The development and applicability of structurally conformable 2D to 3D interpolation

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Summary

The oil and gas industry is experiencing a period of change and economic uncertainty. Its continued viability is dependent on being able to make the most of the resources at its disposal. Structurally conformable 2D to 3D interpolation is a technology that maximizes the potential of existing 2D data and minimizes the financial risks associated with acquiring new 3D data. Two case studies are outlined. Case study 1 is offshore North East Greenland, an area consisting of complex, terminating unconformities and which is inaccessible to 3D streamers, which has been mapped in 3D using SCI. Case study 2 is offshore Mid Norway, where a vast library of vintage 2D and 3D datasets have been utilized to create one continuous 3D volume, again with SCI. These case studies demonstrate the versatility and the validity of SCI technology.

Introduction

In these times of change and economic instability within the oil and gas industry, it is vital that the industry look for ways to exploit the potential of data already acquired and to precisely target new acquisition to gain maximum benefit from minimum outlay. To these ends, TGS has developed a structurally conformable 2D to 3D interpolation engine (otherwise known as 2D$^{\text{cubed}}$). This interpolation engine generates 3D geological horizons from 2D dip fields and layer models allowing distances of kilometers to be bridged, something that would not be possible with conventional interpolation techniques (Whiteside et al, 2013).

Structurally conformable interpolation (SCI) is more economically frugal than conventional 3D acquisition and can be applied to existing 2D datasets. These datasets may be very different in character and/or of a range of vintages as the SCI process has the ability to match these datasets in frequency content, amplitude, phase and time, allowing different surveys to be interpreted as one. In the summing of many surveys as part of the volume generation process, some of the random noise that may be present on older surveys is stacked out, further enhancing the value of existing datasets. Conventional 3D data can then be matched and merged into the larger volume, creating one continuous volume and fully utilizing all the information

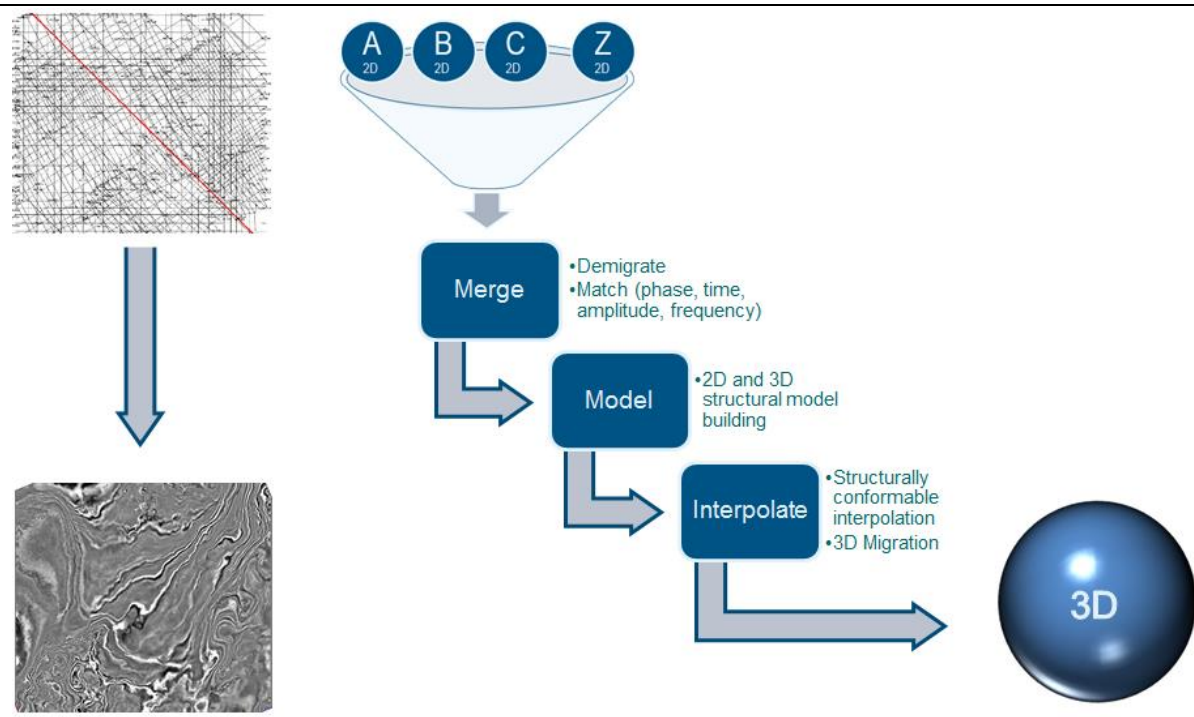

Figure 1: Schematic of the structurally conformable interpolation process.

available in an area to its full potential.

In some parts of the world, it is not possible to acquire streamer 3D, due, for example, to risks related to ice coverage. Although it may be possible to implement node technology in these areas, this is a large financial risk. By first generating an SCI volume, surveys could be more precisely targeted and the risks minimized. This is true of any planned 3D survey – by first analyzing an SCI volume, conventional 3D acquisition can be accurately directed, reducing initial outlay and augmenting returns on investments.

Method

Figure 1 shows a simplified schematic of the SCI process. This process can be broken down into three basic stages – merge, model, interpolate – that will be described briefly here.

Demigrated data is matched and merged. This is a two-pass process - global adjustments are made to the phase, time and frequency spectra of each survey, then windowed adjustments to time and overall amplitude are applied at each intersection and tapered off away from that intersection so that individual geological horizons tie.

After the data has been tied, it is ready to be analyzed for apparent dips. These dips are used to guide the model layers around the input grid. Layer numbers must be consistent between 2D lines and tie at the intersections. These dips and 2D layers are then projected into the spaces in between and used to estimate the position of the 3D geological layer model using a least squares algorithm.

The 3D geological time model is used to guide the seismic interpolation. 2D input amplitudes from around the 3D output point (x,y,t) are drawn together along the 3D layers to form a gather. This gather is processed to form the output sample (Whiteside et al., 2013). The 3D volume can then be subjected to a 3D migration, correctly positioning events, allowing accurate and efficient geological interpretation.

Case Study 1: North East Greenland

North East Greenland is inaccessible to 3D streamer vessels. However, it does have reasonably good 2D coverage (see Figure 2). An opportunity was seen here to create a 3D volume that would aid in the interpretation of some very complex geologies. This volume can also be used as a planning tool for any future node based 3D exploration.

This area presented new challenges for the SCI technology as it contained many unconformities with terminating horizons i.e., non-continuous layers. This challenge was met by approaching the 2D modelling exercise as a series of overlapping blocks, allowing layers to remain continuous in the virtual space surrounding the blocks. A 3D image was achieved that enabled the enhanced visualization of salt dome structures and facilitated facies analysis in the area, as well as improving the apparent positioning of observed events with the 3D migration (Figure 3).

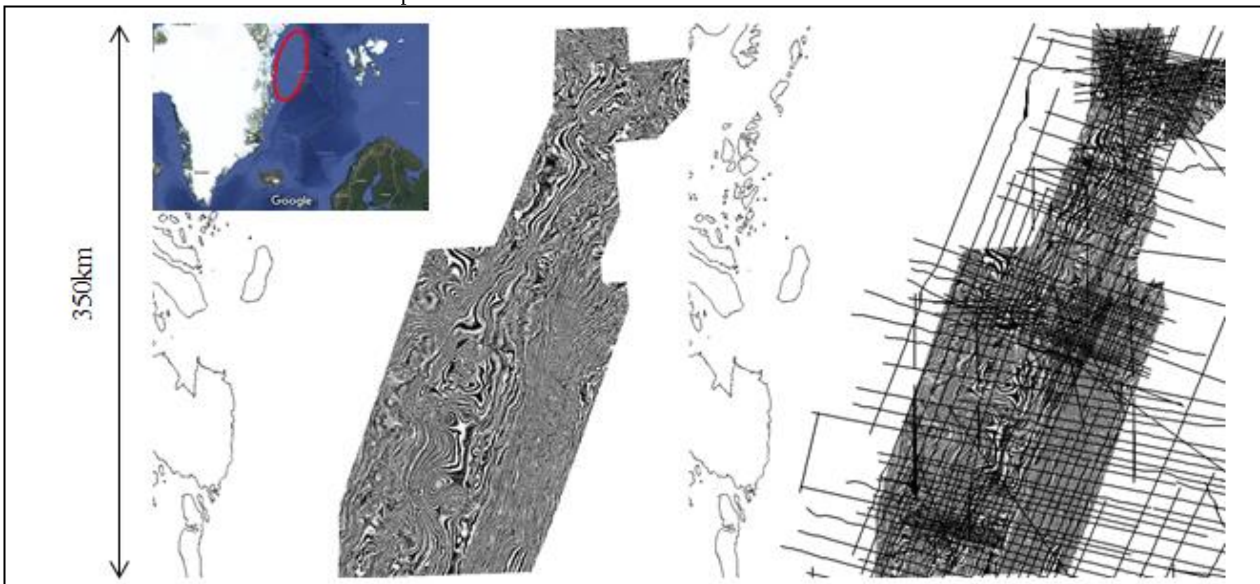

Figure 2: North East Greenland SCI volume, without (left) and with (right) 2D coverage mapped.

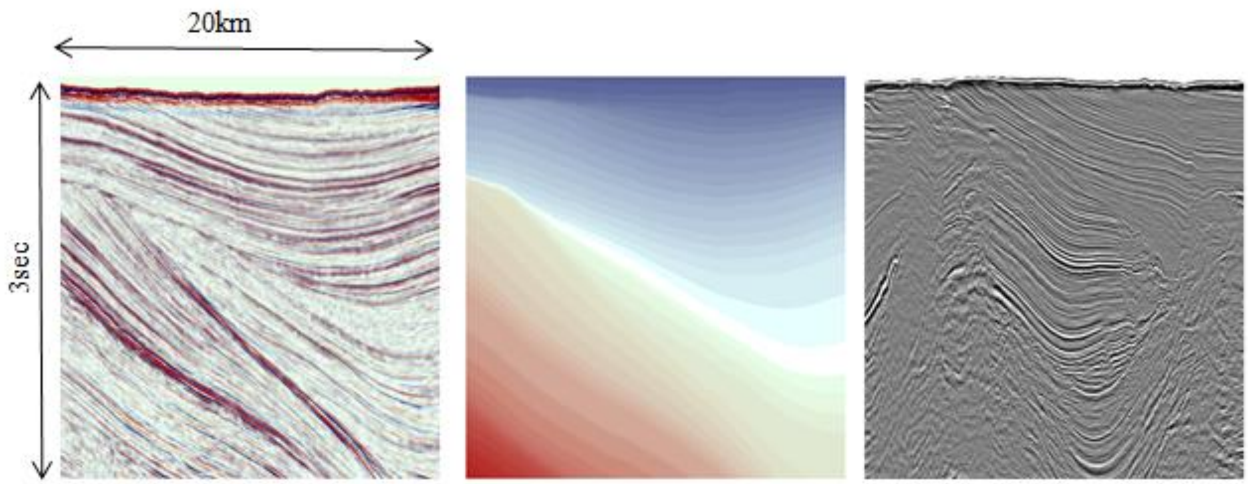

Figure 3: Complex 2D geology (left), layer model (center), SCI generated 3D terminating structure (right).

Case Study 2: Mid Norway

The opportunity was seen to utilize one of the other big advantages of the SCI process, namely its applicability to large areas of 2D due its ability to match and merge disparate 2D datasets (see Figure 4) and, therefore, being able to generate a far larger 3D volume than would be possible with conventional shooting.

Using the SCI technology, approximately 250,000 km of 2D data are used to generate approximately 200,000 km^2 of 3D. The input consisted of 85,000 km of long offset data, the remaining 165,000 km being vintage short offset data. Including the short offset data improved the density of the coverage and thereby the resolution of the 3D image (only events larger than the distance between 2D lines can be reliably modelled). As a final touch, all the existing released 3D data has been matched and merged with the SCI volume, generating the most comprehensive, continuous 3D image possible in the Norwegian Sea. For the purposes of comparison, an example of a matched conventional 3D survey and an equivalent SCI generated volume are show in Figure 5. The same method of survey matching was used on the 3D data as on the 2D data.

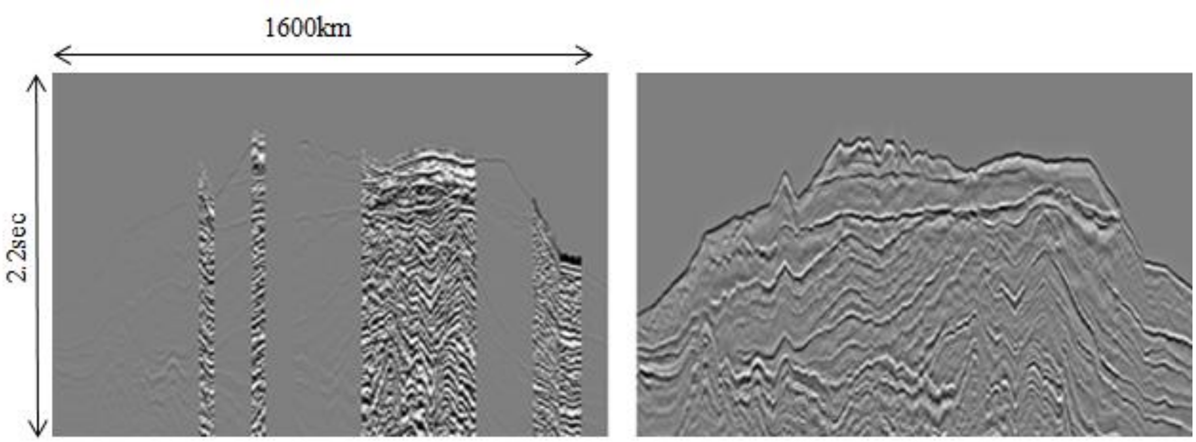

Figure 4: Before (left) and after (right) survey matching. Note the broadband appearance of the matched data compared to the unmatched.

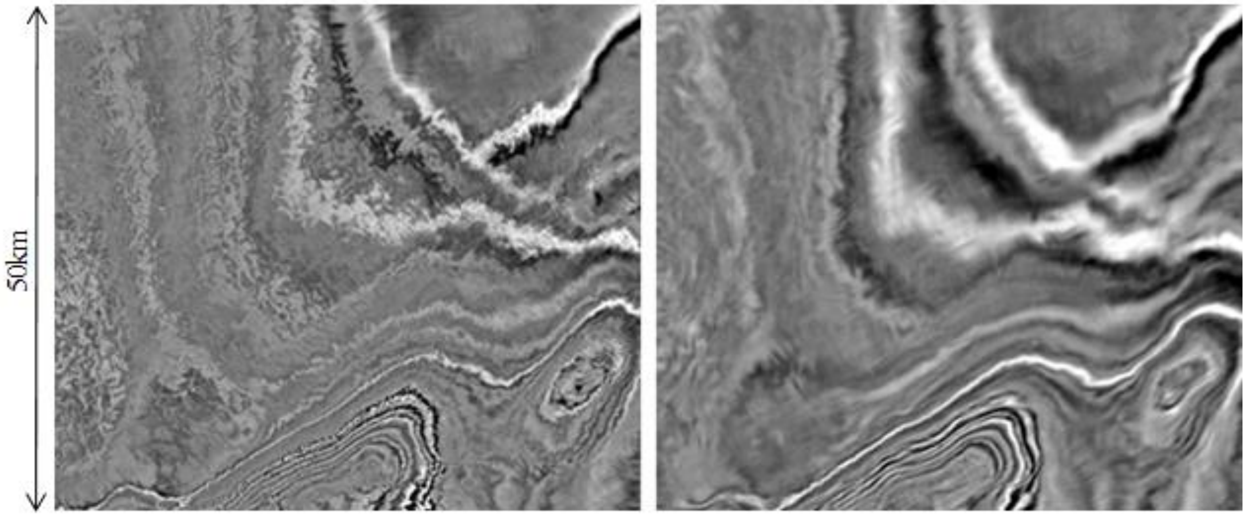

Figure 5: The left hand side of the image shows a conventional 3D volume; the right hand side shows one generated by structurally conformable interpolation.

Conclusions

The oil and gas industry is experiencing a period of change and economic uncertainty. Its continued viability is dependent on being able to make the most of the resources at its disposal. Structurally conformable 2D to 3D interpolation is a technology that maximizes the potential of existing 2D data and minimizes the financial risks associated with acquiring new 3D data. The process can match and merge disparate 2D datasets; allows 2D events to be more correctly positioned by 3D migration; speeds up and enhances interpretation; is highly economical compared to conventional 3D; can be used as a planning tool for new 3D acquisition and be applied in areas inaccessible to 3D streamers. These attributes make SCI an invaluable tool in preparing for, and creating, future opportunities.

EDITED REFERENCES

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REFERENCES

Whiteside, W., B. Wang, H. Bondeson, and Z. Li, 2013, 3D imaging from 2D seismic data, an enhanced methodology: 83rd Annual International Meeting, SEG, Expanded Abstracts, 3618–3622, http://dx.doi.org/10.1190/segam2013-1148.1.