Application of interpolation to regional 2D data to produce 500,000 km^2 of 3D data to visualise exploration plays along the East Coast of India.

Summary

In 2020, we were set the ambitious objective of processing 270,000 sail line km of regional 2D lines to create a 2D^{cubed} dataset (*Whiteside et al, 2013 & O'Keefe 2017*) which would results in a 3D regional screening volume totaling in excess of 550,000 km^2.

This involved the matching and merging of more than 4000 lines of 2D seismic, each with numerous intersections, all from various vintages of acquisition and processing to create a single contiguous dataset that is designed for regional screening.

To add further complexity, this data was to be processed within 1 year, including accessing the data from the government database to delivery of final products. The data was processed in Delhi, India with supervision from the UK, during a time when COViD was rife.

This paper will discuss the many challenges in creating and processing large volumes of data and the steps associated with generating a 3D volume over a vast area.

Geological setting

The passive margin of East India developed after India–Antarctica break-up circa 136-132 Ma. The Basement rock consists of Archean and Proterozoic mobile belts. An interplay of orthogonal, oblique and strike slip segments are present all along passive margin. Crustal architecture shows both non-volcanic and volcanic rifted margin.

East Coast offshore plays exist at most levels from initiation of passive margin rifting in the early Jurassic through to Pleistocene channel sands from the Bengal Fan. As a result of the numerous plays, there is a considerable amount of 2D seismic data available along the East Coast of India covering the Bengal, Mahanadi, Krishna-Godavari, Palar, Cauvery and Mannar Basins. These have been acquired over several decades and were accessed via the National Data Repository (NDR) department of Directorate General of Hydrocarbons (DGH). Despite wide 2D coverage, 3D coverage is focused on a few areas and limits where robust exploration can be executed. Having a regional 3D dataset significantly aides prospect identification and evaluation on a significantly larger area.

Challenges

The first step was to gain access to the DGH database containing all released 2D seismic data and determine what we could use to input to this project. This involved reviewing significant line listings to ensure not only that they satisfied coverage but were also suitable as input to the 2D^{cubed} process. This led to the identification of over 4500 lines of seismic. The transcription of these lines was then performed, which due to the various media types and age of data, was not always a trivial task.

All data were processed in country with support from a variety of global geophysicists. Local processing expertise were trained in both the software and the technology. Remote supervision, guidance and QC was performed from the UK.

Whilst the overall CPU demand was to be fairly low relative to modern 3D processing flows, the processing does contain intense periods of CPU usage and thus the processing was executed on a cloud environment hosted in India. This allowed the team to access over 1000 nodes on demand, which would be necessary not only for the volume of preprocessing, but to also enable the multi-CPU processes of interpolation and migration to be run in an efficient manner.

Data processing

The scope of the processing was to take previously processed 2D final stacks and create a cube using 2D^{cubed} technology. The input data consisted of over 4500 lines of seismic data made up from over 76 surveys and totaled more than

270,000 sail line km of 2D, which is shown in Figure 1.

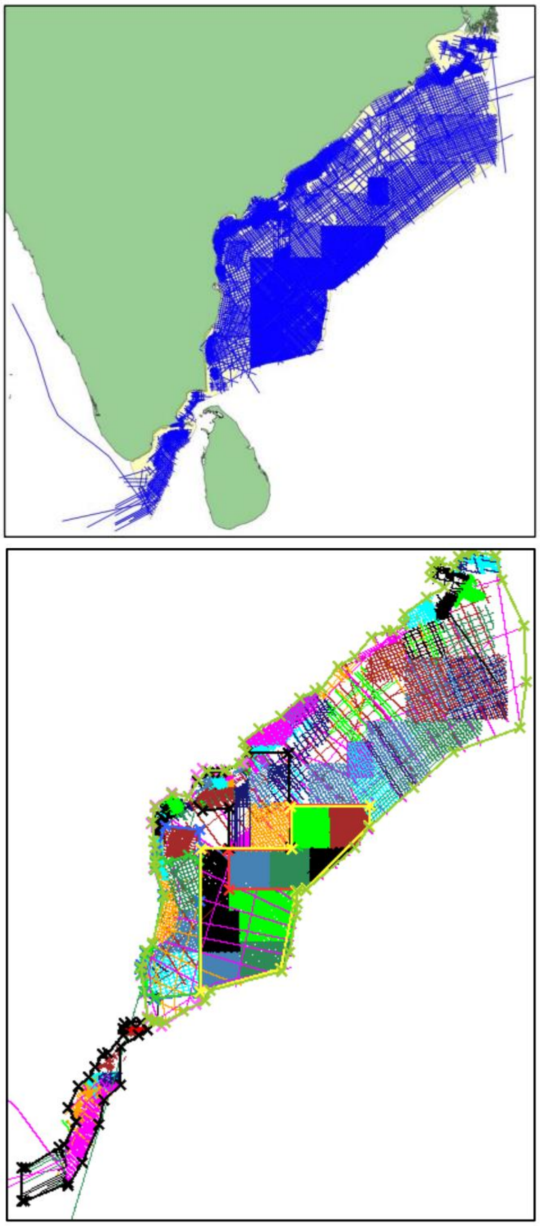

Figure 1 *– Map of input data geographically located (left) and colour coded by survey (right)*

The input data were of different processing vintages, standards and quality. The vintages varied from short offset data acquired and processed in late 1990's to mid 2010's modern acquisition. Equally varied was the processing sequence, some data were DMO with post stack time migration, most were pre-stack time migrated, whilst others had deghosting and/or depth migration.

Significant time was spend understanding all the challenges in the data: wash out's, extreme variations in signal to noise, missing navigation, odd geometry, etc. Some datasets arrived organized by block owner and in some cases, lines needed to be spliced together to form contiguous lines, but due to different naming conventions, and numbering systems, identifying these and the ranges on which to merge were not straightforward. A number of lines were determined to be duplicates, i.e. different versions of the same processing, others were clearly the same data but with different co-ordinates. All these issues had to be resolved prior to the 2D^{cubed} process.

2D^{cubed} processing

The data were provisionally matched via a single amplitude scalar, gain function and time shift per survey. The data were then demigrated and matching of both spectral and decay curves was performed. Next, the key step of intersection matching is run on all lines to ensure there are no busts in the data which would result in poor interpolation. A 2D layer model is then generated for each line which is later converted to a 3D model and used as a priori information in the interpolation of the 2D data to a 3D seismic volume, the interpolated data is then imaged with a 3D Kirchhoff migration (figure 2).

Given the differences in quality of the input data, careful QC was performed before and after global matching. This included comparisons within surveys and the generation of regional lines that were QC'd throughout the processing, an example of which is shown in figure 3.

The migration velocities came from the existing long offset regional (SPAN) lines and although at times, the line spacing exceeded 75km, this was sufficient for the round trip demigration and remigration.

In order to extract maximum value from the processing and to resolve challenges, the data were processed in an iterative manner such that learnings could be incorporated quickly and influence the final products.

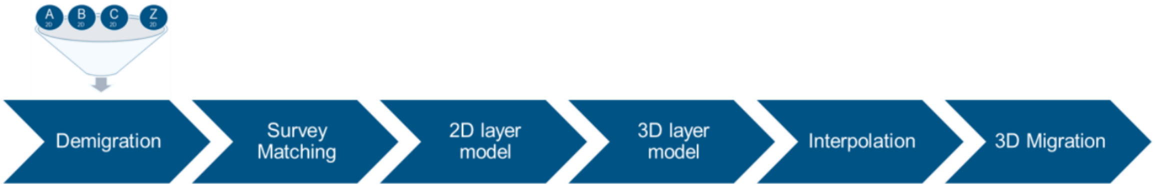

***Figure 2**– Overview of $2D^{cubed}$ processing flow*

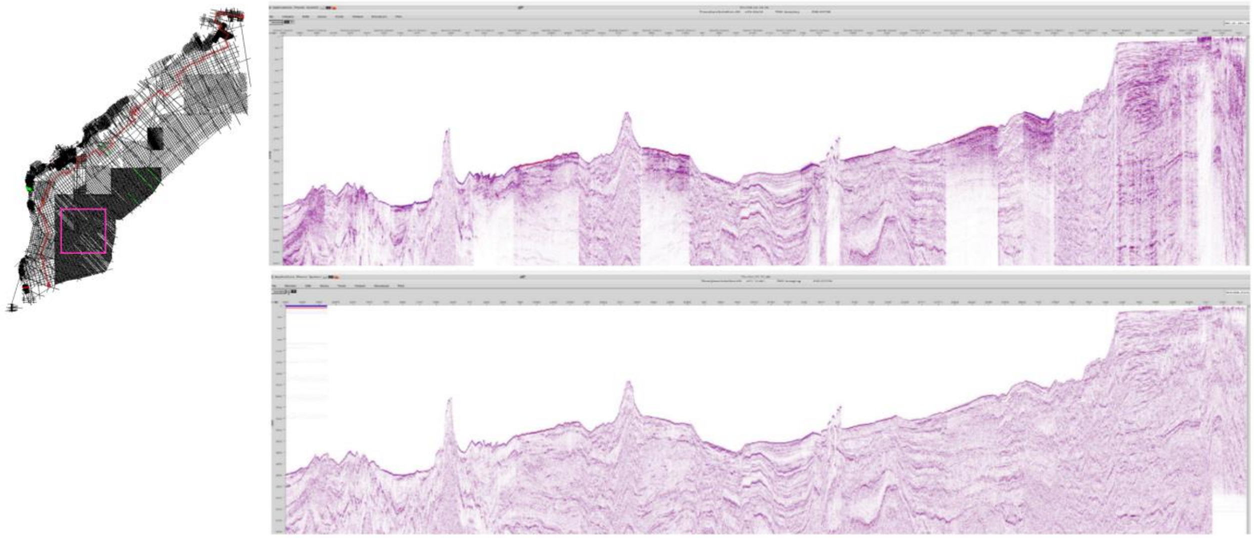

***Figure 3**– Data before and after initial amplitude matching along a fence line that traverses many seismic lines*

The first iteration was used to establish the flow but had several non-optimal parameters. It was focused on the dense area of 2D coverage in the deepwater area known as the EDN area, which covers the Cauvrey and Krishna-Godavari Basins. A key learning from this step, was to process at 4ms, as degrading the data to 8ms increased the possibility of cycle skipping in the matching phase stage.

Updated parameters were used in a 2nd iteration when more data were available and the area was expanded to 420,000 km^2, This iteration had a variety of line spacings and tests were performed to understand the limit of the interpolation. This second iteration was available within 3 months of last data drop and covered the entire area except for the very near shore areas as these harder to match and required significant editing due to data quality concerns. The 2nd iteration generated a significant uplift in continuity but some further improvements in the layer modelling were needed and subsequently applied to the final version.

The final product covered the full 570,000km^2 and was delivered within 6 months of last data. An example of the quality of this product is shown in figure 4 which overlays the 2D lines on a timeslice from the final volume. This clearly shows geological trends that can be tracked from surveys of differing quality and spacings.

Conclusions

The final product yields a 3D cube which is suitable for regional exploration screening and further seismic acquisition survey design studies. Some holes remain in the final 3D data as the 2D coverage was not sufficient to reliably fill these (line spacings in excess of 15 km) but this does not detract from the advantages that such a dataset offers the user.

The comparison of regional lines at the matching phase showed a significant uplift both in terms of amplitude scales, but also intersection matching. However, the most powerful demonstration of the success of the process is a comparison of a timeslice comparing the original 2D points and the interpolated result which is shown in figure 4.

We have demonstrated that it is possible to set up an in-country processing center within a short period of time, bring local staff up to speed and deliver a product that will allow more informed regional screening.

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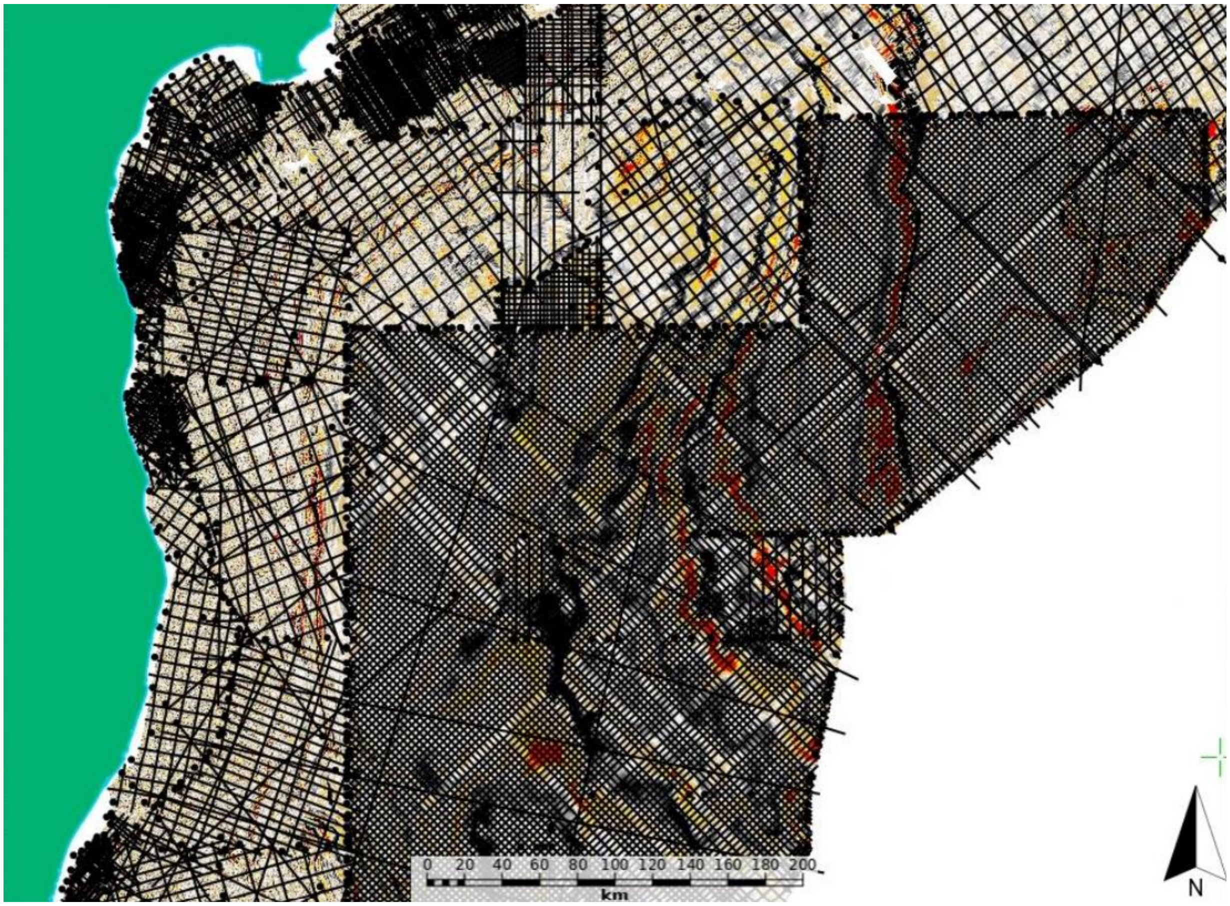

Figure 4 – *input 2D lines overlying a timeslice from the final 3D volume*

References

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