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SEALING AND SUPPORT MATRICES

Nicholas C Collier

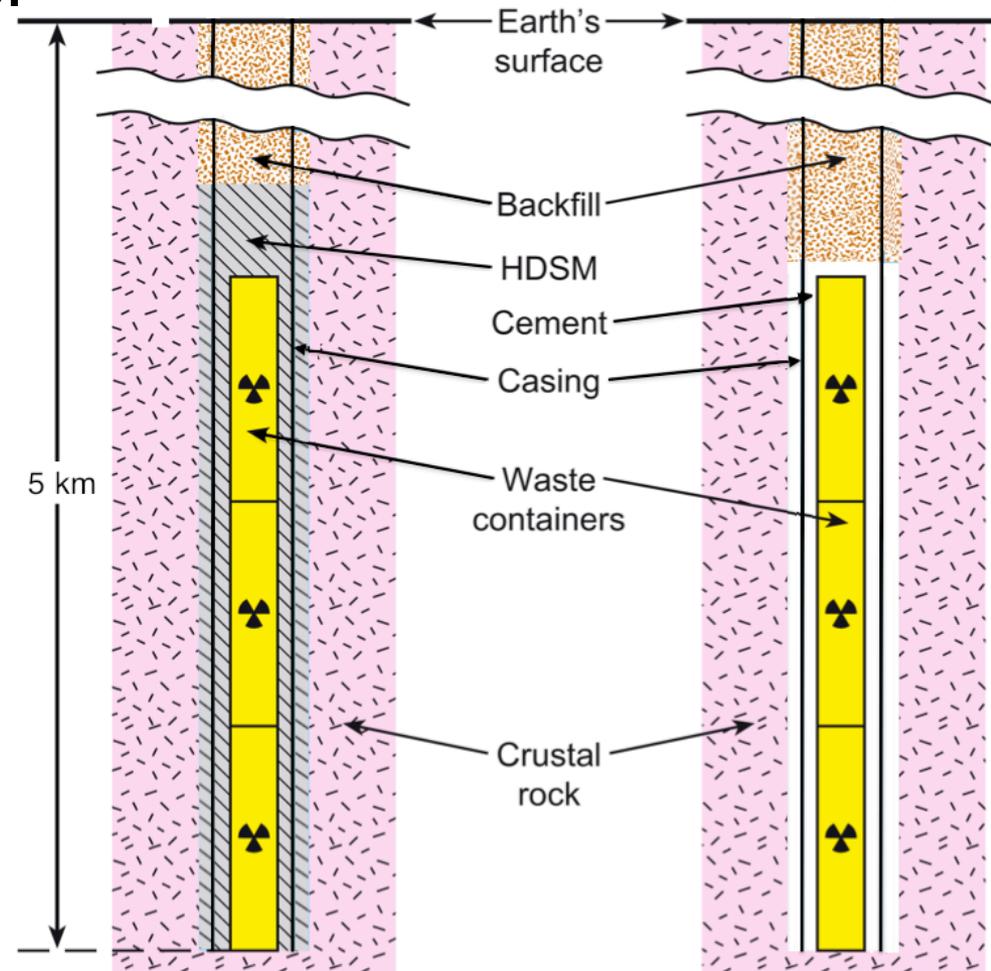
Deep Borehole Disposal Research Group
Immobilisation Science Laboratory
Department of Materials Science & Engineering
The University of Sheffield, UK



Sealing and Support Matrices



- The University of Sheffield DBD concepts use various matrices to fill annular space.
- *Sealing and support matrices (SSMs).*
 - Sealing individual waste packages within the disposal zone.
 - Support individual packages during deployment.
- ***Maximizes near-field safety case.***



After Gibb et al. Nuclear Technology, 2008.



Sealing and Support Matrices



SSM Variants.

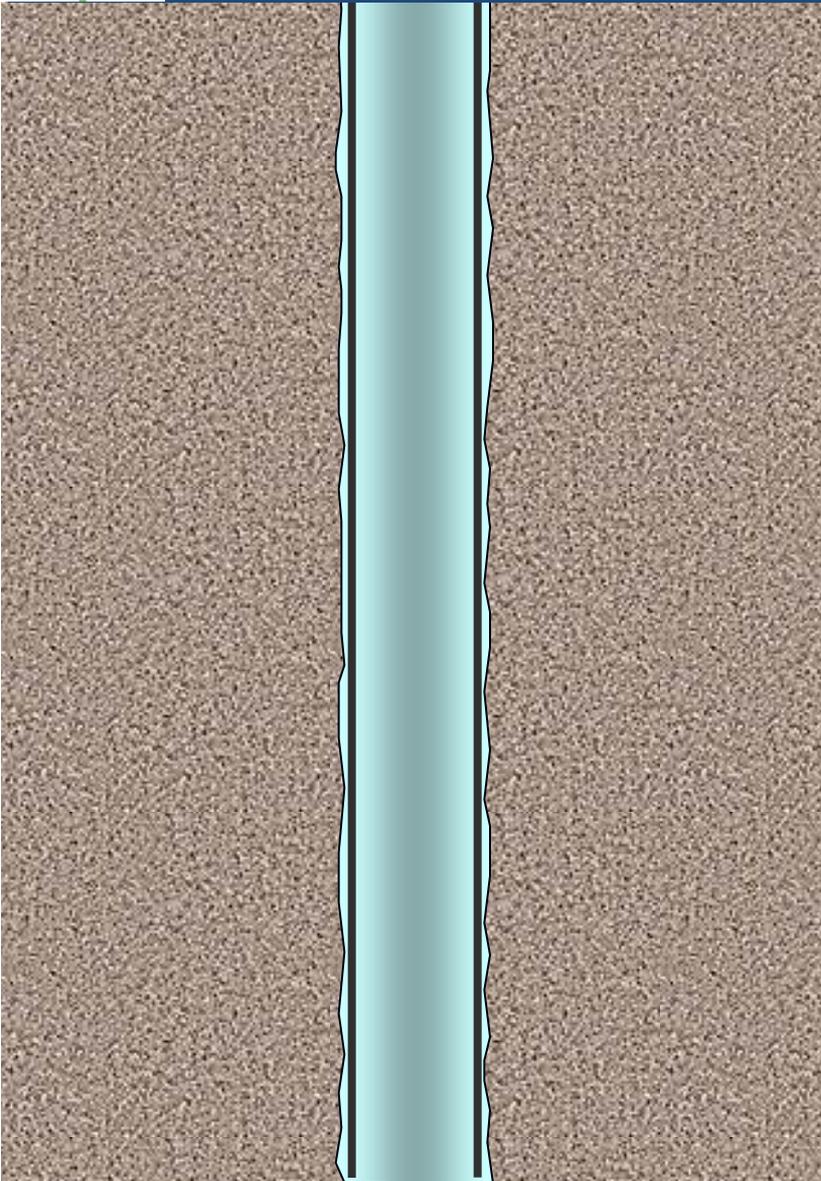
- Preferred option - High Density Support Matrix (HDSM)¹.
 - Pb-based low melting temperature alloy.
 - When temperature throughout annuli between waste package and borehole wall $> \sim 190^{\circ}$ C.
- Low temperature variant - cement grout.
 - Based on BS EN ISO / API Class G Oilwell Cement².
 - When temperature throughout annuli between package and wall $< \sim 190^{\circ}$ C. HDSM cannot be used.

1. Gibb *et al.* J. Nucl. Mat. 374 (2008) 370.

2. BS EN ISO 10426-1:2009, Petroleum and Natural Gas Industries, Cements and Materials for Well Cementing, Specification, British Standard Institute, 2009.



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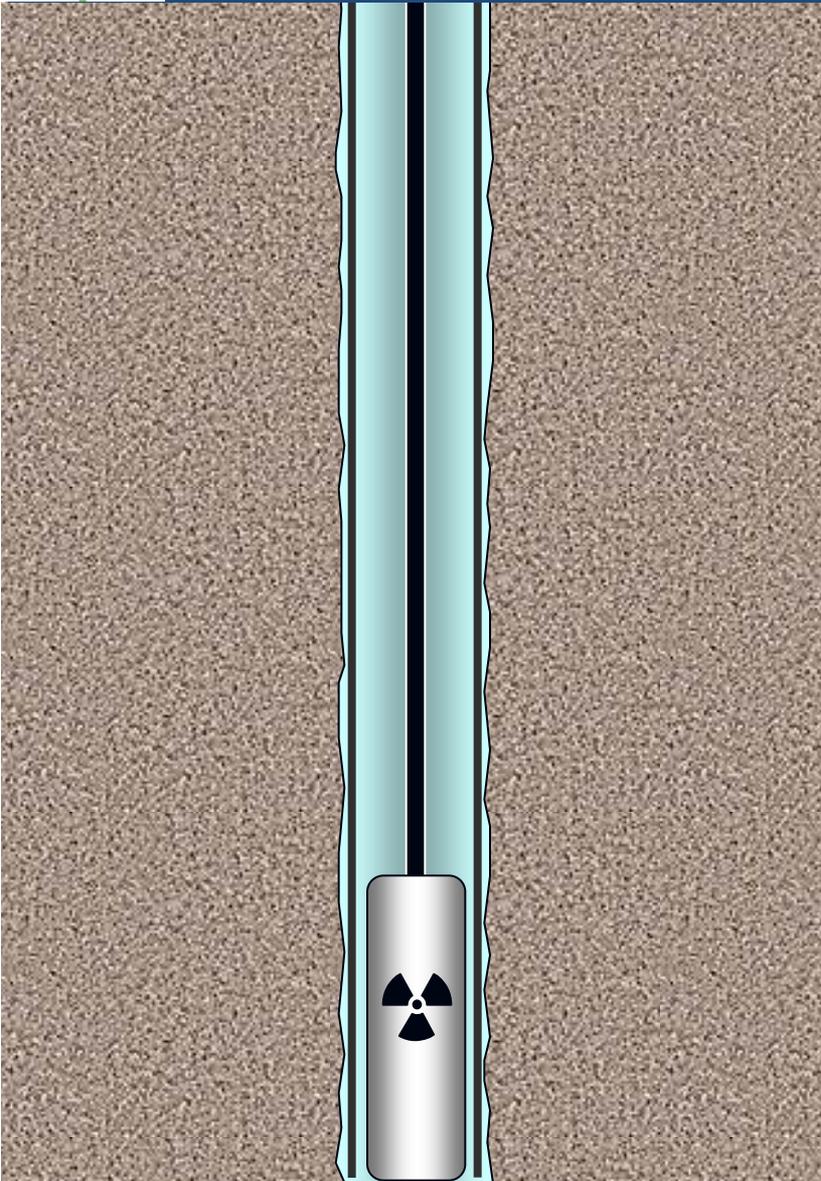


HDSM - Operation.

- Borehole cased with perforated casing.



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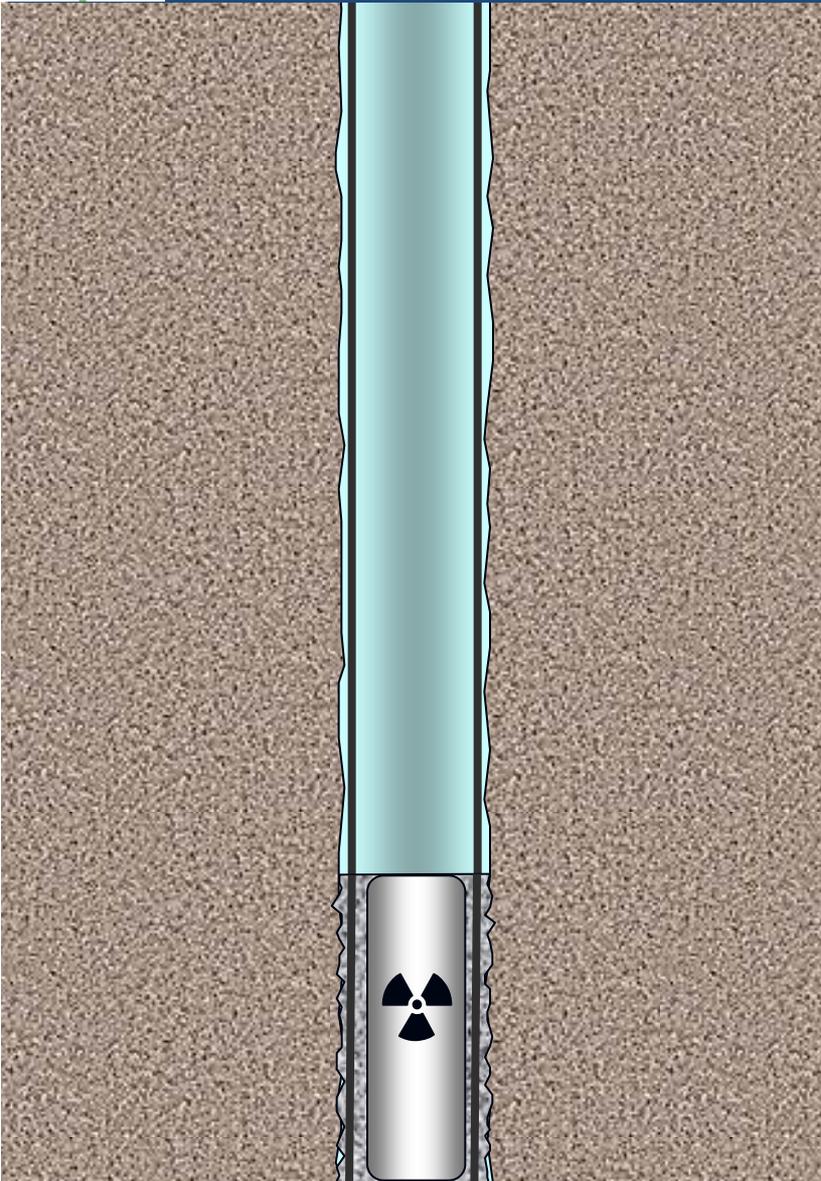


HDSM - Operation.

- Borehole cased with perforated casing.
- Emplace first container using coiled tubing (or drill pipe).



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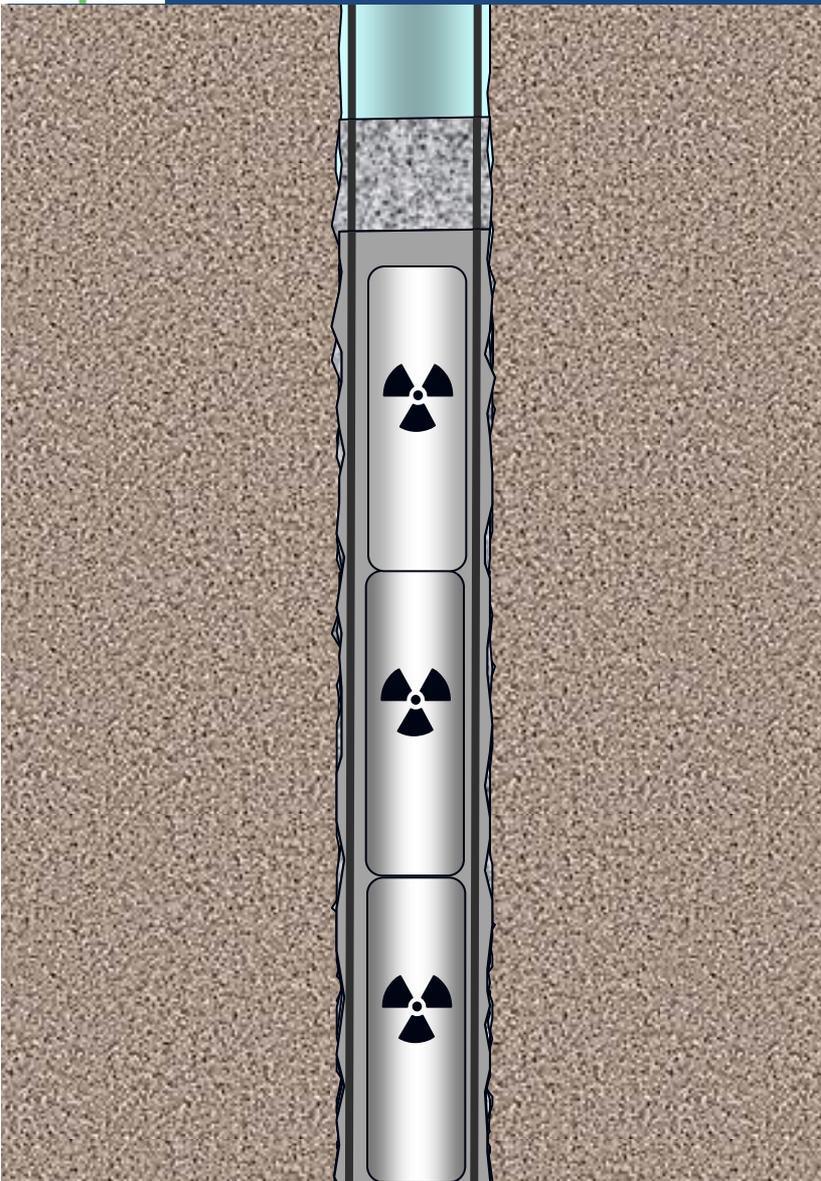


HDSM - Operation.

- Borehole cased with perforated casing.
- Emplace first container using coiled tubing (or drill pipe).
- Immediately followed by release of HDSM to fill annuli.



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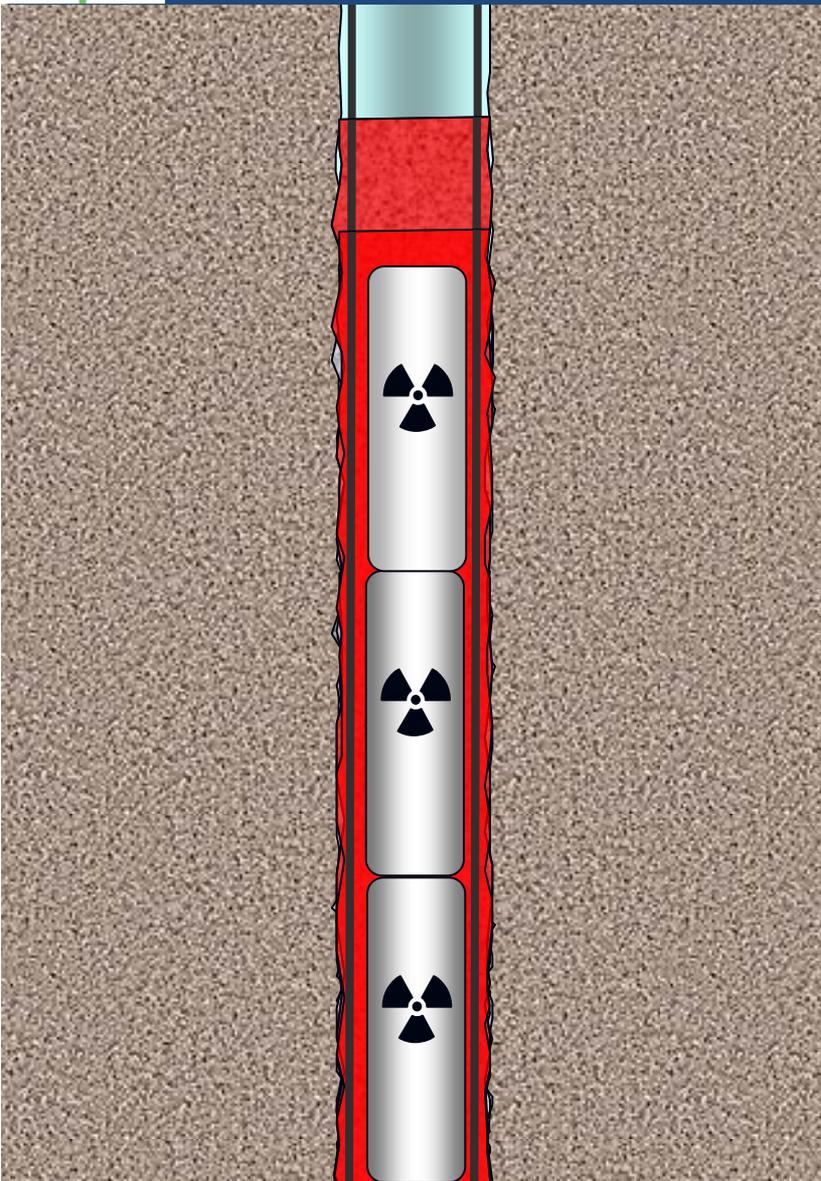


HDSM - Operation.

- Borehole cased with perforated casing.
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- Insert the rest of the containers at intervals each with 'quota' of HDSM then add extra HDSM ("head").



Sealing and Support Matrices

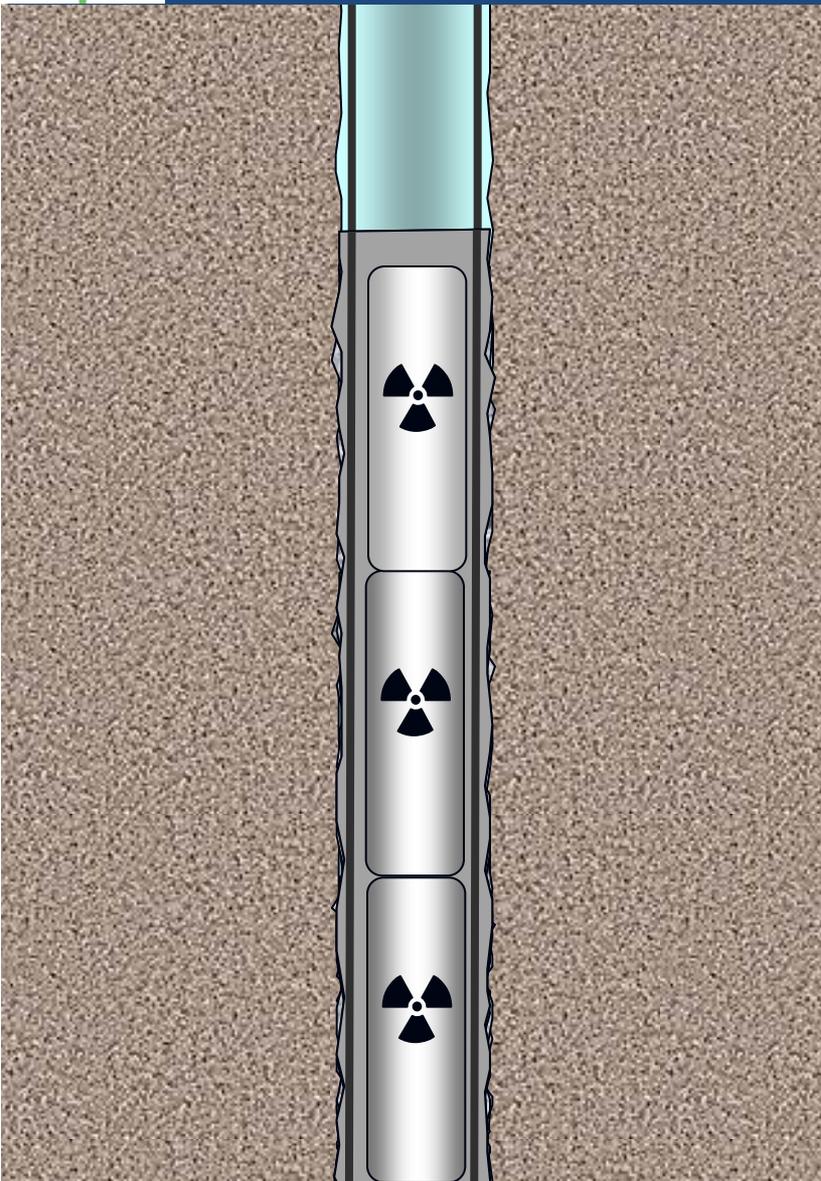


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- HDSM melts, settles into the annuli & eventually solidifies, "soldering" containers into the hole.



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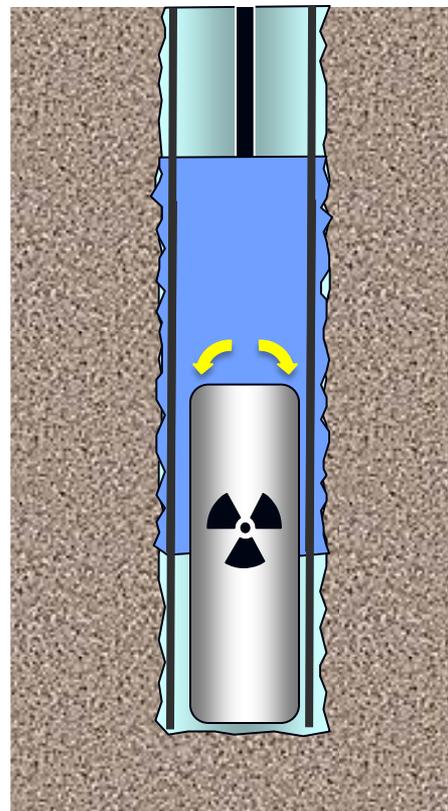


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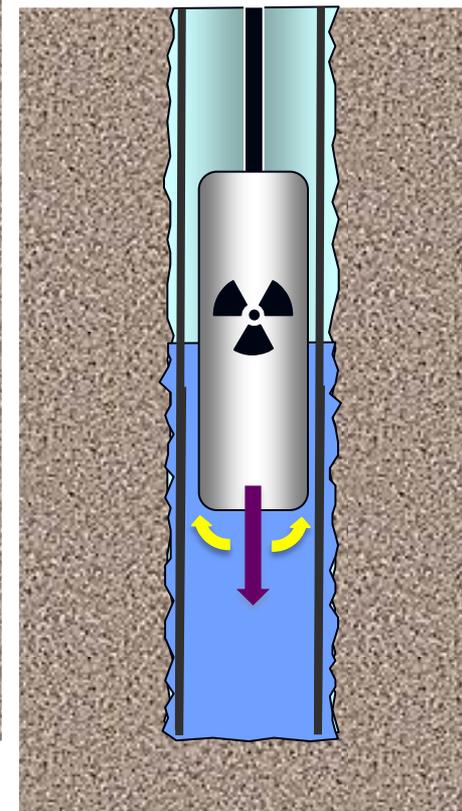


Cement Grout.

- Properties.
 - Physical.
 - Chemical.
- Deployment.
 - Critical times - delivery, flow, setting.
 - Option 1 - waste package first followed by grout.
 - Option 2 - grout first followed by waste package.
 - Delivery method.
 - Pumping.
 - Dump bailer.
 - Bespoke solution.



Option 1



Option 2



Sealing and Support Matrices



Influence of Borehole Environment on Cement Grout.

- Elevated temperature and pressure.
 - Accelerates grout thickening and setting.
 - Affects composition.
- Groundwater composition may influence wet paste properties.
 - Chloride compounds.
- Hardened paste will be durable at likely radiation levels.
 - *cf.* likely dose^{1,2} with literature^{3,4}.

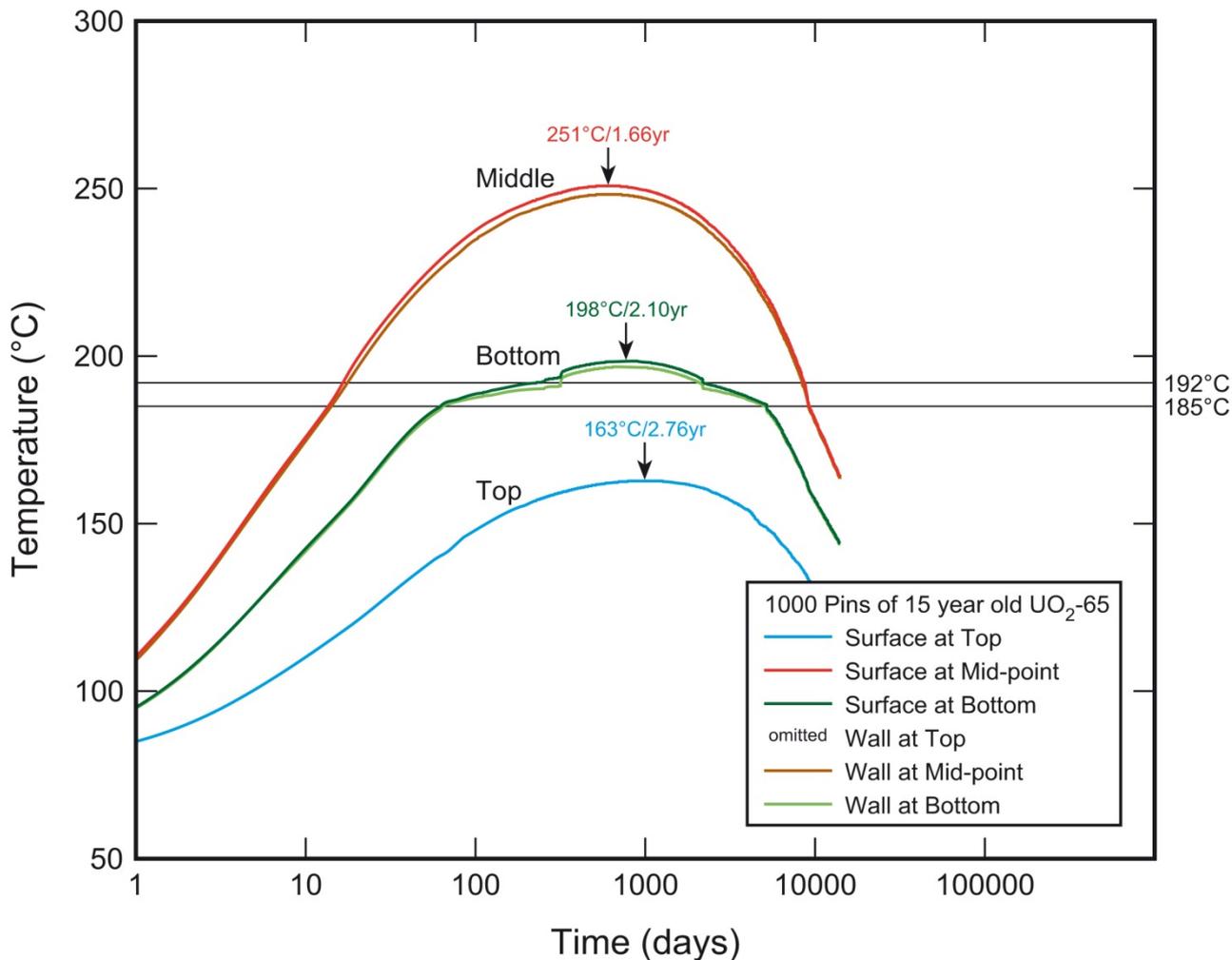
1. Correspondence Pettersson (SKB)/King (Nirex), 7th October 2005 (from UK Nirex Report N/124, 2005). 3. Palmer and Fairhall, Cem. Concr. Res. 22 (1992) 325
2. Vitrified Residue Specification, BNFL, March 1990. 4. Wilding, Cem. Concr. Res. 22 (1992) 299.



Sealing and Support Matrices



Selection of SSM - Heat flow modeling used to select SSM.



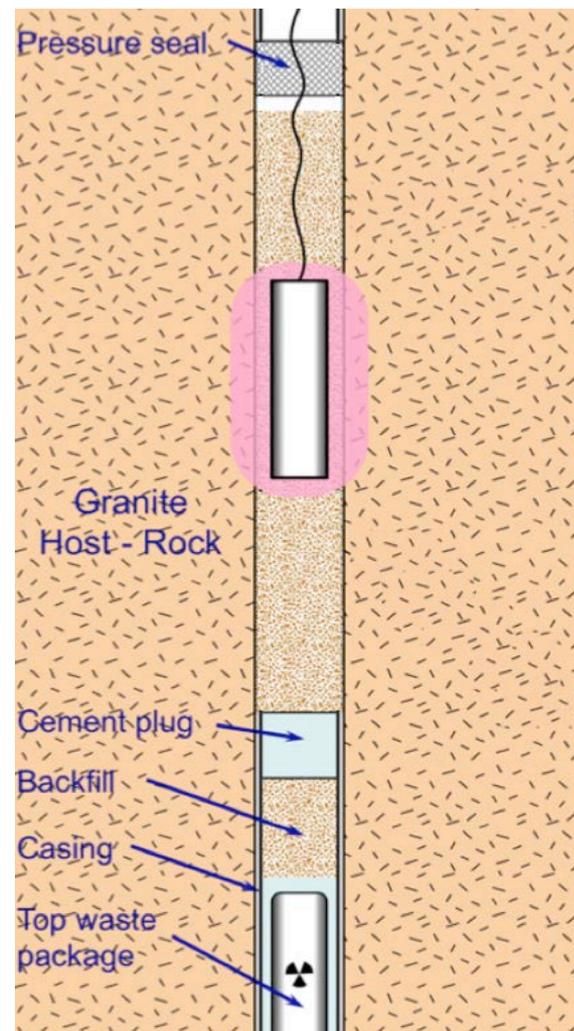
Gibb *et al.* Mineralogical Magazine, 76, 3003-3017 (2012).



Rockwelding



- Under development at The University of Sheffield.
- Purpose - isolation of disposal zone.
- Only method capable of eliminating disturbed rock zone.
- Uses sacrificial electrical heater to melt and fuse together crushed granite backfill and host rock.
- Multiple welds possible above disposal zone.
- R&D activities.



After Gibb & Travis (2014)