ALAN MACDONALD + MANY OTHERS

Hydrogeology of Basement

British Geological Survey

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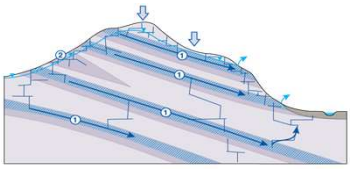
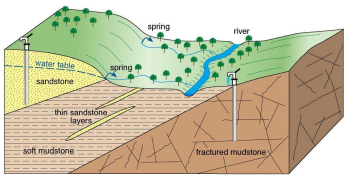
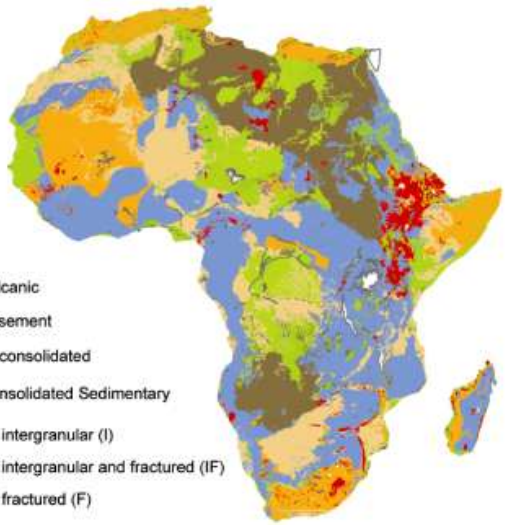
African Hydrogeology

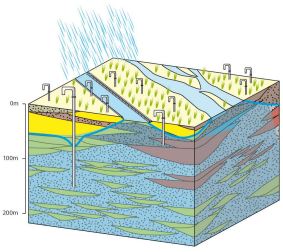


Volcanic rocks 4%

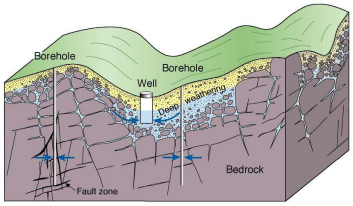


Sedimentary rocks 37%





Unconsolidated 25%



Basement rocks 34%

Sources © UKRI https://doi.org/10.1016/j.desal.2008.05.100
https://doi.org/10.1088/1748-9326/7/2/024009

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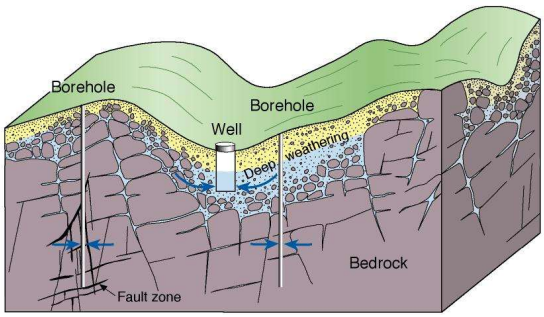
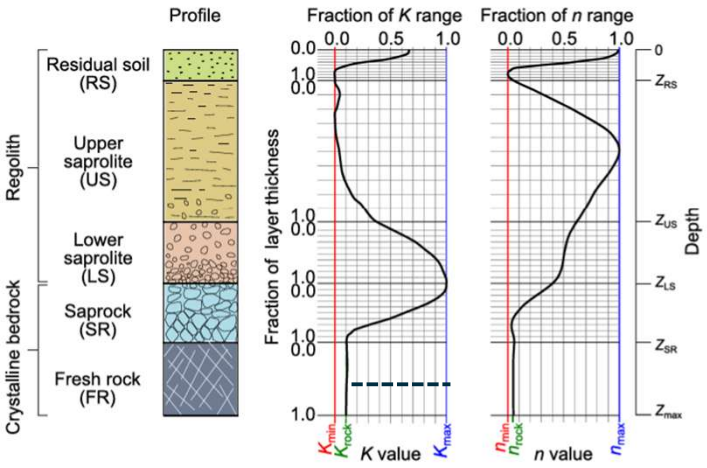
Generalised Weathered basement aquifer





Chilton and Foster 1992; Chilton and Smith Carington1984; Acworth 1987; Jones 1985; Hazell et al.1992; Wright 1992; Taylor and Howard 2000 Dewandel et al.2006; Lachassagne et al.2021

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Generalised Weathered basement aquifer

shutterstock.com · 2018060630

Photos Alan MacDonald BGS © UKRI 2025

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But now – for SDG6 and climate resilient agriculture we need more than just handpumps…

1. Can basement aquifers support this?

2. How can we better predict likely borehole yields?

3. Can we systematically hydrogeologically map basement aquifers better?

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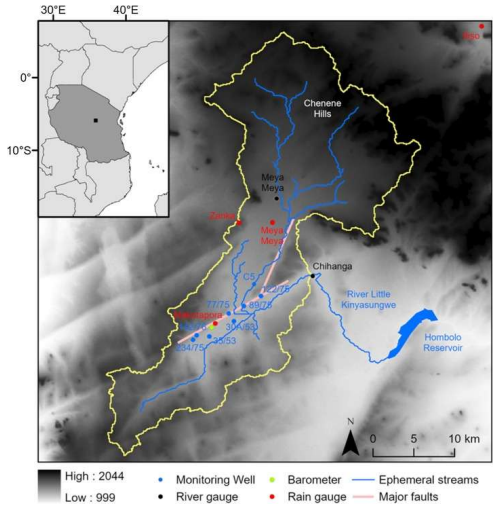
What yields are possible in Africa basement rocks ?



Makutapora >50,000 m^3 /day ?
Kashaigili, Kongola, Taylor, + many others

Singida <5 m^3 /day ?

6

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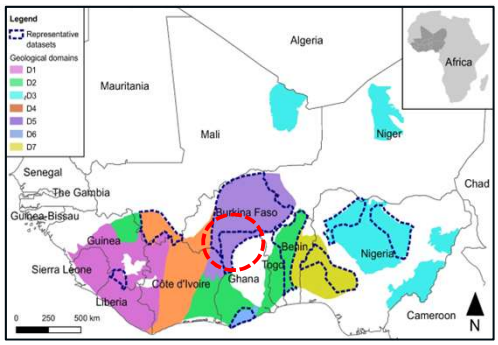
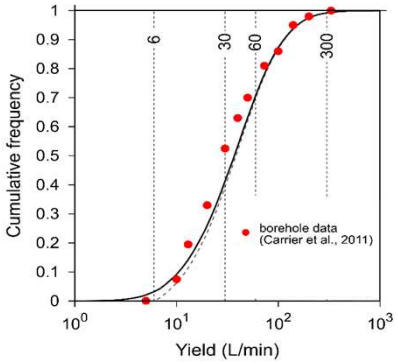
Experiment 1– simulating and extrapolating basement yield data





Good data set of borehole yields

Comprehensive data on boreholes and weathering etc,

97%> 0.1 L/s

30% > 1 L/s

1% > 5 L/s

Bianchi et al. 2020. Water Resources Research https://doi.org/10.1029/2020WR027746
Carrier et al 2011 http://espace.inrs.ca/1647/1/R001326.pdf

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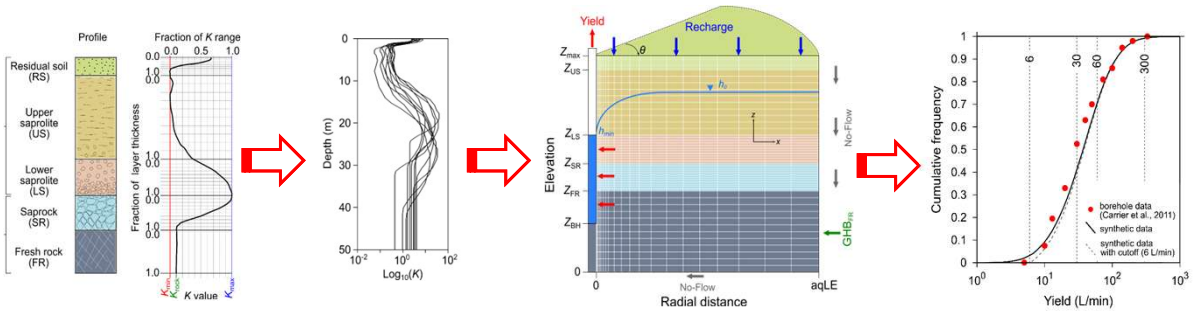

Build a model (Modflow) stochastically parameterised with 13 factors, and calibrated.

Key factors:

- K max in saprock
- Regolith thickness
- Water table depth
- Aquifer extent
- Recharge

Bianchi et al. 2020. Water Resources Research https://doi.org/10.1029/2020WR027746

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So basement can support higher yields in places and we know the significant predictors …

….can we map differences?

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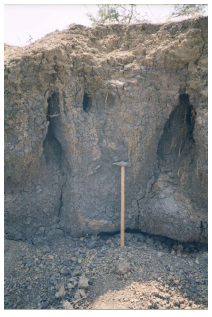

Sources © UKRI From MacDonald et al. 2005

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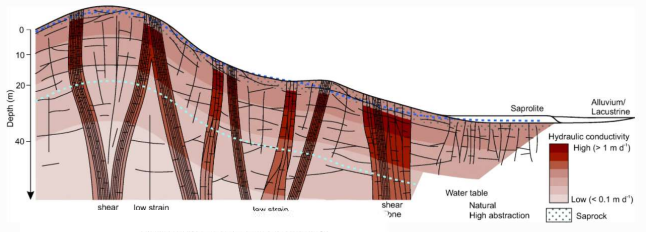
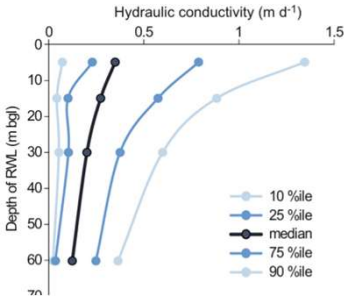
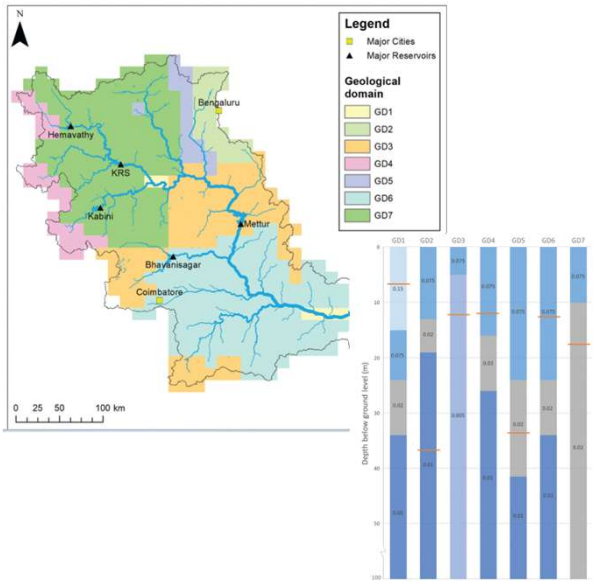
Lessons from India

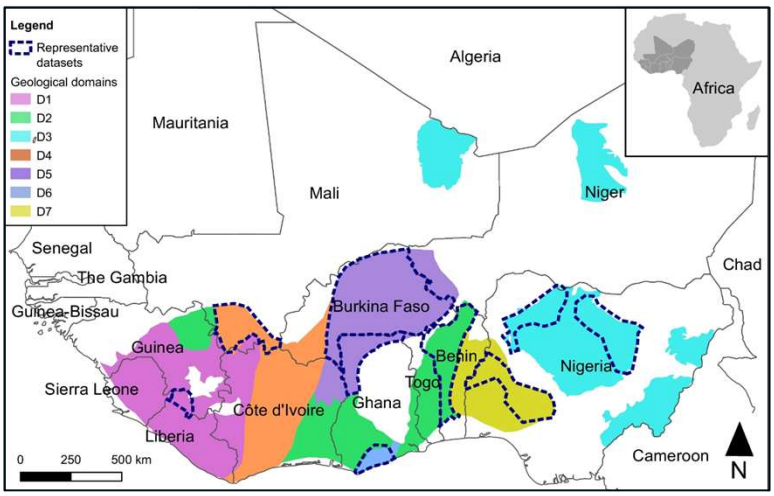


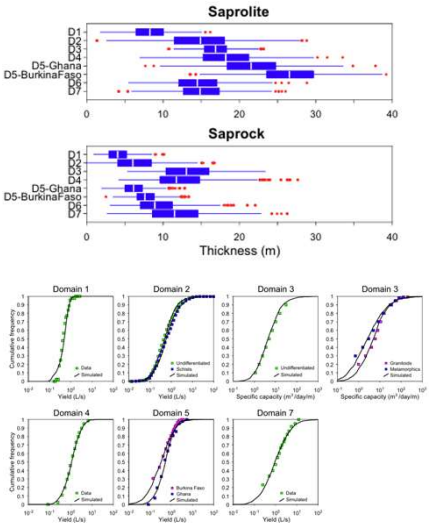




Collins et al 2020 https://doi.org/10.1007/s10040-020-02140-y
Baron et al, 2023 https://nora.nerc.ac.uk/id/eprint/534516/

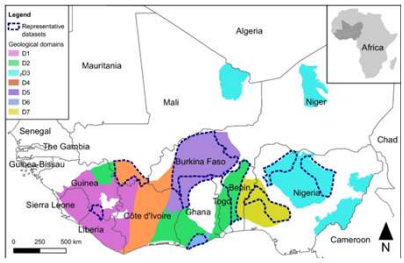
Experiment 2– can we find differences between areas?



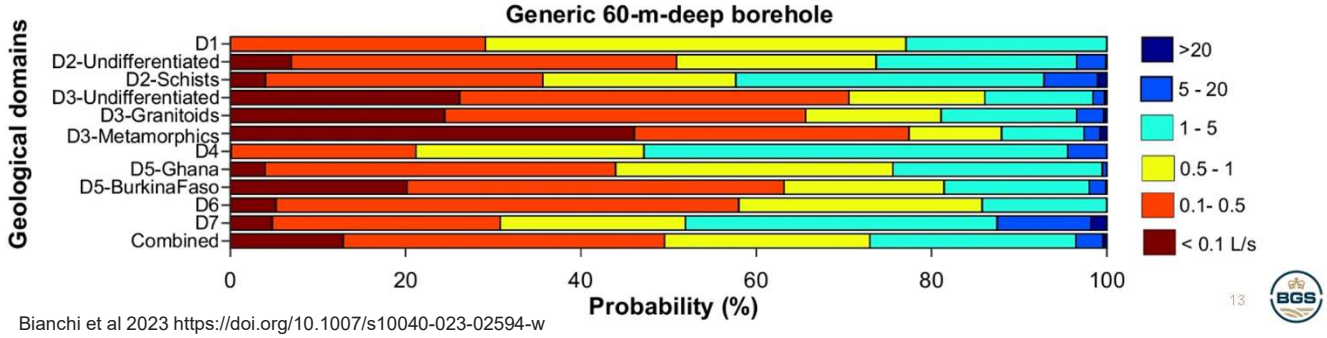


Bianchi et al. 2023, Hydrogeology Journal https://doi.org/10.1007/s10040-023-02594-w .

Experiment 2– can we find differences between areas?



- Significant regional differences
- Over all 25% can sustain > 1 L/s
- Several have >5% of > 5 L/s



Bianchi et al 2023 https://doi.org/10.1007/s10040-023-02594-w

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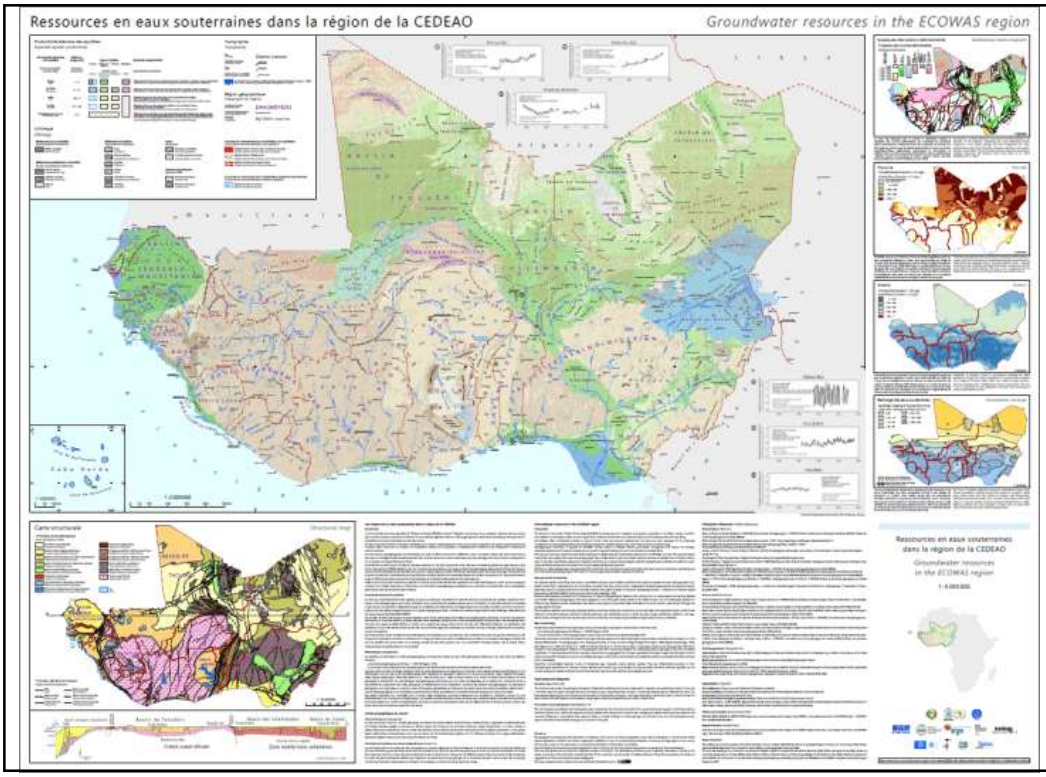

Used to help develop the new ECOWAS hydrogeology map for West Africa

BGR, BGS, BRGM, EAWAG, UNESCO. 2022 *Ressources en eaux souterraines dans la région de la CEDEAO : Groundwater resources in the ECOWAS region.* 1:5000000. Federal Institute for Geosciences and Natural Resources (BGR). https://nora.nerc.ac.uk/id/eprint/532446/

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Experiment 3 – generating typologies for Africa

Collaboration with geologists

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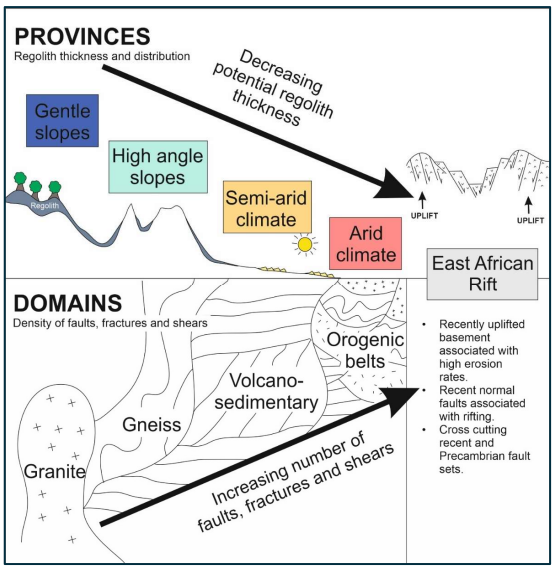
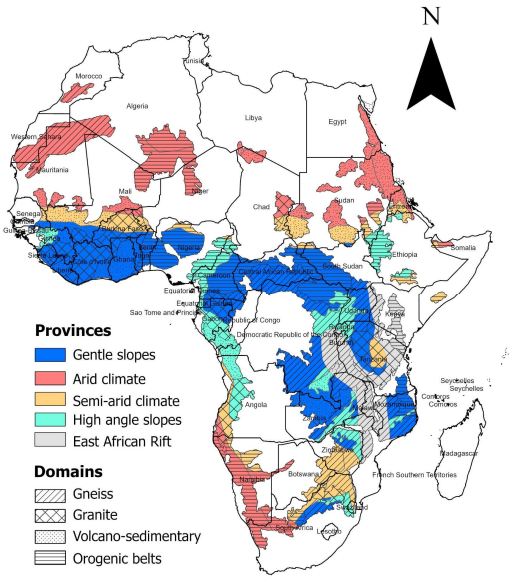
Experiment 3 – generating typologies for Africa





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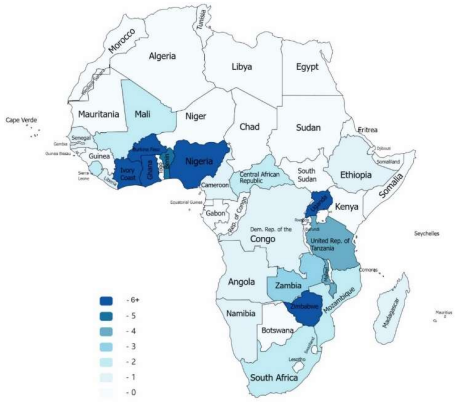
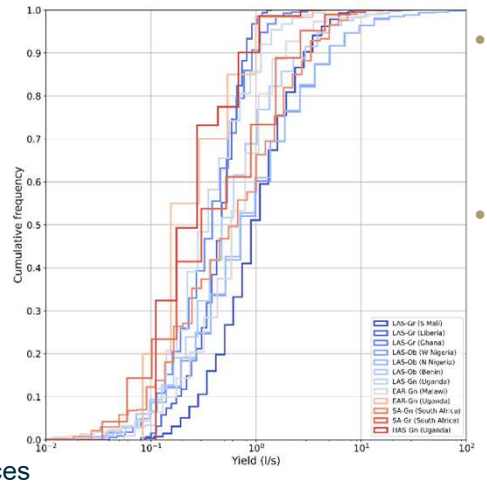
Experiment 3 – generating typologies for Africa





- Provinces forecast to to have thicker regolith have high yields in lower half of distribution
- Domains forecast to have more fractures greater probability in upper half of distribution

Developed case studies for 4 provinces and 5 domains

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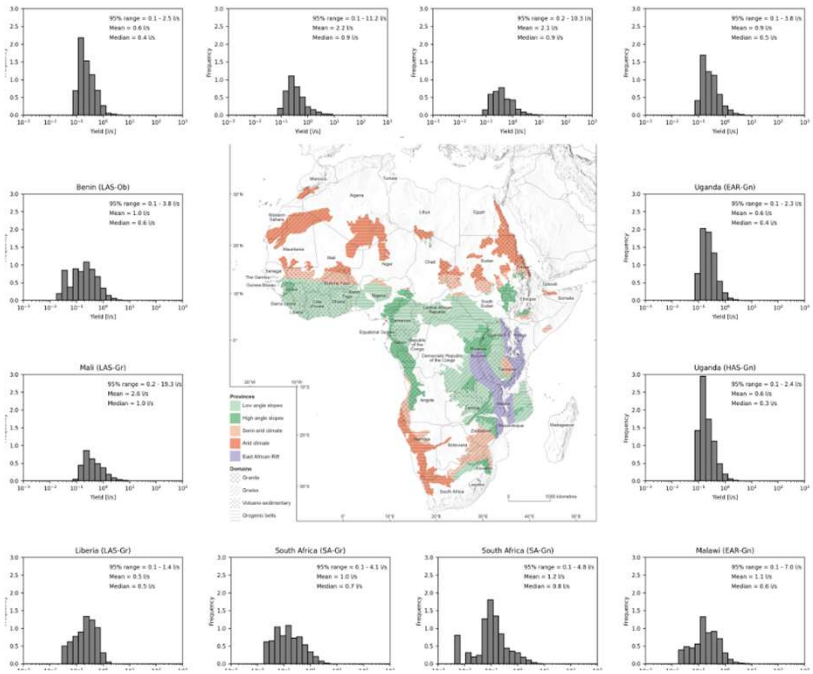

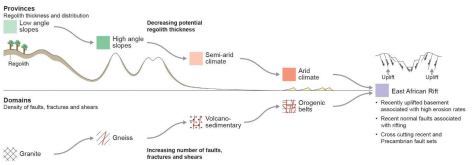

Preview of the final map

Thanks to: David Macdonald,, Richard Owen, Seifu Kebede, Michael Owor, Marco Bianchi, Setareh Nagheli, Alex Mulcahy, Alan MacDonald

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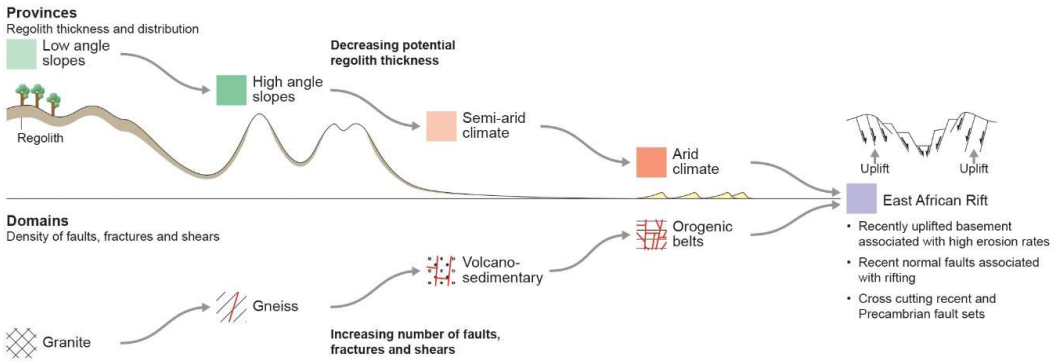
Use similar approach to continental mapping



+ depth to Water table
Topographic position
Fracture mapping
Aquifer extent
Recharge

MacDonald et al in preparation BGS © UKRI

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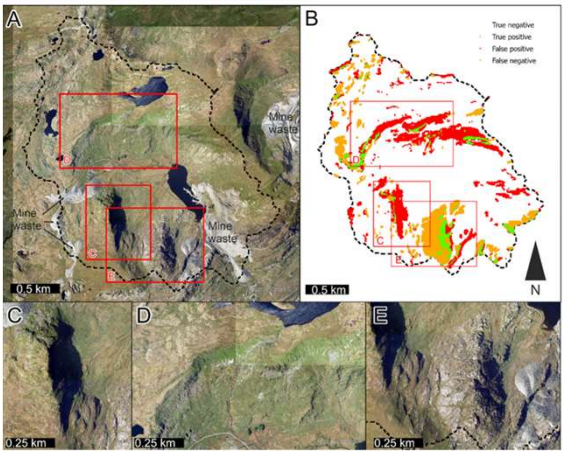
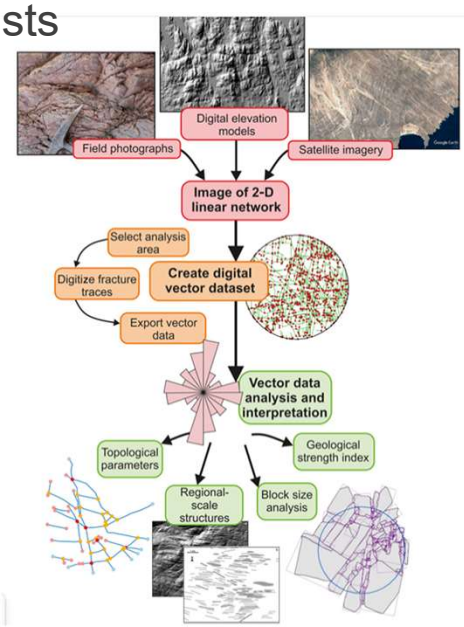
Remote sensing and AI can help geologists



Exposed bedrock

Williams C et al, 2025



Fracture mapping

Palamakumbura, R et al, 2020

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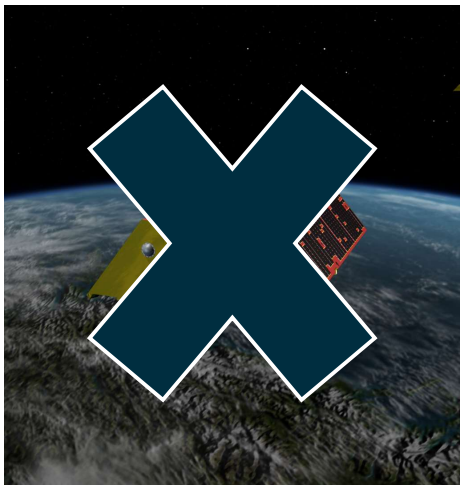
What is the most important thing for hydro mapping ?



Assess borehole transmissivity & record failed boreholes

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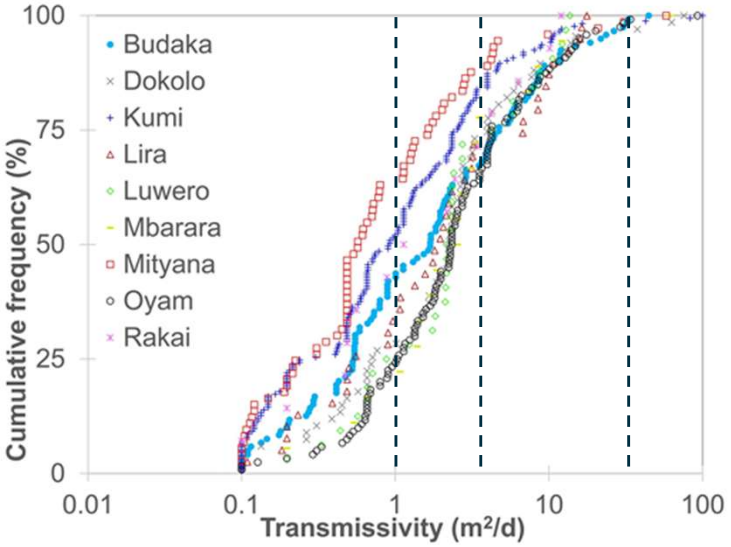
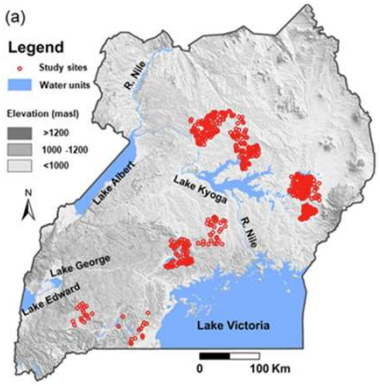
An example from Uganda



Mapping transmissivity by analysing tests from commissioning



Owor et al. 2022 https://doi.org/10.1007/s10040-022-02534-0

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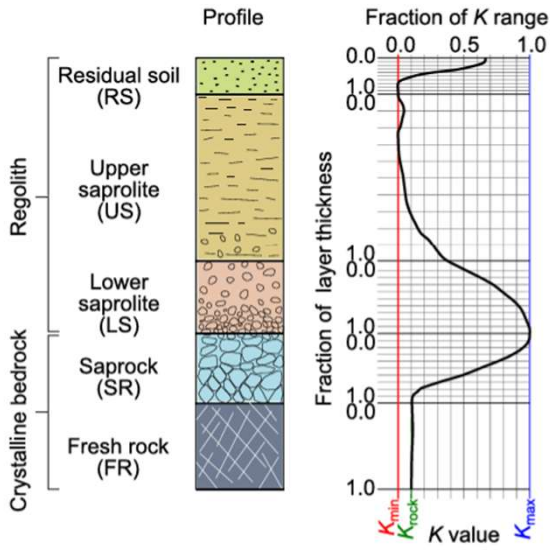
Summary



- We know broadly how to develop basement for handpumps
- Needs to be weathered and fractured to be an aquifer
- New challenges mean we need to site boreholes with yields > 0.5 L/s
- The hydrogeology of basement can be mapped in more detail using typologies
- Approximately 30% of boreholes with handpumps could proiduce > 0.5 L/s
- For some typologies > 5 L/s possible for 10%
- Analysis of routine pumping test data fundamental for future maps

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