1991 CSEG convention as an invited AVO workshop guest panelist.

Industry Courses Taught

The Rules, Rights, Responsibilities and Obligations of Seismic Data Ownership 2005-present

This one-day course identifies and clarifies the unwritten rules practiced in industry as it pertains to seismic data ownership. The course will also identify and address subtle nuances where current standard industry practice is not uniform. The attendee will develop the insight to make their own informed decisions on these matters. The course will focus upon the rules, rights, privileges, responsibilities and obligations of seismic data ownership and their ramifications, permissions and limitations as related to specific business situations.

Geoscience Data Architecture 2003-2007

This two-day course will offer the attendee insights regarding computer system architecture as it pertains to the geological and geophysical disciplines, business unit structures, hardware platforms, and data integrity. The attendee will develop a heightened awareness for the complexities and opportunities for prompt data retrieval and manipulation. The course will also permit the attendee to assess their own data situation and help them to develop optimal processes and procedures to efficiently manage both hardcopy and electronic data to meet their business unit requirements.

Professional Volunteerism

President and Founding Board Member of the Canadian Prairies Jaguar Club (2021-present)

Initiated and acted as Chairman of the Advocacy Committee of the Chief Geophysicists Forum (CGF) which is a standing committee of the Canadian Society of Exploration Geophysicists (CSEG, 2020)

CSEG Foundation Chairman Outreach Committee (2016 – 2018)

Board Member for the Canadian Society of Exploration Geophysicists Foundation (2016 – 2018)

Board Member for the Calgary Geoscience Data Manager's Society (2014- 2018, 2020- present)

Member of the Chief Geophysicist's Forum (since inception in 1998 – present)

Resource member to the CSEG VIG committee (2013-2015)

CSEG President's Advisory Committee member (2003-2012)

Vice President for the Canadian Federation of Earth Scientists, 2012

Chairman of the 2012 CSEG DoodleTrain Committee

Chairman of the 2011 CSEG DoodleTrain Curriculum Committee, Vice Chairman DoodleTrain Committee

Member of the Guidelines for Ethical Use of Geophysical Data, APEGA sub-committee (2007-2010)

Member of the CSEG Outreach Committee (2005-2006)
• Drafted a plan for committee initiatives
• Initiated an Ambassadors program to represent the CSEG domestically and internationally.

Past President of the Canadian Society of Exploration Geophysicists, March 2003 – March 2004
• Initiated and authored a Long-range Plan as a member of the President's Advisory Council
• Chaired Awards and CSEG office personnel committee

President of the Canadian Society of Exploration Geophysicists (CSEG), March 2002 - March 2003
• Implemented a series of internal policies, procedures and structure to the society
• Supported the creation of the CSEG DoodleTrain Continuing Education week.
• Requested better financial reporting and cash-flow statements
• Initiated the need for a CSEG Foundation

Vice President of the CSEG, March 2001 - March 2002
• Improved internal communication between elected Directors, Committee Chairs and the CSEG office staff.

Executive Advisor for the Geo-Canada 2000 convention, October 1998 - May 2000
• Provided general guidance and recommended identifying discretionary expenditures and determining the timing of these expenditures relative to profitability forecasting.

Co-Chairman of the Chief Geophysicists Forum, 1999
• Initiated and conducted a couple of surveys for the members.

Consulted as an advisor to an APEGGA Investigative Committee for Disciplinary Action regarding what comprised industry standard practice.
• Provided expert guidance and council

CSEG Co-Chairman of Geo-Triad '98
• Acted as a visionary leader for the Geo-Triad '98 joint convention as CSEG General Co-Chairman, by re-engineering it at a new venue with the assistance of over 130 volunteers, coordinating the interests of three societies, resulting in over $ 710,000 in net revenues.
• Served on the CSEG Convention Technical Committee on two separate occasions in the 1980s. Organized speaker mementos, secured session chair.