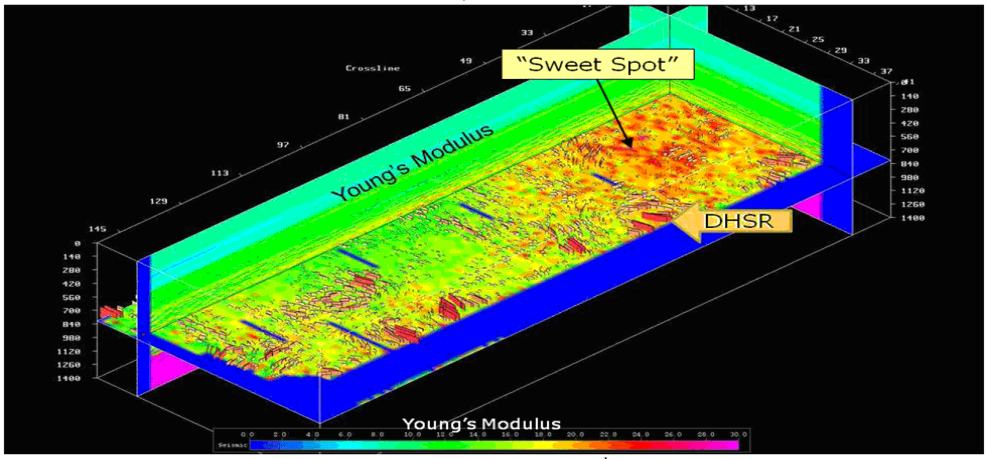
Society of Exploration Geophysicists
2010 Annual Conference and Exhibition
Denver, Colorado



Shale gas sweet spots[1].

Shale gas is the theme of the year. The AAPG in New Orleans, the SPE in Florence and now the SEG in Denver all devoted plenary sessions to the non conventional boom. Little new was said at the SEG – the consensus in the non conventional gas industry is that gas has matured from a 'bridge' role to be a fuel of the future. Lobbying is required to consolidate this position – especially in the face of a strong coal lobby. Public perceptions on the nature of frac fluids also need assuaging. As session chair Rutt Bridges said, '*if you are not telling your story [in Washington], you are losing the battle.*'

There was some frustration in the audience at the near absence of any geophysical content in the plenary session. This likely reflects the impedance mismatch between what the seismic business does really well – 3D and inversion – and the vast geographic extent of the resource play that makes blanket 3D uneconomic. Geophysics does play a role in non conventionals with micro seismic monitoring of hydraulic fractures and specialist processing such as CGGVeritas' differential horizontal stress ratio above. But in general, low gas prices and the 'industrial' approach to non conventional drilling make such extra science that bit harder to justify.

Mainstream seismics is thriving – with several sessions on imaging and inversion and a workshop on high performance computing. We also report from a special session look-back at the life of industry luminary Albert Tarantola who died earlier this year. Tarantola was a seismic thought leader who introduced statistical concepts into seismic processing – turning a deterministic process into a modeling exercise. Modern seismic imaging revolves around solving a very large number of equations with far more unknowns than knowns.

The seismic industry works around this in several ways – by acquiring more 'knowns' with a much higher sample density and by using 'prior knowledge' of the subsurface in the form of a model. More samples are acquired with techniques such as WesternGeco's 'SimSrc' acquisition – with multiple sources shooting simultaneously. Saudi Aramco, working with CGGVeritas, reports up to 40,000 vibration points per day from an onshore crew. Working on the prior model involves the interpreter, but also non-seismic techniques such as potential field. Halliburton's Landmark unit (along with Appro) is offering a seismic acquisition optimization hardware and software bundle to validate coverage in planning.

We report from Schlumberger's Ocean User Group on how the popular Petrel plug-in development kit is being used by companies such as Petrobras and others to extend the Petrel interpretation flagship.

The High Performance Computing Workshop reflected the increasing use of the graphics processing unit (GPU) in seismic imaging, at least in the R&D community. The hoped-for orders of magnitude speedup claims have been tempered by experiment. Rather than 1000x, a 10-15x speedup appears a realistic target for some tasks on GPU (compared to the same task running on a CPU). Although true like for like comparisons are near impossible.

[1] *Image courtesy CGGVeritas.*

Highlights

Unconventional Gas Forum
Ocean User Group
Albert Tarantola Memorial Session
High Performance Computing Workshop

Contents

This Technology Watch report was produced by The Data Room.
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1027_1 SEG Forum on unconventional gas

Jeff Ventura, Jim Hackett, Bill Ritter and Ken Salazar.

Chairman Rutt Bridges (Transform Software and former SEG president) introduced the panel to a good turn out of around 1,500. According to some reports, the Marcellus shale play is, collectively, the second largest natural gas field in the world.

1027_1.1 Ken Salazar – US Department of Interior

Salazar.

Today the focus is on wind and solar, but seismic, fracking[2] technology and horizontal wells are important contributions to the energy mix. There is renewed interest in deep, tight shales and coalbed methane – the question is how develop these right and in the right places. CCS and EOR also ran. The President's vision for energy security includes a shift away from energy dependence – with threats to security and the environment. The first large scale solar plant in the US has now been approved and will generate 400 MW. A decade of gridlock has been broken for offshore wind with the signing of the Cape Wind lease (Nantucket). A comprehensive plan includes oil, gas and traditional fuels as the demand for fossil fuels is set to rise. Natural gas is the fastest growing fuel and will power 90% of new electricity generation. As wind and solar grow, so will the need for natural gas as a backup and as a way of reducing CO2 emissions. The question is how will we meet demand? Resource assessments are up thanks to technology – nearly all wells on federal lands are now stimulated. But there is growing public concern in regard of fracking technology in shale gas wells. More studies are needed here. The current evaluation process currently creates conflict. In 1998, 1% of BLM[3] leases were protested, in 2008 this rose to 40%. We need to bring some sense back to process – to get smart from the start. Safety was previously left behind – this is unacceptable in regard of fracking. Likewise the offshore continental shelf is seeing aggressive reforms that raise the bar on safety equipment and put science back into OCS decision-making. We have implemented reforms that will allow GOM deepwater drilling to start. We are leveraging US know-how in the areas of oil spill containment, blow out response – watch this space. The Nation is in the midst of a major energy revolution with multiple

[2] There has been a lot of agonizing as to how hydraulic fracturing should be shortened – as fracing, fraccing or fracking. While grammar may favor 'fraccing,' we prefer to align with the majority as demonstrated by Google – which gives fracing – 81,000, fraccing 9,000 and fracking 621,000 and a seal of approval from Wikipedia.

[3] *Bureau of Land Management.*

sources and fast evolving technology. This is an exciting moment as we envisage a safer and more secure energy future.

Q&A

RB – On the issue of climate change – renewables provide less than 5% of the energy mix while 40% of CO2 comes from electricity – in other words that 'other' primary fuel, coal. It would seem that natural gas has a strong role as a bridge fuel. Despite the intense effort on renewables, they do not have the same potential of unconventionals.

KS – The President and I consider natural gas to be an important part of the portfolio. We support a natural gas pipeline to Alaska. Developing onshore and offshore resources will be key as peak shavers for renewables. But as we move forward we will come against political brick walls without a move to transparency. We need to avoid a backlash from communities re hydraulic fracturing. People are concerned about the chemicals being injected. If companies just say 'it's proprietary,' that will backfire. There is also a potential role of geophysics to show that there is no connection between producing horizons and drinking water.

Jeff Ventura (Range Resources) – We now disclose frac fluids composition on our website[4]. Contrary to some misleading representations purporting to show 500 'toxic' chemicals in frac fluids, we found only three chemicals that are also used in water treatment and in the manufacture of children's toys.

RB – We also need to sample water wells as a benchmark against potential change.

JV – In Pennsylvania, back in the time when George Washington was a 'scout,' you could set fire to some of the creeks! 40% of the water wells don't meet HSE standards.

1027_1.2 Bill Ritter – Colorado Governor.

Ritter.

Denver suffers from the 'brown cloud' created when thermal inversion traps pollution from coal fired plants. Legislation is forcing a move from coal to combined cycle natural gas plants. In general, transparency avoids locking horns with environmentalists. We recognize the importance of wind power and a clean energy future and are tying clean energy to job creation. 'Clean' is not just about renewables but also about efficiency and clean energy from coal and natural gas. While some don't believe that carbon capture is possible, R&D shows it can be done. Our base notion is that a clean energy future is good for us. Colorado used to rely heavily on coal – but the voters voted for 10% clean and more reliance on domestic energy. Colorado has grown economically every quarter for the last 20 quarters up until the Wall Street crash. The Colorado School of Mines, University of Colorado and Colorado State have combined efforts into a single laboratory. Siemens has a wind test facility and ConocoPhillips has a campus. These companies were enticed here by policy makers. Job creation comes from ideas developed in R&D labs. Examples include thin film photovoltaic (with DoE funding) and the Vestas site with some 2,600 jobs. Rutt mentioned natural gas' role as a bridge fuel – 'I have stopped calling it a bridge fuel because it already plays a significant role in carbon reduction.'

We have now got to the state where we can drill responsibly for oil and gas. In 1999 there were requests for 1000 wells. In 2009 this had risen to around 9,000. Companies have to deal with archaic rules and regulations – they needed a revamp and we are getting there now thanks to collaboration between industry and government. It used to take 65 days to permit a well – now it takes 35. We need a regulatory scheme for the long term. Fracking is not the bogy man. Congress is looking at it – but we need to give the EPA time to investigate and see state by state differences and determine what needs protecting.

In 2020 we expect to have 30% of our energy from renewables. But fossil fuels have a role in the clean energy economy. Old, inefficient coal plants are transitioning to natural gas. There is opposition from the

[4] http://www.rangeresources.com/rangeresources/files/6f/6ff33c64-5acf-4270-95c7-9e991b963771.pdf.

coal lobby and we will see more ads and other challenges. The EPA is brandishing non compliance notices in 37 states. For non conventionals, operators need to work through conflicts along with the Administration and build trust. The advantage in less reliance on coal is that NOx and SO2 are 70-80% down and there is no more mercury pollution.

1027_1.3 Jim Hackett – CEO of Anadarko and chairman of American Natural Gas Alliance (ANGA)

Introducing Hackett, chairman Rutt Bridges mentioned that 'if you are not telling your story [in Washington] you are losing the battle. Fortunately ANGA was there to fight for shale gas.'

Hackett.

Non conventional gas has brought about a new supply paradigm. I never thought this would happen – I considered natural gas way too precious a fuel. There are shale gas basins all over the US except for California and the western seaboard. A study from the Colorado School of Mines Potential Gas Committee[5] estimated that there is over 2TCF of future supply. According to a CERA study 'Fueling North America's Energy Future [6],' the 'shale gale' will make up 50% of US gas supply by 2035. Modeling suggests that this will be achieved without price spikes. With success comes scrutiny – but much is hysteria. Natural gas wells produce from 7,500 ft. and are cased and cemented. We need to reassure people that there is nothing untoward about this activity which is highly regulated with new rules still coming in. We need to work on the important issues around disclosure and minimizing water usage. Here some comparisons with other electricity sources are instructive. In fact deep shale natural gas is 'best of breed' and uses less water than nuclear, coal, oil and (worst) bio fuels. This from the Groundwater Protection Council and Energy Administration's data. Natural gas produces half the CO2 per BTU of coal. Today's energy mix (for electricity) still includes 45% coal. US Forecast is for an extra 250GW of capacity in 10 years. Hackett was skeptical of the chances that nuclear, renewables, or anything else could provide this except … natural gas. Natural gas generation capacity is there now since only 24% of the current 374GW capacity is utilized. Natural gas aligns with Colorado's Clean Air and Clean Jobs Acts. Excelon, Duke and others are now singing from the natural gas 'hymn sheet.' Hackett drives his Tahoe flex fuel SUV 70 miles per day. But there are only two natural gas stations. We need more infrastructure – this could halve Middle East imports. Converting a single heavy duty waste truck from diesel to natural gas equates to taking 325 cars off the road. Write to your congressman – vote for those who will make this happen. More from www.anadarko.com and www.anga.us.

1027_1.4 Jeff Ventura – President and COO, Range Resources[7]

Back in 2004 Range Resources was wondering where the next 'Barnett' would be. Working in the Appalachians, Range checked out the Marcellus shale which had promising TOCs and other indicators – although the engineers were not so keen. Range stuck with the play and made the 1st Marcellus shale production and what could become the second biggest gas field in the world. Despite early non economic test results, Range persevered. Bill Zagorski (VP geology) successfully re-jigged the exploration program, an office was opened up in Pennsylvania and Range has spent $150 million to date (with a maximum per project exposure of $3 million.) By 2009 the environmental problem of what to do with disposed water was

[5] *http://www.mines.edu/Potential-Gas-Committee-reports-unprecedented-increase-in-magnitude-of-U.S.-natural-gas-resource-base.*

[6] *http://www2.cera.com/docs/Executive_Summary.pdf.*

[7] *Range Resources was previously known as Lomak Petroleum and its Appalachian joint venture operated as Great Lakes Energy Partners.*

growing. A water recycling technique has been very successful and there is now zero water discharge. According to Credit Suisse, these are some of the best economics of all plays in the south west wet gas part of the Marcellus with a 500% IRR[8]. Disclosure and transparency are key in public relations. There are over 100 rigs operating in Marcellus. Total reserve potential has been put at 489 TCF (according to Penn State University as published in the Fort Worth Basin Oil and Gas Magazine August 2009[9].) In comparison, Iran's South Pars field, the largest in the world, is estimated at 1,235 TCF and the Russian N°3 at 222 TCF. The US has just passed Russia as the largest natural gas producer in the world. Ventura echoed Hackett's lines of job creation and energy independence though fleet conversion, natural gas vehicles and electricity generation. In regard of water consumption – this is actually small compared with other major users. Shale gas uses less than golf courses and is dwarfed by power generation needs. There remain water challenges – some 0.25% of 34,000 wells drilled in the last 15 years had issues due to poor casing setting or cementation – but none due to hydraulic fracking. Range applies voluntary standards with multiple steel/cement to protect water. Pennsylvania is the largest and most expensive legislature in the country – but only 5% of proposed bills get passed!

Q&A

What geophysical technologies are used for the Marcellus and other plays?

RB – We use a fair amount of technology including some 3D seismic to assess rock frackability of rock. Big variations here can avoid drilling the bad wells. But use is not widespread.

RR – To the extent that GPH can identify early stage targets or, in mature areas, avoid complity. Such techniques will be developed in time.

In USA groundwater contamination perceptions are limiting access. Microseismics can help visualize fracs and alleviate these concerns.

JH – That is not the challenge! You saw the pictures – there are many other real challenges.

BR – Yes but this is a real concern – only alleviated by transparency.

1027_2 Special Session – The Road Ahead

1027_2.1 Airborne gravity – where do we go from here? – Ed Biegert, Shell

Biegert avoided his own question in the title, providing an overview of modern potential field and remote sensing technologies for rapid scanning of large areas. Potential field was highlighted in Geophysics Vol 1 N° 1, in 1935[10], when L.W Blau described 'black magic in geophysical prospecting!' The topics were the same as today. Since then technology has come a long way – with MEMS sensors, airborne ethane detection with LightTouch[11], and (in the future perhaps) bespoke sniffing robots a.k.a. smart dust and underwater mass spectrometry. A Bouger map made from airborne and satellite measurement, over the GOM shows lots of stuff including the Chixclub impact site. Explorers now have GRACE and GOCE satellite data. GRACE provides 1mGal resolution at better than 100km spatial resolution. Gravity is used to de-risk PSDM. The 3D GeoModeller/Editeur Geologique from the BRGM and Des Fitzgerald's Intrepid Geophysics got a plug. Stochastic inversion is used to produce an ensemble of models. 'The purpose of models is not to fit data but to ask the right questions[12].' Marine seeps are studied from satellites. Early stage biotech company Taxon Biosciences also got a mention for its DNA sequencing of micro organisms that eat oil.

1027_2.2 100 years of seismics. What's left to do? – Craig Beasley, WesternGeco

Today, new acquisition is driven by requirements not cost. This has produced multi-azimuth acquisition, WAZ and anisotropic acquisition which is now commonplace. Industry now deploys 30,000 channel onshore 'super crews.' These reflect a quiet revolution in land acquisition – q.v. a presentation by Saudi Aramco at this conference on a 40,000 VP/day survey. Simultaneous source acquisition such as BP's ISS have brought about a 10 fold productivity gain. Dithered slip sweep acquisition, distance separated simultaneous sweep acquisition also ran. Marine is similarly innovative with WAZ geometries, broadband, OBS/OBC and blended acquisition. Integration is a 'fuzzy' notion, but PSTM is helping out in areas of poor refraction statics. Point receiver acquisition enables inversion of surface waves for near surface structure – possibly rolling in gravity in joint inversion. Other novelties include seismic-guided drilling, imaging and

[8] *I nternal rate of return.*

[9] *http://www.fwbog.com/upload/file/EngelderlayoutLowRes.pdf.*

[10] *http://www.mssu.edu/seg-vm/1930.html.*

[11] *A laser sniffing device see http://www-static.shell.com/static/globalsolutions/downloads/innovation/knowledge_centre/latest_news_issue4_2006.pdf.*

[12] *Echoes of Tarantola here – see below.*

earth model building, depth migration and subsalt imaging. BP has been imaging sediments inside salt. On Chevron's Tahiti field, full waveform inversion shows a 40 Hz sub salt image, an 'amazing' improvement over the last 5 years. But there is still a way to go. The biggest challenge is aliasing, even though you may not realize it until you try to do new stuff with data. New acquisition methods include multi component streamers and Schlumberger's SimSrc acquisition[13].

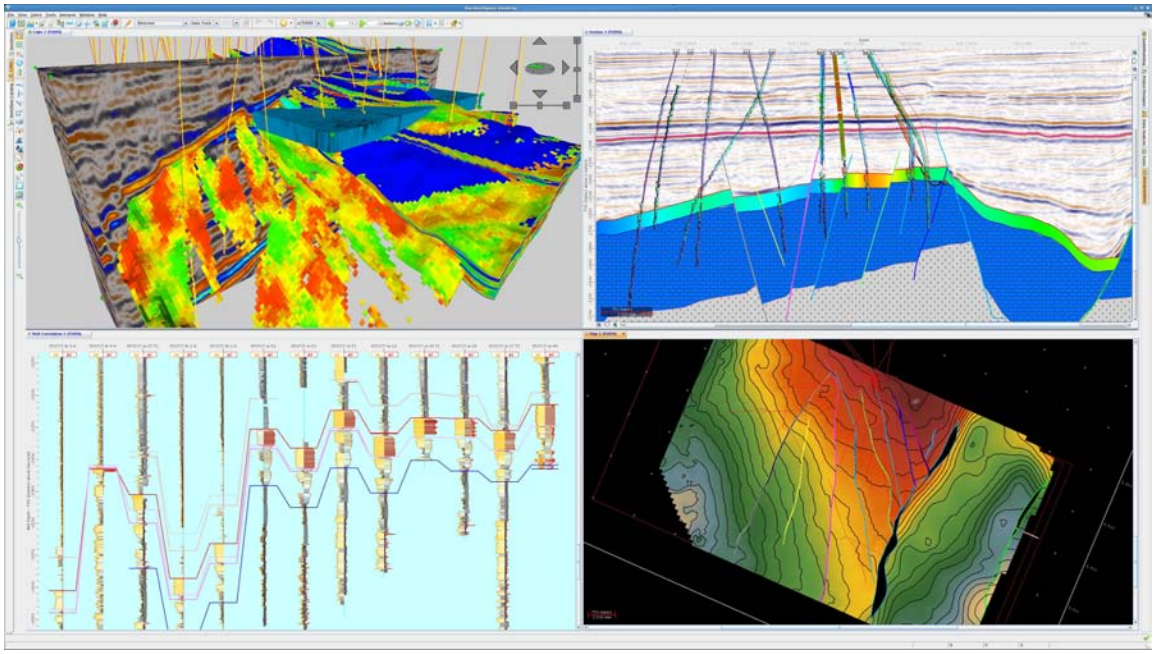
1027_3 Booth presentations

1027_3.1 40 years of seismic anomalies – Mike Forrest (on SMT booth)

Forrest (formerly with Shell Oil), presenting on behalf of Rose & Associates Direct Hydrocarbon Risk Consortium, traced the 40 year history of direct hydrocarbon indicators, starting with a 'health warning,' that bright spots, flat spots, AVO[14] anomalies and so on do not actually indicate the presence of hydrocarbons! Shell coined the 'bright spot' term back in 1960, in the face of considerable skepticism. This was followed by a period of 'peak and valley' days going from optimism to pessimism. Management support and the digital revolution helped with better data and produced significant wins in a 1970 lease sale with the 750 million barrel Eugene Island 330 field which had been identified with the amplitude/background plot, using Aubrey Bassett's 'Payzo' program.

These early successes were followed by pitfall-induced failures and the realization that, for instance a 10% gas saturation gives the same reflection coefficient as an 80% saturation—and this is still a problem today. Successes including the Gulf of Mexico Bullwinkle, Popeye and Tahoe fields confirmed the general usefulness of the techniques. This led to the establishment of Rose & Associates DHI Risk Analysis Consortium in 2001 with 35 members. The consortium is developing a systematic and consistent work process for DHI analysis—not a 'silver bullet.' For Forrest, the three top issues for DHI are 'calibration, calibration and calibration!' You need to check the whole processing sequence, look at the gathers and tie everything to rock physics. Pitfalls include wet sands (23% of all failures in the Consortium's database), geopressure, low saturation gas and hard rock above sand. One example from offshore Barbados shows a huge flat event—but the gas was long gone! Recent DHI successes include the billion barrel discovery in Uganda's Lake Albert, Ghana's Jubilee field and (perhaps) McMoran's Gulf of Mexico Davy Jones discovery. More from Forrest on http://www.searchanddiscovery.net/documents/forrest/index.htm.

1027_3.2 Landmark – Decision Space Desktop[15]



DecisionSpace Desktop[16].

[13] *http://www.westerngeco.com/~/media/Files/WesternGeco/resources/papers/2009/2009eage04.ashx.*

[14] *Amplitude versus Offset – seismic anomalies present in pre-stack data that are charaterized by changes in P and S wave changes at an interface.*

[15] *Demo on Barco 4x HD (3840 x 2160 pixels) with NVIDIA 2x PCI 16.*

[16] *Image courtesy Halliburton/Landmark – www.lgc.com.*

Landmark's new interpretation flagship is described as an integrated workspace for geology, geophysics and earth modeling. DecisionSpace Desktop provides a workflow based approach for a variety of interpretation activities. The demo we saw started with a basin-scale interpretation (originally developed for Statoil) using georeferenced, ad hoc imagery, pulling in maps and scanned cross sections from published literature. 2D seismic lines was compared with a geological sketch cross section and a 3D model. The current release allows ESRI MXD files to be displayed – the next release will have a 2 way link to ESRI. Using new 'geo-shaper' technology, stratigraphic units are picked. All the time the OpenWorks database keeps track of interpretation history – who did what, when. The topology engine[17] is used to build a sealed model. Non pickable events can be captured from well data to create a 'naive' horizon which is mapped using cross sectioning technology to inject a conformance model – top down, bottom up etc. Property modeling leverages geostatistics from Geovariances (in an 'exclusive' relationship). This provides non sequential methods and can be multi-threaded. For non specialist users, 'off the shelf' models are provided for typical basins and reservoirs. Gridding uses vertical grids and was developed by Halliburton and aligned with the Nexus simulator group. Gridding creates a .VDB file (Nexus). RESCUE is used for other simulators such as ECLIPSE. Fluid flow simulation is out of DecisionSpace's current scope although the next release will include a 3D viewer for simulator.

The port and enhancement of Landmark's legacy applications to the new DecisionSpace environment and the future release on Microsoft Windows has been facilitated by the use of Java. A presentation at the 2010 SPE ATCE in Florence showed the new DecisionSpace Well Planning module. This was developed from AssetView (written in Java) and, like the other modules will be ported to Windows using Nokia/Qt. Other Windows-based software – notably the Engineers Data Model-based tools are not Java-based and will not be a part of DecisionSuite. Data connectors to EDM are available.

1027_3.3 Landmark – Geoprobe on Windows

Geoprobe was originally designed exclusively for SGI hardware. It was ported first to Linux and now to 64 bit Windows 7. The demo ran on a Mersive 11 megapixel screen offering 6 x HD (actually it looked a bit washed out). NOAA bathymetry of the whole of the GOM was displayed – around 200 million triangles in a new data format. This is a 'big data solution' for Windows and Linux. Geoprobe offers multi-CRS[18] data across NAD zones – thanks to the OpenWorks R5000 data infrastructure. Wells are loaded with their native CRS – and Geoprobe provides a window into the CRS of choice – transforming data on the fly. Data can be in memory or streamed from disk and always runs at full resolution. Landmark has patented its 'combo-mambo' co-vizualization of coherence and amplitude – this leverages NVIDIA GPU for display. New EZFaults/EZSurface technology allows for interpretation of arbitrary, multi-z, unconnected sealed bodies. There are no current plans to integrate Geoprobe into the new DecisionSpace Desktop. Over time, GP functionality will migrate into the Desktop tools.

1027_3.4 Paradigm – Epos 4 data infrastructure, Phil Neri

Paradigm claims 7,500 Epos users whose data needs are growing rapidly 'from terabytes to petabytes' used in for prestack data roaming. Projects need to stay on line – even when 're-wiring' data. Paradigm's Epos offers flexibility with coordinates – data can be captured in its native CRS. Data security and integrity protects users from accidental or inappropriate edits. While Linux dominates HPC, it is but becoming evident that Windows is the platform of choice for interactive software. Epos is built around the EposNet server, a catalog of all data repositories on the network – both Paradigm's and 'foreign' data in R5000 and other OpenSpirit-enabled sources. The OpenGeo API was mainly used by clients – but the recent Petrosys deal suggests that this position may be evolving. EposNet allows data to be segmented to different geographic areas, distributed and re-connected if required later. Approved users can access data across segments. The system scales to multi office global deployment. The system can bring together data in SQLLite, SQLServer, PostgreSQL and Oracle data stores. Where relational is not appropriate (seismics) the file system is used. Web Asset Manager is the top level data management tool that provides GIS Search with ESRI/Google Earth. A java plug in is available for Internet Explorer or Firefox. More from www.pdgm.com.

1027_3.5 Paradigm – 2011 Release

Paradigm's StratiMagic and VoxelGeo flagships are in need of a refresh. This is coming with new voxel technology and Skua used across cross section modeling to property, flow and gridding. Paradigm is 'redefining interpretation' around Skua – which 'mathematically ties all model representations' including structure, depositional environment, geology, reservoir properties and the geocellular model for simulation.

[17] *Acquired from XoX/GeoSmith.*

[18] *Coordinate reference system.*

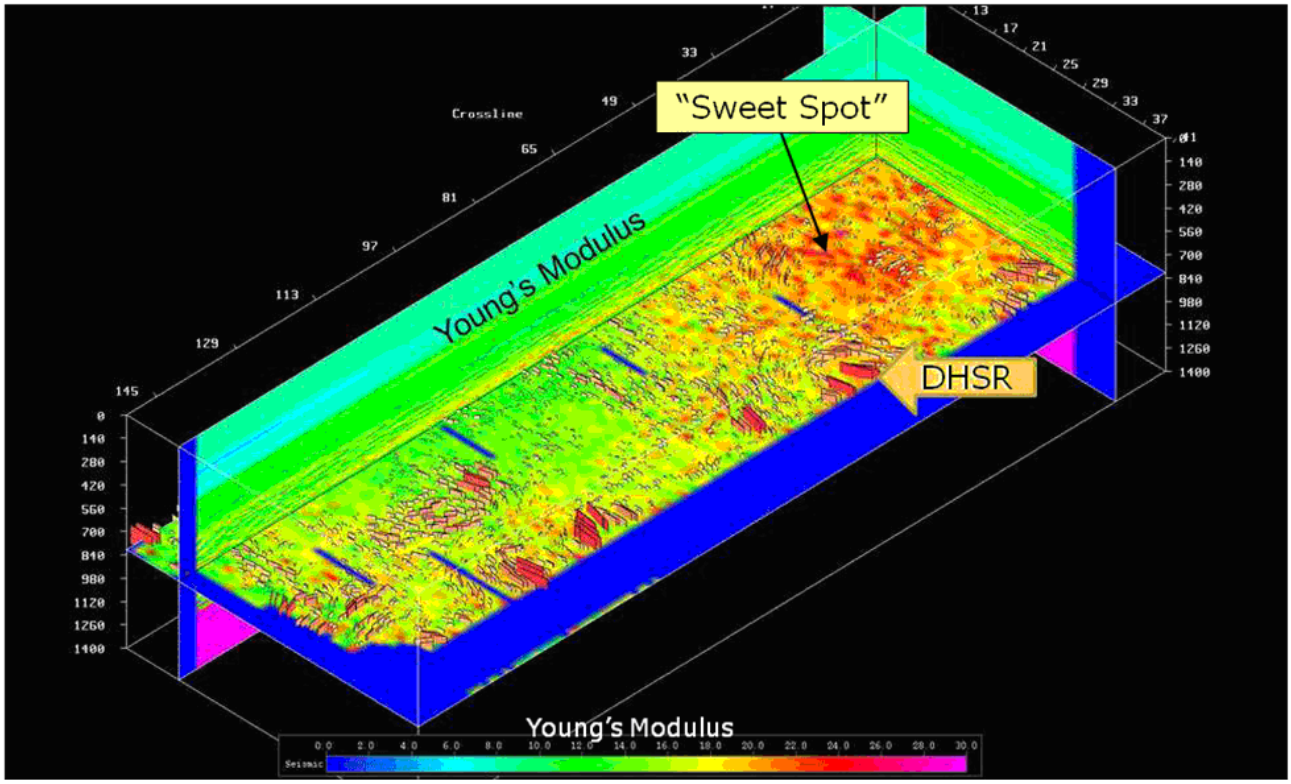
Skua now offers a single model linked by the UVT transformation. Paradigm is also showing preview technology written for the Epos 4 data infrastructure – this will be available as a synchronous release of 15 products and 200 add-ons. There will be more Windows and 'high density computing' with GPU/CPU support. Prestack work is now possible from the main interpretation canvas. Hardware is no longer a barrier with parallel I/O and brick formats. Today's interpreters are 'overwhelmed with attributes' we need systems that are engineered to support multi-attribute interpretation and co-visualization.

1027_4 Exhibitors

1027_4.1 Panorama Technologies – MARVEL GPU-based RTM

Panorama Tech is using NVIDIA Teslas to perform seismic imaging in its MARVELL code base. Around $250,000 worth of hardware can turn around a 30,000 shot deepwater GoM WAZ[19] survey in a couple of weeks. Doing this involved tuning Panorama's code to the CPU. This was done at the compiler level. While OpenCL is supposed to hide the complexity of the GPU, 'optimizing is always hard work.' More from www.panoramatech.com.

1027_4.2 CGGVeritas – shale gas seismic sweet spots



DHSR anomalies show areas of brittle rock and 'frackability[20].'

High-resolution wide-azimuth 3D surveys are used to characterize reservoir properties such as brittleness, pore pressure and local stresses. The differential horizontal stress ratio (DHSR, the ratio of the difference between the maximum and minimum horizontal stresses to the maximum horizontal stress) provides an estimate of estimates of Young's Modulus and hence rock brittleness. More from http://www.cggveritas.com/default.aspx?cid=3662&lang=1.

1027_4.3 SMT Kingdom Unconventional Solution

Seismic Micro-Technology's Kingdom unconventional interpretation offering combines curvature and similarity attribute analysis, azimuthal AVO and microseismics. The tools are used to identify optimal lodations for hydraulic fracturing from anisotropy. Microseismic data is used to delineate induced fractures for dual porosity modeling and reservoir stimulation studies. More from www.seismicmicro.com.

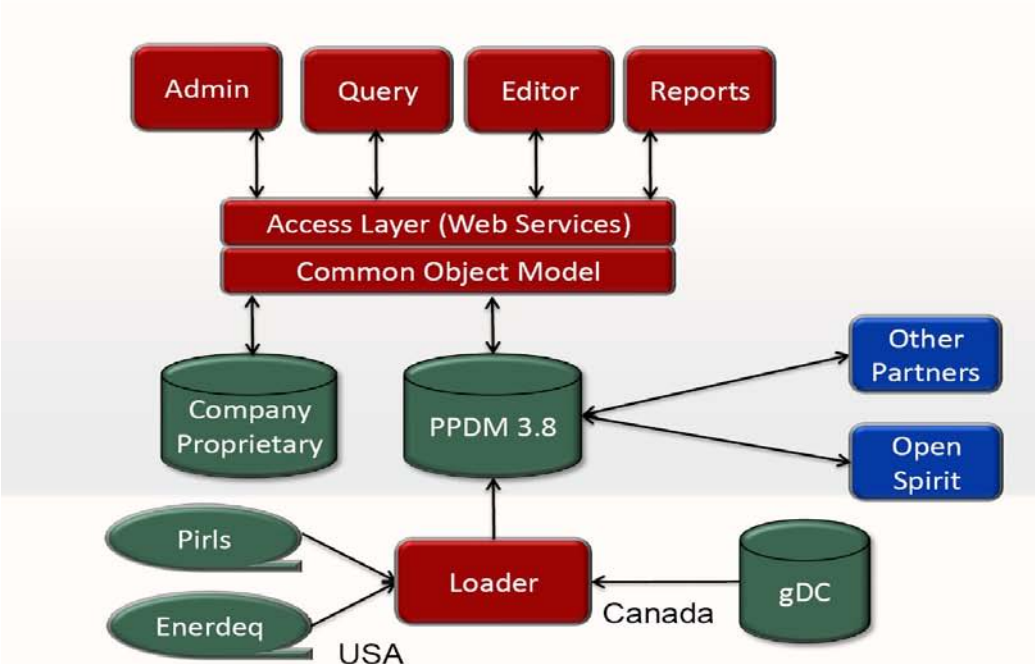
[19] *Wide-azimuth.*

[20] *Image courtesy CGGVeritas.*

1027_4.4 GeoTomo – joint inversion of gravity and seismic data

Shell and GeoTomo have kicked off a JIP to investigate high resolution joint inversion of gravity and seismic data. The project will use GeoTomo's TomoPlus tool to address near-surface velocity models for use in seismic imaging. More from www.geotomo.com/tomoplus.html.

1027_4.5 geoLOGIC Systems and EnergyIQ – PPDM in a box



PPDM in a box[21].

PPDM In a Box is a shrink wrapped deployment of the PPDM 3.8 data model. Web services include mapping with Google Earth. Data can be synchronized with public data sets including Geologic Systems and IHS. PPDM in a Box includes tools for querying, data management and reporting. Data can be versioned and filtered as to 'most trusted' status. More from www.geologic.com and www.energyiq.info.

1027_4.6 SCM Keyboard Companion for Petrel

SCM E&P Solutions' Keyboard Companion for Petrel is described as 'a knowledge portal for Petrel users.' Keyboard Companion combines best practices in a customizable GUI that can embed corporate standards and guidelines. More from www.scminc.com.

1027_4.7 LMKR – Geographix Discovery/Lenovo bundle

Landmark has outsourced Geographix to LMKR. The R5000 release of Geographix is available as a pre-configured bundle on a Lenovo ThinkPad or ThinkStation. The desktop solution includes dual Intel Westmere 5620 processors, 12GB RAM and twin 24" monitors. More from www.geographix.com.

1027_4.8 DataDirect Networks – StorageFusion Architecture 10000E

New storage system for HPC data rationalization scales to petabytes. Earlier versions of the hardware are deployed by Total, ExxonMobil and Saudi Aramco. More from http://www.ddn.com/10000E.

1027_4.9 EasyCopy Graphics Suite

New release (8.5) of montage/plotting solution blends CGM+, GGM, PIP, SVG, JPEG and more files to canvas of unlimited size. 2 and 3D video clips can be created. More from www.myeasycopy.com.

1027_4.10 Landmark/Appro seismic coverage validation engine

A hardware and software bundle from Appro. Landmark's Seismic Coverage Engine offers wave equation forward modeling for seismic illumination and visibility analysis. Hardware is an Appro GreenBlade 32-node solution and Intel's 'Cluster Ready' HPC offering. More from www.appro.com/product/ready-to-go-landmark.asp.

[21] *Image courtesy geoLOGIC and EnergyIQ.*

1027_4.11 Bull – B505 GPU accelerator blade

High-end NVIDIA GPU-based compute blade with 2 NVIDIA Tesla M1060 GPUs and dual Xeon 5600 quad core controllers. CAPS' HMPP middleware avoids direct CUDA coding. More from http://support.bull.com/ols/product/platforms/hw-extremcomp/hw-blade/B505/index.htm.

1027_4.12 Geomodeling – attributes for fracture analysis

AttributeStudio 6.6 correlates microseismic, engineering and seismic attributes to quantify fracture variations and build 'bi-wing' hydraulic fracture models. Various attributes such as curvature are used to identify frackable and brittle rock and to inform future frac jobs. $4 gas means that pattern drilling is no longer economic – 'and you need to frac less.' More from www.geomodeling.com.

1027_4.13 ZeroWait – NetApp reseller

ZeroWait has gotten around NetApp's restrictive licensing conditions and has the right[22] to resell used (ex-lease) NetApp kit at advantageous terms. Three year old NetApp top of the range kit outperforms today's entry level systems. The company also offers independent support. For economic high volume storage, ZeroWait offers 'commodity' SimpleStore Adaptec RAID/Hitatchi boxes scaling to petabytes. More from www.zerowait.com.

1027_5 Ocean User Group[23]

1027_5.1 Brad Youmans – State of the Ocean[24]!

Ocean can be seen as a technology and business ecosystem comprising around 30 oils, 40 software houses and 20 academic institutions. Ocean lets users 'focus on science, not on infrastructure.' For vendors Ocean is an integration pathway to Petrel, the largest and fastest growing upstream software portfolio with upwards of 20,000 users daily. Ocean also is having a major impact within Schlumberger. The wireline, drilling and completions divisions are leveraging Ocean to get their products' data into the shared earth model where Petrel's 3D canvas is the 'point of integration.' The Ocean Store was launched earlier this year along the lines of Apple's AppStore for the iPhone. There are now over 50 plug ins available on the Ocean Store and a further 50 academic projects that are ready for commercialization – e.g. 'Metrel.' Ocean events and trade show booths are building the brand. 870 developers have taken the five day certification course. An EU SIS/Ocean Forum is planned for March 2012.

1027_5.2 Ocean SDK in Petrobras – Luiz Araujo, Petrobras

In 2009 Petrobras had 160 Petrel licenses up from 30 in 2004. Petrel is the most used tool in E&P and is the 'official' reservoir characterization solution. But the software needs to be fine tuned to Petrobras' needs – hence the 'BR-Plugin' program for Ocean development. BR-Plugin builds on earlier test developments with Ocean and aims to homogenize coding, focus development effort and make data connections easier. BR Plug-In' embeds earlier work done at Petrobras' CENPES R&D effort. Tools previously used for software development and testing included Apache Subversion, NUNIT, Ncover, No-GUI, StyleCop and ReviewPal. Then Petrobras saw Microsoft Visual Studio 2010 – 'it was like Alice in Wonderland.' The company decided to move its developpment effort to Visual Studio Team Foundation Server. BRPlug-ins developed include PetroLibNet for licensing, simulation, PetroLibOcean, visualization, units and CRS management. Other plug-ins cover data links to IMEX (CMG), pressure data integration and interpolation with neural nets. BR Tools have been developed for seismic visualization, math kernel and some seismic attributes – 'where not available commercially.' Petrobras has worked to improve the Ocean dev kit with a 'brute force' parser that takes Fortran/C++ etc. as input and generates C#/Ocean code (currently in Beta.) Tools are also under development to automate builds for different Ocean environments. A 'BR NetLic' tool provides license management and logging/access control. 'Despite some limitations, Ocean is a wonderful framework – the best we have found to date.'

Q&A

How do you manage coding and deployment across different Petrel versions?

BR – checks versions and installs as appropriate.

How do you notify users of a new version?

When a user opens Petrel he/she is notified of any out of date plug-ins.

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[22] *While we visited with ZeroWait, NetApp personnel visited and quizzed the company as to its rights to resell NetApp equipment. A similar issue is raised here as in the M-Tech vs. Oracle case.*

[23] Presentations available on http://www.ocean.slb.com/Pages/community-Oceanmeeting.aspx

[24] *http://www.ocean.slb.com/Docs/2010%20User%20Group%20Meeting/1_State%20Of%20the%20Ocean_SIS.pdf*

1027_5.3 Using Ocean as a research tool – Brad Wallet, University of Oklahoma[25]

A lot of code gets written at the University of Oklahoma – using Matlab, Fortran, Java (Wallet's specialty) and Excel (by geologists). Academics like to do 'science' but also need to teach stuff that will be of value to future employers[26]. This can't be done in the above environment. Programming a 10X10x10 cube in Matlab is 'unrealistic[27].' It is hard to bring all these stand alone little programs together. We do want to do science, we don't want to load seismic or develop visualization tools. Hence the Oklahoma University Ocean Initiative – now 2 years old. Wallet wants to train geoscientists to be competent in Ocean programming to prototype new technologies. Current students don't know C# and don't want to become software engineers. They are more likely to know Fortran[28] and reverse time migration. The first course on Ocean programming was a flop with zero signed up. Wallet talked to his boss Professor Kurt Marfurt who 'put pressure' on students. The result was that 12 signed up for GPHY – 6980[29] the first ever course in Ocean. This establishes a basic competence in C# and Ocean for developers with a Fortran/Matlab background. Obstacles are the instructor's experience and lack of documentation. OU is trying to train a computational geoscientist – but they may or may not like Ocean! Rapid prototyping can mean poorly engineered and untested code. Ocean is a rich, complex environment with a significant learning curve. C# is a fantastic language. But the help files are not always great and you can spend a lot of time searching. Documentation is broad rather than deep and not always up to date. The Attribute Assisted Seismic Programming (AASPI) Consortium got a mention (Petrobras et al.).

Q&A

C# is complex and not what we are used to. Windowing, managing collections doesn't make sense to algorithm developers. Not all agree that C# is a great language.

At the University of Nancy, France in a geoscience masters programming we teach C++. Software engineering is here for a reason. We teach science and tools. Software engineering is one of these tools.

OK, but our students don't want to be software engineers.

They may not want to but they often end up being software engineers anyhow!

Have you tried F#?

We did looked at Visual Fortran – there is a large code base to migrate from Linux clusters.

1027_5.4 How to build quality plug-ins[30] – Tore Felix Munck, Resoptima

Munck is a reservoir engineer who worked at Trondheim University where he developed a coal bed methane simulator in Fortran which involved 'more I/O than science[31].' His Thesis included the development of an Ocean plug-in. He then quit the University to found Resoptima and now does Ocean development full time. Resoptima has a 'practice-driven test driven development' (TDD) methodology. This does not test the Ocean framework, rather the interaction of your code with Ocean. Testing leverages JetBrains' ReSharper Visual Studio add-on. The key is to keep tests simple and consistent. TypeMock is used to test code mock ups – 'faking' as yet undeveloped objects and to test methods under development. A continuous integration approach uses nightly builds and more tools – JetBrains' Team City and NCover. FinalBuilder is the recommended tool for test automation, TypeMock Isolator the recommended mocking framework. Crypto Obfuscator got a plug too. Munck also suggested that would-be startups should check out the Microsoft BizSpark program. More from www.resoptima.com.

1027_5.5 Spatial Image Connector[32] – Rob Hall, John Cooper, Blueback Reservoir

Blueback Reservoir (BBR) was founded in 2005 by some of the original Technoguide/Petrel developers. BBR now has over 50 employees developing products and services for 3D geological modeling. 'Ocean-

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[25] *http://www.ocean.slb.com/Docs/2010%20User%20Group%20Meeting/3_Univ_of_Oklahoma.pdf*

[26] *A curious idea, that science is not of value to employers!*

[27] *Another curious statement given that Matlab has parallel extensions (http://www.mathworks.com/products/parallel-computing/) and CUDA capability (http://developer.nvidia.com/object/matlab_cuda.html).*

[28] *Not surprising as Fortran was developed for scientific programming.*

[29] *According to http://catalog.ou.edu/courses/geophysics_courses.htm this is G6980 Research for Doctoral Dissertation. Students can also sign up for 4243 Computational Geosciences ... for MATLAB, the 'standard in scientific computing.'*

[30] *http://www.ocean.slb.com/Docs/2010%20User%20Group%20Meeting/4_Resoptima.pdf*

[31] *As does all programming!*

[32] *http://www.ocean.slb.com/Docs/2010%20User%20Group%20Meeting/5_Blueback_Reservoir.pdf*

oriented' plug-in development includes the BBR GPH toolbox, an EM plug-in and the Earthworks seismic inversion module (a 6 month project). The BBR Reference Project Tracker (provisional name) is a 'silent mode' plug-in that harvests project meta data and stores it in a SQL database.

BBR partnered with Spatial Energy to develop the Spatial Image Connector. This allows digital imagery to be streamed into Petrel. The infrastructure and user interface to access a web map server – complete with an Ocean map view, menus and CRS management took one week to prototype and a couple more days for a usable product. Things slowed down a bit when marketing got involved, in the end it took 2 months to the 'released version.' Apache Corp is a user. The Spatial Image Connector is now available from the Ocean Store for $2,500 per year. A video demo showed the tool used to select WMS layers into a Bing Maps composite view from a live data connection. Alongside the Ocean framework – BBR uses 'agile' development and 'team programming' with two developers working for an 'end user.' BBR also offers libraries – base geo tools, BB library and an Ocean SDK, an extension to the Ocean framework. Creating a tri-mesh takes 26 lines of Ocean code, with BBR it is done in one line.

Q&A

CRS outside of this app?

Just leverage EPSG to interrogate Spatial Energy.

Actually CRS stuff is available now (Schlumberger response).

1027_5.6 Formal launch of Ocean Partner Program – Phil Trayner

The new Ocean Partner Program (OPP) sets out to provide support for the Ocean ecosystem, to 'formalize' the dialog between Ocean developers and Schlumberger in terms of marketing and technology. More from www.ocean.slb.com.

1027_5.7 Petrel and seismic processing – Phil Hodgson, Western Geco

WesternGeco is using Ocean for prototyping with an eye to commercializing tools as plug-ins. Ocean is now supported by WesternGeco with seismic data management, 2D components and a geoscience window for processors. Spatial data is increasingly important for basin-scale exploration across different CRSs. Petrel spatialization is a phased approach that will require multiple spatial data objects and CRS catalog management. Phase 1 targets point and line data types, leveraging ESRI libraries. Phase 2 (currently under test) extends to 3D and native CRS data in store. From 2010.1, Petrel will use the ESRI CRS Catalog. Petrel can now export lat log data to foreign CRSs. Open Spirit connections now automate CRS management. In Petrel 2011, UTM zone transformation will be achieved by 'on the fly' local position estimation – with sub pixel accuracy. A 53 minute webinar on the new Ocean Coordinate Service is available on https://sisevents.webex.com/sisevents/lsr.php?AT=pb&SP=MC&rID=2887487&rKey=6cb684e442e0cce3.

1027_5.8 Other Presentations available online

Spatial changes in Petrel - Phil Hodgson , Schlumberger
Geotoolkit.NET – Paul Schatz, INT
Protecting your IP – Vincent Arneja , Arxan
OpenInventor 8.1 – Federico Gamba, Visual Solutions Group
Ocean 2011 and beyond - Vincent Dury, Schlumberger

1027_6 Tarantola Memorial Special Session

Good turn-out for the Tarantola memorial session – note Sven Treitel in second row.

1027_6.1 Echoes of the real world – Klaus Mosegaard, TU Denmark

Tarantola's grand scheme can be summarized thus – as a vision of future data integration, dedicated to the probabilistic, objectivist, rational viewpoint. His astrophysics background (general relativity) provided a grasp of hard math and laws independent of a reference frame. In 1980 he turned to inverse theory – a.k.a. the theory of (interpretation of) measurement. Tarantola considered the 'regularization methods' of the 1970s as 'unscientific.' 'I hate regularization.' He had more respect for Backus and Gilbert – maximizing resolution and stability. He saw the inverse problem as a 'quest for information.' This led to least squares inversion of the seismic waveform, one of most difficult inverse problems in geosciences. Also the 'adjoint' method – using a source waveform plus hypothetical back propagating wavefield from receivers. To do this you need a background velocity field – enter Monte Carlo estimation of the velocity field. Next comes the the question of how to chose between multiple solutions. In 2003, Tarantola met with a statistician – and figured out how to start from a prior model of 'acceptable' geological structure that is consistent with the data. This can be achieved by generating 'geologically reasonable' models as multiple realizations – and throwing away those that do not fit the data. This proved to be a 'pragmatic' way of integrating geostatistical and geophysical data into a 'Bayesian data base.'

1027_6.2 Imaging and inversion with adjoint theory – Jeroen Tromp, Princeton

Open source spectral-element software is available from www.geodynamics.org. SPECFEM3D shows how far we have come in forward modeling. Princeton's collaboration with Total started in 2009 working on salt in layered structure and forward modeling of fully coupled acoustic elastic simulation. Now working on GPU-based solvers – where Tarantola was very excited. Waveform tomography is used to compare model with data although 'we don't like this even though it is very popular in industry.' It is better to use forward and adjoint wave fields. Enter the 'banana-donut' kernel[33] that is used in crustal seismology to forward model earthquakes (the adjoint wave runs backward). This is Claerbout's imaging principle. Used to model crustal scale seismic interferometry data collected over Southern California.

1027_6.3 Target-oriented survey design – Hugues Djikpesse, Schlumberger

Are we spending too much on acquisition session? No we are not spending enough and need to spend more *and* spend smarter. Survey design involves complex, non linear optimization. Current methods optimal experimental design (OED) is too compute intensive. Djikpesse's method tunes acquisition for imaging a specific area of interest – say a subsalt target from borehole seismic. The method – guided Bayesian optimal experimental design is patented[34]. More from http://iopscience.iop.org/0266-5611/26/5/055008;jsessionid=4544FCC9EAA57E3528D0693EE5942C44.c3.

1027_6.4 Tarantola and the scope of the inverse problem – John Scales, Colorado School of Mines

Scales works at the Colorado Mesoscopic Physics Lab. In the mid 1980s he worked for Amoco and confessed to have 'no knowledge of inversion or geophysics.' He was working on inversion without seeing the big picture. He was seconded to Tarantola's group where even the simplest aspect of the inversion problem involved deep philosophical issues like 'semiotics,' and questions like 'what does it mean to know something.' The essential problem is how do you make inferences from limited measurements – and how inferences are based on models. This is a ubiquitous problem – with echoes of Russel's uncertainty of all human knowledge. Sir Harold Jeffreys also got a mention in regard of the fundamental problem of scientific progress – in particular his 1931 book on Scientific Inference. For instance, we may be interested in knowing 'the density of chalk.' An easy problem – use a pycnometer to get a volume and a scale for mass. Except that mass is inferred from the strain on a gauge with the potential for systematic errors – and what if the density is not uniform and so on... This led to the controversy between bayesian and frequentist statisticians. Scales noted *en passant* that 'Bayes was not a Bayesian!' Tarantola and Bernard Valette worked on the inversion of elastic waveform on the ConnectionMachine 2. The hope was that the CM2 'would solve everything.' But this was before the 'curse of dimensionality' was understood. Seismic volumes are 'pathological' in high dimension spaces with many local extrema of the misfit function. This is a sampling problem, not optimization. This is where 'smart' Markov chain Monte Carlo methods were introduced by Tarantola and Mosegaard.

1027_6.5 North Sea non linear inversion – Christophe Barnes, CGGVeritas

Elf Aquitaine sponsored an offset vertical seismic profile project using Markov Chain Monte Carlo travel time inversion. Phase 2 of the project was presented yesterday. The offset VSP on Brent was acquired with a

[33] *http://en.wikipedia.org/wiki/Banana_Doughnut_theory.*

[34] *The US Patent Office currently has around 50 applications citing Schlumberger and Bayesian statistics.*

1.6 km geophone array and a 2km source offset. Horizontal and vertical components were recorded and the east and west records were 'very different.' Offset VSP is an under determined inverse problem. Barnes recommends you 'don't compromise on the physics.' What took 1,000 hours on the ConnexionMachine now takes around one hour on a PC! More in the same vein from http://www.ipgp.fr/~tarantola/Files/Professional/Papers_PDF/ChararaAndBarnes.pdf.

1027_6.6 The 'GVT' paper and 'le Camembert fondu' – William Symes, Rice

In a 1986 Geophysics paper, Gauthier, Virieux and Tarantola[35] provided 'all you wanted to know but were afraid to ask' about seismic imaging. The 'GVT paper' outlined how adjoint state reflection is hard, transmission easier and the key issues of interaction with sparse spectral data and non linearity. Realistic inversion problems are generally non linear and deterministic iterative methods are not useful as described in another seminal (1995) paper from Mosegaard and Tarantola[36]. Full waveform inversion is the method of choice – and there are no less than 5 sessions on the subject at the SEG this week. Rice has reproduced the iconic 'Camembert' results with its IWAVE++/FWI based on IWAVE modeling. For reflection, the message is that the Camembert has 'melted' – there is nothing in the middle. The results are better for transmission. Reflection remains the hard case – the remedy is to start with a good initial model. How good? We don't know. Symes cited Bunks et al.'s first successful inversion of the Marmousi model. This week's SEG includes many examples of successful use of the technique – especially re diving waves. The GVT paper was the first exposition of full waveform inversion and anticipated the current state of the art – even though the work in this paper is a litany of failures! But these have been tremendously instructive and it was important that they should be published. More on IWAVE from http://www.trip.caam.rice.edu/software/iwave/doc/html/index.html.

1027_6.7 How well did you know Albert? – Wafik Beydoun, Total

As an entrepreneur, Tarantola had the courage to set up the Geophysical Tomography Group (GTG) in France and persuaded the French Government to buy the Connexion Machine. Elf (now Total) was a founding member the consortium. Tarantola used data to falsify models as described by Landa in Popper, Bayes, Tarantola and the inverse problem[37]. More from www.ipgp.fr/~tarantola/

1027_7 HPC Workshop

Around 120 in attendance at this post conference workshop.

1027_7.1 The Trilinos parallel framework – Michael Wolf, Sandia National Labs

Sandia Labs 'Trilinos' object-oriented framework for large scale science promises 'painless parallelism' across multi core architectures. Trilinos leverages templated C++ code and parallel abstractions. Code is written once and runs on a variety of shared memory architectures including multi core CPUs, GPUs and NUMA. It is a challenge to get performance without changing code. Actually, Trilinos is pitched as mid way between a fine grain tune to each node and a 'code once' paradigm. Trilinos leverages 'Kokkos,' a small number of parallel constructs for each architecture. A kernel is written in terms of constructs. These are then run with Intel's thread building blocks, or CUDA via Thrust or Pthread, Serial node. New classes are developed as new architectures come along. Parallel constructs include a `parallel_for()` routine. The system was tested on the Mantevo 'HPCPCG' mini-app. More from http://trilinos.sandia.gov and http://www.speedup.ch/workshops/w39_2010/slides/baker.pdf.

1027_7.2 PSTM for GPUs – Vlad Bashkardin, Bureau of Economic Geology

GPUs offer an order of magnitude performance hike at the expense of recoding. PSTM appears a good candidate for such a port. But how much faster is the GPU in reality? A 10-1000 fold speedup is often claimed. But such comparisons often compare optimized GPU code against an outdated, suboptimal CPU code. See Victor W. Lee on 'Debunking the GPU speedup myth[38].' The ISCA 10 best case showed a 15 fold speedup. The real test of RTM was run on 470k traces, 20k CMP locations for a 10 to 15 x. i.e. 7 hours on a CPU vs 28 mins on GPU. But PSTM is something of a best case. For more sophisticated imaging 10 x and 200 Gflops will be an excellent result. Acknowledgments to Chevron and the Texas Advanced Computer Center.

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[35] *http://www-lgit.obs.ujf-grenoble.fr/~virieuxj/IMG/pdf/GPY_1986_GAUTHIER.pdf.*

[36] *http://www2.imm.dtu.dk/~kmos/papers/B4-MT1995-LaTeX.pdf.*

[37] *http://www.ipgp.fr/~tarantola/Files/Professional/Papers_PDF/NaturePhysicsTarantola.pdf*

[38] *http://portal.acm.org/citation.cfm?id=1816021.*

1027_7.3 The Green Wave Project – Jens Kruger, Fraunhofer

RTM electrical power requirements are huge and growing. Technology including CPU, GPU, Blue Gene makes for a vibrant market for embedded chip design. In 2008, John Shalf's Green Flash project set out to design hardware, software and algorithms at the same time leveraging Tensilica chips. The Green Wave project builds on this and on RAMP hardware acceleration. Design and test of the algorithm/hardware combo is carried out before fabrication using the 'BEE3' Berkeley Emulation Engine FPGA[39]. BEE3 will be on show at SC1010 in New Orleans next month. Green Wave specs include 128 cores/socket, 1GHz clock and a 45 watt 'concentrated torus' architecture tuned to the algorithm[40]. Green Wave currently falls between a Nehalem and Tesla in performance but wins out in terms of stencil megapoints per watt (10x re Nehalem and 3x re GPU). The first real chip fab is slotted for Q4 2011 (Tensilica are behind the project). Note that the x86 has a lots of instructions that are not used. These take up die space and thus power.

Q&A

Why don't you use OpenCL instead of CUDA?

We did consider OpenCL. But the main reason is that CUDA is templated. OpenCL would need more work.

1027_7.4 The MaxBox/MaxRing – Oliver Pell, Maxeler

A 1000 x speedup is claimed for the FPGA which can leverage terabytes of memory bandwidth but is handicapped by a 100MHz clock. Maxeler's MaxBox contains 8 Max2 FPGA cards with a high speed 'MaxRing' interconnect. Two MaxBoxes surround an X86 CPU controller. This is programmed with a 'MaxGenFD' hi level library (Java). Good scalability is claimed. 'Propagating 70Hz waves is practicable.' One 8 x Max2 card node is equivalent to 2K cores. More from www.maxeler.com.

1027_7.5 Resistivity modeling on GPU – Gregory Newman, Lawrence Berkeley National Lab

Co-inversion of marine CSEM and MT data involves tens of millions of field unknowns. A Campos basin test took 24 hours on an IBM Blue Gene to conclude that the data did not fit with an isotropic model. A known oilfield showed up as a weakish anomaly with a stronger off-structure response. EM modeling was also tested on a GPU to optimize sparse matrix vector multiplication – see NVIDIA Tech Report NVR 2008-004. A Quasi-Minimal Residual Method (QMR) solver was implemented in CUDA as 'a cost effective computing alternative.'

1027_7.6 The future of supercomputing – Gladys Gonzalez, Repsol

What will the next generation super computer look like and what programming tools do we need in our plan? Repsol and the Barcelona Supercomputing Center (BSC) are looking at OpenCL to harness the power of accelerators (which outperform the CPU by 20x, Cell BE 5x and the FPGA 12x.) There remain issues with host to accelerator interoperability, code portability and maintainability. For a threads programming model, industrial software needs industrial standards. OpenCL is the most mature standard for GPU programming. But even here, programmers need to know every detail of the stack. The good news is the GMAC library – offering a unified virtual address space and data management. GMAC offers good performance compared with CUDA alone, near linear scalability and under 3% overhead. A GMAC port to OpenCL is underway (the current version is built on CUDA). This would enable, for example, a port to AMD. GMAC on OpenCL is currently an academic effort at BSC – but the consortium is after industrial partners. More from www.bsc.es

1027_7.7 Benchmarking oil and gas applications – Melinda McDade, Oracle

Sun/Oracle is using 'intelligent multi-job provisioning proactive cache' on solid state devices (SSD) a.k.a. 'RTM on flash' this is 'very effective.' The idea is to keep data on chip in cores. Scientific data can be stored in the database – as used by Schlumberger's Seabed and Halliburton's R5000. SEGY headers are stored as metadata with trace data as 'parallel data objects.' The resource scheduler streams the data objects cache more efficiently. Hyper threading benchmarks are available for Eclipse and ProMax. More on RTM and Intel hyper threading from http://blogs.sun.com/BestPerf/. Oracle believes that companies should investigate an HPC 'private' cloud as oil and gas data is 'too sensitive for Amazon.' Many existing tools (such as Petrel) still communicate through shared files – you need to 'get rid of them' (the shared files, not the tools!) Oracle's 'Coherence' is a good alternative to MPI.

[39] *http://research.microsoft.com/en-us/projects/bee3/default.aspx*.

[40] *As compared to Nehalem and Tesla – 300 and 400 watts respectively.*

1027_7.8 Seismic development processing architecture – Peter Freundt, Fraunhofer Institute

With the ever increasing core count[41], and thousand node HPC architectures, there is a growing need for an efficient parallel programming paradigm. But in parallel and HPC, 'simple ideas don't work!' Parallelism and data management are hard problems. Simply put, SeismicUnix does parallelize across terabytes of data. Today, to parallelize a good serial algorithm through MPI and integrate into a processing workflow takes months. To address this, Fraunhofer has developed the Seismic Data Processing Architecture (SDPA). SPDA replaces the popular MPI HPC infrastructure and replaces it with a virtualized global memory for 'persistent, performant and fault tolerant storage.' The global memory is based on GPI/Infiniband, works at 'wire speed' and scales to petabytes. 'Where MPI fails, GPI takes off.'

Fraunhofer then addressed programming, 'the hard part,' separating workflow orchestration (a.k.a coordination) from algorithm development. Algorithms (a.k.a. kernels or filters) are written as modules in high level languages. Coordination and low level memory management uses modified PetriNets and 'easy to learn' domain abstractions. SDPA allows any programming language to be used – Fortran, C, Java... For instance, modules like `segyread` can be piped through `sugain` etc., just as in regular SeismicUnix. Real world workflow complexity for data load, output and storage is all handled by SDPA – leaving geophysical algorithm coding to the geophysicist. The orchestration layer provides auto parallelization taking account of hardware constraints such as GPU/CPU availability, Petri nets and data management. Orchestration is described in XML. SDPA's 'magic' is to recognize data and task parallelization. SPDA uses a functional language, described as 'close to the compiler.' Programs can be dynamically re-written on the fly to optimize for the current hardware configuration. SPD 'understands' seismic data structures.

Fraunhofer is now working on a complete seismic library for trace operations such as Kirchoff migration. A simulator provides hints on how to adapt to a given machine configuration. Some benchmarks compares well with hand-crafted optimization. In conclusion, this is 'parallelization made easy' and offers 'excellent performance without much tuning.' Geophysisicts use a simple domain specific language for existing codes and it is easy to develop new modules. HPC experts gets tools to tune the code. SDPA is currently being trialed with Statoil. A parallelized version of SU, 'su-parallel' was developed in 2 hours during a Statoil workshop. More from http://www.itwm.fraunhofer.de/abteilungen/competence-center-high-performance-computing/sdpa.html.

1027_8 From the DVD

1027_8.1 Fiber-only seismic recording[42] - Jan Langhammer, Optoplan AS[43]

Optical fiber is deployed as a seabed seismic recording system without geophones. The fiber itself is a recording device. The system has been deployed on Ekofisk – www.optoplan.com.

1027_8.2 40,000 vibrator points per day – Peter Pecholcs, Saudi Aramco

Use of distance separated simultaneous sweeping seismic acquisition by CGGVeritas.

1027_8.3 Low frequency acquisition – Peter Maxwell, CGGVeritas

Use of pseudorandom sweeps to extend bandwidth (with geoMagic).

1027_8.4 Prestack interpretation – Larry Fink, Landmark Graphics.

A 'completely new perspective' on prestack seismic data, achieved by turning the offset data cube on its side! The apparently trivial patented process is described in a 10 page document which can be downloaded from http://www.google.com/patents/about?id=ej-nAAAAEBAJ&dq=7,319,637.

1027_8.5 Seismic and non-seismic and joint inversion – Daniele Colombo, Saudi Aramco

Complex surface statics are evaluated with simultaneous joint inversion of seismic, EM and gravity measurement in 'advanced imaging workflows' such as pre-stack redatuming in time and pre-stack depth migration. EM data is used to derive information about the water table and constrain surface geological features.

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[41] *As exemplified by Intel's new 'Knights Corner' 50 core HPC chip.*

[42] *'Performance characteristics of 4C fiber optic ocean bottom cables for permanent reservoir monitoring'*

[43] *Now part of CGGVeritas – www.cggveritas.com. The product has been rebranded as Sercel Optowave – http://www.sercel.com/Products/obc/systems/optowave.php.*

1027_8.6 Reservoir characterization with particle swarm optimizers – Juan Luis Fernández-Martínez, Stanford and Oviedo Universities

Particle swarm optimizers (PSO) applied to 'ill-posed' history matching problems on the the synthetic Stanford VI sand-and-shale reservoir. More from http://www.springerlink.com/content/n314u251hr1745p1/.

1027_8.7 Dual-sensor acquisition – Cyrille Reiser, PGS

Describes improvement to reservoir characterization with dual-sensor streamer seismic acquisition. Dual sensor streamer technology provides increased bandwidth at low and the high ends of the spectrum and 'clearly adds value' at the reservoir.

1027_8.8 Extending the 'Promise' inversion engine – Paul Gelderblom, Shell

Shell's proprietary 'Promise' stochastic inversion engine has been extended with 'geologically constrained' inversion that 'takes lateral continuity and well constraints into account.' Promise produces reservoir-size models that match seismic and well data. More from http://scitation.aip.org/getabs/servlet/GetabsServlet?prog=normal&id=SEGEAB000029000001002825000001&idtype=cvips&gifs=yes&ref=no.

1027_8.9 Land SimSrc – Craig Beasley, WesternGeco

A 'new paradigm [..] dramatically improves the cost/value proposition for land data acquisition[44].' Distance-separated simultaneous source is the land seismic equivalent of WesternGeco's marine 'SimSrc' technique. Independent Simultaneous Sweeping (ISS) produces 'stunning' efficiency gains with 20,000 vibration points per day. Data quality is enhanced by better sampling that produces higher fold and full azimuth data. The apparent problem of crosstalk (overlapping signals) is solved in processing. 'It has been noted that it is much better to deal with interfering shots than it is to try to interpolate missing shots.'

1027_9 The Data Room – Technology Watch

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[44] *This language is hardly appropriate for a scientific paper. More generally, the tone of this paper (and many others in the extended abstracts DVD) is of a rather commercial nature.*