British Geological Survey
NATURAL ENVIRONMENT RESEARCH COUNCIL

Aquifères de socle altérés et fracturés d'Afrique : d'un concept unique à divers modèles d'aquifères
African Weathered and Fractured Basement Aquifers: From Single Concept to Diverse Aquifer Models

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International Conference Hard-Rock Aquifers:
Up-to-date Concepts and Practical Applications - La Roche sur Yon 2015.

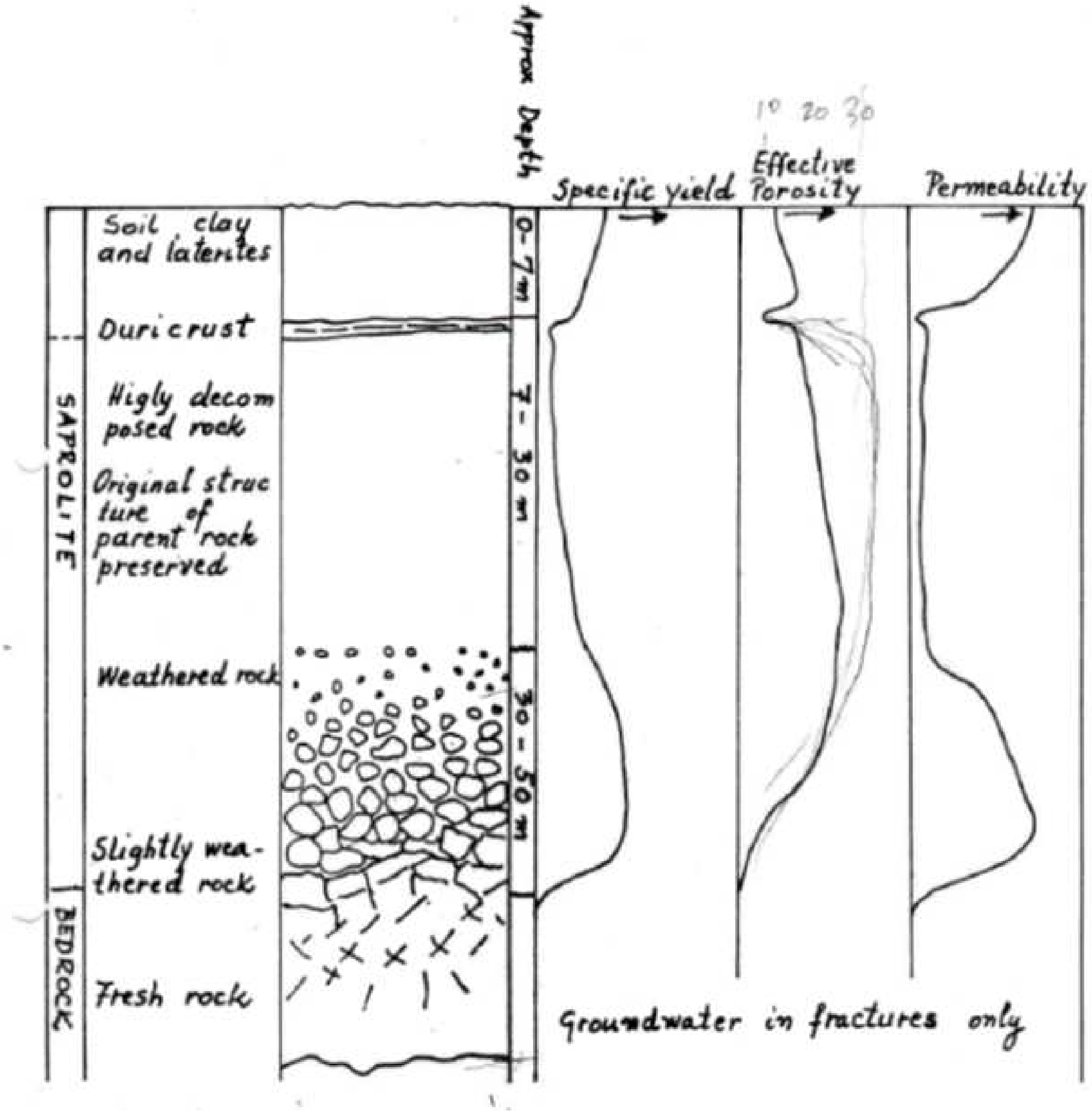
Factors Affecting Rates of Weathering

- Climate – subtropical to semi-arid environments
- Rainfall/evaporation – infiltration, Impact of rainfall/drought on water levels
- Temperature – Higher temperatures increases weathering rates
- Geomorphology –erosion surfaces and valley incision
- Mineralogy – metamorphic and igneous rocks mineralogy susceptibility to decomposition
- Tectonics – regional structures, fracture zones, joints, dykes/sills, rift valleys
- Depth of weathering - recharge and circulation patterns controls depth of weathering front
- Groundwater movement – transport of weathering products, permeability, porosity, storage and transmissivity
- Soils – permeability varies with clays, duricrusts, shallow through-flow
- Hydrology – baseflow drainage rates from regolith to streams

Weathering Profile - Elements

- Soil – Duricrusts and clays
- Saprolite – Rotten rock chemical weathering
- Saprock – Fractured rock physical weathering
- Bedrock – Hard rock some fractures
- Deep bedrock – Hard rock few fractures

Weathered Profile (Carl Bro et al, 1982)



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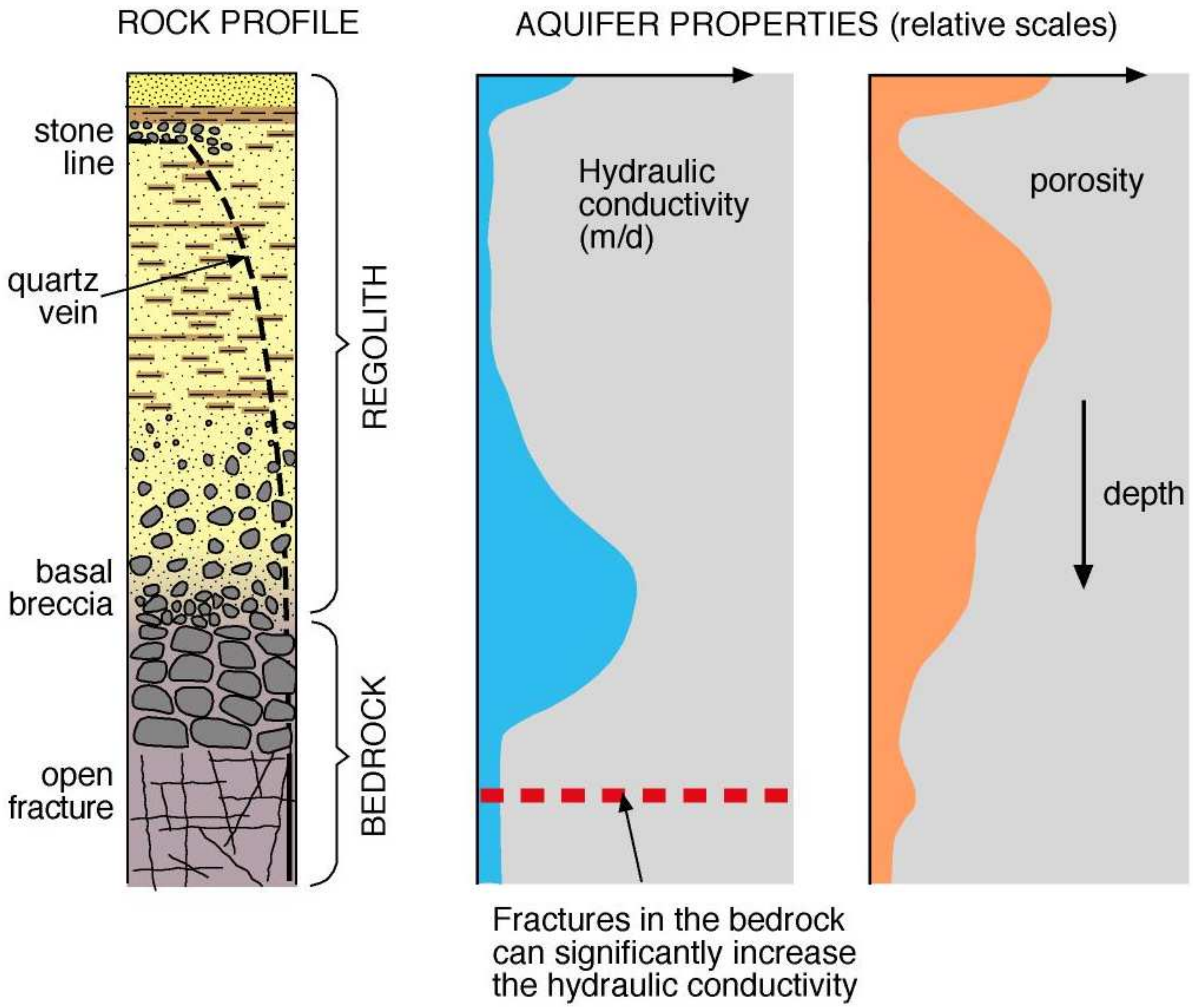
Standard Profile, Jones/Chilton/Foster



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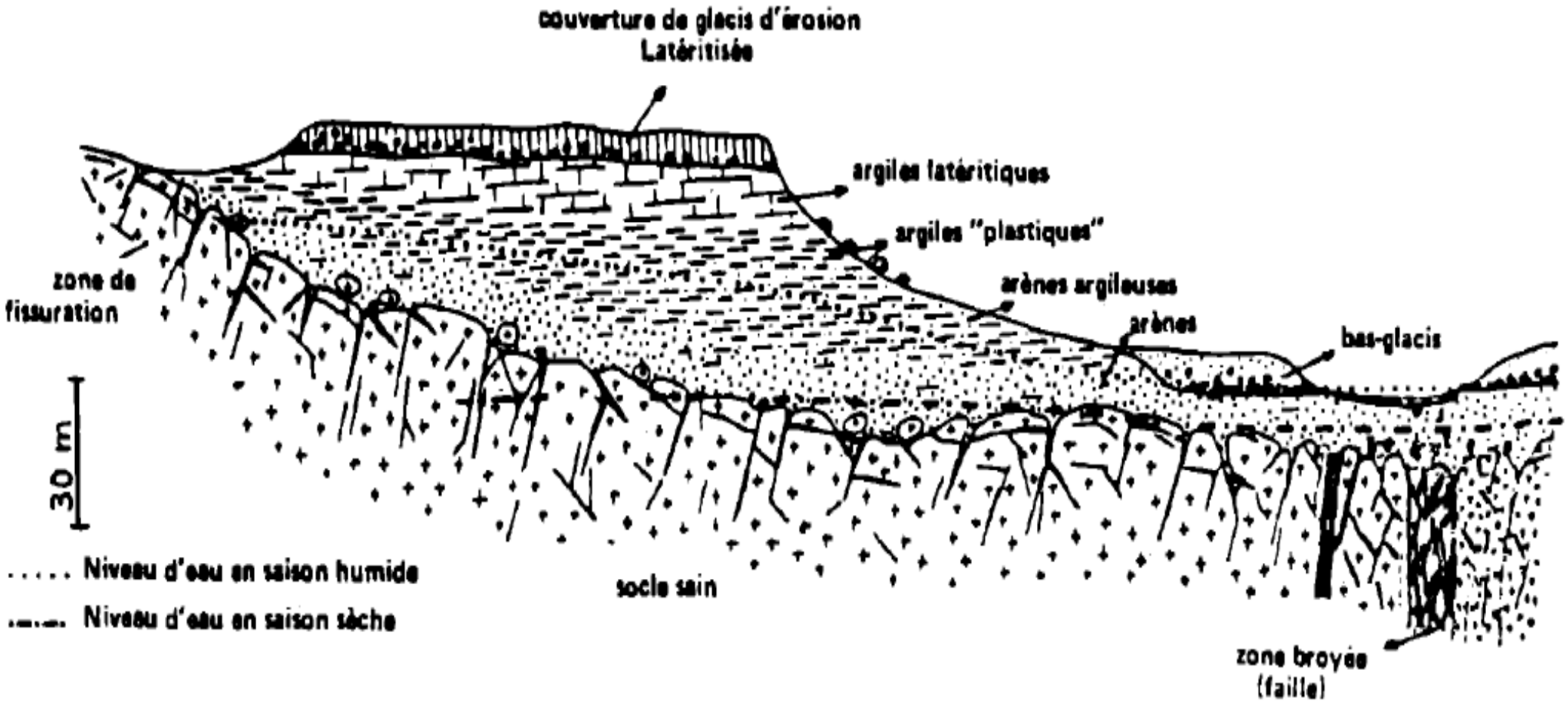
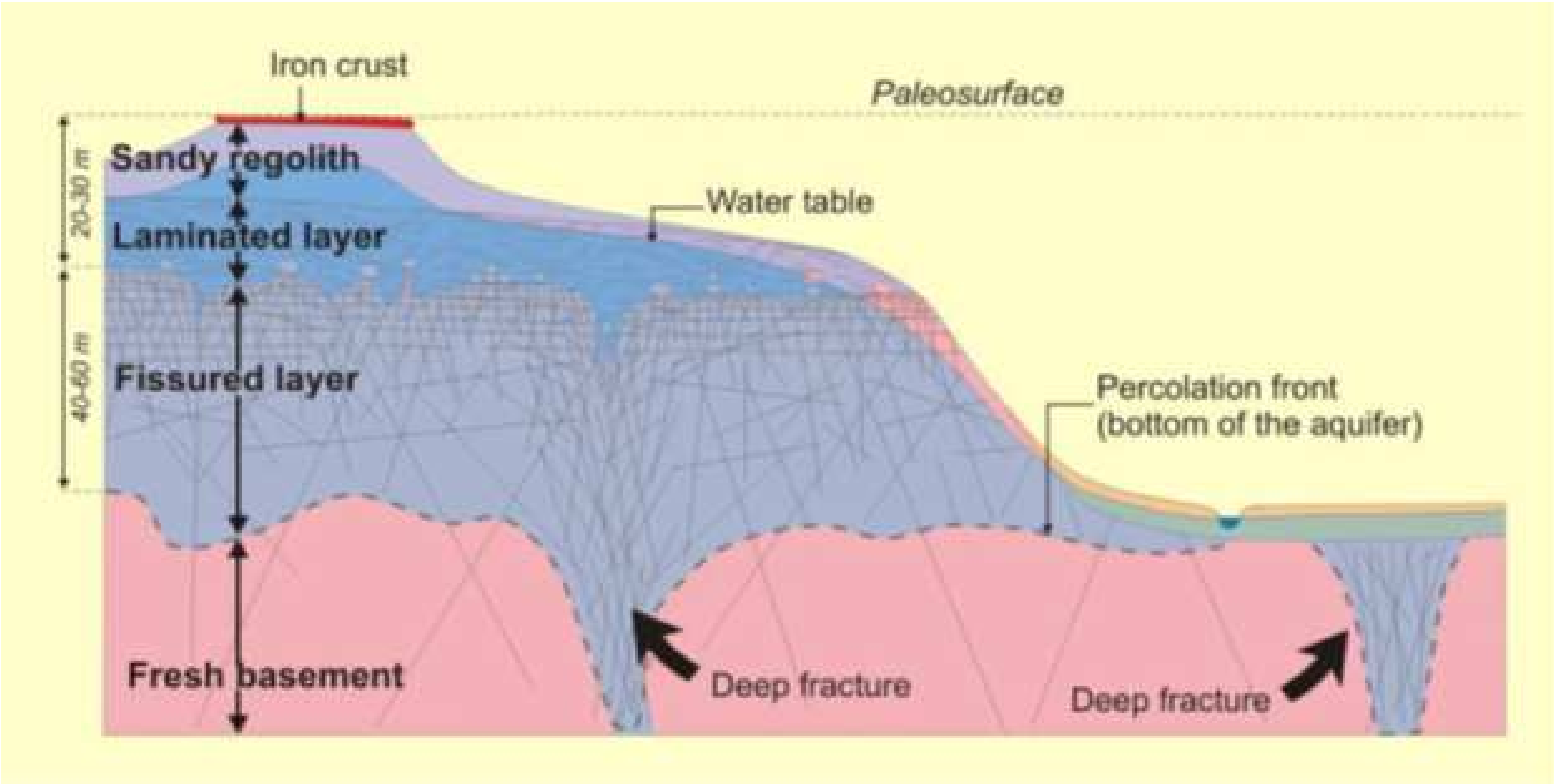
Weathered Granite Profile
Guiraud, 1988



Weathered Profile
Lachassagne, Dewandel and Wyns, 2014



Tanzania

Elevation (masl)	(Area) Geology	No. Bhs	Soil Base (m)	Saprolite Base (m)	Saprock Base (m)	Mean Bh Depth (m)	Yield (l/s)
700-1000	(1) Granite and gneiss	12	2.9	15.3	35.3	47.4	2.9
1000-1800	(1) Granite and gneiss	46	4.5	19.1	42.4	66.7	1.26
1100-1300	(2) Granite and gneiss	25	7.5	24.1	41.1	47.7	1.17
1100-1300	(3) Green-schist Belt	28	6.1	22.4	34.3	43.3	1.0

Mean weathering profile element depths, mean borehole yields and depths within elevation ranges in basement areas of south-western (1) and central (2,3) Tanzania

Malawi

Elevation (masl)	(Area) Geology	No. Bhs	Soil Base (m)	Saprolite Base (m)	Saprock Base (m)	Mean Bh Depth (m)	Yield (l/s)
500-1500	(1) WB Granite/ gneiss	867	5.7	18.8	34.6	41.6	0.82
500-1500	(2) FB Granite/ gneiss	248	7.0	16.5	33.2	41.1	0.66
1000-1500	(3) Granite/ gneiss	112	5.2	20.8	38.3	49.4	0.7
500-1000	(4) Granite/ gneiss	705	4.4	20.3	37.7	50.7	0.67

Mean weathering profile element depths, mean borehole yields and depths with elevation ranges in basement areas of central (1,2) and south-eastern (3,4) Malawi.

Zimbabwe

Elevation (masl)	Geology	No. Bhs	Soil Base (m)	Saprolite Base (m)	Saprock Base (m)	Mean Bh Depth (m)	Yield (l/s)
1000-1500	(1) Granite	156	1.6	17.1	33.4	42.0	0.82
1000-1500	(1) Gneiss	19	2.2	17.4	41.9	53.5	1.16
500-1000	(2) Granite	156	1.8	17.0	29.4	44.5	0.67
500-1000	(2) Gneiss	190	1.5	18.7	33.1	44.7	0.64
500-1000	(2) Schist	16	2.4	13.4	34.5	46.3	5.0

Mean weathering profile element depths, mean borehole yields and depths with elevation ranges in basement areas of central (1) and southern (2) Zimbabwe.

Ghana – Afram Plains

Elevation masl	Geology	No. Bhs	Regolith Base (m)	Mean Bh Depth (m)	Yield (l/s)
99 - 242	Voltaian Basin Sediments	122	9.2	34.2	2.42
99 - 116	Non-fractured Shale and Sandstone	8	2	31.9	1.47
121 - 220	Massive Conglomerate and Sandstone	54	12.3	36.7	2.23
160 - 242	Quartzitic Sandstone and Conglomerate	21	12.8	34.6	1.24
113 - 216	Feldspathic Sandstone, Siltstone and Mudstone	39	4.3	30.8	3.4

Mean regolith depths, borehole yields and depths within elevation ranges in the Voltaian aquifers of the Afram Plains, Ghana.

Ghana – Northern Region

Geological Formation	Lithologies	No. Bhs	Elevation (masl)	Mean Bh Depth (m)	Yield (l/s)
Afram	Mudstones, siltstones	95	87-161	58	1.0
Anyaboni	Sandstones	104	108-248	50.3	4.4
Bimbila	Mudstones, siltstones, sandstones	1208	104-260	54.1	1.3
Bunya	Siltstones, Sandstones	630	110-260	49.1	2.5
Chereponi	Sandstones	186	104-213	50.8	1.3
Darebe	Tuffs	86	80-210	56.5	2.7
Panabako	Sandstones	469	130-450	55.3	1.3
Tamale	Sandstones	55	150-190	60.9	2.5
Obosum	Mudstones, siltstones	913	70-200	60.3	1.0

Mean borehole yields and depths within elevation ranges in the Voltaian Basin formations of Northern Region, Ghana.

Summary

- Many boreholes drilled, few accurate data collected
- Basement aquifers are poorly understood
- Soils are thin (1.5-7.5m, mean4.1m); variable lithology; thinnest in Zimbabwe and deepest in Tanzania. Clays and duricrusts hinder recharge
- Saprolite of clayey decomposed rock found to 13-24m depth (mean 18.5m); thinnest in Zimbabwe and deepest in Tanzania.
- Saprock of fractured hard rock found to 29-42m depth (mean 36m); thinnest in Malawi and deepest in Tanzania; variable in Zimbabwe.
- Regolith depth in the Voltaian metasediments in Ghana shallow 2-12.8m depth (mean 7.9m); groundwater mainly in deeper fracture zones. Although yields higher often unsustainable.

Conclusions

- Standard conceptual model of weathering profile in Basement aquifers does not cover the range of profiles seen in the field.
- In sub-Saharan Africa need to identify profile types as sub-sets of the original model.
- Subsets defined using variations in climate, past climate and landform morphology. Standard conceptual model is misleading.
- Traditional basement aquifer profiles to include sub-sets to enable better understand groundwater occurrence.
- Sub-sets are required for effective evaluation and sustainable development of groundwater resources in Basement Complex aquifers.