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Reducing pitfalls in Seismic Data Management

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Summary

Geophysical data especially seismic data is the main exploration tool and later, integration with other data, it is used to manage the prospects throughout their life cycle. It is exchanged many times between the acquisition operator, processing agencies and the operator(s) and partners of the leased block. Given the amount of manual data entry at different stages and that the navigation data is managed separately, the seismic user should be aware that errors can still occur. In addition, different Application Software modules store data in their own proprietary formats and most of the legacy applications do not capture project metadata, and thus the onus is on the user to know what is what. To understand the data related issues and validate such data before putting it to use can lead to delays and lost opportunities. Many data related problems faced are due to lack of metadata or non-availability of the history and/or parameters describing the data. Non-resolving of the data related issues can result in exploration and/or development failures and can affect the business decisions. We review the pitfalls that occur across the recognized geophysical activities: acquisition, processing, and interpretation, plus positioning and data management to make a business point and describe the current status of an ongoing collaborative effort to identify potential opportunities to improve the quality and streamline the use of geophysical data to reduce risks, delays and help make better business decisions.

Review of earlier work

Historically, different countries used different ellipsoids in order to simplify surveying in their regions. Moving to WGS84 will require major changes to all existing maps & records and require high costs of reproduction and QC. Matthew (2009) brings out the need for awareness of multiple coordinate systems in vogue and the ability to transform from one coordinate system to another in the context of Nigeria. In his article "Oil companies underscore importance of geodetic positioning", Rayson (1998) discusses some important issues and pitfalls on how transformations of the positional information associated with source-receivers and well locations are often misunderstood. Confusion still exists around use of local coordinates (UTM's) and geographic coordinates (Lat/Long) which can lead to very large errors in position. Dave Monk (1999) concludes that everything performed during acquisition of seismic data has an impact on the final volume, which can never be perfect. Not recognizing the impact is one of the biggest interpretation pitfalls.

Acquisition pitfalls can lead to drilling wells in the wrong place and/or on non-geologic features. These problems cannot be "fixed" in processing; in fact, processing simply adds another series of potential pitfalls!

Conversions of coordinates are another source of introducing errors into seismic and well data. Giving the real example which is shown in Fig. 1, Brad Torry & Mark Watson, based on their historical experience, estimate that approximately 5% of all audited surveys received from all auditors is miss-positioned (2006). Geophysical Technician must be diligent to confirm the survey datum prior to loading the SEGY data.

Due to the adaptation of latest GPS systems and datum equivalent to WGS 84, many seismic and well coordinates recorded in the earlier geodetic systems are converted to WGS84 or equivalent datum. Thomas (2004) describes how difficult, time consuming and expensive is the conversion process and gives example of one large



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integrated company who did their offshore conversion over a period of six months and at a cost of \$100,000.

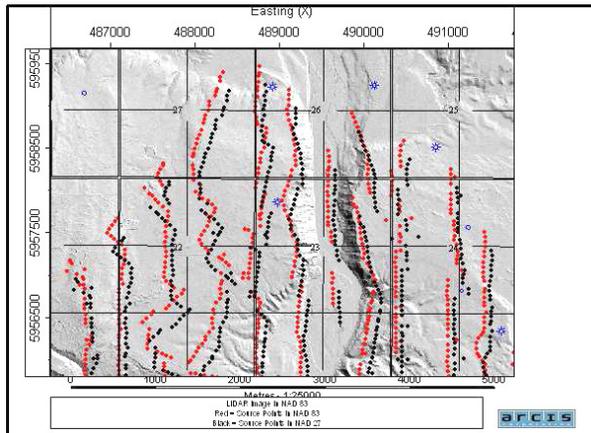


Fig.1 Errors due to Conversions of coordinates

The most difficult data to convert was the subsurface interpreted geophysical data. Fault polygons, picks, horizons, all had to be exported, transformed and re-loaded to the projects.

Good-quality seismic data alone is of no use without the associated navigational data to accurately locate areas of interest. Peder Solheim (2007) emphasizes ensuring the quality of the navigation data. This is in part related to the increased use of 4-D seismic where it is critical that the navigation data is correct for both the base survey and the repeat survey, but also because wells have been drilled in the wrong place due to incorrect navigation.

Mega mergers of contiguous seismic data acquired over a period of time have become the order of day. In addition to providing coverage of entire sections of basins, the reprocessing of the historical data during the merging allows application of latest processing techniques on the earlier data and provides better imaging. However, the merging of the surveys mean conditioning of the different surveys, for the differences in charge size, hole depths, variation in geometry and other problems due to logistics etc and need meticulous details of observers reports and other meta data. Murali Mohan et al (2007) presented the additional efforts needed and times consumed to QC and correct the improper receiver line definitions and lack of

recording delay information in SPS data etc. The following example in Fig.2 is from his article.

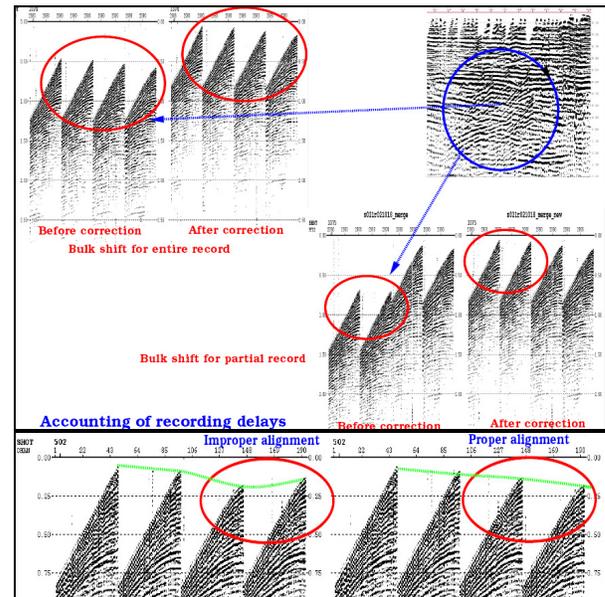


Fig.2 Incomplete metadata and channel set description in SPS reports

Many EBCDIC headers or the seismic data history, are silent on the phase or polarity of the data stored in the SEG Y tape/file. Alistair Brown (2005) believes that many dry holes have been drilled by those who failed to determine or verify the phase and polarity of his or her data as data phase and polarity critically determine seismic character and character is more important than amplitude in identifying hydrocarbons.

Ajay Badachhape (2001) and Dennis Meisinger (2004) describe confusion related to floating point representation of seismic trace data values by computers due to inconsistent binary header information. One of the authors recalls how he had to struggle for two weeks to decode the floating point format as that of VAX system when the tape header was silent on the floating point format of trace samples and no indication was given that the tape was generated on a micro-vax system. Fig.3 is an example of the distortion of the signal due to floating point confusion.



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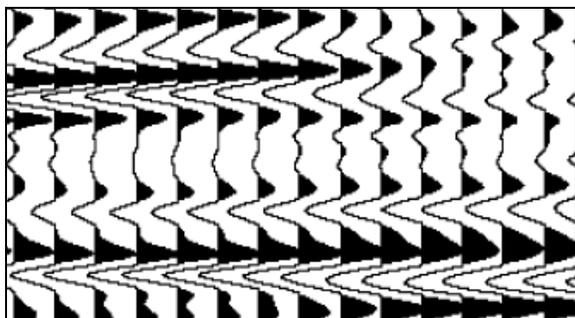


Fig. 3a Data loaded correctly

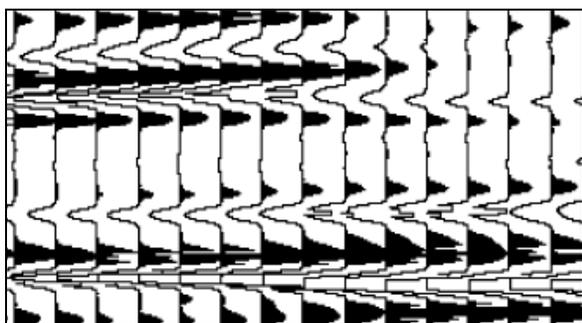


Fig.3b Data loaded incorrectly due to floating (IEEE loaded as IBM) point confusion due to improper header information

Some of the unforeseen things that can create panic when the time was so critical could be as simple as observer sheets supplied in Russian language and the processor does not understand it or the interpreter gets the UFS dump of the project data on DLT cartridges (both were real experiences). Oil companies, service providers and regulating agencies who are using the geophysical data experience such issues and must have spent time and money in remedial measures taken.

However, no systematic analysis or assessment made was reported on the time lost due to such problems associated with seismic data as brought out in the many references such as given above. In this paper a collaborative effort made by oil companies, service providers and operators in association with Energistics is presented.

Introduction

Geophysical techniques for acquisition, processing interpretation and data management activities have evolved enormously in the last two decades. Advances in information technologies have enabled significant changes in data storage, while computing capacities have also enabled routine use of sophisticated geophysical processing techniques. In addition, a host of attribute volumes are generated and the number of data volumes as well as size of individual volumes have increased and will continue to increase by orders of magnitude. Large number of new objects is added as a part of interpretation and managing the multitude of E&P data generated throughout the life cycle of the reservoir is not possible without adhering to standards. With reference to seismic related data alone, based on the experience gained while building exploration database and loading over a million line kilometers of seismic and related data by ONGC, a list of approximately sixty opportunities for improving work processes across the full geophysical activity cycle comprising acquisition, processing, interpretation (including modeling) and data management were identified. Oil companies, Operators and service providers operating from India in association with Energistics attempted to address these opportunities using collaborative techniques similar to the successful WITSML (Wellsite Information Transfer Standard Markup Language) and PRODML (Production Markup Language) initiatives in the drilling and production business domains. To make a business case several examples drawn from different problems faced by different companies/operators compiled under review of earlier work and many more examples were presented at different forums and the ppts are available at www.witsml.org.

From the business point of view, increasing demand for hydrocarbons sees geophysics continuing to be used in exploration, and increasingly to be used in the development and production phases of E&P operations, thus creating ever larger data volumes to be managed for a decade or longer subsequently. The advent of real-time production optimization and use of geophysics in reservoir monitoring will require higher degrees than hitherto of automation and hence standardization in geophysics work processes. The business case for improving work practices in geophysics arises from both technology and business perspectives. Standard mechanisms need to be evolved that facilitate sharing of information with partners, regulatory agencies



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and service companies. Ideally, these mechanisms should be standardized, simple, non-proprietary and reliable to avoid pitfalls in data management.

Assessment

The approach for assessing the identified opportunities for improvement in quality and work practices has four elements: the first was to identify the main sources of delay and hence the opportunities for improvement. The second was to analyze and rank the opportunities in terms of the time cost of each delay; identifying the needed improvements and the ease of formulating the improvements. The third was to produce a report on the assessment of the opportunities, including an outline of the needed remedies, business case, and plan for the longer program. The fourth element is to select those which are most widely supported and to develop and deploy the improved work practices in the use of existing data and related standards; and to propose and provide data and metadata standards where they are needed but lacking.

1. Identify the main sources of delay and hence the opportunities for improvement.

The identified sixty and odd sources of delay within and between acquisition, processing, and interpretation are shared with the companies and service providers operating in India. As companies were spending valuable time and resources on data validation and manipulation tasks, a need was felt to standardize work practices to ensure availability of correct data readily for the different G&G applications. An Assessment Work Group was formed as the initial unit of the Geophysics Special Interest Group (SIG) under Energistics, with exploration and production companies and service providers active in India who added to and validated the opportunities.

2. Analyze and rank the opportunities.

The opportunities were assessed in terms of the size of the delays incurred while correcting deficiencies in data during each of the activities, the number of subsequent exploration and production activities potentially impacted by deficiencies in results from preceding geophysical work processes, and the ease of remediating the cause of each delay. It became apparent that positioning and data management should be treated as distinct work processes. Based on the feedback for the questionnaire filled in by the geoscientists who are active in their respective fields of

Acquisition, Processing and Interpretation from different companies, the average delays were worked out. Table 1 shows the estimated average typical delays in hours or days caused by data problems in each of the activities, assuming a survey size of 2000 line-km of 2-D survey or a 200km² of land 3-D survey. The typical cumulative delay is 83 work days when multiple problems occur in the same project. Therefore, the overall project/business decision will be delayed by nearly four calendar months assuming 22 work days per month. The maximum and minimum typical delays were approximately twice and half of the average figures. Note that these delays are base cases. If the deficiencies are not discovered until several work processes subsequently, then one or several processes may have to be repeated, thereby incurring further delay to the ability to make decisions such as acreage acquisition or drilling locations with minimal risk and uncertainty.

Geophysical (Seismic) Activity	Number of Opportunities	Cumulative average delays (days)	Percentage of Total Delay (%)
Acquisition	26	32	38.6
Positioning	14	19	22.9
Processing	11	6	7.2
Interpretation	4	8	9.6
Data Management	12	18	21.7
Total	67	83	100.0

Table 1. Typical delays arising from data problems in various geophysical activities.

The size of the tasks of specifying improvements is expressed on a scale of 1 to 10 and uses a method from Agile software engineering which is particularly appropriate where the ultimate nature of the task is not well understood at the outset (Cohn, 2006, pp 35 – 41). The results of these analyses are summarized below and described in detail in Maton and Doniger (2008).



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	Impact	Impact - Days lost			Effort
		Number of impacted geophysics processes	Min	Av	
Geophysical activity					Specification of Improvements: 'Task size'
Acquisition	3	17	31.5	49	2
Positioning	3	6.5	19	38	2
Processing	2	3.5	6	9	2
Interpretation	1	6	8	12	4
Data Management	3	8.5	18	26	2
Total (for days lost)		41.5	82.5	134	

Table 2: Impact (number of processes and typical delays) and Effort (to specify improvements)

3. Report on the assessment of the opportunities, and outline the needed improvements.

The geophysics assessment report by Maton and Doniger (2008) contains an outline of the improvements needed to reduce delays in the geophysics information cycle time. The improvements are of three kinds: new or enhanced standards for exchange of data, better use of existing standards, and improved work practices.

4. On-going selection, development and deployment of improved work practices and data standards.

Four guiding principles are proposed for the improved work practices and data standards:

- Define roles and responsibilities for both the data themselves, and the work processes of using and managing the data. These should apply orthogonally on organizational and technical discipline lines. For example, data should be owned at business unit level, but responsibility for geophysics work processes, training, etc. should be at corporate level.
- Define and apply appropriate procedures for the entire life cycle of the data. Requirements exist and should be met during initial acquisition that will sustain the usefulness and value of the data subsequently.
- Use available, practical data standards, be they global, regional, or at any appropriate level.
- Assign sufficient resources to manage the data assets effectively.

Both data standards and improved work practices will have two stages: enablement and subsequent routine application. Recent team collaboration has identified the following areas for prioritized development and usage:

- Metadata standards for inputs and results of interpretation and for geophysical data management generally;
- Naming conventions and standards for seismic surveys, lines and datasets;
- Velocity exchange format standard;
- Technical Agreements/Profiles: work practice of improved specification of data requirements in acquisition and processing service agreements, making better use of existing standards;
- Data Compression: guidelines for suitability of compression techniques for storing, imaging and network transmission;
- Integration of Position & Seismic data: early adoption and sharing of experience with SEG D revision 3 and related exchange formats.

Acquisition and Positioning. Table 1 shows acquisition and positioning together typically accounting for over 60% of the delays. The main opportunity is the integration of the seismic trace data with position data, compounded by the iterative nature of this process. The SEG D revision 3 pre-stack data exchange format is expected to be released in 2009: it enables fully specified position data to be integrated in trace headers, as well as inclusion of position data files, observers' logs and other supporting data in trailer blocks. Careful and consistent use of this standard should alleviate many of the identified issues.

AUTOMATIC RECORDING

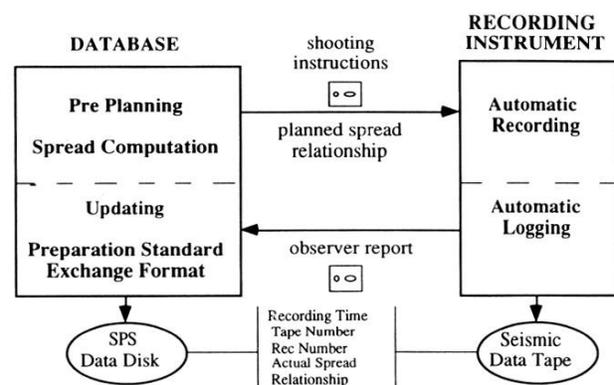


Fig.4 Envisaged automatic recording of all field data with seismic data taken from SEG booklet



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Similarly, many seismic equipment parameters, responses and settings may optionally be captured in SEG D rev 3, potentially satisfying many other identified data issues. Many of the seismic acquisition related opportunities identified are already envisaged in SEG-D revision 3 through automated recording of all field data including observer (meta) data as given in Fig 4. The definition of observer report is very wide and the intention is that all reports will be transported digitally along with the seismic records.

Towards maintaining standards by a single entity, the Society of Exploration Geophysicists has transferred custodianship of its positioning data exchange formats (SEG-P) to the International Association of Oil & Gas Producers (OGP). OGP sought public comment to inform its revision processes for two of these standards. Positioning standards revisions are needed to address wireless, seabed/ocean-bottom, and multisource technologies also. The new SEG-P standards will be based on XML similar to WITSML. SEG will focus on revisions to seismic data exchange formats and the Geophysics community should extend support for early implementation and adhere to those standards.

Processing. Seven of the eleven opportunities under processing relate to exchange formats for seismic velocity data. The issue is the number (at least 35) of existing so called 'standard' formats, and the costs of time and efforts to handle them even though it may be a simple task. A sub-team has designed a schema for transfer of velocity data. The schema enables capture of data derived from seismic or in-well measurements, for which positions, kinds of velocity, datum corrections, wave types and polarizations, and units of measure are explicitly modeled, along with optional interpretive or geologic correlations. The schema will be implemented in XML. The processing history and metadata associated with each of the processed versions needs to be properly captured.

Interpretation. The opportunities in interpretation include metadata for the inputs to and results of the interpretation, and the need for interoperability between different vendor interpretation systems. Presently, most of the interpretation software vendors are addressing the storage and exchange of metadata in their own way and can import RESCUE data files. RESCUE compliant software provides transfer of 3D geological models between several vendor software

packages and upscaling of these models to major reservoir simulator systems.

Current plans are for a Geophysics SIG team to define requirements for the metadata for interpreted seismic and geological features (horizons, faults, formations, facies, unconformities, etc.), and input, output data and software identities, and related information. The team will collaborate on this specification with the RESQML SIG which is addressing reservoir characterization and simulation modeling data standards, in which similar data are created and used. Commonalities clearly exist and should be leveraged.

Conclusions

To streamline the data storage in a standard way, the geophysical communities customized existing formats to meet their internal needs and there are too many standards and large data exists in those customized formats. As the internal standards between companies differ, data exchanged is incomplete and sometimes inconsistent. Several authors have highlighted the problems of not adhering to standards and the consequent loss of time and money. Now it is recognized that instead of insisting on the universally standard format, it is time to focus on how to describe the data in the customized files. Here comes XML that is a cross-platform, software and hardware independent tool for transmitting information in systematically accurate and consistent way. Therefore, except for the main seismic trace data in SEG formats, all the rest of the data is now considered to be exchanged through XML based standards.

Towards standardization of E&P data, especially seismic related data, oil companies and service providers in India have identified sixty-seven problem areas in seismic acquisition, positioning, processing, interpretation and data management. These have been documented and analyzed, and a set of recommendations on improved work practices, including better use of existing, imminent and proposed data standards. Six related recommendations have been selected for development, deployment and use of existing, imminent and new standards and related work practices. Further progress on the work items identified depends upon continuing participation, support, and resources for the Geophysics SIG.



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