Earth Sciences in the 21st Century, a Forward Look
CONSULTATION RESPONSE

www.ukgeoscience.org.uk

Compiled by Helen Burke and Vicky Hards

Overarching comments

Overall feedback from the consultation respondents endorsed the whole exercise. The overarching message was that the main driver(s) should be *societal needs*: energy, water (and food), minerals (primary minerals will remain essential to delivering new environmental technologies) and security of supply issues, waste management and mitigation of natural hazards. Another issue highlighted was the dynamic nature of the Earth System and the essential understanding of the impacts of anthropogenic activity. Uncertainty and the understanding of this was another big issue highlighted, necessitating modelling. In this context the value of the full understanding of the geological record - the past is our only real benchmark - must be recognised.

Nonetheless, it was felt that the workshop (18-19 January 2010) had put too much emphasis on geology (probably as much a reflection of the participants' expertise), and that topics such as planetary science, geophysics, geomagnetism, sea level change, palaeobiology, soils and contaminated land required more implicit inclusion in the final report. Industry, and the needs and activities was also under represented and the interface between the academic (research) community and Research Councils required greater emphasis.

Specific feedback on Workshop Reports
- Comments, and points for inclusion

Breakout Group 1: *Applied Geoscience to serve society*

- Most oil fields contain more oil in them when abandoned than total amount extracted. Improvements will be made through simulations that better represent geological complexity
- Making use of heavy oil to optimise extraction. No mention of shale gas, oil shale, tight gas, basin centre (low saturation) gas, coal bed methane, enhanced coal bed methane. Europe is way behind the US, where unconventional gas accounts for ½ domestic production Geophysical surveying was successful in N Ireland, using the survey parameters of magnetic field, gamma radiation and time domain EM surveys, which can be carried out relatively cheaply in a single pass(3rd generation geophysics (group 1) and geophysical imaging (group 2)) Helps with location& characterisation of economic earth materials, such as peat, sand & gravel, and potentially higher value minerals; location of pollution plumes from known and unknown dumps; detailed geological and structure mapping; radon risk mapping; establishing baselines for comparing emergency surveys after nuclear accidents.

- The UK lags the world in modern seismic coverage, and leads the world in demonstrating what can be done (see Tellus and GSNI reports)

Breakout Group 2: *Natural resources and energy*

- Coal is mentioned in 4 but not 3. The UK and global minable coal outstrips oil & gas, and deep coal (unmineable, but not inaccessible) is a huge resource. We need technology to access this cleanly
- Geothermal is only mentioned once here, but is a renewable energy source and needs more development using oil & gas technology

Breakout Group 3: *Natural Hazards*

- CCS is mentioned as subsurface storage, but why not sequestration?
- Combinations of technology should be considered, e.g. combining peridotite sequestration of CO2 with water to mediate the reaction, and the resulting geothermal water could be used to generate electricity. Hot water from oil fields can be used to generate power, CO2 or digested sewage can increase oil recovery, CO2 sequestration with slag to give road/building material

Breakout Group 4: *Putting the Earth into /Earth System Science*

- Geothermal is only mentioned once here, but is a renewable energy source and needs more development using oil & gas technology

Breakout Group 5: *Critical Zone and marine processes*

- Suggest re-writing as 'Extending the climate envelope to fully explore climate histories through the deep sedimentary and biological records

Breakout Group 6: *Deep Earth*

No specific comments on this breakout

Initiative 1: *Earth and environmental sensitivity: enabling prediction and adaptation for the future*

The key research areas covered by respondents were geodiversity, geohazards and climate change:

Geodiversity

- Geodiversity can help with the management of coastal habitats, especially in response to sea level change, river management plans and sustainable flood management and planning for the future of the natural environment e.g. coastal and fluvial processes, soil formation and function, hydrological and hydro geological processes and mass movement, many of which were not in the agenda

Geohazards

- There was an overemphasis of 'spectacular' geohazards, such as earthquakes, volcanoes etc. overshadowing the need for research into soil erosion, swell-shrink clay and the weathering of construction materials
- natural hazard prediction (earthquakes, tsunami, volcanic eruptions, more extreme weather)

Climate change

- Climate change section focused on temperature and did not include precipitation/evaporation balance and the timing of wet and dry periods
- The sedimentary record of past climate change can potentially calibrate and tune climate sensitivity and non linearity against natural examples using Climate and Earth System models, which will improve predictions and reduce uncertainty
- The need to predict *rates* of environmental change was not mentioned
- Did not use 'future scenarios' approach adopted by the 'Science Futures' team, which was established to identify what the earth science requirements of society will be under different future scenarios
- Understanding how Earth systems and processes have responded to past climate change can link in with predicting future climate change. Modifying the coastlines and rivers, determining the nature and quality of soils and providing our water supply are all vulnerable to climate change. Erosion & drought have impacts on society. An understanding of these processes is needed if we are to understand the impacts of climate change on landscapes, land use and agricultural practices and develop strategies to adapt to change
- increasing social tolerance of 'extreme' natural events

Initiative 2: *Resource security and waste management*

The majority of responses concentrated on oil & gas resources (see below), with one respondent suggesting that food should be recognised as a resource, in terms of pressure on

supply with increasing population growth; and another respondent referred to natural zeolite minerals in Western Europe, which are used in fertilizers.

All resources:

- A challenge is the efficient use of finite natural resources as is the recognition of the changing needs of advancing society (e.g. the advent of a low C economy).

Oil & gas

- It was noted that industry was under-represented, and that the oil & gas industry and NERC science are completely detached from one-another, which needs to be addressed, as it could generate financial support etc.

Several respondents observed that geophysics was missing from the workshop agenda, and highlighted the need for a collaborative approach to future research

- Geologists will need to work in multidisciplinary teams to develop more efficient and novel methods of mining and processing; state of the art geophysics, geochemistry and geology will be needed to locate and exploit more obscure, deeper and different ore deposits.
- A whole system modelling approach is needed to integrate geological, geochemical and petroleum histories to understand oil & gas generation, migration and accumulation
- Geophysical imaging of subsurface using 3D and Electromagnetic surveys to analyse hydrocarbon reservoirs without drilling wells
- Modelling the interactions between rock fractures, chemistry and fluid flow from regional to nano-scales to enable total recovery from ageing oil fields, modelling fracture simulation from unconventional gas reservoirs, improved and more efficient mining, and future CO2 storage. This is a current research area

Initiative 3: *Forcing, fluxes and feedbacks: the Deep Earth-surface interaction*
Several respondents observed that the agenda was too Earth-focused and that planetary science was omitted altogether, but this is an important research area

- Planetology can contribute to Deep Earth research, such as planetary magnetic fields and magnetospheres
- Key questions, such as '*what was the nature of the Hadean environment?*' were included, but few research objectives address them
- Lunar research on the Hadean crust, such as meteorites in regolith on surface of moon was a suggested research area. Also suggested were enhanced understanding of magnetospheres of Jupiter and Mercury, effects of orbital dynamics on Earth's climate cyclicity through studying the sedimentary record on Mars, thick-skinned global tectonic regimes applicable to early Earth by analogy with tectonics on active icy satellites of Jupiter and Saturn, viability of the 'black smoker' origin of life hypothesis by studying hydrothermal vents on the floor of Europe's ocean

The lithosphere and sea level were also thought to have inadequately represented

- As well as looking at the Deep Earth, more emphasis is needed on the lithosphere, including understanding its structure
- Sea level curves should be corrected for mantle/tectonically induced vertical motion to isolate climate-controlled changes
- Tectonics set boundary conditions for ocean circulation in the past, which is important for understanding palaeo-climate
- 3D and 4D perception and understanding are needed

Initiative 4: *Origins: How did the atmosphere, oceans, continents, core and life itself originate, and how do they influence/have they influenced each other?*
Again, planetary science came up here

- Initiative 4 is right in looking at the Earth as a system in its own right, but it should also consider the Earth-Moon system and the effects of space phenomena on the Earth, including the role of the Earth's geomagnetic field in protecting the Earth's atmosphere, the influence of cosmic ray fluxes on the chemistry of the Earth's

atmosphere and the generation of electrical fields in the Earth's crust through geomagnetic induction
- The influence of the Earth in Space should be considered, including the Earth's geomagnetic field (both missing from the agenda)

Palaeobiological aspects of earth science are severely under-represented; microscopic life underpins many Earth cycles, and is crucial in resource exploration, yet all Research Council supported research/teaching programmes in micropalaeontology have closed. Palaeobiology is important, particularly at the Polar Regions, in the context of the evolution of life, especially in terms of speciation and biotic gradients.

Training and Infrastructure needs to deliver Initiatives

Training

- There is a clear need for well-trained doctoral students (and MScs) that fit into the employer areas, but NERC is not currently addressing this
- Graduates need field work, numeracy skills and exposure to labs and industry
- Fundamental stratigraphic skills are declining in universities, yet stratigraphy is at the heart of geology itself, and is especially vital in the search for and exploitation of new resources
- Overseas graduates are out-competing UK graduates for jobs and post-graduate research placements
- More co-ordinated interaction with schools and teachers who set the curriculum to provide useful teaching materials
- Better links needed with the media and industry
- More emphasis on landscape conservation, contaminated land studies, hydrogeology, engineering geology and geomorphology in MSc courses
- Training & research on mineralogy, geochemistry, structural geology and petrology to underpin research in CCS, and nuclear waste disposal

Infrastructure

Several respondents recognised the need for greater computing power and data storage capacity, and the need for data sharing across disciplines

- A cyber-infrastructure needs to be designed that can support a huge flow of information, can link results with other information sources, with high connectivity, large information storage capacity, rapid analysis, selection, pattern detection, visualisation and communication
- Linked data on publication, impact of Information Technology on earth sciences and data collection, management, distribution, e.g. via the Web
- Need continuing access to strategic research equipment, e.g. The Synchotron and ion microprobe
- Access to existing and innovative geophysical equipment through NERC and private partnerships, independent of industry e.g. ocean bottom seismographs

Science and society

The importance of science and society was also raised. It is therefore recommended that the final report clearly lays out the geoscience research critical to underpinning future policy making. Policy makers themselves, and the general public, are not scientists – there is the notable lack of scientists in government. This must therefore influence how the final report is presented, offering up solutions as opposed to more academic research topics.

This also has a bearing on public attitudes to science. As the current workshop reports stand, the only major issues of 'social importance' explicitly covered were natural resources and water, which is detrimental to raising Government (and therefore public) awareness. Respondents stress that this is especially important in light of recent budget cuts, and fact that the wider public are very conscious of how public money is being spent.
