

Trends and Techniques in Seismic Data Acquisition, Processing, and Interpretation

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Abstract – Seismic data remains the most widely adopted geophysical approach for subsurface imaging in both terrestrial and marine environments. The effectiveness of seismic exploration relies on the careful acquisition of high-quality data and its subsequent processing to produce accurate cross-sectional representations of the Earth. This involves not only ensuring adequate data coverage but also applying advanced processing techniques to suppress unwanted energy, such as multiples, and to correctly position significant subsurface events. At the same time, seismic operations must balance safety, environmental responsibility, cost efficiency, and timeliness. This article presents a comprehensive overview of the fundamental principles and commonly used methods in seismic data acquisition, processing, and interpretation. It highlights the standardized workflows that have evolved over time while also addressing the inherent challenges in designing efficient and reliable seismic data processing pipelines. The discussion aims to provide readers with a clear and structured understanding of the end-to-end seismic data workflow, serving as a foundation for further research and practical applications in geophysical exploration.

Keywords – Seismic Data, Seismic Imaging, Seismic Signals, Data Acquisition, Data Interpretation, Data Processing.

I. INTRODUCTION

Generating seismic signals (artificial) on land (above or below the surface) or in water, receiving them after they have circumnavigated the globe's interior, and (digitally) recording them for subsequent study is what is known as seismic data collection. Seismic data processing, on the other hand, refers to the analysis of seismic signals that have been recorded in order to effectively filter (eliminate or reduce) unwanted elements (such as noise), design images of sub-surfaces to enable the interpretation of geology, and finally obtain approximations of different property distribution of materials in sub-surfaces.

According to Chen, Nagaso, and Tong [1], subsurface mapping, or subsurface seismic imaging based on the application of seismic waves, is a field that utilizes a remote sensing approach to analysis the interior section of the Earth. Seismic imaging uses recorded data of ground motion alongside the wellbore surfaces and processes it in a number of ways to reveal differences in seismic velocity and density deep below the Earth's core. The seismic sensors (e.g., seismometer and geophones on land, or the hydrophones, and seismometer ocean bottom at sea) record tremors because the medium they are placed in have a reaction to the seismic wave energy passing through them. This chapter's initial focus is on the methods used to collect, analyze, and interpret seismic data. For the sake of computer storage and analysis, practically all current seismic data are in digital form, and as a result, we need to familiarize ourselves with some fundamental ideas concerning sampled time series, integrating aliasing and sampling rate, the former of which is the artifact stimulated by under-sampling. Seismic attributes refer to a wide variety of meaningful and measurable characteristics of seismic data used in exploratory seismology.

Seismic wiggles' amplitude and phase are two of the most typical seismic properties. Many time-domain seismic features may be retrieved with the help of the Hilbert transform, which is explained here along with pertinent processing difficulties including gain control and the phase aspects of wavelets. The fundamentals of data formatting, the guidelines for the storage of seismic data in computer systems, must also be understood before we can begin processing actual seismic data. There must be various quality control tests to ensure the data processing is effective. These two issues are addressed simultaneously since, in fact, certain elementary procedures for quality controls have to be implemented at the outset of a processing scheme. To be successful as a novice in seismic data processing, one must be familiar with the basic

concepts and popular technical jargon used in the area. Terms and topics that are unique to this work are defined and explained in italicized sections.

In order to fully grasp each new phrase or idea, the reader should first attempt to describe it in his or her own terms. In order to effectively quantify physical principles and reasoning underlying the sequence of processing, the domain of seismic data processing often employs the usage of mathematical formulae. Each formula has a physical foundation and potential applications, thus the reader should do all they can to study the appropriate mathematics. Scholars or readers are urged to utilize any freely available or commercially available software for seismic processing to learn and practice seismic data processing processes and exercises, notwithstanding the paper's inability to recommend specific software. To fully grasp the practical challenges and constraints, a more experienced student should attempt to develop computer code for key processing stages.

The major goal of this article is to provide the reader with an in-depth grasp of the basic ideologies behind standard seismic data processing and analysis methods. Over time, a standardization of sorts has developed for the progression from collecting raw seismic data to delivering it in a form suited for analysis. Designing an efficient processing pipeline for seismic data is a non-trivial task. The rest of the paper is organized as follows: Section II presents the basic ideologies of seismic survey. Section III presents a conclusion of seismic data acquisition, interpretation, and processing. In this Section, various themes will be discussed: digital seismic data, geometry of seismic data gathering, seismic illumination and CMP binning, CMP and SNR stacking, and sequence of data processing. The last Section IV, a conclusion to the research is drawn.

II. BASIC IDEOLOGIES OF SEISMIC SURVEY

Data acquisition is the initial phase in seismic exploration and is often performed on the ground [2]. Reviewing the fundamental elements that control the propagation of seismic waves over the layered medium is essential for making sense of the seismic data. Love waves, ground roll (Rayleigh), S-wave (shear), and P-wave (compressive) are the four kinds of seismic waves that may be generated by a source of seismic waves at a particular location on the globe and propagate through its strata (see **Fig 1**). Both density and speed will be calibrated for each stratum. Both Rayleigh and Love waves travel roughly perpendicular to the surface of the Earth as they travel along it. While surface waves travel to great depths inside the Earth, they do not go straight into its interior and hence have no effect on oil and gas exploration.

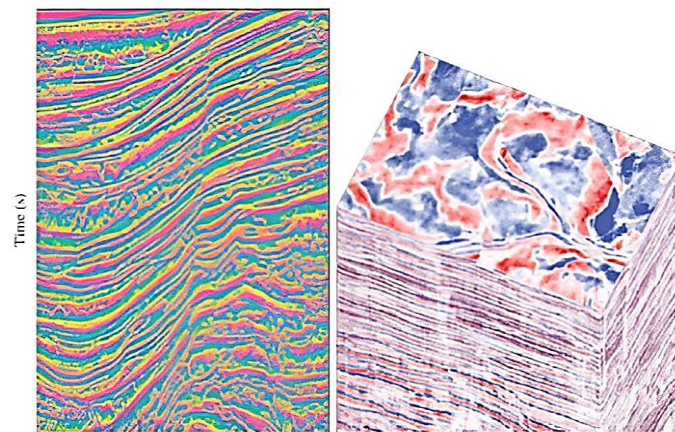


Fig 1. Subsurface Imaging by Two-Dimensional (In the Right), and Three-Dimensional (In the Left) Reflection.

P- and S-waves, on the other hand, are dubbed body waves due to the fact that they spread in all dimensions from the source and penetrate the Earth's core, making them very important to seismic research. The pressure exerted in the directions that P-waves are traveling defines it as a longitudinal wave. If that's the case, the ground will shift in that direction. As Earth itself is incompressible, energy may be transported to it rather rapidly. It is necessary for the medium to shift from materials closer to it to effectively induce the shear and enhance S-wave transmission. This displacement occurs transversely to the direction of travel (up and down, relative to the line of motion). This is why the S-wave in seismic occurrences travels at a slower rate than the P-wave. Due to the lack of shearing capability in fluids, S-waves are unable to propagate through them (see **Fig 2**).

P-waves cause ground motion along the path of propagation, whereas S-waves cause motion at right angles to the propagation axis. Rayleigh waves cause ground motion that is elliptical in shape, moving either forward or backward depending on whether the wave is traveling with or against the direction of propagation. As a love wave hits the ground, it sends shockwaves in a perpendicular direction to the wave's dispersion.

III. SEISMIC DATA ACQUISITION, INTERPRETATION, AND PROCESSING

It is relevant to first comprehend the wide image of data, including the goals and methods of seismic data processing now and in the future, as well as how this discipline relates to others in its sector. The definitions of the most basic terms used in this discipline must be understood. Seismic data, including term such as signal to noise ratio (SNR) [3], different seismic collects, common midpoint (CMP) binning [4] and fold, stacking, post-stack vs. pre-stack data, and pre-processing vs. advanced processing, are mentioned in this section. As the field of subsurface seismic imaging is made up of these three interrelated and complementary processes, the link between the collections, interpretation, and processing of seismic data is presented here.

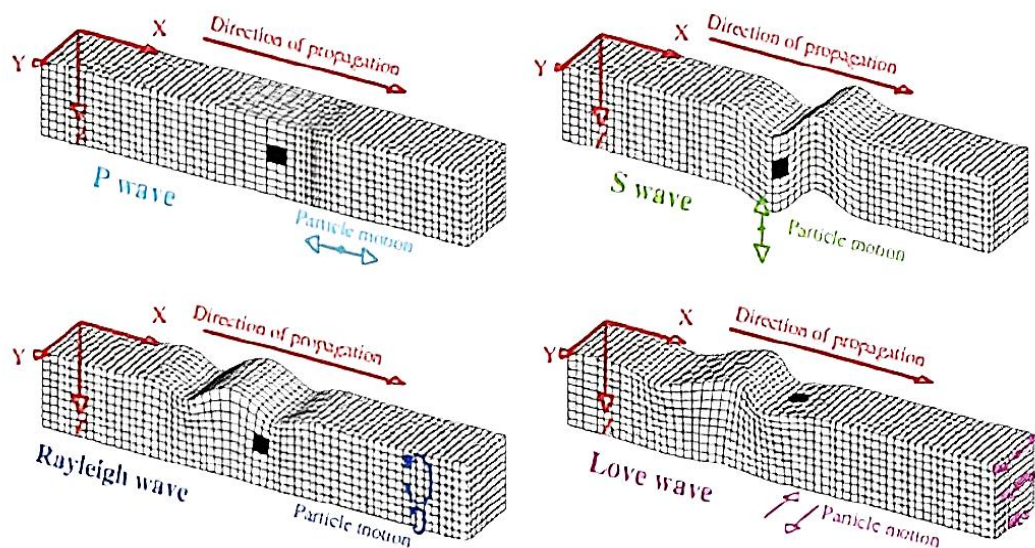


Fig. 2: Particle Movements and the Subsequent Body (S and P) and Interface (Love and Rayleigh) Wave Transmission.

Digital Seismic Data

Physical estimations, observations, or measurements of difference seismic waves, seismic sources, and the propagation of medium constitute what we call seismic data. Seismic, gravitational, magnetic, geothermal, rock physics, electromagnetic, tectonophysical, atmospheric data, and oceanographic is all subcategories of greater geographical data fields. Seismic information comes in various formats, e.g., analog maps, graphs, texts, digital time series, and different concepts. In this study, we focus on the processing of digital seismic data. Here, we analyze data on the propagation of body waves, particularly P-waves, across media of various types (including transmission, reflection, diffraction, refraction, and bending).

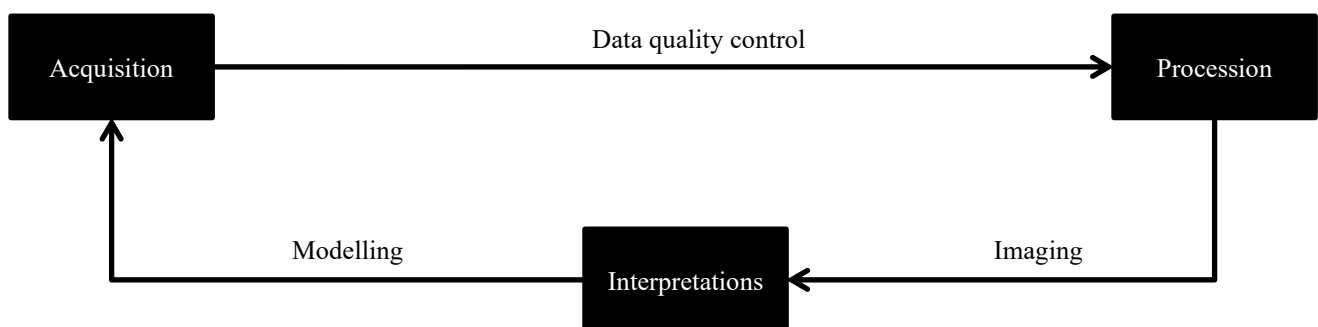


Fig 3. Relationships Between Data Interpretation, Acquisition and Processing.

Similar ideas are used in the processing of various types of seismic data and many other types of data as well. Gathering and analyzing seismic data helps scientists better understand the inner workings of the planet. In order to learn more about Earth, it is necessary to first establish some concrete connections between research goals and observable quantities. Next, we'll acquire problem-specific data, process it to isolate and amplify the signal of interest, and last, evaluate our findings using the refined signal. The different processes of data processing, interpretation, and collection are not independent of one another but rather mutually supportive, as seen in **Fig 3**. Data quality controls refer to the activities, which should be undertaken after the collection of data but before the processing of data. This means verifying that the quantity and quality of datasets are adequate for our research aims by inspecting its survey geometry, data format, and consistency across its many components. Quality control (QC) of data is often performed at the pre-processing phase.

Seismic imaging is used to provide a variety of visuals used in the interpretation process after the data has been pre-processed to reduce unwanted noise.

Seismic imaging techniques, as per Pinheiro et al. [5], include a wide range of techniques for obtaining different types of seismic features, from seismic migration to seismic tomography. Seismic imaging techniques are sometimes referred to as "state-of-the-art" processing. The whole process, from pre-processing through seismic imaging, is within the purview of this study. The interpretation of data is typically double-checked by doing seismic modeling using perceived models and the real information/data geometry to offer predictions, which could be contrasted with the actual observations. The three interior arrows in **Fig 3** show how the third element impacts the relations between two distinct elements (in this case, the data quality checks, modeling procedures, and imaging).

Geometry of Seismic Data Gathering

A variety of acquisition geometries are used to gather seismic data for the energy sector. **Fig 4** shows two seismic acquisition dispersions, or the integration of receivers and shooters, in seismic survey, in cross-sectional perspectives. Shown in panel (a) represents the split spread, where the shots are situated in the middle, while the receivers are all spaced out around it. Geophones are often spaced this far apart when doing onshore acquisitions utilizing dynamite or Vibroseis technologies as the source. Topographic variances, uneven source and receiver locations in three dimensions, and curved raypaths all make the problem much more intricate in the actual world. Panel (b) depicts a spread from the end, with the shot at one end while all the receivers interlinked to one side of balls.

Many of the offshore seismic evaluations using controllable sources and the airguns close to boats and single/different hydrophone ribbons as the receiver use this separation. Offshore seismic data [6] often have substantially greater quality than onshore seismic data due to a variety of advantageous characteristics. They include stable and reliable sources, excellent coupling settings at source materials and terminals, and similar water nature as channels. Offshore seismic dataset, however, could have dissimilar noise sources, such as multipath propagation, and the current state of affairs of most 3D seismic surveys offshore is significantly more limited in azimuth than onshore.

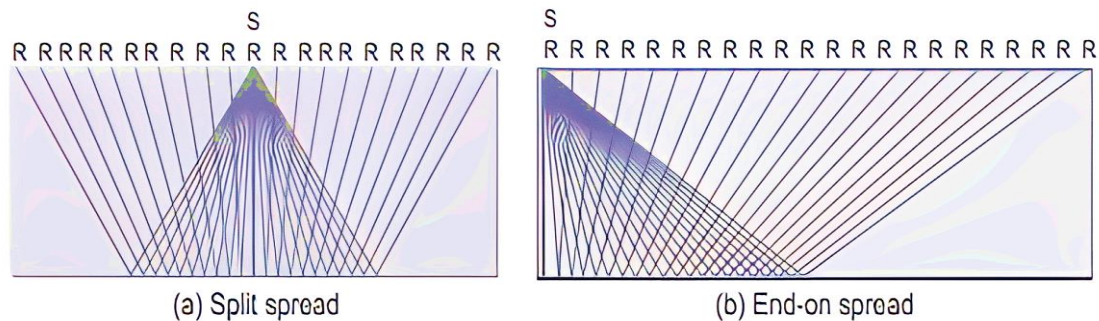


Fig 4. Two Seismic Data Collection Spreads and Raypaths, Cross-Sectioned.

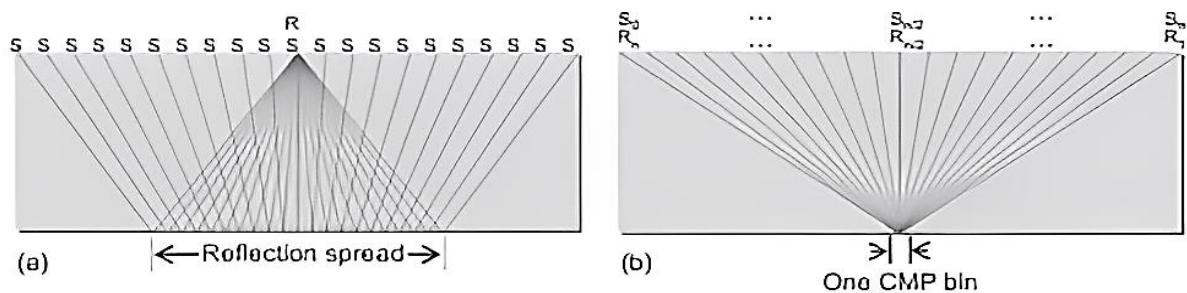


Fig 5. A Cross-Section Perspective of (a) A Similar Receiver Gathering, and (b) CMP – Common Midpoint Gathering.

A common shot gather (CSG) [7] is created by combining the traces of seismic data from different sensors, which have obtained similar shots, as shown in **Fig 4**. Seismic gathers consist of a collection of pre-stack seismic traces that share a common thread. Unlike "post-stack" or "stacked traces," which are the consequence of adding or summing several traces together, "pre-stack traces" refer to data tracing, which preserve the initial sources and receiver position. **Fig 5a** depicts a common receiver gather (CRG) [8], which is a group of traces from many shots recorded by the same receiver, and **Fig 5b** depicts CMP gather that is a segment of traces whose receiver-to-source midpoints occur inside one tiny region, termed a CMP bin. When a flat reflector is placed under a constant velocity medium, the CMP gathering has a minor reflection spreading of the three typical kinds of seismic gathers (**Fig 5b**). A CIG (common image-point) [9] gather refers to a collection of migration traces in similar imaging bin. While being conceptually a common offset section, the term "common offset gather" is often used to refer to a gathering of the traces with similar offset amounts from the sources to the receivers.

Seismic Illumination and CMP Binning

Due to the little variation in reflection point among CMP gathers, the traces from all of the gathers may be added together to produce a single stacked trace. To get a zero-offset tracing that is achieved by having a receiver and a shot at similar position, the stacked tracing is often utilized as a stand-in. The ratio of signal-to-noise of the stacked trace is high because it incorporates the common properties of the original traces used to create the stack. In many seismic data processing techniques, CMP collects are thus recommended. As the CRG or CSG data are gathered in the field, however, they must be reorganized to conform to the CMP format. The two-dimensional line ranges or the three-dimensional survey regions are binned to the equal-size CMP bin, and the traces whose midpoints lie inside each bin are gathered for that bin.

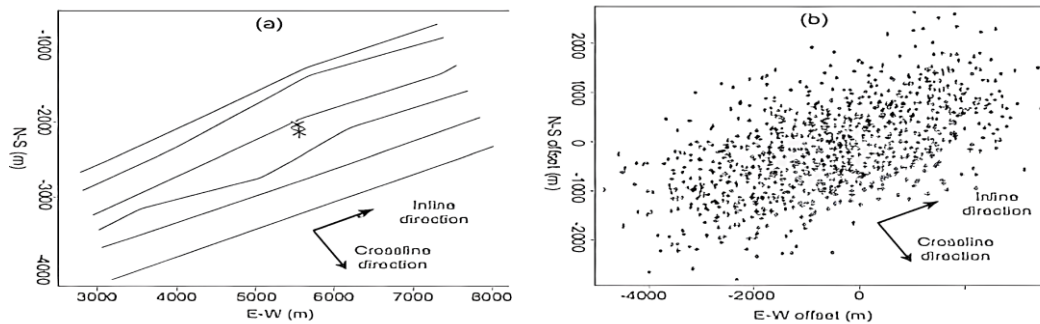


Fig 6. Map Perceptions of Acquisition Geometry of Canadian Rocky. (A) Shot Locations (The Asterisks), and Dots (Receivers) for Different Shot Gathers. (B) 1000-Trace Offset, Selected Randomly.

The fold is the trace number (midpoints) integrated in every CMP bin. Folding indicates the abundance of CMP data, making it a crucial metric in seismic surveys. Geometries of two different on- and off-shore 3D surveys are shown in **Fig 6** and **Fig 7**, respectively. The left panels of these Figures depict the positions of receivers and shots, whereas the panels to the right show the midway positions of one thousand traces chosen at random from the relevant survey. Seismic illumination is best preserved when the fold is sufficiently high and as uniformly distributed as feasible over the survey region. In actual reality, the need for adequate seismic lighting must be weighed against the need to maximize survey efficiency and cut down on time and money spent.

To optimize the azimuthal range of every swath (the patch of territory documented by a collection of a sensor at once) in 3D onshore seismic investigations [10], the alignments of shot line are generally orthogonal to the configurations of the reception lines. In most cases, the spatial sampling is denser along the inline directions compared to it in an orthogonal cross-line direction. As the receivers are often spaced more closely together than the shots, the inline tends to run along the receiver direction line, as illustrated in **Fig 6a**. Nevertheless, if the populations of shots and receiver lines are very non-normal, as illustrated in **Fig 7b**, an inline direction could be obtained by the data midpoint distribution.

For the best possible seismic illumination, it is sometimes necessary to use non-standard arrangements of shot and receivers. In **Fig 8** we see an illustration of a 3D seismic survey geometry that is unique to the area above the Vinton salt dome in southwestern Louisiana. The receivers of the survey were positioned in radial lines, and the shots were taken in a circular pattern with their centers directly above the subterranean salt diapir. When it comes to most fields of applied research, competing priorities of quality and cost (in both monetary and temporal terms) may be frustratingly common. In this case, the radial lines provide ideal deployment geometry for modern geophones, which are linked together through cables. The power here came from Vibroseis trucks, which can be maneuvered with relative ease on the elliptical routes. In the same way, while processing seismic data, we need to balance the competing priorities of quality and cost.

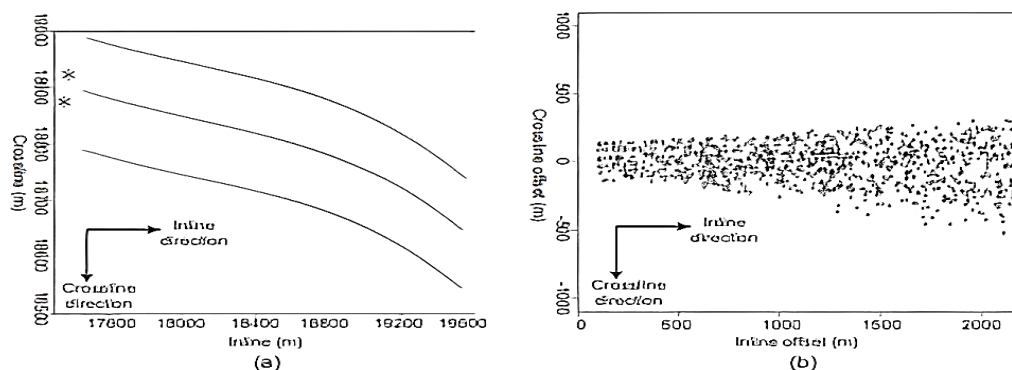


Fig 7. Map Perspective of 3-Streamer Acquisitions for North Sea. (a) Shot Locations (The Asterisks) and Dots (Receiver) of Two Shot Gathers. (b) 1000-Trace Offset, Selected Randomly.

CMP and SNR Stacking

The signal in geophysical data is the information that is useful for achieving the goals of the project, whereas the noise is everything else. Signal-to-noise ratio (SNR) improvement is a primary focus in digital data processing, including seismic data processing. SNR is often defined in the field of seismology as the comparison of the two amplitudes of the signal and noise components of seismic traces. The round lines represent the shots, while the straight radial lines represent the locations of the receivers. Coverage of reflected waves from the salt dome's border is maximized by carefully planning the shot and receiver geometries.

The significance of signal against noise in practice depends on the aims of the research and the data processing approach used. In a similar vein, the output and input of the processing task may be the source and destination of the raw data and processed data, respectively. Because of the presence of noise, seismic data is often analyzed using statistical methods. The term "common midpoint" (CMP) stacking is used to describe the process of adding seismic tracing whose reflection is forecasted to happen within a single timeframe or the same depth of reflection. Enhancing the ratio of signal-to-noise is the driving force for such stacking. In several fields of observational research, stacking is the primary method for boosting signal-to-noise ratio. A source-receiver pair's midpoint is geographically located anywhere in the center of the two nodes. All the reflectors for a particular receiver and source will have their midpoints positioned below the vertical midpoint of a layer cake model of the subsurface (see Fig 9).

Real-world reflectors' lateral locations tend to be rather near to the middle, making the layer-cake model the default assumption since it is seen to be the most statistically representative case. Hence, seismic traces are often plotted in the middle of cross-sections. One may see that numerous traces have a common center. It is the fold that determines how many traces are placed in each CMP bin during setup. Using CMP stacking to create stacked sections is a standard procedure in seismic data processing. Hence, we may classify seismic reflection data as either pre-stack or post-stack, and similarly classify seismic processing as either pre- or post-stack. Stacking and subsequently post-stack migration are the standard methods for obtaining time sections.

In the layer-cake model shown in Fig 9, all reflection spots are situated just below the midpoint M. In order to create depth sections that presumably have less error in reflector shape and amplitude, contemporary processing typically utilizes pre-stack migration and processing. With a velocity-depth function, one may also convert between time sections and depth sections. Seismic data processed after a stack has been built may be processed for less money and with more stability, but at the expense of precision. Pre-stack seismic processing, on the other hand, may be more precise than post-stack processing, although being more expensive and less reliable in general.

Sequence of Data Processing

In the years since the advent of digital recording, a standard operating procedure for handling seismic data has developed. This fundamental progression will now be detailed so that a complete comprehension of each stage may be attained. Seismic data processing typically entails three main procedures: deconvolution, layering, and migration. The seismic data volumes at midpoint, offsets, and time are shown in Fig 10 for processing purposes. Deconvolution is a linear process that occurs over time. It improves the temporal resolution of the recorded seismic trace by eliminating the fundamental seismic waveform (the source time functional modulated by different impacts of the earth and recorder device). By reducing the size of the wavelet, de-convolution accomplishes this. Compression occurs with stacking as well (velocity evaluation and statics adjustments).

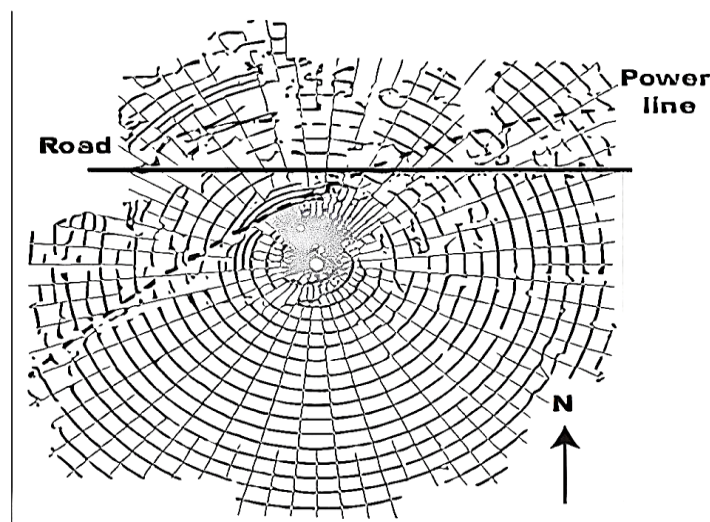


Fig 8. Map Orientations of Three-Dimensional Seismic Surveys Over the Western Louisiana Vinton Salt Dome.

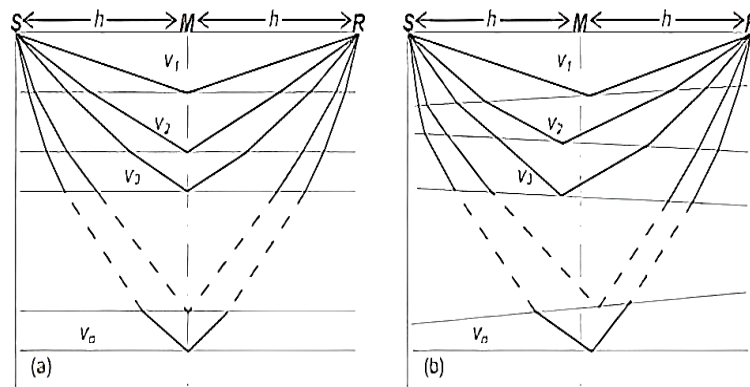


Fig 9. The Rays of Reflection (Shown by Black Lines) Originating from the Source to the Receiver in (A) Layer-Cake Framework and (B) Dipping Layer Framework.

Fig. 10 shows that the volume of data before typical move-outs corrections is rectified to the trace from each CMP gathers (speed assessment and statics corrections), and then added to the offset axis to establish the midpoint-time plane at a zero offsets (the front edge of the prismatic). Because of this, a stacked part has been produced. (Stacked section, CMP stacking, and stack are commonly used interchangeably.) Last but not least, layered data is a typical candidate for the transfer process. It's a technique for determining the likely subsurface locations of dipping occurrences on a stack section by collapsing diffractions. The process of migration may be thought of as a kind of spatial de-convolution, which enhances the spatial resolution.

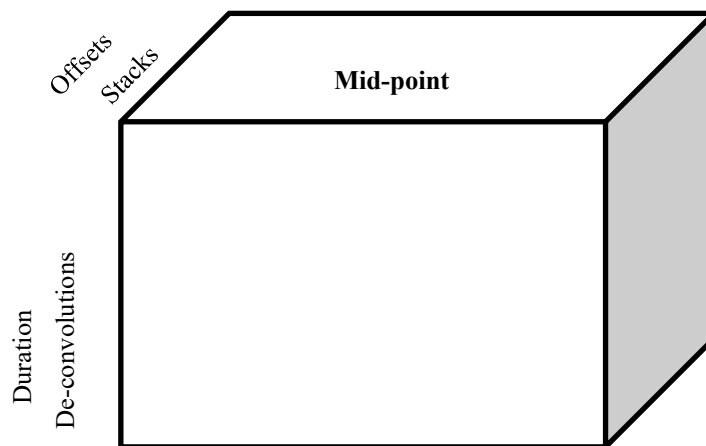


Fig 10. The Volume of Seismic Data Signified in the Processing Coordinates (The Midpoint-To-Offset-To-Time).

To improve temporal resolution, as shown in **Fig 10**, Deconvolution operates along the time axis of the data. When data is stacked, it is compressed alongside an offset axis, and the resulting plane is called the "stacked section" (the front prismatic face). Thereafter, migration identifies the dip occurrence to correct surface region and tends to compress the diffraction resulting in improved lateral resolution.

To the extent that they enhance the efficiency of the main processes, all the techniques of processing could be categorized as secondary. The estimation of autocorrelation depends on the energy of reflection, which is devoid of these noises; hence it may be necessary to use a process like dip filtering before deconvolution. Removal of extremely high and low frequency noise may also need the use of broad band-pass filtering. To restore the lost amplitude due to wavefront divergence, geometric spreading must be corrected for before deconvolution may begin. Several attenuation and residual statics adjustments enhance velocity analysis, a crucial stage in the stacking process.

Several tertiary operations are geared at making data agreeable with the presumptions of the three major operations. A minimum-stage source wavelet and the white reflection series barred with noise are used in deconvolution. The source is assumed to be stationary, and the light will be coming in at a vertical angle. Migrating is predicated on a zero-offset (primaries only) wavefield, whereas stacking is predicated on hyperbolic moveout [11]. It's possible that a pessimist would argue that none of these presumptions holds water. When applied to field data, however, these methods provide a representation of the subsurface that is very similar to the real thing. Since the performance of these three processes is rather insensitive to the assumptions used in their theoretical formulation, they are considered robust. It is important to remember that the results of a processing step are dependent on both the parameters chosen for that step and the results of the stages before it. To illustrate the primary steps in processing, we will use a Caspian Sea 2-D seismic line as an

example. Beginning at a depth of about 750 meters, the water depth gradually drops to around 200 meters by the time the line reaches its opposite end.

An initial processing flow sample for the reflection seismic information is shown in **Fig 11**. This example is almost 30 years old. The processing sequence shown in this diagram for creating post-stack portions is mostly unchanged from its historical implementation. The processing of seismic is undertaken to assist in the interpretation, or the drawing processes of conclusion from different datasets.

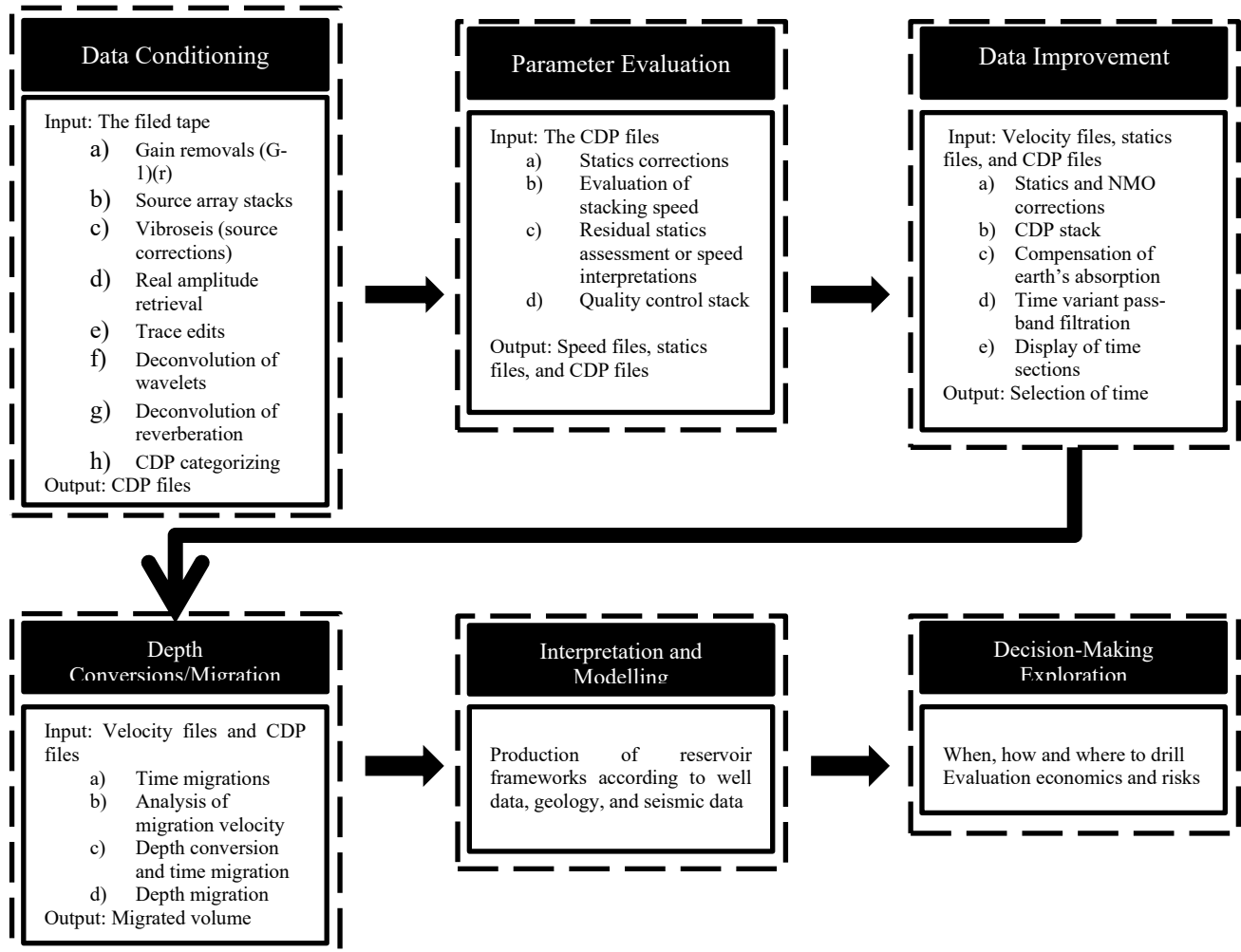


Fig 11. A Generic Processing Flow in the Wake of Schneider.

The goal of this process is to change raw data into formats that are more effectual to the extraction of signals. The terminology "optimal" suggests picking a better option after all the essential data has been weighed. Resultantly, we need to make choices as part of the analysis process for seismic data. Physical and geological theories are the backbone of any technique used to analyze seismic data, since they provide the conceptual framework for understanding the relationship between the two. For instance, the notion of seismic anisotropy might be used to the issue of inferring aligned fractures. The data processing that follows will make use of this theory to try to reduce the noise that can interfere with the signal extraction procedure and extract the signals of the fracture direction based on the angular fluctuation of traveling speed.

Typically, alternative hypotheses are tested by repeating steps c, d, and e. To aid in the creation of a velocity model, it is common practice to do pre-stack processing following post-stack processing. Pre-stack processing with restricted offsets has also been reported.

IV. CONCLUSION

An in-depth familiarity with standard seismic data processing and analysis methods is the major goal of this article. Certain components of the progression from collecting raw seismic data to completing the data in a form suited for interpretation have become more or less standard throughout the years. Designing a correct sequence of processing, also known as a processing flow, for seismic data is a non-trivial task. Seismic data collecting and processing aims to provide outputs that are analogous to earth cross-sections. To achieve this goal, it is necessary to collect the right quantity and quality of data,

and then use processing to get rid of excess energy (such multiples) and to put the necessary events in the right place. Although ensuring safe operations and minimizing environmental impact are essential, it is also crucial to keep costs low and data up to date. Subsurface seismic imaging, also known as mapping the subsurface using seismic waves, is a field that uses the remote sensing approach to assess the interior section of the Earth. The procedures followed to achieve data processing are used to the recorded ground motion at the surface and in wellbores to create seismic images of the interior section of the Earth according to the differences in seismic density, and velocity.

CRedit Author Statement

The author reviewed the results and approved the final version of the manuscript.

Data Availability

The datasets used and/or analysed during the current study available from the corresponding author on reasonable request.

Conflicts of Interests

The author declares no conflict of interest

Funding

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Competing Interests

There are no competing interests.

References

- [1]. J. Chen, M. Nagaso, and P. Tong, “TomoATT: A Software Package of Adjoint-State Traveltime Tomography for Imaging Subsurface Velocity Heterogeneity and Seismic Anisotropy.” May 2023, doi: 10.5194/egusphere-egu23-10556.
- [2]. T. Hildén, H. Badran, J. Turunen, K. Peräjärvi, and R. Pöllänen, “Novel Compton suppression equipment in γ -ray spectrometry with list mode data acquisition,” *Appl. Radiat. Isot.* vol. 193, p. 110668, p. 110668, May 2023, doi.org/10.1016/j.apradiso.2023.110668.
- [3]. K. Yang, W. Tong, Z. Huang, T. Qiu, and Z. Lai, “Signal-to-noise ratio improvement of the signal immersed in the strong background noise using a bistable circuit with tunable potential-well depth,” *Mechanical Systems and Signal Processing*, vol. 177, p. 109201, Sep. 2022, doi: 10.1016/j.ymssp.2022.109201.
- [4]. D. Picchi and S. Brell-Çokcan, “A modified common midpoint approach for GPR radars,” *Construction Robotics*, vol. 6, no. 3–4, pp. 319–328, Dec. 2022, doi: 10.1007/s41693-022-00086-z.
- [5]. L. M. Pinheiro et al., “Detailed 2-D imaging of the Mediterranean outflow and meddies off W Iberia from multichannel seismic data,” *Journal of Marine Systems*, vol. 79, no. 1–2, pp. 89–100, Jan. 2010, doi: 10.1016/j.jmarsys.2009.07.004.
- [6]. J. Zheng et al., “The application of a homemade boomer source in offshore seismic survey: From field data acquisition to post-processing,” *Journal of Applied Geophysics*, vol. 210, p. 104945, Mar. 2023, doi: 10.1016/j.jappgeo.2023.104945.
- [7]. W. Sun, L.-Y. Fu, and B. Zhou, “Common-angle image gathers for shot-profile migration: an efficient and stable strategy,” *Exploration Geophysics*, vol. 43, no. 1, pp. 1–7, Mar. 2012, doi: 10.1071/eg11038.
- [8]. T. Shu, K. Yang, and H. Li, “Gaussian-packet based slope tomography assisted by demigration to common receiver gather,” *SEG Technical Program Expanded Abstracts 2019*, pp. 5159–5163, Aug. 2019, doi: 10.1190/segam2019-3215287.1.
- [9]. J. E. Rickett and P. C. Sava, “Offset and angle-domain common image-point gathers for shot-profile migration,” *Geophysics*, vol. 67, no. 3, pp. 883–889, 2002.
- [10]. B. B. Bate, O. A. Boboye, K. F. Fozao, E. A. Ndip, and N. O. Anene, “Petrophysical characterization and 3D seismic interpretation of reservoirs in the Baris Field, onshore Niger Delta Basin, Nigeria,” *Energy Geoscience*, vol. 4, no. 1, pp. 103–116, 2023.
- [11]. V. Grechka and I. Tsvankin, “15. Velocity Analysis of Converted Waves Based on the Hyperbolic Moveout Equation: The RTM Method,” *Anisotropy* 2000, pp. 291–310, Jan. 2001, doi: 10.1190/1.9781560801771.ch15.

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