Multidisciplinary fieldwork and modelling skills for applied geoscience

Provisional dates: 28th September to 9th October 2017

Background

This course builds on two successful NERC ATSCs – Multidisciplinary fieldwork training in a professional geoscience environment and Multidisciplinary fieldwork and modelling skills for the mining industry. The natural resource (hydrocarbon, minerals and water) industries require numerate, multidisciplined geoscientists with a strong core of field-based observational skills coupled with knowledge of field-based instrumentation. This course will provide practical fieldwork training in a professional geoscience environment by focussing on an application for the mining industry. It will emphasise developing field observation skills relevant to mineral exploration and for applied earth science research into volcanic and magmatic processes. It will also include field deployment of several instrument technologies such as spectroscopy, portable XRF, portable XRD and ground LiDAR. The concept behind the course is to enable doctoral and early career researchers to experience the work flow used in the planning, capture and interpretation of field data. It will also utilise statistically-based analysis of spatial data to define mineral deposit targets. This will enable delegates to understand the key requirements for industry investment in mineral exploration projects and to use this knowledge in their career development. The training will be delivered in two parts:

1. Initial reconnaissance, campaign planning, interpretation and analysis of remotely sensed data in BGS' offices in Nottingham; this will include use of high resolution airborne imagery to create social and environmental risk maps

2. Training in a range of field observational skills that are relevant to mineral exploration, volcanology and geothermal energy in active volcanic-hydrothermal environment on the island of Milos, Greece. In addition to improving technical expertise, the course will also develop skills in leadership, team working, task delegation and an appreciation of the social, community and environmental issues associated with mineral exploration and extraction.

Though the focus of the course is in providing additional skills to help equip delegates for a geoscience career outside academia, which is where the large majority of geoscience doctoral and early career researchers will be employed, their personal research programmes will benefit from them gaining direct field training in a mineralised volcanic environment, remote sensing analysis, use of large datasets and fieldwork planning using remote sensing and legacy data. This will benefit delegates with research topics in most branches of the geosciences, but in particular those with mineral deposit geology, volcanology or magmatic process as their main research focus.

Course description

The training will be delivered by tutors from BGS, the Natural History Museum, the universities of Hull, Leicester and Nottingham plus mining industry professionals with over 75 years cumulative experience of geosciences in a business environment. This combination of expertise will provide course delegates with a unique opportunity to develop skills appropriate to a range of end-users in a multidisciplinary setting. The course will deliver environmental science training in several national priority areas:

1. The initial scoping, using data from the NERC geoscience and Earth observation data centres, will expose course delegates to a range of data processing techniques. They will also gain an appreciation of how geoscience and Earth observation data can be used in visualisation and analysis to help augment field work;
2. Access to the knowledge and expertise of professional field geoscientists will significantly enhance field identification and survey skills. There will be the opportunity to learn and apply a range of field techniques such as sampling, collection and recording protocols and methodologies. They will also deploy field technologies such as field spectroscopy, portable XRF/XRD analysis and terrestrial laser scanning;
3. The use of field and remotely sensed data coupled with a statistically-based prospectivity analysis will introduce and give delegates an understanding of quantitative and qualitative modelling approaches that underpin mineral exploration strategies.

Expected outcomes and impacts include:

1. The development of critical field observational skills for use in their own research and future careers and to know how to use large data resources to support research and inform results in a business setting;
2. Knowledge of how field based-instrumentation can be used in a mineral exploration context and transfer this to their own research. For example, the use of terrestrial LiDAR to create virtual outcrops of inaccessible localities
3. An understanding of the use of geoscience information through statistical analysis to assess the quality and uncertainty of those data;
4. The development of the skills needed for quantitative risk-based mineral prospectivity analysis;
5. The ability to communicate research approaches and results across disciplines;
6. Recognition and implementation of best practice project management and planning in a team environment;
7. An appreciation of the data that underpins geoscience models and how they can be used to communicate complex science ideas to a range of publics;
8. An appreciation of the environmental and social impacts and challenges within the mining industry.

Excluding travel, the course will last 12 days and take place in the offices of BGS and Milos island Greece

Part 1 – Assessment and planning (BGS): BGS is the national geoscience data centre and the course attendees will have access to a range of digital data. Delegates will be given a clear project brief by to assess the mineral potential of Milos island Greece. They will have access to a fully processed NERC Airborne Research & Survey Facility data set (LiDAR, digital photography, EAGLE-HAWK) and will receive training in the BGS 3D visualisation and Remote Sensing laboratory facilities to enable them to carry out 'virtual field reconnaissance' to identify mineral targets and plan a field campaign. This part of the course will also introduce delegates to statistically-based prospectivity analysis, which will be further developed during the field-based activities. In the BGS-based component of the course Sartala, a company specialising in corporate risk, will train delegates in the use of high resolution airborne imagery to create social and environmental risk maps.

Part 2 – Collecting field data and field office (Milos): Course attendees will develop a range of new geoscience observational skills with a mineral exploration focus, but also appropriate for working in a range of professional geoscience environments. In the field, they will be shown how to: (i) recognise a range of volcanic products and relate them to volcanic processes (ii) identify features associated with hydrothermal alteration plus associated mineralisation and (iii) use field spectroscopy, terrestrial LiDAR, portable XRF and XRD to identify different types of alteration mineralogy and metal contents of mineralised material; (iv) design and undertake a geochemical sampling programme. Fieldwork will also include team mapping exercises, using portable XRF, spectroscopy, and technologies for digital field data capture, such as the BGS–SIGMA system. Afternoons and evenings (2–3 hrs) will be used to provide additional training to process and interpret remote sensing data and to build a GIS. At the end of the fieldtrip, working in teams, the delegates will be expected use the observations and knowledge gained to identify targets and present a case for further work and potential exploration investment, including an assessment of environmental and community issues.

Milos is selected as a field location for the following reasons: 1. A NERC ARSF high resolution survey comprising a LiDAR DEM, hyperspectral imagery and aerial photography supports the virtual field reconnaissance training; 2. It is renowned as a natural laboratory for examining volcanism and mineralisation, with several different styles and variations of each well exposed and easily accessible; 3. It is geothermally active allowing the comparison of active and paleogeothermal processes; 4. The course tutors have considerable experience of the geology of Milos; 5. With an active mine there is an opportunity to investigate the social, community and environmental issues associated with mineral exploration and extraction; 6. Good weather guarantees maximum time for developing a range of field-based observational skills.

Course tutors

The course will be delivered by 9 tutors with significant experience and a range of expertise to cover the diversity of skills being taught and to provide high quality individualised training. **Jonathan Naden** will be course leader and he is responsible for the BGS programme of doctoral training. He is an international expert in mineralisation associated with volcanic processes and has over 15-years of research experience on Milos. In addition, he has also developed and delivered several field-based courses. **Graham Brown** has 35-years' experience in the mining and exploration business employed as an independent consultant, senior executive at Anglo American and global leader of a highly successful discovery team. He is currently an SEG councillor, Chair of the BGS Advisory Board and member of the NHM Scientific Advisory Board. **Dan Smith** is a leading young geoscience researcher and can provide valuable insights into career pathways for course delegates. He served on the expert panel for the Security of Supply of Mineral Resources Expert. He currently, the lead PI on a £3m Research grant in the NERC Mineral Resources Programme. He is an international expert on magmatic and hydrothermal processes in volcanic environments and teaches courses in environmental geoscience, mineral deposit formation, and mineral economics. **Richard Herrington** is Head of the Department of Earth Sciences at the NHM with >25 years research experience following on from 8 years working in the mineral exploration industry. He has a range experience as the PI on several major RCUK, EU and industry funded projects focused on using mineralogy to improve the efficiency as well as reducing the environmental and carbon impact of deposit discovery, mining and mineral processing. He helped to successfully deliver two ATSC short courses on 'Soils' at the NHM in 2014 and 'Fieldwork' in Milos in 2016. **Sarah Gordon** is a Director at Satarla a company specialising in risk management and training. She is also on council at the Geological Society and is a visiting academic at Imperial College. She also has >10 years experience working in exploration and sustainability within the mining sector at Anglo American **Stephen Grebby** is a remote sensing geoscientist with over 12 years of experience in the application and development of cutting-edge remote sensing techniques for geological mapping, mineral exploration and monitoring of geohazards. He has developed and delivered university M-level courses in Remote Sensing and GIS for Geologists. **Luke Bateson** is a senior remote sensing geologist with over 14-years of experience. These have included UK and overseas mapping, monitoring of ground motions using radar interferometry. He is the lead BGS CPD trainer for the visualisation, integration and interpretation of 3D datasets using BGS' 3D visualisation software. **Bob Lister** is an applied geochemist with over 25-years of experience in geochemical mapping for national baseline and exploration purposes, both in the UK and abroad. He is manager of the BGS's GBase project, with responsibilities including field programme, and analytical data management. He has led a number of CPD training courses in geochemical mapping; in the UK and abroad. **Graham Ferrier** is an international expert in the geological applications of remote sensing data with a particular specialism in hyperspectral, spectral emittance imaging, thermal, FTIR spectroscopy, terrestrial laser scanning, ground penetrating radar and imaging resistivity. He has over 15-years' research experience on Milos which includes airborne remote sensing data acquisitions.

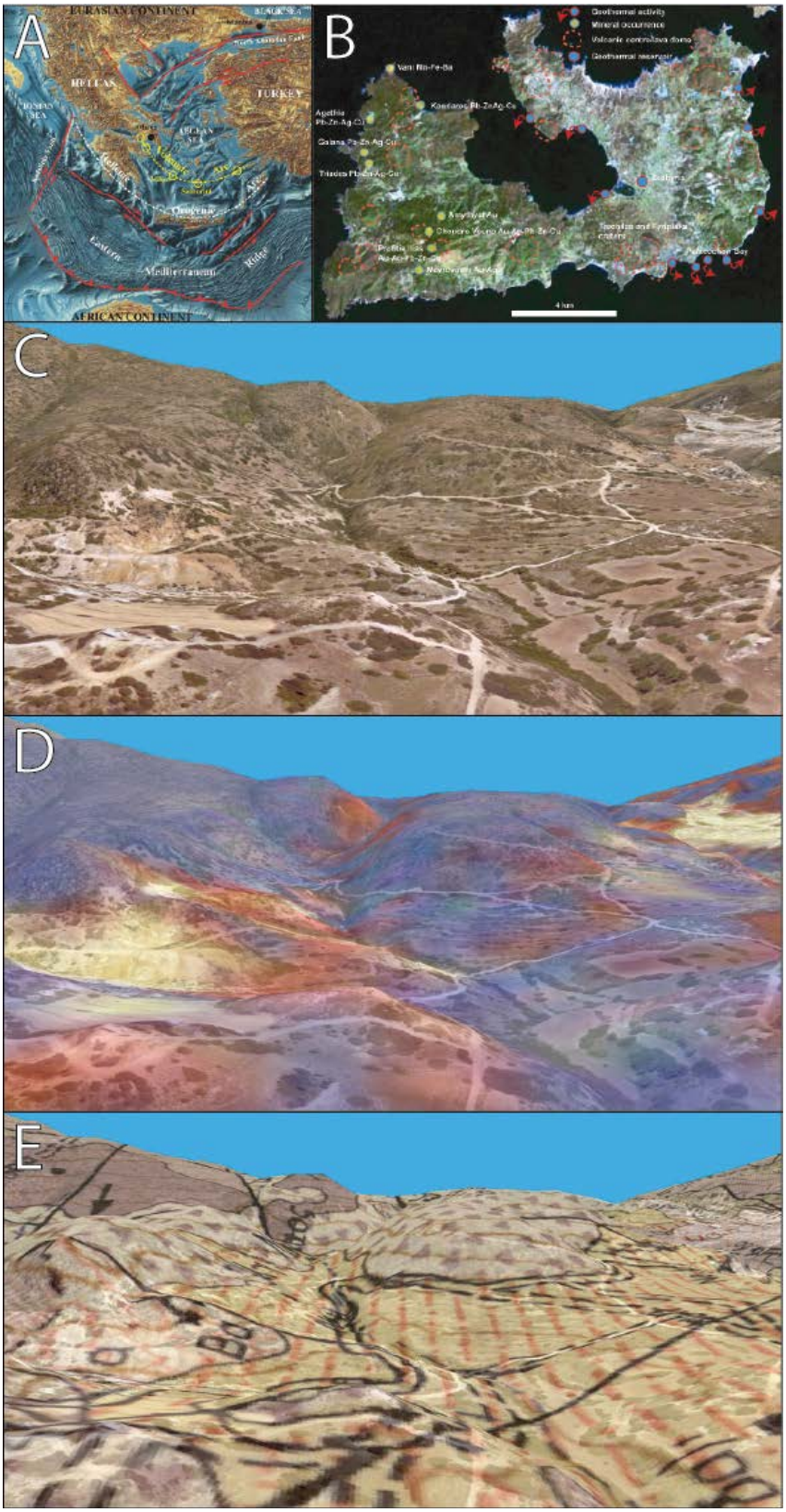
Equipment and technologies available to delegates

3D Visualisation: BGS has a 3D visualisation suite that can accommodate groups of 20 people (training groups to be rotated accordingly) and IT training suites.

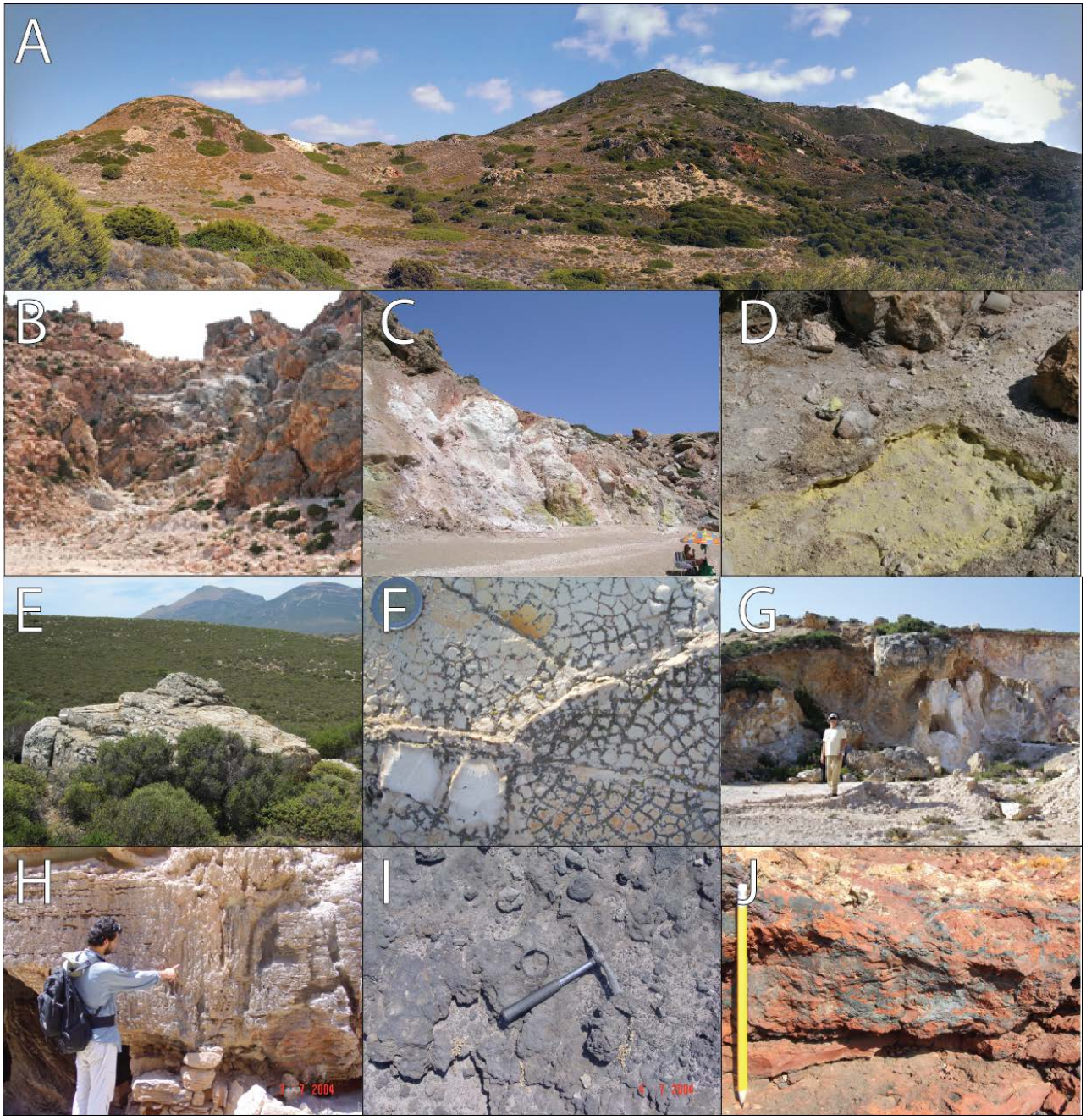
Remote sensing: The BGS remote sensing laboratory is part of the European Association of Remote Sensing Laboratories and is equipped with high specification PC and LINUX machines running the full range of 3D image processing and manipulation systems such as ENVI, ERDAS Imagine, BAE GXP, GAMMA, APLCore, Photoscan, MATLAB, GeoVisionary and ESRI ArcGIS.

Field instrumentation Terrestrial laser scanner, Portable Infrared Mineral Analyser, Portable XRF, portable XRD, tablet PCs for digital field data capture

Illustrations of course content



Location maps and virtual field landscapes from Milos created using high resolution remote sensing data. **A**. Location of Milos in the active Aegean arc; **B**. Satellite image of Milos Island with key mineral, hydrothermal, and volcanological features located; **C**. Computer generated virtual landscape (aerial photography draped over a 2m-resolution LiDAR digital elevation model) of the Triades Pb-Zn-Ag-Cu deposit (spoil heaps located in centre left of image); **D**. Virtual landscape of the same area with a Landsat clay alteration map overlain – white and red areas indicate intense clay alteration; **E**. Virtual landscape with draped geology showing the distribution of submarine lava domes (purple) and their hyaloclastite aprons (purple triangles and orange dashed lines).



Field images from Milos of a range of mineralisation features **A**. Exhumed submarine paleotopography – high ground comprises lava domes with the slopes and lower ground formed of hyaloclastic material; **B** & **C**. Active fumaroles and associated advanced argillic alteration; **D**. Native sulfur forming around an active fumarole; **E**. Possible geyser vent mound – high ground in the background is the Proftis Ilias–Chondro Vouno Au-Ag deposit; **F**. Sinter with syneresis cracks **G**. Steam-heated alteration with flat lying silica ridge formed at the paleogroundwater table; **H**. Submarine diffuse sub-seafloor vent system in baritised sandstone; **I**. Algal mats and manganese oxide mineralisation forming on the paleoseafloor; **J**. hydrothermal iron-rich cherts.