



**British
Geological Survey**

NATURAL ENVIRONMENT RESEARCH COUNCIL

Applied geoscience for our
changing Earth

Geological settings for the disposal of higher activity radioactive waste

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Main Criteria

Geology contributes to long-term isolation of radioactive waste

Ideally need:

Physical stability (constructability/operational safety);

Long groundwater return time;

Relatively simple, predictable groundwater flow regimes;

Slow groundwater movement/low hydraulic gradients;

Long term stability;

and.....



Some other considerations

.....may also consider:

Resources;

Climate change;

..... and other factors including
public acceptability
transport



Some Favourable Rock Types

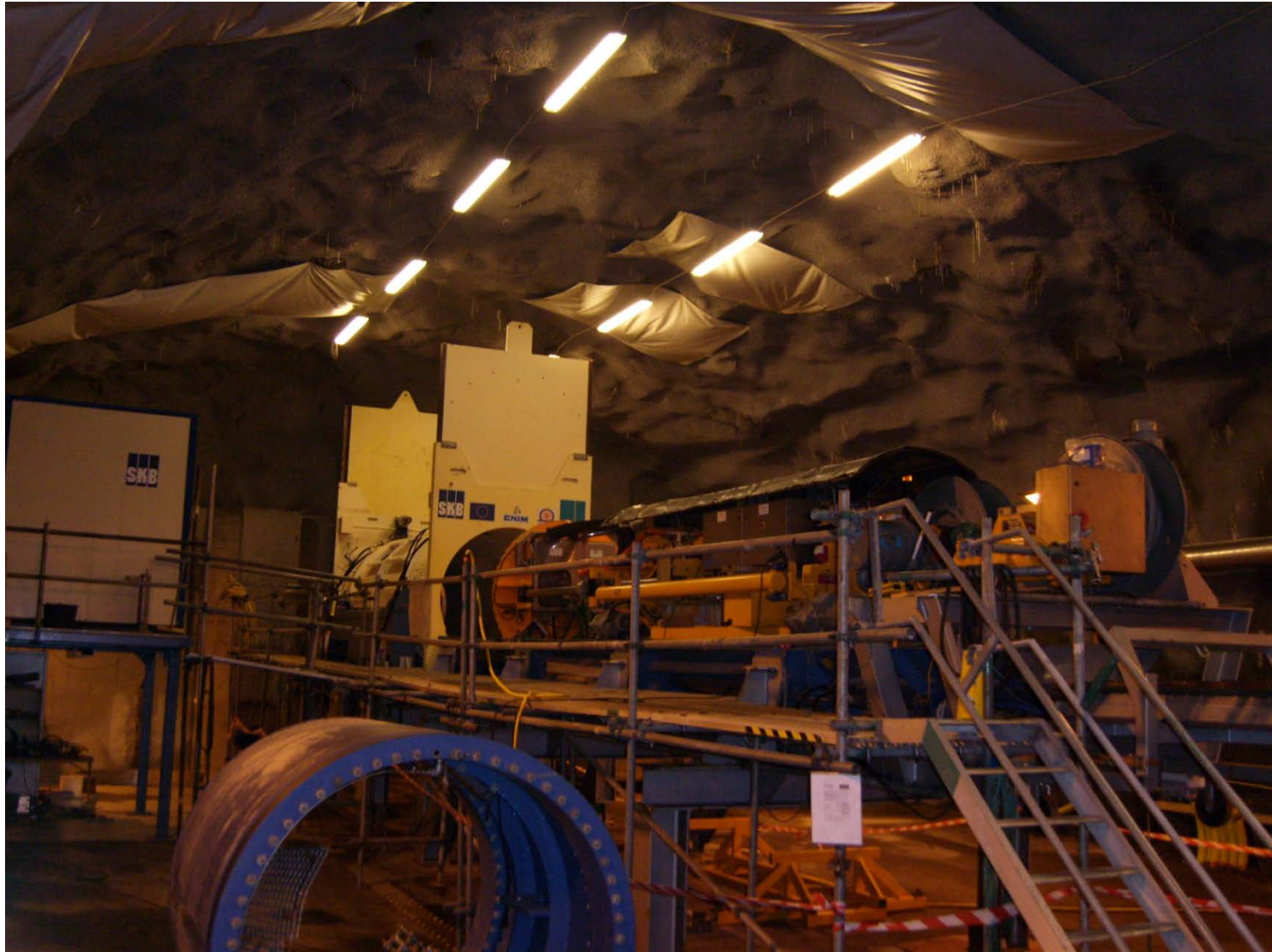
Mudrocks





Some Favourable Rock Types

‘Hard’ rock





Some Favourable Rock Types

Salt





UK Geology highly varied

Offers a number of disposal options for the geological disposal of radioactive waste





Favourable Geological Situations

Basement under sedimentary cover (BUSC)

Large inland sedimentary basins

Low permeability sedimentary rocks

Low permeability 'basement' rocks

Low relief terrain (inc small islands)

Many of these overlap

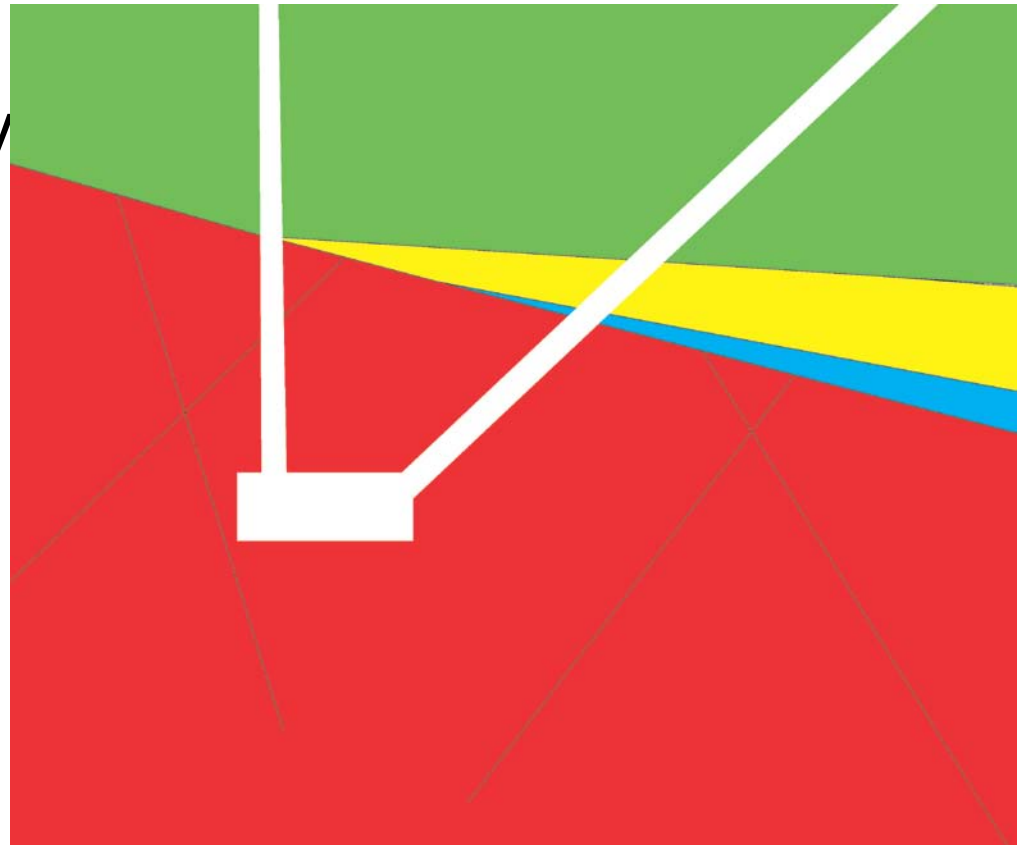


Favourable Geological Situations

BUSC

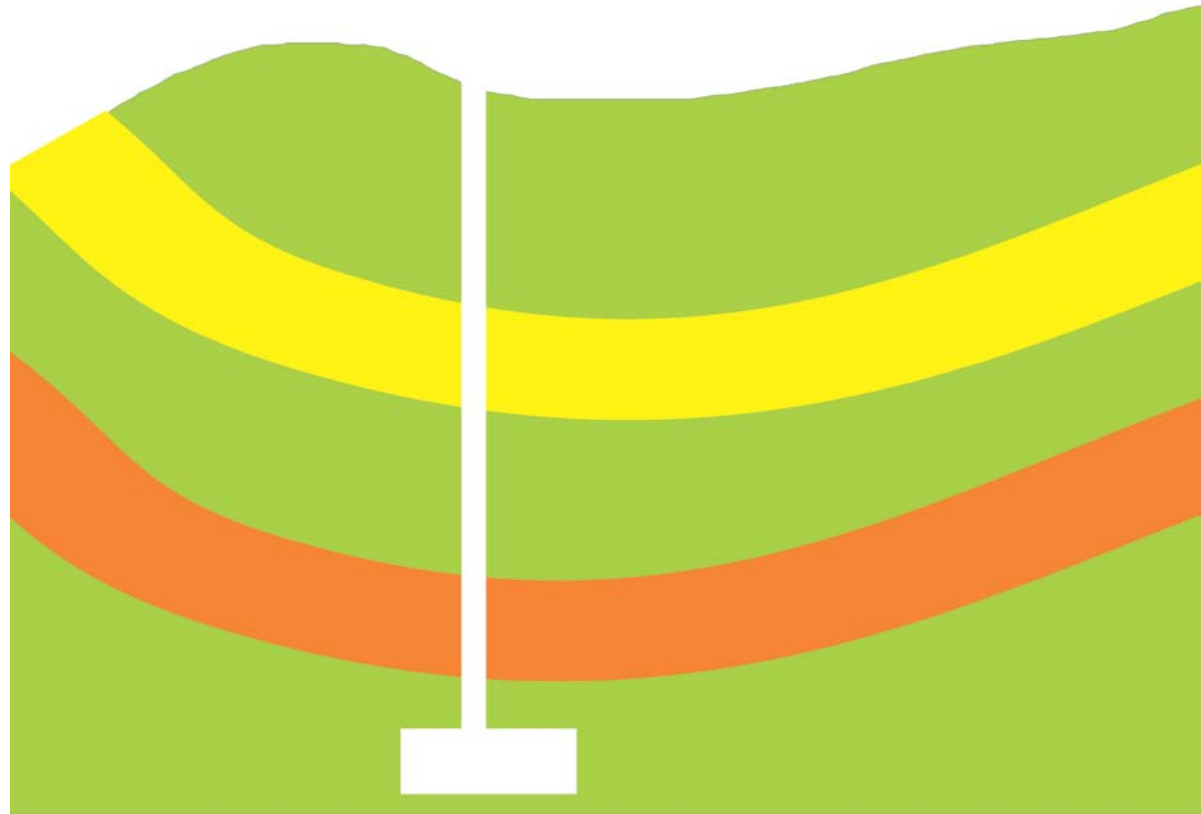
Well known model
(Sellafield and Dounreay
are variants)

Hosted in 'basement'
With cover rocks
Potentially providing
long flow paths and
dilution.



Favourable Geological Situations

Large inland sedimentary basins
Likely to have disposal options in:
Evaporite deposits;
Thick mudstone
sequences;
Basinal brines
that are stagnant.

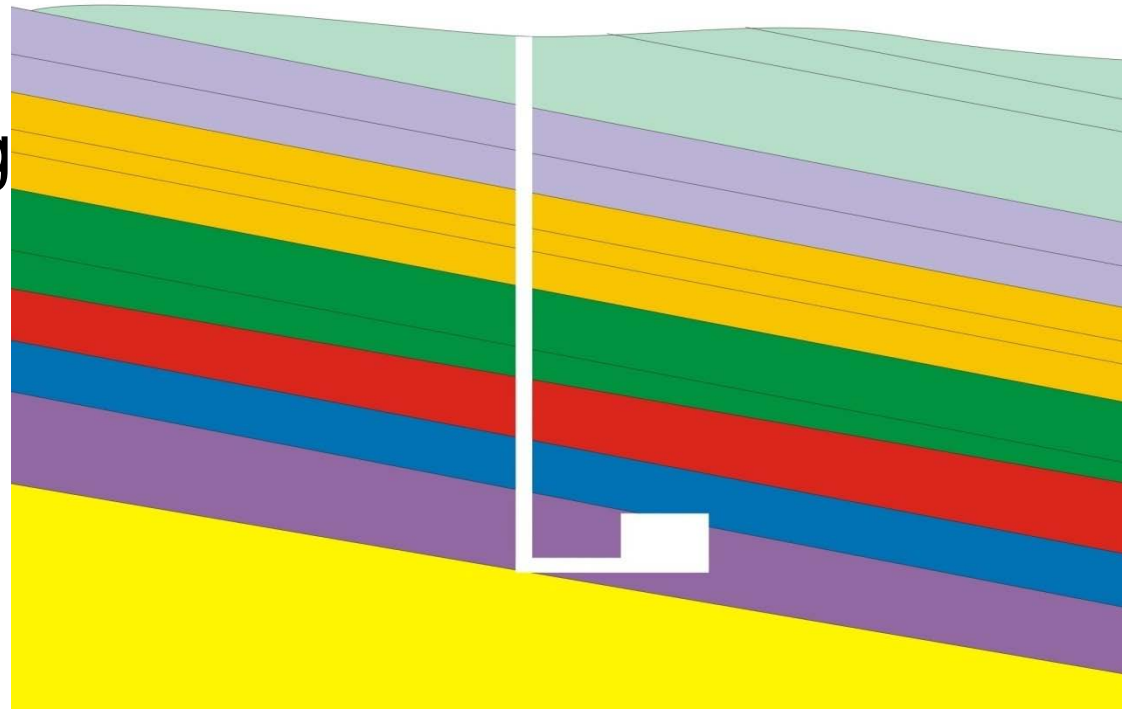


Favourable Geological Situations

Low permeability sedimentary rocks

Packages of sedimentary rocks with mudstone sections thick enough for construction of a repository

Offer potentially long migration pathways and traps in overlying deposits.

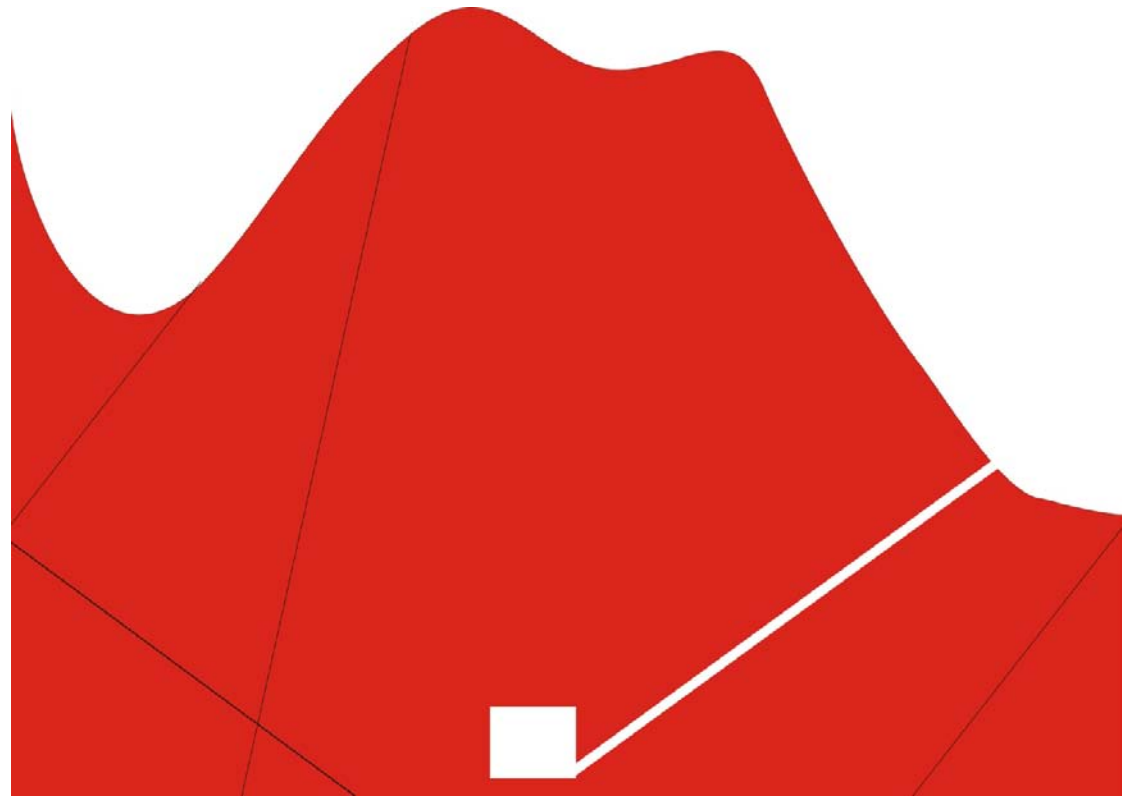


Favourable Geological Situations

Low permeability basement ('hard') rocks

Rocks with low bulk rock permeability rocks at surface, regardless of surface relief

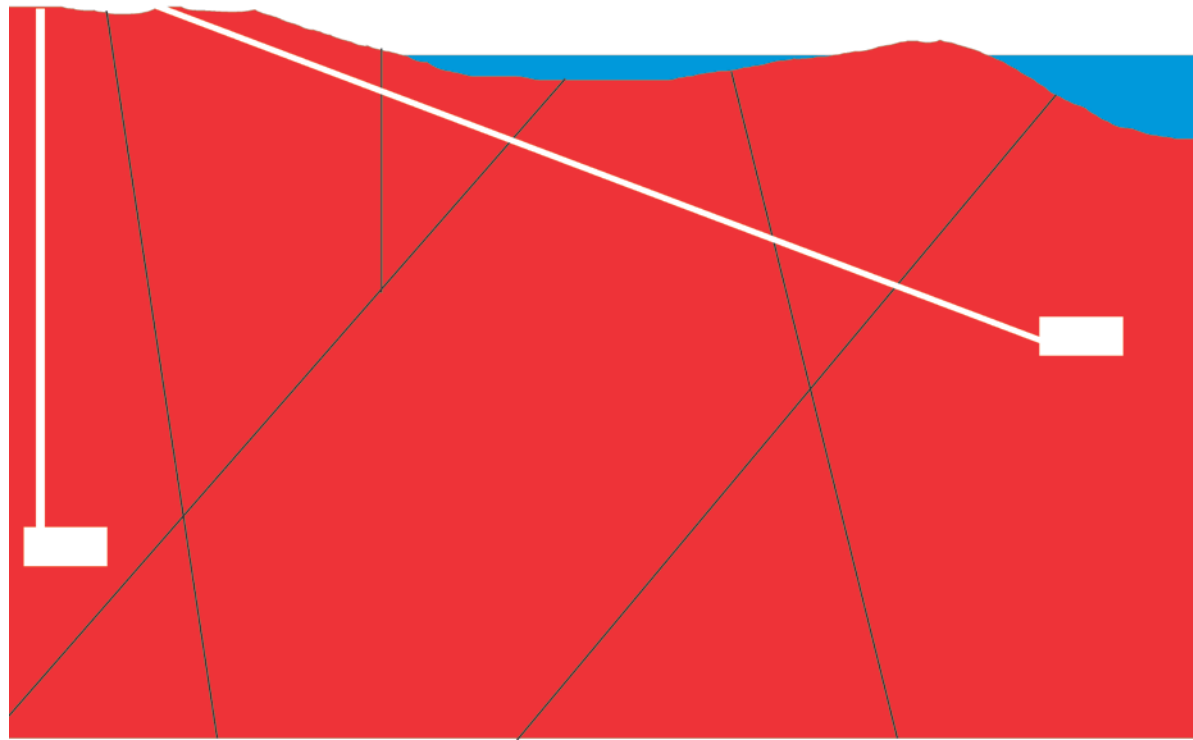
Potential problems of complex geology (sometimes) and short return pathways



Favourable Geological Situations

Low relief terrain (inc small islands)

Includes basement and areas of cover rock.



Less Suitable Geological Situations

Within an aquifer

High groundwater fluxes

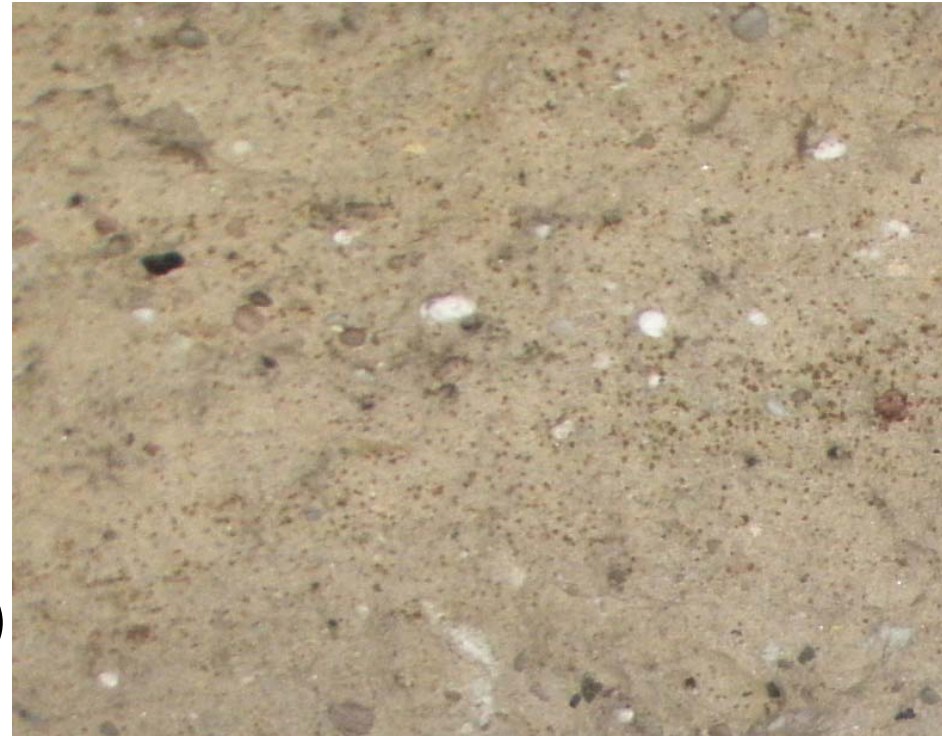
Natural resources (coal etc)

High geological complexity

Not a current issue here in the UK but

High seismicity

Active volcanism



What other countries are doing?

- Finland
- Sweden



What other countries are doing?

- France
- Germany
- Switzerland
- Belgium



What other countries are doing?

- Spain
- Netherlands

- Scotland



What other countries are doing?

- USA
- Japan



Benefits of nuclear power

- Low CO₂ emissions
- Low waste volume
- Low fuel consumption (1000MW PP nuclear 30 tonnes vs coal 4,000,000 tonnes pa)

Problems of nuclear power

- Radioactivity
- Military uses of nuclear materials
- High capital Cost



Table 1. Total lifetime releases of CO₂ from electricity generating technologies

	Coal	Gas	Solar PV	Nuclear	Wind	Hydro
	kg CO ₂ /MW h					
ExternE [1]	815	362	53	20	7	-
UK SDC [2]	891	356	-	16	-	-
U. of Wisconsin [3]	974	469	39	15	14	-
CRIEPI, Japan [4]	990	653 (a)	59	21	37	18
Paul Scherrer Inst. [5]	949 (b)	485	79	8	14	3
UK Energy Review [6]	755	385	-	11–22	11–37	-
IAEA [7]	968 (c)	440 (c)	100 (c)	9–21	9–36	4–23
Vattenfall AB [8]	980	450	50	6	6	3
British Energy [9]	900	400	-	5	-	-

The units are kilograms of CO₂-equivalent emitted per megawatt-hour of electricity generated.

The figures refer to total emissions for the whole life cycle of the generating plant.

Notes:

(a) The figures for gas refer to combined cycle where available, the CRIEPI figure is for thermal.

(b) The PSI data are the “minimum” value data-set from the PSI report.

(c) Figures for best 1990s technology.

Current UK Context

- March 1997 – no Government policy on disposal
- MRWS – ongoing review now in final (4th) phase
- CoRWM - reported July 2006
- October 2006 – Government accepted main CoRWM recommendations – UK now has a policy of geological disposal
- Exclusion screening criteria
- Consultation
- June 2008 - MRWS White Paper
 - Call for volunteer communities



Current UK Context

- Copeland and Allerdale have expressed interest
- Call remains open

Next steps:

- Application of Exclusion Criteria (now)
- Public Engagement (after screen report) (autumn 2010)
- Decision to participate (?mid 2011)
 - With right to withdraw
- Site selection
- Site characterisation (+3 years??)
- Repository (2035-2040???)



Managing radioactive waste safely programme

In 2000, the Government established the Managing Radioactive Waste Safely (MRWS) programme to identify and implement long-term solutions for the UK's higher-activity radioactive wastes. Under the programme, the Committee on Radioactive Waste Management (CoRWM) examined options for safe management of the UK's radioactive waste and recommended in 2006 that deep geological disposal was the best means available of managing our radioactive waste and that the process of selecting a site should be based on community 'volunteerism'



Volunteer Screening

The MRWS White Paper says that screen out of clearly geologically unsuitable areas will be carried out by BGS.



Table B1: Summary table of initial sub-surface screening criteria

	To be applied as exclusion criteria?	Reasons/explanations and qualifying comments
Natural resources		
Coal	Yes	Intrusion risk to depth, only when resource at >100m depth
Oil and gas	Yes	Intrusion risk to depth
Oil shales	Yes	Intrusion risk to depth
Industrial minerals (except evaporites)	No	Low resource value – limiting the potential for economic exploitation at depth
Evaporite minerals	No	Wide distribution – insufficient resource loss and intrusion risk to justify exclusion
Metal ores	Some ores	Intrusion risk only where mined at depth, i.e. >100m
Bulk rock resources	No	Not exploited at depth
Disposal of wastes/gas storage	Yes	Only where already committed or approved at >100m depth
Geothermal energy – shallow ¹ ground source heat	No	Not exploited at depth
Geothermal energy – low grade heat extraction from deep rocks and groundwaters	No	Not an a priori general exclusion – value for development is currently speculative
Groundwater		
Aquifers	Yes	Where all or part of the geological disposal facility host rock is located within the aquifer
Shallow ¹ permeable formations	Yes	Where all or part of the geological disposal facility host rock would be provided by permeable formations that might reasonably be exploited in the future
Deep permeable saline formations	No	No potential as exploitable groundwater resources

1. "Shallow", in this context, means less than 500 metres below the surface. Therefore, "deep" and "at depth" mean more than 500 metres below the surface.

Table B1: Summary table of initial sub-surface screening criteria (continued)

	To be applied as exclusion criteria?	Reasons/explanations and qualifying comments
Formations neighbouring exploitable groundwater	No	Where the host rock volume provides adequate long-term isolation of the waste
Specific complex hydro-geological environments	Yes	Deep karstic formations and known source rocks for thermal springs
Geological stability		
Earthquakes & faults	No	Later assessment of potential impact on sites
Uplift and erosion	No	Influence on geological disposal facility depth and design and later site exclusion in extreme cases
Other geohazards	No	Site specific risk assessment will be required later in the process
Geotechnical Issues		
Rock stress and engineering issues	No	Later assessment when detailed site data are available
Other sub-surface criteria		
Specific complex geological environments	No	Need not be excluded at this stage
Other geological and hydrogeological characteristics	No	Only required at in-situ geoscientific investigation stage

Table B1 from Annex B of Managing Radioactive Waste Safely: A Framework for Implementing Geological Disposal crown copyright 2008

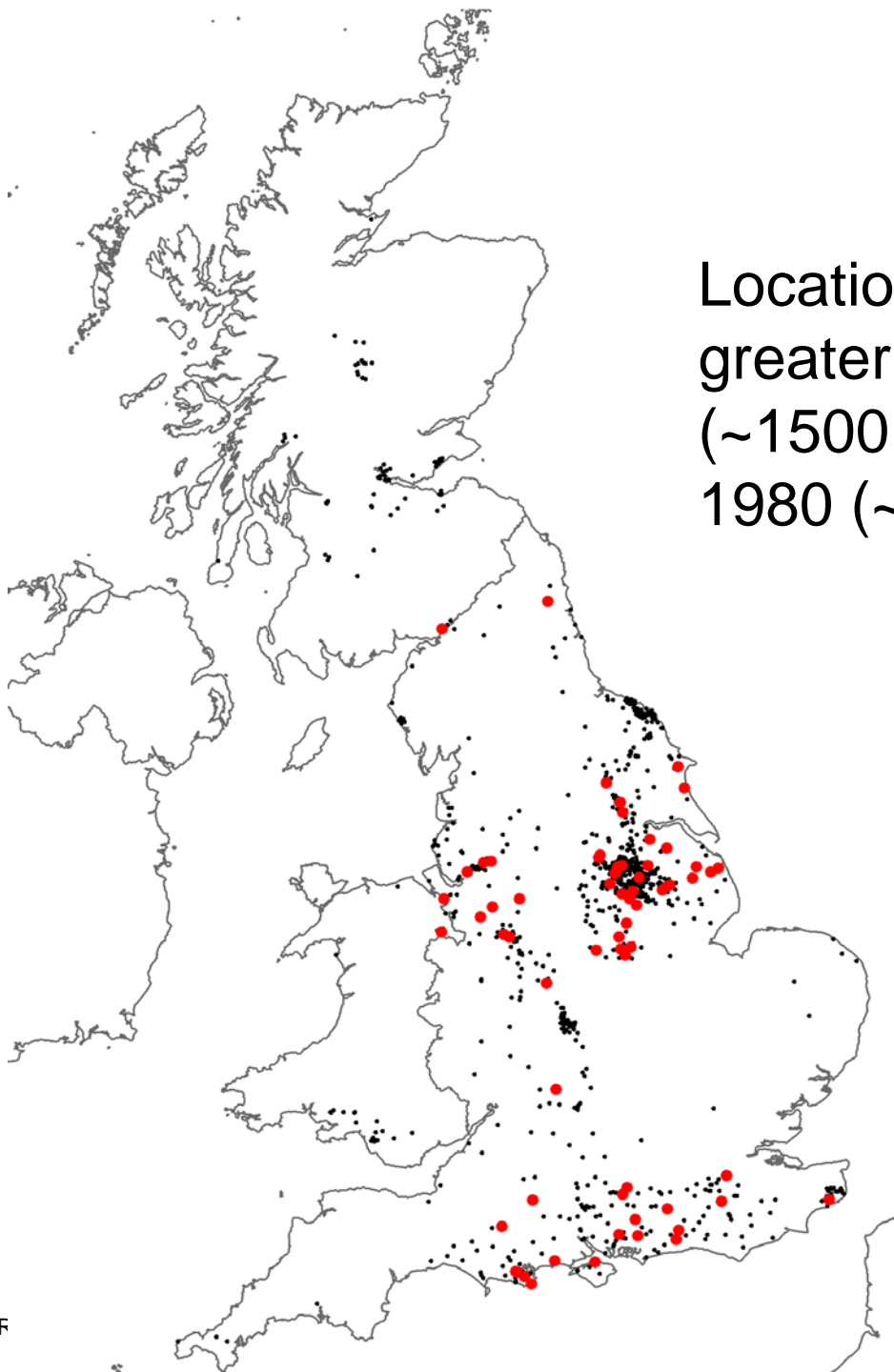
Deep Geological Information

Information largely restricted to coal and hydrocarbon exploration activities including:

- Boreholes



Location of all registered boreholes greater than 1000m drilled depth (~1500 since 1850), those drilled post 1980 (~180) highlighted in red.



Deep Geological Information

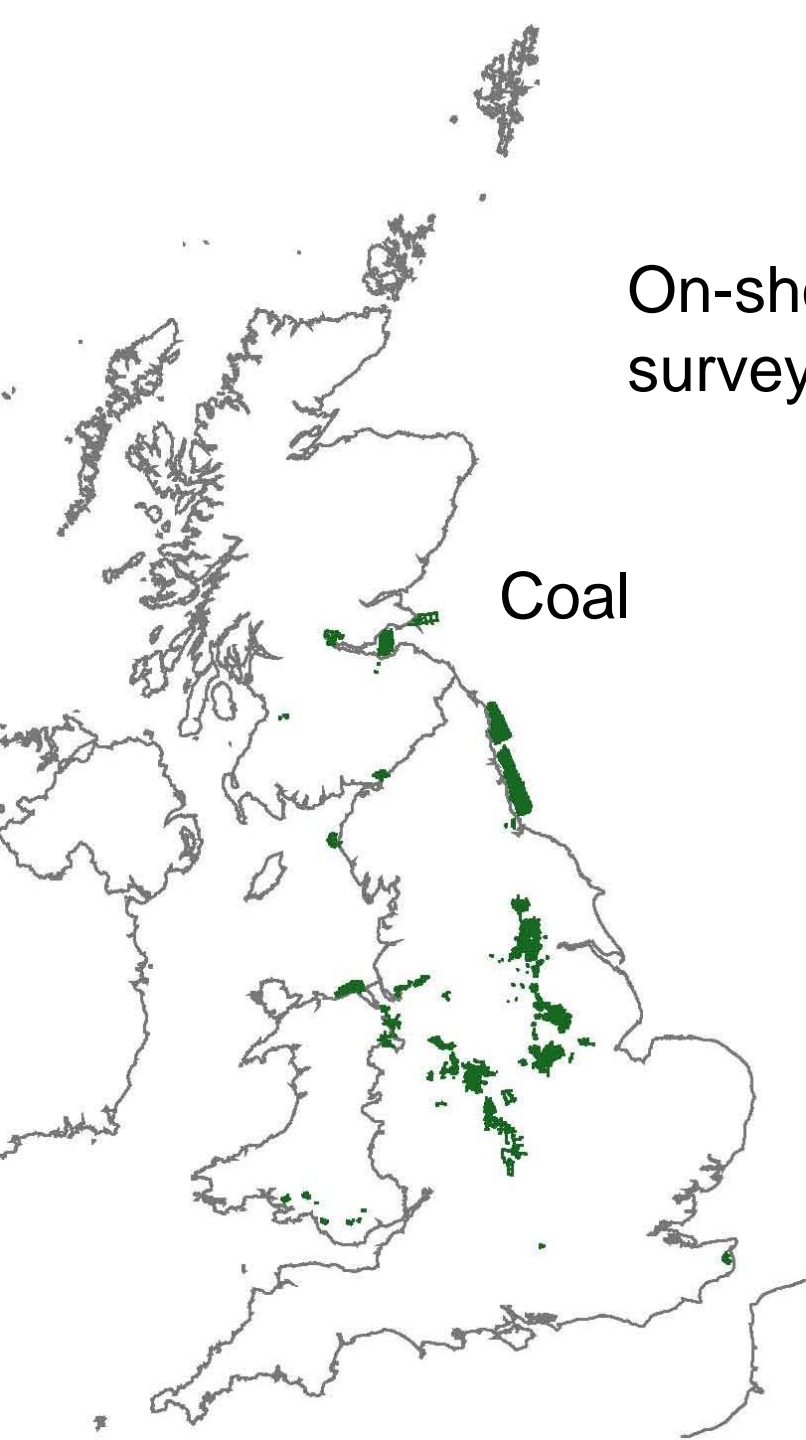
Information largely restricted to coal and hydrocarbon exploration activities including:

- Boreholes
- **Seismic Surveys**

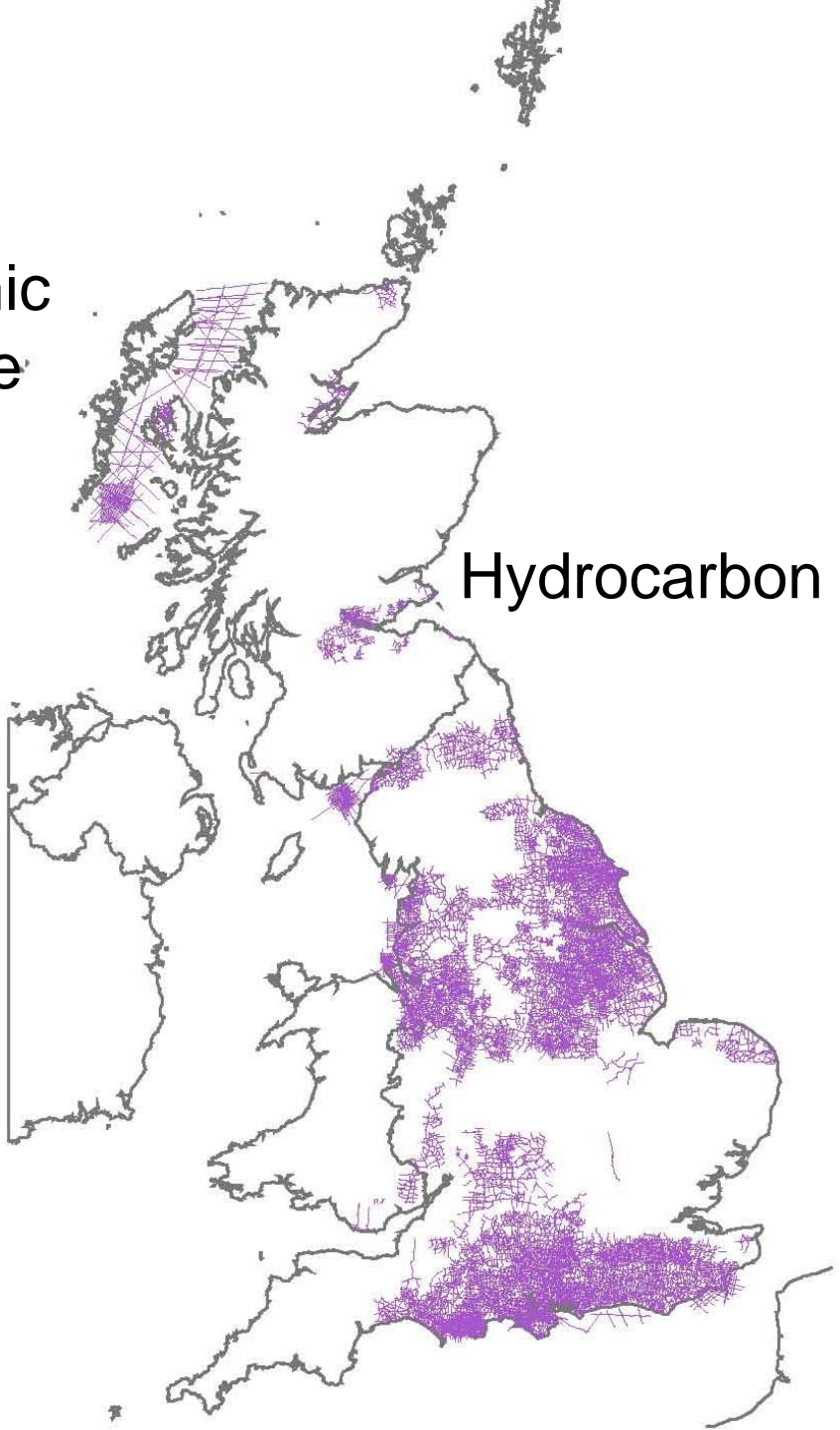


On-shore seismic
survey coverage

Coal



Hydrocarbon

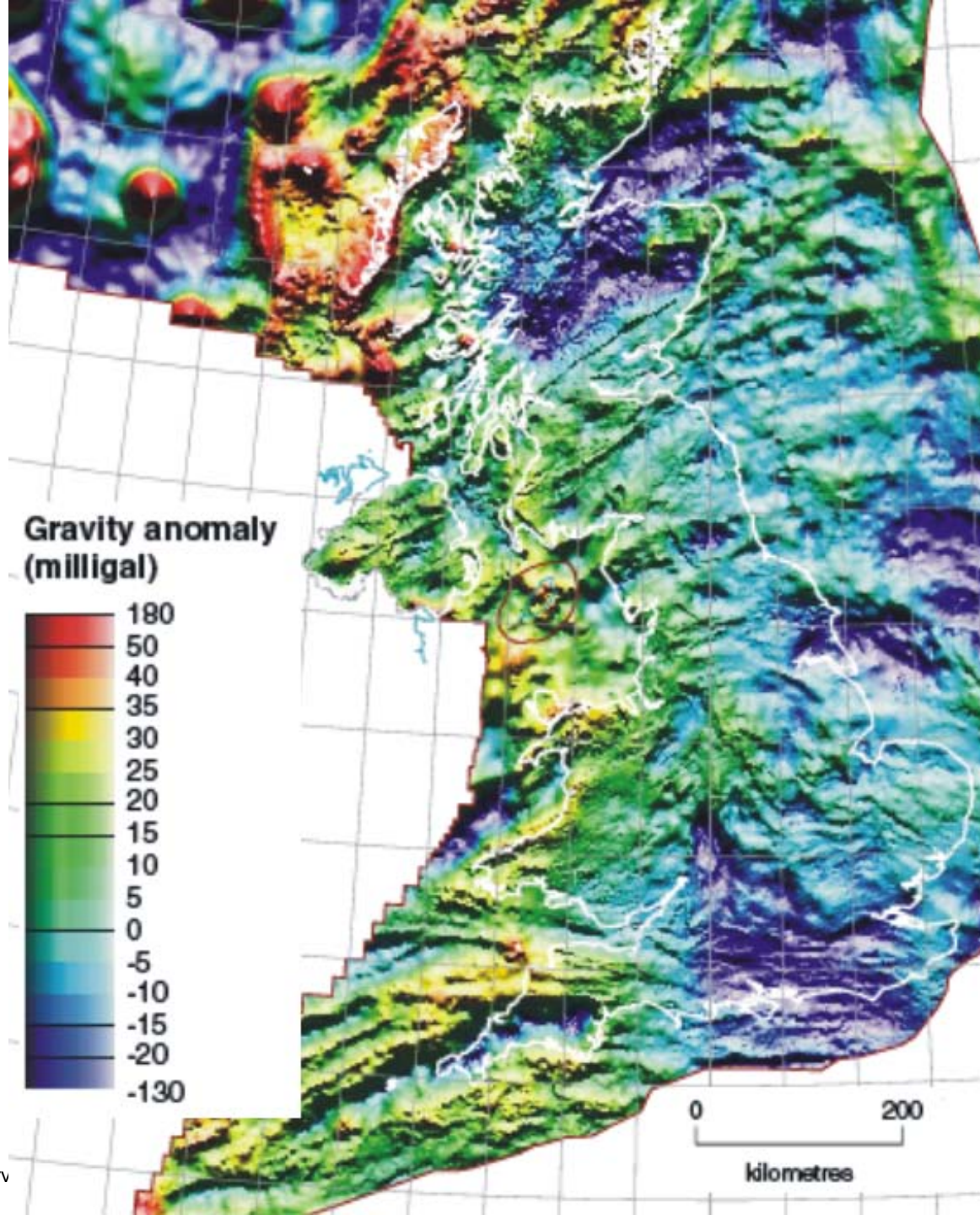


Deep Geological Information

Information largely restricted to coal and hydrocarbon exploration activities including:

- Boreholes
- Seismic Surveys
- National/Regional geophysical datasets including gravity, magnetics etc
- Site specific data





Given geological variability and the number of potentially suitable geological environments available in the UK the geological disposal of radioactive waste is a viable option.

