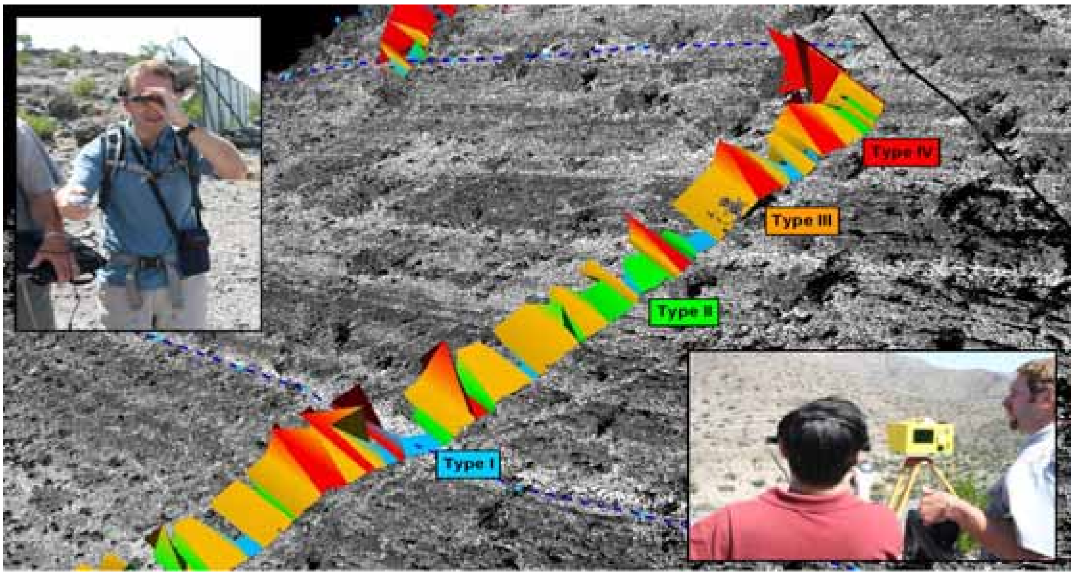
Geological Society Petroleum Group

Digital geology – from outcrop to asset, Manchester 2007



Head-up display and gyroscopic mouse blend virtual and real worlds[1].

65 delegates (20 oil company geologists) attended the London Geological Society Petroleum Group's meeting 'From Outcrop to Asset' held at Manchester University. The meeting subtitle was 'recent advances in digital outcrop data collection and modeling,' but it could equally have been 'a revolution in field geology.' Today's field geologist may still carry a hammer, hand lens and Brunton Gauge, but observations are increasingly captured, not in the notebook, but straight into a 3D geological model. The enabling technology for this is Light Detection and Ranging[2] – LIDAR[3], Laser mapping of outcrop from ground stations of helicopters. This, along with GPS surveys and high resolution digital photography enables the field geologist to build a 3D framework into which other, more conventional measurements can be incorporated. The model can even be taken back into the field and viewed with virtual reality technologies like the 'head-up' display above. Another aspect of analog studies, described as the 'holy grail' of the modeler is to be able to extract 3D information from a 1D borehole measurement. Dave Hodgson (Liverpool University) is investigating this by drilling and logging shallow research boreholes behind the outcrop front in order to simulate field development.

The technology comes at a good time for petroleum geologists studying increasingly heterogeneous reservoirs as Chris Leppard (Hydro) stated, 'Rather than studying the reservoir at the limited resolution of seismic-scale observations, why not work at the resolution you can see in your 3D outcrops?' At outcrop scale, all details are visible allowing for a better comprehension of geological processes that can then be modeled in 3D. This leads to another conference subtitle of 'how can you work in 3D all the way from the outcrop to the workstation.'

Once the model framework has been built, other data like ground penetrating radar (GPRS) shallow borehole can be easily added. Moreover models can be re-oriented to offer a better view of large or awkward exposures on inaccessible sea cliffs. As every geologist knows, the present is the key to past. But what if there are no present day analogs available to study? According to Erwin Adams (Shell) there are no present day analogs to the prolific carbonate platforms of the Middle East. So Shell's Oman unit is building extensive models of ancient analogs in France and Morocco for upscaling and flow modeling experiments.

Modeling these rather unusual data types involves a plethora of 'not fit for purpose' software tools. To bring some order to this situation, Dave Hodgetts (Manchester University) has written the Virtual Reality Geological Studio – a package that allows for the multi discipline measurements above to be embedded in the LIDAR-based model. Such novel presentations of geological fieldwork have considerable implications for the future of geological publishing. This was addressed in a paper by Jeroen Kenter (Chevron) announcing the WODAD project – a new web-based public archive of geological analogs. Finally, to paraphrase Total's Richard Labourdette, LIDAR is 'a unique analog reference tool – no other technique allows so much information of such direct use to the reservoir modeler.'

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[1] *Image courtesy Shell.*

[2] *http://en.wikipedia.org/wiki/LIDAR.*

[3] *A.k.a LADAR.*

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Highlights

VR geology in Hydro
Data collection
Web-based digital analog database, WODAD
VR Geological Studio
Sweep/swing channel mapping from LIDAR
Geo to Flow modeling
Head-up display in field geology
Pseudo-seismics from LIDAR

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TW0623_1 Keynote – Chris Leppard[4], Hydro Energy Research Center

Leppard asks, 'Rather than studying the reservoir at the limited resolution of seismic-scale observations, why not work at the resolution you can see in your 3D outcrops?' At outcrop scale, all details are visible allowing for a better comprehension of geological processes that can then be modeled in 3D. An alternative title for the conference might be 'how to work in 3D all the way from the outcrop to the reservoir model.' Traditional field geology, a.k.a. 'Walking out' across a surface outcrop always involved interpretation. Subsequent reinterpretation inevitably meant going back to the field. Modern technology allows 'objective' outcrop capture with photogrammetry and LIDAR, 'taking the rocks home to lab.' Such 'once and for all' data collection is 'never interpretation' and the technique scales to whole outcrops.

LIDAR is a new generation of laser scanner that produces very large 'point cloud' data sets and requires little or no processing. The downside is the high data volumes and high equipment costs. Photorealistic models combine LIDAR with digital photography to produce a textured triangulated model. These are easy to use and view results. The most powerful systems, with both LIDAR and a high resolution camera, are expensive.

Processing involves 'intelligently decimated meshing' to create the outcrop surface over which the high-res photos are draped. Leppard showed very compelling images of prograding beds offshore Ireland. Once the 3D model has been built, it can be viewed from 'impossible' locations.

Virtual reality (VR) in Hydro began in 1997 and soon expanded beyond well planning to other fields including 'virtual geology'. All Hydro's geoscientists and engineers have VR on the desktop and can work remotely with colleagues in the US who pop up as characters in the VR workspace[5]. Hydro's VR was commercialized with SIS as InsideReality but development in Hydro continues.

In 2001 Hydro VR extended to include 3D outcrop data (textured models). Now users can include shallow seismics and GPR[6] data. Subsurface data such as well logs, reservoir models and flow simulations can be added. This work resulted in the development of the Hydro Outcrop Digitizer (HOD), which is now available license free. HOD is an easy to use tool for working with 3D photorealistic models. HOD accepts point cloud (xyz) data and snaps photo imagery to the outcrop surface. Models can be output in GoCad OSG format. A HOD demo showed how paleo current directions were obtained from a model of the Tullig Point (West Ireland) carboniferous delta. HOD is now used at several Universities and in Hydro for interpretation and training. HOD is also used for large scale reconnaissance of aerial photo data and planning seismic acquisition. In Iran, the technique avoided fieldwork in land- mine areas. HOD works with 10GB size data sets.

One of the largest integrated mapping projects was conducted over the turbidite deposits around Ainsa (Spain). Here a reservoir-scale model was built from 3D outcrop data. GPR data and seismic models (Barents Sea) were added. 'Co-visualization' of different data sets was 'very helpful,' integrating data from Irap RMS. A reservoir model of the outcrop was built at the scale of the flow model and tested to see if flow properties were scale dependent. This was a 'very valuable, major exercise for Hydro.' Comparisons between sophisticated flow model streamlines and 'conventional' coarse flow models showed that although there was twice as much oil in the conventional model, it produced half as much as the detailed model!

Looking to the future, Leppard would like to see lighter LIDAR systems and more automated processing including hyper spectral texturing (slicing the data at different frequencies.) New tools may gain acceptance such as optical tracking and haptic devices. Haptic (force feedback) devices that let you 'feel the geology' are being investigated in the 'GOHIT' (geological outcrop haptic interpretation technology.) Work with Schlumberger is in progress on automated interpretation, extending SIS' 'Ant tracking', and exporting the results to Petrel.

Q&A

What are the challenges in converting pseudo 3D outcrop data to geocellular models.

These models are all pseudo 3D, they are not 3D models in the true sense. In general, there is always interpretation going from outcrop to model. We provide tools, we do not replace the geologist.

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[4] *Authors Tore Løseth, Ole Martinsen and Paul Gillespie, received the 2006 Hydro Innovation Award for their work on virtual geology.*

[5] *Notwithstanding Hydro's enthusiasm for VR, working in full 'immersive' VR is 'very tiring and disorienting.' Not all have access to IVR.*

[6] *Ground penetrating RADAR.*

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TW0623_2 Data collection for virtual outcrop geology – John Howell, University of Bergen et al.

To understand virtual outcrop geology (VOG), think of how intimidating it can be standing at the bottom of a cliff, looking up at the geology. VOG brings this hard to access data into a model than can be viewed, manipulated and measured. The main tools of the trade are the Riegl laser scanner and differential GPS. This collects 5,000 points/second over a 360° field of view and range up to 800m with an accuracy of 5mm. GPS allows for work in geographical coordinate systems. The digital camera is mounted on the scanner and the whole apparatus weighs 70kg. Logistical planning is important to get good sunlight for photos. A typical VOG survey of 20km sq is collected in 1 to 3 days. University of Bergen has acquired 24 data sets to date. Processing software includes Riscan and Innovmetrics' Polyworks. Point cloud data is decimated 'manually' to create a triangulated surface, eliminating scree slopes, vegetation and to focus on the outcrop of interest. Photoshop is used for color balancing to homogenize photos – a time-consuming process. Survey data over relay ramps (Devils Lane, Canyonlands Utah) was imported to Irap RMS for pseudo 'well' planning and flow simulation[7]. Another study of the Apricena Canyonlands, Utah performed for Woodside, involved fracture extraction with image analysis and 2D/3D mapping. The future will see hyperspectral mapping and helicopter mounted LIDAR. Even now, data collection is fast and efficient, the current bottleneck is building and using the model. Current software is considered restrictive, with numerous, not fit for purpose packages required.

Q&A

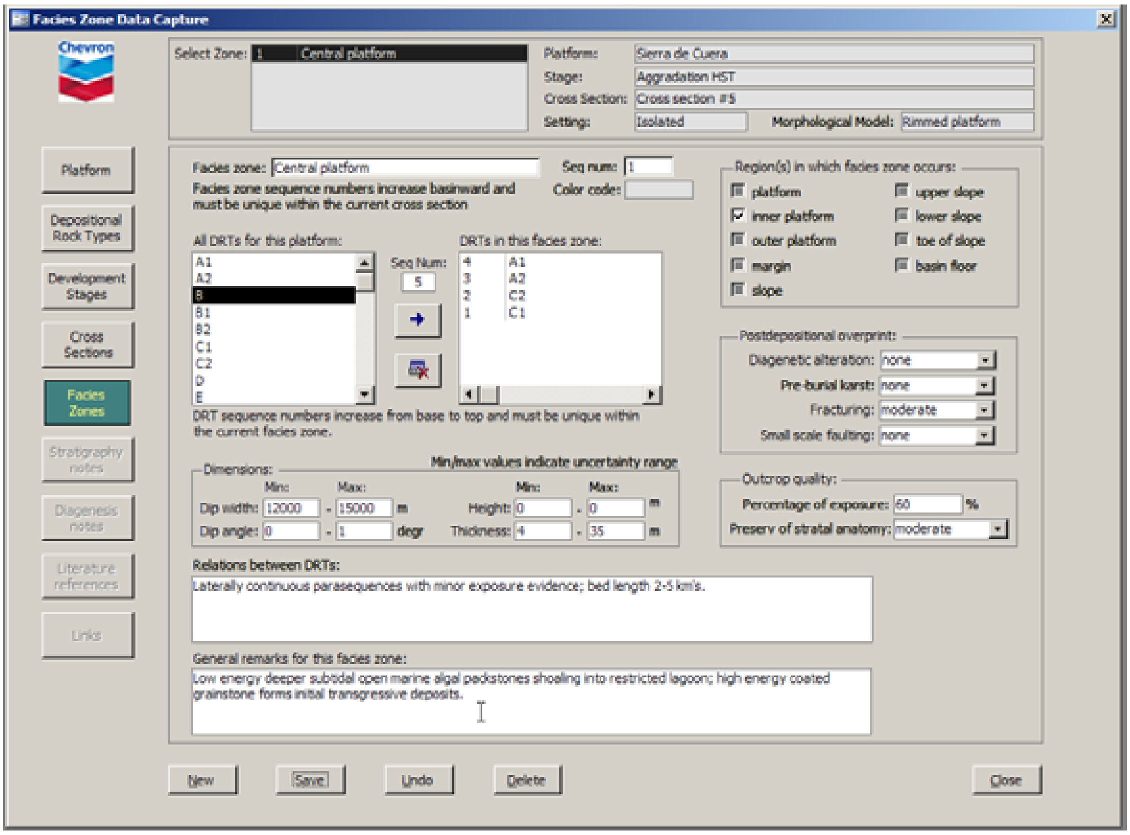
Data standards for VO?

Everyone uses Riscan.

Yes but what about geological standards for outcrop description?

None that I know of – hope something comes out of this meeting[8].

TW0623_3 Web based outcrop digital analog database (WODAD) – Jeroen Kenter, Chevron



WODAD data entry screen shot[9].

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[7] *Part of an ongoing VR geology teaching program from Berger – see http://www.nagt.org/files/nagt/jge/abstracts/Hesthammer_etal_v50n5p528.pdf.*

[8] *It didn't!*

[9] *Image courtesy Chevron.*

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Geologists are in general poorly organized and would benefit from standards for capturing outcrops and general geological information. Chevron's Web based outcrop digital analog database (WODAD) is a public, searchable, text/relational database. WODAD is compatible with C&C reservoirs' Digital Analogs database. WODAD was built with PHP and PostgreSQL etc. Kenter made a call for participants. WODAD appears to present a rather unpreposessing form based interface. The database will be available for contributions in Q3/4 2007. The aim is to publish a digital carbonate volume in 2008-2009. VUA Group and Chevron funding. or sign up on www.wodad.org and peruse Kenter's single (but comprehensive) Sierra de Cuera entry. The plan is to publish WODAD as a 'digital open literature' project in 2008. More from info@wodad.org.

Q&A

Will people provide data that they paid to acquire?

We feel that yes, outcrop data is most/best used by academia.

TW0623_4 Geospatial Acquisition, Visualization and Analysis – Tom Brown, RRG Durham et al.

The Reactivation Research Group (RRG) at Durham University has developed the Geospatial Acquisition, Visualization and Analysis (GAVA) method for data acquisition workflows, leveraging BP's Virtual Outcrop (VO) project[10]. GAVA enables outcrop and regional scale interpretation, fault network extraction and comparison with offshore targets.Another project, the Fractured Reservoir 3D Digital Atlas Fr3DA consortium (Shell, BG, DTI, ITF), studies fractured reservoirs in 3D to model fluid flow with 'real' parameters. Fr3DA is working on a 3D fault map of an open cast coal mine in Northumberland, the mine is re-surveyed every now an again as working cuts back through the formation. A Royal Society-funded (with BP) project is investigating basement structures' effect on outcrops with reference to the Caspian, comparing the offshore ACG structure with Kirmaky valley outcrop, Azerbaijan. Durham is also working on CoViz from Dynamic Graphics to integrate 3D subsurface data with wells, testing and extending CoViz to handle 2D outcrop data including multi scale, multi data types from geological maps to Iconos satellite data and outcrop photomosaics.

TW0623_5 Incorporating published data into geological models – Alice Thomas et al., Neftex

Neftex Petroleum Consultants publishes palaeogeographic maps of the Middle East and North Africa (Neftex MENA)[11], incorporating outcrop and public domain data. Tools include Neftex' Sequence Stratigraphic Model and PGL's Oilfield Data Manager (ODM). When a new paper appears, for instance in the Journal of the Geological Society, covering an area of interest, Neftex extracts and digitizes relevant information (age and facies data), scanning images, measuring sections and inputting the results to ODM..

Q&A

Shows how anachronistic publishing to pdf is – scan and rebuild original data set. Need some standards for publishing digital geology.

Yes that would be nice.

TW0623_6 'Solid image' analysis of outcrop data – Bruno Fricout, LGA[12] Chambery, France et al.

Fricout introduces a novel method for combining point cloud (LIDAR) data with high resolution digital photography. The usual technique is to create a mesh from the LIDAR data onto which the imagery data is resampled and draped. Fricout's method does the opposite – keeping the spatial sampling of the photography and mapping the point cloud data onto the image. The technique is claimed to produce a higher resolution, more accurately located model that is amenable for high resolution interpretation techniques like fracture analysis. The LGA uses these models to perform 'safe, quick structural and stability analysis of steep outcrops.' Safety is important when analyzing risk of rock fall and road subsidence. The solid image (SI) includes xyz of each pixel and preserves full image resolution (no decimation). The LGA uses public domain software for analysis. Examples shown include the Rocher du Midi, which presents a 'very tangential' viewpoint for land based laser work. Helicopter acquisition was therefore used to further investigate fractures with stereo nets from field work, photogrammetry and the solid image. Results showed a fracture family parallel to the laser that was not seen in the

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[10] *See http://www.beg.utexas.edu/mainweb/news_eventsrkiv/sept02.htm for more on BP's outcrop analysis and ILRIS scanning in Baku, Azerbaijan. 'Digital outcrop data provides analog information for reservoir modeling and is to produce 'virtual outcrops' for simultaneous viewing by geoscientists, engineers, and drillers in BP's London and Baku offices.'*

[11] *http://www.neftex.com/neftex/info/neftexmena.*

[12] *Laboratoire de Géodynamique Alpin.*

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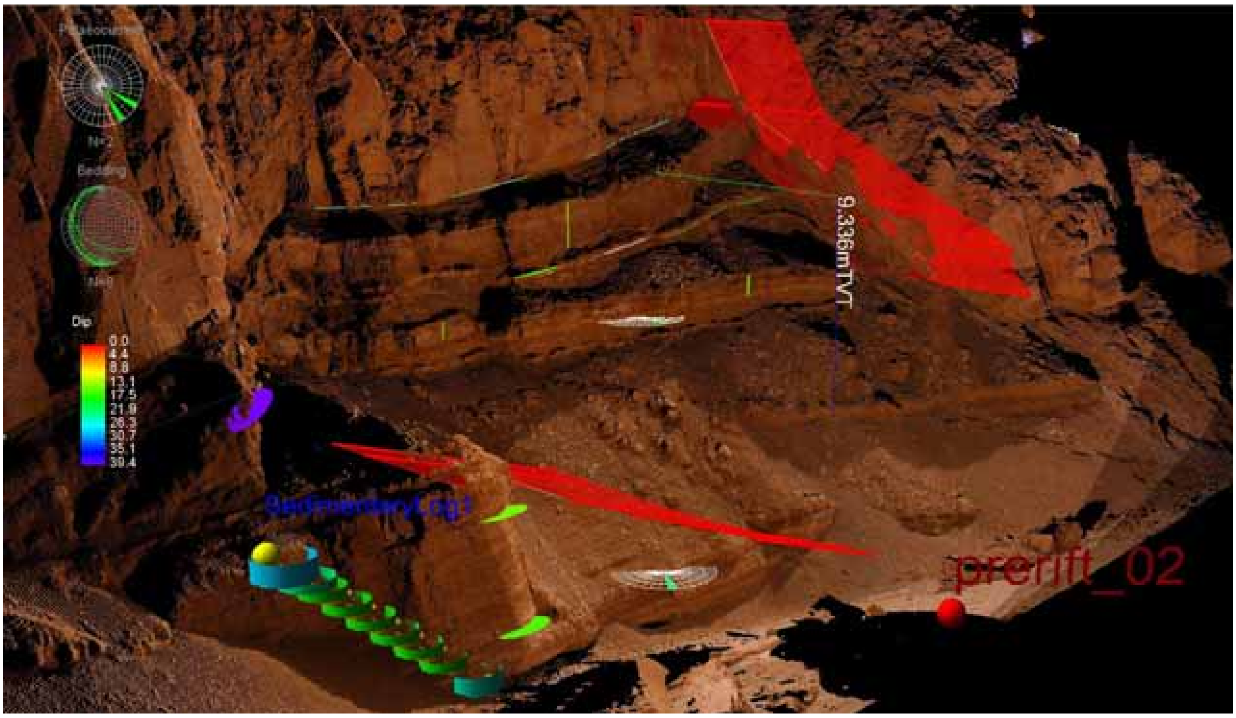
image pixels. Helicopter-mounted LIDAR was also used to map the Rocher de la Bougeoise with a 10cm accuracy but 3cm resolution. [13]

TW0623_7 VR Geological Studio – David Hodgetts, Manchester University et al.



Geo objects on LIDAR backdrop[14].

Virtual outcrop geology (VOG) mobilizes a large range of software including Polyworks, Riscal, Petrel, Irap RMS, Gocad, Paraview and ArcInfo. But these tools were not designed by or for field geologists. So Hodgetts has developed VRGS. VRGS was developed in Visual C++ and works on a tablet PC for field work. VRGS flagship is the Rift Analogs project – an investigation of syn rift sediments in the Gulf of Suez. Some 4 billion data points were obtained from 85 LIDAR scans and 5,000 photos and 800 strike/dip measurements on the outcrop. VRGS includes a new mesh generation algorithm that claims to do a better job of respecting fault throws than conventional modeling packages. The model includes database pointers to the original point cloud data and photography.

Q&A

What is the status of this package – is it commercialized, open source?

It is available for academic use. It is not open source.

TW0623_8 Keynote Presentation – Renaud Bouroullec[15], Bureau of Economic Geology[16], Austin TX

The Bureau of Economic Geology of the University of Texas at Austin uses ground-based LIDAR to build ‘meaningful views’ of awkward outcrops including waterfronts or vegetation-covered locations. Software used includes InnovMetric’s PolyWorks, Roxar IrapRMS, GoCad, SIS Petrel and ERMapper (used for photo draping). Triangulated surfaces are built with Cosmoworld VRML and PolyWorks. Bourollec provided a veritable tour de force in geo mapping from a wide range of basins. The following illustrations show LIDAR acquisition over a deep-water slope channel in the Carboniferous Ross Sandstone at Rinevella, Ireland.

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[13] *More on re-sampling LIDAR/Photo data in appendix 1.*

[14] *Image courtesy Dave Hodgetts.*

[15] *Bouroullec is now with the Chevron Center of Research Excellence (CoRE) at the Colorado School of Mines –* http://www.mines.edu/research/chevrontexaco-ge/.

[16] http://www.beg.utexas.edu/.

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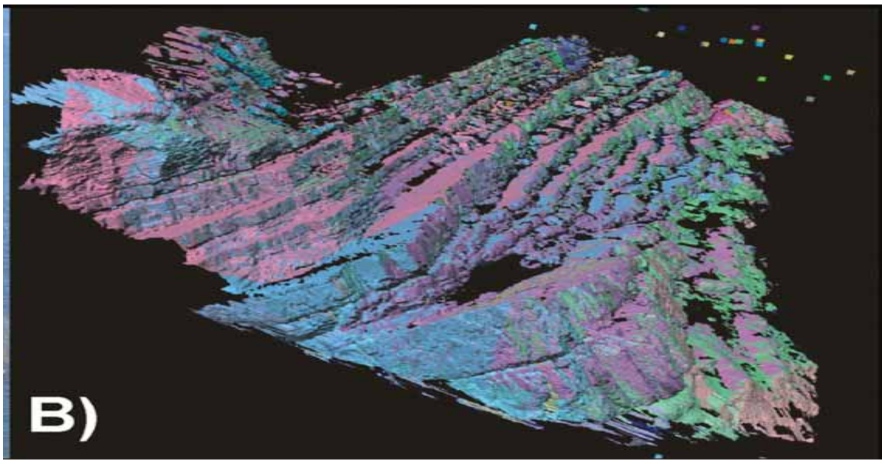
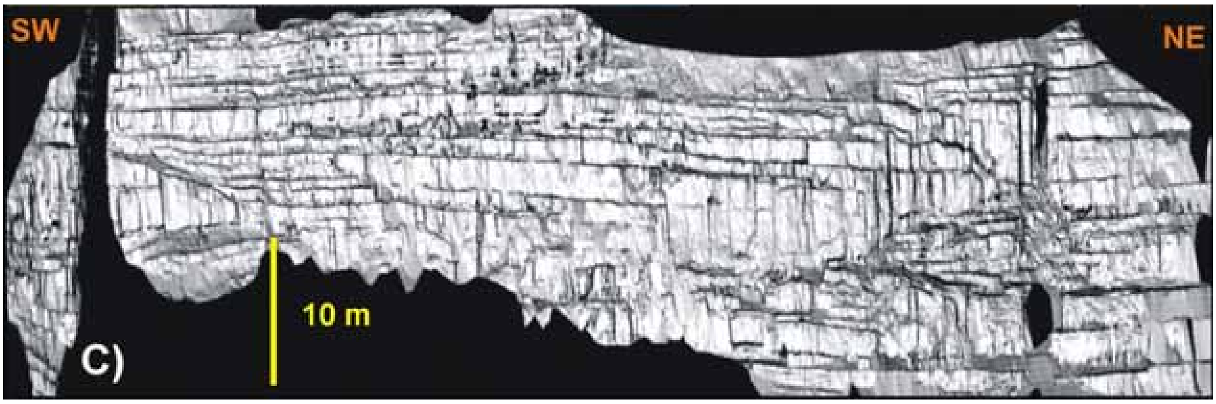
Geologist using the OPTECH ILRIS-3D ground-based LIDAR[17].



Composite point cloud from 51 merged LIDAR scans.



Rotated and elevated view of the same channel from all 110 scans.

Note that this display allows for easy imaging of the stratigraphic architecture – which was impossible from the original field survey.

Another study of the Beacon channel outcrop in West Texas demonstrated 'sweep and swing' movement of channels – something that has been deduced before from seismics but not before in outcrop. This involved a lots of manual input – palaeocurrent interpretation etc. Sweep/swing was mapped across two or three stacked channels.

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[17] All images in this section courtesy Renaud Bouroullec, Mark Tomasso, David Pyles and David Jennette and the Laser-Assisted Analogs of Siliciclastic Reservoir Consortium, Bureau of Economic Geology, Jackson School of Geosciences, University of Texas at Austin.

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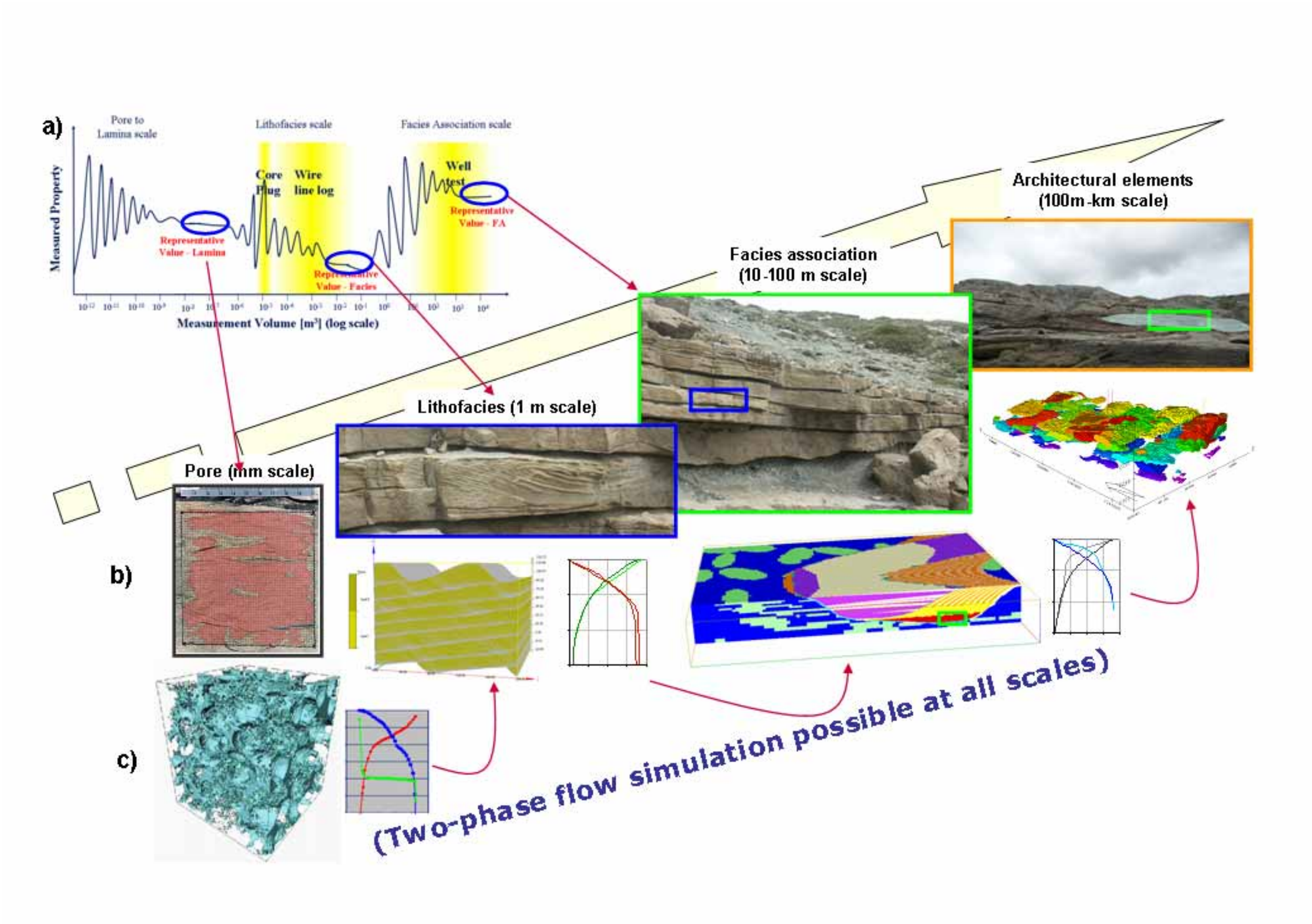
These studies have relevance for West African deepwater slope channels. An exercise in 'forward geological and seismic modeling.'

Q&A

Aerial LIDAR sees through trees what about ground-based LIDAR?

Yes it works great in airborne – but trees on ground are harder[18].

TW0623_9 'Geo to Flow' modeling from outcrop data libraries – Allard Martinius, Statoil et al.



Statoil's multi scale 'Geo to Flow' methodology[19].

From a Statoil operating asset standpoint, multiscale digital outcrop libraries are used in reservoir modeling (not as yet for collaborative visualization). A workflow involves building the modeled, performing fluid flow simulations on multiple realizations of multiple scenarios and using experimental design to rank the results. Behind this workflow lie multiple scaling problems – from core, log, well test to seismic scales, 'how do you integrate disparate scale data?' Outcrop analogs help by supplying scale-related data for depositional understanding, capturing parameter variability and allowing multi-scale models to be built. Studying multiple outcrop settings is also key to understanding reservoirs. Analog data is increasingly important as we look for poorer quality reservoirs.

Models are used to resolve 'Geo to flow[20]' issues such as which heterogeneities matter most and under which drainage scenarios. Martinius advocates building and testing flow models early in the workflow. Geomodeling Technology's SBED is used to condition models. A model based (not measurement-based) approach is preferred –

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[18] *Comment – There are different LIDAR acquisition techniques. Point cloud data appears to be a gated, first arrival measurement giving a position in 3D space. Airborne LIDAR is full waveform (see for instance http://www.isprs.org/commission3/proceedings06/singlepapers/O_18.pdf) and can visualize both the tree canopy and the ground.*

[19] *Image courtesy Statoil.*

[20] *See also http://www.oilit.com/2journal/2article/0510_8.htm - probably not the same project!*

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'basic measurements cannot be upscaled – only models can.' A 'representative value' (REV)[21] (Nordhal 2005) is defined as a measured property as function of volume measured. The next step is to look for stability for each measurement class – thin section, core/wireline, well test. The REV is stored in the library. Tools are used as a function of scale of investigation – eCore (mm), SBED (m), SBED Studio (10-100m) and IrapRMS (100-1km). Add in LIDAR, NGS, FMI data and store multi scale models in library (the future). Today models are 'function based;'

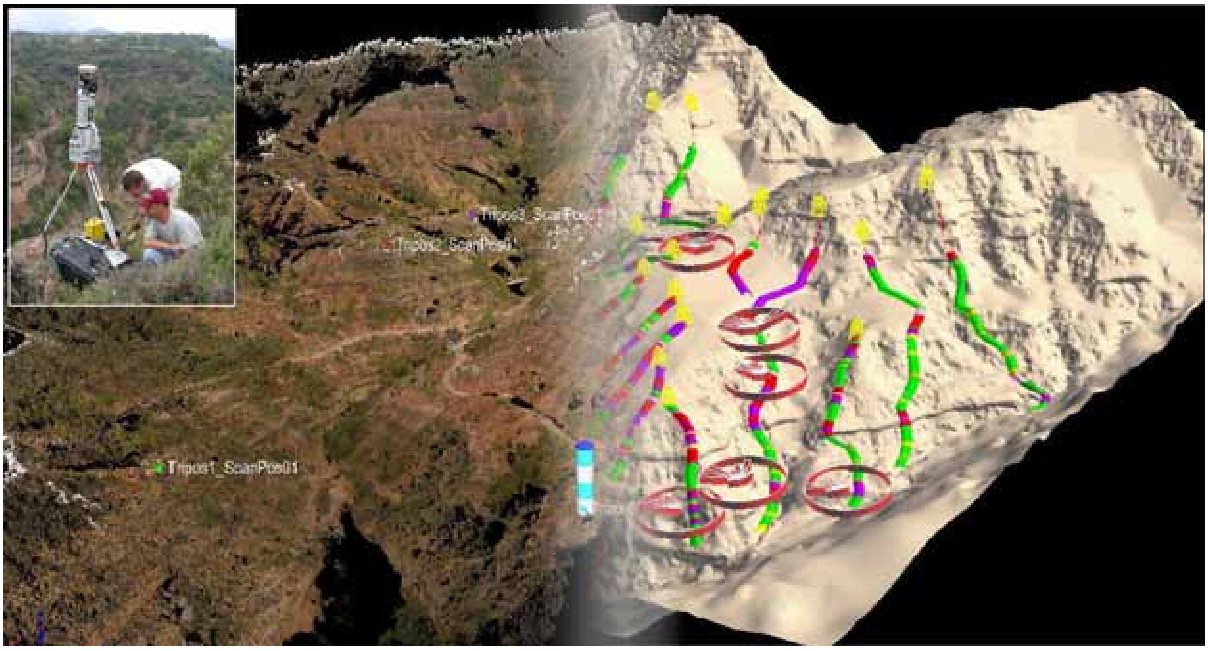
The Geo-to-Flow workflow[22] has been tested and is used for pore scale modeling. Meter-sized rock samples are also sliced up to study the internal architecture. This is used to improve SBED modeling. FMI logs and NOMAD also ran. A very detailed model was created showing point bars, channels and other facies in the fluvial environment (Lourinha, Portugal). Statoil has simulated fluid flow on the outcrop model and is using ANOVA[23] statistical techniques to analyze results. Martinius asks 'What is the value of digital outcrop data?' A matrix shows the high value of parasequence position in a shallow marine environment and the low value of fault seal in tidal (along with many other variables). This presentation helps conceptual geological understanding and was somehow related to 'an expected $350 million increase in NPV[24] on the Smorbukk development.'

Q&A

What about the eternal question as to what is the right analog? Does the digital library allow for data mining and resolution of such questions?

It should do.

TW0623_10 Escanilla formation, Ainsa Spain – Richard Labourdette, Total[25] et al.



Aerial photography, LIDAR and pseudo logs over Escarillia formation[26].

Analog of fluvial reservoirs

A combination of aerial photographs and LIDAR was used to map laterally amalgamated channels in the Escarillia formation (Ainsa, Spain). The study targeted flood plain relics by extracting geobodies from the LIDAR imagery. This provides information on lateral reservoir heterogeneity. Sedimentological pseudo-logs were extracted from

[21] *http://www.force.org/PDW-Seminars/From%20Scale%20to%20Modelling_16_October_2006/Janka_presentasjoner/PDF/Why%20SBED%20Force%20Seminar%20Oct2006_Phillip%20Ringrose.pdf.*

[22] *A NumericalRocks image was shown but not cited – see TW0617_6.10.*

[23] *http://en.wikipedia.org/wiki/Analysis_of_variance.*

[24] *Net present value.*

[25] *Co author Richard Jones, Geospatial Research Ltd., Department of Earth Sciences, University of Durham, UK www.geospatial-research.com.*

[26] *Image courtesy Total.*

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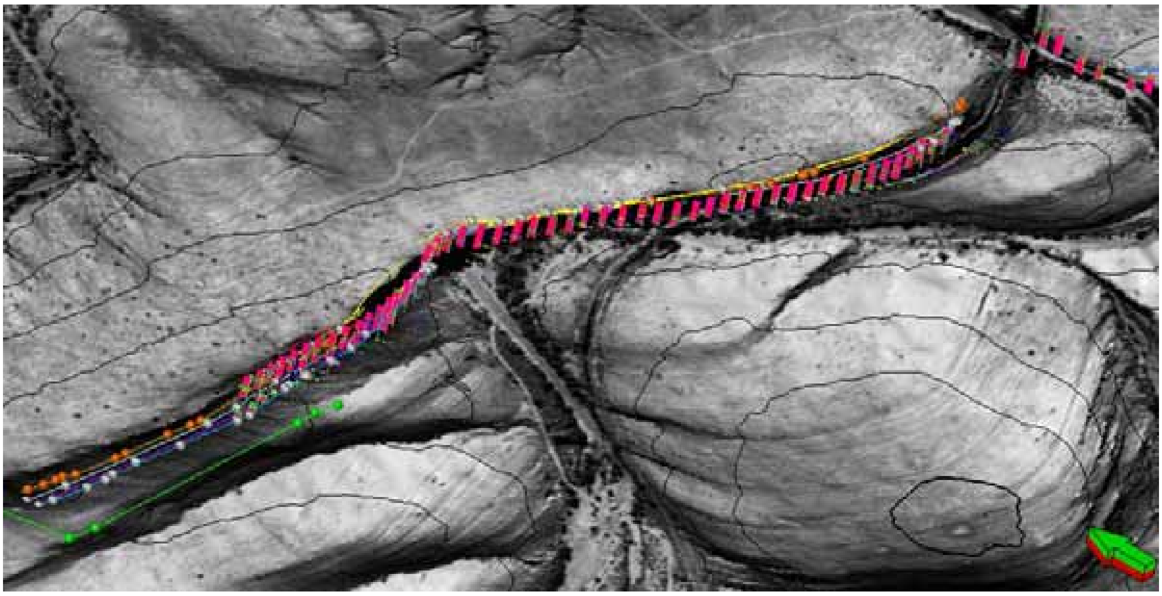
the Lidar database. 3D spatial coherence provided 'counter-intuitive' results, such as the static connectivity created by vertical gravel chimneys. LIDAR was deemed a 'unique analog reference tool – no other technique allows so much information of direct use to reservoir modeler.' Labourdette summarized the application of the techniques as follows, 'LIDAR is used to construct deterministic models that accurately reflect the spatial relationships of stratigraphic surfaces and architectural elements to a degree hitherto impossible to achieve. Such results can easily be incorporated into reservoir models and used as conditioning trends for stochastic modeling of subsurface geobodies and heterogeneities. The introduction of such spatial evolution of architectural element morphology is a significant step in reducing uncertainties linked with random subsurface stochastic modeling.'

Q&A

How did you integrate the pseudo logs with LIDAR?

Inside GoCad.

TW0623_11 Comparison of digtal outcrop techniques – Jamie Pringle, Keele[27] et al.



Outcrop data integrated within Schlumberger Petrel[28].

The SLOPE2 project is a multi measure study of the Skeiding formation (Laingsburg – Karoo, S Africa) involving a 'walking out' RTK differential GPS survey of main horizons with sedimentary logging and correlation. Hodgetts' VRGS software (above) was used along with Petrel. Ground penetrating radar (GPR) also ran. Ground based LIDAR was 'not much help.' All results are collected in a single Petrel model. Modern digital techniques were found to complement traditional acquisition as follows...

Digital aerial photogrammetry	Regional-scale correlation Build framework for other digital outcrop data
High-resolution differential GPS	Mapping of key horizons Quantitative analysis of body geometry that would be hard to get with conventional methods Accurate positioning of both palaeocurrent and structural sampling positions
Ground penetrating radar	Image key buried horizons (in certain circumstances)
Ground-based LiDAR surveys	Limited where exposure is less than perfect Useful to map out stratigraphic horizons on inaccessible cliff-faces

Q&A

Depth conversion and penetration of GPR data?

Depth conversion is not an exact science – a 1m/nanosecond velocity can be used. Penetration is frequency dependent.

[27] *School of Earth Sciences & Geography – Keele University (UK) – www.esci.keele.ac.uk.*

[28] *Image courtesy Jamie Pringle.*

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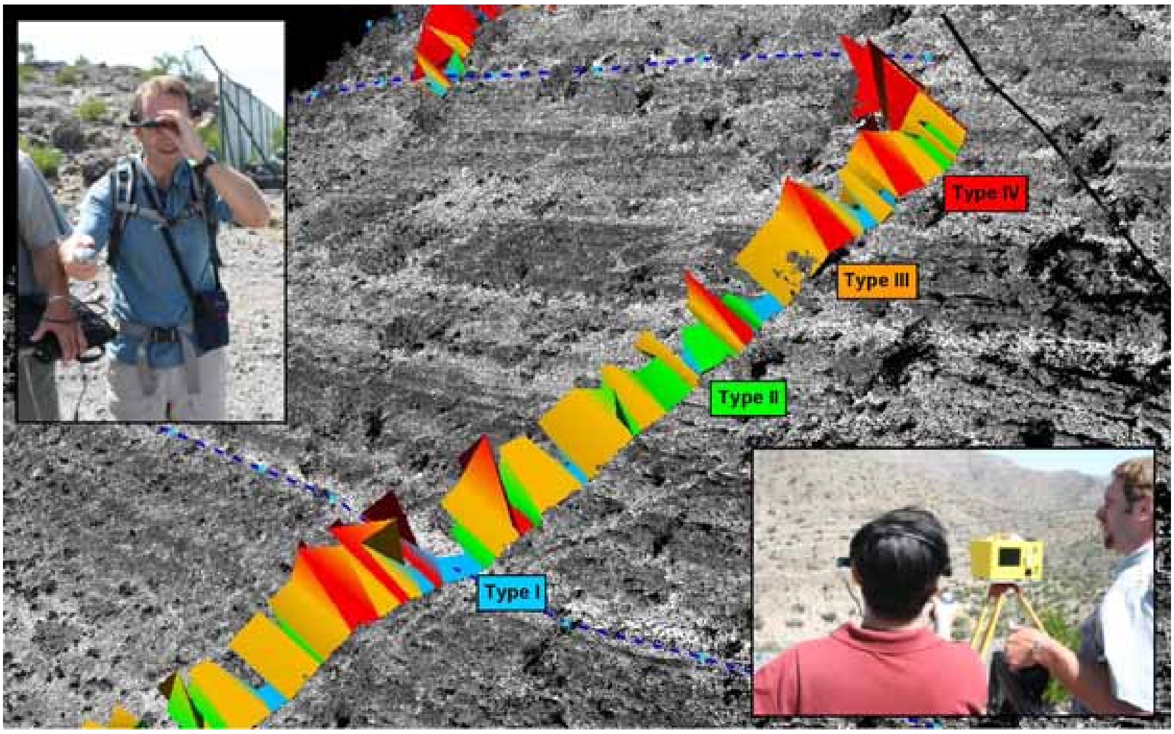
TW0623_12 Carbonate reservoir categorization – Erwin Adams, Shell et al.

Analog of Middle East Carbonate Oilfields



Head-up display and gyroscopic mouse blend virtual and real worlds[29].

No systematic approach has been developed for quantitative carbonate analysis and you can't do experiments as for clastics. This leads to the interest in carbonate outcrop analogs. Shell uses an in-house developed 'Simple Visualization Software' tool to visualize RTK[30] GPS and LIDAR. Shell prefers raw LIDAR data without decimation and drape. RTK GPS is used for 'logging' and calibration of LIDAR. Outcrop selection is key, it has to be a 'pseudo 3D' geometry. Shell imports photo imagery into Petrel for interpretation. (See Jerome Bellian's poster paper below on use of head-up display in field data collection.)

Carbonate platforms are traditionally modeled as homogenous layer cakes. There are no present day analogs. A study for Shell's Oman unit leveraged LIDAR and Quickbird satellite data. Field work, 'walking out' with RTK GPS was used to map the channel base. The Scotese palaeomap project was used to show the shallow sea east of Arabia during the Albian. Seismics show clinoforms and incisions into a prograding platform (but you need long lines to see them[31]). No single outcrop shows all. The model lets you zoom in on one channel to characterize the nature of the incision. This was another very impressive demonstration of a range of technologies.

A study of the Cretaceous Vercors platform (France) leveraged airborne LIDAR (with the University of Provence). Another survey was carried out over a Jurassic platform in Morocco (with Chevron). Work with the BEG[32] involves classifying rock types according to their LIDAR intensity (spectral reflectance). This 'seems to work.' An intriguing head-up display (HUD) and gyroscopic mouse was used during fieldwork to compare the real and virtual worlds during LIDAR acquisition is in progress.

Q&A

What equipment was used for acquisition?

An Optech Ilris LIDAR was used – this may produce more information than the Riegl device.

How useful was the head-up device (HUD)?

The HUD was the latest technology, fresh from the US army. Actually it was quite useful.

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[29] *Image courtesy Shell.*

[30] *Real time kinematic GPS – see http://pro.magellangps.com/en/products/aboutgps/rtk.asp. .*

[31] *Q.V. Peter Vail – AAPG Memoir 27!*

[32] *Bureau of Economic Geology at the University of Texas at Austin.*

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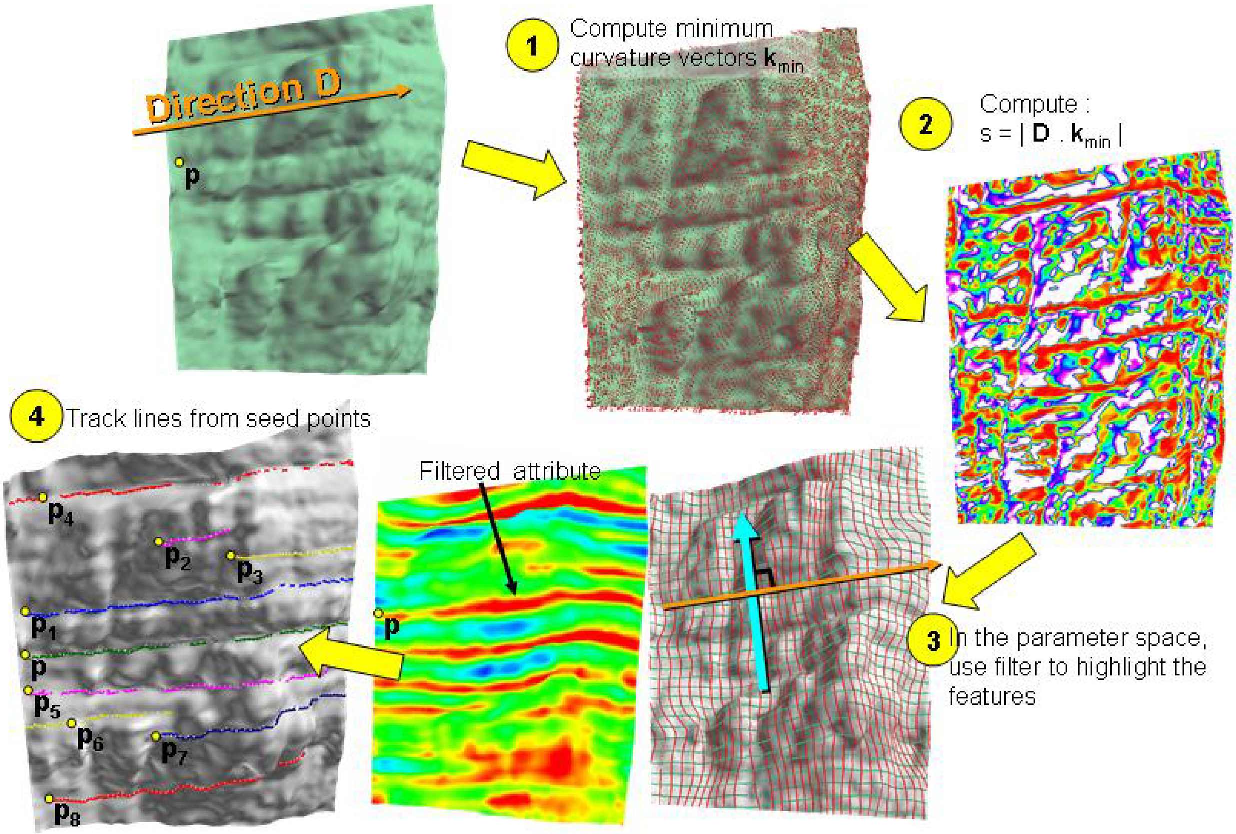
TW0623_13 Seismic-like facies mapping of Vercors – Sophie Viseur, University of Provence[33] et al.



Pseudo-seismic data generation and auto-picking from LIDAR outcrop data.

Viseur was confronted with the problem of processing and interpreting 20km of helicopter LIDAR data along the spectacular Vercors cliff face. Two algorithms were tried - partitioning with mesh optimization and seismic-like facies mapping (See Cohen-Steiner et al. 2004 and Levy 2004). 'Graphite' partitioning works on change of slope of outcrop but this did not work in the Vercors dataset. Instead, 'attributes' of intensity, maximum curvature were used to show fractures and bed boundaries. Other algorithms were better for interpretation – with seed points and auto picking. Add a bit of fk filtering[34], color and you have a seismic section! Demo with GeolTools.

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[33] *Laboratoire de Géologie des Systèmes Carbonatés – Université de Provence – www.up.univ-mrs.fr/gsc/.*

[34] *Frequency wave number – accentuates data of given dip/strike.*

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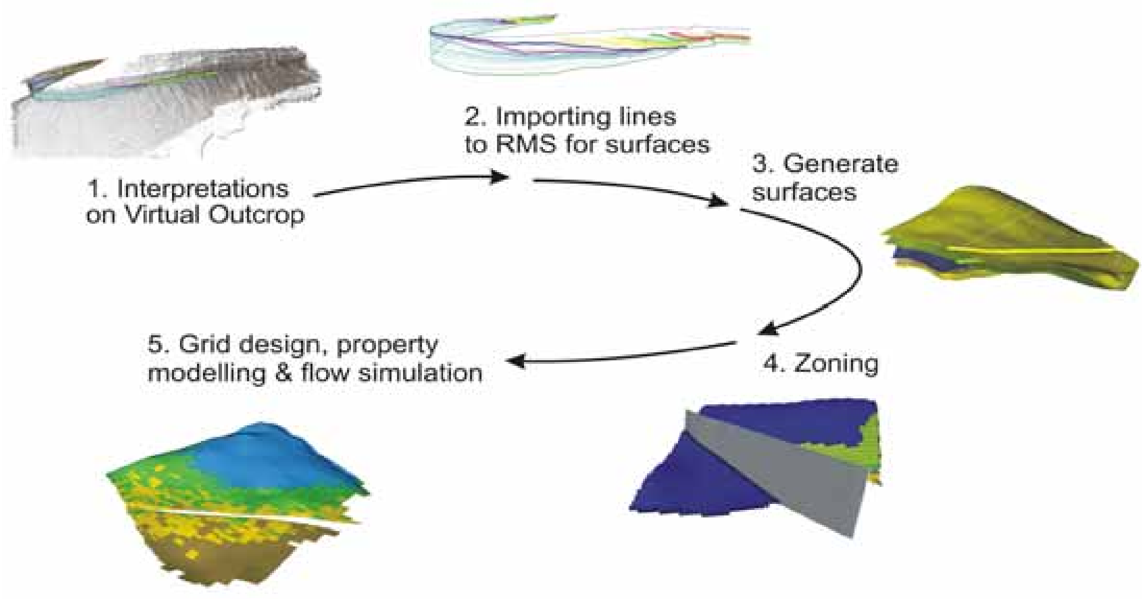
TW0623_14 The Virtual Outcrop project – Håvard Enge, Bergen University[35] et al.



Workflow from outcrop to reservoir model.

The Virtual Outcrop project uses Laser scanning as a sedimentology tool. ReScan software was used for data preparation before export to Irap RMS. The study focused on clinoforms which act as flow barriers in some Norwegian North Sea reservoirs.

TW0623_15 Other Presentations

0623_15.1 Ferron Sandstone, Utah – Peter Deveugle, Imperial College, London[36] et al.

Analog of deltaic reservoirs such as Prudhoe Bay and Sakhalin

A study of the Ferron Sandstone (South of Salt Lake City, Utah) investigated the impact on fluid flow of geological heterogeneities, defining a reference case for the study of sparser data sets. Stochastic workflows were designed and tested. Data includes digital elevation models, satellite photos, photopans, GPS, LIDAR, wells and outcrop measurements. Deveugle has code that imports photopan amplitudes into Petrel seismics for interpretation.

0623_15.2 Outcrop sedimentology from field to model – Ivan Fabuel-Perez –University of Manchester[37] et al.

Analog of Algerian TAGI[38] Formation.

Oukaimeden Sandstone, High Atlas, Morocco is a good analog to the TAGI formation, a producer in Algeria. Perez showed an amazing 3D photo-draped model of a 3km long by 300m high outcrop. Hodgett's VRGS was used to integrate data – described as 'a powerful tool for integration of traditional field data with digital information.'

Q&A

Can you use LIDAR for sedimentological field work?

Yes – Dave Hodgett want's to use tablet PC's in the field to do this.

0623_15.3 Value of research boreholes in outcrop studies – Dave Hodgson, Liverpool University[39] et al.

The NOMAD project on the Tanka-Karoo fans drilled and cored shallow wells across Karoo basin floor fan outcrop, South Africa. The boreholes were logged with GR-ECS-FMI logs. Delft University's artificial neural nets were applied to the log data to extract lithofacies from the GR – this was 'very successful.' Also got palaeocurrent

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[35] *Co authors Simon Buckley (2),John Howell (2), Åsmund Vassel (1), Beate Leren (1) and Allard Martinius (3) (1) Centre for Integrated Petroleum Research / Department of Earth Science, University of Bergen www.cipr.uib.no, Norway (2) Centre for Integrated Petroleum Research, University of Bergen, Norway (3) Statoil.*

[36] *ExxonMobil-sponsored PhD student.*

[37] *North Africa Research Group.*

[38] *Triassic Argilo-Gréseux Inférieur – one Algeria's most productive reservoirs.*

[39] *Strat Group - http://pcwww.liv.ac.uk/strat/.*

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data from FMI and Built palaeocurrent maps for each fan. The 'holy grail' is to be able to extract 3D information from the 1D borehole measurement – 'simulating field development'. Data was modeled with David Hodgetts VRGS tool. Hodgson concluded that the 'conceptual depositional model is key to 1D to 3D extrapolation.'

0623_15.4 Real Time Kinematic GPS (poster) – Jerome Bellian, BEG[40], Austin et al.

The 'bionic' geologist[41].

Real Time Kinematic GPS and head-up display used to present log/model data over outcrop to field geologist. Interaction with the computer model with a wireless gyroscopic mouse.

0623_15.5 Multi-scale outcrop data libraries – Bjørn Terje Oftedal et al., Statoil et al.

East Greenland airborne LIDAR survey by Blom Geomatics for Statoil[42].

[40] www.beg.utexas.edu.

[41] *Image courtesy Shell.*

[42] *Image courtesy Statoil and BLOM Geomatics.*

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Analog – Jurassic of Halten Terrace, offshore Norway

An airborne LIDAR survey of the area around Liaselv, Jamesonland, East Greenland investigated the spectacular cliffs of the Pelion Formation, deemed to be a good analog for the Garn Formation of the Mid Norwegian Shelf. Part of a vast, ongoing study of multi-scale heterogeneity modeling and upscaling.

TW0623_16 Resources

Riegl Laser Scanners	http://www.riegl.com/.
Optech Ilris Scanner	http://www.optech.ca/i3dfeat-ilris.htm
ISite 3D Laser Imaging	http://www.isite3d.com/studio.html
Laser-Assisted Analogs of Siliciclastic Reservoirs (LASR) Project	http://www.beg.utexas.edu/indassoc/lasr/index.htm
CosmoWorld	Cosmo VR player http://www.karmanaut.com/cosmo/player/
Innovmetric Software	http://www.innovmetric.com/manufacturing/su_techspecs.aspx?lang=en
Reactivation Research Group	http://www.dur.ac.uk/react.res/RRG_web/
GAVA	http://www.dur.ac.uk/react.res/RRG_web/GAVA.htm

TW0623_17 Appendix 1 – sampling LIDAR and digital photo data – Dave Hodgetts

The point of meshing and texture mapping a point cloud dataset is to use the extra information in the photographs to fill in the gaps between the data points. This only works if the area a pixel covers on the outcrop is smaller than the data spacing of your points. The down side of texture mapping comes from the increase in the amount of data to be visualized - therefore slowing it down. If you consider drawing a point cloud each data point is drawn once, however if you triangulate the data, each triangle you draw has 3 points to it, and many points from the point cloud will exist in more than one triangle. Therefore you are in fact sending a lot more data to the graphics card. In order to address this problem the mesh may be decimated. This is done by looking at each vertex in the mesh and checking to see if you remove it and re-mesh that part of the surface how much difference will it make to the geometry. If the change is negligible then the point can be removed. A flat surface does not need many points to define it so more points would be removed, a complex surface however would change a lot and needs more point to keep its shape and less are removed. Obviously in doing this you are degrading the data, the amount the data is degraded depends on the geometry and the parameters used in the decimation algorithm. Ideally you would not decimate the mesh, but in many cases the undecimated mesh is so slow to use it is impractical.

TW0623_18 Technology Watch subscription information

This report has been produced as part of The Data Room's Technology Watch reporting service. For more on this subscription-based service please visit the Technology Watch home page or email tw@oilit.com.

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