

# ***DEEP BOREHOLE DISPOSAL OF RADIOACTIVE WASTE***

**AN ALTERNATIVE TO A DEEP MINED  
REPOSITORY**

**DISPOSAL IN DEEP LARGE DIAMETER  
BOREHOLES**

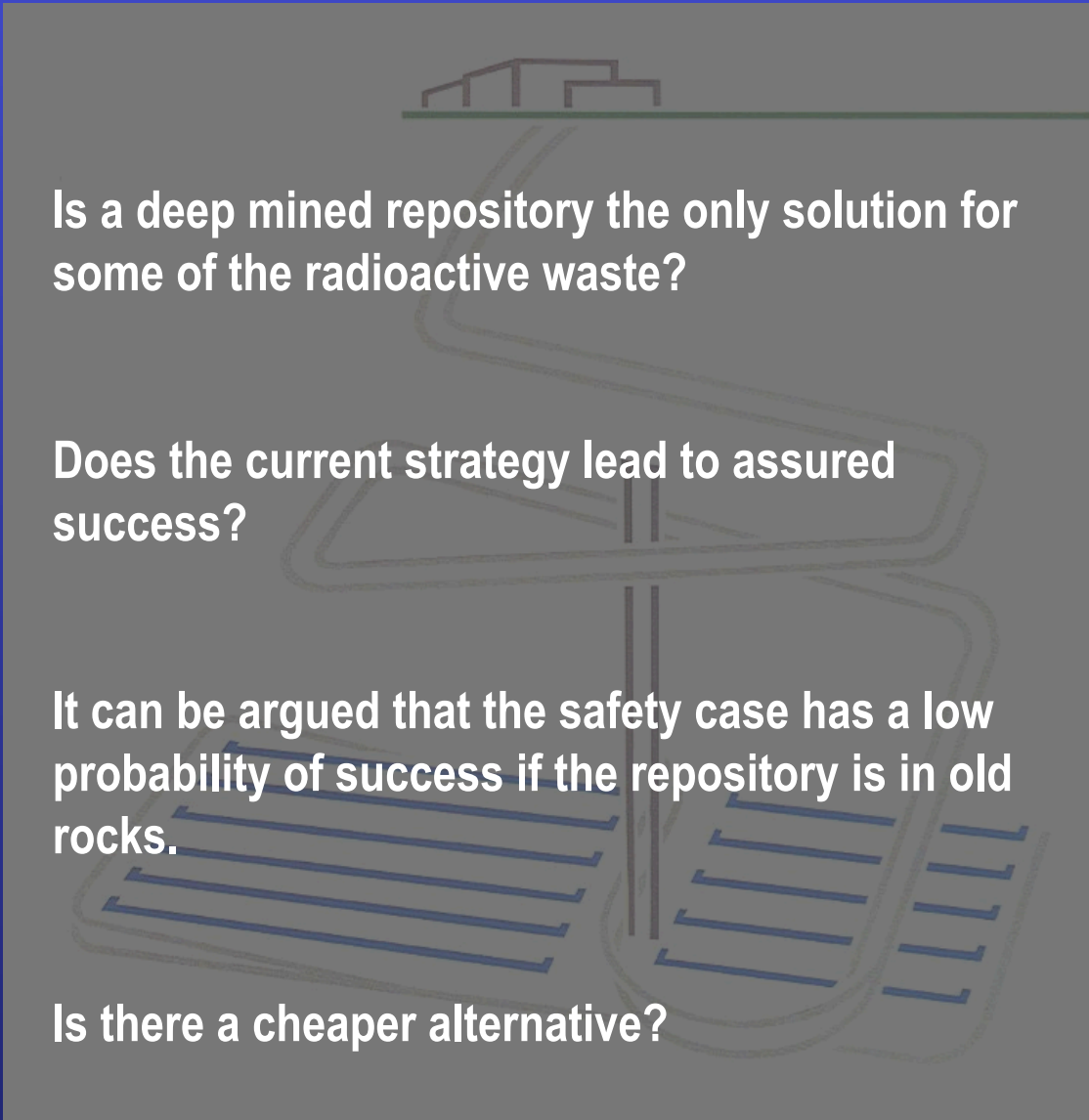
**HISTORY, KEY ISSUES AND CHALLENGES**



**John Beswick**



# GEOLOGICAL DISPOSAL – KEY QUESTIONS



Is a deep mined repository the only solution for some of the radioactive waste?

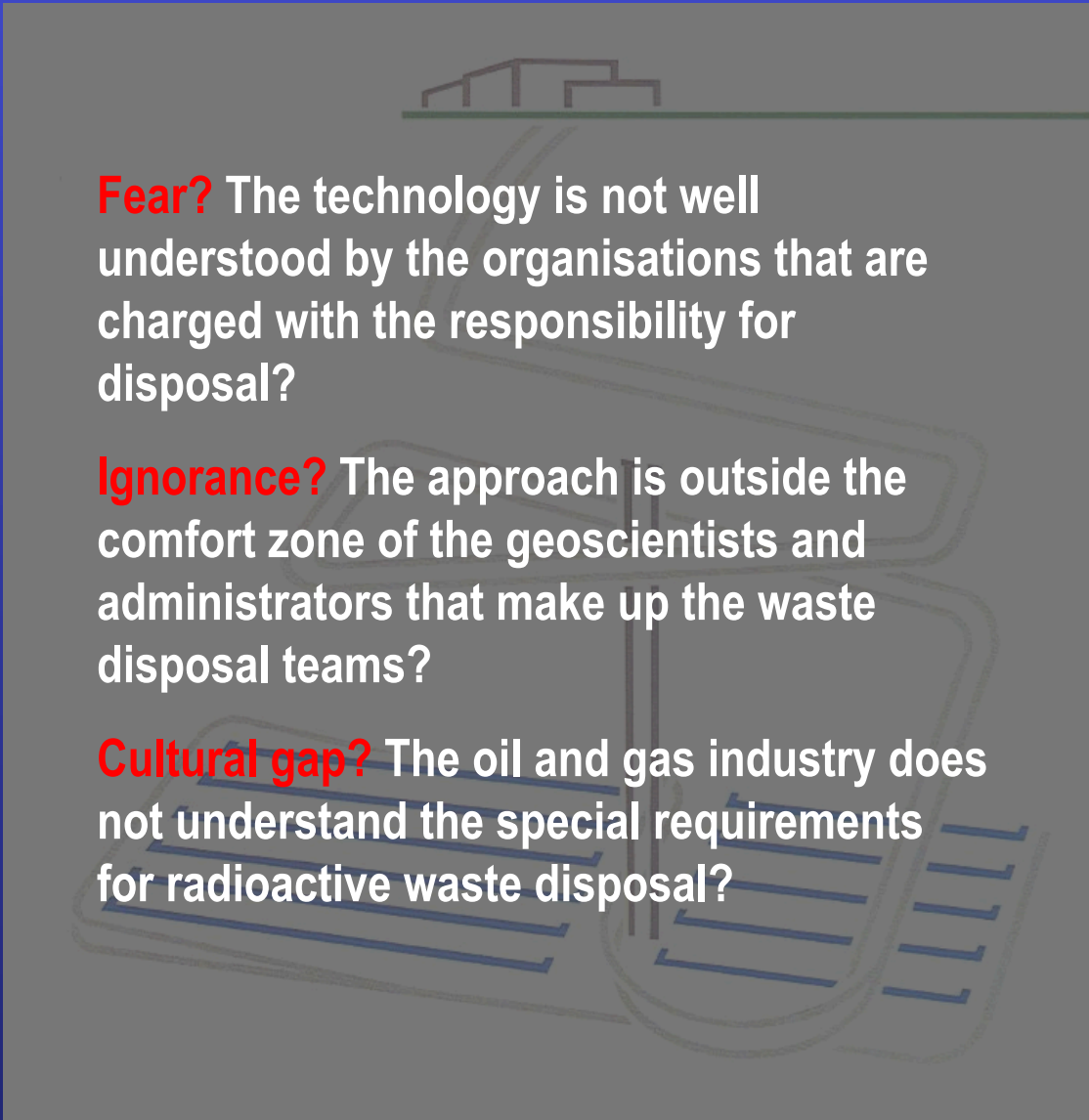
Does the current strategy lead to assured success?

It can be argued that the safety case has a low probability of success if the repository is in old rocks.

Is there a cheaper alternative?



# WHY IS BOREHOLE DISPOSAL NOT TAKEN SERIOUSLY?

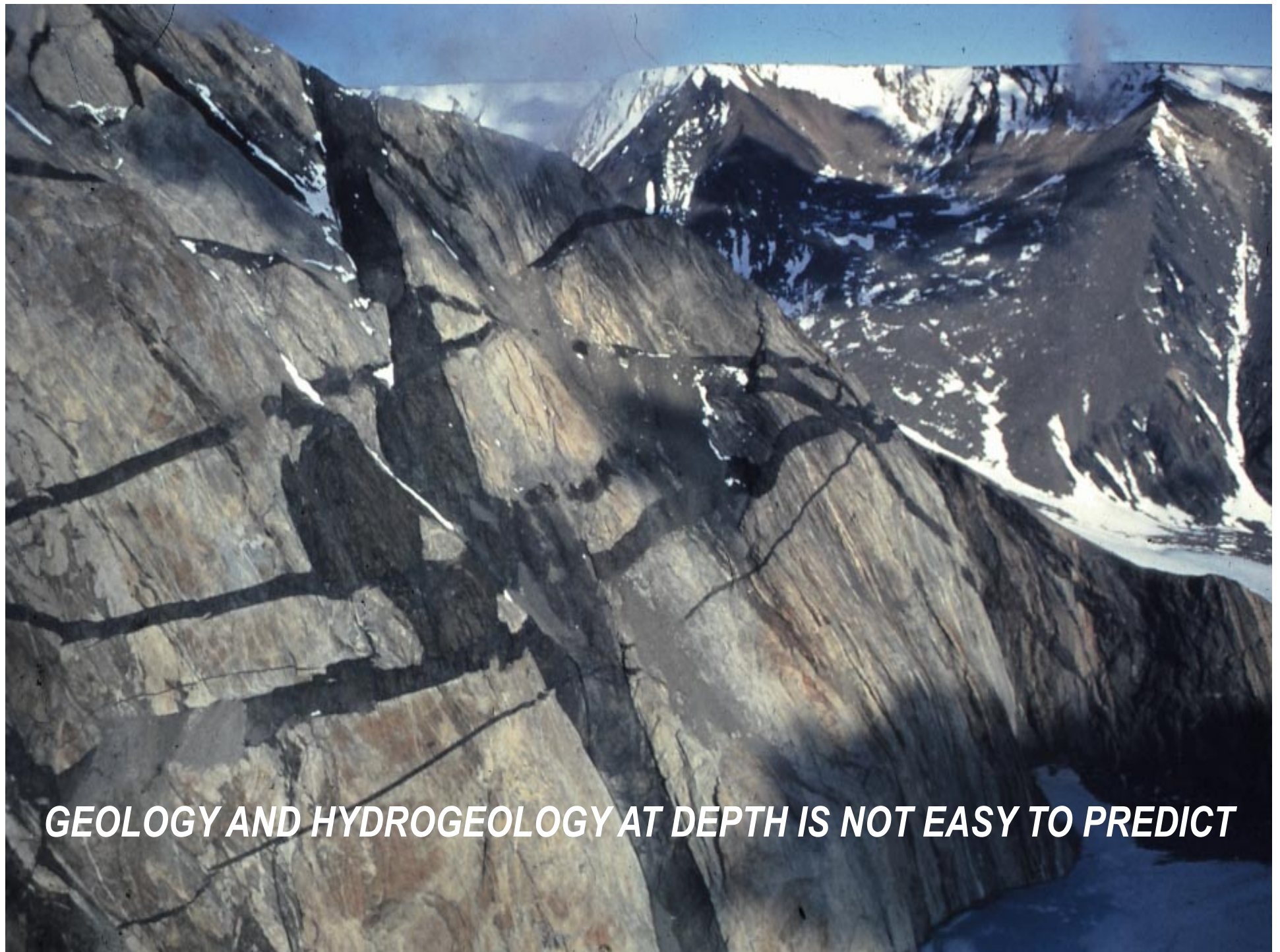


**Fear?** The technology is not well understood by the organisations that are charged with the responsibility for disposal?

**Ignorance?** The approach is outside the comfort zone of the geoscientists and administrators that make up the waste disposal teams?

**Cultural gap?** The oil and gas industry does not understand the special requirements for radioactive waste disposal?





***GEOLOGY AND HYDROGEOLOGY AT DEPTH IS NOT EASY TO PREDICT***

## ***THE CASE FOR A DEEP BOREHOLE APPROACH***

- Technically feasible at usable diameters
- Can be implemented in many locations
- Faster to implement and earlier start possible
- Potentially cheaper
- Technology known or can be developed in the time scale under debate
- The safety case is probably easier to demonstrate than for a mined repository in old rocks



# *HISTORY OF DEEP DISPOSAL CONCEPT STUDIES*



US Department of Energy

early 1980s

Denmark

early 1980s

SKB Sweden

late 1980s and 2000

Nirex (NDA)

2007



## ***SOME DEEP DRILLING PROJECTS INTO THE BASEMENT***

### **HFR PROJECTS**

Los Alamos, USA

Urach, Germany

Rosemanowes, England

Soultz, France

Cooper Basin, Australia

Basel, Switzerland

### **GEOSCIENTIFIC**

Kola

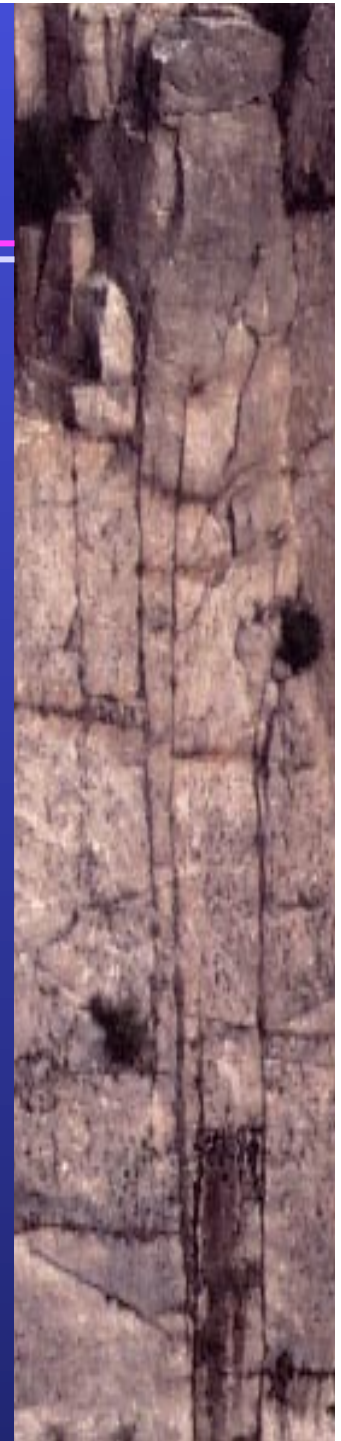
Gravberg

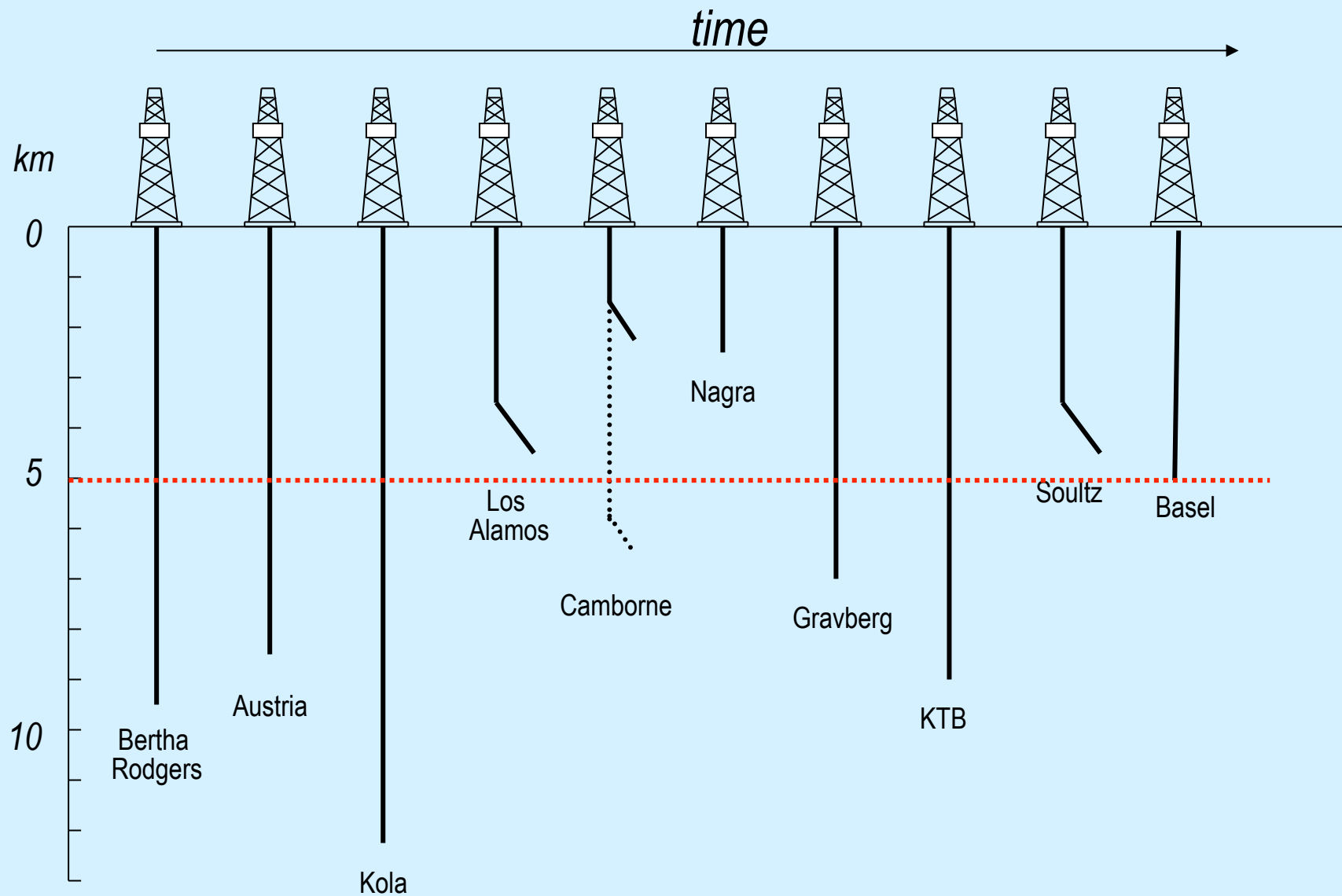
Cajon Pass

KTB

Nagra

Nirex





***SOME DEEP WELLS INTO BASEMENT***

# ***HISTORICAL PROJECTS OVER THE LAST 40 YEARS***



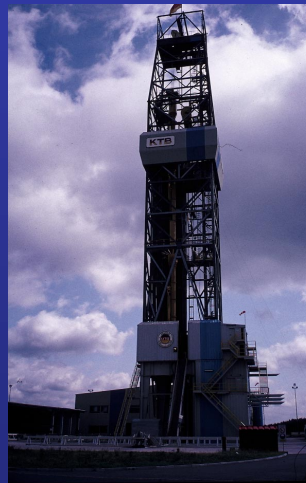
*Kola*



*Los Alamos*



*Rosemanowes*



*KTB*

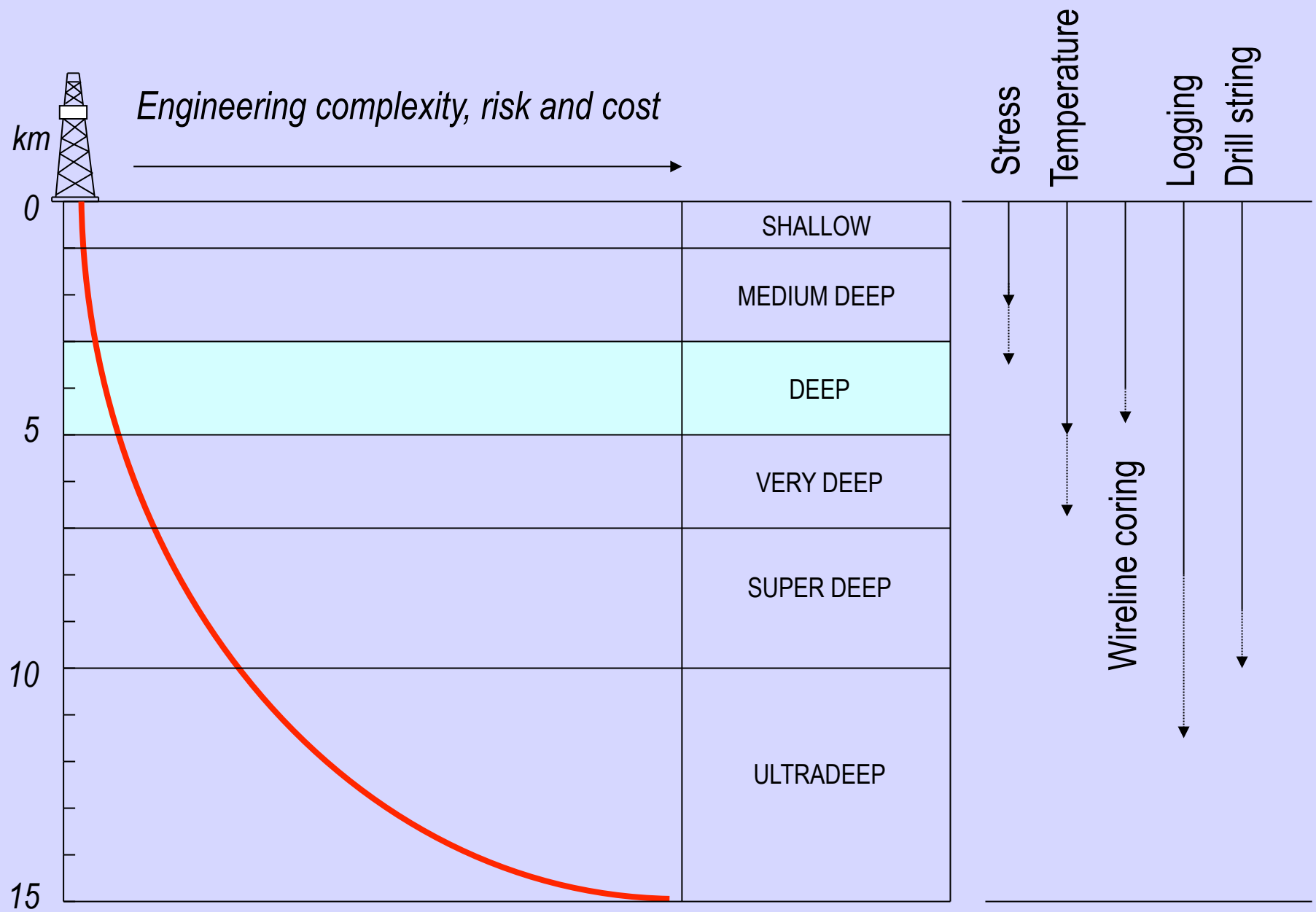


*Gravberg*

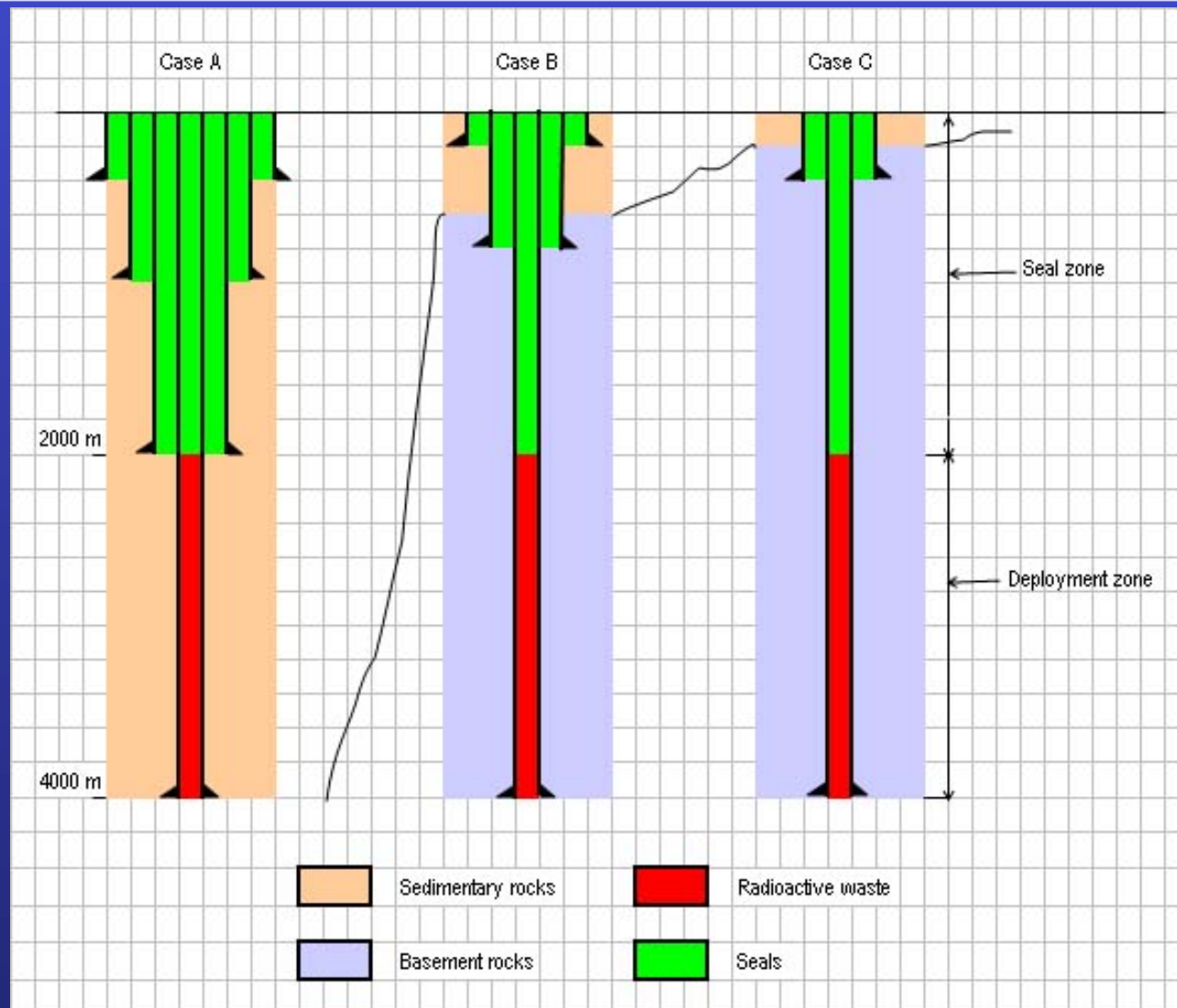


## ***GEOSCIENTIFIC PROGRAMMES HAVE ADDED DATA***

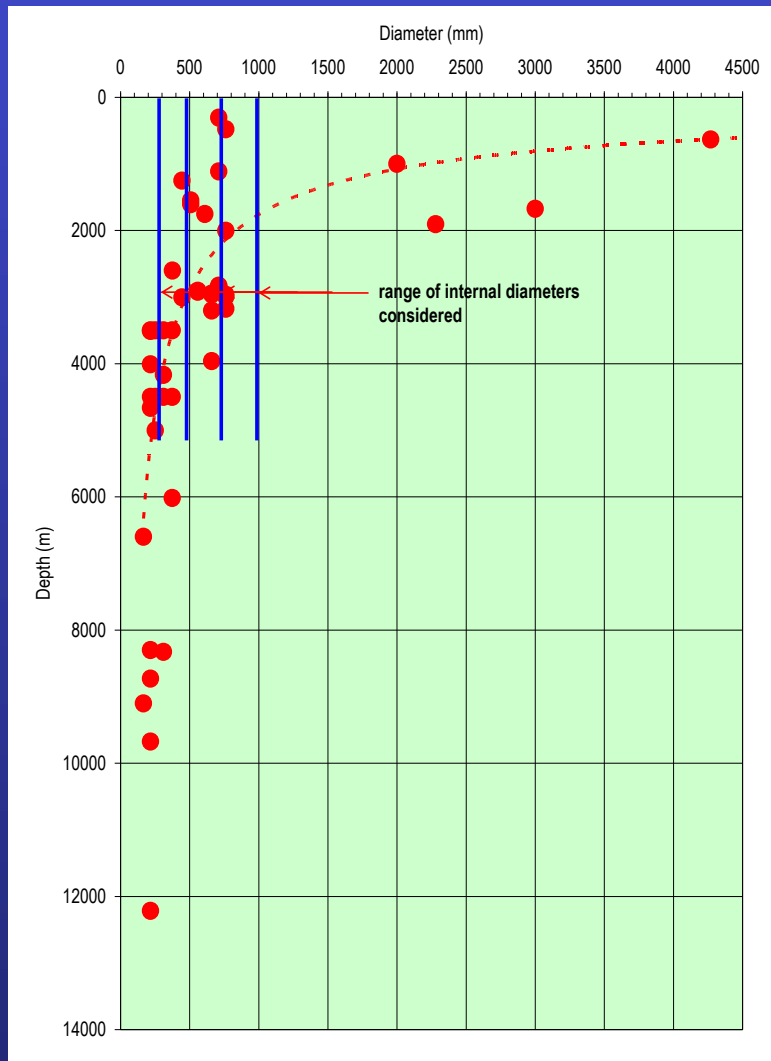




# GEOLOGICAL SCENARIOS



## DEPTH v DIAMETER : EXPERIENCE TO DATE

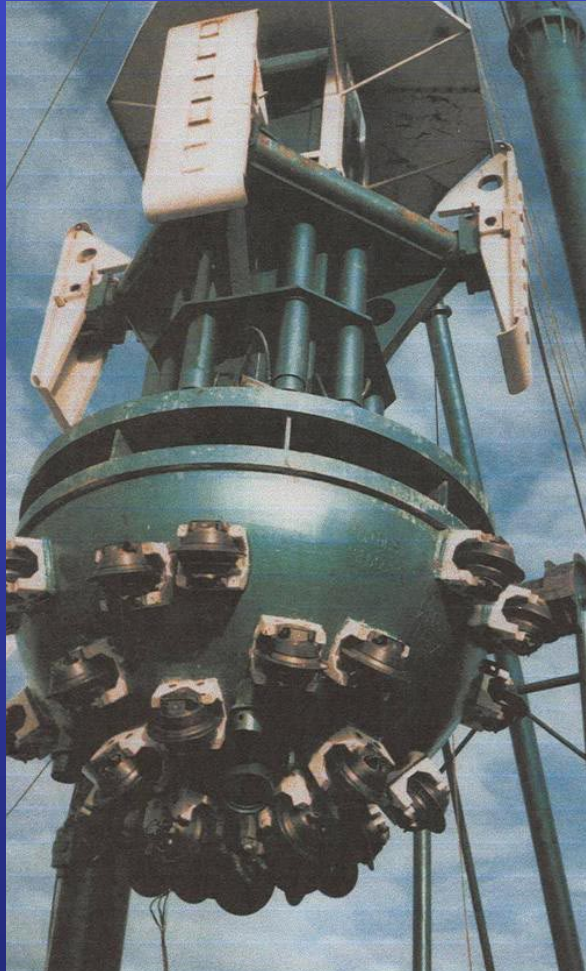


The borehole diameter can be tailored to suit the waste packaging.

A 500 mm to 600 mm diameter well to 5000 m in crystalline rock is not far outside the current experience envelope



# ***BIG HOLE DRILLING***



# HEAVY DRILLING RIGS ARE AVAILABLE



*New concept 425 mton rig Germany 2009*



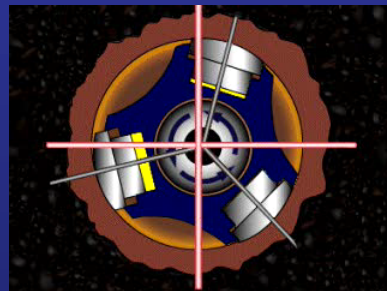
*Conventional 4000 HP oil and gas rig USA 1982*



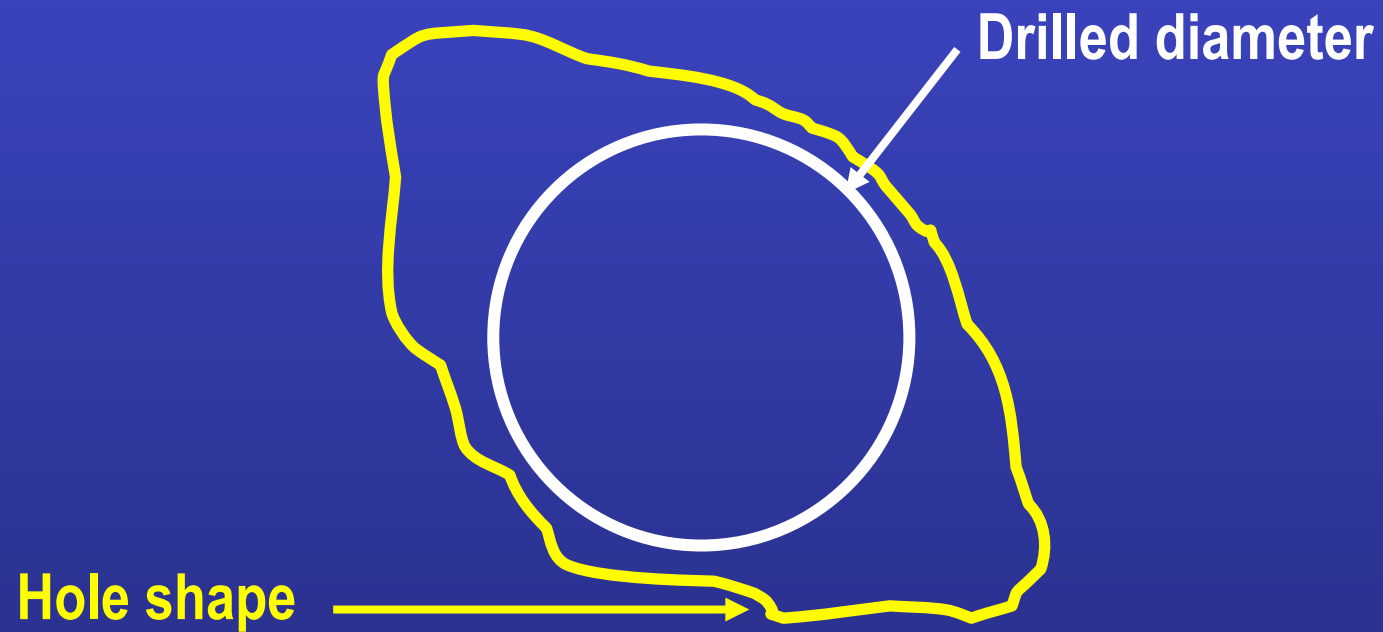
## VERTICALITY CONTROL

Vertical drilling systems can now assure verticality notwithstanding stress breakout influences.

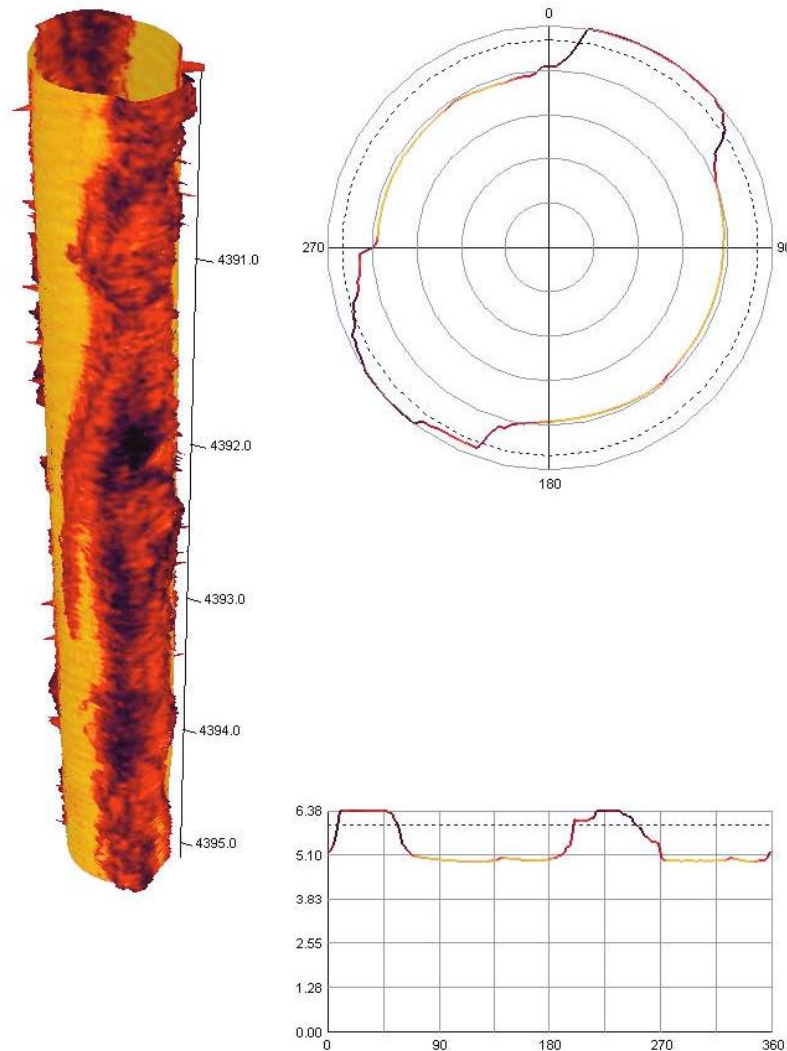
A depth of 7.15 km with a verticality within  $1.5^\circ$  was achieved in Germany in the basement.



## ***HOLE BREAKOUT DUE TO STRESS***



# ROCK STRESS ISSUES



Stress breakout is a feature of deep wells particularly in strong rock.

Hence casing throughout the full depth of the borehole is essential



## CURRENT STATUS OF EXPERIENCE

Depth (km)	Completed internal diameter (mm)			
	300	500	750	1000
2				
3				
4				
5				



Feasible with current technology and favourable geological conditions



Achievable with tool and process development



Considered impractical in the foreseeable future



## WASTE DEPLOYMENT BY COILED TUBING

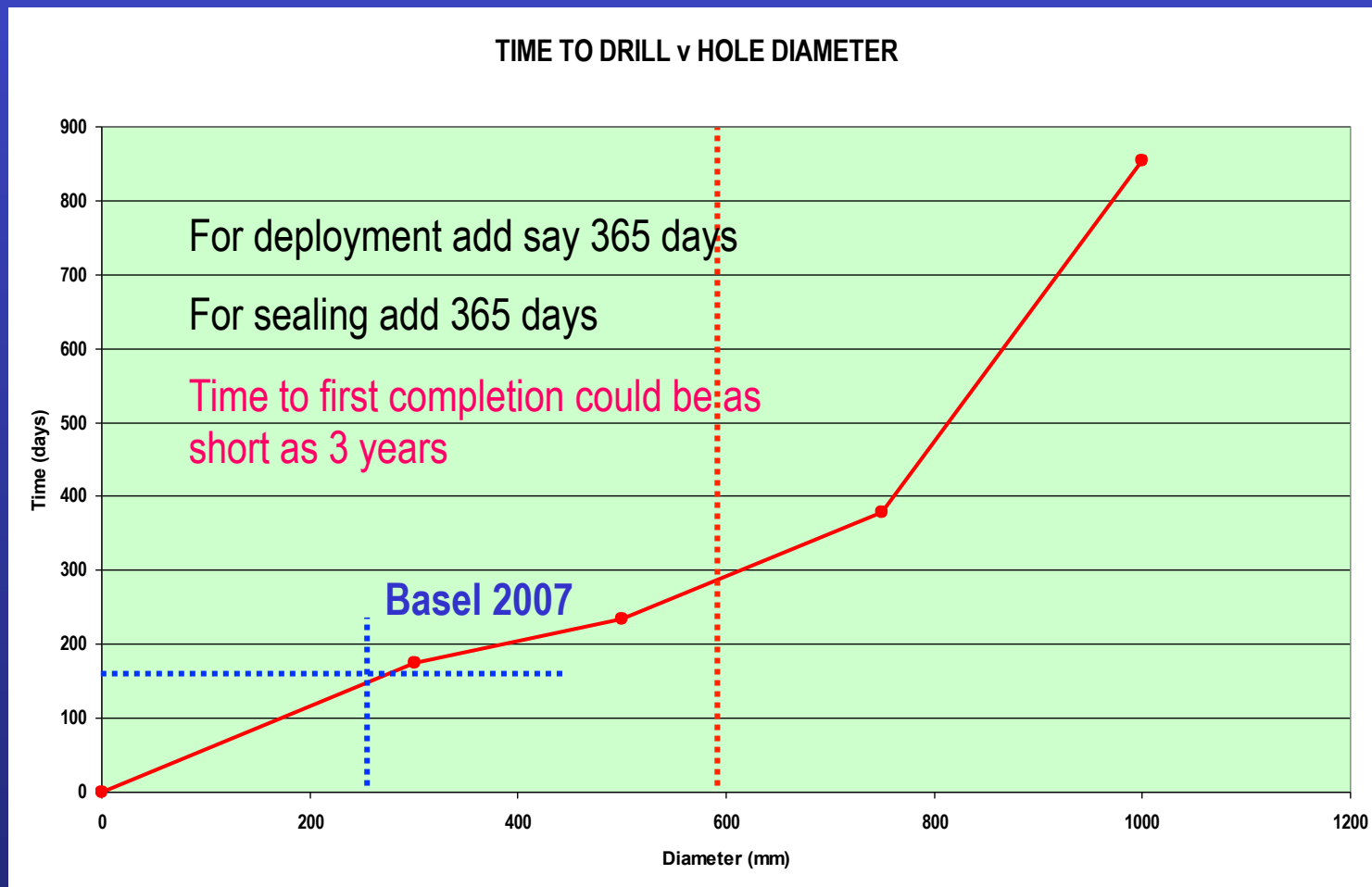


Continuous coiled tubing is available in sizes up to 4.50 in (114 mm) diameter and some developments up to 6-5/8 in (168 mm) diameter.

Coiled tubing can include an electrical cable for data transfer and/or control of downhole tools.



# DRILLING TIME



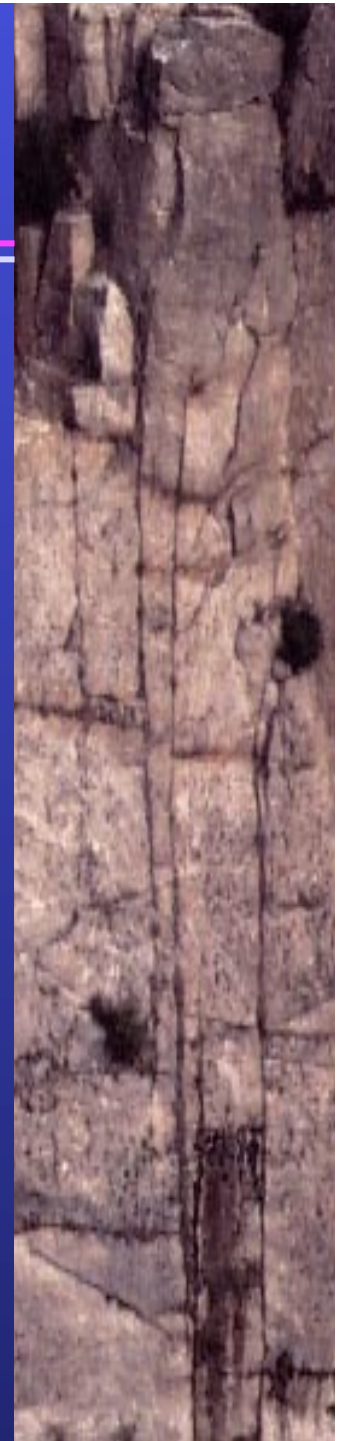
## COST

£?

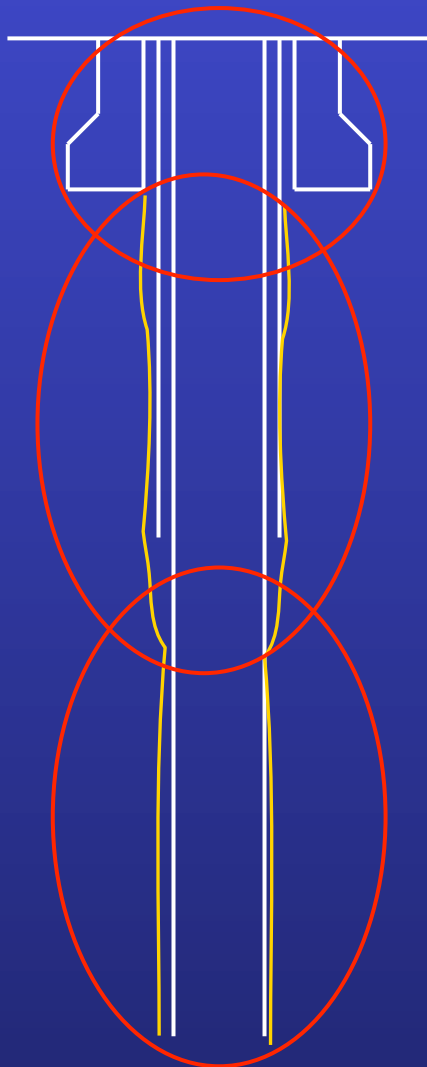
For a 500 mm diameter borehole to 5000 m, the cost would be of the order of £35 - £40 million for the first boreholes.

Subsequent boreholes would be less, say £25 - £30 million.

If a system for drilling, waste deployment and sealing can be perfected, these costs could be significantly reduced.



# SEALING



A mined abutment which could be carried out prior to drilling and used to complete the seal. Depth say 300 m.

A series of seals formed by cutting intervals of casing and filling with an appropriate sealing material to create a multiple barrier.

Sealing of the waste within the lowermost casing with an appropriate sealing material which may or may not be emplaced though voids in the deployment zone casing.



# ***ISSUES THAT NEED RESEARCH AND DEVELOPMENT***

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**Large diameter drilling tools and drill string**

**Casing design and installation procedures for large diameters**

**Casing design for deployment zone – voids for annulus filling?**

**Cementation methods for upper large diameter casing**

**Waste deployment procedure and handling tools**

**Annulus sealing in the deployment zone**

**Upper borehole seals and near surface abutment**



## WHERE IS THE TECHNOLOGY AND HOW FAR TO GO?

Drilling technology



Directional control (verticality)



Casing design



Cementing



Zone isolation (sealing)



Instrumentation



Waste deployment in deep boreholes



- *Where we were 25 years ago*  
*Where will we be in another 25 years?*



# CONCLUSIONS

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- *Deep borehole disposal is a real and an important alternative*
  - *There are things to do to bring the status up to an acceptable operational level, but so are there with any other disposal concept*
  - *A pilot scheme for developing processes, systems and tools is relatively cheap*
  - *In the end the Safety Case may be easier to achieve for a deep borehole solution than for a mined repository in old rock where the geology and hydrogeological are difficult to predict*
  - *Casing-cement-rock integrity issues are real as well as sealing and these need special attention*
  - *Deep borehole disposal will probably be cheaper for the wastes that can be accommodated*
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***YOU NEVER KNOW, SOME PEOPLE MAY LOVE US!***



## ***DEEP BOREHOLE DISPOSAL OF RADIOACTIVE WASTE***

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Thank you!

