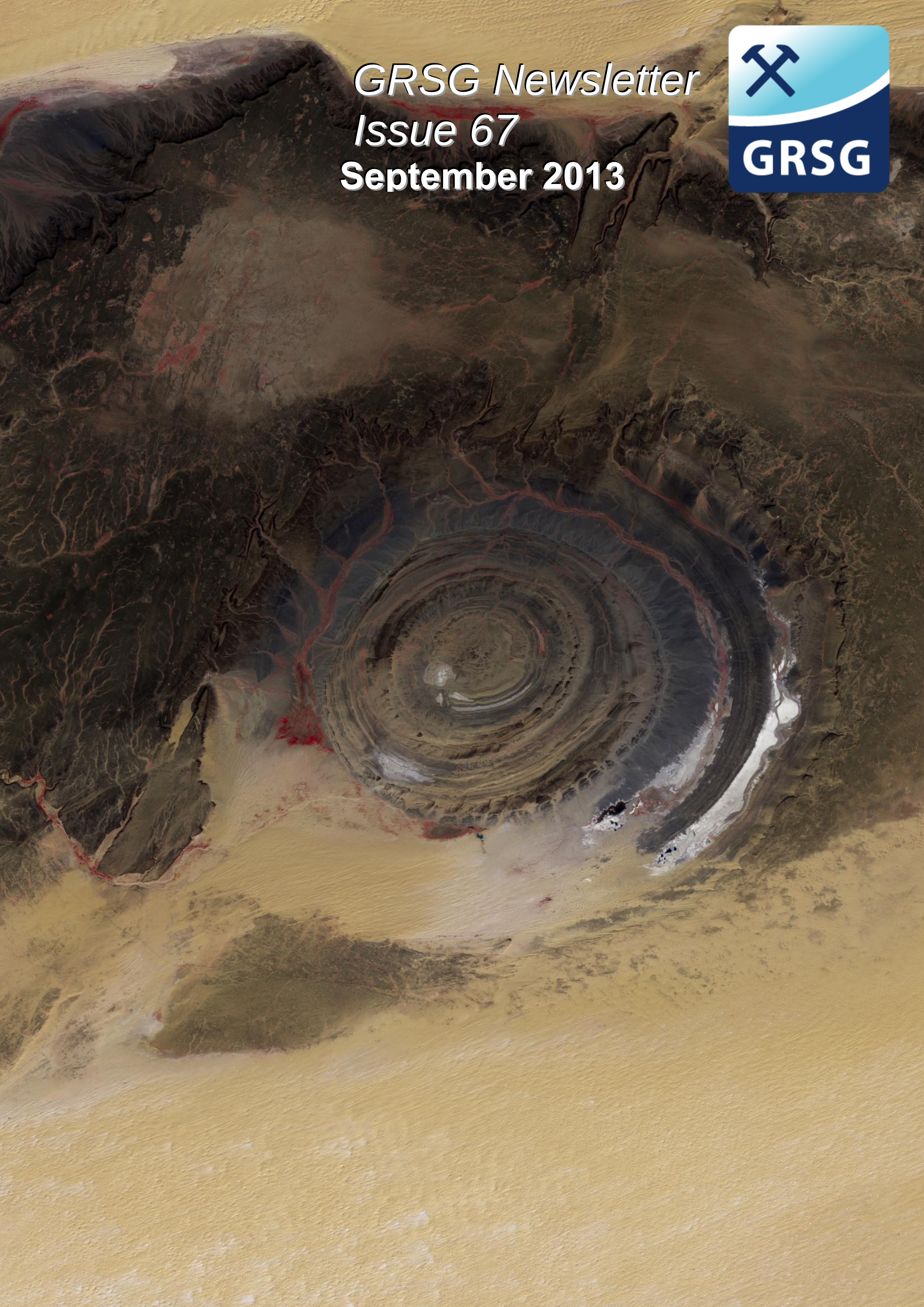
GRSG Newsletter
Issue 67
September 2013



GRSG committee

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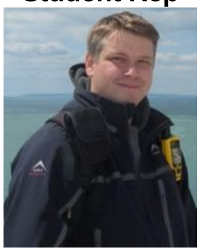

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Committee

Contents Issue 67

The Geological Remote Sensing Group (GRSG) is a Special Interest Group affiliated jointly with The Geological Society of London and the Remote Sensing and Photogrammetry Society. It was founded in 1989 to raise awareness and encourage the use of remote sensing technologies in the geoscientific and related communities. The GRSG seeks to represent the views of industry, government and academic individuals and organisations - resulting in a balanced scientific, technological and commercial viewpoint.

Front Cover

Richat Structure, Mauritania acquired by UK-DMC2 satellite image© [2012] SSTL, all rights reserved, supplied by DMCii.

Chairman's message

Dear Members

The stunning cover image that Charlotte (GRSG Secretary & interim Newsletter Editor) has chosen for this edition of the newsletter is the famous Richat structure in Mauritanian Sahara. Two lessons come from this image: firstly it reminds us of *scaling factor in nature (how natural forms often repeat at multiple scales)* - the image could easily be a close up image of a wood knot and burr of a tree trunk; secondly, *uncertainty* – the origins of this structure have been debated for a long time (including evidence from geological remote sensing specialists), with for many years the Richat structure being considered to be a meteorite impact crater, but the consensus now is that the origin is not extra-terrestrial but rather an eroded stratigraphic dome of sedimentary rocks and ring dykes – quite a combination – more here courtesy of wiki http://en.wikipedia.org/wiki/Richat_Structure. Maton et al (2005) http://geology.gsapubs.org/content/33/8/665.short describe the origin as *"The circular Richat structure and its breccia core thus represent the superficial expression of a Cretaceous alkaline complex with an exceptionally well preserved hydrothermal karst infilling at its summit".* So, all in all the Richat structure helps to remind us that remote sensing geologists may not know it all (all the time) and can benefit by still getting out in the field at times!

It is now 2 months to go until the Berlin meeting (9-11 December 2013) and Conference planning is progressing well. The theme of 24th AGM GRSG2013 is **'Status and developments in geological remote sensing'.** This year the organising committee have received a record number of abstracts. Whilst this has made the task of selecting abstracts to approve more difficult and unfortunately some potentially excellent presentations shall have to be omitted, it does mean we have a full programme comprising an excellent range of presentations (and posters) at the meetings. Topics and sessions will cover a range of areas, including: geological mapping, mineral exploration, hyperspectral, oil and gas; radar, new developments, geohazards & environment, DEM and geomorphology and planetary remote sensing. We also have three confirmed keynote presentations that should be of great interest:

- Ernst Hauber (Institute of Planetary Research, German Aerospace Center DLR) – 'Morphometrics on Mars and Earth – comparative geomorphology'
- Trude King (USGS) – 'Spectroscopic Remote Sensing: A Tool for Resource Evaluations in Afghanistan'
- Andreas Mueller (DLR) – 'EnMap - the new hyperspectral satellite system, new application in mineral identification'

A small exhibition will also accompany the conference and a wide range of networking opportunities have been programmed, with an ice-breaker (8 Dec), wine reception (9 Dec) and conference dinner (10 Dec) in addition to lunches and regular coffee breaks.

The GRSG are grateful for the support of conference sponsors: **Astrium, Intergraph, Itres, SphereOptics, NPA Satellite Mapping, GeoSense, Southern Mapping, Digital Globe, Excelis, Arup, Spectral Evolution, Riegl and RapidEye**. Conference sponsors presence at the event (most with booths and/or presenting) help to make the GRSG meetings a success as it provides an opportunity for GRSG members to see some of the service offerings from leading organisations involved in remote sensing. A number of booth spaces are still available, so if you are interested in having a booth or sponsoring the event please contact treasurer@grsg.org.uk for more information
Committee changes – Jacques Malaprade has recently stepped down from the GRSG committee and we are grateful for his assistance on the committee over the last year. Huma Irfan (Geonergy) is our very proficient website manager (we hope you all like the improvements to the website over

the last year) and has now taken on additional responsibility for membership. New committee members we have welcomed to the GRSG committee in 2013 year include Xue Wan (Imperial College) and Elspeth Robertson (University of Bristol). Elspeth has kindly volunteered to take over as Newsletter Editor from Charlotte (from the next edition). Huge thanks are due to Charlotte for so ably managing and producing the excellent newsletter over the last few years.

In addition to thanking the UK committee for their efforts sitting on this voluntary committee I also offer significant thanks to our German GRSG members who are on the organising committee for the upcoming Berlin meeting: Friedrich Kuehn, Cornelia Glaesser and Christian Fischer.

Contact details of the GRSG committee can be found at https://www.grsg.org.uk/about-grsg/committee/ Please contact us should you have any contributions or content. Prospective committee members would be welcome, in particular we would be keen to have additional committee members from the oil and gas and mineral exploration industries.

For this newsletter I also provide you with a little quiz – hopefully you will enjoy

I look forward to hearing from you soon and to seeing many of you in Berlin.
Best wishes

Jason Manning (GRSG Chairman)

Jason Manning
chairman@grsg.org

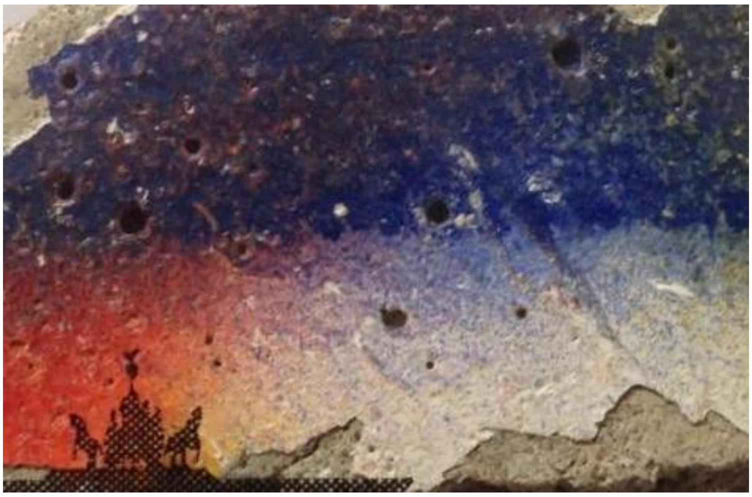
Quiz - multiple choice:

Question: Where in the wider world is the following image?

A) ***HiRISE image of Gale crater, Mars, showing basaltic sands (blue) merging to phyllosilicate rich sediments (red) and olivine rich bedrock (grey),***

B) ***ASTER band ratio (RGB 12/13, 11/12, 14/13) Craters of the Moon National Monument, Idaho, or***

C) ***RGB Berlin***



Editor's message: The last hurrah

Greetings all,

I hope you are all well and have enjoyed good summers (or winters) wherever you are in the world.

Its time to say goodbye.....

It has been on the cards since December 2012 when I actually stepped down from this role but unfortunately we had no one to fill it, but I can now inform you that this will be my last Newsletter following the appointment of Elspeth Robertson to the role at our last committee meeting. The email contact address below does not change its just the person you will be talking to will be different. It has been an absolute pleasure writing the newsletter over the last 4 years even if I was duped into being the newsletter editor at the Afterglow of the 2008 AGM in London following some rather desperate pleas and a couple of free drinks I accepted (thanks to Richard Teeuw and Dan Taranik for that). But, in all honesty it has been brilliant I have had the opportunity to meet some great people doing this role and many of whom I can very happily call my friends but it was time to let someone else put their stamp on the newsletter and as I have been GRSG Secretary since January 2013 it has been quite difficult juggling two roles so many thanks to Elspeth for taking this on, I wish you lots of luck for the role I hope you enjoy it as much as I have. I shall miss contacting many of you quarterly for inputs but I am sure many of you will be relieved that you don't see my name keep popping into your inbox (although it will now be Elspeth's...sorry)!

Now onto the standard Editor message waffle that I couldn't miss out particularly as this is my last newsletter....

I am familiar with the concept of charity animal adoptions of tigers, pandas, dormice and even goats that you can do to support worthy causes yourself or to buy as gifts for people however I never thought this would apply to satellites. Whilst I would totally LOVE (not that this will be a surprise to most people who know me) the opportunity to adopt an actual satellite it seems that this might still be a little while off (shame) but the reality of adopting your own Landsat pixel is here, hoorah! No this is not a joke it is entirely real, set up by NASA/USGS largely to help them calibrate Landsat 8. All you have to have is a camera, compass, internet and then choose a location (e.g. one you visit regularly) and take a picture north, south, east, west and straight up and straight down and then upload them to (www.flickr.com/groups/landsat-adopt-a-pixel) with all the relevant locational information. I guess sadly unlike the traditional charitable 'adoption' that you can do you do not receive a sticker, certificate or updates on your pixel every quarter but the concept is pretty cool and is designed to get people involved in science more in a pretty fun and unique way. How they then police that you 'own' that specific pixel, so no one else can take advantage of 'your' pixel is anyone's guess (perhaps electrified fences around 'your' 30mx30m square?!)... but I still think it is brilliant.

Anyway, back to this issue as usual it is a very packed issue with a number of articles including one from one of our previous student award winners, Martin Airey who has written an article on his work on Volcanism on Venus, an article from Corescan on their system and some recent examples, Spatial Energy on how they used 4m Pleiades DEM to support seismic planning, Proteus on their bathymetric modelling as well as ENVI who have sent through articles on mineral exploration as well as some recent developments and much much more. As usual we also have the usual spread of news and developments, events and most importantly we are gearing up for the GRSG 2013 in Berlin. We have been inundated with presentations this year and are in the process of finalising the programme which we hope to release sometime in the next few weeks.

My thanks again to all those who have contributed to this issue and all of the other newsletters I have had the pleasure to be editor of including, although he is not a GRSG member, my brother who prepared all of the cartoons you see intermingled in the newsletters I might owe him a few beers for that. Many of you are regular contributors and whilst I know at times I have pestered some of you quite a lot I really appreciated all of the support you as members and sponsors have given the GRSG to make the newsletter as good as it can be....all I do is compile it and this newsletter really would be nothing without you. All I can say is please keep it up so we can continue to provide a full and comprehensive newsletter every quarter.

As usual if you have any comments (good or bad) then I (or from now on Elspeth) am always happy to receive them, this newsletter is prepared for you, the membership, so if there is something you don't like then please let us know. Likewise if you have any items you would like included e.g. images for the front cover, conferences, news items, articles etc then please send them through and they will go in the next newsletter.

I look forward to seeing you many of you in December and thank you all again for everything...its been awesome.

All the best

Charlotte Bishop
GRSG Newsletter Editor - newsletter@grsg.org.uk

All past GRSG newsletters (1-66no.) are available on the website
https://www.grsg.org.uk/newsletters/

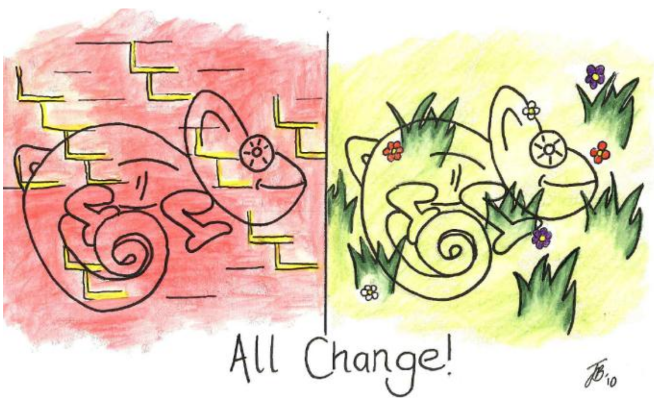
GRSG News

The abstracts and presentations for the GRSG 2012 AGM are now available on the website for you to review and download. Apologies it has taken some time to collate these but we had some outstanding presentation approvals that we wanted to finalise before we made them all available.

GRSG AGM 2013 is proving to be a popular event, we have been inundated with presentations to the point where there will be some we will not be able to accept on this occasion. A first draft programme will be released in the coming weeks and we urge you to register early to avoid disappointment. We are anticipating this to be a very popular event and do not want you to miss out. Registration can be done through the website (https://www.grsg.org.uk/agm/) or contact the treasurer@grsg.org.uk if you are interested in sponsorship opportunities (which also provide delegate registration). We look forward to seeing you in Berlin!

We also have a couple of mid year committee changes. It is with regret that we say goodbye to Jacques Malaprade who stepped in as our Membership Secretary following Robin Coackley leaving the committee earlier in the year. Jacques has now left the committee to pursue a PhD at UCL we are sorry to see him go but we wish him well. Given the link of the Membership role with our new online membership system Huma has very kindly said that she will take on this role in conjunction with her Website Editing so thank you Huma! In addition, having already stepped down from the newsletter role in December 2012 we now have a replacement newsletter editor and I step down to take on the role of Secretary leaving Elspeth Robertson (University of Bristol) to take over the newsletter.

Finally, as some of you may know GRSG now has its own Group pages on both LinkedIn (www.linkedin.com) and Facebook (www.facebook.com) but now we are also on Twitter (www.twitter.com) with 47 followers and counting! Search for us under GRSG – Geological Remote Sensing Group (LinkedIn and Facebook) or @grsg_geolsoc on Twitter and join in the discussions and meet other like minded people. For more information on these groups please contact Huma Irfan.



News and Developments

Landsat surface reflectance data available on demand from Earth Explorer

Surface reflectance is now available as a Landsat climate data record (CDR) product. These products are generated on-demand from Landsat 5 TM and Landsat 7 ETM+ data and are also available for the Global Land Survey 2000, 2005, and 2010 collections

(left) TOA reflectance (right) surface reflectance product

Source: NASA Press release May 17th 2013 :http://landsat.gsfc.nasa.gov/?p=5929 and http://landsat.usgs.gov/documents/cdr_sr_product_guide.pdf

Kompsat-5 launches successfully

Kompsat-5 an X band radar, similar to Cosmoskymed launched successfully on 22nd August 2013. South Korea's new multipurpose satellite made contact with a ground station in the Asian country early Friday, confirming its successful deployment into its target orbit, officials in Yasny said.

The first communication contact was made at 2:35 a.m. (5:35 a.m. KST), according to the officials from the Korea Aerospace Research Institute (KARI).

The satellite, also known as the Arirang 5, is South Korea's fourth multipurpose satellite and the first with a synthetic aperture radar, which is an advanced form of side-looking airborne radar that uses radio waves to detect changes in its target area, enabling observation of the earth's surface even at night and regardless of weather conditions.

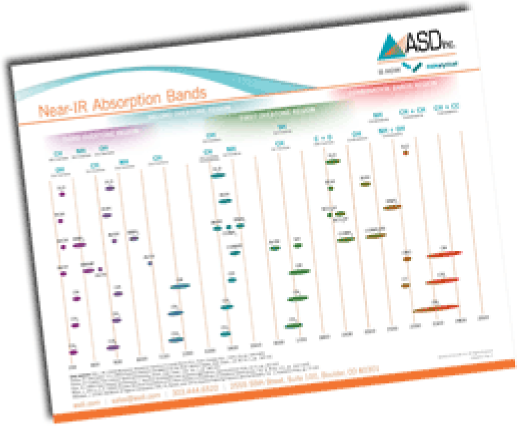
South Korea plans to launch another satellite, the KOMPSAT-3A, late next year. It will be South Korea's first satellite with infrared radar that can detect changes in temperatures on the earth's surface and underground, enabling the country to monitor underground activities, such as volcanoes and earthquakes.

Source:
*http://www.space-travel.com/reports/Telemetry_data_confirms_launch_of_South_Koreab_satellite_999.*html

Near Infrared Absorption bands chart - Free download

Created by the ASD Inc. near-infrared spectroscopy experts, this chart shows the regions where various chemical groups cause spectral features as a result of the fundamentals originating in the mid-infrared region. The features repeat throughout the near-infrared region.

By using this helpful chart, the user can understand which areas of the spectrum are likely to be influenced by these chemical groups. Likewise, the developers of calibrations can identify regions that are not useful to the material or chemical that they are trying to model. The chart is also useful to understand which chemical groups may be confused with each other at specific wavelengths.

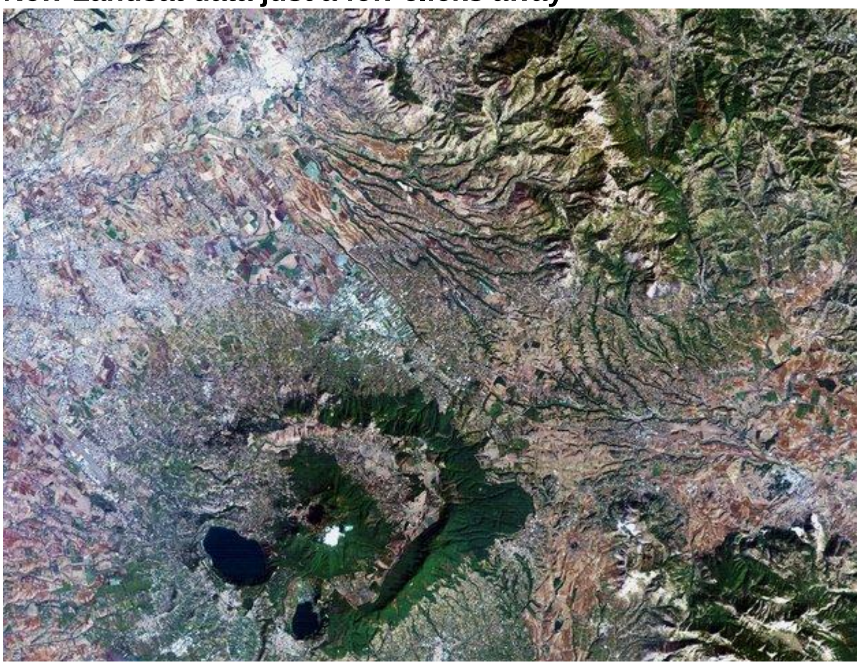


Want to know more?
see http://discover.asdi.com/bid/99700/Near-infrared-Absorption-Bands-Chart-Free-Download?utm_campaign=fieldspec-advisor&utm_source=hs_email&utm_medium=email&utm_content=9982060&_hsenc=p2ANqtz-8lLn2fAuhUQ614qBhLTIHWXxxV2IwRVsAUkVtAio-7LT1-7u7zU3MLjD4s7L91itPKartgQAFCXfDxecy10fUV4okHFw&_hsmi=9982060

Quickbird degrading orbit

DigitalGlobe's QuickBird satellite offers sub-meter resolution imagery, high geolocational accuracy, and large on-board storage. With global collection of panchromatic and multispectral imagery, QuickBird is designed to support a wide range of geospatial applications. Previously at an operational altitude of 482 km, QuickBird is currently operating at an altitude of 450 km and will continue in an gradual descent until its end of mission life at an altitude of 300 km.
See full article at: https://www.digitalglobe.com/sites/default/files/QuickBird-DS-QB-PROD.pdf

New Landsat data just a few clicks away



Thousands of never-before-seen data products from the US Landsat satellites acquired over 30 years have been released for online access. In addition, the newest data over Europe from the latest satellite in the series, Landsat-8, are now accessible in near-real time through a new portal hosted by ESA. About 150,000 new products from the Landsat-5 satellite are available for direct download, free of charge. The products from the satellite's Thematic Mapper instrument were acquired by the Kiruna ground station in northern Sweden between 1983 and 2011.

Source:
http://www.esa.int/Our_Activities/Observing_the_Earth/New_Landsat_data_just_a_few_clicks_away
Image ESA, ESRIN, Frascati Italy ©USGS

Psychadelic mountains

Whilst we suspect a little bit of Photoshop enhancement going one here these are still amazing.... The mountains are part of the Zhangye Danxia Landform Geological Park in China. Layers of different colored sandstone and minerals were pressed together over 24 million years and then buckled up by tectonic plates, according to the Telegraph. There's a similar formation in British Columbia called *the Rainbow Range formed from a mixture of volcanic rock and various minerals*

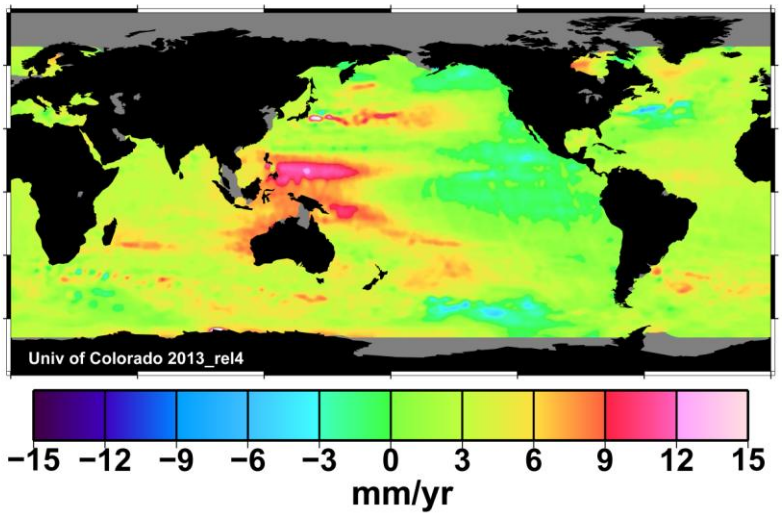
Source:
http://www.huffingtonpost.com/2013/07/31/rainbow-mountains-china-danxia-landform_n_3683840.html?icid=maing-grid7|htmlws-main-bb|dl14|sec1_lnk3%26pLid%3D352238&utm_hp_ref=fb&src=sp&comm_ref=false

GeoEye orbit raise

DigitalGlobe, with the approval of the U.S. Government, will begin an orbital adjustment expected in August (late summer U.S.) 2013 of the GeoEye-1 satellite. DigitalGlobe will raise the orbit of GeoEye-1 to enable true constellation coordination with WorldView-2 (already at 770 km) which has the same sensor optics and resolution.

DigitalGlobe will raise the orbit of the GeoEye-1 satellite from 681 kilometers. This will make GeoEye-1's new nadir ground sample distance (GSD) 46cm; however in line with U.S. government restrictions the products will still be delivered at 50cm GSD.
Source: GeoEye Partner update July 2013

Jason-1 decommissioned



The curtain has come down on a superstar of the satellite oceanography world that played the "Great Blue Way" of the world's ocean for 11-1/2 years. The successful joint NASA and Centre National d'Etudes Spatiales (CNES) Jason-1 ocean altimetry satellite was decommissioned this week following the loss of its last remaining transmitter.

Launched Dec. 7, 2001, and designed to last three to five years, Jason-1 helped create a revolutionary 20-plus-year climate data record of global ocean surface topography that began in 1992 with the launch of the NASA/CNES Topex/Poseidon satellite. For more than 53,500 orbits of our planet, Jason-1 precisely mapped sea level, wind speed and wave height for more than 95 percent of Earth's ice-free ocean every 10 days. The mission provided new insights into ocean circulation, tracked our rising seas and enabled more accurate weather, ocean and climate forecasts.

For full article see: http://www.jpl.nasa.gov/news/news.php?release=2013-213&cid=release_2013-213

Egyption dust plume, Red sea seen by astronaut

This astronaut photograph acquired on June 22, 2013 provides a panoramic view of most of the length of the Red Sea. The northernmost end, the Gulf of Suez, is just visible at the top center of the image and is fully 1,900 kilometers (1,200 miles) in ground distance from the International Space Station (ISS). The Nile River snakes its way northward through the Sahara Desert on the left.

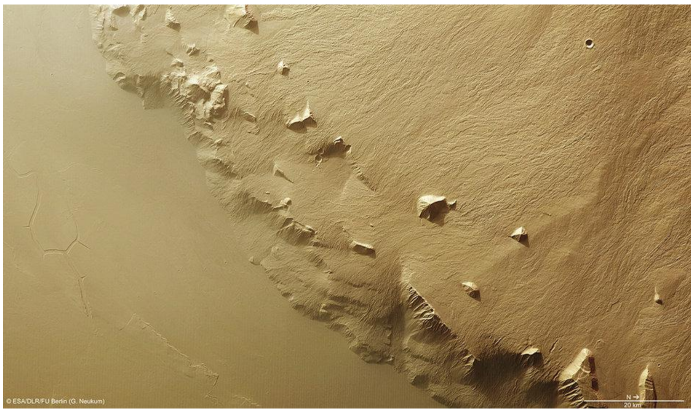
Much closer to the camera—but still more than 550 kilometers (340 miles) from the ISS—is a dust plume surging out over the Red Sea and reaching most of the way to Saudi Arabia. The point source of this plume is the delta of the southern Egyptian river Khor Baraka. Astronaut images have shown that this delta is a common source for dust plumes, mainly because it is a relatively large area of exposed, loose sand and clay that can be easily lofted into the air. The river also cuts a narrow valley through a high range of hills that channels the wind, making it blow faster.
Source: http://www.nasa.gov/content/egyptian-dust-plume-red-sea/

Exelis Vis participation at the Esri EMEA User Conference next October 2013.

Exelis VIS is Platinum Sponsor at the Esri EMEA User Conference. Exelis Visual Information Solutions will highlight recent advances in its ENVI image analysis software for desktop, web and mobile devices at the Esri EMEA User Conference in Munich, October 23-25. Exelis partners closely with Esri, the developers of the ArcGIS® software platform, to deliver technologies that allow geographic information systems (GIS) users to extract important information from imagery and use it to make more informed decisions.
Link to the event : http://emeauc.esri.com/

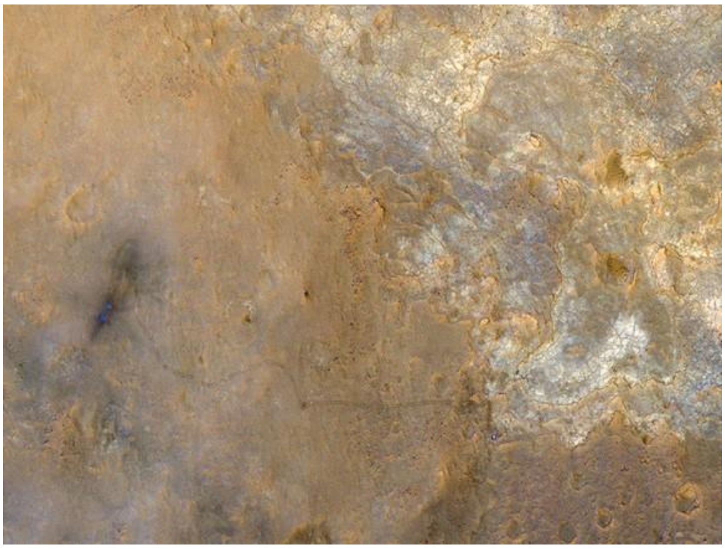
Olympus Mons SE flank

a portion of the southeastern flank of Olympus Mons as imaged by the High Resolution Stereo Camera on ESA's Mars Express on 21 January 2013 (orbit 11524), with a ground resolution of approximately 17 m per pixel. The image centre is located at approximately 14°N / 229°E. North is to the right.
The image highlights the stark contrast between the hundreds of narrow, individual lava flows on the flanks of the volcano, and the smooth lava plains that surround it.



Source: http://spaceinimages.esa.int/Images/2013/07/Olympus_Mons_SE_flank

I spy with my little eye something beginning with.....'C'

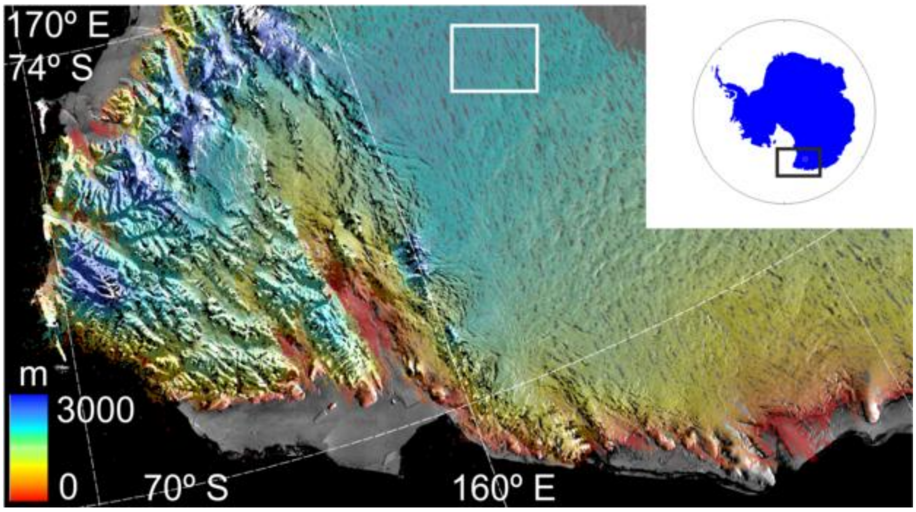


I spy the Curiosity Rover! With the Sun over its shoulders, the High Resolution Imaging Science Experiment (HiRISE) camera on the Mars Reconnaissance Orbiter snapped this image of the Curiosity rover on June 27, 2013, when Curiosity was at an outcrop called "Shaler" in the "Glenelg" area of Gale Crater. The rover appears as a bluish dot near the lower right corner of this enhanced-color image, and also visible are the rover's tracks.

"The rover tracks stand out clearly in this view," wrote HiRISE principal investigator Alfred McEwen on the HiRISE website, "extending west to the landing site where two bright, relatively blue spots indicate where MSL's landing jets cleared off the redder surface dust."

Source: *http://www.universetoday.com/103704/hirise-camera-spots-curiosity-rover-and-tracks-on-mars/#ixzz2bUFldiWT*

Cryosat maps largest eve flood beneath Antarctica



ESA's CryoSat satellite has found a vast crater in Antarctica's icy surface. Scientists believe the crater was left behind when a lake lying under about 3 km of ice suddenly drained.

Far below the thick ice sheet that covers Antarctica, there are lakes of fresh water without a direct connection to the ocean. These lakes are of great interest to scientists who are trying to understand water transport and ice dynamics beneath the frozen Antarctic surface – but this information is not easy to obtain.

One method is to drill holes through kilometres of ice to the water – a difficult endeavour in the harsh conditions of the polar regions. But instead of looking down towards the ice, a team of European scientists is looking to the sky to improve our understanding of subglacial water and its transport.

By combining new measurements acquired by CryoSat with older data from NASA's ICESat satellite, the team has mapped the large crater left behind by a lake, and even determined the scale of the flood that formed it. From 2007 to 2008, six cubic kilometres of water – about the same amount that is stored in Scotland's Loch Ness – drained from the lake, making it the largest event of its kind ever recorded.

Source: http://www.esa.int/Our_Activities/Observing_the_Earth/CryoSat/CryoSat_maps_largest-ever_flood_beneath_Antarctica

MSL SAM instrument Sings Happy Birthday to Curiosity Rover

NASA's Curiosity rover marks one year on Mars next week and has already achieved its main science goal of revealing ancient Mars could have supported life. The mobile laboratory also is guiding designs for future planetary missions. "Successes of our Curiosity -- that dramatic touchdown a year ago and the science findings since then -- advance us toward further exploration, including sending humans to an asteroid and Mars," said NASA Administrator Charles Bolden. "Wheel tracks now, will lead to boot prints later."

After inspiring millions of people worldwide with its successful landing in a crater on the Red Planet on Aug. 6, 2012 (Aug. 5, 2012, PDT), Curiosity has provided more than 190 gigabits of data; returned more than 36,700 full images and 35,000 thumbnail images; fired more than 75,000 laser shots to investigate the composition of targets; collected and analyzed sample material from two rocks; and driven more than one mile (1.6 kilometers).

Source for video : http://www.universetoday.com/103949/msl-sam-instrument-sings-happy-birthday-to-curiosity-rover/
source for article
http://www.marsdaily.com/reports/NASA_Curiosity_Rover_Approaches_First_Anniversary_on_Mars_999.html

For more news and information about GRSG check out the news feed on our new website!
http://www.grsg.org.uk/

Students

Attention all students!!

Students are also reminded that membership fees are being held at only £7 to encourage more student members to join GRSG. If you would like to join or would like to know more information please contact the GRSG Student Representative Mathias Leidig (Mathias.Leidig@port.ac.uk) or the GRSG Membership Secretary, Michael Hall (membership@grsg.org.uk).

GRSG Travel Bursary

Once again the GRSG is making a number of travel bursaries available to students who would like to attend the 2013 AGM in Berlin in December. The bursaries are each £150, towards travel and accommodation costs. All GRSG student members are eligible to apply (Student membership is only £7!!).

If you are interested in applying for this bursary then please apply using the application form https://www.grsg.org.uk/news/grsg-student-travel-bursary-deadline-for-grsg-agm-2013-is-friday-the-27-09-2013/. Deadline is 27th September 2013. Please note that this deadline is independent on the abstract deadline. Please consider submitting an abstract before applying for a bursary. Preference for the student travel bursary will be given to students having a poster or an oral presentation. Our travel bursary award winners will be notified of the committee's decision in October

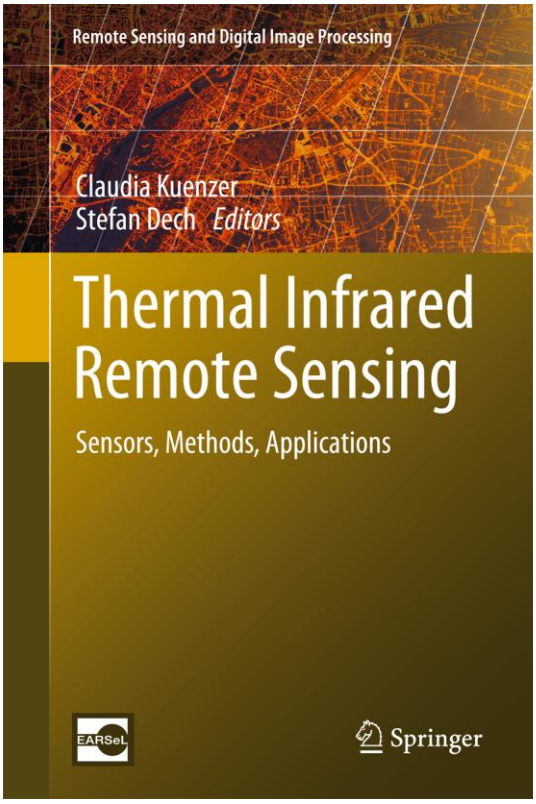
Fieldwork Bursary

Nigel Press was very honoured by the GRSG's gesture in making him Life-time Member of the GRSG following the support of Nigel Press Associates Ltd (now Fugro NPA) in GRSG activities for a number of years. Recognising that there is still much needed scientific progress to be made in our discipline, he wanted to offer some continuing contribution for the future in return. Nigel is therefore pleased to announce that a fieldwork bursary fund run by his family is being opened to Members of GRSG. The Fund provides a few bursaries each year, mainly to MSc students, to undertake fieldwork which has a humanitarian, sociological or environmental benefit, and ideally is carried out in conjunction with an NGO. Selection of projects is made purely on merit; last year The Fund partly supported a GRSG member, Naomi Morris, on a very ambitious trip to work on geo-hazards in Papua New Guinea, other recipients included undergraduates from Oxford who worked on the Colima volcano in Mexico and L'Aquila earthquake site in Italy.

More details on this opportunity and how to apply can be found at www.lydiapress.org

NEW TIR Book: Thermal Infrared Remote Sensing

- Thermal Remote Sensing is a discipline with a growing user community
- The book provides a comprehensive overview of available sensors, methods and applications
- The book is of interest to environmental planners and decision makers, climatologists, hydrologists, ecologists, urban scientists, forest fire and other fire experts



This book provides a comprehensive overview of the state of the art in the field of thermal infrared remote sensing. Temperature is one of the most important physical environmental variables monitored by earth observing remote sensing systems. Temperature ranges define the boundaries of habitats on our planet. Thermal hazards endanger our resources and well-being. In this book renowned international experts have contributed chapters on currently available thermal sensors as well as innovative plans for future missions. Further chapters discuss the underlying physics and image processing techniques for analyzing thermal data. Ground-breaking chapters on applications present a wide variety of case studies leading to a deepened understanding of land and sea surface temperature dynamics, urban heat island effects, forest fires, volcanic eruption precursors, underground coal fires, geothermal systems, soil moisture variability, and temperature-based mineral discrimination. 'Thermal Infrared Remote Sensing: Sensors, Methods, Applications' is unique because of the large field it spans, the potentials it reveals, and the detail it provides.

This book is an indispensable volume for scientists, lecturers, and decision makers interested in thermal infrared technology, methods, and applications.

Oil & Gas Embraces Space

Dr. Peter Hausknecht, Chairman of OGP Geomatics Earth Observation Subcommittee

Dear GRSG members,

Many of you will have heard the name OGEO - the Oil and Gas Earth Observation interest group, which was formed over three years ago and the GRSG was quite involved in it's setting up under the then GRSG chairman Richard Eyers. As you may recall we even had a joint workshop in Frascati in 2011 – the first for GRSG outside the UK – with many interesting papers and a memorable workshop dinner at the Villa Grazioli. For those who couldn't go, the presentations are still available online (http://earth.eo.esa.int/workshops/grsg2011/) and can be downloaded for free. The contributions from the 2010 & 2012 OGEO workshops are also still online and can be found at: http://earth.eo.esa.int/workshops/gasoil2010 & http://www.esa-ogeo.org

What happened to OGEO? As some of you may have heard at last years GRSG meeting in London - we have formalized the somewhat loose group in late 2012. The OGP (International Association of Oil and Gas Producers) Geomatics Committee has asked us to set up a formal Earth Observation sub-committee and promote the uptake of the Earth Observation technology within the industry to the benefit of OGP members, and not only in the Geomatics community but including the Metocean and Environment communities as well. In this role we have expanded the group with more members from the oil and gas industry and attracted the participation of new companies. We also invited the previous stakeholders in OGEO, ESA and EARSC as participating members as well as the GRSG (represented by its current chairman Jason Manning) to participate in our regular teleconferences and be briefed on ongoing and planned activities in the O&G industry relating to Earth Observation.

The new sub-committee will actively support joint industry projects (JIP) where Earth Observation plays a major role, such as the Oil Spill Response JIP led by IPIECA and OGP. Other activities will include sea-ice monitoring, environmental baseline mapping and monitoring, and improved mapping and modelling of Metocean parameters.

Spatial information derived from Earth Observation (space borne or airborne) is important to the Oil & Gas industry, not only in a crisis, such as an oil spill, but also as part of the regular oil & gas exploration and production life cycle of a facility - from the initial exploration (e.g. with enhanced geological surface mapping) through to development and production and during daily operations until its final decommissioning. Such satellite data and derived products can save time and money for the industry and help reduce the risk of operations. In new project developments it allows historic environmental baselines to be established efficiently and throughout the project execution it can help minimise the risk to personnel and assets during routine monitoring operations, such as environmental compliance or localized subsidence.

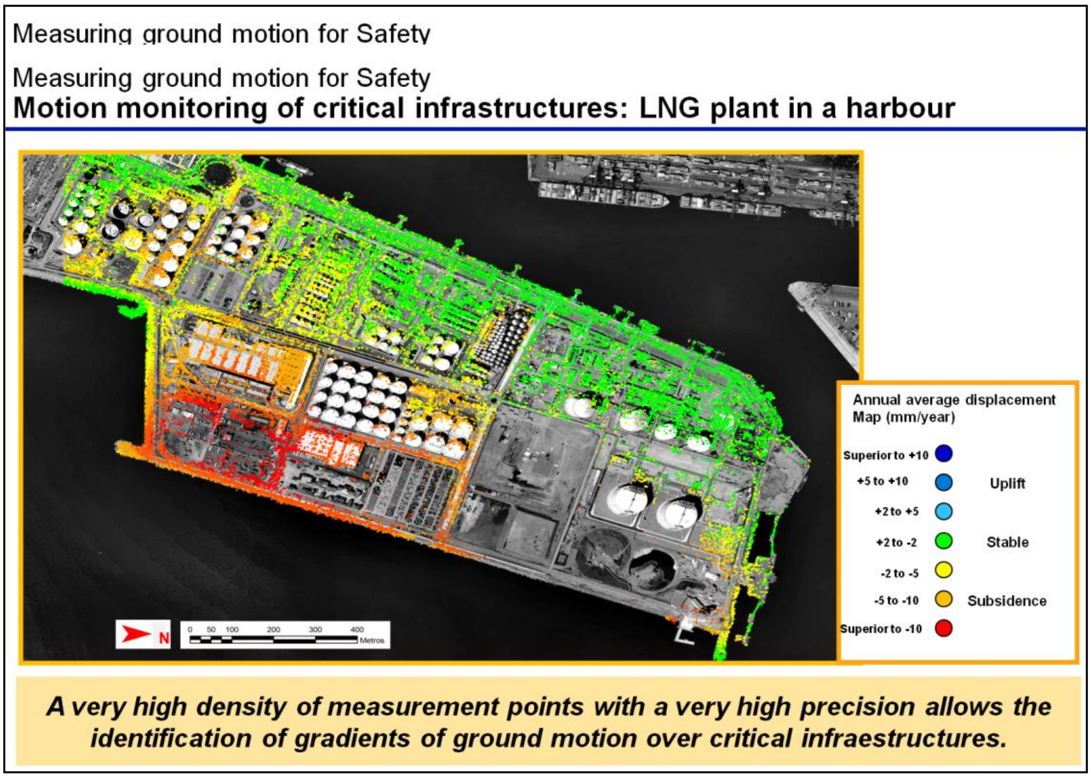
… and there is the OGEO Portal - http://www.ogeo-portal.eu/ - an information exchange platform between the oil and gas and earth observation/geo-information professional communities.
We now have over 216 signed-up members. The rules are simple: you can sign up if you work for an oil & gas company, which could be eligible for an OGP membership (but doesn't have to be) or for an EO service provider, who could become a member of EARSC or a similar organization on their continent (but doesn't have to be). We expect new members to be active participants and not just to consume and download content. The initial funding for the portal was provided by ESA and EARSC adds invaluable support to the maintenance and content.

The OGP EO sub-committee will promote an industry-wide awareness and rapid implementation of new EO technologies, to utilise new opportunities and to maximise the benefits of EO technology and data to the oil and gas industry.

Regards, and all the best for future activities - Peter Hausknecht

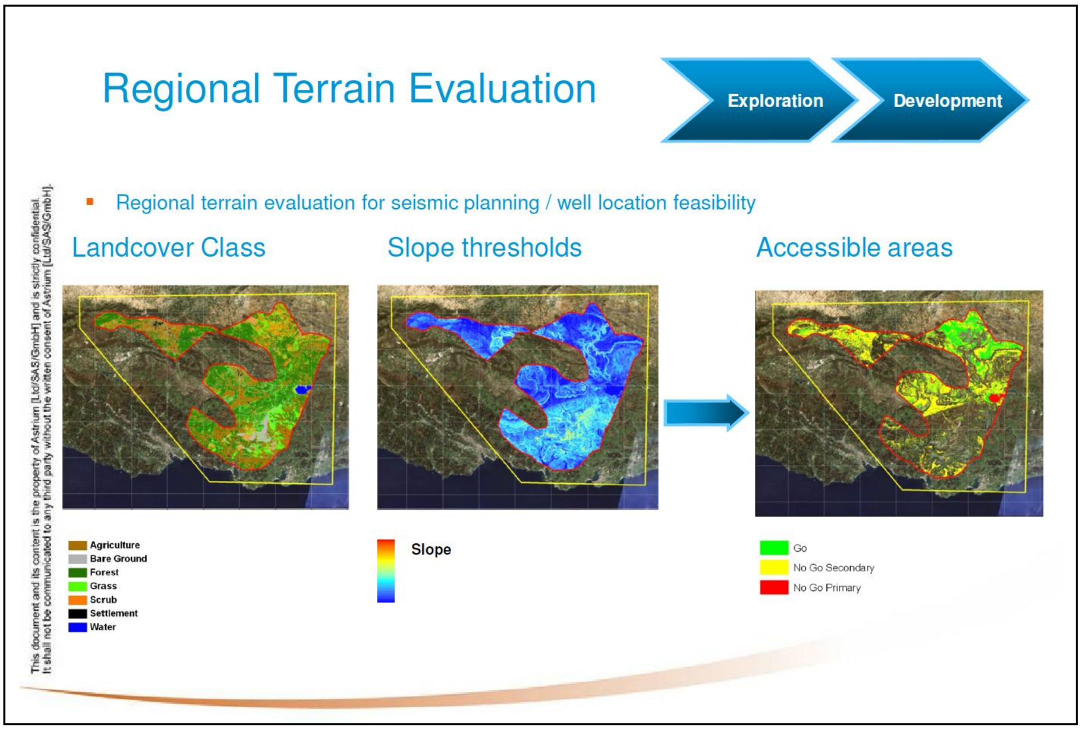
Please find a few examples for EO applications in the oil and gas industry from the previous workshops; Images are published with permission of the presenting author.

A) Using Radar Satellite Interferometry for subsidence measurements



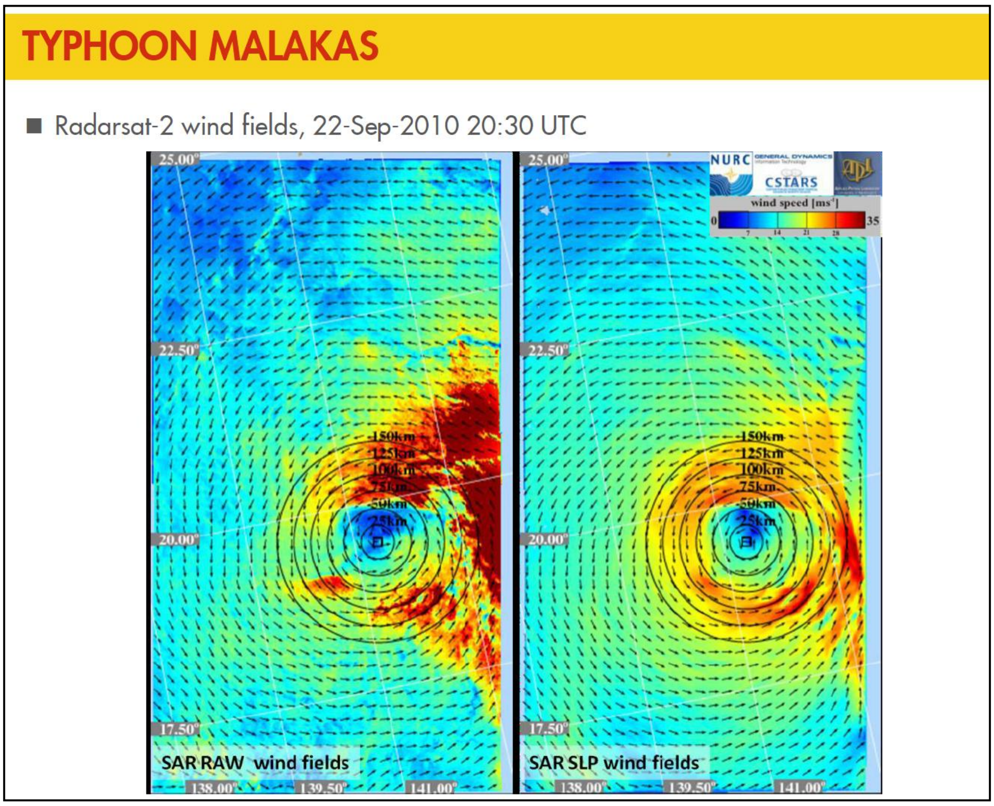
OGEO workshop 2012 – Session 4, Alain Arnaud and Guan Oon, Altamira, InSAR monitoring for the Oil and Gas industry

B) Using Satellite derived terrain information for land accessibility



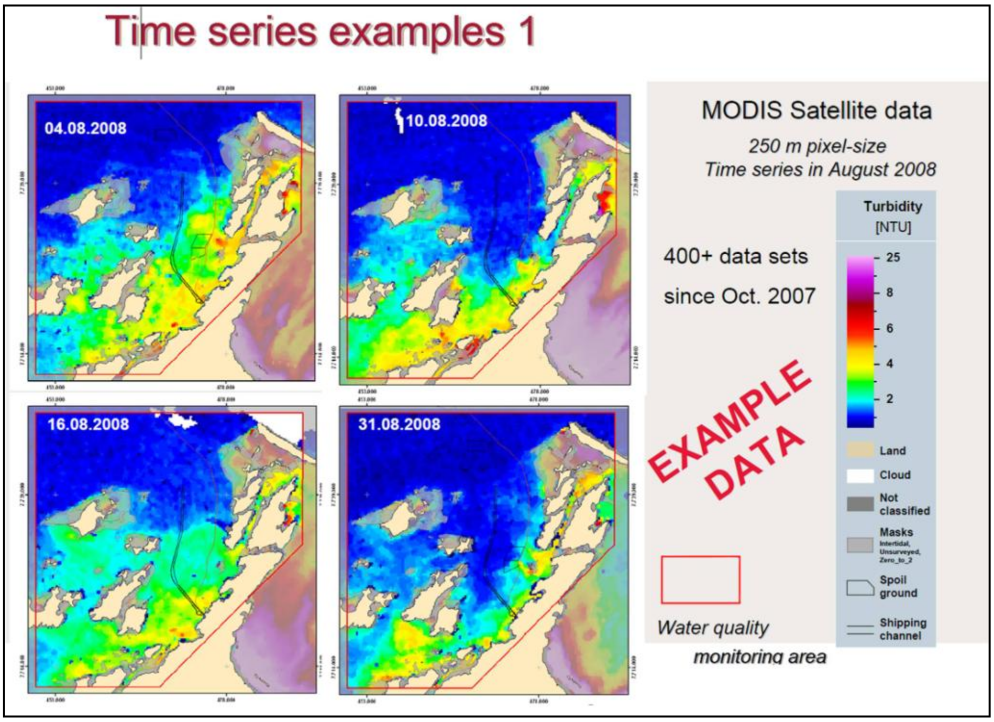
OGEO workshop 2012 – Session 4, Michael Hall, Astrium, Satellite Assessment and Monitoring for Infrastructure, Environmental and Engineering Applications

C) Using Satellite data to improve forecasting of tropical cyclones



OGEO workshop 2012 – Session 3, Jan Flynn , Shell Dev. Australia, Hans Graber, CSTARS – Uni. Miami, Vince Cardone, Oceanweather Inc, Use of SAR imagery in tropical cyclone forecasting

D) Using Satellite data to monitor dredging operation for pipeline installations



OGEO workshop 2010 – Session 3, Peter Hausknecht, Woodside Energy, Operational MODIS Satellite based water turbidity monitoring for dredging operations in Woodside

Imagery Derived Bathymetry and Seabed Classification Validated

Helen Needham, Proteus FZC, Dr Kurt Hartman, EOMAP and Graham Mimpriss, UKHO

In summer 2012, the United Kingdom Hydrographic Office (UKHO) contracted the Proteus-led team in a pilot trial of satellite-derived bathymetry and seabed classification to assess the quality and the potential for satellite-derived bathymetry as a data gathering technique in the very shallow-water or nearshore environment. The UKHO are interested in using new techniques to enable them to update charts in remote areas more frequently and more efficiently than solely relying on waterborne methods.

Two project sites, one comprising a 50-km stretch of coastline (Area A) and another about half that size (Area B) were identified in the Mediterranean for the pilot. Per instructions from UKHO, the Proteus team was required to work entirely remotely with no access to horizontal and vertical ground truthing data and to achieve depths from the zero contour or surf zone to the maximum depth possible.

Coastal Blue Band Makes the Difference

This project and the process tested were made possible by the launch of DigitalGlobe's WorldView 2 satellite. This high-resolution satellite captures eight multispectral bands of imagery, and most notably includes the coastal blue band, see Figure 1. All bands are utilised for bathymetry and determining seabed type through seabed classification extraction, however, the introduction of the coastal blue band starting at 400nm has significantly improved this technology and brought this methodology as an alternative solution to the hydrographic sector.

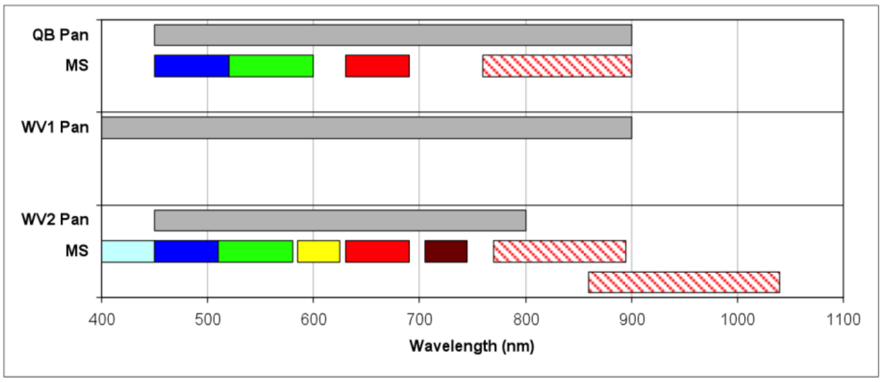


Figure1: DigitalGlobe's Quickbird (QB), WorldView-1 (WV-1) and WorldView-2 (WV-2) multispectral band comparison.

DigitalGlobe has a vast library of multispectral imagery providing global coverage to the hydrographer. For this project, participants decided to task the satellite by capturing a new image for the two survey areas. Dedicated tasking parameters were calculated and assigned to the project. The angle of the satellite camera is an important variable when capturing an image for bathymetry applications, so team members tasked the satellite to acquire images with a maximum incidence angle of 30° from nadir. Suitable imagery was captured for the areas with minimal cloud cover and favourable environmental conditions. For this type of application, desired conditions include little or no wind so as to minimise turbidity in the shallow waters near the shore. The satellite images a total coastline length of over 100 kilometres with a survey time of less than 10 seconds.

New Processing Technique

Imagery was downloaded from the satellite within 6-24 hours of capture and delivered to EOMAP for processing. The imagery was quickly assessed for quality and suitability for hydrographic purposes. In this instance, excess cloud cover obscured the northern section of Area A which required acquisition of another image. The UKHO chose to apply tidal corrections itself using tidal gauge data available over the internet. This required the project technicians to deliver bathymetric results for the time collected. This actual tidal data improved the vertical accuracy of the measurements.

EOMAP has developed an in-house processing suite called the Modular Inversion and Processing system, or MIP. This proprietary program extracts seafloor reflectance and converts this into water depth and seabed classification measurements. MIP is designed for the physical based recovery of hydro-biological parameters from multi-and hyperspectral remote sensing data and used for environmental mapping of aquatic shallow and deep water of inland waters, coastal zones and wetlands. The architecture of the program binds a set of general and transferable computational schemes in a chain, connecting bio-physical parameters with the measured sensor radiances. The schemes include a number of algorithms to extract the depth information from the imagery.

Atmospheric, sun glitter, water surface and underwater bi-directional effects of the underwater light field are all accounted for, as depicted on Figure 2.

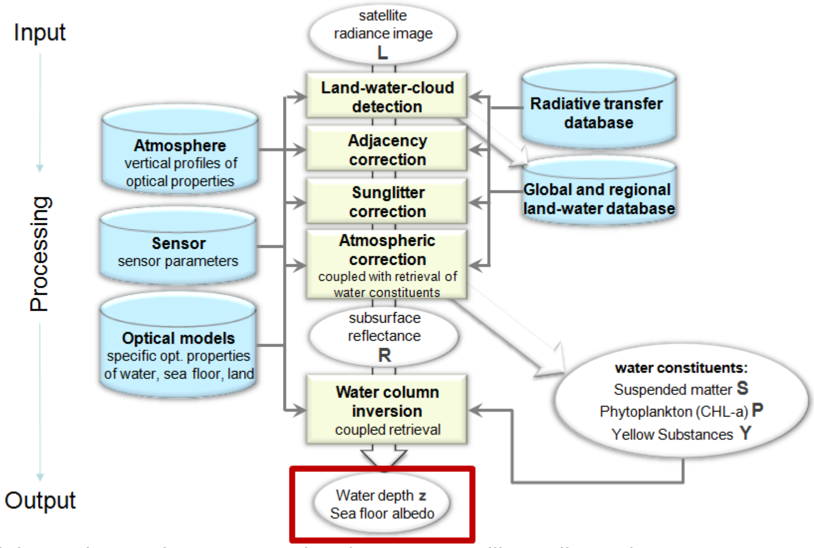


Figure2: Scheme of the Modular and Inversion Program (MIP). Input: Satellite radiance image; Output: Water depth information and sea floor / bottom reflectance.

The flow line incorporates a number of correction factors. The multispectral signals are subject to refraction and absorption through the atmosphere and water column. These need to be accounted for to establish seafloor reflectance value before converting reflectance into depth and seabed classification data. The bathymetry processing flow line is sensor independent, allowing different hyperspectral and multi spectral imagery to be used. WorldView-2 multispectral imagery has a resolution of 2m and the eight-band multispectral bands provide better vertical accuracy and depth penetration than previously seen. The seabed classification processing line is based on either supervised or unsupervised classification methods.

For this project no ground truth data was made available for either bathymetry or seabed classification, and hence extraction was undertaken on an unsupervised basis. In contrast to the land classification, the satellite input image was not only corrected to atmospheric influences, but also to the effects of sun reflectance on the sea surface and the effects of the water column. This unique semi-automatic approach was developed and maintained by EOMAP and implemented in MIP. The program processed radiance satellite imagery and outputs a bottom reflectance image, which represent the reflectance of the sea-surface bottom without the effects of water column and atmosphere, see Figure 3.

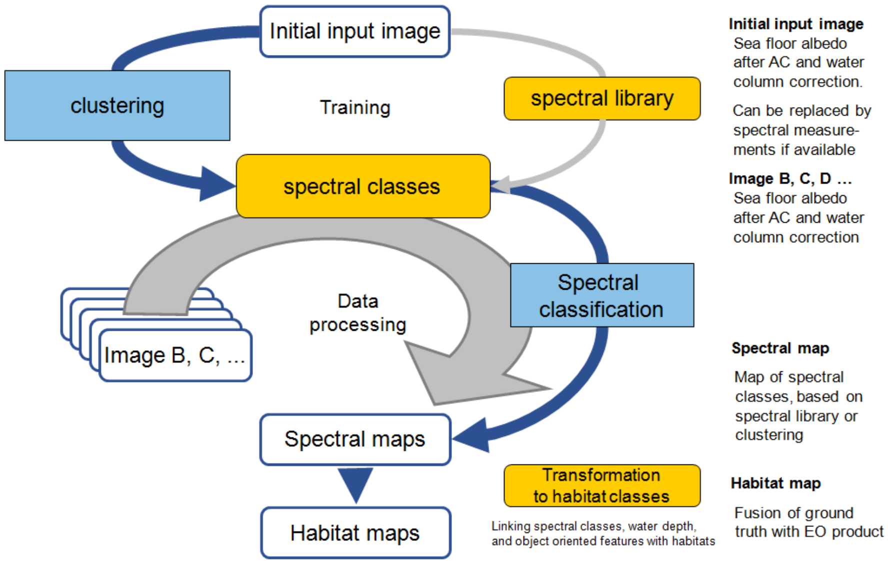


Figure 3: Scheme of the unsupervised classification method. Input image: Sea floor / bottom reflectance.

Faster, Safer Results

Proteus delivered bathymetry and seabed classification mapping, high-resolution satellite imagery, quality mapping, metadata and technical reporting to the UKHO where they undertook a comprehensive review of the results. The UKHO used historical single beam data from acoustic devices to compare the results. Bathymetry covered nearly 100% seafloor coverage, with the exception of surface objects e.g. vessels and navigation marks. Objects with the size of greater than 4m were detected and mapped. Despite the no ground control restrictions required by the UKHO vertical accuracies achieved were 10 – 15% of water depth and a positional accuracy of 10m CEP 90% were seen. However a small amount of ground truthing data would have comfortably seen an accuracy improvement to 10% of depth and 6.5m 90% CEP would have been achievable. Seabed classification was also successful, with four seabed types being identified; sand, rock/debris, vegetation and mixed seafloor (mainly vegetation). The 2m resolution seafloor mapping supported and corresponded with the bathymetry and provided essential information for hydrography application scientific or engineering applications.

Figure 4 shows the bathymetry results, with depths ranging from 0.1m to 10 m, after 10m the turbidity of the water column slightly reduced the overall accuracy, but still provided results acceptable for this application.

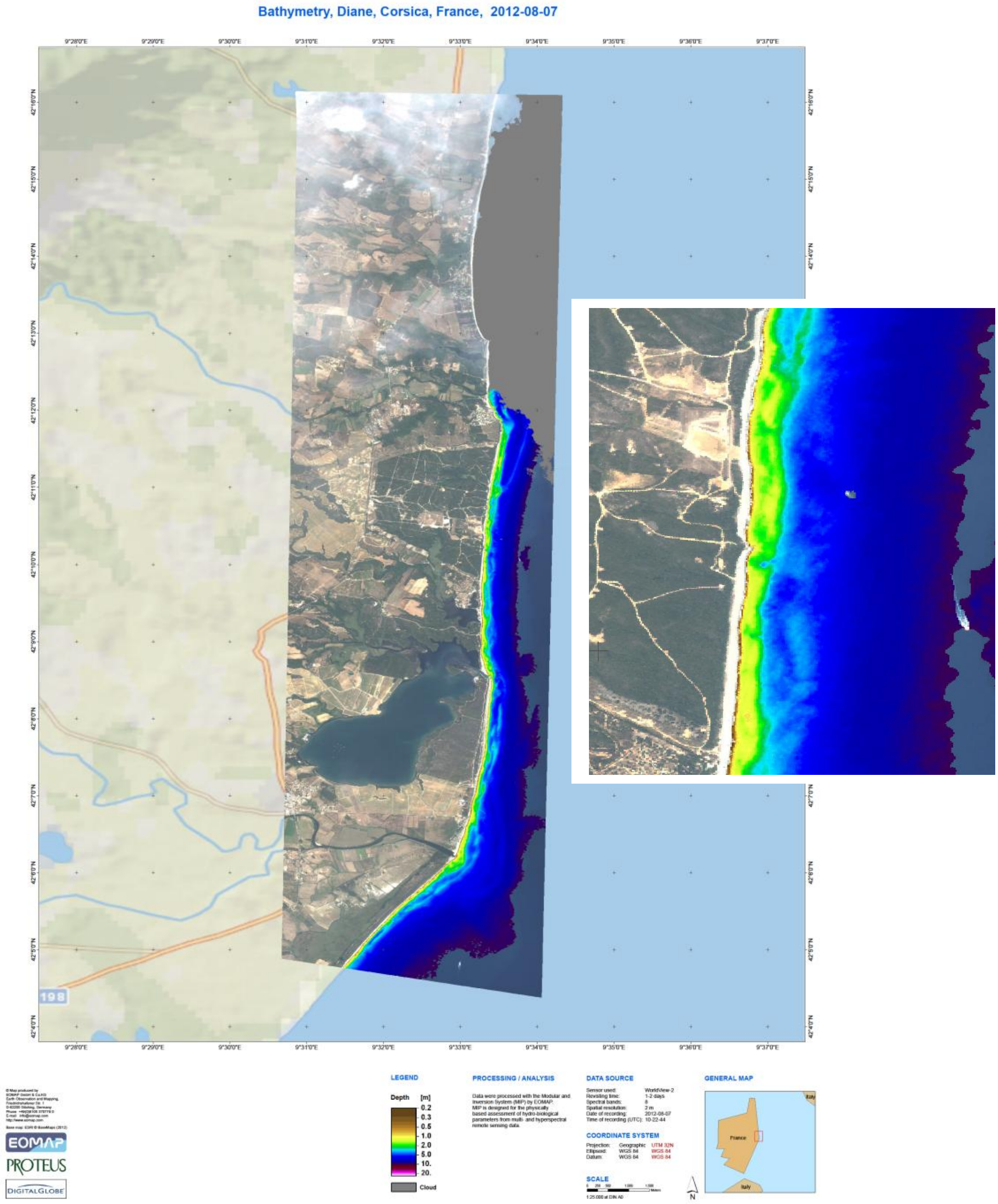


Figure 4: Bathymetry for subsection of area, with detailed bathymetry.

Figure 5 shows the seafloor classification for the same area. With four seabed types being identified and mapped to a high resolution, these being sand, rock/debris, vegetation and mixed seafloor (mainly vegetation). In areas where the turbidity exceeded the tolerances of the processing system the depths recorded aired on the side of safety. When the satellite depths were compromised by the environmental conditions then the system reported shoal depths, thus erring on the side of safety.

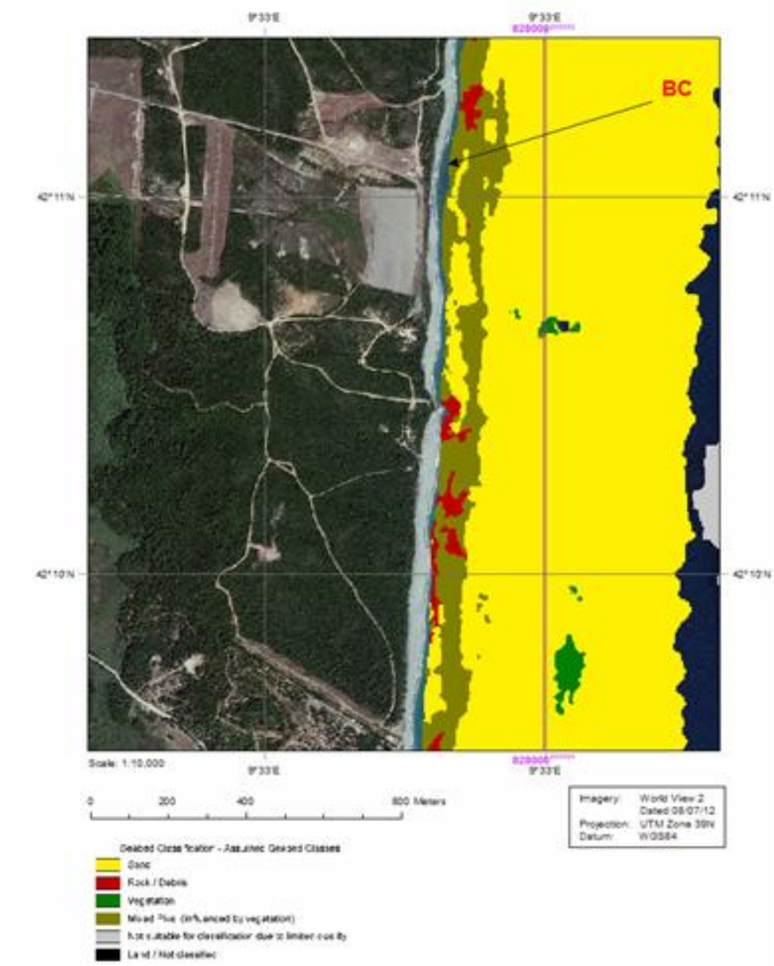


Figure 5: Detailed high resolution seafloor classification for area A.

A crucial metric used in judging the pilot's success was timeliness. The entire project, even with re-acquisition of some imagery, was completed in eight weeks. The same project would have taken months if it had been undertaken with traditional acoustic hydrographic surveys, which have inherent dangers operating in the shallow, near-shore environment of the Mediterranean.

Lessons Learned

Project participants learned several lessons during the course of this pilot in the Mediterranean. Firstly, using multiple satellite images would increase the point density and enable a shoal bias product to be created. This would increase the cost of the product; however, it would also increase the safety element for survey or engineering applications. An average depth value is suitable for environmental / engineering and marine resources planning applications, however, for some advanced applications then a shoal depth is required. Secondly, stationary surface objects provide valuable information for this application, however, moving objects e.g. vessels would prefer to be removed from the bathymetry and reported separately on their characteristics, size; direction and speed of vessel. Satellite tasking parameters are location and time dependent. They are important for survey planning and considered when trying to produce the highest degree of vertical accuracy.

Conclusion

Without the use of ground control data for horizontal and vertical referencing – as dictated by the project guidelines – the results are reliable and consistent to 10-11m water depths throughout all of the areas of interest where environmental conditions have allowed. Quality mapping is an essential deliverable for users when viewing and working with the deliverables. For the purpose of survey reconnaissance and survey planning, this technique has delivered results good enough for serious consideration as a rapid, cost effective alternative to airborne and waterborne survey techniques in many environments. Being able to survey considerable volume areas quickly and remotely is a cost-effective and safe solution. DigitalGlobe's archive of recent imagery, EOMAP's technology and Proteus's expertise enables bathymetry and seabed classification data to be produced within weeks. In the event of tasking the satellite for new imagery, the project life cycle is extended, but this process is still faster and has considerable advantages over traditional methods.

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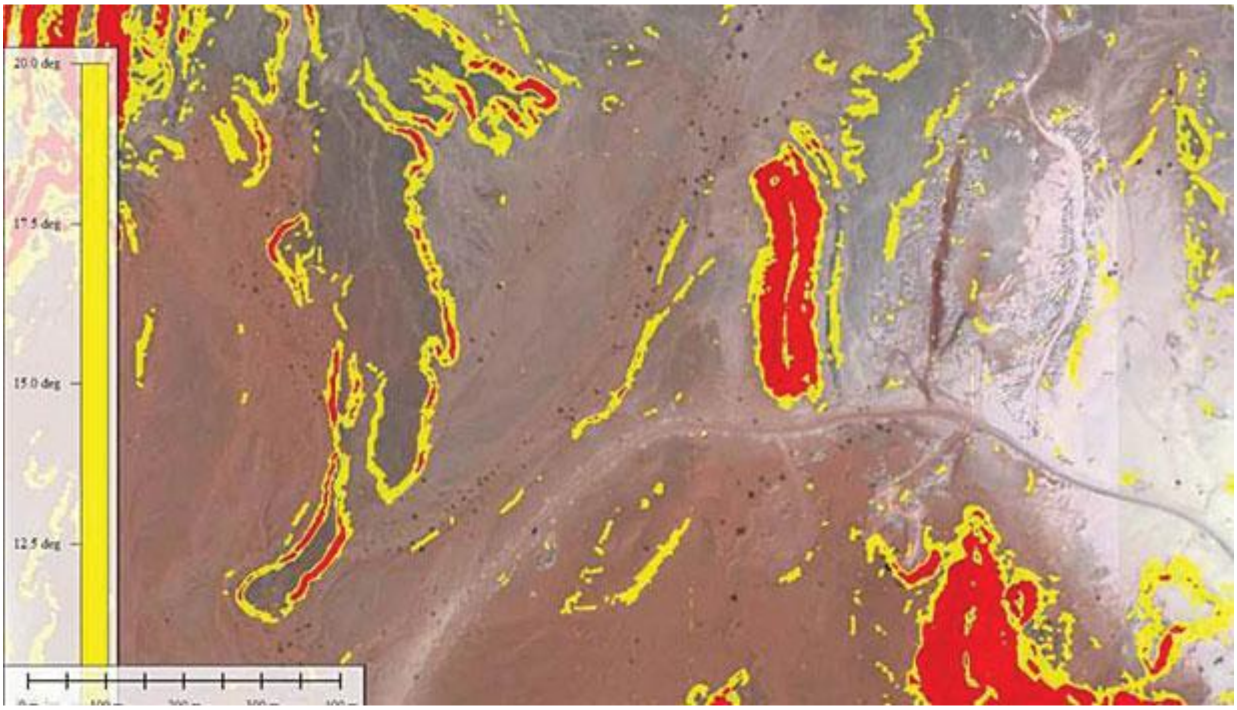
Satellite Imagery Improves Quality of Seismic Surveys

Vele Galovski, Spatial Energy



For nearly a century, energy companies have relied on seismic surveys as crucial information sources in the quest to discover subsurface oil and gas reservoirs. Advances in computing power have dramatically improved the fidelity of reservoir simulations, driving the need for more complex and precise seismic surveys. Increasingly, these are planned with satellite imagery.

Geophysicists use seismic survey data to create two- or three-dimensional views of the geologic structures beneath the Earth's surface. During hydrocarbon exploration, these subsurface perspectives help identify formations that could serve as traps for oil and natural gas. Once potential reservoirs are located, sophisticated computer simulations combine seismic and other geophysical data to model the best methods of extracting the hydrocarbons.

Seismic data is collected by applying sound waves to the surface, either in the form of vibrations or explosions. These waves travel through the underlying strata where they are reflected and refracted according to characteristics of the geologic layers. A multitude of receivers on the surface, known as geophones, captures and measures these returned waves. The strength, location and timing of the signals are processed to reveal the depth, position and composition of geologic structures.

Gary Crews, vice president of customer service and operations manager for Spatial Energy, a Boulder, Colo.-based company that provides geospatial imagery for energy companies, says the use of satellite imagery for seismic surveying is growing.

"The earlier satellite image products can be introduced to the design process, the better the results will be in terms of survey quality, project cost and risk mitigation," says Crews.

Spatial Energy helps clients apply high-resolution imagery and DEMs throughout the planning and operations phases of a seismic survey. When conditions in the field differ from what was anticipated during the planning stage, the survey may have to be redesigned at significant cost of time and money for the operator and vendor. In the worst cases, shoddy planning work can result in damage to the environment or equipment, and the risk of injury to field crews can be greater.

"Using high quality satellite imagery and terrain data is all about risk mitigation," says Bob Brook, CEO of Salamanca Energy. "The overall cost is usually less than 1 percent of a typical seismic survey–a small expense to significantly reduce the risk."

Spatial Energy utilizes submeter imagery and derived DEMs from the twin Pléiades optical satellites. Launched in December 2011 and December 2012, the Pléiades 1A and 1B satellites operated by Astrium, a space technology company, capture panchromatic and four-band multispectral data processed to generate 50-centimeter, orthorectified, color imagery.

Each satellite can pivot in orbit to acquire fore- and aft-looking stereo images in the same pass. The Pléiades satellites can even roll fast enough to capture a third nadir-looking dataset for tri-stereo imaging, a necessity for accurate DEM generation in extremely steep terrain. Same-pass stereo acquisition means that all images are captured under identical ground conditions, which leads to higher elevation data quality overall.

"The Pléiades stereo images can be processed to two levels of DEM post-spacing: 1 and 4 meters," says Crews. "We have found the Pléiades 4-meter DEM product, called Elevation4, offers the best combination of cost and accuracy for seismic survey planning."

Post-spacing refers to the distance between elevation points in the DEM. Elevation4, therefore, has a measured elevation point every 4 meters. The vertical accuracy of this elevation model is 3 meters. Spatial Energy sells the Elevation4 DEMs and the images from which they are generated in a package that ensures consistency in both products because they are derived from the same source data.

As is true with most phases of hydrocarbon operations, satellite imagery plays multiple roles in seismic survey planning. The first is as a logistics tool. Seismic crews usually include hundreds of people, dozens of large vehicles and tons of equipment, all of which must be transported to the site. During planning, a seismic company views the imagery to find existing access roads, water sources, modern infrastructure and towns to support the endeavor.

Next, the imagery is used for planning the actual layout of the survey lines and geophone locations, and this is where the multispectral content and high-resolution of the Pléiades imagery makes a difference. Planners use the imagery, often classified by land-cover and land-use type, to evaluate the ground surfaces in the project area to determine the most and least conducive to seismic operations.

The centerpieces of most seismic surveys are vibration trucks, or large vehicles equipped with vibrators on their undersides. The trucks move along the survey line stopping at prescribed intervals where they lower the vibrator to the ground and apply high-frequency sound waves. These vibrators need flat surfaces to achieve sufficient contact with the ground to transmit quality signals.

As the imagery is being used to evaluate land cover, the satellite-derived DEMs are analyzed for consideration of the most suitable topography for operations. The vibration trucks can only be operated safely on slopes of 20 degrees or less. The four-meter Pléiades elevation models offer just the right detail for planners to determine where the terrain is safe.

Some topographies are too steep and rugged for vibration truck operations even with the assistance of earth moving vehicles. When these slopes coincide with where the seismic lines must be run, the planners opt to use explosives instead. Knowing ahead of time when and where vibration trucks versus explosives will be used is crucial to the detailed planning process because the explosives are considerably more expensive.

"Between the land-cover information in the high-resolution imagery and the ground slope detail in the DEMs, the seismic planner in the office can design a grid of survey lines and geophone locations that is both safe and effective," says Crews. "Precise advance planning reduces the risk of having to delay a 100-person crew onsite because something unexpected is encountered in the field."

The same geospatial information is valuable in other areas, too, because surveys will be required for subsequent planning for well drilling and other operations.

"We use the data over and over again, for everything from refining our geological mapping and modeling through the production and development phase," Brook says. "It's well worth the investment."

The sharing and reuse of datasets by several vendors has never been easier thanks to cloud-based platforms. Spatial Energy offers Spatial on Demand, a cloud-based data management service that provides delivery of data into oil and gas computer applications, enabling internal and external collaboration throughout the exploration and production lifecycle.

"Just as the seismic planners are increasingly analyzing imagery and elevation data to design their survey grids, geologists and petroleum engineers have long applied the same datasets to drilling, production and environmental remediation phases," Crews says. "The applications are almost identical, just further downstream in the operation. Certain other activities, such as selection of pipeline and processing plant locations, may require use of the higher resolution Elevation 1 DEMs."

Article taken from http://www.pobonline.com/articles/97001-satellite-imagery-improves-quality-of-seismic-surveys with permission from Spatial Energy

DigitalGlobe Webinar Series

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2013 LEAD Webinar Series

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25 September	**Indexes and thematic maps for urban planning and soil loss evaluation**	Claudio La Mantia, *Geoservices Technical Manager of Government & Security SBU*, *Planetek Italia*
2 October	**Mapping cultural heritage from space: How protecting the past is good for business**	Dr. Sarah Parcak, *CEO*, *SpectralGlobe Technologies*
23 October	**How SIRADEL helps cities to be smarter**	Emmanuel Baverel, *EMEA Account Manager*, *SIRADEL*
30 October	**Automated technology solutions utilizing multispectral high-resolution satellite images**	Oleg Sizov, *Senior Engineer of Thematic Data Processing*, *Sovzond Company Ltd*
6 November	**DigitalGlobe imagery expedites mineral exploration in Africa**	Alex Fortescue, *Remote Sensing & GIS Manager*, *Southern Mapping Company*

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ENVI extends possibilities in mineral exploration

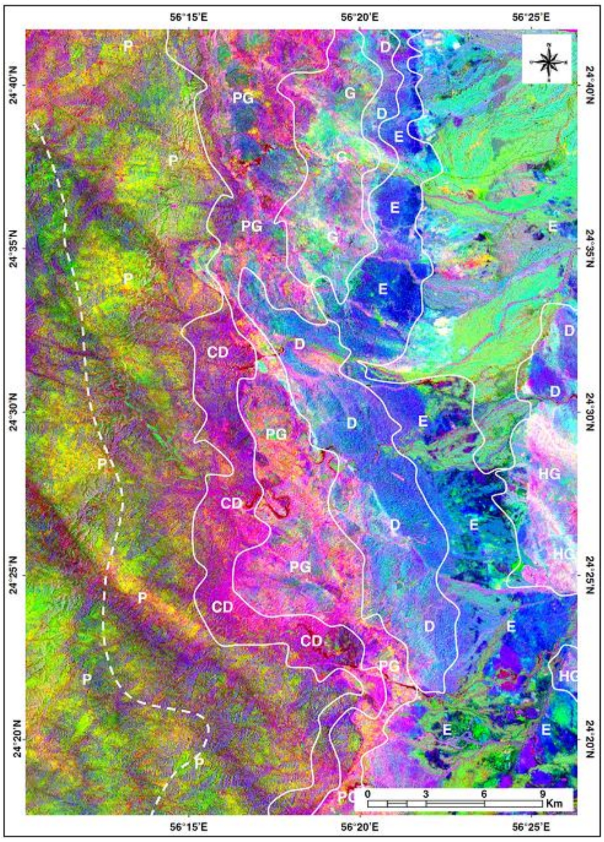
Customer Challenge
Dr Sankaran Rajendran teaches in the Department of Earth Sciences at Sultan Qaboos University (SQU) in Oman. His teaching and research specialism is remote sensing and GIS techniques in mineral exploration.

A recent study by Dr Rajendran aimed to show how Advanced Spaceborne Thermal Emission and Reflection Radiometer (ASTER) images can be used to map chromite occurrences in the Semail area of Oman.

Chromite is an oxide mineral composed of chromium, iron and oxygen, dark gray to black in colour with a metallic appearance. Chromite is an ore of chromium, an essential element for a wide variety of metal, chemical and manufactured products. The alloy produced is stainless steel which can alloyed with iron and nickel producing nichrome used to make heating units, ovens and other appliances. Thin coatings of chromium alloys are also used as a plating on auto parts, appliances known as chrome plated. Although other minerals contain chromium none are found in deposits that can be economically mined to produce chromium.

Geologic mapping of this region has historically proved challenging primarily because of inaccessibility but also due to the complexity of the structures and difficulties of lithological differentiation using conventional mapping techniques.

Solution Achieved
ENVI's geospatial image processing tools allowed Dr Rajendran to discriminate and evaluate the occurrences of chromites bearing mineralized zones within ophiolites. He did this by analysing the capabilities of Landsat TM and ASTER satellite data using a number of image processing methods – namely decorrelated stretching, different band rationing and principal component analysis.



"ENVI was the perfect solution to achieve the goals of the study," said Dr Rajendran. "The results show that the processed VNIR and SWIR spectral wavelength regions are promising in detecting the areas of potential chromite, proving to be successful for the mapping of serpentinized harzburgite containing chromites."
"The extensions and options of the tools in ENVI allow me to fully explore my area of expertise, while the results of the study will help exploration geologists, industrialists and mine owners adopt techniques and avoid the limits in field data alone for more exploration and exploitation of areas having chromite deposits in arid regions."

ASTER image studied using principal component analysis (RGB image of PC7, PC5 and PC4) shows the occurrences of different rock types – (E — Basic extrusives mostly spilites with pillow lava or conglomerate; D — Diabase dyke swarms; G — Gabbro; HG — Gabbroid hypabyssal rocks; PG — Cumulate layered gabbro; P and CD — Sheared serpentinized harzburgite) in Semail Ophiolite Massifs. Potential chromite mineralized zones areinterpreted from image between below the Moho (line separating PG) to run about 1 to 5 km (up to dashed line).

Image courtesy: Dr. Sankaran Rajendran, SQU

Key Benefits

Dr Rajendran has used ENVI since 2002. He highlights the following as the key benefits:

- Pre-processing of different satellite data in different methods
- Analysing and processing of data using different image processing methods
- Providing best results in different scales
- Easy-to-use – SQU students learn ENVI quickly and use with ease in the laboratory.
- ENVI is applications oriented and user-friendly.

Full details can be found in a study published in Ore Geology Reviews, Volume 44 by Dr. Sankaran Rajendran of Earth Sciences department SQU shows how ASTER images can be used to map chromite occurrences in Semail area of Oman. Reference - *www.sciencedirect.com*

Corescan: Driving Resource Exploration and Development with Hyperspectral Technology

Brigitte Martini, Corescan

The unprecedented mineral and textural mapping of the Corescan system is ushering in a new chapter for geological data collection in the mining and energy industries. Advanced hyperspectral technology implemented in Corescan elevates traditional qualitative rock properties to automated, consistent, quantitative rock mineralogy and texture. Such variables are the very backbone of modeling (both for exploration and development), planning (mine sites/pit design, well design, environmental assessments) and exploitation (mineral processing, metallurgy, reservoir development).

The Core Paradox

Logging drill core and cuttings is one of the most important aspects of mineral and energy exploration and development. No single expenditure costs more (in both money and time) than drilling and no single piece of data is more important than fundamental rock data (mineralogy and texture) extracted from the chips, core and pulps produced from drilling rigs – whether it's metals exploration and mining, oil and gas development or geothermal.

Considering the importance of this material – both for geological and business assessments – it is thus striking and paradoxical how comparatively unsophisticated the current state of most core and mud logging is. The least experienced geologists are usually tasked with logging; couple this with the inherent subjectivity of mineral and lithology identification and the stage is set for mis-identification and non-identification errors. These errors have vast implications for deposit and reservoir models including under or over-estimating resource existence, potential, environmental effects and longevity.

Furthermore, this valuable rock material is stored in variable conditions including cardboard, plasticized cardboard, wood, plastic and metal trays for core to cloth bags, paper packets and plastic trays for cuttings and hand samples. These various containers are then stored in the open (frequently), under partial cover, in sheds, in climate-controlled repositories (in-frequently) or simply disposed of when their perceived use is deemed at an end. Such reasoning undoubtedly proves faulty in the face of time and changing economic conditions; who would have predicted $1300/oz gold or the golden age of shale gas/oil? While a portion of legacy core and chip material has survived from previously un-economic gold and oil fields explored in the past, untold amounts of this material rotted away or found its' way to landfills and reclaimed terrain.
The paradox is thus defined: the material that is most important and most expensive is the material that is often entrusted to our least experienced geologists, our least sophisticated technologies and is likely to be the first data discarded or forgotten.

The Corescan HCI-3 System

The Corescan automated hyperspectral logging system (HCI-3) is revolutionizing the resource industry by providing consistent, accurate and automated mineralogical and textural data and map products. Since 2006, the engineers and scientists at Corescan offices in Perth, Australia have been developing, optimizing and operating turn-key logging systems, engineered for mobilization around the world (Figure 1a). The systems, operating in either centralised bureaus or on-site labs, are provided on a turn-key basis which includes not only scanning services, but interpretation and on-line serving of data at www.coreshed.com
The HCI-3 system itself consists of not only one of the most advanced hyperspectral spectrometers available (conceived of and designed by Dr. Frank Honey), but also high resolution digital true-color photography and high resolution laser profilometery (Table 1).

HCI-3 System Specification	
Spectrometers	3 (VNIR, SWIR-A, SWIR-B)
Spectral range	450nm to 2500nm
Spectral resolution	~4nm
Scan modes	0.5mm square pixels
Spectral calibration	Detailed full width scan Reconnaissance profile scan
Radiometric calibration	Spectralon reflectance standard, dark current
RGB image resolution	60um
Height profile resolution	20um
Core tray sizes	Up to 0.6m x 1.5m (W x L)
Scan rates	200m to 1000m per day Depending on operational constraints

Table 1. System specifications for the Corescan HCI-3

HCI-3 operates across the VNIR and SWIR portion of the electromagnetic spectrum from 450nm to 2500nm at a spectral resolution (FWHM) of 4nm. This wavelength range covers the spectral region where a wide range of fundamental rock-forming and hydrothermal alteration minerals exhibit specific, unique combinations of spectral absorption features.

High quality optics focus the spectral measurement to a 0.5 mm point on the core, maximizing signal and minimizing spectral mixing. The revolutionary design of HCI-3 reduces the uncertainties associated with spectral mixing inherent in traditional measurement systems, thus providing a 'near pure' spectral signature at each point on the core, with none of the atmospheric or mixing issues inherent to airborne hyperspectral systems. This results in ~100,000 spectra per metre of scanned core.

A spectrally calibrated RGB camera provides a high resolution visual record of the core at 60 micron pixel size. Measurement of core surface features, texture and shape is complemented using a 3D laser profiler with a surface profile resolution of 20um. The system comprises a scan unit housing the optics, spectrometers, cameras and 3D profiling sensors; a translation table with conveyor driven core tray loading system and a high speed data acquisition, processing and control computer (Figure 1b).

Figure 1: A. *Mobile Corescan field lab; fully containerized in a standard 22' sea-tainer capable of transport by ship, air and road to any desired location including mine sites, drill pads, coresheds, etc.* ***B.*** *The Corescan system; core or cuttings are placed on the translation table while the three imaging systems* (hyperspectral, RGB photography and laser profiler) scan over each length of core within the tray separately. A trained operator monitors the scanning, performing QC for all data in real-time.

HCI-3 Operation

As each tray is loaded, an automated tray management system identifies sections of core and masks out unwanted materials such as the core tray and depth markers. Depth coordinates, scan modes and image resolutions are then confirmed by the operator for individual core sections prior to scanning. Similar processes occur for chip trays.

The logging of spatial coordinates along with the automated identification and extraction of core sections means visualization of the core and mineral mapping products are readily available in a spatially referenced context, eliminating the time consuming process of image reconstruction overhead associated with traditional core tray imaging approaches. Core is scaled and reconstructed in real time even where core recovery is less than 100%.

A range of scan modes from full core detailed imaging through to rapid reconnaissance profiling are available to optimize image resolution with core throughput and data storage. Sample densities may also be varied with each scan mode, typically between 0.5 mm and 5.0 mm. Scan rates of up to 50 m per hour are achieved depending upon the scan mode required.

The simultaneous measurement of surface features using the 3D laser profiler offers an enormous advantage to structural geologists, metallurgists, mineral process engineers and reservoir engineers. In uncut core, structural features such as bedding, cleavage, fracture and vein orientations are visualised in the imagery allowing computation of orientation.

HCI-3's in-field processing and visual software allows the geologist to review core mineralogy in real-time during the drilling program. Analyses of core are then compared against pre-defined mineralogical models. In addition, section of core scanned in high speed reconnaissance mode may be re-scanned immediately at detailed resolution should mineralogy of significance be detected.

Corescan Data Products

The HCI-3 system produces unprecedented mineral and textural map products, in respect to both their spatial and spectral scale and sensitivity. The HCI-3's ability to spectrally image drill core and cuttings at sub-millimetre resolution offers distinct advantages in the processing, analysis and interpretation of spectra as well as in the derivation of trends in both the alteration assemblages and the chemical variations of individual minerals.

Unlike traditional spectral systems used in rock sampling (generally hand-held/lab-based commercial spectrometers used to measure single points along lengths of core at set distances), the fine spatial resolution and continuous imaging capacity of HCI-3 is able to capture a large number of pure pixels providing a comprehensive and easily determined group of end member minerals that are subsequently mapped throughout the borehole. Due to the imaging nature of the data, the spatial relationships of these minerals are thus immediately apparent (eg. disseminated, veined, intra-fracture, etc.). Figure 2 shows detailed mineral mapping results from a portion of core. HCI-3 reveals far more information about this metamorphic core than was previously known both texturally (revealing a hidden secondary vein population and more completely mapping the primary vein population) and mineralogically (identifying and mapping the definitive mineral assemblage and ore vectors for this gold district).

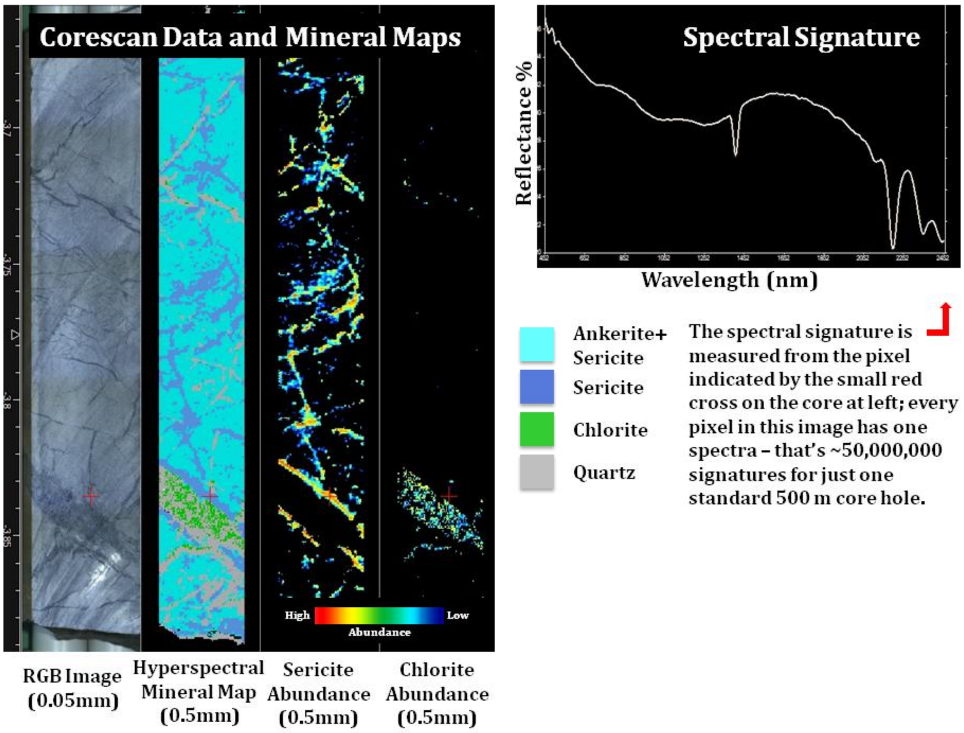


Figure 2. *Examples of Corescan data and processing results. The mineral maps demonstrate the fine spectral resolution and ability to identify important ore-vector assemblages as well as the ability to 'see' minerals which are invisible to the human eye. While the quartz vein population is easily logged by traditional means, the sericite vein population is only identified by Corescan. The spectral signature extracted from the pixel at the small red cross is of this secondary sericite population.*

The high spectral resolution and SNR of HCI-3 also allows for confident mapping of compositional parameters of individual alteration minerals present throughout a section of core. The variations of these parameters (such as degree of crystallinity, amount of aluminum, iron, magnesium etc.) may relate to pre- and syn- mineralisation phases which can be distinguished from those parameters relating to post-mineralisation events. Such parameters may also say something about formation temperatures, reservoir chemistry (in oil/gas and geothermal applications) and source fluids.

Furthermore, the calculated mineral map for a section of core (or cuttings) can be used to compute quantitative down-hole mineralogy. This digital mineralogical assay data is easily exported for use in third party 3D visualisation software for mine or reservoir planning or into logging software for comparison with traditional down-hole data (eg. metals assay, temperature, conductivity, etc.)(Figure 3).

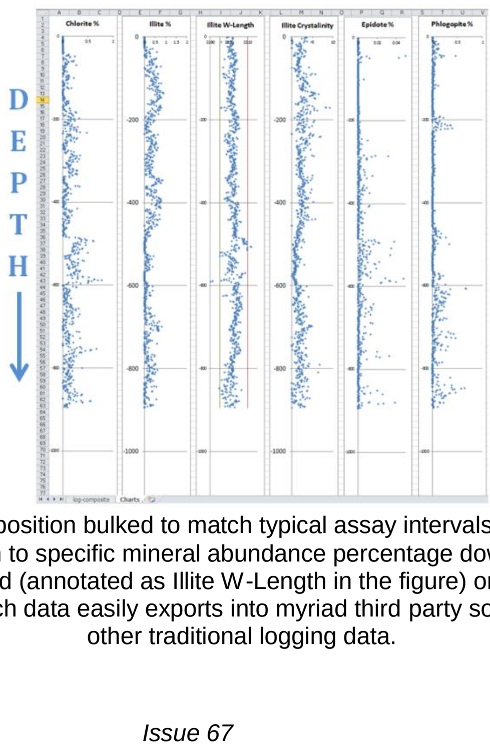


Figure 3. Mineral abundance and composition bulked to match typical assay intervals (1 m sampling), though any interval is possible (e.g. 1 cm to 100 m). In addition to specific mineral abundance percentage down-hole, chemical changes (such as the variation of Al within illite) can be measured (annotated as Illite W-Length in the figure) or molecular level structure such as degree of crystallinity within specific minerals. Such data easily exports into myriad third party software suites and is easily compared with other traditional logging data.

Both physical and mineralogical textures are also easily tracked with the HCI-3 system. General texture such as degree of veining or dissemination is identified using the hyperspectral-derived mineral maps. This differs greatly from historic methods that utilise simple photography and basic mineral colour; a method prone to high levels of error and subjectivity. Physical texture, such as faults, fractures and qRQD (quick RQD) are performed using the high resolution laser profiler data. The combination of derived mineralogy with texture produces sophisticated new products which drive mining technology and efficiency forward (Figure 4).

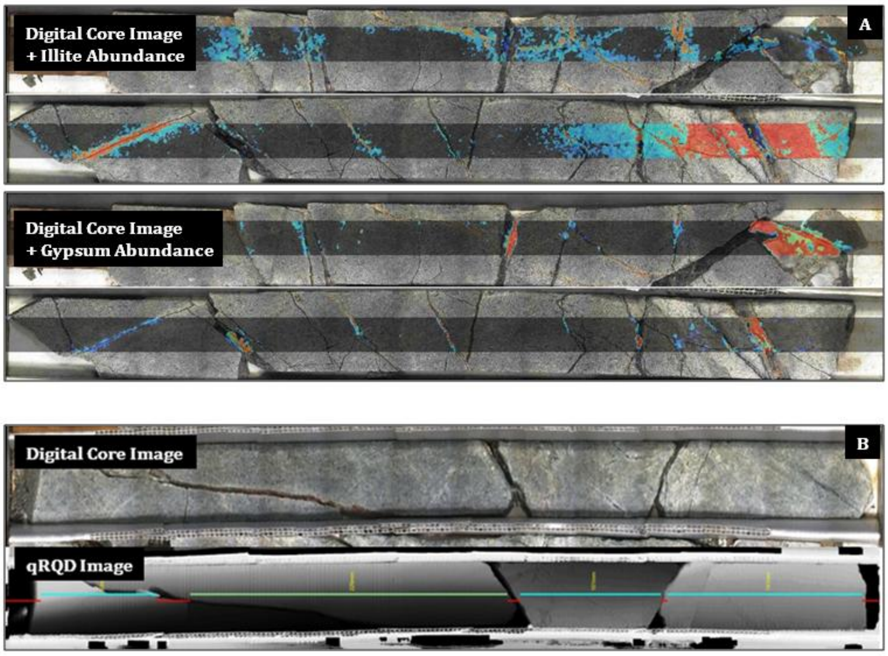


Figure 4A. Mineral end-member maps overlaid on high resolution digital imagery that demonstrate the power of synthesis of specific mineral data with mapped faults, fractures and veins. Such data representation advances the logging geologist from basic, time-consuming mineral and texture mapping immediately to lithological and geological mapping. **B.** The addition of qRQD data removes additional burden from the logging geologist by automatically picking breaks and computing a quick rock quality measurement for use in process mineralogy studies and metallurgy.

Driving Technology and Efficiency Forward

While Corescan's hyperspectral data and derived mineral maps certainly do not replace a trained geologist, the data suite puts the modern geologist far ahead of the game in terms of deposit to district scale assessment. Minerals are objectively identified throughout a deposit. For that matter, type mineral assemblages in one type of deposit (e.g. a copper porphyry) can finally be compared reliably to mineral assemblages in similar deposits, but in different locations (spatially and temporally). The quantitative nature of the data also allows for rigorous statistical analysis of mineralogical data using third party software. While done in the past with traditionally logged data, it is understood that the consistent mineralogical data from Corescan comes closest to real, unbiased input data for such models and improves the accuracy and consistency of ore/resource projections for exploration, mineral process and metallurgical studies.

Perhaps most importantly, the valuable (and expensive) information inherent to drilled rock material is scanned and archived within the digital core libraries of Corescan and our clients. Even if the core rots from its box or the cuttings are dumped back into a sump – the measured mineralogy, texture and visual imagery of the core and cuttings remain for future investigations (both economic and geological).

Furthermore, these data and derived products (both image-based and quantitative mineralogical data) from HCI-3 easily merges into myriad third party software packages (eg. Leapfrog, ENVI, IOgas, acquire).
The speed, reliability and efficiency of Corescan data production and the ease of use and cloud-based access to finished products make this technology a true game changer for world mining and energy development.

Application of hyperspectral remote sensing techniques for real world environmental monitoring

Bradly Thornton and Alice McClure, Digby Wells Environmental; and Alex Fortesque, Southern Mapping.

Introduction

Hyperspectral Remote Sensing is the acquisition of electromagnetic data from an aerial platform, which goes beyond the wave-lengths of visible light, for the application of isolating certain target features on the Earth's surface. Essentially, it is a remote (usually airborne) survey of electromagnetic energy from the Earth, which can be used to identify environmental features and pollutants. Historically, the application of Hyperspectral Remote Sensing techniques in South Africa has been limited; partially due to the fact that the science is relatively new, and the data sets are massive requiring advanced processing power.

The advantages of using this technology for environmental analyses are numerous; it offers scientifically defensible analyses, at a snap-shot in time (provides historical proof). It can deliver results analysing large tracts which would be difficult to cover accurately via fieldwork, and with a lower relative cost implication. Hyperspectral remote sensing is a rapid method to assess many aspects of the natural environment and can be used over longer periods of time to identify environmental changes in natural ecosystems and man-made systems, based on visual, chemical and mineral aspects. It can be successfully utilised by organisations to help meet their environmental legislative requirements, reduce overall environmental liability and save costs.

The technology was used for an environmental application in coal mining in South Africa in 2011 by Digby Wells Environmental and Southern Mapping (in partnership with SpecTIR) for Xstrata Coal, when a Hyperspectral Remote Sensing pilot project was carried out on a portion of Xstrata's operations near Emalahleni. The pilot project was deemed an overall success; thus, a comprehensive Hyperspectral Remote Sensing project for all of the collective Xstrata operations in the Emalahleni area was initiated in 2012.

The aim of this comprehensive project was to utilise state-of-the-art Hyperspectral Remote Sensing technology to detect aspects and capture data pertaining to:

- Hydrocarbon spillages at the mine operations;
- Alien vegetation including Blue Gum and Black Wattle; and to
- Establish vegetation health responses on rehabilitated areas.

Methodology

An aerial survey was conducted between 15th and 17th of November 2012 by Digby Wells Environmental and Southern Mapping (in partnership with SpecTIR) which entailed the acquisition of 360 bands of electromagnetic energy in the Near-Infrared (NIR) and Short Wave Infrared (SWIR) portions of the electromagnetic spectrum (450nm-2500nm). The data collected were orthorectified and output into a hyperspectral "data cube". The hyperspectral data cube essentially contains an image layer per wave length band at nominal 5nm intervals making up a total of 360 suitable bands for analysis. Image pixels were extracted from the data cube using spectral signatures collected in situ with a handheld spectrometer. The extracted data was then interrogated in a GIS (Geographic Information System) environment. Once the hyperspectral data had been interrogated and interesting patterns or anomalies observed; two field visits were carried out in order to verify and further investigate the hyperspectral findings.

Findings and Applications

Alien Vegetation

The alien vegetation data that was acquired using Hyperspectral Remote Sensing techniques proved to be very useful as an indicator tool to identify *Eucalyptus spp.* (Blue Gum) and *Acacia Mearnsii spp.* (Black Wattle) stands. Stands of Blue Gum and Black Wattle were successfully recorded, while single trees were slightly more inconspicuous within the hyperspectral data. There were only two cases of false positive classification of alien vegetation within the hyperspectral data; these cases occurred due to the presence of tracts of wet ground that confounded the hyperspectral signature for Black Wattle. Omitting the lack of sufficient signal from the hyperspectral data for single trees or exposed tree canopies smaller than $7m^2$, the hyperspectral data was estimated to have a mapping accuracy of 95% after ground truthing activities were translated into a standard error matrix. An example of alien vegetation distribution mapping is shown in Figure 1 below.

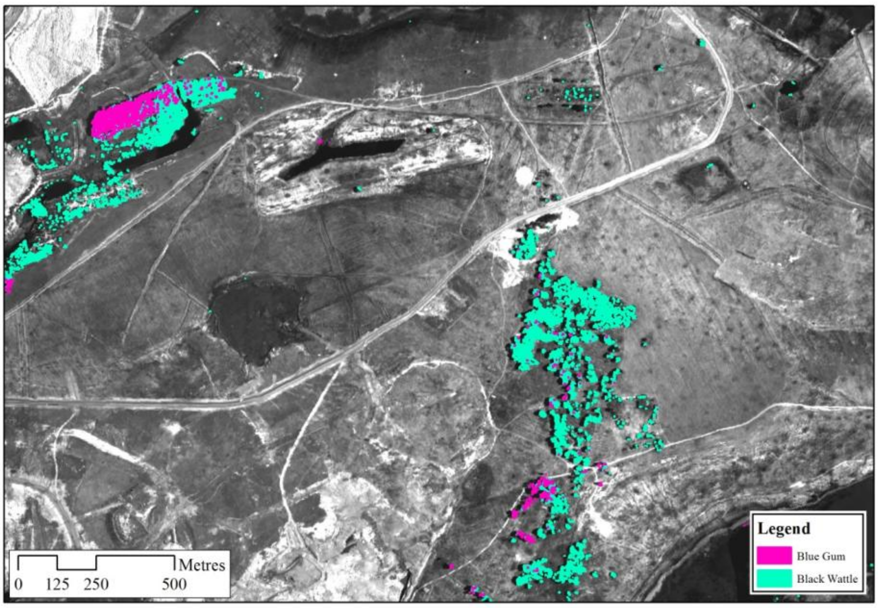


Figure 1: Alien Vegetation map

The intermittent mapping of vegetation species of interest using Hyperspectral Remote Sensing can serve as a useful tool to visualise spatial-temporal relationships. Figure 2 shows the comparison of a particular stand of Blue Gum that was mapped during the 2011 Hyperspectral Remote Sensing Project to the very same stand that was mapped in 2012. The aerial photographs show how the extent of the stand has decreased from one year to the next. The two hyperspectral data layers (2011 and 2012) for Blue Gum correlate with their relevant aerial images; there are fewer features (polygons) for that particular stand within the 2012 Blue Gum data set than there are in the 2011 Blue Gum data set due to the active alien vegetation clearing program at the site. This application illustrates how alien eradication programs' effectiveness can be measured over time.

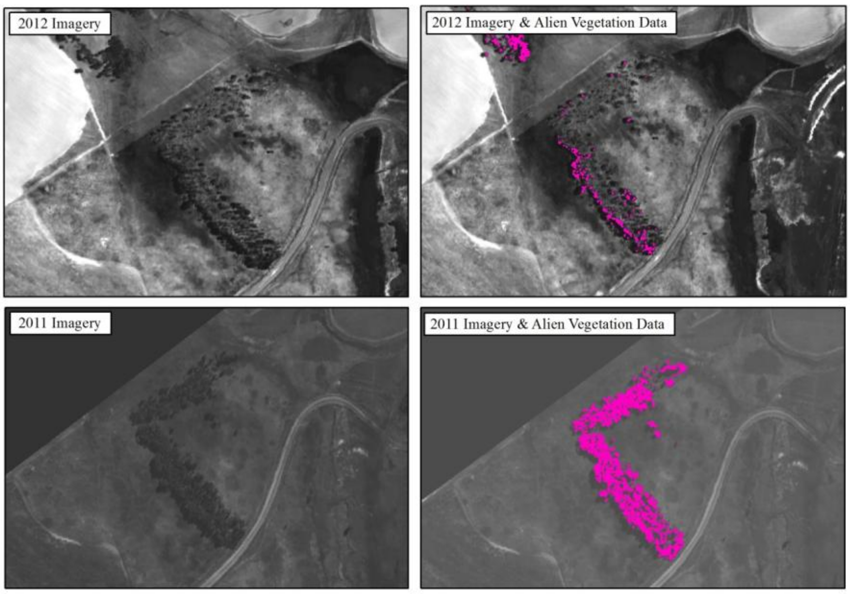


Figure 2: Temporal change of a blue gum stand (decrease over time)

Since the hyperspectral data products are output in a GIS format, the alien vegetation areas can be further measured and compared. Such statistics, which are measured over such a large area of land, would be difficult to determine in the same time frames without the application of Hyperspectral Remote Sensing. Alien eradication and management plans can be formulated implemented and monitored, targeting those areas or operations that have a higher infestation of alien vegetation.

Hydrocarbons analysis

The hydrocarbon analysis focussed on the search for hydrocarbon spills (oil & diesel). The results of the hydrocarbon analysis were stratified into low probability, medium probability and high probability classes. “False positives” were identified within the hydrocarbons layer due to the fact that hydrocarbon signatures are the same for oil, petroleum, and derivatives of these materials such as plastics and oil based paints. These “false positives” included plastic water tanks, construction plastic and oil-based paint that is used on vehicles and on roof tops. Where obvious, the pseudo “false positives” (building roofs and cars) were manually removed from the final output hydrocarbons vector layer so as to report a more accurate estimate on hydrocarbon spillage areas. The final layer is however likely to include plastic wastes and can therefore be used as an indicator tool to locate areas where oil spills have occurred or where oil is being stored or disposed of in a concerning manner, and also to pinpoint areas that might require other forms of simpler clean-up; such as collecting and disposing of plastic litter. A typical hydrocarbons probability map is shown in figure 3.

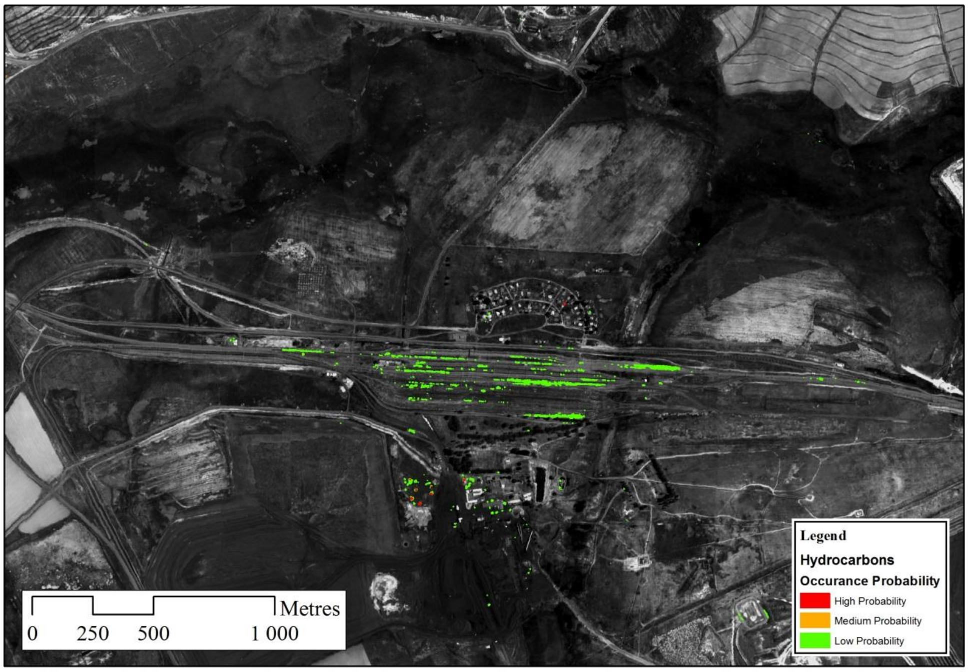


Figure 3: Hydrocarbon Occurrence Probability Map

Once again, these statistics cannot be perceived as the absolute truth, but give an indication as to where hydrocarbon spill and waste clean-up management efforts need to be directed over a large piece of land.

Normalized Difference Vegetation Index

A Normalized Difference Vegetation Index (NDVI) essentially exploits the fact that the more chlorophyll in the leaves of plants the higher the infra-red reflectance and the higher the productivity of the plant. Derived from the red and infra-red wavelength bands, the NDVI layer is a coarse index which can be quickly and usefully applied as a tool for assessing the relative health responses of the rehabilitated mining areas. An example of an NDVI map is illustrated in figure 4.

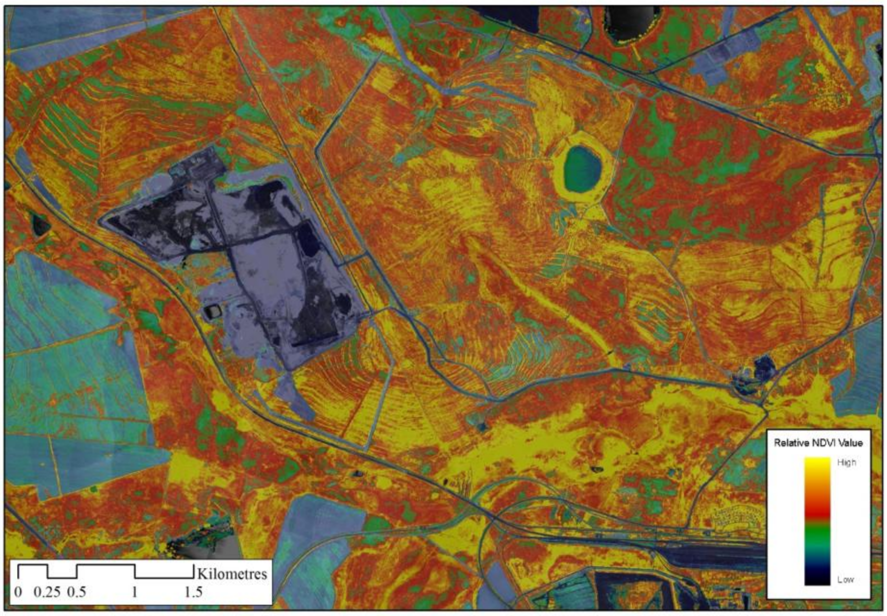


Figure 4: NDVI Map

The NDVI layer is not only effective for monitoring the progress of rehabilitated areas over time, but is also beneficial when anomalies are observed within the layer. An example of this application was noted when a ground-truthing timeline transect was conducted from the south-western to the north-eastern corner of a rehabilitated mining area, which effectively allowed three consecutive years of rehabilitation to be assessed from 2009-2011. One would expect a steadily decreasing NDVI through the rehabilitation timeline since the vegetation in the areas that were rehabilitated earlier in the timeline have had more time to establish itself in terms of building biomass. However, the area that was rehabilitated in 2009 proves to have the lowest NDVI out of all three of the sequentially rehabilitated areas, as seen in the figure 5 below.

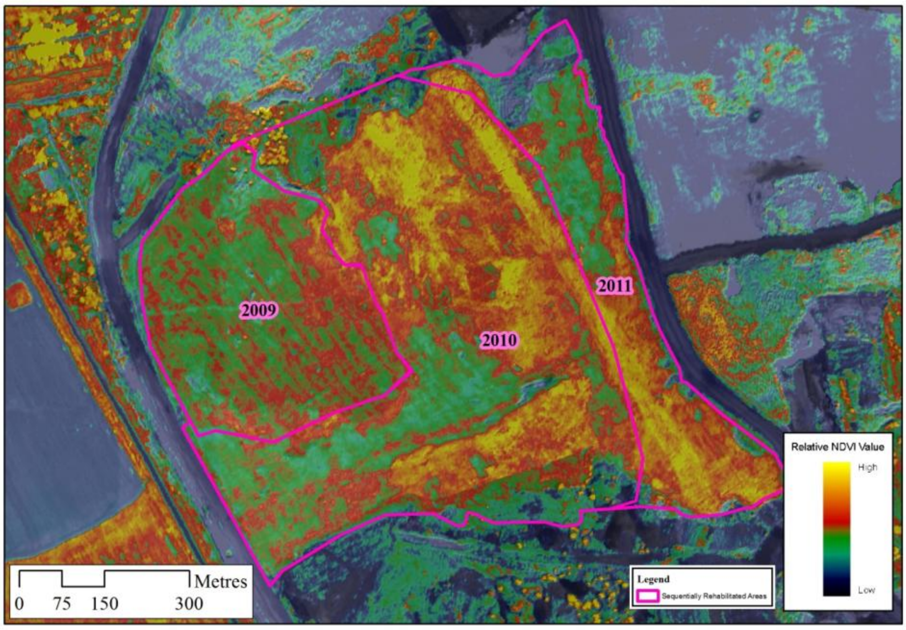


Figure 5: NDVI Map of three sequentially rehabilitated mining areas.

Figure 6: Field verification of areas rehabilitated in 2009, 2010 and 2011. 2010 showing most successful rehabilitation of mining land.

This anomaly can be explored further to determine the cause of this trend; the rehabilitation methods, maintenance protocols or seed mixes used might have varied between years, resulting in the variation in rehabilitation effectiveness. There are a number of factors that could be explored further, but Hyperspectral Remote Sensing has shown that the rehabilitation efforts from 2009 are not as effective as those of 2010.

Lessons Learnt and Way Forward

Although the results, in their rawest form, were presented as findings of the study, in order to experience the maximum benefits of applying Hyperspectral Remote Sensing Techniques, this data needs to be interrogated further and exploited by the relevant environmental officers. Interesting patterns, such as the success and failure of rehabilitated areas throughout the timeline will be analysed in the form of follow-on studies.

The application of this science is relatively novel and it is important to document the lessons learnt from each project in an attempt to adapt and refine the process. It is important to note that the entire process, from data acquisition to mapping of results, takes a period of time, dependant on the size of the area analysed. It is also important to remember that the data, once it has been processed, might need to be refined and checked to display practical results that are relevant and specific to the project. Since hyperspectral remote sensing techniques are effective for assessing or monitoring spatial-temporal environmental patterns, it is important to carry out data acquisition processes at the same seasonal time each year (or monitoring period) when aspects such as relative NDVI are of interest. If data is acquired at different times of the year, the changes in the NDVI layer might simply be mapping changes in vegetation health due to seasonal variations.

There is still a fair amount to learn about the application of hyperspectral remote sensing techniques for environmental monitoring. Those organisations that are willing to explore and apply progressive techniques, such as Hyperspectral Remote Sensing, are being recognised for their innovation in the field of environmental monitoring and planning. Xstrata Coal Group Services has been recognised as an industry leader in utilising this technology for environmental monitoring, and has been in receipt of numerous environmental awards for their efforts.

In a world where scientific research is being revolutionised on an almost constant basis, it is important to apply this research in real-world and practical situations. In doing so, failures and successes are documented and techniques are adapted and refined to close the daunting gap between scientific research and implementation.

Acknowledgements: We would like to thank Xstrata Coal for permission to use project material in this case study.

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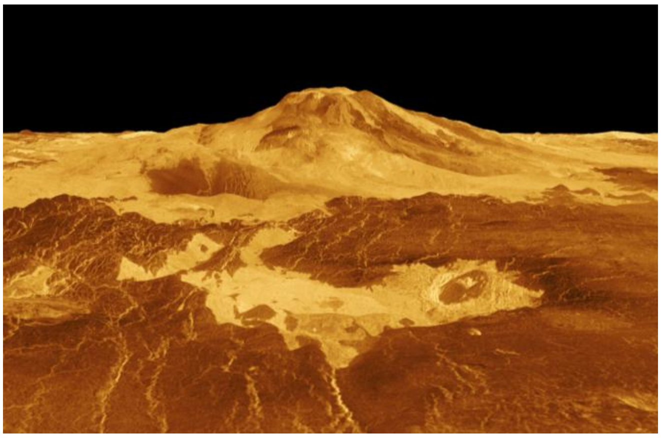
Volcanism as an Active Planetary Process on Venus

Martin Airey, University of Oxford

Venus is a planet very similar to our own in many ways. For example, its size and mass are very similar with a mean planetary radius of 6051.8 km and a mass of 4.87×10^{24} kg (0.950 and 0.816 times those of Earth, respectively). Its orbit is in the same region of the solar system, although it is around 40 million km closer to the Sun, and it is thought to be broadly compositionally similar to Earth. It also differs a great deal in some respects. It has an orbital period of 224 Earth days and a very slow retrograde rotation, completing one rotation about its axis every 243 Earth days. The surface is characterised by what we would describe as extreme conditions compared to Earth. It has an atmospheric pressure equivalent to around 92 Earth atmospheres and a temperature at the surface of around 730 K. These conditions are due to the dense CO_2-rich atmosphere. The climates of Venus and Earth have clearly evolved very differently through time.

After more than 50 years of spaceborne and Earth-based study, one of the most exciting discoveries to have come to light is the evidence for intense, planet-wide volcanic activity. There is clear evidence for past volcanism, including unimaginably large volcanoes as well as vast fields of small volcanoes. My project aims to understand the ways in which volcanism occurs on Venus, and the role volcanism has had, and may possibly continue to have, on Venus' planetary evolution.

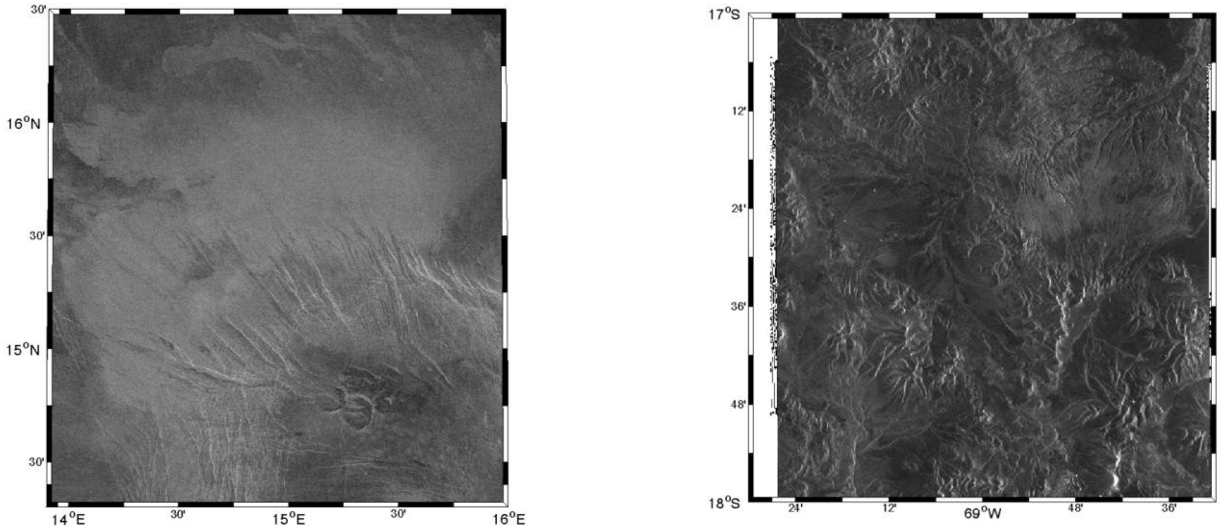


False coloured perspective view of Maat Mons, Venus. Magellan SAR data are superimposed on a vertically exaggerated topographic surface. The volcano is around 9 km high but is around 500 km in diameter. NASA/JPL.

One aspect of my work has been to use computational models based on the well-known physics of volcanic processes on Earth. These can be used to simulate how volcanic activity might occur under the conditions on Venus. I use a conduit flow model to estimate the speed at which material is ejected from the vent, and an eruption column model to simulate plume behaviour. The style of volcanic activity on Venus is likely to be almost exclusively represented by lava flows as the explosivity of volcanoes is severely inhibited for various reasons. These include the likely low abundance of water in the mantle and the incredibly high atmospheric pressure.

We can tell whether or not an eruption behaved explosively from the deposits left behind after the eruption. When we know this, the modelling exercise can be used to better constrain the range of initial conditions that would result in those deposits. This allows us to learn more about the nature of Venusian volcanism, and in finer detail. The problem here is that differentiating between lava flows and explosive deposits in the available Venus data is difficult and largely depends on an individual's interpretation.

This is where the remote sensing aspect of my work comes in. I hope to ground-truth my interpretations of Venusian deposits by using terrestrial deposits of known provenance and properties. This will allow me to make my interpretations with more confidence. The ground-truthing is achieved by comparing observations of a range of terrestrial deposits from Envisat ASAR (Advanced Synthetic Aperture Radar) retrievals with observations of deposits on Venus' surface made by Magellan in the early 1990s. The backscatter coefficients can be calculated and compared directly for these deposits, highlighting surface-dependent trends in the radar returns. I can then find ways of telling the difference between these deposits when I already know what they are and apply the same process to the Venusian deposits. Some deposits that may have resulted from explosive volcanism have been tentatively identified and ongoing analysis is underway to attempt to reduce the uncertainty in these identifications.



Magellan SAR image of deposits flanking Irnini Mons, Venus (left) suggestive of an explosive origin, and Envisat ASAR image of a section of the Bolivian Altiplano, Earth (right). The Bolivian data provide the radar signature for ignimbrite deposits of a known explosive origin, which can be compared with the Venus data of less certain origin. NASA/JPL (left), ESA (right).

In addition to these direct comparisons, I am collecting a slew of radar-derived properties such as emissivity, dielectric constant, elevation, and geographical relationships. With these I will look for other trends and relationships that may help us to understand the nature and properties of volcanism on Venus. Hopefully these investigations will help us to better understand the role played by volcanism in the Venus-system and how it affects and is affected by other planetary processes in the atmosphere and solid planet.

As a recipient of a GRSG student award, I was able to present my preliminary results at the 44th Lunar and Planetary Science Conference in Houston, Texas (March 2013). I received valuable feedback from Venus science experts as well as networking opportunities with the wider planetary science community.

Tracing soil particle movement with spectral approaches

Freek van der Meer and Harald van der Werff, University of Twente, Faculty ITC

On, July, 3 2013, Mrs. Mila Luleva (UT-ITC) successfully defended her PhD dissertation with the title ”Tracing soil particle movement; Towards a spectral approach to spatial monitoring of soil erosion’ at the University of Twente. The supervisors of the work were Prof. Freek van der Meer, Prof. Victor Jetten and Dr. Harald van der Werff.

Figure 1: Mila Luleva, middle with PhD diploma, after having successfully defended her PhD dissertation on July 3, 2013.

In the thesis, potassium is proposed as an tracer for soil particle movement as an alternative to the use of Ceasium137. It is demonstrated that potentially potassium can be spectrally detected and linked to soil particle movement and thus to soil erosion and deposition. The PhD thesis can be downloaded from: http://www.itc.nl/library/papers_2013/phd/luleva.pdf. Below is the summary of the dissertation.

Assessing soil erosion over large areas has been a challenge for decades. The large spatial extent of the process creates difficulties in data acquisition, for both measuring and validation. Remotely sensed data provide spatial coverage and are used to derive information for various soil erosion parameters, such as vegetation cover, topography, and soil moisture. As part of this work, various applications of remotely sensed data in soil erosion studies were reviewed to identify gaps in current soil erosion research. To date, infrared spectroscopy has been applied in only a limited number of studies. A way to better integrate these data in studies of soil erosion was to detect the chemical composition of the soil and apply the method for soil chemical particle tracing.

Figure 2: set up of erosion plots in the field (loess area, Limburg, Netherlands).

To identify a potential soil particle tracer that has similar physical and chemical properties as the commonly used radioactive isotope Ceasium137 (137Cs), but at the same time does possess a distinctive spectral signature, a number of abundant in the environment chemical elements were tested. Wavelength ranges that statistically predict and quantify soluble fractions of chemical elements, from infrared spectroscopy were identified. Partial least squares regression (PLSR) was used to develop prediction models for naturally occurring Calcium (Ca), Magnesium (Mg), Potassium (K), Sodium (Na), Iron (Fe), and acidity (pH) in silt loam soil samples. Significant wavelength ranges were determined by establishing direct and indirect relationships between soil spectra and soluble fractions of these elements.

The feasibility of using Partial Least Squares Regression for identifying soluble fractions of soil chemical elements in silt loam soils using infrared spectroscopy was tested. By outlining wavelength ranges where the change in reflectance was associated with change in the concentration of the element, Potassium was identified as having the closest to 137Cs properties that can be predicted from infrared spectra.

A laboratory based study on the use of Potassium (K) as a potential replacement of 137Cs in soil particle tracing was then conducted. The element was found to have similar electrical, chemical and physical properties. In order to test the suitability of the element as a particle tracer, heavy clay, clay loam, loam, silty loam and sandy loam and fine sand soils were sampled for the study. Sensitivity analyses were performed on soil chemical properties and spectra to identify the wavelength range related to K concentration. Different concentrations of K fertilizer were added to soils with varying texture in order to establish spectral characteristics of the absorption feature associated with K. Quantifying concentrations of K by using commercial fertilizer and infrared spectroscopy was possible for soils with sandy and sandy silt texture. The current study suggested the method as a new approach that could potentially grow to a technique for rapid monitoring of soil particle movement. A flow experiment was conducted in the area of the Guadalentin basin in Murcia, South East Spain in order to identify soil particle movement using Potassium fertilizer and infrared spectroscopy in the field. The severe soil erosion that takes place in the region, as well as the silty loam texture of the soil, determined the selection of the field area. This experiment allowed identification of key factors that determine the detection of K, when tested as a potential particle tracer. A follow up experiment was designed to take into consideration soil clay content, runoff data and concentrations of applied fertilizer. Consequently, a fieldbased water flow experiment was conducted on 6 plots in silty loam soils in the Netherlands. The field area was selected due to the fact that the soils were developed on Loess, and were characterized with limited clay content. The plots were treated with various concentrations of K2O and one plot was used as reference. Infrared reflectance spectra were collected to observe spatial variation in available K, before and after application of fertilizer, and after runoff simulation by water flow. The runoff sediment was also collected in order to establish potential removal of fertilizer under the influence of the water flow.

Fig 3: spectral field measurements on the soil erosion plots.

Exploring K as a soil particle tracer introduced a number of advantages to current erosion studies. It is applied annually as a fertilizer and therefore does not have a halflife as radioactive elements do. The scope of the study, however, was limited to K concentrations that are not harmful to the environment, and are regularly applied during agricultural practices. Although high concentrations of Potassium in the laboratory show promising results, high amounts of fertilizer were not used in the field experiments. Thus, the methodology would be suitable for effective monitoring of early signs of soil erosion. The focus of this study was put on the removal of K under the influence of water flow. Therefore, in order to establish whether sedimentation and deposition can be measured, additional tests should be conducted at the locations where the flow stops. Moreover, it was recommended that further tests on K leaching should be performed, despite that leaching is unlikely to occur for the duration of the proposed experiment. There is a strong need to find an alternative to 137Cs for soil erosion modeling, considering the radioactive properties and half life of the element. If used as a particle tracer, potassium is environmentally friendly, readily available in the form of a fertilizer, and its abundance can be detected with infrared spectroscopy in dry, silty loam or sandy soils, with low clay content.

From Orbit to the Tablet: The ENVI Services Engine for cloud based Deployment of image analysis functionality

By Thomas Bahr, Exelis Visual Information Solutions

Introduction

Geospatial software users are looking for tools to get answers from imagery anywhere, anytime. As organizations grow and more users employ image analysis in their decision making process, these organizations have a need to centrally deploy and manage applications, tools and data. Additionally, as users are located in a variety of environments, results need to be available on thin clients such as a web browser or native mobile device (O'CONNOR, A., LAUSTEN, K., OKUBO, B. & HARRIS, T. 2012).
Desktop software only solutions no longer meet these needs for geospatial processing. Therefore, we solved the above in an interoperable, standards-based REST (Representational State Transfer) solution.
The ENVI Services Engine (ESE) is a cloud-based deployment of image analysis functionality that integrates into geospatial platforms. The ESE is comprised of a RESTful API that allows users access to ENVI's imagery exploitation capabilities, as well as the necessary components to publish and deploy these consumable web services into any enterprise environment. By offering on-line, on-demand image analysis, geospatial users have access to information derived from remotely sensed data from any location at any time.

ENVI-Based Services in the Enterprise

ENVI – Environment for Visualizing Images

ENVI solutions combine spectral image processing and image analysis technology to get detailed information from geospatial imagery. Data gathered from today's satellite and airborne sensors, including panchromatic, multispectral, hyperspectral, radar, thermal, and LiDAR, is supported. ENVI ingests, reads, and extracts information from these various sources, and can fuse multiple data modalities to exploit the strengths of each data type. It works with any size data set and has automated tools to prepare big and small geospatial imagery for viewing or further analysis. Data preprocessing and analysis includes a comprehensive suite of tools for, e.g. atmospheric correction, registration, ortho-rectification, filtering, geospatial statistics, topographic modelling, and object based feature extraction, etc. ENVI is written in the IDL programming language. This allows users to extend or customize ENVI features and functionality to fit both image analysis requirements and specific project needs (Exelis Visual Information Solutions (Ed.) 2013a).

ENVI Services Engine Overview

The ESE incorporates open source standards, and, as a result, supports integration into many different types of systems. By running ENVI or IDL algorithms and routines as enterprise services, users can access any of the image analysis components they need for data exploitation. Once an ENVI or IDL routine is developed, it is quite simple to wrap it as a service and deploy it in the engine for consumption.

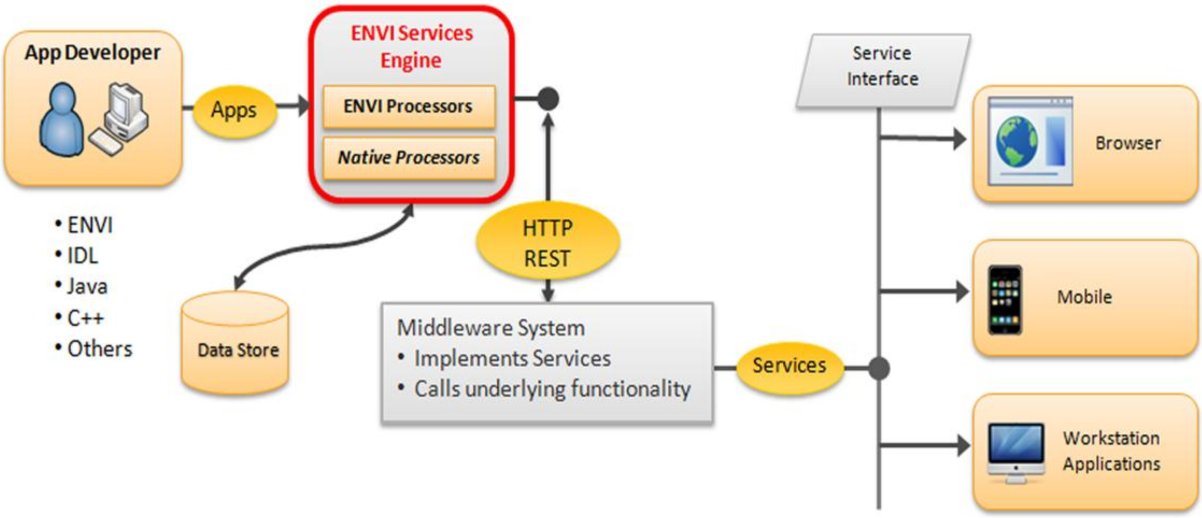


Fig. 1: *ENVI Services Engine conceptual rendering. ESE runs e.g. ENVI and IDL routines through a standard HTTP RESTful interface. Data requests are handled via WCS or WPS calls. ESE is called by a web client or mobile app via an optional middleware component (Exelis Visual Information Solutions (Ed.) 2012).*

The ESE runs these algorithms through a standard HTTP RESTful interface, allowing users to provide basic user interfaces to complex analysis tasks via lightweight client. (see figure 1). In particular, it is based on ESRI's GeoServices REST specification (Esri (Ed.) 2010). The ESE implements a superset of ESRI's specification wherever it makes sense for IDL and ENVI processing (Exelis Visual Information Solutions (Ed.) 2013b).

Results are returned to the client via standard HTTP mechanisms. They can be saved and displayed in a variety of clients, including online, desktop, and mobile clients, depending on the user's implementation. These image analysis applications and components can be integrated into a cloud environment, independent of any existing middleware configuration (see figure 1). The ESE is therefore a flexible and easy to use framework that functions within the user's existing infrastructure.

As well as offering on-demand, online access to ENVI functionality, the ESE can be used to develop and expose unique analytics, allowing organizations to create their own enterprise image analysis workflows. Using existing ENVI functionality in a cloud environment will help to save time and resources, as the user can develop an algorithm once and deploy it to multiple locations. Additionally, the user can release new applications and functionality as mission needs change and evolve.

One of the largest benefits of deploying image analytics in the cloud is the ability to run complex, resource-intensive analysis on extremely large datasets from thin or mobile clients. By having both the data and analysis components on the web, lightweight applications can be used to call the analysis functions, making the analysis workflow more efficient for users and moving image exploitation closer to the end user.

Architecture

The ESE application consists of one "master" process and one or more "worker" processes (see figure 2). Processing requests are passed to the ESE via HTTP REST calls. The master contains an embedded web server. The master's job is to manage requests and jobs for worker processes. Worker processes contain an IDL interpreter and do the actual IDL and ENVI processing. When workers complete a job, they notify the master of the results and the master returns those results to the client (Exelis Visual Information Solutions (Ed.) 2013b).

Processing requests are passed to the ESE via HTTP REST calls. The master contains an embedded web server. The master's job is to manage requests and jobs for worker processes. Worker processes contain an IDL interpreter and do the actual IDL and ENVI processing. When workers complete a job, they notify the master of the results and the master returns those results to the client (Exelis Visual Information Solutions (Ed.) 2013b).

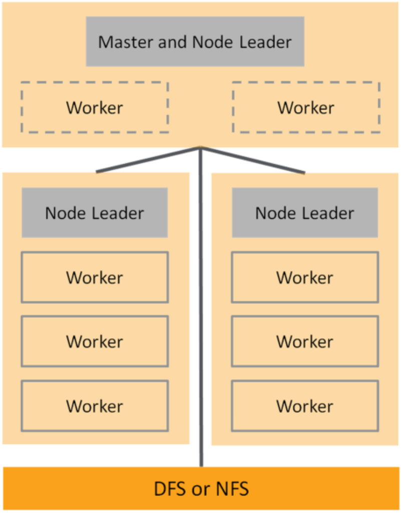


Fig. 2:

ENVI Services Engine architecture: "master" process and associated "worker" processes (Exelis Visual Information Solutions (Ed.) 2013a)

An ESE process assumes the role of master if it is the first instance of the process that is started up on the machine that is designated the master machine. On any other machine in the cluster, the first instance is run as a node leader. A node leader will launch and monitor a configurable number of worker processes. (Exelis Visual Information Solutions (Ed.) 2013b).

The important need of scalability is supported by the ability to scale and load balance because it implements a REST architecture and is designed to run on a cluster. As requests arrive from any number of clients, the master process' web server will accept and route the request. If the request is to perform a task, then the master will give the request to one of its worker processes. Worker processes can run on any machine in the ESE's cluster. The cluster is a collection of machines tied to one particular master machine. Namely, a machine is part of the cluster if it is running an instance of the ESE executable and that executable is wired to communicate with the same master as other machines on the cluster. The master machine is specified by a configuration file (Exelis Visual Information Solutions (Ed.) 2013b).

Developing Apps

ESE is designed for such enterprise web services and can be configured to work with multiple types of thin-and-thick clients including web browsers, mobile devices (Android, iOS) and workstation applications such as ENVI or ArcGIS (see figure 3).

The advantage of this approach is that analysts can access specific image science algorithms, tools and configured workflows through discrete Apps that are easy to update and maintain.
The benefits for the developers creating Apps to use with the ESE include (Exelis Visual Information Solutions (Ed.) 2012):

- Access to 100+ different formats and modalities of imaging data.
- Ability to exploit multi-source image data using proven analytic methods such as Target Detection, Object-Based Feature Extraction, Change Detection.
- Ability to deliver derived products in easily consumable formats (.shp, kml, NITF, etc.).
- Access to analytic methods that have been widely used in the scientific community for decades.
- Ability to fuse multiple sources of information, resulting in higher confidence in derived products.
- Extensibility allows for quick insertion of capabilities to support new and emerging modalities and/or analytic approaches.

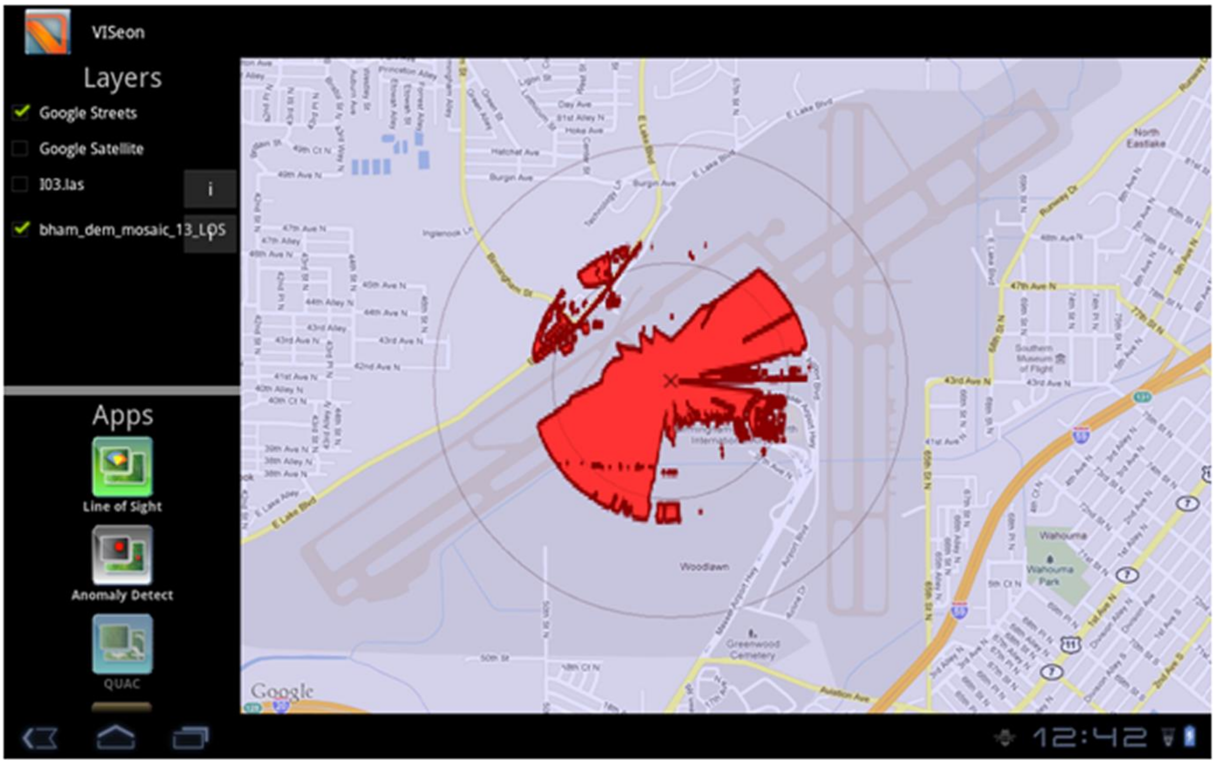


Fig. 3: *An interactive Line-Of-Sight App, launched from Native Android Client. The user locates an AOI and draws an interactive circle to indicate parameters. The middleware passes the location and the AOI to the ENVI Services Engine. The ESE finds the appropriate data in the catalogue and returns the vector result showing the line of sight. This vector result is passed through the middleware to the client. Finally, the client renders the result in the appropriate geographic location in the interface (EXELIS VISUAL INFORMATION SOLUTIONS (Ed.) 2012).*

A Reference Application

In an effort to provide examples of how the ESE can be used, Exelis VIS created a reference implementation that redeploys several pieces of existing ENVI code as Apps. These include (O'CONNOR, A., LAUSTEN, K., OKUBO, B. & HARRIS, T. 2012):

- *Anomaly Detection* for detection of spurious material in a large image.
- *Pan Sharpening* for enhancing multispectral data with high resolution panchromatic imagery.
- *Vegetation Delineation* for identifying vegetation presence and level of vigor.
- *Line of Sight* to create a viewshed using terrain data (see figure 3).
- *Spectral Identification* to show using a spectral library to classify materials in a hyperspectral dataset.

This implementation envisions a web client or mobile app calling the ESE via a middleware component such as MapServer, GeoServer, or some other development environment and employs a web based GUI and/or a mobile app for Android or iPhone as an access mechanism. Thin and mobile clients are used to discover data using a cataloguing specification such as Web Catalog Service (WCS) and to make Open Geospatial Consortium (OGC)-compliant analysis requests via Web Processing Service (WPS) calls to the ENVI Services Engine via the middleware.

One use case example could be looking at the Landsat archival data with the vegetation delineation tool. For a region or a specific scene, this ESE implementation would facilitate in discovering imagery, identifying vegetation and analyzing change over time. Results could include an animation, a profile of vegetation change over time, or specific points correlated to ground truth measurements. These results could be delivered to web, mobile or desktop clients.

Conclusion and Outlook

The ENVI Services Engine (ESE) provides the community with a flexible and easy-to-use framework for creating and using image science Apps. Tasks such as detecting target signatures from hyperspectral imagery or calculating a Line of Sight (LOS) from LIDAR data are simple to execute and easy to share. The power comes from exposing all of ENVIs image processing algorithms and tools as RESTful web services and using ENVI/IDL, Java or other development languages/tools to create Apps for image science tasks such as orthorectification, classification, etc.. Benefits of the ESE approach include (EXELIS VISUAL INFORMATION SOLUTIONS (Ed.) 2012):

- The flexibility to integrate into any architecture that can make http calls.
- Delivers an online, on-demand approach to data analytics.
- Takes advantage of open standards allowing for integration with other Apps.
- Allows experts to compile and expose their workflows and tradecraft, enabling end users to create their own tailored GEOProcessing products.
- Minimizes desktop software licensing costs.
- Emphasizes the use of server side hardware by offloading processing tasks previously performed at the desktop level.

The way imagery data is being stored and analyzed is changing. ENVI and IDL have long been tools used in Earth science communities. The ESE helps scientific data users transition to the cloud while still being able to use legacy code and algorithms. The ability to host and disseminate data and complex functionality within the cloud will lead to wider enterprise-wide hosting and dissemination of earth science data in the future. The work behind ESE is aimed at making this concept a reality. More people being able to access and process scientific data means more discoveries, more collaboration, and more progress, e.g. toward future environmental challenges (O'CONNOR, A., LAUSTEN, K., OKUBO, B. & HARRIS, T. 2012).

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Confirmed GRSG AGM Sponsors 2013

GRSG Meetings

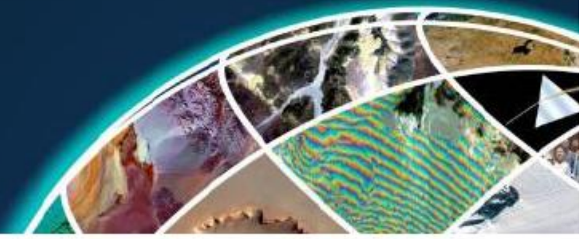
We are pleased to announce the date and location for the December 2013 conference:

9 - 11 December 2013, Berlin, Germany
'Status and developments in geological remote sensing'

** Place this date in your diary – more info to follow very soon **

Planning for the Berlin meeting is well underway and a draft programme should be released at the end of September, the most recent Call for Papers including the sponsors to date (there is still time to sponsor), and the keynotes is provided below. The organising committee for GRSG Berlin 2013 include the UK-GRSG committee and also GRSG members in Germany: Cornelia Glaesser (Martin Luther University Halle-Wittenberg, MLU), Friedrich Kuehn (BGR) and Christian Fischer (DLR).

GRSG Geological Remote Sensing Group



SECOND CALL FOR PAPERS

'Status and Developments in Geological Remote Sensing'

9th - 11th December 2013, Berlin, Germany

The Geological Remote Sensing Group (GRSG) announces the **Second Call for Papers** for the 24th Annual Meeting of GRSG, to be held in Berlin from 9-11 December 2013.

Abstracts are welcome on a wide range of remote sensing themes, including:

- New sensors, technological developments, analytical methods & algorithms
- Data fusion ; Bridging the divide between data and applications
- Latest developments, research and applied uses of RS for:
  - Mineral exploration
  - Oil & Gas
  - Geological applications (lithostructural mapping, tectonics and seismology)
  - Geomorphology
  - Geohazards, engineering/geotechnical, and environmental/contamination
  - Terrain, bathymetry and DEM analytical techniques
  - Classification, multi-temporal analysis and modelling
- Planetary science & comparative geomorphology
- Hyperspectral & Multispectral; Radar / InSAR; Optical & high resolution

Abstracts (Oral presentations or posters): Title, author(s) and 300 word abstract should be sent to:
agm@grsg.org.uk

Important Dates:	
Call for papers opens:	1 May 2013
Registration opens:	15 May 2013
Deadline for abstracts:	1 Sept 2013

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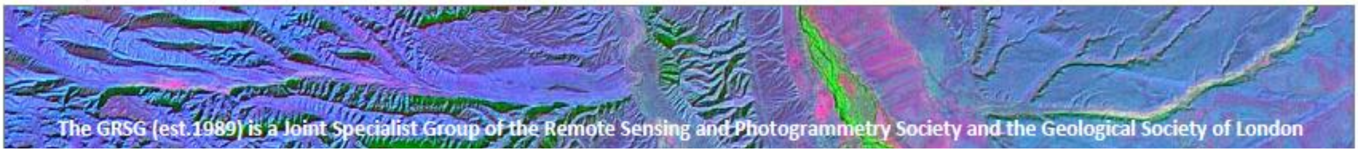

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Confirmed Keynotes:

Spectroscopic Remote Sensing: A Tool for Resource Evaluations in Afghanistan, Trude King, United States Geological Survey (USGS)

EnMap - the new hyperspectral satellite system, new strategies in hyperspectral mineral analysis, Charlie Kaufman, Deutsches GeoForschungs Zentrum/German Research Center for Geosciences (GFZ), Potsdam & Andreas Mueller, German Aerospace Center (DLR)

Morphometrics on Mars and Earth – comparative geomorphology, Ernst Hauber, Institute of Planetary Research, German Aerospace Center (DLR)

For further information, Sponsorship opportunities and Logistics

see www.grsg.org.uk

Other Meetings

October

10th - 11th: ***EO MINERS Final Scientific and Technical conference***. Versailles, France

see flyers overleaf

November

4th - 8th: ***AfricaGIS 2013,*** Addis Ababa, Ethiopia

EIS-Africa, the GSDI Association, the International Geospatial Society, the United Nations Economic Commission for Africa (UNECA) and EiABC Addis Ababa University are pleased to announce a close partnership in offering the joint and fully integrated **AfricaGIS 2013 Conference** and **GSDI 14 World Conference**.

This combined conference will take place at the UNECA Conference Center (video) in Addis Abbaba, Ethiopia from November 4-8, 2013.

The joint conference theme is **Spatial Enablement in Support of Economic Development and Poverty Reduction**. **AfricaGIS** is the largest regularly occurring GIS conference in Africa with participants from the entirety of the continent. The **GSDI World Conference** has built a reputation for excellence in content and moves across the globe to offer geospatial specialists in all parts of the world opportunities to better exchange ideas and learn from global peers in building spatial data infrastructure.

Numerous high quality hotels are conveniently available near the Conference Center and flights are readily available from across Europe, Africa and the Middle East.

Substantial reductions in registration fees are available for local participants and for members of EIS-Africa and the International Geospatial Society from low income per capita nations. Substantial reductions in Exhibit and Sponsorship fees are available for companies and agencies that are members of the GSDI Association.

For more information see http://www.gsdi.org/gsdiconf/gsdi14/

December

2nd - 4th: ***Mines and Money*** London, UK

Mines and Money London is Europe's leading mining investment and capital raising conference and exhibition, bringing together over 3,000 investors, financiers, brokers and mining developers, for up to five days of business matching, knowledge sharing and deal-making.

With 260 mining companies on display, some of the world's largest natural resources fund managers in attendance, and a packed programme of keynotes, market analysis, company presentations, panels and workshops, Mines and Money London 2013 is designed to reinvigorate the industry, with fresh investment and capital raising ideas and opportunities.
In 2013, the conference and exhibition expands to a 3-day (Mon-Wed) format, with a specialty investor day on Sunday (Canada & Australia Day) and optional workshop on Thursday (Practical strategies for cost cutting and efficiency). The new-look format provides attendees with more time to meet with industry colleagues and more chances to identify capital raising and mining investment opportunities.

for more information see http://www.minesandmoney.com/london/

11th - 12th: ***PROSPEX 2013,*** London UK

PESGB and DECC are pleased to bring you the 11th show in the highly successful series of Prospects Fairs: the UK's leading networking event for exploration and development

PROSPEX is a two day exhibition with a parallel speaker programme including the highly popular ‘Prospectsto Go’ sessions, for more information about the show, please click here or contact Ben Gardner (ben@pesgb.org.uk)

9th - 13th: ***AGU Fall Meeting,*** San Francisco, California USA

Welcome to the American Geophysical Union’s 46th annual Fall Meeting! Join more than 22,000 Earth and space scientists, educators, students, and other leaders in San Francisco, California, 9-13 December, as they gather to present groundbreaking research and connect with colleagues.

The AGU Fall Meeting is the largest worldwide conference in the geophysical sciences, attracting more than 24,000 Earth and space scientists, educators, students, and other leaders. For 46 years, energized and passionate Earth and space scientists from around the world gather at the AGU Fall Meeting to connect with colleagues, broaden their knowledge base, and embrace the joy of science. The 2013 meeting takes place Monday 9 – Friday 13 December 2013.

Each year, the Fall Meeting takes place in the North, South, and West buildings of the Moscone Center, at the intersection of Fourth and Howard Streets, San Francisco, CA 94103. The Moscone Center is accessible by BART and MUNI public transit lines, and also in walking distance of many hotels.

For more information, contact fm-help@agu.org. or see http://fallmeeting.agu.org/2013/

eo miners

GEO GROUP ON EARTH OBSERVATIONS

creating a unity for the future

EO-MINERS
Earth Observation for Monitoring and Observing Environmental and Societal Impacts of Mineral Resources Exploration and Exploitation

announcement

EO-MINERS final scientific and technical conference

October 10 – 11, 2013, Versailles, France

The EO-MINERS project

Non-energy raw materials are vital inputs for the EU's economy and maintaining fair and undistorted access to these materials for EU industry and citizens is increasingly difficult. Within the EU, exploration and extraction have to face increased competition for different land uses and a highly regulated environment. While the EU is currently dependent on the importation of many metals, the overall potential for mining and quarrying in Europe is strong. In spite of this, the land area available for extraction in the EU is constantly decreasing, turning access to land into a key challenge for the extractive industry.

The EO-MINERS project aims at contributing to demonstrate how to improve the EU capacity in implementing new mining sites and their societal and environmental acceptability. The overall objective of EO-MINERS (Earth Observation for Monitoring and Observing Environmental and Societal Impacts of Mineral Resources Exploration and Exploitation) is to bring into play EO-based methods and tools to facilitate and improve interaction between the mineral extractive industry and the society in view of its sustainable development while improving its societal acceptability.

EO offers a unique opportunity to collect necessary spatial parameters that play a key role for better assessments of mining-related environmental and societal impacts. It could enable the development of means to identify the site-specific environmental and societal footprints of mineral resource extraction and to determine their respective significance. This understanding of global and cumulative footprints along a causal chain is needed in order to target policy measures. In this way the expected reduction of environmental and societal footprints in the mining sector can be most effective for the environment and more cost-efficient for public authorities and commercial operators.

The EO-MINERS developments

Development of EO-based monitoring tools has been carried out over three demonstration sites: the lignite open pit of Sokolov in Czech Republic, the Mpumalanga coalfield centred on the town of Emalahleni (previously Witbank) in South Africa, and the Makmal gold mine in Kyrgyzstan. The project first defined environmental, socio-economic, societal, and sustainable development indicators and criteria that can possibly be dealt with using EO techniques. After an analysis of policies related to the environmental and social footprint of mineral industries, project expertise and stakeholder interviews (national and on-site) as well as site investigations led to the establishment of a list of indicators to be monitored by EO, either directly or indirectly, through accessible parameters. From these developments, it is subsequently intended to contribute to the development of generic, standardised EO data integration schemes, in particular in view of characterising affected ecosystems, populations, and societies and prepare indisputable documents that will make the basis for a sound "trialogue" between industry, governmental organisations, and stakeholders.

7 COOPERATION

GROUP ON EARTH OBSERVATIONS

creating a unity for the future

The EO-MINERS final conference

The EO-MINERS final conference aims at presenting the project developments and results to parties interested in Earth Observation especially applied to environmental and societal issues, with a special focus on mining activity.

The sessions will include a general presentation of the project and its objectives, the main scientific developments carried out and the products developed to meet stakeholder requirements.

Invitees are welcome to present their relevant activities, both on form of presentations and/or posters.

Date and Venue

Date: 10 and 11 October 2013

Venue: University of Versailles - St Quentin, Saint-Quentin-en-Yvelines

A shuttle service might be organised from hotels in Versailles to the university in Saint-Quentin-en-Yvelines, depending on availability.

For those interested a visit of the Versailles castle could be organised on

Conference provisional schedule

The conference will start on Thursday October 10 at 3:00 pm and terminate on Friday October 11 at 5:00 pm

A first session will take place from 3:00 to 5:30 pm on 10th, followed by a reception around posters at the university foyer. It will consist in a general presentation of the project and its context, a review of the relevant policies, and the development and choice of relevant indicators, along with the methodological steps from indicators to EO-based integrated products.

The second session will occur on 11th from 9:30 am to 12:30 (including a coffee break) and will focus on scientific developments in EO data processing, including standards, and a presentation of the main EO-based integrated products developed during the course of the project.

The third and final session will come off on 11th from 2:00 to 5:00 pm, including a coffee break. It will be dedicated to presentations by invited scientists, followed by a wrap up session, focusing on Horizon 2020.

Contacts / Information

For more information, please contact us at:
http://www.eo-miners.eu

PLEASE NOTE:

The participation in the conference will be free of charge. However, available places may be limited and will be provided on first come first serve basis. So please return the attached registration completed to:
final@eo-miners.eu

We will make soon recommendations for accommodation, either in Versailles or Saint-Quentin-en-Yvelines

COOPERATION

creating a unity for the future

EO-MINERS
Earth Observation for Monitoring and Observing Environmental and Societal Impacts of Mineral Resources Exploration and Exploitation

EO-MINERS final scientific and technical conference
October 10 – 11, 2013, Versailles, France

Registration

Yes, I'd like to participate in the workshop.

* Mandatory information

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*Name:		
*Surname:		
*Organisation:		
Address:		
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I intend to present	Presentation :	Poster :
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The available places for the workshop may be limited and will be provided on first come first serve basis. So please return this registration quickly and completed to:

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Stuart Marsh, BGS, Services to the committee & Chairman

Philippa Mason, HME Partnership/Imperial College, Services to the committee & Secretary

John McMahon Moore, Imperial College, Services to the committee & Vice Chairman

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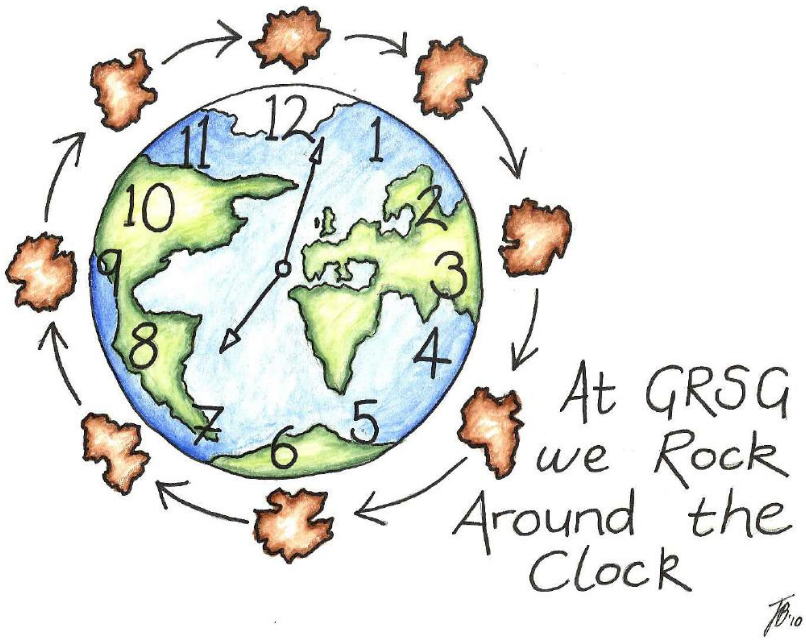

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GRSG Membership Renewal

Please print out and sign the completed form (we need your signature) and scan and email or return by fax or post

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Company/Organisation		
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Quiz answer

Quiz Answer: C - Fragment of Berlin Wall (true colour RGB !)

Pre-1989 graffiti on concrete (5cm x 5cm) mounted in Perspex, deconstructed by social action and elevated to an historical artefact

GRSG was founded in 1989 – one of the most historic events of that year (and Century) was the fall of the Berlin wall (November 1989) – so it is just a little coincidence to be having our 24th AGM meeting this year in Berlin.
See you in Berlin!

Disclaimer

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