

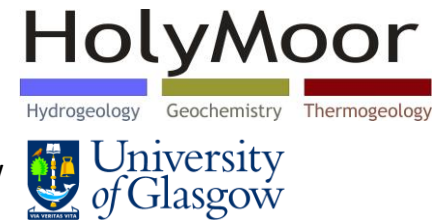


*"The age of coal is ending and the new age needs new skill  
With the fuel cell and atomics, there's another world to build.  
And those who built the old world, their kind will build the new,  
For a world's not built by power alone, but by the likes of me and you"*  
(Ewan MacColl, 1960)

Dave Banks

Director, Holymoore Consultancy Ltd.

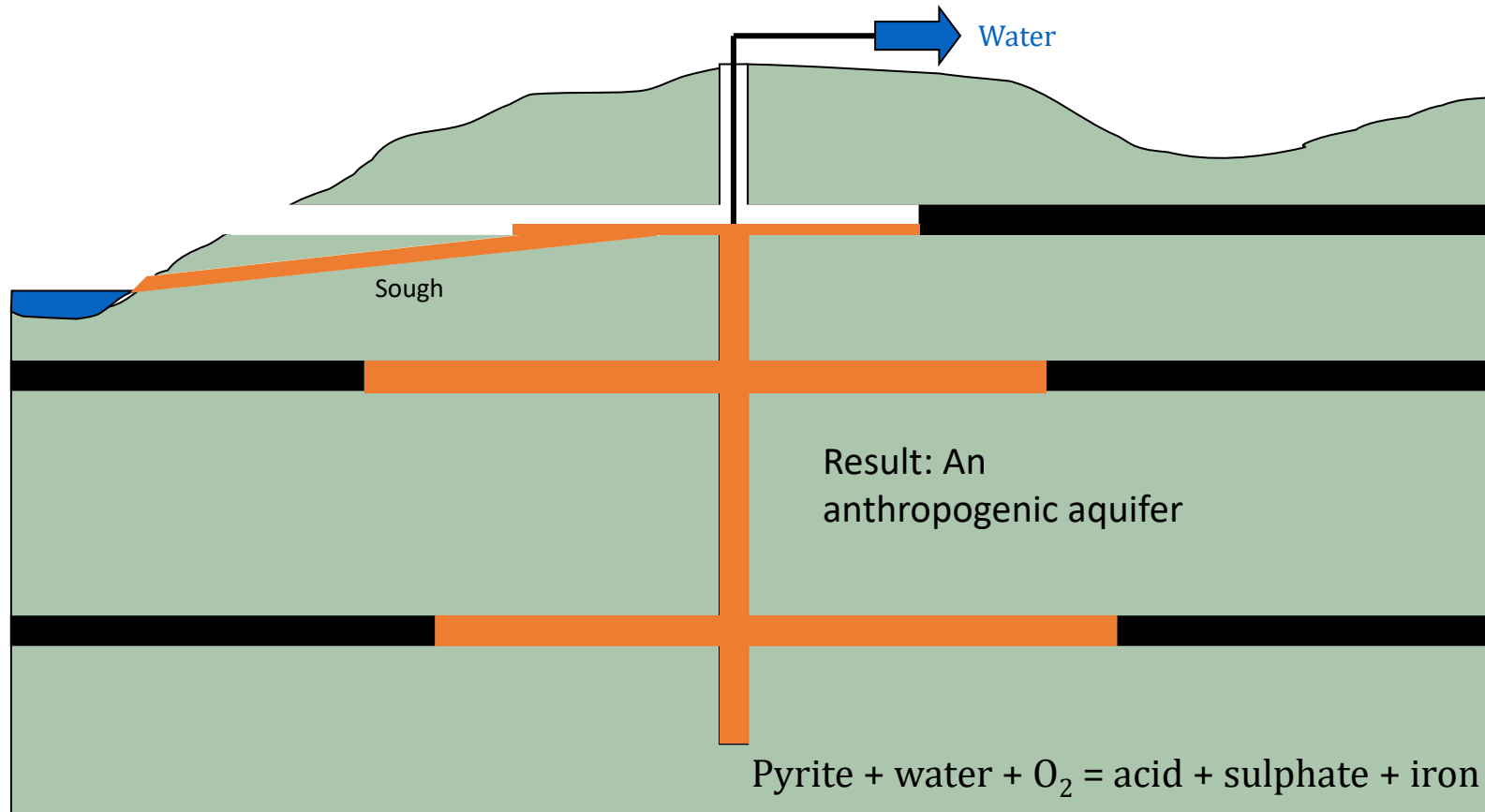
and Senior Research Fellow, University of Glasgow



Come all you gallant colliers...  
a mine energy renaissance?

3/12/20

# A brief history of coal mining in 10½ seconds

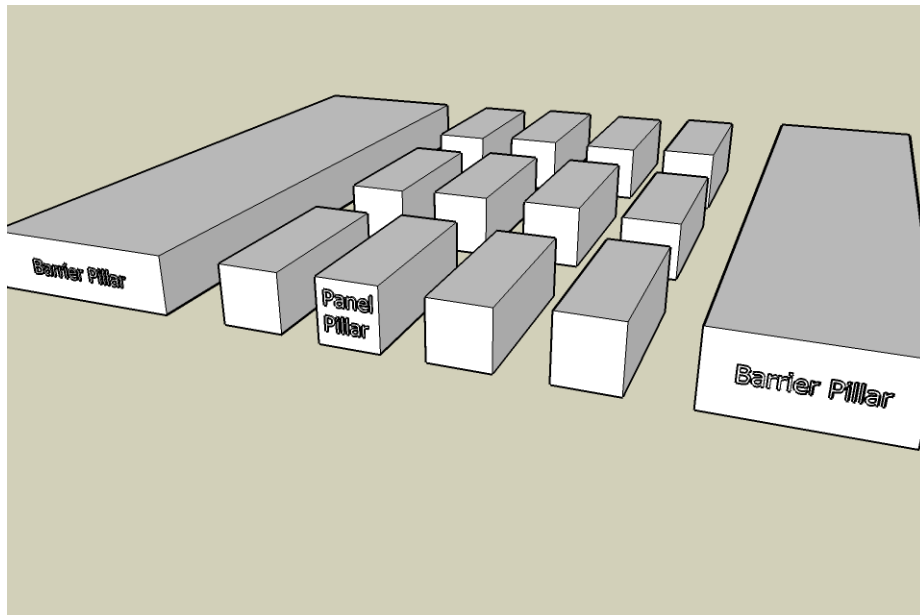


Near Dollar, Clackmannanshire



# Modes of mining

## Room and pillar



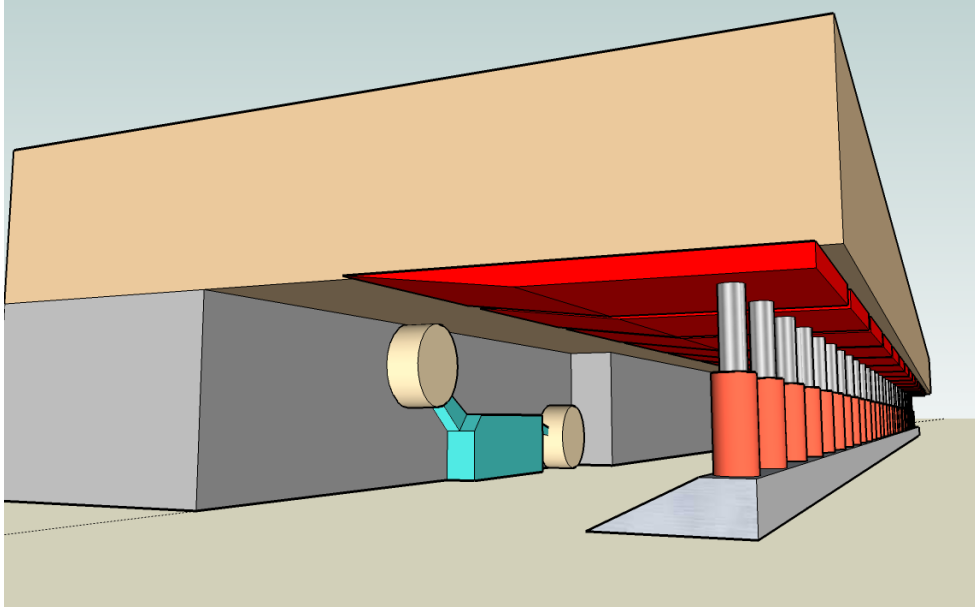
By Swinsto101, CC BY-SA 3.0, from  
[https://en.wikipedia.org/wiki/Room\\_and\\_pillar\\_mining#/media/File:Barrier\\_Panel.png](https://en.wikipedia.org/wiki/Room_and_pillar_mining#/media/File:Barrier_Panel.png)



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[https://en.wikipedia.org/wiki/Room\\_and\\_pillar\\_mining#/media/File:OldRoomAndPillar.png](https://en.wikipedia.org/wiki/Room_and_pillar_mining#/media/File:OldRoomAndPillar.png)

# Modes of mining

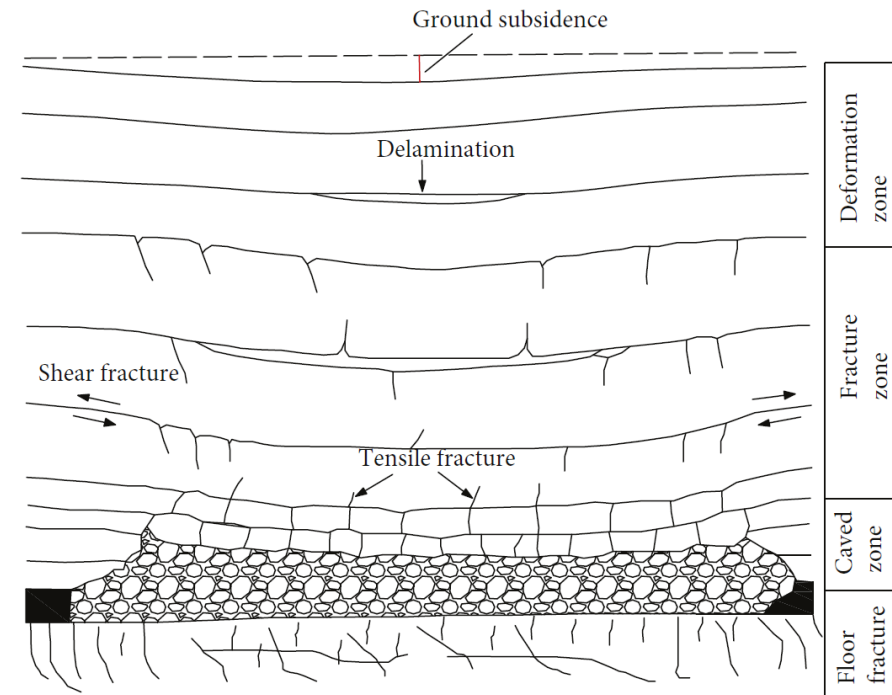
## Longwall



By TCP0203, CC BY 3.0, from [https://en.wikipedia.org/wiki/Longwall\\_mining#/media/File:Longwall2.png](https://en.wikipedia.org/wiki/Longwall_mining#/media/File:Longwall2.png)



By <http://www.eickhoff-bochum.de/de/> CC BY-SA 3.0, from [https://en.wikipedia.org/wiki/Longwall\\_mining#/media/File:SL500\\_01.jpg](https://en.wikipedia.org/wiki/Longwall_mining#/media/File:SL500_01.jpg)

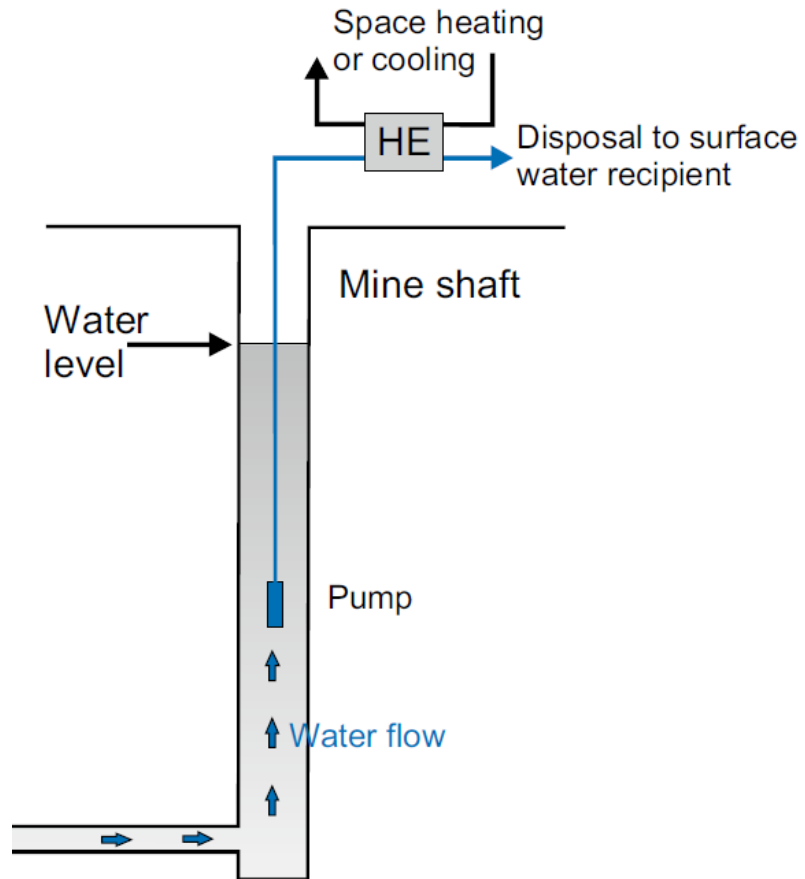


From Bai and Tu (2019) *Geofluids*. Doi: 10.1155/2019/3089292



# Mode 1 Pump and dispose

- Caphouse, Yorkshire





Barredo mine shaft  
Mieres, northern  
Spain

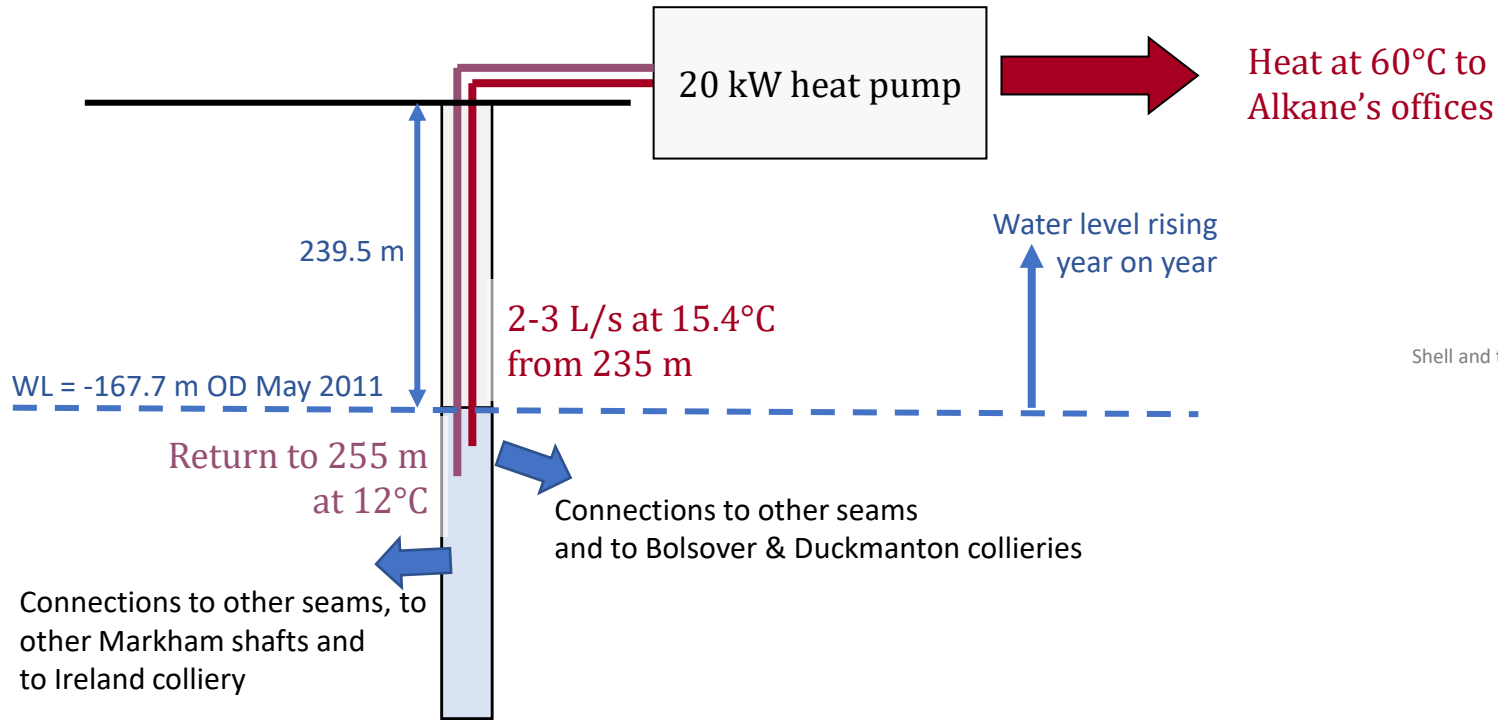
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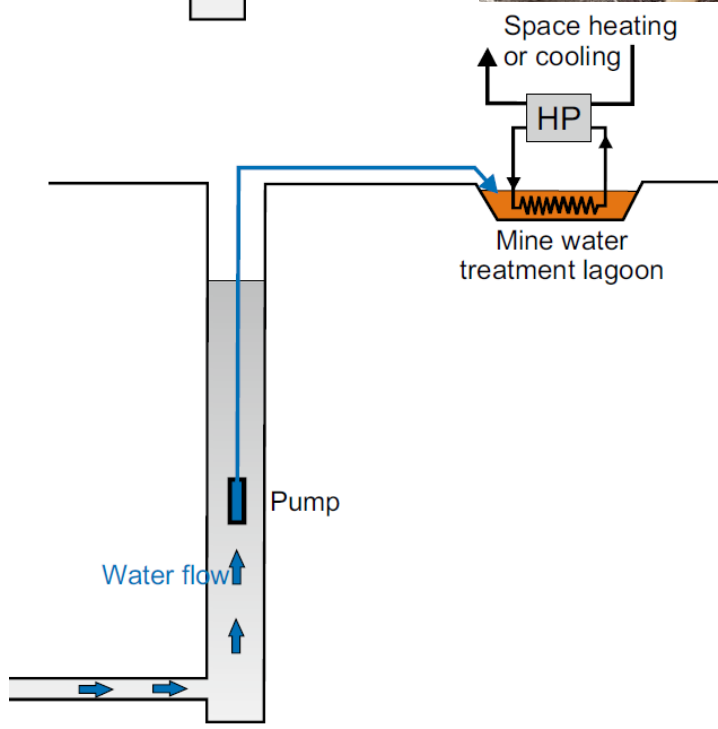
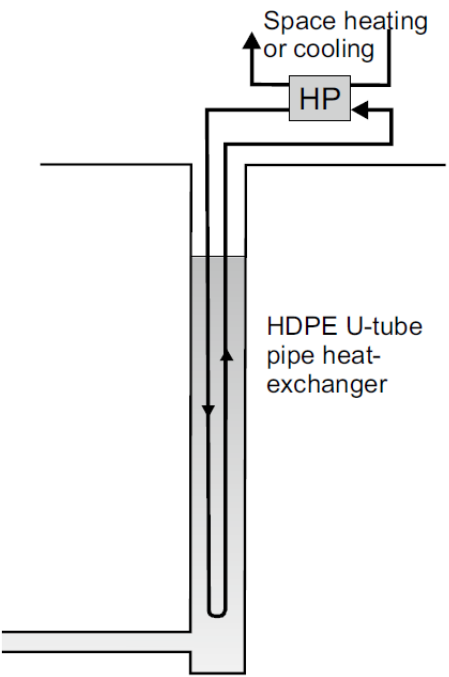
# Mode 2 Standing column

Alkane heat pump system,  
Markham Colliery, near Bolsover





# Mode 3 Closed loop





# Mode 4 Abstraction – reinjection doublet

Need long flow pathways in a doublet

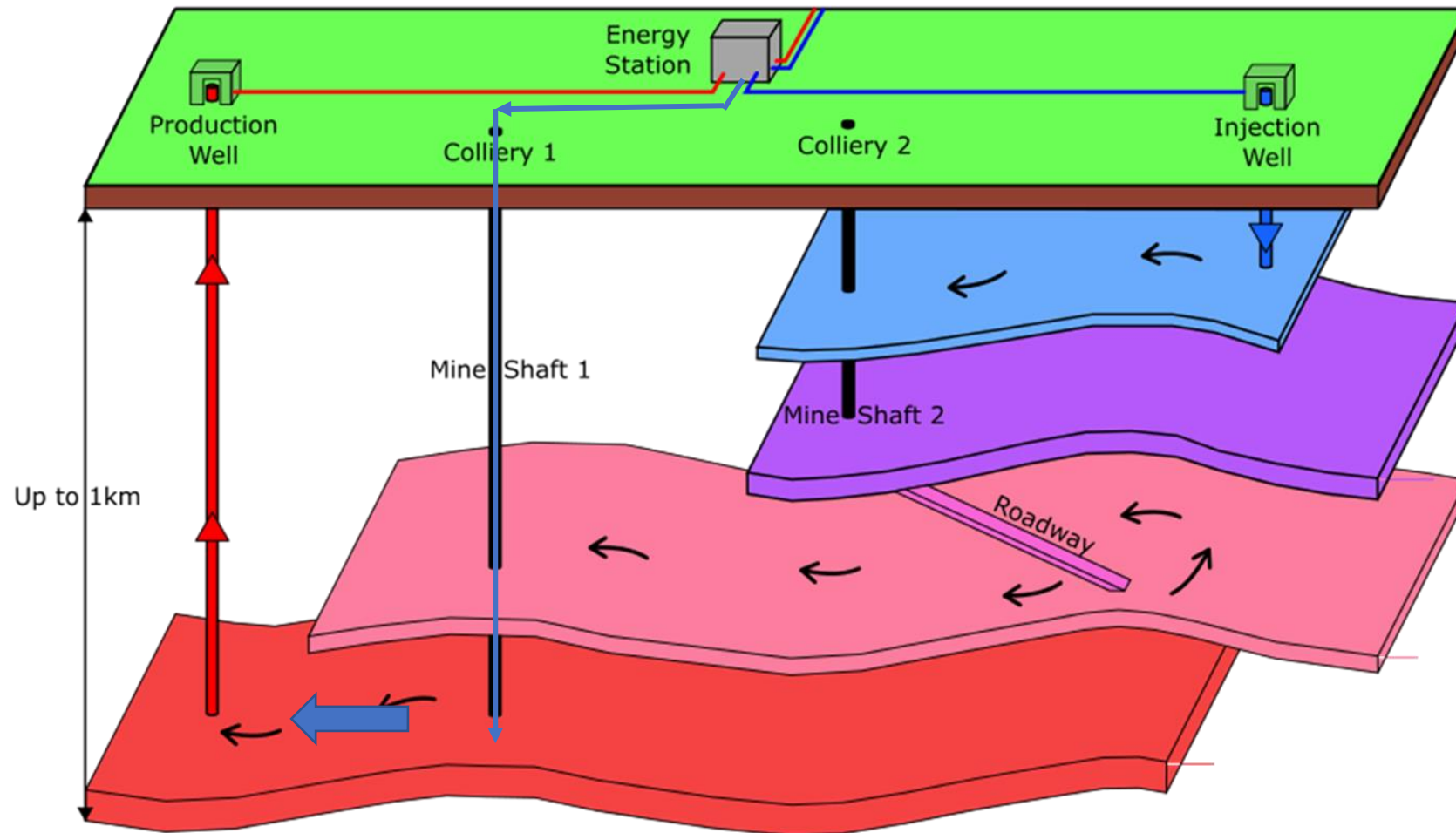


Figure reproduced by  
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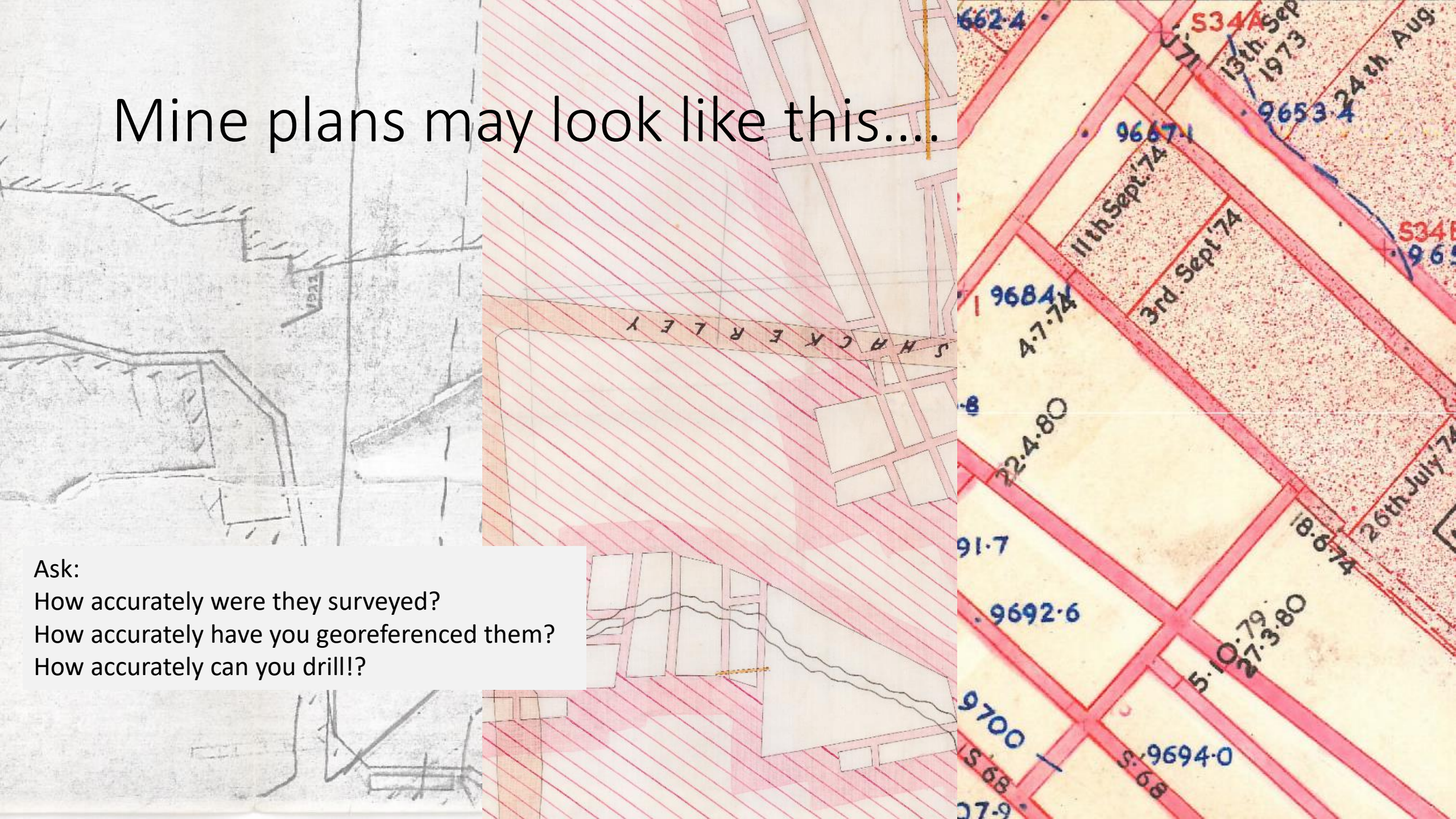


# Risks – uncertainties – what can go wrong

- Mine networks have *very* uncertain hydraulic properties
  - Backfilled shafts? Closed doors?  
Unmarked dams? Collapses?
- Mine plans: how reliable?
- Risk profile. High up-front uncertainty and capital cost (drilling mined strata properly is expensive). No guaranteed success
- Tricky regulatory process.
- Water chemistry? Possibly saline. Iron- & manganese rich
- Ongoing maintenance commitment.



Mine plans may look like this....



Ask:

How accurately were they surveyed?

How accurately have you georeferenced them?

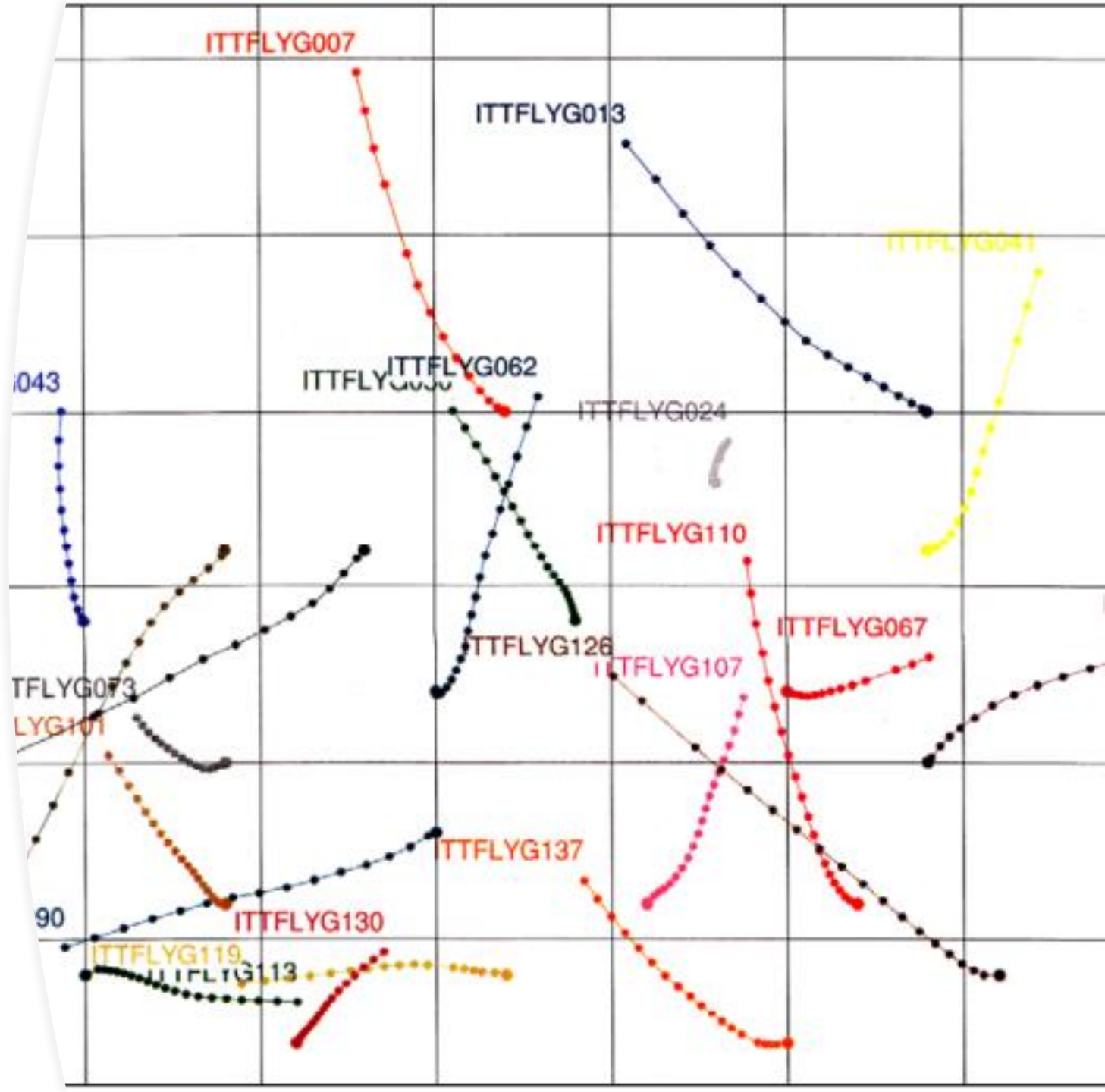
How accurately can you drill!?



## Deviation (m) of 21 randomly selected DTH boreholes (150 m depth) at Emmaboda, Sweden.

- Average deviation 16 m

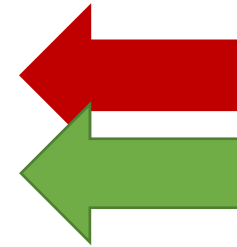
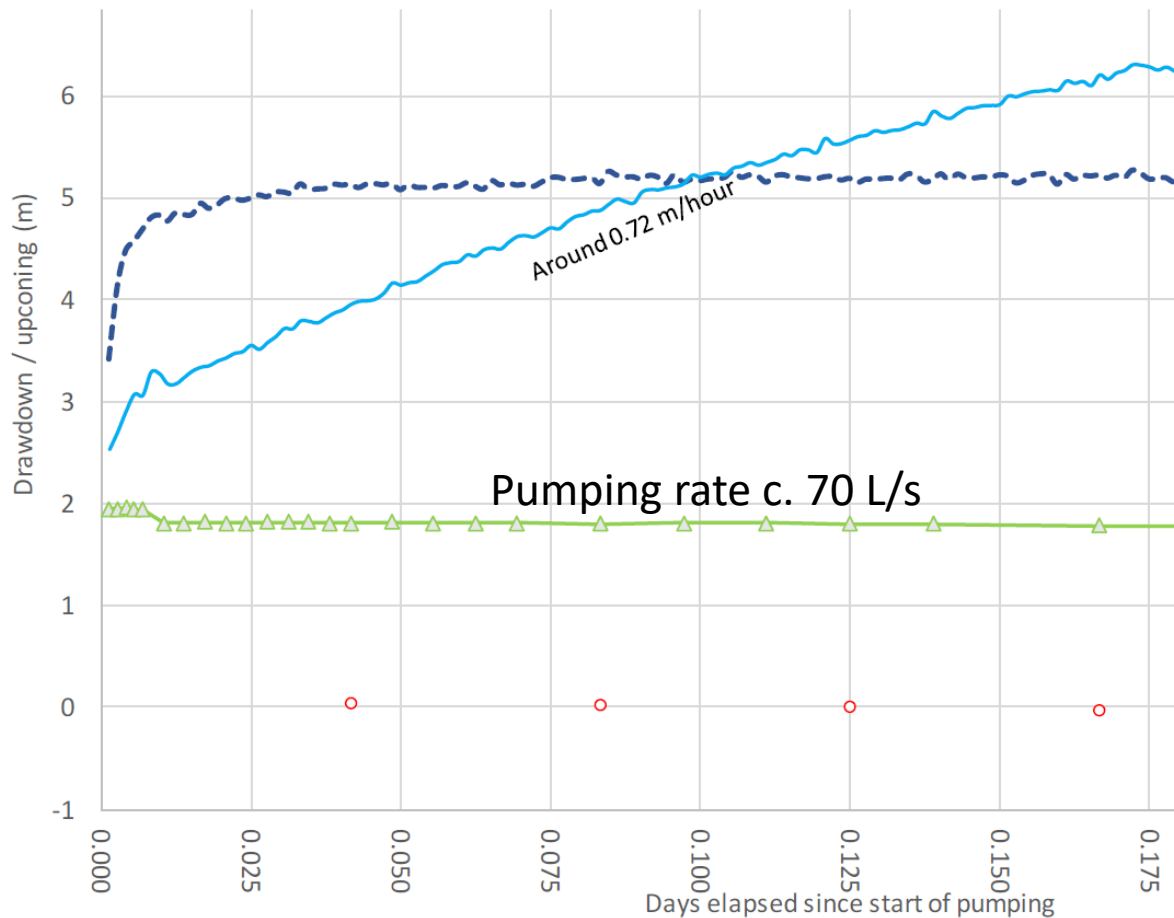
Nordell B, Scorpo AL, Andersson O, Rydell L & Carlsson B (2015) Long-term Long Term Evaluation of Operation and Design of the Emmaboda BTES. Operation and Experiences 2010-2015. Luleå University of Technology





# Unpredictable hydraulic properties

Two different seams at same site



Deep seam behaves like a filling bath

Shallow seam, response flattens very quickly (recharge from overlying estuary??)

Neither seam behaves in a nice polite  
This-like manner!

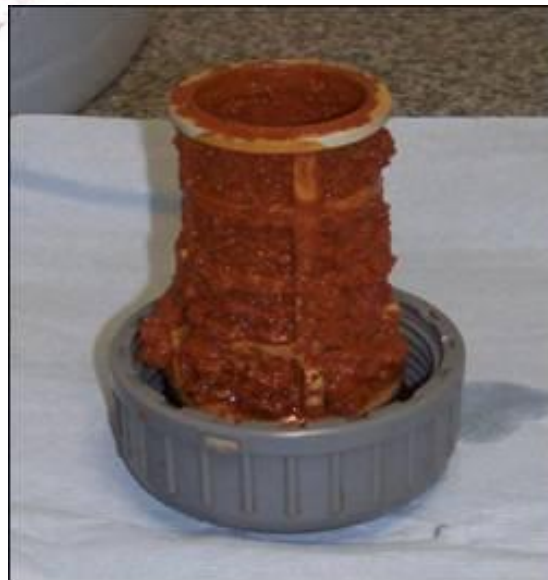


# Long term maintenance; clogging

- Access to oxygen allows dissolved ferrous iron to oxidise to ferric hydroxide (aka ochre, aka orange sludge)



Lumphinnans (clogged reinjection well)  
See Banks et al (2009)  
Doi: [10.1144/1470-9236/08-081](https://doi.org/10.1144/1470-9236/08-081)



(c)

Markham, after 2.5 years. Little problem  
See Banks et al. (2019) doi: [10.1007/s40899-017-0094-7](https://doi.org/10.1007/s40899-017-0094-7)



(d)

Dawdon (when treated, aerated water was used)  
When raw, unoxygenated mine water used, no problem with iron hydroxide clogging!  
Figure from Watson I (2012) Dawdon mine water heat pump trial. 14-Dec-12  
See Bailey et al (2013) doi: [10.36487/ACG\\_rep/1352\\_47\\_Bailey](https://doi.org/10.36487/ACG_rep/1352_47_Bailey)



## Regular maintenance

- Shell and tube HEX *may* be less prone to clogging than plate HEX
- At this site, citric acid was used for flushing a plate HEX with resulting improvement.
- Oxalic acid probably a better choice for downhole, as citric acid can be a food for biofilm bacteria.





# Demand, timing, regulation, subsidy

- Getting the demand lined up is often the trickiest aspect.
- Mines aren't always at centres of heating and cooling demand (but they can be)
- Timing is everything. Get your ducks in a row!
- Regulators are unsure about permitting mine systems. It can take a lot of time.
- You need abstraction discharge permits from Environment Agency, and heat access agreement from Coal Authority



# Questions.....

and thank you  
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