EXPERT ANSWERS

Coordinated by Satinder Chopra

The 'Expert Answers' column this month features answers to a set of questions that were forwarded to me by Doug Bogstie, CSEG President. These questions were sent to many geophysicists and responses were received very sportingly from Dave Monk (Apache), Mel Best (BEMEX Consulting), John Logel (Talisman), Arthur Cheng (Cambridge Geosciences), Jean-Michel Buchoud (Total) and Doug Pruden (Nose Creek Geophysical), who thus form the panel of experts answering them.

The order of the responses below is the order in which we received them. We thank the experts for sending in their responses.

Satinder Chopra

Questions

Q1. What exploration problems are we currently facing, or will face in the next 10 years that technology will help in solving?

Q2. Are technologies being developed that we need to keep our eyes open to or be involved in?

Q3. In your opinion, what technologies do we need to invest in that are not being developed today?

Q4. What needs to be done that would aid the development and implementation of such technologies – finance consortia/research organizations, attend conferences and courses or anything else?

Q1. Answer

The biggest problem facing us today is simply the rising costs of seismic data and rig rates. In some situations costs have escalated by close to an order of magnitude over the last 5 years. Even with sustained $60 oil, there are projects which are not happening because the cost benefit has been eroded. However, the seismic industry has a habit of dramatic correction for these type of problems, and I see a mid term softening of pricing when the marine vessel supply increases significantly in the next 24 months let alone 10 years. But can technology help in this case? I believe it can. The only question that we really want to answer is whether we can predict and measure remotely the location of commercially producible hydrocarbons. Any technology that moves us in this direction ends up reducing the number of dry holes we drill, and therefore reducing the overall costs of exploration.

–Dave Monk

Shallow basalt flows cover all or portions of potential hydrocarbon basins in several areas in the world. The Columbia plateau in the U S and the Nechako basin in Canada are two examples in North America. International examples are areas of the Lybian dessert and areas of central India. There are even seafloor basalt flows that cover potential hydrocarbon regions. Mapping sedimentary structures beneath basalt cover has always been a difficult problem for the exploration community. Many exploration companies have been reluctant to explore in these areas because of the high risk. However interest in these areas has increased with rising oil prices. One exploration problem industry is facing therefore is to successfully map sedimentary basins beneath basalt cover.

I believe technology will play a significant role in solving this problem. Several areas where I think technology advances will help are listed below.

- Acquisition of 2D and 3D seismic using long offsets and multi-component recording will provide the redundancy necessary to eliminate or partially eliminate the incoherency associated with basalt's inhomogeneous velocity structure. To obtain this objective technology advances in seismic acquisition such as acquisition without cables will play a key role when fully developed.
- Gravity data can provide constraints on basalt thickness and velocity variability which can be used as input to seismic modeling packages. Integration of the two techniques will provide better ray path modeling for static and other corrections. Continuing technological advances in airborne gravity will make such integration cost effective.
- Integration EM data , either MT or controlled source EM, with gravity and seismic data will provide additional constraints that can be used for modelling seismic ray paths. EM methods will provide information on sediment resistivity which can be used as additional and independent information for a more integrated interpretation. EM can also map inter bedded volcanics within the sedimentary package. EM technology advances include lighter, more portable equipment, more channels and faster digitizing. Improved software interpretation and inversion packages are being developed as well.
- Modern processing will help improve incoherency and static problems. For example a company reprocessed 1980's 2D seismic data in the Nechako basin for Gesocience BC using modern state-of-the-art processing. The results show that significant improvements can be achieved over a large section of the original survey area. Further research is still needed though to determine why some areas still remain so noisy that structural features are obscurred. For example how much of this problem is related to acquisition and how much is related to processing needs to be determined.

–Mel Best

I believe that the largest exploration problem we face is environmental in nature. I think that the "footprint" that we cause and subsequently correct will continue to be more and more limited. The acquisition of seismic and the drilling of wells will continue to be under greater and greater scrutiny by the stakeholders of the land and resources. Our business will require much better planning and consultation to ensure that our targets and plans continue to keep up with the growing demand of our product. The technologies that

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will help are already showing up in better terrain models and methods, lower impact seismic equipment and sources, coil tubing drilling and other smaller sized operations and will continue to evolve.

–John Logel

In my opinion, the main exploration problem for the next 10 years is still deep-water sub-salt exploration. Some of the issues in this is imaging below salt, and various drilling related problems such as proper location of the well in the seismic section, and borehole stability issues resulting from the complex stress field near the salt flank.

Other exploration problems are: carbonate reservoirs, and land exploration when the near surface conditions make the imaging difficult. In Asia (both China and Russia) there are a lot of under explored land reservoirs.

–Arthur Cheng

Let's split exploration into 2 items: conventional and unconventional

- Conventional: should not be a problem (stratigraphic plays can be addressed with good quality 3D data – and we know that the quality is improving almost daily-, structurally complex plays can be addressed with Pre Stack Depth Migration (see foothills or subsalt (multi azimuth acquisition)); my concerns are more for how to produce in arctic conditions
- Unconventional: includes oil sands, CBM, tight reservoirs and hydrates; I can see more and more environmental impact, except maybe for tight reservoirs

–Jean-Michel Buchoud

The exploration frontiers are moving more and more into parts of the planet with difficult environmental conditions or severely constrained access. The seismic challenges that we are now facing and will continue to face over the next decade will be primarily in the arena of data acquisition and associated technologies. As the price of hydrocarbons continues to rise, the economics of exploring in previously environmentally difficult areas will continue to become more favorable. In some environments, such as Western Canada, rising commodity prices and the demand for access to reserves will come

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into increasing conflict with environmental groups, restrictive access policies by numerous regulatory bodies, and increasingly belligerent surface rights holders.

Current examples of restricted access abound, but some of the more publicized examples have been access to large exploration regions in Alaska, as well as politically restricted access by First Nations' interests in Western Canada.

–Doug Pruden

Q2. Are technologies being developed that we need to keep our eyes open to or be involved in?

Answer

In the marine environment removal of the ghost associated with the sea surface has always been an issue. While OBC techniques have the potential to take care of some of this, there is still the ghost associated with the source. I think that "over under source", finally looks as though it will become viable, and over under streamers involving more than 2 levels (depths) of streamer also holds considerable promise as a data enhancement tool. Recent work with dual sensor streamers (hydrophone and geophone in the streamer) also holds some promise if the noise problems can be addressed, and this may end up being a replacement for multi level streamers.

In the land environment, as the industry moves towards 100,000's of live channels over the next decade, it seems clear that these will not be connected with wire. We are already looking at various wireless systems, and I believe there will be several mature, commercially viable, systems competing in the next few years. Such "point receiver" systems will be complemented by point source, and for Vibroseis work it would seem likely that massive numbers of single Vibe locations will evolve to be attractive if "slip sweep" or something similar can be developed to handle 10 or more vibrator fleets at the same time.

Commercial EM work for hydrocarbon exploration really has only a short history compared to the seismic industry. I see this as continuing to evolve and becoming more closely linked with seismic data. I think that it is likely that this method will develop rapidly.

–Dave Monk

Environmental constraints on seismic acquisition (both land and marine) are becoming more prohibitive. We need to investigate technologies that can eliminate or reduce e the impact of cut lines on land surveys and to reduce the impact of seismic sources on land and marine surveys.

Technological advances that eliminate the need for acquisition cables are being developed and I expect they will be routinely available in the future. These advances will reduce the environmental footprint as well as reducing manpower and costs. Development of smaller and more accurate GPS receivers that can be built into geophones could also reduce the need for cut lines.

Passive seismic methods and interferometry techniques are emerging technologies that may help reduce the environmental impact of land and marine acquisition. There has been recent work by the University of Colorado with universities and government agencies in New Zealand making use of natural noise sources (ocean wave noise to be exact) to map shear wave versus depth using the Rayleigh and Love waves associated with the noise. The original work focused on lower resolution and deeper structures using Rayleigh waves but they are now looking in the upper 2 to 3 kilometres in an area of volcanic activity in New Zealand. This is a passive seismic technique that measures noise from distant natural sources and does not use controlled sources at all.

A presentation at the SEG meeting in New Orleans last year showed the results of collecting random noise over a series of time windows from an array of geophones on the sea floor. The data in these windows was subsequently used to generate a 2D seismic section from virtual sources using intereferometric techniques. The 2D section generated by this method was able to reproduce many of the structural features seen in the corresponding 2D section from a conventional 3D survey. Again no controlled sources were used.

In the June, 2007 issue of World oil there is an article by Rodney Calvert of Shell discussing virtual sources and interferometric techniques. The article is worth reading in detail since he expands on the applications discussed above. He outlines some of the inherent pitfalls as well.

–Mel Best

The technologies that are being developed that should impact our business the most are the more digital monitoring and remote working tools. The ability to see "real time" seismic or microseismic, and drilling operation will allow us to react better in emergency situation and allow us to work in a more favorable and safe environment as well as safeguard the environment and indigenous wildlife and general population. The ability for professional, governments and stakeholders to be continuously in touch and communicating as well as virtual interaction will be a necessity.

TOTAL E&P CANADA is presently deeply involved in the oil sands; so let me discuss our own interests. Bitumen in-place evaluation is not easy, but we can make it; the problem comes with the reserves evaluation; in another word, what are the optimum recovery processes. I know those are not pure exploration problems, but the way we calculate the reserves has a strong impact on our exploration programs. What about the technology? Is it SAGD the tool? How to monitor the steam chamber? The industry is already involved in this domain, but it still remains a R&D domain. So, keep both eyes open.

–Jean-Michel Buchoud

One of the hottest development is "controlled source" or "seabed" electromagnetic methods. This is complementary to seismic methods and we need to learn how to interpret them together.

I think fast, accurate modeling algorithms are still needed. Right now we have fast modeling algorithms that are not complete or accurate (i.e. ray tracing or one way wave equation), and complete algorithms that are slow (i.e. full finite difference elastic wave propagation).

In addition, I think we need to pay much more attention to rock physics. Most geophysicists still use rock physics models that are 40 years old and totally inappropriate for carbonates, shear wave propagation, stress dependence, and any number of related issues. Rock physics is also the glue that ties seismic to electromagnetic properties of rocks.

–Arthur Cheng

Many of these problems will not be immediately addressable by existing technology due to the political nature of the problems. The

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requirements of adequate 3D subsurface sampling are often in direct conflict with the limited footprint desired by surface rights holders. In some cases, much of the difficulty can be addressed by superior planning prior to discussions with the surface rights holders. Such existing technologies such as Satellite imaging, LIDAR, current aerial photography and helicopter reconnaissance can go a long way towards effective pre-planning. By and large, however, most of these issues must be addressed by old fashioned communication and the building of working relationships with the surface rights holders.

Government demands for narrower and fewer cut lines in forested areas can in many cases be addressed by heliportable operations. The continued development of light weight, drilling rigs can benefit here. Continued development of telemetry acquisition systems is also assisting in this area. Some environments, however do not lend themselves to dynamite acquisition, such as parts of the Arctic where government restrictions limit the use of dynamite and require vibroseis as a primary energy source. While on the open tundra this is not necessarily a major impediment, further south, in forested areas, government demands for narrower cut lines associated with restrictions on the use of dynamite severely compromise the utility of vibroseis. Development of vibrator technology for narrow cutline environments is required.

–Doug Pruden

Q3. In your opinion, what technologies do we need to invest in that are not being developed today?

Answer

The increasing impact of environmental considerations in our exploration efforts will drive what we do in the future. I can't predict exactly what technology will win this race, but it is likely that we will be pushed to leave less of a "footprint" as a result of our exploration efforts. Disposable detectors and sources on land, with no surface visitation may help onshore, but it's not clear how our marine industry will evolve through technology that has an even lower environmental impact that we currently have.

–Dave Monk

The technologies that really reduce our environmental and surface "footprint" should be a top priority as well as those that help preserve and protect our air and our water. I think that wireless seismic, smaller more compact sources, and drill rigs that are easier to move and take up less area are required. Additional growth would be in less exposed pumping units and facilities. Our business is driven to find new resources and the ability to do that in an environmental and cultural "friendly" manner would be a great addition.

–John Logel

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Bitumen in poor quality reservoirs.

–Jean-Michel Buchoud

Hard to say. I would say most technologies that have potential are being looked at. However some are being under-funded, or not properly tested, or not applied to the right problem. In my field, I would say that the effect of uni-axial or tri-axial stresses on rocks is not well understood and needs a lot more study.

–Arthur Cheng

We are beginning to see an emphasis on the integration of non-seismic technologies in our work. EM, gravity and HRAM data are being used more often in conjunction with seismic data to develop better models of the subsurface. Satellite imagery and surface geochemistry are being employed to detect indicators of hydrocarbon halos at the surface over economic accumulations. Continued research in these areas has the potential to change the way exploration is conducted in many places where seismic data is poor, limited or unavailable.

Some have said that one of the most significant advances for seismic technology occurred when CMP recording was developed. Increasing channel capacity has continued to make multifold recording the most powerful noise reduction technique we have in our toolbox. It is a simple, effective technique that addresses random noise and some multiple reflection issues very effectively. My argument is that this technique is now close to 50 years old. I speculate that our advancing understanding of the seismic wave field and increasing computational powers may lead to another technological leap beyond the brute force of CMP recording. I think we see hints of it in our development of offset analysis techniques, but we are still heavily reliant on redundancy in our seismic recording. This, of course, places pressure on our acquisition requirements and hence our increased conflicts with surface interest holders for access for purposes of adequate imaging and fold. I have no idea of what form such a technology leap will take. It will likely involve the adaptations of technologies currently being developed outside of the oil and gas industry. It will likely take the form of computational algorithms, noise reduction schemes and other techniques we have not thought of applying to the seismic problem. If we can reduce the required number of surface source points and be able to retain our ability to image the targets at depth, our acquisition costs will be reduced and our surface access footprint can be reduced. While this may be idle dreaming on my part, wouldn't it be a wonderful major development if it could happen?

–Doug Pruden

Q4. What needs to be done that would aid the development and implementation of such technologies – finance consortia/research organizations, attend conferences and courses or anything else?

Answer

Our industry has evolved in a way that most of the technical developments we see today have been driven directly by the contractors that use them. We have seen little investment by the oil companies, and consortia have not proved particularly successful at development into commercial products (there as some exceptions of course). It might be argued that given the current buoyant state of the finances of the seismic contractors, that they should bear the costs of technology development. However, I don't think this is the case. There needs to be more joint development projects directly between oil companies and contractors where funding is sourced from both sides for mutual benefit in the results.

–Dave Monk

I think there is always a resistance to these new technologies for two reasons: 1) being the unknown, the unsure, the untested. The fear that something is being over sold and may not work or work badly. This can be disastrous in our short fused world, and 2) being the uncompetitive higher cost at the evolving phase of a technology. The solution to these is to get new technologies tested and into the business in a more controlled environment (consortia) and funded by several companies to limit cash exposure. These can then be rolled out with some success cases and confidence.

–John Logel

I would favour consortia/research organizations; conferences and courses will follow "naturally".

–Jean-Michel Buchoud

All of the above. However, running a coordinated program is not trivial. Perhaps CSEG can play a part in this. The SEG has formed the SEG Advanced Modeling Consortium (SEAM for short) to address the need for modeling. It is a small step in this direction.

–Arthur Cheng

Clearly we must begin to look outside of the oil and gas community for technologies to address our problems. Better use of satellite imagery and LIDAR technologies will be found there. Telecommunications technologies can assist in the development of the next generation of seismic acquisition instrumentation. Somewhere out there, someone has developed techniques being applied to some other field that can be adapted to our problems. This has happened in the other direction in the past. 3D seismic imaging technologies were used to develop medical imaging technologies in the late 1990's. It is time for us to look outside of ourselves and see what the global environment of the 21st century has to offer us.

–Doug Pruden