# Using geological domains to characterise regional to continental scale aquifers across eastern Africa

**Donald John MacAllister[1], Romesh Palamakumbura[1], Alan MacDonald[1], David Macdonald[2], Maarten Krabbendam[1], Teddy Reeves[1], Ben Murphy[1], Abede Ketema[3], Zenaw Tessema[4], Chrysanthus Gicheruh[5], Daniela Benedicto van Dalen[6], and Theo Kleinendorst[6]**

[1] British Geological Survey, The Lyell Centre, Edinburgh; [2] British Geological Survey, Wallingford; [3] Acacia Water, Ethiopia; [4] Aquacon Engineering, Ethiopia; [5] Earth Water, Kenya; [6] Acacia Water, Netherlands

We have developed a geological domains-approach to characterise the spatial variability of key aspects of the geology that directly impact the hydrogeology of aquifers from local site to a continental scale. This approach utilises a range of datasets, including geological maps, terrain maps, satellite imagery, research papers and thematic datasets such as fault maps or climatic zones to develop a set of spatial geological domains. The specific variables and subsurface depth represented by the domains will depend on the objective of the specific mapping exercise and/or the type of hydrogeological modelling being undertaken. The quality of geological and geomorphological spatial data can be highly variable on a regional to continental-scale and this can be qualitatively represented with a description of the uncertainty of each individual domain.

## Local scale

### Southwest Ethiopia

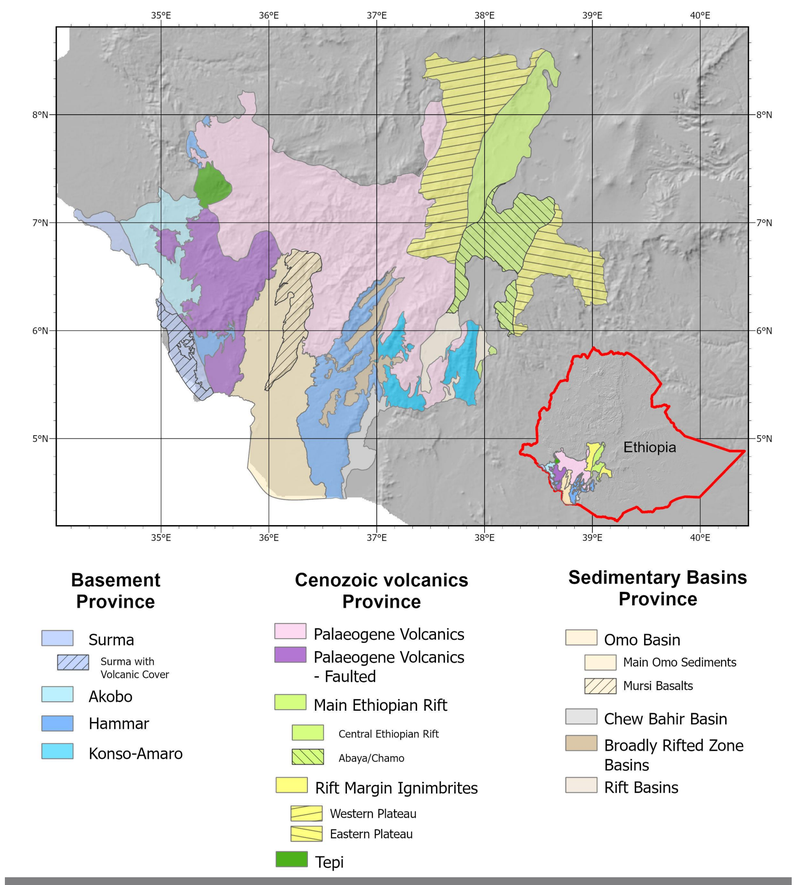


**Figure 1**: Province, domains and subdomains of southwest Ethiopia reflecting key spatial differences in the bedrock lithology, faults and fractures and superficial cover.

A **hierarchical approach** is taken to develop geological provinces and domains, to represent key aspects of the shallow aquifer including bedrock geology, faults, landscape and regolith across a site.

For example, in southwest Ethiopia (Fig. 1-2) the approach defines three provinces, including crystalline basement, sedimentary basins and Cenozoic volcanics. Each province contains 4-5 domains reflecting local changes in bedrock lithology, fault density and landscape. Finally, several of the domains contains sub-domains to provide a higher resolution of spatial geological characterisation.

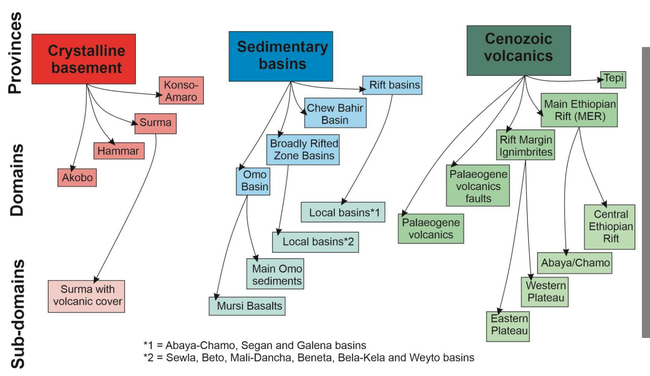


**Figure 2**: Overview of the southwest Ethiopia provinces, domains and subdomains model.

## Regional scale

### Eastern Africa

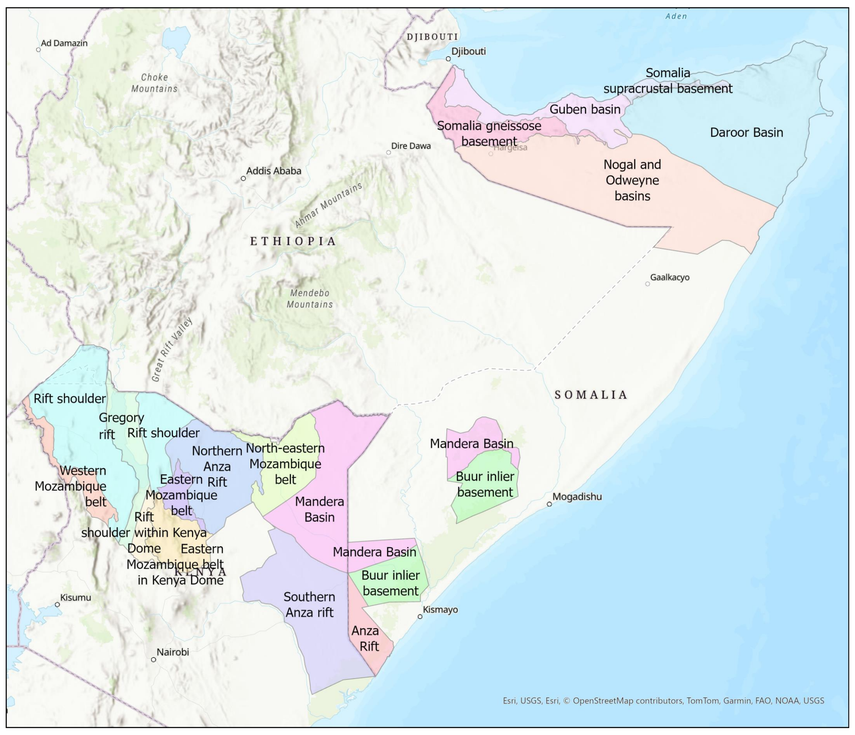


**Figure 3**: Provinces, domains and subdomains from eastern Africa reflecting key spatial differences in the bedrock lithology, faults and fractures, superficial cover and regolith.

The same hierarchical approach can be upscaled from a regional to a continental scale (Fig. 3). The approach be can used to provide **quantitative and qualitative data** of shallow to deep geological parameters that impact the groundwater aquifer

For example, seismic analysis and borehole data was used to understand deep sedimentary facies and lineament analysis was undertaken in crystalline basement in central Kenya (Fig. 4) to understand density and orientation of major structures across the domain.

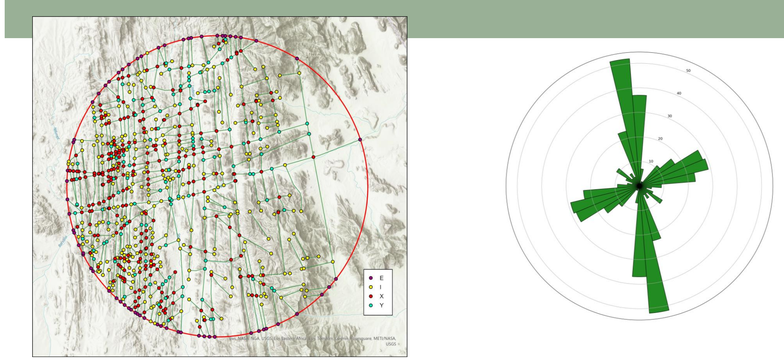


**Figure 4**: Lineament analysis of crystalline basement with topological analysis and a rose plot of lineament orientation.

However, the approach is highly dependent on the availability of high-quality geological data for the area of interest. Where data is not available the domain approach can be used reflect qualitative uncertainty.

## Continental scale

### African Crystalline basement

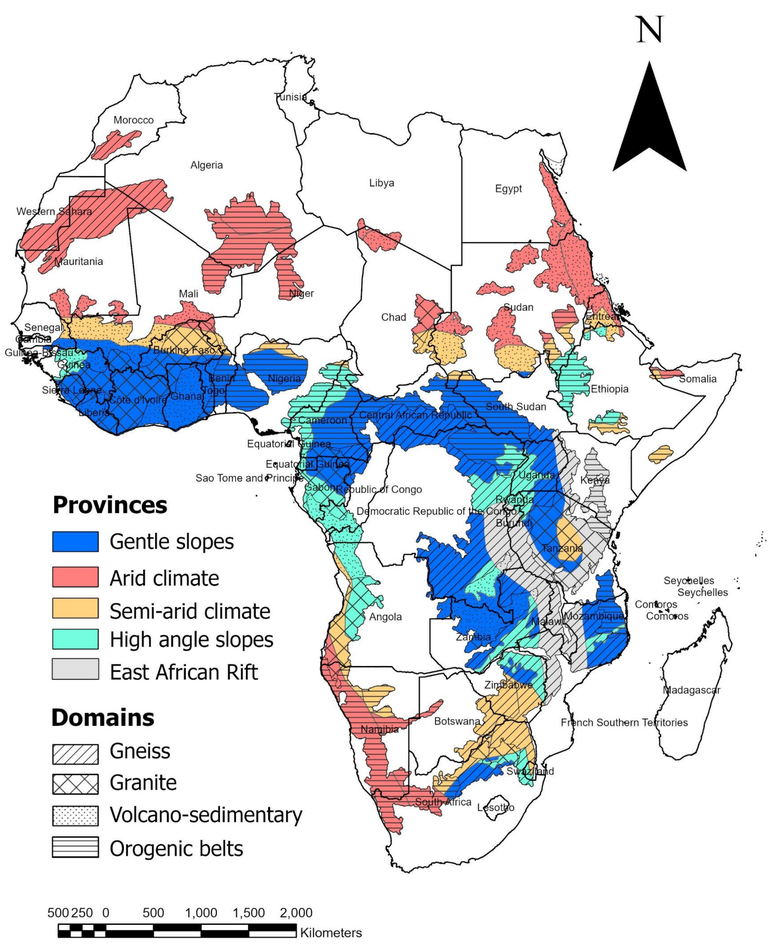


**Figure 5:** African crystalline basement provinces and domains reflecting key spatial differences in the bedrock lithology, faults and fractures and regolith thickness and distribution.

At **continental-scale a model driven approach** can be used (Fig. 5), for example in in African crystalline basement province and domains. The provinces reflect continental scale controls of subaerial erosion and weathering rates, and relatively recent tectonic processes.

The domains reflect changes of dominant basement lithology or key tectonic processes within each province that are likely to have significant impacts on the fault and fracture density (Fig. 6).

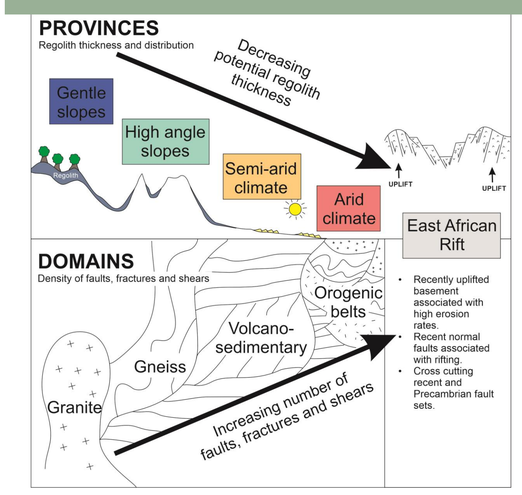


**Figure 6**: Continental scale model reflecting the impact of key geological parameters on the shallow aquifer.

Donald John MacAllister donmac@bgs.ac.uk

www.bgs.ac.uk