Documentary evidence of correct use of University of Glasgow affiliation in published papers and other documents, 1999-2016

by

David Smythe

Emeritus Professor of Geophysics, University of Glasgow

This document reproduces the title pages and, where relevant, CV information, from the published documents. It is divided into the following sections:

1. Academic papers, abstracts, patent, correspondence and other refereed, edited or examined publications.
2. Formal submissions and proofs of evidence to government consultations, committees, local planning applications and planning inquiries.
3. Miscellaneous PDF files for download from my website (only those where a title or affiliation is present).

The listing under each of the headings above is in chronological order.

I have never used my University of Glasgow affiliation, nor my title of Emeritus Professor, in any publications or broadcasts other than in connection with my professional expertise in geophysics.

I have used the university address and/or university email address only on academic publications, as specified in my severance agreement of 1998. As can be seen from the appended pages, I always add my home address, where appropriate, and on all other publications I have only used my home address.

The title and address(es) are highlighted in yellow on the pages appended herein.

1. Academic papers, abstracts, patent, correspondence and other refereed, edited or examined publications

Geology, 2002

Spec. Pub. Geol. Soc London, 2003

US Patent, 2004

Brit. J. Oral Maxillofacial Surgery, 2009

Physics Today, 2011

Nature, 2013

Geoscientist, 2013

Solid Earth Discussions, 2016

Slice of intraoceanic arc: Insights from the first multichannel seismic reflection profile across the South Sandwich island arc

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ABSTRACT

We present the first multichannel seismic (MCS) reflection line that crosses the South Sandwich Trench, South Sandwich island arc, and East Scotia Sea backarc basin. The line is used in combination with earthquake catalogue data to interpret the strain distribution across the Sandwich plate and the relationship of forearc structures to processes operating at the trench. The MCS data reveal a 1.2-km-high fault scarp associated with a 20-km-wide arcward-tilted block in the mid-forearc; these features indicate large-scale gravitational collapse, and earthquake data are consistent with trench-normal extension at shallow depth in this area. There is, however, little evidence of distributed extension within the interior of the Sandwich plate. The MCS data show a small frontal wedge that achieves its maximum thickness only 18 km from the trench. Backarc magnetic data, mid-forearc extension, and the small size of the frontal wedge are all consistent with long-term and ongoing subduction erosion. Earthquake data suggest that this erosion is taking place in an environment of low interplate stress.

Keywords: earthquakes, South Sandwich Islands, seismic reflection data, subduction.

INTRODUCTION

Strain regimes in modern arc and forearc regions constitute a test for mechanical models that attempt to explain forces operating in subduction zones and the contribution of these forces to plate motions (Bird, 1978, 1998; Jarrard, 1986). Improved estimates of rates of sediment subduction and subduction erosion are needed in order to establish the global mass balance of continental crust and to assess their contribution to the evolution of the mantle (von Huene and Scholl, 1991). These two issues are linked by the fact that interplate stress is widely considered to influence the balance between accretion and subduction erosion, although opinions differ concerning the mechanism, and even the direction, of the effect (Cloos and Shreve, 1988; von Huene and Culotta, 1989; Vanneste and Larter, 2002).

Seismic profiling across modern arc-trench systems provides evidence relating to strain regime and the balance between accretion and erosion. The method is particularly effective when applied to intraoceanic subduction systems because these generally have a relatively short subduction history. This limits ambiguity concerning whether features are related to the present tectonic regime or are inherited.

The South Sandwich island arc is a classic intraoceanic arc in the southernmost Atlantic Ocean (Fig. 1). The South American plate converges with the Sandwich plate, on which the island arc is situated, at 70–85 mm/yr and is subducted at the South Sandwich Trench (Pelayo and Wiens, 1989). Farther west, the Sandwich plate is separating from the Scotia plate at the East Scotia Ridge, where the full spreading rate is 65–70 mm/yr (Livermore et al., 1997). This relatively simple tectonic setting has changed little since 15 Ma, except that the absolute and relative rates of motion of the Sandwich plate have accelerated since 7 Ma (Barker, 1995). Magnetic anomalies in the East Scotia Sea indicate that most of the present arc is on crust formed ca. 10 Ma (chron 5) at the East Scotia Ridge (Fig. 1). Therefore crust conjugate to that formed on the western flank of the ridge between 15 and 10 Ma (chrons 5B–5) must be beneath the modern inner forearc.

Here we present the first multichannel seis-

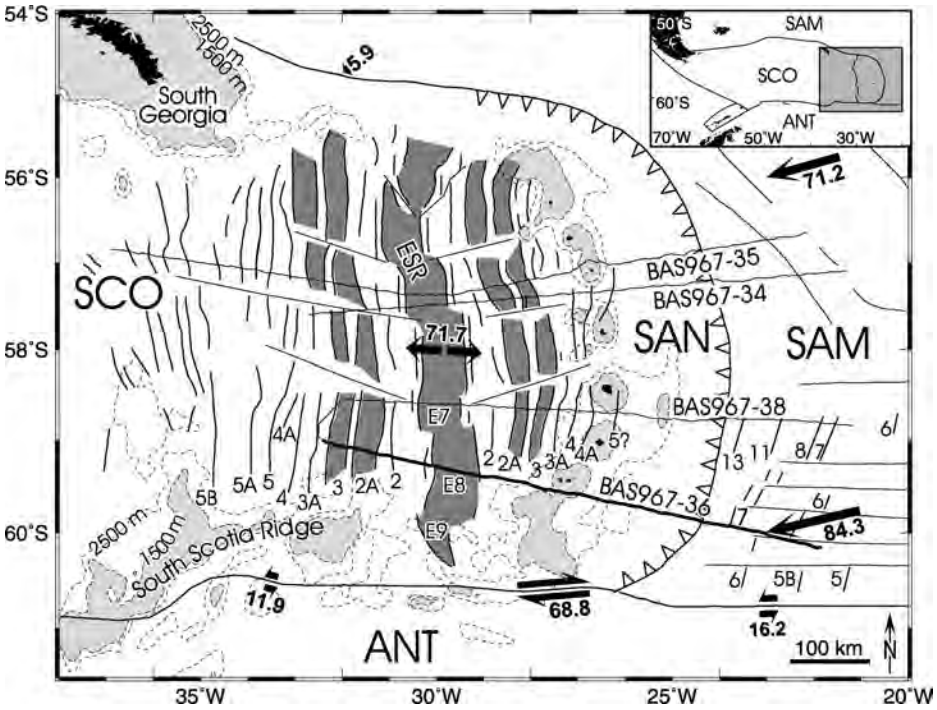

Figure 1. Magnetic anomaly map of East Scotia Sea, modified from Vanneste and Larter (2002). Gray box in inset shows location of map. Central Brunhes anomaly, as well as anomalies 2A and 3, are shaded dark gray. East Scotia Ridge (ESR) crest segments E7–E9 are labeled. Magnetic-anomaly identifications on South American oceanic crust are based on Barker and Lawver (1988). Arrows indicate azimuths of relative motion between Scotia (SCO), Sandwich (SAN), South American (SAM), and Antarctic (ANT) plates, based on Euler vectors of Pelayo and Wiens (1989). Arrow lengths are proportional to rates (mm/yr). Locations of four Sandwich Lithospheric and Crustal Experiment (SLICE) multichannel seismic lines that cross trench, arc, and East Scotia Ridge are shown. Line BAS967-36, shown in Figures 2 (loose insert) and 3, is represented by thicker line; 2500 m contour (dashed line) and 1500 m contour (filled, light gray) define South Sandwich arc, South Georgia microcontinental block, and South Scotia Ridge. Barbed line represents trench.

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Structure and tectonic evolution of the South Sandwich arc

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Abstract: Detailed analysis of marine magnetic profiles from the western part of the East Scotia Sea confirms continuous, organized back-arc spreading since at least 15 Ma ago. In the eastern part of the East Scotia Sea, the South Sandwich arc lies on crust that formed at the back-arc spreading centre since 10 Ma ago, so older back-arc crust forms the basement of the present inner forearc. Interpretations of two multichannel seismic reflection profiles reveal the main structural components of the arc at shallow depth, including evidence of trench-normal extension in the mid-forearc, and other features consistent with ongoing subduction erosion. The seismic profile interpretations have been used to constrain simple two-dimensional gravity models. The models were designed to provide constraints on the maximum possible thickness of the arc crust, and it is concluded that this is 20 and 19.2 km on the northern and southern lines, respectively. On the northern line the models indicate that the forearc crust cannot be much thicker than normal oceanic crust. Even with such thin crust, however, the magmatic growth rate implied by the cross-section of the arc crust is within the range recently estimated for two other arcs that have been built over a much longer interval.

The South Sandwich island arc is a classic intra-oceanic arc in the southernmost Atlantic Ocean (Fig. 1). The arc is situated on the small Sandwich Plate, which is overriding the southernmost part of the South American Plate at the South Sandwich Trench at a rate of 67–81 mm a^{-1} (Pelayo & Wiens 1989; Thomas *et al.* 2003) (Fig. 1). Further west, the Sandwich Plate is separating from the Scotia Plate at the East Scotia Ridge (ESR) back-arc spreading centre, where the full spreading rate is 60–70 mm a^{-1} (Thomas *et al.* 2003).

Early studies of marine magnetic profiles from the East Scotia Sea showed that E–W back-arc spreading had been active since at least 8 Ma ago (Barker 1970, 1972; Barker & Hill 1981). More recently Barker (1995) identified lineated magnetic anomalies out to at least anomaly 5 (9.7–10.9 Ma) and probably out to anomaly 5B (*c.* 15 Ma) on the western flank of the ESR. On the eastern flank of the ESR, the central part of the South Sandwich island arc lies on crust formed at the ESR during anomaly 5. Therefore, the identification of anomalies older than anomaly 5, if confirmed, has important implications for the tectonic evolution of the arc and can provide a basis for quantitative estimates of rates of processes such as sediment subduction and subduction erosion (Vanneste & Larter 2002).

In this paper we present a detailed analysis of new and archive magnetic profiles across the western margin of the East Scotia Sea, confirming that organized back-arc spreading has been active since at least 15 Ma ago. We speculate that spreading was probably preceded by a phase of arc rifting, as observed in other back-arc basins (e.g. Parson & Hawkins 1994; Martinez *et al.* 1995; Baker *et al.* 1996; Parson & Wright 1996), and that rifting was triggered by a change in South American–Antarctic plate motion about 20 Ma ago. We also present interpretations of two multichannel seismic (MCS) reflection profiles that cross the trench, arc and ESR, and use these to constrain two-dimensional gravity models. Implications of the MCS interpretations and gravity modelling results are discussed in the context of the confirmed history of >15 Ma of continuous, organized back-arc spreading.

Marine magnetic record of back-arc spreading

Marine magnetic profiles were examined to constrain the time of onset and early history of back-arc spreading in the East Scotia Sea. Several long profiles were selected for analysis, including eight that cross the oldest back-arc crust at the western limit of the East Scotia Sea

From: LARTER, R.D. & LEAT, P.T. 2003. *Intra-Oceanic Subduction Systems: Tectonic and Magmatic Processes.* Geological Society, London, Special Publications, **219**, 255–284. 0305-8719/03/$15.00

US006702745B1

(12) **United States Patent**
Smythe

(10) **Patent No.: US 6,702,745 B1**
(45) **Date of Patent: Mar. 9, 2004**

(54) **3D/4D ULTRASOUND IMAGING SYSTEM**

(76) Inventor: **David Smythe**, 191 Wilton Street, Glasgow G20 6DF (GB)

(*) Notice: Subject to any disclaimer, the term of this patent is extended or adjusted under 35 U.S.C. 154(b) by 0 days.

(21) Appl. No.: **09/889,781**

(22) PCT Filed: **Jan. 21, 2000**

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§ 371 (c)(1),
(2), (4) Date: **Oct. 17, 2001**

(87) PCT Pub. No.: **WO00/43809**

PCT Pub. Date: **Jul. 27, 2000**

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(52) **U.S. Cl.** **600/443**
(58) **Field of Search** 600/437, 443, 600/447; 128/916, 922; 73/602

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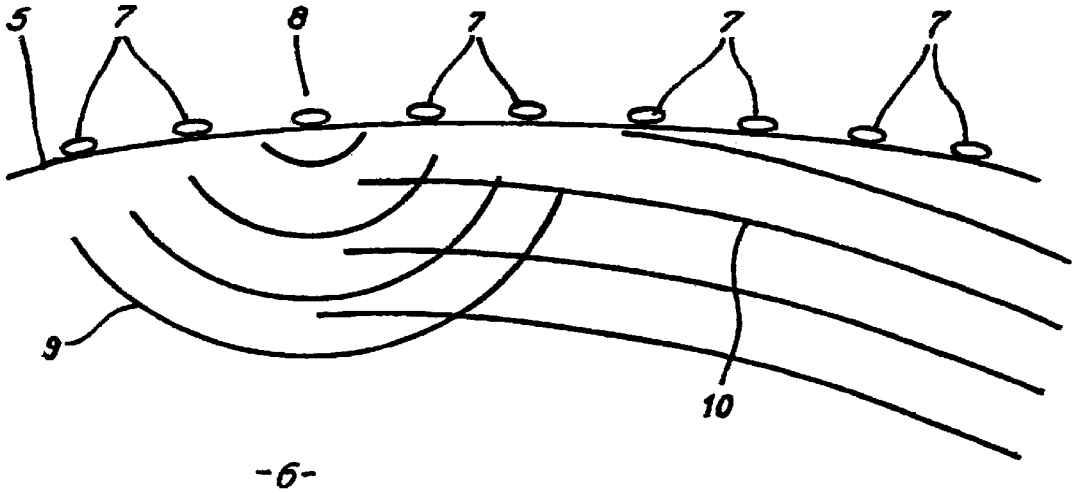
Primary Examiner—Francis J. Jaworski
(74) *Attorney, Agent, or Firm*—Fleshner & Kim, LLP

(57) **ABSTRACT**

Method and apparatus for 3D/4D ultrasonic imaging. An array of ultrasonic sources and receivers **(7)** positioned over or near tissue **(6)** transmit short encoded omnidirectional ultrasonic shots **(9)**. The amplitude and phase of the resulting reflected waves **(10)** are detected, sampled and digitised. Traces from each shot are reconstructed by digital data processing. A three dimensional data volume is constructed corresponding to reflection amplitude through a regular volume. The data volume may then be imaged through any arbitrary plane. Time varying images can be readily produced as the process takes only a fraction of a second.

30 Claims, 2 Drawing Sheets



We reviewed all patients who underwent major surgery for head and neck cancer in our department from 2003 to 2008, to determine the incidence of troponin positive myocardial infarction.

Prior to the introduction of TDA admissions, 7% of 131 patients had troponin positive cardiac events during the post-operative recovery phase. This increased to 20% during the seven month period of TDA admissions, and subsequently returned to 2% following re-introduction of pre-operative ward admission.

The surgical stress response is a systemic reaction to injury that includes endocrine, immunological, and haematological effects, with a magnitude and duration proportional to the injury. The combination of a patient's anxiety associated with admission to hospital, and the serious stress response from an extensive operation, are probable contributory factors to postoperative complications such as myocardial infarction. TDA may therefore not be appropriate for all patients having major operations.

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Three-dimensional imaging and characterisation of bone using a novel omnidirectional ultrasound array: proof of concept

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Introduction/aims: Fundamental to bone surgery is our inability to assess the progression of bone healing. Currently we have to wait for rigid union. Ideally, when is the best time to remove fixation? How successful are bone morphogenic proteins and other advanced techniques? In short, we need better ways to see healing bone.

Materials/methods: We have built and tested a novel prototype 2D ultrasound array in association with the Universities of Strathclyde and Bristol, employing principles derived from seismic reflection imaging. The 550 elements in our planar array are omnidirectional. Each is activated in turn as a point source illuminating the whole volume beneath the array, while all 550 simultaneously receive the backscattered echoes. The conversion of the resulting dataset into a true 3D volumetric image is done using standard geophysical industry software. The full image is obtained within an inverted pyramid about 60 mm below the 48 mm × 42 mm array. Resolution is 1 mm horizontally and about 0.3 mm vertically, but in contrast to conventional ultrasound methods does not degrade with depth.

Results: Imaged inorganic phantoms and cut samples of bovine bone show that the technology transfer of 3D imaging from the seismological to the medical ultrasound domain is successful, even though the elements at present have limited omnidirectionality and a frequency of only 2 MHz.

Conclusions/clinical relevance: The image makes allowance for the widely different sound velocities of bone/tissue: the elastic properties (and hence strength) of bone can be estimated directly from the data.

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Ultrasound guided interstitial photodynamic therapy of deep seated lesions

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UCLH Head & Neck Centre, London, United Kingdom

Introduction: Photodynamic therapy is a minimally invasive therapy that results from the interaction between a photosensitiser, oxygen and light. The delivery of light can by either by surface illumination or interstitial application.

We describe the intraoperative application of ultrasound in guiding light delivery in photodynamic therapy.

Method and materials: A total of 60 patients with various deep seated pathologies in the head and neck, upper and lower limbs were treated with mTHPC-photodynamic therapy. 2D Ultrasound was used to guide the needle insertion in the diseased area.

Results: It was possible to clearly identify the needles during insertion in all treatments and it was possible to guide parallel needle insertions using ultrasound. Although the resolution of ultrasound is not as good as other imaging modalities (i.e. CT, MRI) it was satisfactory in identifying the centre and the peripheries of the pathological lesions.

Ultrasound is very easy to perform, non-invasive, relatively inexpensive, quick and convenient, suited to imaging soft tissues and does not cause any discomfort.

Conclusion: Ultrasound can be used to guide 'real-time' photodynamic therapy of deep seated tumours and other malformations and can augment the information from other imaging modalities without affecting the patient's treatment outcome.

doi:10.1016/j.bjoms.2009.06.040

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Binge drinking amongst 8845 13–14-year-old English pupils and the harms they suffered

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Introduction: The aim of the research was to find out about attitudes to drinking and the drinking habits of young people in order to inform intervention programmes to discourage binge drinking.

PHYSICS TODAY: POINTS OF VIEW

An objective nuclear accident magnitude scale for quantification of severe and catastrophic events

December 12, 2011

By David Smythe

Introduction and summary

Deficiencies in the existing International Nuclear Event Scale (INES)[1] have become clear in the light of comparisons between the 1986 Chernobyl and 2011 Fukushima Daiichi nuclear power plant accidents.[2–4] First, the scale is essentially a discrete qualitative ranking, not defined beyond event level 7. Second, it was designed as a public relations tool, not an objective scientific scale. Third, its most serious shortcoming is that it conflates magnitude with intensity.

I propose a new quantitative nuclear accident magnitude scale (NAMS). It uses the earthquake magnitude approach to calculate the accident magnitude $M = \log(20R)$, where R = off-site atmospheric release of radioactivity, normalized to iodine-131-equivalent terabecquerels. In NAMS the observed frequency-magnitude distribution of 33 well-quantified events over the past 60 years follows an inverse power law, as with earthquakes,[5] but NAMS highlights four exceptional accidents that are greater by 2–3 orders of magnitude than the next largest. These are, in decreasing order of severity, Chernobyl, Three Mile Island, Fukushima Daiichi, and Kyshtym. Such catastrophic accidents can be expected to occur every 12–15 years.

The problem with INES

The International Atomic Energy Agency (IAEA) developed the INES in 1990. It is based in part on a loose analogy with the logarithmic earthquake-magnitude Richter scale, in that one unit difference in event level between 4 and 7 corresponds approximately to a factor of 10 in amplitude. Despite its reference to decade threshold values for off-site radionuclide release for discriminating between levels 4 through 7, the INES is essentially a discrete qualitative ranking. A true location-specific intensity scale measures exposure at a particular time and place due to an accident. Figure 1 shows a popular representation of the scale as a pyramid.

Figure 1. A popular way of depicting the International Nuclear Event Scale pyramid of nuclear event levels 0 to 7. This document is concerned with levels 4 to 7, classed by INES as "accidents," having off-site effects.

The IAEA, although created under the aegis of the United Nations, is a nuclear industry trade association whose aim is to promote civil nuclear power. Article II of its statute reads, "The Agency shall seek to accelerate and enlarge the contribution of atomic energy to peace, health and prosperity throughout the world." The IAEA has an

14. B. Sovacool, *Contesting the Future of Nuclear Power: A Critical Global Assessment of Atomic Energy*, World Scientific, Hackensack, NJ (2011).
15. G. A. M. Webb, R. W. Anderson, M. J. S. Gaffney, *J. Radiol. Prot.* **26**, 33 (2006).
16. International Atomic Energy Agency, "Significant Incidents in Nuclear Fuel Cycle Facilities,".

David Smythe is Emeritus Professor of Geophysics in the University of Glasgow, but now lives in France. He is currently engaged in persuading the UK government to abandon its plans for a high-level nuclear waste repository in West Cumbria, where, he contends, both the geology and hydrogeology are completely unsuitable. He was a founder and bass player of the Rezillos, Scotland's best-known pop group of the late 1970s, but now prefers to sing the solo tenor classical song repertoire.

Table 1

The 33 accidents of International Nuclear Event Scale (INES) levels 4—7 for which the magnitude *M* can be quantified. Eight further accidents of level ≥3 are appended, but for which the off-site release, and therefore *M*, cannot currently be quantified. Sources of the quoted INES level are the reference numbers in the last column (reference 0 = this paper; W = Wikipedia; A = Appendix).

Date	INES level	Location	Release (TBq)	M	INES Ref.
1949-12-02	4	Hanford, WA, USA	289	3.8	9
1955-03-25	4	Sellafield, UK	1000	4.3	15
1955-07-14	3	Sellafield, UK	0.0002	-2.4	15
1955-12-08	3	Sellafield, UK	0.0001	-2.7	15
1957-09-11	5	Rocky Flats, CO, USA	7800	5.2	0, 9
1957-09-29	6	Kyshtym (Mayak), Russia	1,000,000	7.3	15, W
1957-10-07	5	Windscale (Sellafield), UK	1786	4.6	15, W
1961-01-03	4	SL-1, Idaho Falls, ID, USA	41	2.9	W
1961-06-19	3	Sellafield, UK	540	4.0	15
1965-01-20	4	Lawrence Livermore, CA, USA	259	3.7	0
1967-04-01	5	Chelyabinsk; Lake Karachai, Russia	5600	5.0	0
1968-05-01	4	Sellafield, UK	550	4.0	15
1969-03-05	3	Sellafield, UK	2.1	1.6	15
1969-05-11	4	Rocky Flats, CO, USA	10	2.3	0
1969-10-12	4	Sellafield, UK	9	2.3	15
1970-02-10	3	Sellafield, UK	5	2.0	15
1970-03-10	3	Sellafield, UK	18	2.6	15
1970-08-06	4	Lawrence Livermore, CA, USA	222	3.6	0

Your editorial (7 February 2013) on nuclear waste disposal in the UK requires many corrections. Firstly the "*group*" (i.e. Nirex) created in 1982 was not independent; it was a government agency. Nirex bowed to political pressure in 1991 to choose one of two nuclear industry sites, not the geologically most suitable (Stanford, Norfolk) from the list of 537 potentially available locations. Its planning application to develop an underground laboratory at Longlands Farm, near Sellafield, failed in 1997 because Nirex did not understand the complex geology. Longlands Farm was not even in the original list of potential sites.

Nirex then devised a new 'voluntarism' strategy in 2000, ignoring the geological suitability or otherwise of any potential locality. This was a back-door attempt to return to the Sellafield district, in defiance of the House of Lords 1999 recommendation that national search criteria to find 15-20 national sites should be "*primarily, but not exclusively, geological and hydrogeological*". It also defies all other international guidelines and practice on how to search for disposal sites. Finland, Sweden, France and Switzerland have all carried out national geological searches before seeking the assent or veto of local communities.

The UK process reeks of predetermination, led by Nirex, which was not 'abolished' but subsumed into the Nuclear Decommissioning Agency (NDA) only in 2007. You blame "*lack of political will*" for the failure of the NDA to "*sell the facility to local residents*". Quite the contrary; £3.5M was spent on PR in West Cumbria during the last two years, in the oxymoronic Managing Radioactive Waste Safely (MRWS) process. MRWS initially acted as if the 1997 planning inquiry had never happened, and then, only after I had put the inquiry inspector's report back online and raised the many fundamental problems of the geology of that area, did it react by claiming 'we don't know enough' about the geology. Yes we do; furthermore, none of my scientific evidence (a 168-page report), submitted to the consultation last year, has ever been challenged. So Cumbria County Council has demonstrated *strong* political will by listening both to the geological and the democratic arguments against proceeding further.

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Correspondence

Online integrity training falls short

Education in the responsible conduct of research (RCR) will receive a long-overdue critique at a conference discussing the work of the US Office of Research Integrity on 3–5 April in Baltimore, Maryland.

The US National Institutes of Health has required recipients of training grants to receive RCR education since 1990, and it has been a prerequisite of the US National Science Foundation (NSF) since 2010 for all students and postdocs funded by its research grants.

In 2012, under contract from the National Center for Professional and Research Ethics at the University of Illinois, I reviewed the NSF policies of 27 major universities. I found that 26 depend solely (12) or largely (14) on online RCR training, with all but two using the Collaborative Institutional Training Initiative (CITI; www.citiprogram.org).

Outsourcing ethics education in this way suggests that RCR education is developed and executed with an eye to expedience rather than excellence. It risks sending a message to young researchers that the university and its scientists do not place much emphasis on responsible conduct.

European universities, which do not yet have RCR mandates in place (see N. Axelsen and X. Bosch *Nature* **489,** 208; 2012), should learn from the US experience and develop meaningful RCR programmes. These need to be taught by the people the students want to emulate — scientists.

Kenneth D. Pimple *Indiana University, Bloomington, USA.*
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Too much reliance on anonymous tip-offs

Several scientific journals and ethics committees are deferring to anonymous judgment when it comes to charges of plagiarism and falsification of results in published research papers. As a bioethicist, I believe that this practice is risky, even when the tipster's views are valid: it could itself damage the integrity of scientific research.

The authors of the blog Retraction Watch (www.retractionwatch.com) hold the view that anomalies detected by someone using the pseudonym 'Clare Francis' are useful to scientific journals, irrespective of his or her anonymity (see A. Marcus and I. Oransky *Lab Times* **7,** 39; 2011). But this unorthodox 'review' process pollutes the ethics that underpin scientific progress.

The practice could stimulate witch-hunting and pillorying. There is a danger that research-integrity committees could succumb to moralistic drift and confuse errors with misdeeds, underestimating context and a scientist's professional record. Stigmatized researchers might be tempted to exact revenge on their colleagues.

In my opinion, this is not the way to improve the moral standards of science's contribution to society or to build public engagement in science.

Gilberto Corbellini *Sapienza University of Rome, Italy.*
gilberto.corbellini@uniroma1.it

Standardize records of place of death

We suggest that a record of the place of death should be incorporated into death-registration data as a useful additional health metric (*Nature* **494,** 281; 2013).

End-of-life care is a major public-health issue, given the rising number of deaths from chronic illnesses that have multiple and complex symptoms. Knowing where people die can be an indicator of where they were cared for, which is important for allocating health-care resources and for assessing related public-health policies.

Despite surveys that show a prevailing preference for home death among patients, care-givers and the public, most deaths in Europe still occur in hospital (B. Gomes *et al. BMC Palliat. Care* **12,** 7; 2013). We are supplying Portugal with such survey information to help improve the recording of place of death in its electronic death-registration system.

The place of death is registered in a few other countries (the United States and Canada, for example), but its categorization is inconsistent — sometimes even within a country. Location categories need to be internationally standardized (J. Cohen *et al. BMC Public Health* **7,** 283; 2007) and this potentially valuable health-care resource put under the political spotlight.

Barbara Gomes* *King's College London, UK.*
barbara.gomes@kcl.ac.uk
**On behalf of 4 co-signatories (see go.nature.com/jm4tki for full list).*

Nuclear-waste site geology is paramount

As a former geological adviser to the UK government on nuclear-waste repositories, I would like to clarify some points in your discussion of the quest for a British nuclear-waste disposal site (*Nature* **494,** 5–6; 2013).

Nirex was a UK government agency (not an "independent group") that was set up in 1982 to find a geologically suitable site. In 1991, it chose Sellafield in Cumbria — one of two nuclear industry sites — from a list of 537 potentially available locations. Neither of these two sites was among the geologically most suitable, according to Nirex's seven-stage selection process. Its 1997 planning application for an underground laboratory at Longlands Farm, near Sellafield, failed because the inquiry inspector concluded that Nirex did not understand the site's complex geology (see go.nature.com/5p7yae).

The government's 2008 White Paper, Managing Radioactive Waste Safely (MRWS), put the fact that Cumbria volunteered to consider housing the waste ahead of scientific considerations. This contravenes international guidelines and practice in which national geological searches are conducted before seeking permission from local communities.

To some, this seemed like a back-door attempt to return to the Sellafield district, ignoring both the inspector's original report and the geological problems of the area (see go.nature.com/wob9rf).

You blame a "lack of political will" for the failure of the Nuclear Decommissioning Agency to "sell the facility to local residents". On the contrary, the now-defunct West Cumbria MRWS process spent £3.5 million (US$5.3 million) on publicity over the past two years.

So Cumbria County Council has demonstrated strong political will by listening to both the geological and the democratic arguments against proceeding with a deep repository for nuclear waste in the region.

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CORRECTIONS

The Outlook article 'A many layered thing' (*Nature* **492,** S52–S54; 2012) contained an error in the graphic 'Caught in a loop'. The labels for the Th1 and Th17 cells were shown switched over.

And in the Outlook article 'Mine, all mine!' (*Nature* **495,** S2–S3; 2013), the map 'Where does gold come from?' originally presented world gold production figures in kilograms but with the label of tonnes. The values have been corrected online to show tonnes.

Fallout over radwaste

BY STUART HASZELDINE & DAVID SMYTHE

Stuart Haszeldine and **David Smythe** * respond to Bruce Yardley's criticisms published here in April and still available on *Geoscientist Online* under 'Previous Issues'

Bruce Yardley resorts to *ad hominem* criticism[1] of our scientific views on nuclear waste disposal, accusing us of 'campaigning' on science matters of public interest, in contrast to scientists (himself presumably included) who dispassionately and neutrally 'advise'. However, he has evidently not taken the trouble to look out and study the highly detailed online evidence[2,3] underlying our summary views[4,5] concerning West Cumbria.

NIREX

During the 1990s Nirex undertook a national site search with BGS help, but finally targeted an inland Sellafield site which had not even featured in the working list of 537 sites[6]. Nirex drilled, cored, and interpreted 29 boreholes, as well as undertaking various geophysical surveys, to produce geological and hydrogeological models of the West Cumbria district, at a cost of £400M. It proved to have exceptionally fractured geology, complex hydrogeology and geochemistry. The Nirex planning inquiry of 1995-96 rejected construction of an underground test laboratory there[7], recommending that alternative UK sites should be investigated[8].

Reports in 1999 by the Royal Society[9] and the House of Lords Science and Technology Committee[10] recommended a national site search, led by geological criteria. However the 2001 Defra white paper *Managing Radioactive Waste Safely*[11] ignored this advice, proposing 'voluntarism'. CoRWM, the committee set up to develop deep geological disposal for UK intermediate and high-level radwaste, which reported in 2006, contained not a single Earth scientist.

BIASED?

Are we partial and/or biased, according to Yardley, because our conclusions "overwhelmingly" support our case? It follows that the case for anthropogenic global warming is similarly campaign-induced, because the overwhelming majority (97%) of climate scientists accept it[12]. The Nirex planning inquiry inspector concluded[7] that "The indications are, in my judgement, still *overwhelmingly* that this site is not suitable for the proposed repository, and that investigations should now be moved to one of the more promising sites elsewhere" [our emphasis]. Was he another biased 'campaigner'?

Yardley says that we "characterised the geology of west Cumbria as well-known, *yet* also so unpredictable that finding a safe repository site there was impossible" [our emphasis], implying that well-understood geology is necessarily predictable. But predictability does not necessarily arise from detailed measurement of a complex system. NASA calculated prior to the 1986 Challenger space shuttle disaster that the compound probability of failure from well-known components was one in 100,000. The real probability turned out to be more like one in 10.

Yardley makes the startling claim that the subsurface water geochemistry at west Cumbria is suitable for waste containment, based on cerium geochemistry from the PADAMOT project[13]. The full portfolio of evidence permits an outline reconstruction of both modern and palaeo-hydrogeology. Unsuitable oxic waters with Eh greater than +50 mV have clearly dominated to a depth of 1km, spanning all prospective repository depths. He has chosen his evidence to fit his prejudice. Yardley is an 'agnotologist'[14]; one who argues that we never know enough; 'we do not yet have enough data' – much like climate sceptics and in earlier times, apologists for big tobacco[15,16]. Our full technical response to Yardley is available online[2,3].

The references cited in this piece are listed in its online version. *Editor*

*Stuart Haszeldine FRSE FGS CGeol is Professor of Sedimentary Geology, University of Edinburgh
David Smythe is Emeritus Professor of Geophysics, University of Glasgow

SOAPBOX CALLING!

Soapbox is open to contributions from all Fellows. You can always write a letter to the Editor, of course: but perhaps you feel you need more space?

If you can write it entertainingly in **500 words**, the Editor would like to hear from you.

Email your piece, and a self-portrait, to **ted.nield@geolsoc.org.uk**. Copy can only be accepted electronically. No diagrams, tables or other illustrations please.

Pictures should be of print quality – as a rule of thumb, anything over a few hundred kilobytes should do.

Precedence will always be given to more topical contributions. Any one contributor may not appear more often than once per volume (once every 12 months).

> CORWM, THE COMMITTEE SET UP TO DEVELOP DEEP GEOLOGICAL DISPOSAL FOR UK INTERMEDIATE AND HIGH-LEVEL RADWASTE, WHICH REPORTED IN 2006, CONTAINED NOT A SINGLE EARTH SCIENTIST
> **Stuart Haszeldine & David Smythe**

Solid Earth Discuss., doi:10.5194/se-2015-134, 2016
Manuscript under review for journal Solid Earth
Published: 27 January 2016

Solid Earth Discussions
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Hydraulic fracturing in thick shale basins: problems in identifying faults in the Bowland and Weald Basins, UK

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Correspondence to: David Smythe (david.smythe@glasgow.ac.uk)

Abstract. North American shale basins differ from their European counterparts in that the latter are one to two orders of magnitude smaller in area, but correspondingly thicker, and are cut or bounded by normal faults penetrating from the shale to the surface. There is thus an inherent risk of groundwater resource contamination *via* these faults during or after unconventional resource appraisal and development. US shale exploration experience cannot simply be transferred to the UK. The Bowland Basin, with 1900 m of Lower Carboniferous shale, is in the vanguard of UK shale gas development. A vertical appraisal well to test the shale by hydraulic fracturing (fracking), the first such in the UK, triggered earthquakes. Re-interpretation of the 3D seismic reflection data, and independently the well casing deformation data, both show that the well was drilled through the earthquake fault, and did not avoid it, as concluded by the exploration operator. Faulting in this thick shale is evidently difficult to recognise. The Weald Basin is a shallower Upper Jurassic unconventional oil play with stratigraphic similarities to the Bakken play of the Williston Basin, USA. Two Weald licensees have drilled, or have applied to drill, horizontal appraisal wells based on inadequate 2D seismic reflection data coverage. I show, using the data from the one horizontal well drilled to date, that one operator failed identify two small but significant through-going normal faults. The other operator portrayed a seismic line as an example of fault-free structure, but faulting had been smeared out by reprocessing. The case histories presented show that: (1) UK shale exploration to date is characterised by a low degree of technical competence, and (2) regulation, which is divided between four separate authorities, is not up to the task. If UK shale is to be exploited safely: (1) more sophisticated seismic imaging methods need to be developed and applied to both basins, to identify faults in shale with throws as small as 4-5 m, and (2) the current lax and inadequate regulatory regime must be overhauled, unified, and tightened up.

1 Introduction

The progress of unconventional hydrocarbon development in the USA cannot be emulated in the UK for many reasons, not least because the origin and structure of the shale basins are very different. I have

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In conclusion, the complex faulted geology of the UK shale basins does not favour exploitation by unconventional means. A moratorium of, say, five years would permit the necessary advances in fault understanding and imaging to take place. If fracking of shale is ever to proceed in the UK on a safe environmental basis, far more rigorous regulation of the operators is also required than is current practice.

Acknowledgments

This work is not funded by any external agency. I have no link to any current research group at the University of Glasgow, and declare no competing interests. I thank Andy Skuce and Stuart Haszeldine for commenting on an early version of part of this paper, Séverin Pistre for discussions of French unconventional exploration, and Mike Hill for discussions on UK shale regulation.

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2. Formal submissions and proofs of evidence to government consultations, committees, local planning applications and planning inquiries

Defra consultation: response, October 2007.

DECC MRWS call for evidence: response, June 2013.

House of Lords Economic Affairs Select Committee: evidence submitted, December 2013.

DECC consultation: response, December 2013.

Ad hoc committee of Cumbrian MPs: submission, December 2013.

Ad hoc committee of Cumbrian MPs: submission as published by the committee, January 2014.

DECC MRWS: Final comments to Decision Making Bodies, January 2014.

West Sussex County Council: Celtique Energie planning application Fernhurst; objection, January 2014.

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West Sussex County Council: Celtique Energie planning application Wisborough Green; objection, June 2014.

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Lancashire County Council: Objection to Cuadrilla planning application, Preston New Road, September 2014.

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Lancashire County Council: new information, April 2015.

Lancashire County Council: additional comments, June 2015.

Lancashire County Council: presentation to Development Control Committee, June 2015.

Lancashire County Council: comment on Officer Report, June 2015.

Nottinghamshire County Council: IGas planning application, Springs, Road, Misson; objection, December 2015.

Consultation exercise: geological disposal of nuclear waste

Statement by Professor David Smythe

1. SUMMARY

I have relevant expertise and experience in the geological aspects of siting of a potential deep radioactive waste repository in the UK. There is clear evidence, after the expenditure of some £400M, mostly directed to the Sellafield area, that West Cumbria possesses no suitable rocks in which to site such a repository. However, the current consultation exercise is flawed, in that it places the 'voluntarism' of potential host communities ahead of scientific considerations. The result is that only one community, that in the Sellafield locality, may come forward. The undue concentration of effort on research at Sellafield (and Dounreay) in the past, which may be due to non-scientific considerations rather than sound science, means that many other potentially promising localities in the UK have never been investigated further. To choose Sellafield yet again, by way of community voluntarism, and despite the lessons that have been learned, would be wrong and possibly illegal in international law.

2. RELEVANT PERSONAL DETAILS FROM MY CV

I am Emeritus Professor of Geophysics in the University of Glasgow. Although I am now a French resident I remain a British citizen, and take an active interest in UK, French and foreign affairs, as well as in various facets of scientific research.

Prior to my taking up the Chair of Geophysics at the University of Glasgow in 1988 I was employed by the British Geological Survey (BGS) in Edinburgh, from 1973 to 1987. I was a research scientist, rising to the post of Principal Scientific Officer. During that phase of my career I remember being asked to comment briefly on the suitability of offshore islands west of the UK, and of offshore salt domes in the southern North Sea, as potential nuclear waste repositories.

I served on the BNFL Geological Review Panel from 1990 to 1991. I was invited to join the panel by one of its members, Professor John Lloyd, a hydrogeologist from the University of Birmingham. The panel comprised four university professors, with expertise in: hydrogeology (Lloyd), structural geology (Coward), sedimentology (Williams) and geophysics (myself). I served on this panel to support BNFL's case for a Sellafield site for a Potential Repository Zone (PRZ), at the time when Nirex was investigating both Dounreay and Sellafield. I resigned from the panel after the case for Sellafield had been successfully made.

I was closely involved with Nirex during the early 1990s. I was surprised that Nirex had ruled out the feasibility of three-dimensional (3D) seismic surveys at Sellafield, and offered to conduct for Nirex an experimental 3D survey, which took place in 1994. The survey was over a proposed rock characterisation facility (RCF) – a deep underground laboratory planned as a precursor to actual waste disposal. This was a double world 'first' – the first ever 3D seismic survey of such a site, and the first academic group to use this method, which is now an essential tool of the oil exploration industry. Unfortunately, the results showed that the geology of the site was far more

Response form

Please use this form to respond to this call for evidence on Managing Radioactive Waste Safely: Review of the Siting Process for a Geological Disposal Facility.

The closing date for the submission of responses is **10 June 2013**.

Responses can be returned by email (preferable) or post.

Email address: radioactivewaste@decc.gsi.gov.uk

Or by post to: The Managing Radioactive Waste Safely team
Department of Energy and Climate Change
Room M07
55 Whitehall
London
SW1A 2EY

Name	David Smythe
Organisation / Company	formerly University of Glasgow
Organisation Size (no. of employees)	
Organisation Type	
Job Title	Emeritus Professor
Department	-
Address	La Fontenille 1, rue du Couchant 11120 Ventenac en Minervois France
Email	david.smythe@lafontenille.org
Telephone	0033468321563
Fax	

Would you like to be kept informed of developments with the MRWS programme?	Yes
Would you like your response to be kept confidential? If yes please give a reason	No

House of Lords Economic Affairs Select Committee
The economic impact on UK energy policy of shale gas and oil

Written evidence submitted by

David K. Smythe BSc, PhD
Emeritus Professor of Geophysics, University of Glasgow

Address : La Fontenille, 1, rue du Couchant, 11120 Ventenac en Minervois, France

Summary

- The geology of the US shale basins is *fundamentally different* from western Europe.
- The UK shale basins are *heavily faulted*, from the shale layer right to the surface, in contrast to those of the USA.
- Pre-existing faults provide a potential *fast-track pathway* for fracking fluid and produced gas to escape upwards into drinking water aquifers and even to the surface
- This fault-leak problem associated with fracking has been *recognised in France and Germany*, but not in the UK.
- The current UK regulatory regime *is ill-equipped* to deal with this problem.
- Fracking for gas or oil should be banned in areas of complex faulted geology; in effect this means an *overall ban in the UK*.
- There will be no 'shale gas revolution' in the UK because in complex geology the *production process is uneconomic.*

Brief CV

1. I am a geophysicist and structural geologist with forty years' experience. I was with the British Geological Survey before taking up a new Chair of Geophysics at Glasgow University in 1988. I worked closely with the Department of Energy on oil and gas prospects during these years, and also prepared briefings for F&CO. At Glasgow I organised and led a complex multinational experiment near Murmansk in the USSR (now Russia) in the winter of 1992 to image the earth's crust at the world's deepest borehole, the aim being to characterise possible fluid layers.
2. I then worked on radioactive waste disposal, carrying out a large research contract for Nirex at Sellafield. This was the first-ever three-dimensional seismic image of a potential disposal site. But in the light of what I discovered about the complexity of the geology I appeared against Nirex as an expert witness at the Local Planning Inquiry of 1995-96.
3. I retired in 1998 following the closure of the earth science department at Glasgow. I pursue scientific research and occasionally consult for the oil and gas industry. In the last two years I submitted geological evidence to the DECC Managing Radioactive Waste Safely programme, and also delivered several public lectures in West Cumbria, showing why the geology of that entire region is unsuitable for siting a radioactive waste repository. This helped to persuade Cumbria County Council to withdraw from the MRWS process in January this year. I have also been studying the pertinent geology of shale gas basins in the USA, UK and France, with a view to understanding why the European experience will be different from that of the USA.
4. This submission is made in a personal capacity. I have no interests to declare. I am at the disposal of the committee to be examined as a witness. Numbered references in square brackets are available in a separate pdf document.

Response to DECC consultation:
Review of the Siting Process for a Geological Disposal Facility
September 2013

by

David K. Smythe

Emeritus Professor of Geophysics, University of Glasgow

December 2013

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11120 Ventenac en Minervois
France
david.smythe@lafontenille.org
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1. Introduction

1.1 I have been intermittently concerned with UK nuclear waste disposal since the mid 1970s, when as an officer of the British Geological Survey (BGS) I was asked to check out a list of low-lying islands west of Scotland as to their suitability for a geological disposal facility (GDF). I sat on a British Nuclear Fuels Ltd (BNFL) Geological Review Panel, then carried out a major seismic project for Nirex at Longlands Farm in 1994, and was an expert witness for Friends of the Earth at the Nirex planning inquiry of 1995-96. I have since submitted responses to various consultations, including the West Cumbria MRWS Partnership consultation of 2012. My evidence about the unsuitability of West Cumbrian geology for hosting a GDF helped to persuade Cumbria County Council (CCC) not to proceed further in the MRWS process.

1.2 Note: Previous electronic submissions of mine appear to have been printed out, then re-scanned with poor quality, thus rendering them partially illegible when made available on DECC's website. I presume that this process reflects merely incompetence on DECC's part and not an overt desire to suppress my submissions.

1.3 For the record, DECC's incompetence at running the consultation extends to misquoting the email address to which responses are to be sent. The email address on page 58 is given as radioactivewaste@decc.gov.uk, whereas it should have been radioactivewaste@decc.gsi.gov.uk.

1.4 Also for the record, as of midday 5 December 2013, the two DECC websites were still indicating a deadline of 11.45pm on that day, even though the deadline had been extended to 19 December to attempt to compensate for DECC's incompetence in providing an erroneous email address.

Summary: DECC displays an unusual degree of incompetence in running this and

Summary evidence for the Cumbrian MPs *ad hoc* committee
(Chair: Sir Tony Cunningham MP)

Why the current MRWS process should not proceed to Stage 4

by
David K. Smythe
(Emeritus Professor of Geophysics, University of Glasgow)

Where I stand. I am grateful for this opportunity to present written evidence to the *ad hoc* committee. Due to personal circumstances I was unable to accept the invitation to appear in person.

I am a retired academic, whose career spanned firstly, the British Geological Survey (BGS), followed by the University of Glasgow. I believe in the (now outmoded) concept of public service; I have no axe to grind, either over the nuclear industry or West Cumbria; I have no financial or personal interests to declare; I no longer even live in the UK, and am in the process of applying for French nationality; I believe in honest impartial science in the aid of civilised society; I follow current affairs closely, especially from a European perspective.

I served on the BNFL Geological Revew Panel, 1990-91. I proposed and carried out the trial 3D seismic reflection survey at Longlands Farm for Nirex in 1994 (a double world first – the first time that an academic research group had used this then novel method, and the first time that a potential radwaste site had been surveyed in this way). But I was so concerned about Nirex's lack of understanding of the highly complex geology there that I felt obliged to appear against Nirex, as an expert witness for FoE, at the Nirex Planning Inquiry in early 1996.

My concerns about radwaste disposal in West Cumbria were revived with the publication of the Defra MRWS White Paper in 2008, to the consultation of which I had submitted a response, pointing out that the 'voluntarist' approach left open a return to consideration of West Cumbria. My fears then have proved to be correct.

This submission summarises my views at Stage 3 of the MRWS process. I have tried to complement rather than duplicate the submission of my former Glasgow colleague Professor Stuart Haszeldine, whose views I largely share, and who is appearing before the committee in my place. It is based on many months of (*pro bono*) full-time study and research. My project folder hosts some 9000 files, of which some 1600 are pdfs of research papers and the like, and some 1700 of which concern BGS publications, and so on. I have spent over £1K purchasing BGS maps, data, and reports where necessary. Fuller details of my results can be found in my MRWS consultation submission (some 168 pages) and on my website.

Why the geology is crucial. The final and most important barrier to limit radioactive escape from a repository into the environment is the geology. Engineers may (over-)confidently predict that their 'engineered barrier systems' will succeed, so that the geology of the repository hardly matters, but this is not true. Let us look at the example of the Swedish copper radwaste canisters, the KBS-3 concept. It comprises:

- Fuel placed in isolating copper canisters,
- With a high-strength cast iron insert.
- Canisters are surrounded by bentonite clay,
- In individual holes at 500 m depth,
- In granitic bedrock.

The NDA has adopted this model for the UK. The Swedes developed this concept in the 1970s, and as late as 1999 were still predicting that the canister would be corrosion-resistant (in the right groundwater conditions) for a million years. But the Swedes also fund an independent NGO office to undertake independent critical research (something lacking in the UK); this office funded and published a comprehensive study in 2011 showing that there is a previously unknown leaching mechanism which can eat away all the copper within a 1000-year timescale. The several lessons to be learned here are:

- The UK must fund truly independent critical research.
- The research timescales are decades-long (the

Annex 4: Submission from Professor David Smythe, University of Glasgow (emeritus)

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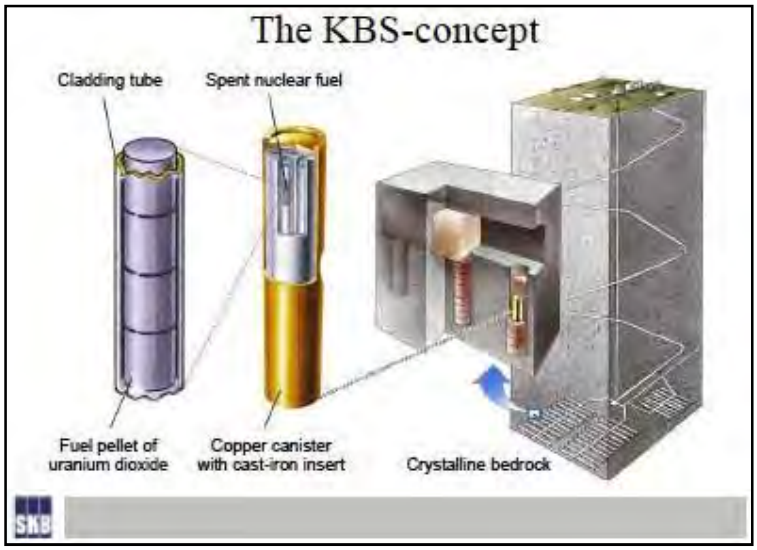

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Final comments by Professors Smythe and Haszeldine to the DMBs ahead of the 30 January decisions

This note is brief, as we know that you will have to consider many representations ahead of the vote next Wednesday. We are two genuinely independent expert earth scientists, who have studied the problem, without funding, and in our own time, because we do not like to see the findings of earth science in this application either ignored or distorted. Our views are based on public domain research largely carried out by Nirex, the British Geological Survey (BGS), the NDA and ourselves.

The Decision and the Process

You have to balance the potential benefits of further studies and investigations, against the certain disbenefits of disruptive site investigations, the uncertain employment of local staff, an unclear package of community benefits, and the immense impact of construction, should a GDF be constructed. Yet it is now clear that what is to be decided, and why, has a different rationale.

We assert that a desk-study of geology envisaged by MRWS-4 has already been undertaken by us, and no promising areas are apparent. It is clear from letters written by Minister Verma to CALC, to the LDNPA and by direct statements to us that central government (DECC) immediately intends to move through MRWS-4, should a "yes" vote be obtained, and commence invasive investigations of MRWS-5. From the evidence to Cumbria MP's (10 Jan 2013), we know that NDA intends to commit £50 million to this before end 2018. That will bring in specialist teams, not local employment. You are being asked to vote for 4 but will get 5. This is not what has been put to the electorate during the MRWS dialogue, and is a huge investigation of one UK region, when other regions have deliberately not been considered. DECC is forcing Cumbria through, not debating.

The Right of Withdrawal is very unclear. There is still no legal contract. There is a statement of intent to make a RoW "legally binding". But compare a Westminster legislative timescale to DECC's intent to "move faster" through to MRWS-5 and beyond, and there is the distinct probability that you will be faced with decisions on invasive surveying and drilling, before a RoW agreement has been concluded. Several of you may have been personally contacted by Minister Verma or other Westminster officials during the past few days. She is, of course, an experienced and adept Party Whip. Whatever has been said in public, it appears that DECC and NDA are bringing a huge pressure to bear on those of you in the DMB with the responsibility. Imagine how much more pressure will be exerted when tens of millions have been committed. By moving forward now, how can you defend against the inevitability of MRWS-6, the full excavation, being forced upon you? Are you representing DECC, or representing the local communities who voted for you? And many voters in those communities and parishes have clearly opposed being part of this process.

Geology

We have won the geological argument, which is that ***nowhere within the Partnership area is suitable for a Geological Disposal Facility (GDF)***. No substantive arguments have been produced to challenge or refute our claim, which is founded upon several hundred pages of technical evidence submitted to the MRWS consultation. The fact that such detailed evidence has not been properly assessed is alone a ground for a judicial review.

Bruce McKirdy (Managing Director of the NDA's Radioactive Waste Management Directorate) claims that "*many geologists*" agree that there are "*reasonable prospects*" of finding suitable geology. But the NDA is purposefully vague; it quote no names, refuses to name sites and, in any case, science does not progress by simple head-counts of For or Against. It is the force of argument and evidence that matter. In contrast, the Nirex Inspector, his Assessor, and even the MRWS consultant Dr Jeremy Dearlove all publicly concede that the likelihood of finding a site in the MRWS Partnership area is, at best, low.

The alleged support for proceeding to Stage 4, solicited by MRWS from the Geological Society of London (GSL) is misleading, because firstly, the Geological Society neither supports nor even comments on specific proposals (we have checked this with the Geological Society Policy Officer). Second, the statement merely says that it is possible to know more information about West Cumbria. That statement can be made about any geological site on Earth. Third, that statement does not represent the views of the 10,000 Fellows of the Society. The statement was prepared by a so-called 'contact group'of just three geologists, and not put out for prior consultation, as was normally the case. The group

development are not scaremongering or exaggeration; they are taken directly from NDA reports on GDF surveying, design and development. We also know that NDA has deliberately kept its ownership of Longlands Farm since 1997; that this land can form the entrance to a 10-15 km tunnel access to beneath the central Lake District; and that diagrams published by BGS would fit perfectly as extracts from a larger tunnel plan. Yet the NDA's own chief geological consultant has shown clearly that such sites are not viable – because of the complex geology and the return of deep groundwater from a GDF to the surface.

Pre-Determination

In 1997, at a point equivalent to MRWS-6, the Nirex application was overturned by Planning Inquiry. At that time Cumbria CC was a leading Objector to the proposition. The Inspector's conclusion, re-iterated to MRWS in 2012, was that the choice of west Cumbria was irrational, the region shows very little geological promise, and that future investigations should be directed elsewhere. In the intervening years DTI, then DECC, has failed to make those investigations, or to engage seriously with other potential volunteer communities. Instead, what has occurred is substantial planning of a political process, with contract reports to Nirex, then NDA, and carefully phased roll-out of an MRWS strategy which deliberately keeps everything vague for as long as possible. This is not a good procedure for Cumbria - politically pilloried to take the UK's waste - and not a good procedure for the UK – where is the backup plan to discover a GDF region? The retention of Longlands Farm, and the combination of MRWS-4 into MRWS-5 are the clearest examples that Government makes the rules. Where does that leave your RoW? Predetermination is a reasonable explanation for so many perverse actions by government and its agencies since 1997.

Options and Recommendations

Even with the most optimistic timelines, for a GDF, much legacy waste remains inadequately processed and packaged at Sellafield. Safe surface storage at Sellafield must be developed now.

A central tenet of the engineered barrier approach has been shown to be flawed. The NDA has to embark on a fresh programme of research on engineered barriers, while at the same time DECC must fund a long-term, careful study to find a variety of geological sites in the UK that really have potential. This is what has happened internationally. In Switzerland and France, the high quality of radioactivity retention by a good geological site means that the engineered barriers assume much less importance. The process of identifying a site cannot be rushed. It may require 20-25 years.

We urge you decisively to reject Stage 4, and leave MRWS. However, if some Councillors remain unpersuaded by our arguments, then you should at the very least demand another delay, of 12 months. Within that time frame DECC must provide:

- The legally-binding Right of Withdrawal that you have already requested,
- Significant funding (£1 million) for independent scientific and performance reviews of Cumbria, undertaken by organisations which do not benefit from UK policy or actions on a GDF.
- Substantive evidence (which we would expect to run to at least a hundred pages of technical detail) that some or all of our geological arguments are unfounded,
- A precise and legally-watertight definition of what exactly constitutes a 'community', since it is clear that the current DMBs do not represent the wishes of various local communities that stand to be affected by their decisions.
- A set of publicly understandable and numerical definitions, by which to assess a 'good' potential site – and by implication the criteria by which a candidate site would 'fail'.
- A number of rival candidate regions for a GDF in the UK, selected by geology

If you are minded to proceed, on the basis of local jobs and benefits, then we suggest that much better knowledge is needed of how many jobs, for whom, and when? What type of local benefits are envisaged, and how do those differ from the benefits necessary for the GDF? Will local Partnerships be funded to obtain genuinely independent advice ?

Various documents, including why Canada's voluntarism is not applicable to the UK, the BBC radio broadcast transcript, the KBS-3 barrier problem, the Cumbria MP's inquiry, and illustrated presentations, etc., can be found here:

Smythe:
http://www.davidsmythe.org/nuclear/documents.htm
Haszeldine :
http://www.geos.ed.ac.uk/homes/rsh

Planning application no. SDNP/1305896/CM

by Celtique Energie to drill at

Fernhurst, West Sussex:

Critique of environmental statement in the context

of relevant geology and hydrogeology

By

David K. Smythe

Emeritus Professor of Geophysics, University of Glasgow

La Fontenille

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25 January 2014

Version 1.3

1 INTRODUCTION

1.1 Relevant personal details from my CV

I am Emeritus Professor of Geophysics in the University of Glasgow. Although I am now a French resident I remain a British citizen, and take an active interest in UK, French and foreign affairs, as well as in various facets of scientific research.

Prior to my taking up the Chair of Geophysics at the University of Glasgow in 1988 I was employed by the British Geological Survey (BGS) in Edinburgh, from 1973 to 1987. I was a research scientist, rising to the post of Principal Scientific Officer. My work in the BGS from 1973 to 1986 was funded by the UK Department of Energy as part of a Commissioned Research programme on the geology of the offshore UK region. I also gave geological advice to the Foreign & Commonwealth Office on matters pertaining to UK territorial claims offshore. This was during the exciting phase of early discoveries and development of the North Sea. I headed a team of seismic interpreters working mainly on the prospectivity of the western margins of the UK, using the industry seismic and well data supplied to the Department of Energy. As a result I became the UK's leading expert on the deep geology of the continental margin west of the British Isles. Although our interpretation groups in the BGS were never able to commission our own wildcat wells, we had many 'virtual successes', where our independent interpretations were confirmed by subsequent drilling, and where the industry operator was proved spectacularly off-course.

In the 1990s I was closely involved in the search for a UK underground nuclear waste repository. I served on the BNFL Geological Review Panel from 1990 to 1991. I was invited to join the panel by one of its members, Professor John Lloyd, a hydrogeologist from the University of Birmingham. I served on this panel to support BNFL's case for a Sellafield site for a Potential Repository Zone (PRZ), at the time when Nirex was investigating both Dounreay and Sellafield. I resigned from the panel after the case for Sellafield had been successfully made.

I was closely involved with Nirex at this epoch, and conducted for Nirex an experimental 3D seismic reflection survey, which took place in 1994. The survey encompassed the volume of the proposed rock characterisation facility (RCF) – a deep underground laboratory planned as a precursor to actual waste disposal. This was a double world 'first' – the first ever 3D

TOWN AND COUNTRY PLANNING (APPEALS) (SCOTLAND) REGULATIONS 2013

APPEAL UNDER SECTION 47(2) OF THE TOWN AND COUNTRY PLANNING (SCOTLAND) ACT 1997 BY DART ENERGY (FORTH VALLEY) LTD CONCERNING COAL BED METHANE PRODUCTION, INCLUDING DRILLING, WELL SITE ESTABLISHMENT AT 14 LOCATIONS AND ASSOCIATED INFRASTRUCTURE AT LETHAM MOSS, FALKIRK, AND POWDRAKE ROAD, NEAR AIRTH, PLEAN

(REFERENCES PPA-240-2032 AND PPA-390-2029)

PRECOGNITION BY PROFESSOR DAVID K. SMYTHE

ON BEHALF OF

CONCERNED COMMUNITIES OF FALKIRK

(AND SUPPORTERS)

Printing note: If printed, this document must be printed in colour throughout.

1 INTRODUCTION

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1.1.2 Prior to my taking up the Chair of Geophysics at the University of Glasgow in 1988 I was employed by the British Geological Survey (BGS) in Edinburgh, from 1973 to 1987. I was a research scientist, rising to the post of Principal Scientific Officer. My professional qualifications are: BSc Geology (Glasgow 1970), PhD Geophysics (Glasgow 1987), Chartered Geologist.

1.1.3 In the 1990s I was closely involved in the search for a UK underground nuclear waste repository. I served on the BNFL Geological Review Panel from 1990 to 1991. I was invited to join the panel by one of its members, Professor John Lloyd, a hydrogeologist from the University of Birmingham. I served on this panel to support BNFL's case for a Sellafield site for a Potential Repository Zone (PRZ), at the time when Nirex was investigating both Dounreay and Sellafield. I resigned from the panel after the case for Sellafield had been successfully made.

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1.1.5 I have published 44 papers in the peer-reviewed literature, and written many other research reports and presentations. I am familiar with the geology of the Midland Valley (the central belt of Scotland) through teaching and undergraduate field excursions. One of my papers concerns the dykes of the Midland Valley (vertical sheets of igneous rock), which pass through the area of the planning appeal and extend into the North Sea.

1.1.6 Since my retirement from the university in 1998 I have carried out private research, acted as a consultant to the oil industry, and maintained an interest in the geological problems raised by nuclear waste disposal, shale gas exploration and coal-bed methane exploration.

Planning application no. WSCC/083/13/KD

by Celtique Energie to drill at

Boxal Bridge, Wisborough Green, West Sussex:

Critique of environmental statement in the context

of relevant geology and hydrogeology

By

David K. Smythe

Emeritus Professor of Geophysics, University of Glasgow

La Fontenille

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June 2014

Version 1.3

1 INTRODUCTION

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Planning application no. SDNP/1305896/CM by Celtique Energie

to drill at Fernhurst, West Sussex:

Comments upon report to SDNPA by Prof. R. C. Selley

By

David K. Smythe

Emeritus Professor of Geophysics, University of Glasgow

La Fontenille, 1, rue du Couchant, 11120 Ventenac en Minervois, France

8 August 2014

Introduction

Professor Selley has supplied a report to the SDNPA dated 3 July 2014, in response to a request from the SDNPA dated 24 June 2014 (not 26 June 2014, as he states). I wish to comment on a number of contentious points and factual errors made by Prof. Selley, and note, for the record as well as for consideration by the appropriate Planning Committee, the issues upon which he did not respond, or responded in an incomplete manner.

In separate numbered sections, I quote from the report by Prof. Selley, in which he has first re-stated an extract from the SDNPA letter (upright black text), and then followed it by his response in *blue italics*. These pairs of extracts are indented and placed between quotation marks. My comments are in green.

Summary

Prof. Selley is complacent and uncritical regarding the completeness of the information supplied by the Applicant. He has failed to answer the question about whether the same geology can be found outside the licence area, choosing instead to offer some irrelevant information. He is factually in error regarding the Applicant's targets. He is also inaccurate regarding the nature of the Kimmeridgian limestones, and again has failed to answer a specific question asked of him - whether or not the limestones will require fracking.

Planning application no. LCC/2014/0096

by Cuadrilla Bowland Limited to drill at

Preston New Road, Lancashire:

Objection on grounds of geology and hydrogeology

By

David K. Smythe

Emeritus Professor of Geophysics, University of Glasgow

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September 2014

Version 1.3

1 INTRODUCTION

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Planning application no. LCC/2014/0101

by Cuadrilla Bowland Limited to drill at

Roseacre Wood, Lancashire:

Objection on grounds of geology and hydrogeology

By

David K. Smythe

Emeritus Professor of Geophysics, University of Glasgow

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September 2014

Version 1.0

1 INTRODUCTION

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New information on
Planning applications by Cuadrilla Bowland Limited to drill at Preston New Road (no. LCC/2014/0096)
and
Roseacre Wood (no. LCC/2014/0101)
Objection on grounds of geology and hydrogeology
by

Professor David Smythe
Emeritus Professor of Geophysics, University of Glasgow

Summary

New information has emerged since my previous submissions to LCC and presentations to the Development Committee in January 2015.

The Environment Agency's decision document regarding Roseacre Wood is, like its earlier decision on Preston New Road, inconsistent on the question of whether or not the Woodsfold Fault is transmissive to fluids. This fault separates the zone planned for shale gas development below the Fylde from the important sandstone Principal Aquifer to the east between Preston and Garstang.

The EA concludes that the deep groundwater resource in the Sherwood Sandstone Group (SSG) below the whole of the Fylde is unusable for drinking because it is highly saline. But this is not supported by data from the Kirkham deep well and other water wells, nor from historical evidence. The hypersaline samples taken in the Kirkham well probably resulted from halite (salt) beds in the Mercia Mudstone Group, and have no direct bearing on water quality of the deeper SSG.The geology of the area around Kirkham is far more complex than appears on publications and maps of the British Geological Survey, which have been altered several times to try to account for new data.

A new hydrogeological modelling study of Fylde geology shows that under certain circumstances of hydraulic fracturing of the Bowland Shale, the SSG aquifer could be contaminated in about 100 years by fracking fluid. The study has many flaws, but more work is required in this area of research before drilling starts.

A paper recently published by Cuadrilla Resources Ltd in the scientific literature has located the earthquakes on a fault triggered by the Preese Hall-1 well in 2011. The fault lies some hundreds of metres east of the wellbore. My re-analysis of the fault identified by this paper shows that it runs at a lower angle than interpreted by Cudrilla, and passes through the wellbore itself. This explains the severe well casing deformation. The main lesson from this study is that important faults in the thick Bowland Shale are very hard to identify.

Legislation on the questions of the safe minimum horizontal distance that fracking should take place from pre-existing faults has not yet been defined. There is also legal uncertainty about the fate of produced water from any eventual shale gas production; can it be re-injected back down adjacent boreholes, or not?

I therefore recommend to LCC's Development Control Committee that it puts in place its own fracking moratorium until such time as the outstanding problems are resolved. This means that both the proposed developments should be refused.

Additional comments relevant to Planning applications by Cuadrilla Bowland Limited to drill at Preston New Road (no. LCC/2014/0096) and Roseacre Wood (no. LCC/2014/0101) Objection on grounds of geology and hydrogeology

by

Professor David Smythe

Emeritus Professor of Geophysics, University of Glasgow

Summary

Further new information has emerged following my previous submission to LCC in April 2015. Firstly, I respond to comments submitted to LCC by the Environment Agency (EA), which commented upon my previous report of April 2015. Secondly, I comment on a new peer-reviewed scientific paper proving for the first time that unconventional gas production has contaminated groundwater supplies via faults and fractures. Lastly, I briefly comment on a very recent draft report published the US Environment Protection Agency on the impact of fracking on drinking water resources.

The EA appears to be unaware that polyacrylamide, a friction reducer used in hydraulic fracturing (fracking) contains small quantities of highly toxic acrylamide. Given that: the friction reducer is used in large volumes; that 60-90% of frack fluid remains underground; and that such fluid may migrate, essentially undiluted, up to drinking water supplies, polyacrylamide should no longer be classed as a non-hazardous chemical *when used in fracking.*

The EA commented upon my eight concluding summary points of objection, but has failed to add any substantive new evidence. On the contrary, it agrees that the area around the application sites is geologically complex, and that the location of the Woodsfold Fault is problematic. There appear to be at least three different geological interpretations of the area. The EA has not resolved the question of how saline (or not) is the potential groundwater resource below the Fylde. The EA does not appear to see the requirement for a minimum safety, or 'respect' distance of the fracking zone from any fault, but instead mistakenly assures the Council that its own monitoring of the development work will suffice. In conclusion, my eight points of objection still stand.

At the time of writing Cuadrilla Resources Limited, the Applicant, appears not to have submitted a technical response to any of my previous comments.

A new paper outlining the history and hydrogeology of a fracking-related contamination incident in NE Pennsylvania, USA, proves beyond reasonable doubt that faults and/or fractures played a crucial part in the contamination of drinking water wells and the Susquehanna River. Prior to this study, incidents of groundwater contamination had been attributed to faulty well construction, whereas faulted geology had always been exonerated. The study reports a new ultra-sensitive method of fingerprinting the source of the contamination, which should be introduced to the UK.

I therefore continue recommend to LCC's Development Control Committee that it puts in place its own fracking moratorium until such time as the outstanding problems are resolved. This means that both the proposed developments should be refused.

Planning application no. LCC/2014/0096 by Cuadrilla Bowland Limited to drill at Preston New Road, Lancashire
and
Planning application no. LCC/2014/0101 by Cuadrilla Bowland Limited to drill at Roseacre Wood, Lancashire:

Objection on grounds of geology and hydrogeology

by

Professor David Smythe

Emeritus Professor of Geophysics, University of Glasgow

For 18 June 2015

Inadequate and prejudicial Officer Report

[Planning applications by Cuadrilla Bowland Limited to drill at Preston New Road no. LCC/2014/0096 and Roseacre Wood no. LCC/2014/0101]

Professor David Smythe

Emeritus Professor of Geophysics, University of Glasgow

21 June 2015

1. Marginalisation of expert witness evidence

The Officer Report, published by LCC on 15 June 2015, has deliberately sought to downplay and marginalise the evidence of at least three expert witnesses, myself included. At p. 532 I am described in the following terms:

> "*Comments that the geology of Lancashire is not suitable for fracking have been provided by a professor who retired 18 years ago and is now living in France running a B&B. Evidence in the US and UK is to the contrary.* "

This outrageous comment, appearing in a section entitled *Minimal environmental risks*, has no place in a report such as this. I am clearly identifiable. It is a calculated denigration of an expert witness. I took early retirement from the Chair of Geophysics at the University of Glasgow some 16 years ago, and spent around a decade from 2001 onwards consulting for a variety of oil companies. Projects lasted from a few weeks to a couple of years, involving studies of onshore and offshore India, Western Australia, offshore Madagascar, southern England (both onshore and offshore), and the UK-Irish margin of the NE Atlantic (during this period my wife, not I, ran a B&B for about three years).

I have requested information from LCC under FOI legislation to discover the origin of the statement quoted above, as I have been unable to find it elsewhere in the published application documents.

The Officer Report similarly denigrates the professional expertise and integrity of two other clearly identifiable expert witnesses, Mr Mike Hill and Dr Frank Rugman. At page 311 the Report states, *à propos* of the Medact Report:

> "*The Medact report has not produced new epidemiological research but has reviewed published literature and has requested short papers from relevant experts in particular subject areas. It has also interviewed academics and experts. Unfortunately, one of the contributors (contributing to three of the report's six chapters – chapters 2, 4 and 5) has led a high profile campaign in the Fylde related to shale gas. Another contributor to the report (chapter 3) has previously expressed firm views on shale gas and has objected to this application. This has led to questions from some quarters about the report's objectivity. In light of these uncertainties it is not clear how much weight the County Council should attach to the report*."

Firstly, why should an alleged "*high profile campaign*" by the first contributing expert mentioned (Mr Hill) "*unfortunately*" reduce the weight given to his evidence? What is the source of the "*questions from some quarters*"? Regarding the second expert, Dr Rugman, why should his supposedly "*firm views*" nullify or reduce the value of his expert contribution?

I have requested information from LCC under FOI legislation to discover the origin of the several statements quoted above. Even if they are contained in submissions by the applicant or other individuals or organisations supporting the applications, they have no place in an objective and balanced Officer Report.

Planning application no. ES/3379 by Island Gas Limited to drill at Springs Road, Misson, Nottinghamshire: Objection on grounds of geology and hydrogeology

By

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December 2015

Version 1.1

[If this document is printed, only pages 42-58 need to be in colour]

1 INTRODUCTION

1.1 Relevant personal details from my CV

I am Emeritus Professor of Geophysics in the University of Glasgow. I have no current link with any research group at the University, nor would I wish to. Although I am now a French resident I remain a British citizen, and take an active interest in UK, French and foreign affairs, as well as in various facets of scientific research.

Prior to my taking up the Chair of Geophysics at the University of Glasgow in 1988 I was employed by the British Geological Survey (BGS) in Edinburgh, from 1973 to 1987. I was a research scientist, rising to the post of Principal Scientific Officer. My work in the BGS from 1973 to 1986 was funded by the UK Department of Energy as part of a Commissioned Research programme on the geology of the offshore UK region. I also gave geological advice to the Foreign & Commonwealth Office on matters pertaining to UK territorial claims offshore. This was during the exciting phase of early discoveries and development of the North Sea. I headed a team of seismic interpreters working mainly on the prospectivity of the western margins of the UK, using the industry seismic and well data supplied to the Department of Energy. As a result I became the UK's leading expert on the deep geology of the continental margin west of the British Isles. Although our interpretation groups in the BGS were never able to commission our own wildcat wells, we had many 'virtual successes', where our independent interpretations were confirmed by subsequent drilling, and where the industry operator was proved spectacularly off-course.

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Since my retirement from the university in 1998 I have carried out private research, acted as a consultant to the oil industry, and maintained an interest in the geological problems raised by nuclear waste disposal, shale gas exploration and coal-bed methane exploration. My tools for this work are up-to-date; I have my own licence for ProMAX 3D on a Linux workstation (seismic data processing), and currently hold on loan industry-owned licences for SMT Kingdom (seismic and well interpretation) and ModelVision (gravity/magnetic modelling including tensor fields).

1.2 Declaration of interest and non-liability

I have no conflicting interests to declare. This document was requested by the local objectors' group Bassetlaw Against Fracking, and has been provided for a modest honorarium. I am not connected to, nor am I a member of any activist group, political party, or other organisation. I am solely responsible for its contents. It is supplied in good faith, but I can accept no liability resulting from any errors or omissions.

3. Miscellaneous PDF files for download from my website

Why the whole of West Cumbria is unsuitable for a nuclear waste repository, November 2010.

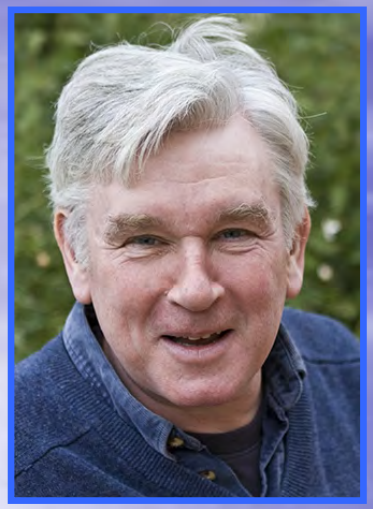
Why a deep nuclear waste repository should not be sited in Cumbria: a geological review, April 2011.

Critique of Cuadrilla proposals, Balcombe, August 2013.

Geology:
Why the whole of West Cumbria is unsuitable for a nuclear waste repository

David Smythe

November 2010



David Smythe: CV

Emeritus Professor of Geophysics, University of Glasgow
BSc (Geology, 1970), PhD (Geophysics, 1987)

- Principal Scientific Officer, BGS 1973 – 1987
- Chair of Geophysics, University of Glasgow 1988 - 1998
- BNFL Geological Review Panel 1990 – 1991
- Nirex research contract 1993 - 1995:
  - -Trial 3D seismic survey of potential repository zone
    - *First-ever 3D survey of such a site*
    - *First-ever academic research 3D survey*
- Expert Witness for FoE at Planning Inquiry 1995 - 1996

Why a deep nuclear waste repository should not be sited in Cumbria: a geological review

David Smythe
Emeritus Professor of Geophysics, University of Glasgow
12 April 2011

West Cumbria is an area in which the landscape and the working lives of local people are dominated by the underlying geology.
(Peter Cook, Director, British Geological Survey, 1997)

Summary

The assertion by the Committee on Radioactive Waste Management **"** *that there is presently no credible scientific case to support the contention that all of West Cumbria is geologically unsuitable.*" is reviewed and refuted. The current criteria for examining potential suitability of sites for waste disposal are examined and found to be essentially devoid of geological content; the Managing Radioactive Waste Safely process is saying merely that a 'suitable host rock' will be chosen. In effect, the Nuclear Decommissioning Authority is regressing the understanding of the geology of potential repository sites by a generation.

The Potential Repository Zone at Longlands Farm was selected by a scientifically irrational process in which the political need for a site at an existing nuclear facility took precedence over rigorous assessment of the geology. The concept of basement under sedimentary cover (BUSC) was misappropriated to make sure that the site was shortlisted, despite having been introduced very late in the search process. The prior national search by the British Geological Survey (BGS) had identified no such category of site anywhere in NW England.

The coastal strip of West Cumbria is well understood but highly complex. The Longlands Farm site, although flawed, is the least unsuitable location in the region. It failed the test of the public planning inquiry of 1995-96. Northern Cumbria, between the National Park and the Solway, is geologically even more complex. The whole northern region under consideration has been the subject of hydrocarbon exploration for 40 years; applying logically the exclusion criteria defined by the BGS means that it should have been screened out.

National and international criteria for choosing a suitable waste repository are in agreement that the geology should be simple and predictable; the site should be located in a region with low hydraulic gradients. A significant change in view from the 1980s, however, is that to permit the possibility of marine discharges is now considered unlawful. Sellafield falls into such a category, since Nirex modelling of the flow paths from a leaking repository predicts such a discharge.

The regional hydrogeological regime in west and north Cumbria is dominated by the presence of the Cumbrian mountains. The extreme relief is about twenty times greater than desirable for categories of waste repository hosted in crystalline rocks. That fact alone is sufficient to characterise the region as hydrogeologically unsuitable, quite apart from the demonstrable complexity of the geology.

The well-understood geology and hydrogeology, and hence the inherent safety of any chosen potential site, is categorically against the region's suitability to host a nuclear waste repository. New searches should be undertaken elsewhere in England and Wales.

Critique of Cuadrilla's plans and proposals for drilling near Balcombe, West Sussex

by

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