Data processing steps forward

The marine seismic acquisition market may soon be hit by oil company exploration budget cuts, but the continuing demand for data processing may provide a modest lifeline to some companies. **Andrew McBarnet** explains.

Rarely does the processing of seismic data make any kind of headline. In one respect it's not surprising. This kind of science and technology is not a conversation stopper, although it probably should be. The reality is that the math, computing and geophysics involved are way too complex for most people in the E&P community to follow in any detail, never mind anyone else.

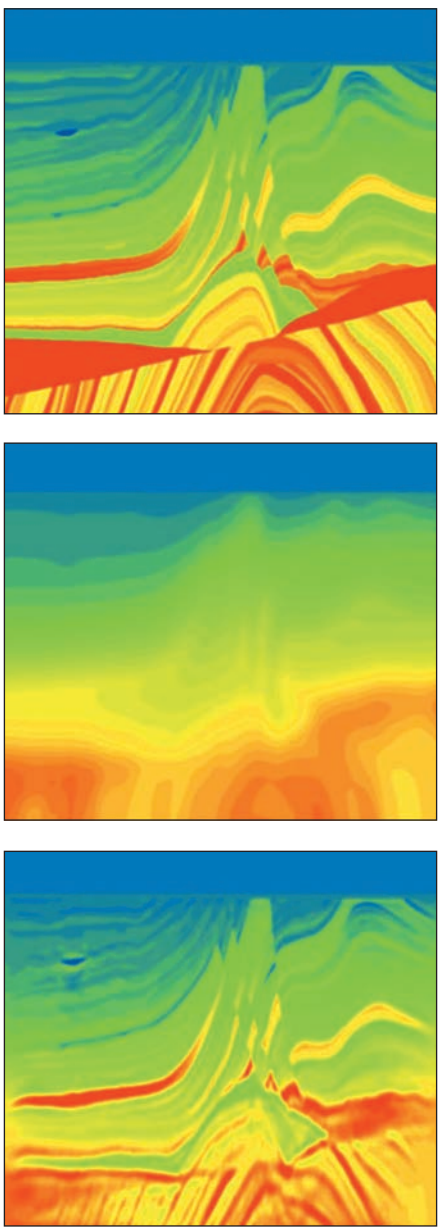
Yet, the notable advances in marine seismic acquisition over the last few decades, for example 3D, 4D and 4C ocean bottom seismic owe a debt to the ability of data processing brains in academia and the industry who have been able to figure out how to make sense of recorded seismic reflections and turn them into an interpretable form for modelling the subsurface. There is a pantheon of names such as Jon Claerbout, AJ Berkhout, Oz Yilmaz, Ken Larner, Leon Thomsen, Sven Treitel, Bill French, and many others (they know who they are) who have made major contributions to the science in the modern era. Nowadays the boundary between processing and interpretation is increasingly blurred, and indeed seismic survey acquisition planning must also take account of subsequent processing options.

Data processing probably constitutes 10-15% of the value of any seismic survey project, so is an important segment of business, more so right now. The anchor is clearly beginning to drag on the marine seismic acquisition survey market with contractors lowering their expectations for new business once the current backlog for their vessels has been fulfilled. But this turn of events may not make a commensurate dent in the demand for processing of seismic data, for a while at least. The processing of survey data is a time-consuming, computer intensive exercise. Although onboard data processing will provide oil companies with a first impression of the quality of data likely to be available from a marine survey, it's probably around six months after the survey before fully interpretable data is available.

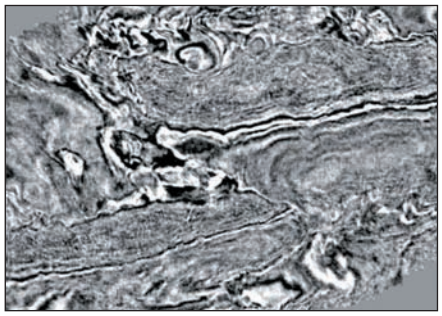
There is a great deal involved in the processing sequence. Very simplistically, bad seismic traces, due to noise or any fault in the recording equipment, have to be edited out. The traces are then reordered so that each gather of traces belongs to what is referred to as a common reflection point. Non-reflected arrivals, such as surface waves and direct arrivals not caused by the seismic energy bouncing back from reflectors in the subsurface, have to be removed by digital filtering and/or muting (zeroing of the data). Correction has to be made for the time the reflected ray spends travelling laterally, so that the reflected arrivals line-up in the gathers. The traces within each gather are then added to produce a single output trace. This stacking process helps to cancel out random noise and reinforce the reflected signals. The waveform is then shrunk by frequency filtering or deconvolution to improve the resolution.

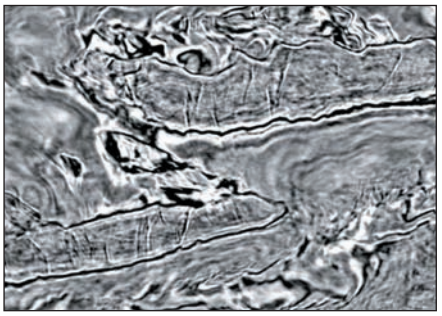
It is common now for processors to apply a prestack migration process which simultaneously improves both the lateral resolution and the signal-to-noise quality of the seismic image. This is because all the data contained in the individual traces are available during imaging, whereas stacking can destroy information that only appears at certain offsets. Prestack migration thereby replaces the functions of both stacking and poststack migration but for 3D data sets the increase in data size makes enormous demands on computer speed and memory.

A distinction has to be made between time and depth processing. Time migration assumes that the variations in velocity are a function of depth alone. When large lateral velocity variations occur, whether they are within a layer or whether they involve layer boundaries, time migration may result in significant mispositioning of the reflectors. The advantage of time migration lies in the fact that the migration algorithms are relatively simple and thus require less



WesternGeco velocity modelling.





*Continuity and reduced noise and much improved fault imaging (*right*) achieved by CGGVeritas controlled beam image, compared with conventional Kirchoff method (*left*).*

computer performance and memory, but more importantly, due to its simplistic assumptions, time migration does not require a laborious velocity model building procedure. However, where structures are complex and large variations in lateral velocity occur, these simplifying assumptions are no longer acceptable, and depth migration is necessary.

This is why prestack depth migration has gained increased currency in recent years, for example in imaging subsalt in the Gulf of Mexico and elsewhere. Depth migration uses an input velocity model to calculate ray refractions as part of building the subsurface image. The quality of the depth migration is sensitive to the accuracy of the velocity model that is employed. Because defining a depth velocity model is inherently an interpretative function, depth migration does to a greater extent blur the division between processing and interpretation.

Lead roles

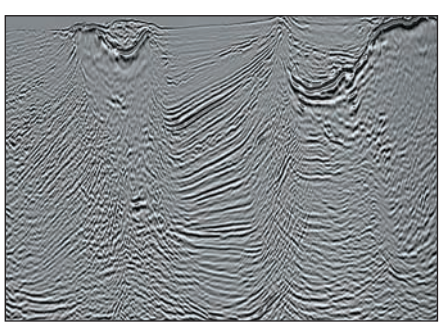
Historically, it has proved hard for any of the service companies to establish a significant technology lead in the processing side of the business even though R&D is intensive. Six months to a maximum of a couple of years is about the best a company can expect in terms of commercial advantage. The reality seems that as soon as a new algorithm is created, the competition comes up with something similar. As one insider puts it, 'there can be no secrets'. If a company has an innovation, the quickest way of spreading the word is via industry conferences and symposia, and then it is only a matter of time before approximations of the same procedure emerge. Patents on the whole have not provided much protection. One exception was Amoco's defence of its Coherency Cube breakthrough in the 1990s, notably from an alleged infringement by Landmark Graphics. It is also often said that oil companies as clients have little interest in an effective processing method remaining proprietary to one contractor because it gives them no leverage with regard to price or service. When one provider offers them some new piece of wizardry, an oil company can in the interest of good business ask another party whether it can do something similar, which will by necessity involve divulging the detail of the new technique.

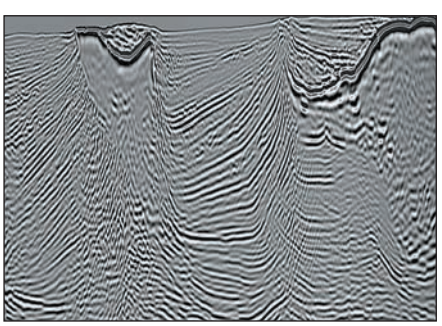
In a sense suppliers are forever fighting an uphill battle to prevent the processing side of the seismic business becoming commoditised to the extent that oil companies simply shop around for the best deal. The market is of course determined to an extent by the nature of the acquisition survey data. In the 1990s one of the consequences of the 3D seismic revolution was the impact on processing. There was an explosion in the volume of data to be handled putting pressure on the computer power of the day, both hardware and software. At that time companies with the resources to invest in the necessary computer technology at dedicated centres and on board vessels headed the field. Today, the scalable solutions possible using Linux clusters mean that compute power is less critical: to take on an unusually large job, a small company can in theory simply add clusters on the fly.

However, it is still true that geophysicists continue to conceive of treatments to extract more value from seismic data than even today's computers can manage. Prestack depth migration was certainly only possible with the emergence of the supercomputer. Some of the newer approaches in seismic data processing which stretch existing computer power had been discussed in theory for decades. It is as though geophysicists have a wish list frustrated by the lack of computer resources.

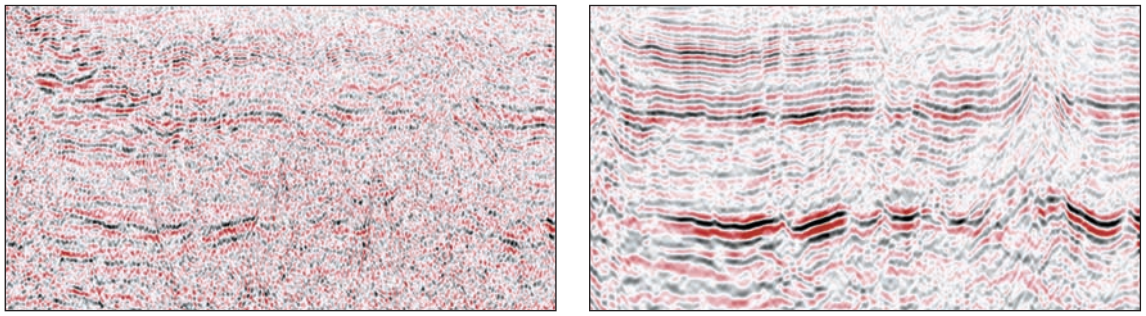
Reverse time migration (RTM) is a case in point. It is a technique being enthusiastically embraced by, among others, GXT, which built its reputation as a specialist in prestack depth migration before being taken over by ION Geophysical in 2004. Last year it announced the extending of its use of RTM to meet the requirements of wide-azimuth seismic along with a reduction in the turnaround time for the service. However, ION acknowledges that RTM was not a new concept but that its application had been limited by the ability to execute the RTM algorithms cost effectively and in a timely manner. RTM's value lies in enabling the imaging of complicated subsurface geological structures such as those encountered in the deepwater subsalt basins of the Gulf of Mexico. According to ION, the RTM method works by running the seismic wave equation forward in time for the source and backwards in time for the receiver. In so doing it overcomes the compromising assumptions of other depth migration methods by properly propagating acoustic wave fields through the most complex velocity regimes, including subsalt, for structures having dips in excess of 900, and in the presence of reflection boundaries that may generate internal multiples.

By way of contrast, prestack beam migration based on a system first tried in the 1930s was introduced commercially by AGS, a small Houston-based processing house, now part of Petroleum Geo-





*PGS prestack depth migration: one-wave equation (*left*), reverse time migration (*right*).*



*Comparison of vintage 2000 original data (*left*) processing results with Geotrace 2009 reprocessing (*right*).*

Services (PGS), which wanted to get into 3D depth migration without access to the resources typical of its larger rivals. Now the technique is recognised by the larger contractors as a significant addition to the processing toolbox for complex surveys such as wide-azimuth data acquisition. CGGVeritas offers a version called controlled beam migration specifically targeted at imaging steeply dipping events and enhancing the signal-to-noise ratio of marine and land data sets.

Another method in a similar category would be 3D SRME (surface-related multiple elimination), offered by a number of companies. The removal of complex free-surface multiples from seismic reflection data has been considered an essential processing step before the application of prestack migration, but was not realisable until relatively recently.

Vertical integration

In practice the market for marine seismic data processing is not a level playing field. This is mainly because the big three players – WesternGeco, CGGVeritas and PGS – between them dominate marine acquisition survey market and it is in their interest to convince their clients that they should not only acquire but also process the data from the surveys they have been commissioned to undertake. In most cases the arrangement will suit the oil company client as the survey becomes an integrated package, and there is often a good argument for the same contractor to be able to plan the acquisition with particular processing parameters in mind. In the case of WesternGeco when using its proprietary Q-Marine technology, it would be highly unlikely that an oil company could find a data processing alternative to the one offered by WesternGeco. The net result is that the bigger companies end up processing a very high percentage of the data they acquire. In addition to the convenience, they also have a global network of processing centres so they can serve oil companies all over the world, often uploading data from satellite offices to be worked on at larger regional centres. Of the major marine seismic acquisition contractors, only Fugro does not support a big data processing capacity.

It follows that any company with the resources will process the data from their own multi-client surveys.

TGS-Nopec, for example, has over the years proven itself to be far and away the most successful company in the multi-client business. It has made a number of purchases over the years to build a processing business on the back of its acquisition activity starting with UK-based BiPS (Bedford Interactive Processing Services) in 1998, followed in 2004 by NuTeC, a prestack depth migration specialist, and most recently in 2007 by Parallel Data Systems (PDS). The enhanced processing capacity enables TGS-Nopec to add processed value to the multi-client data which it acquires in its own right and allows it also to compete for outside work.

On a much more modest scale Spectrum, recently spun off from its Norwegian parent GGS, has its long established processing capability to serve the recently upgraded GGS Atlantic 2D vessel, currently working offshore India.

In a sense GXT has gone about things the other way around. Initially a processing operation, the company has initiated its own Span multi-client 2D data acquisition programmes in many of the hydrocarbon basins of the world, and more recently 3D wide-azimuth projects in the Gulf of Mexico. A main thrust of its marketing is that, along with other expertise from its parent ION, the survey comes as an 'integrated seismic solution' from pre-planning right through to sophisticated time and depth prestack depth migration of the acquired data set.

GXT's parent company has also sought the 'partnership' route to securing its business stream. For example, the Norwegian company Reservoir Exploration Technology (RXT), which specialises in ocean bed cable seismic, has exclusive use of ION's VectorSeis Ocean cable-based recording system. In what is a first for GXT, it has signed up with the Polarcus group of companies to provide seismic data processing services in an exclusive agreement which calls for GXT to provide hardware, software and geophysicists to support a seismic project's entire imaging lifecycle, from the vessel to an onshore data processing centre. The deal also makes sense to Polarcus, the company working with a Dubai-based shipbuilder to launch six towed streamer vessels. As a new entrant into a challenging market, outsourcing of data processing seems a logical choice. Whether the company can develop enough business is another matter.

In any event, cosy data processing arrangements don't always work out, as the US company Geotrace Technologies has found out. Until a month or two ago it had a very significant amount of secure work from its co-operation agreement with the aggressively expanding Norwegian marine geophysical services company Wavefield Inseis. The deal involved supply of full onboard and onshore data processing services with Geotrace onboard processing systems and personnel on all seven Wavefield vessels plus a dedicated processing centre in Oslo. Unfortunately for Geotrace, the successful purchase of Wavefield by CGGVeritas, arguably the number one processing company in the world, is likely to see its agreement given notice at the earliest opportunity.

This is obviously not a time to be losing data processing market share. Competition for the available marine seismic data processing jobs is likely to get fiercer with pressure on margins. In addition to the bigger names in processing, there are numerous smaller entities, often offering specialist services but equally hungry for work. But the consensus seems to be that the expected exploration budget cuts for 2009/10 which are bound to affect future marine seismic, may not have as much impact on the data processing side of the house. There is a healthy backlog of work arising from surveys currently underway or recently completed.

In addition, oil companies unwilling to initiate new seismic or drilling, may still feel inclined to spend some dollars on reprocessing their existing data, maybe more than usual. Reprocessing is an economic way to update data already in the bank using the latest methods in a rapidly evolving technology, and there's always a chance that the enhanced images may reveal fresh clues to finding extra reserves. OE