SeeKaquA: Semi-airborne electromagnetic exploration of Kalahari's aquifers, Africa

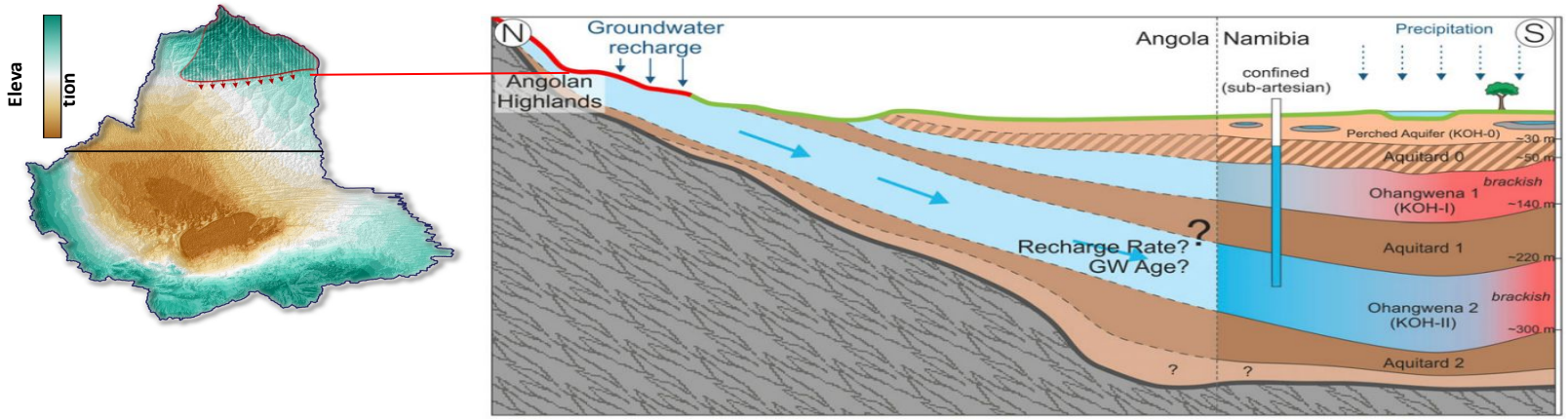
W. Mörbe, R. Rochlitz, J. Hamutoko, M. Ndongo, C. Mazibuko, R. Bäumle, S. Gürsoy, A. Wilhelm, D. Adams

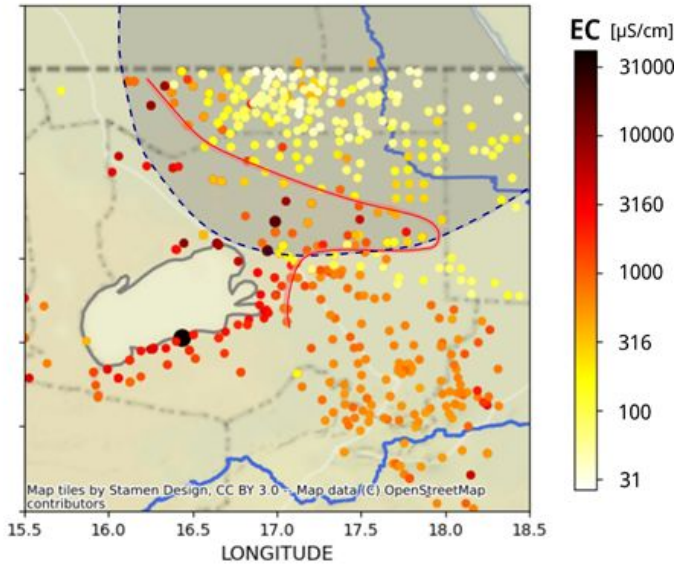
7. Oct. 2025

Part I: Motivation and Methods

SeeKaquA - Motivation

- Sustainable groundwater supply in (semi)-arid climate increasingly affected by climate change (e.g., Carvalho et al., 2023)
- Deep groundwater resources can be considered to increase climate resilience of region (e.g., Bäumle et al., 2024)
- Poor understanding of: Deep aquifer boundaries and vertical separation, salt/freshwater boundaries, saltwater intrusion, flow mechanics
- Risks: fluoride and vanadium concentrations, over-exploitation





Groundwater salinity at surface in Cubango megafan area

Regional conception of KOH aquifer Systems in Cubango megafan area, salinity critical in central basin area

SeeKaquA - Motivation

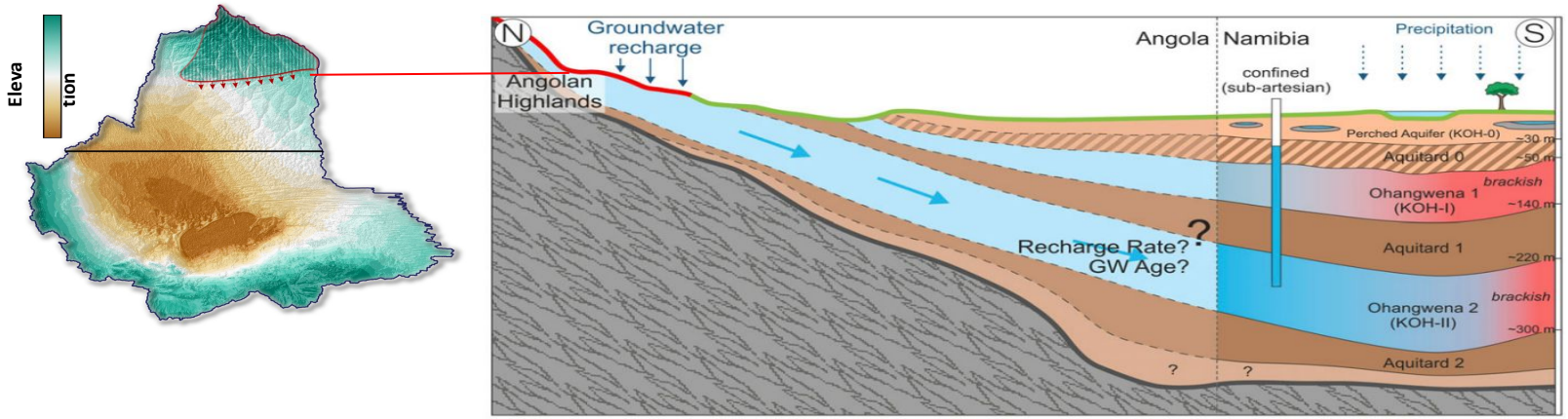
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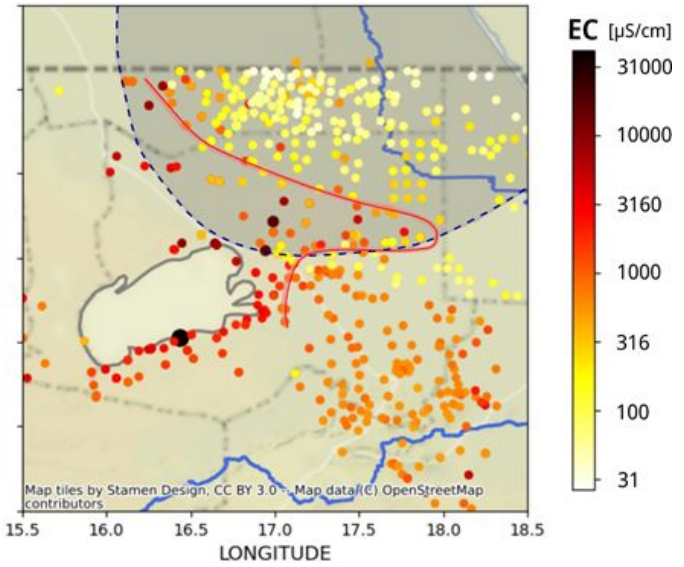
Geophysics

- Poor understanding of: Deep aquifer boundaries and vertical separation, salt/freshwater boundaries, saltwater intrusion, flow mechanics

Geochemistry/Hydrogeology

- Risks: fluoride and vanadium concentrations, over-exploitation



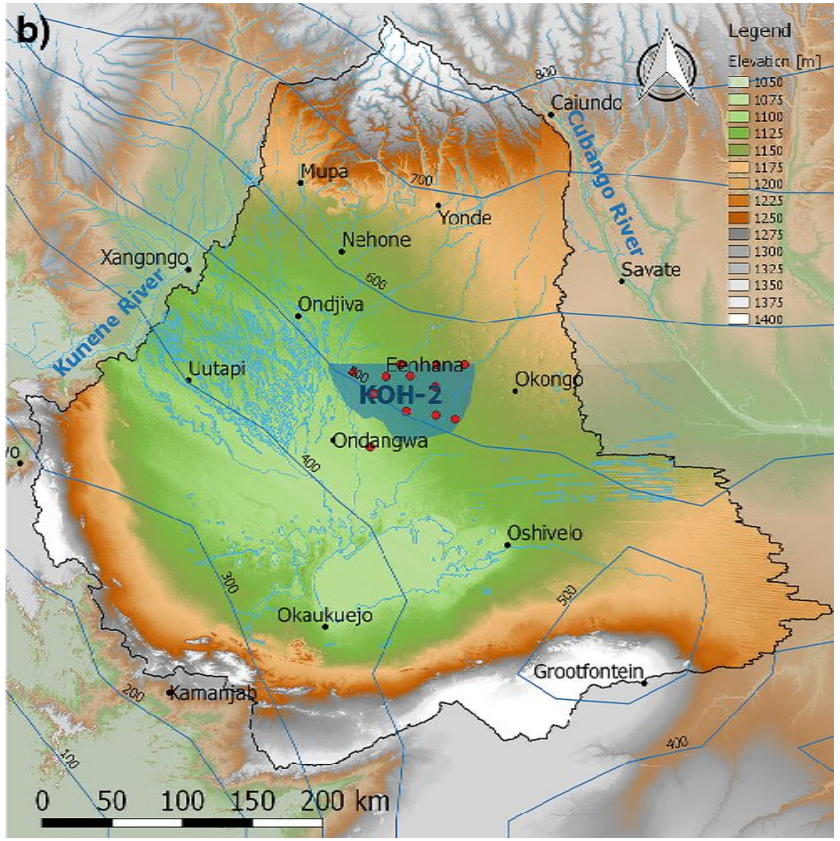


Groundwater salinity at surface in Cubango megafan area

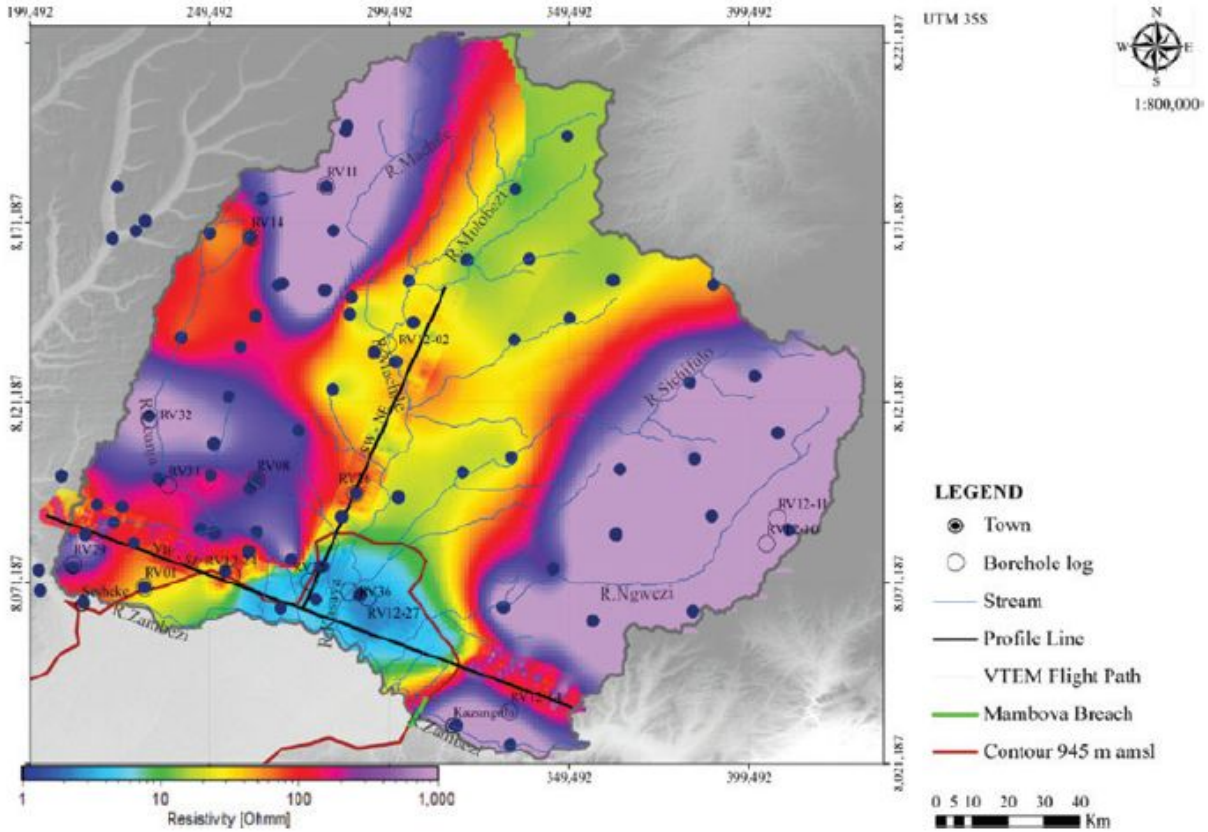
Regional conception of KOH aquifer Systems in Cubango megafan area, salinity critical in central basin area

SeeKaquA– Survey Sites

Cuvelai-Etosha Basin, Namibia



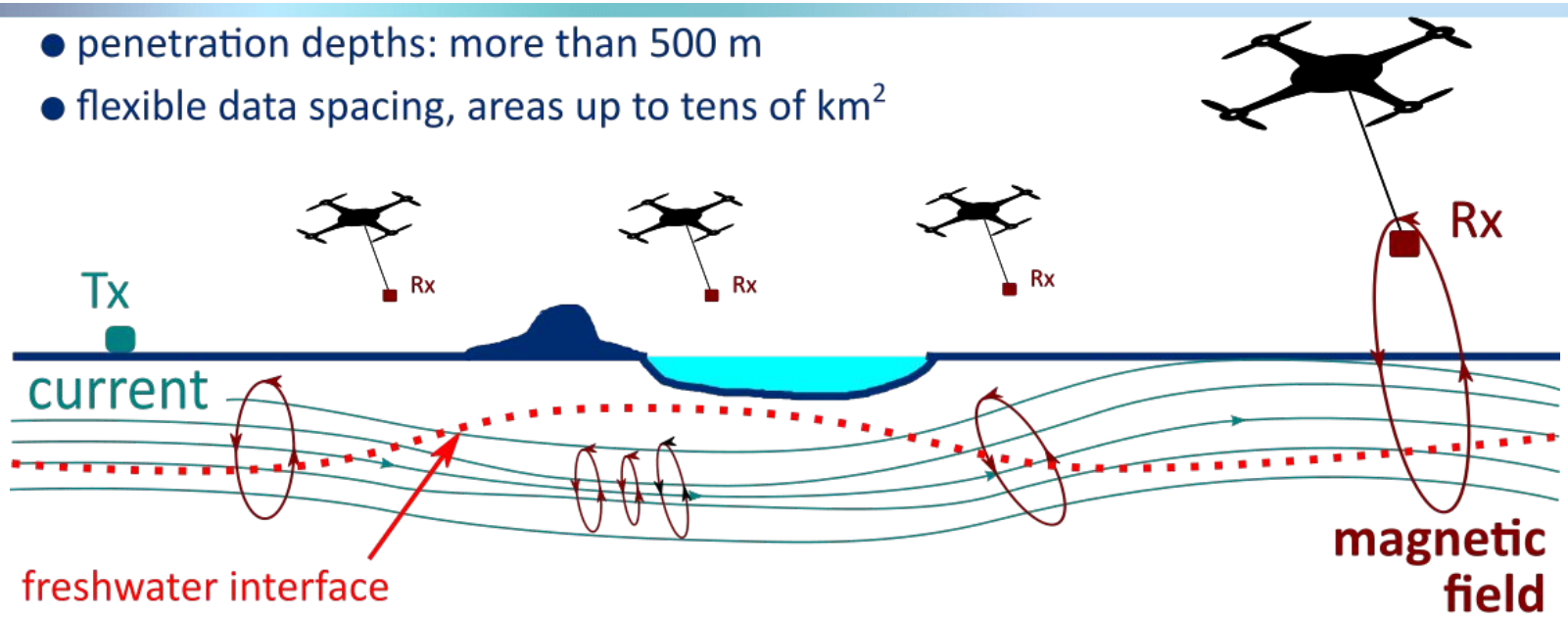
Machile-Zambezi Basin, Zambia



Chongo et al.

Semi-airborne EM – in a nutshell

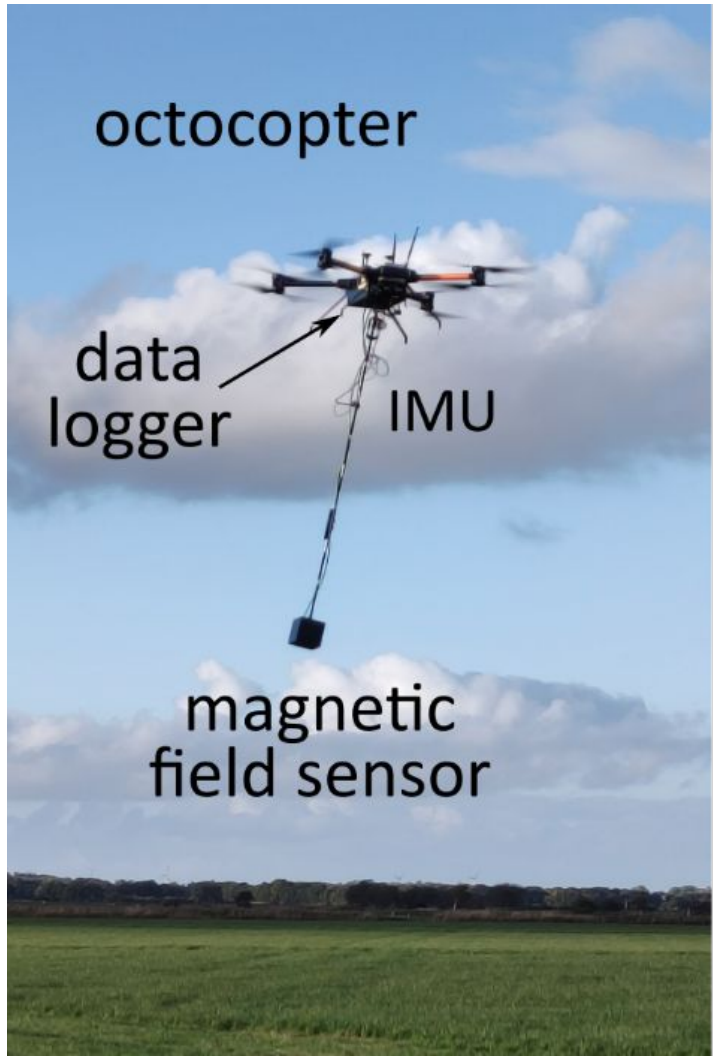
- penetration depths: more than 500 m
- flexible data spacing, areas up to tens of km^2





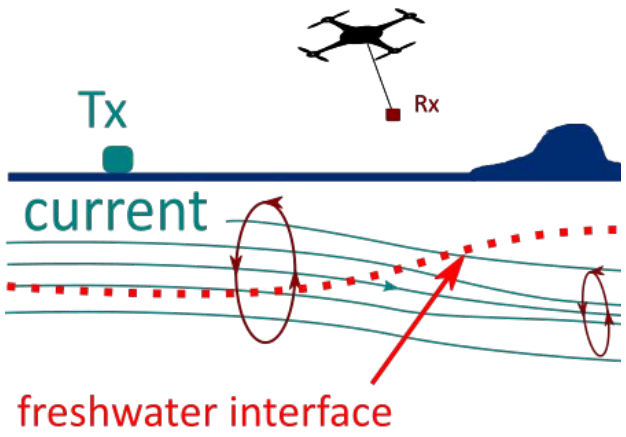
Current generator and transmitter

UAV-based receiver system (state 2022)

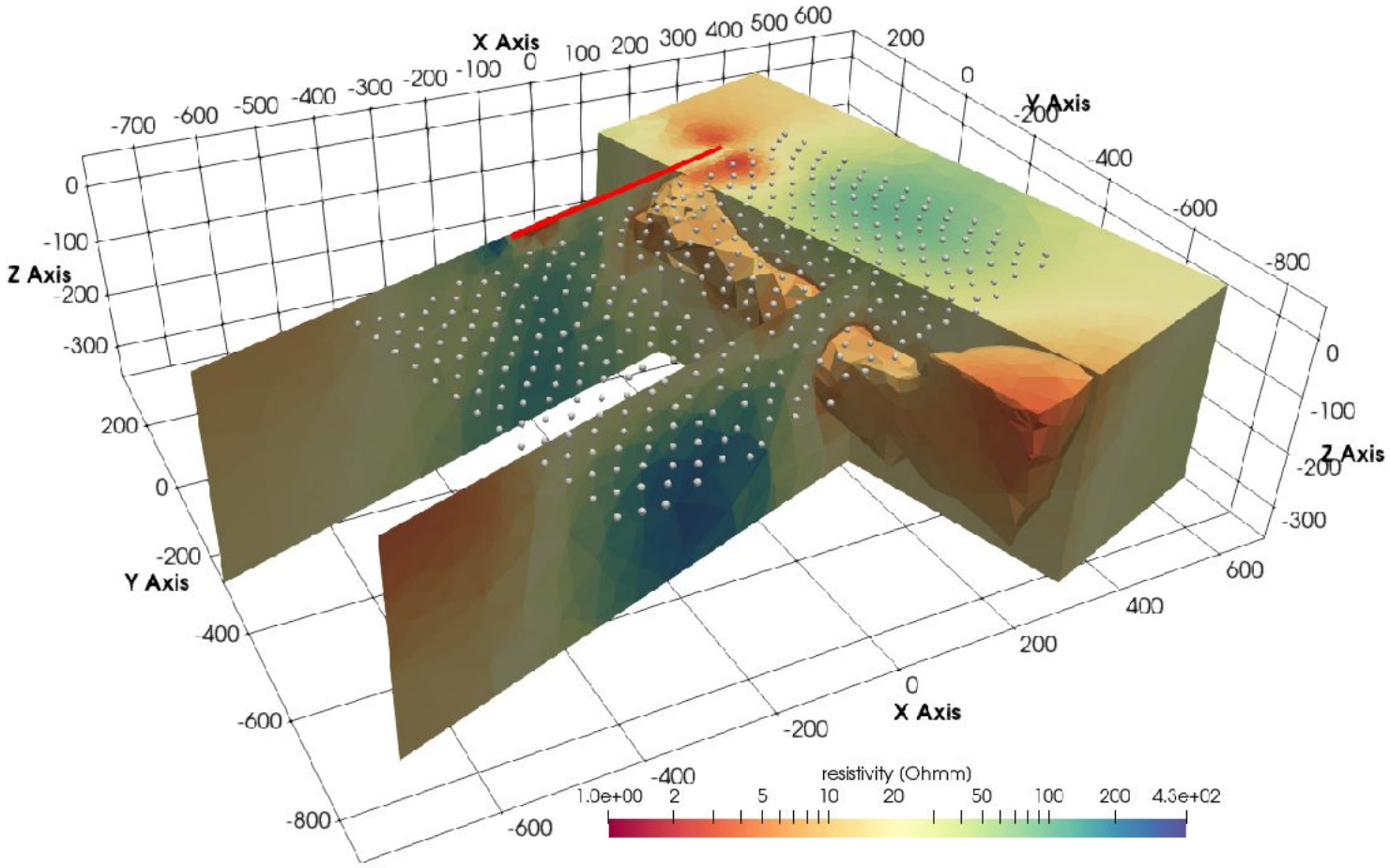


Semi-airborne EM – Result for Interpretation

- penetration depths: more than 500 m
- flexible data spacing, areas up to tens of km^2



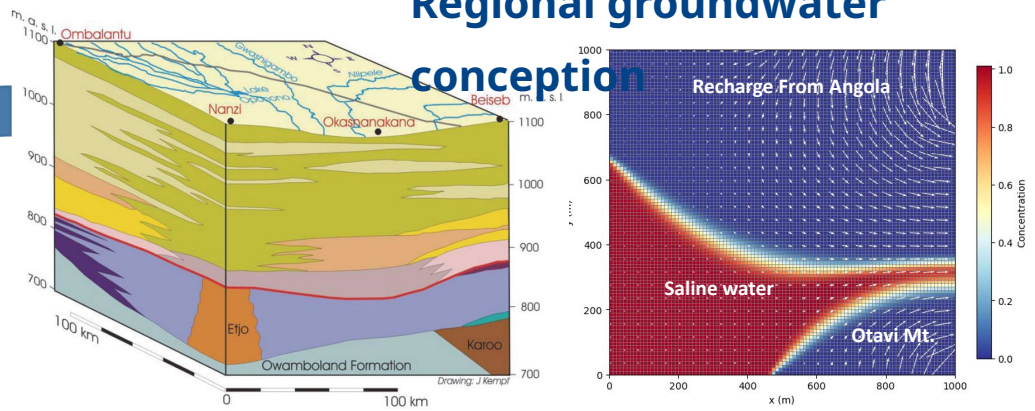




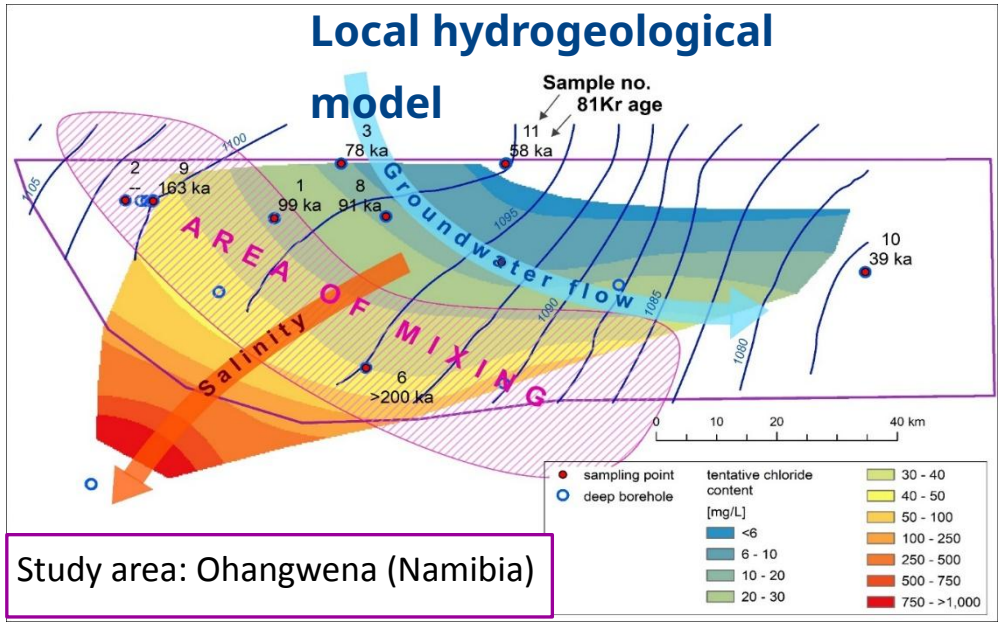
Groundwater Modeling

- Transformation of electrical conductivities into chloride/fluoride concentrations
- Geochemical modelling: salinity distribution, rock-water interactions
- Integrate 3D resistivity models (geophysics) into the hydrogeological interpretation to create improved hydrogeological model

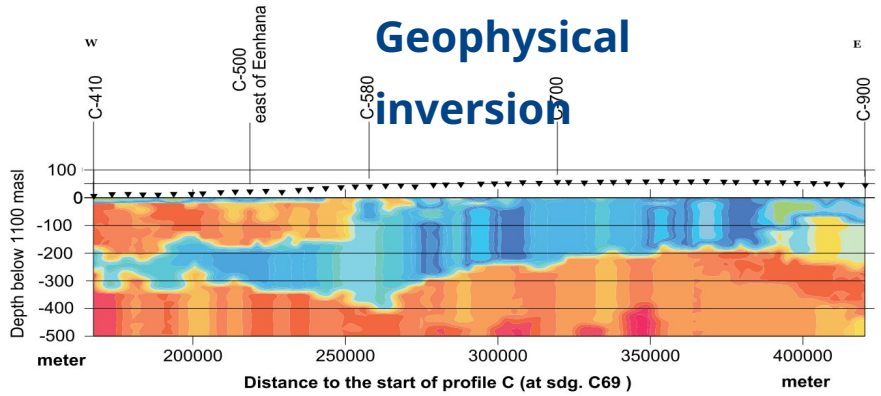
Regional groundwater conception



Local hydrogeological model



Geophysical inversion



Capacity Development

- Technological innovation: Novel modular SAEM system, technology and knowhow transferred to terratec with offices in Namibia
- Knowledge transfer to academic partners by cooperation with UNAM/UNZA during project phase, transfer and upscaling to stakeholders in Southern Africa







custEM

pyGIMLi
Geophysical Inversion & Modelling Library

F A I R
Findable Accessible Interoperable Reusable

CUVECOM
ÁO DO CURSO DE ÁGUA DO CU

MINISTRY OF AGRICULTURE, WATER AND LAND REFORM

NAMWATER
Namibia Water Corporation Ltd

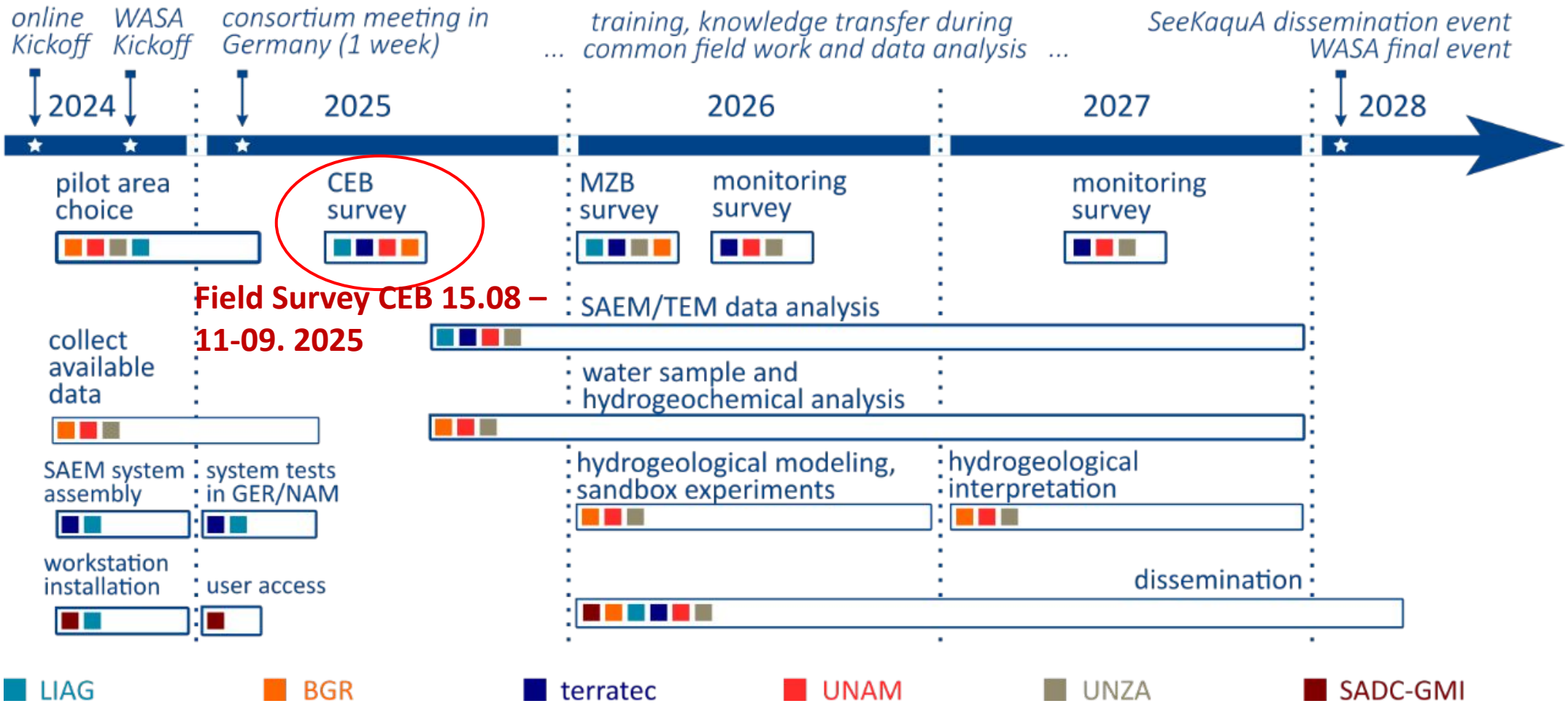
Ministry of Water Development & Sanitation

WARMA

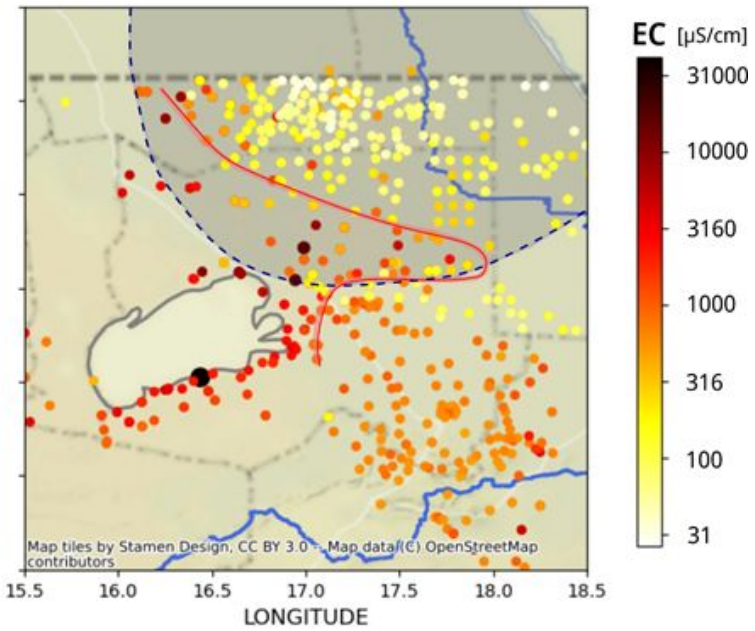
Every drop counts
AMCOW
Count every drop
AFRICAN MINISTERS' COUNCIL ON WATER

Part II: Current Progress – CEB Field Survey

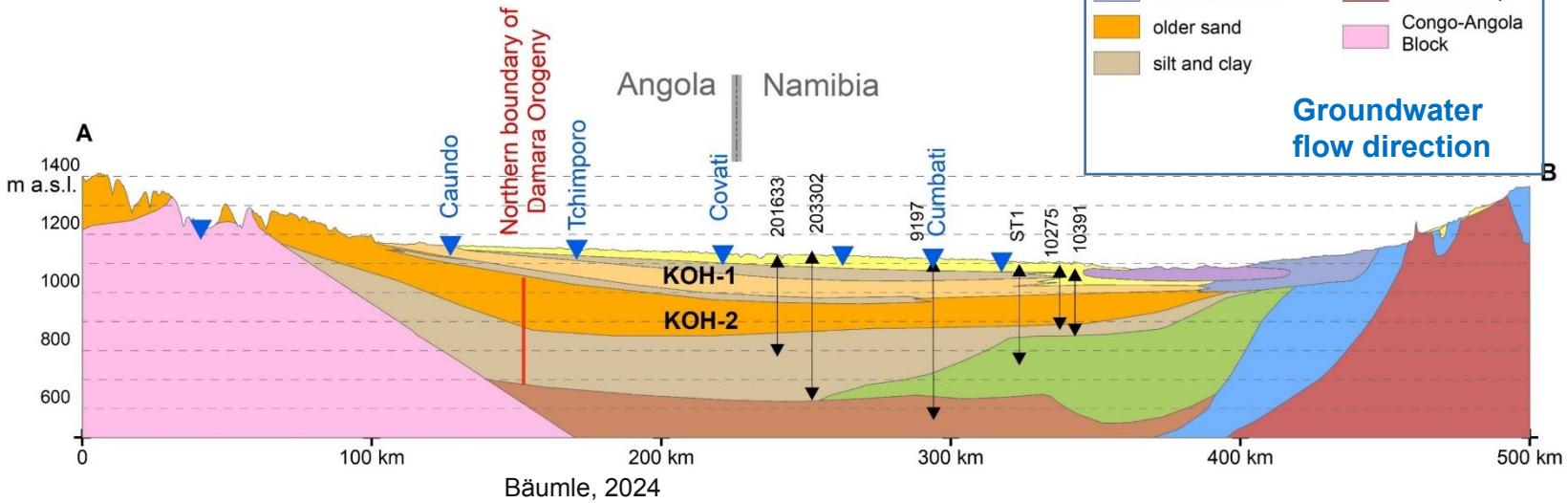
Timeline & Current Progress



SeeKaquA – Cuvelai Etosha Basin

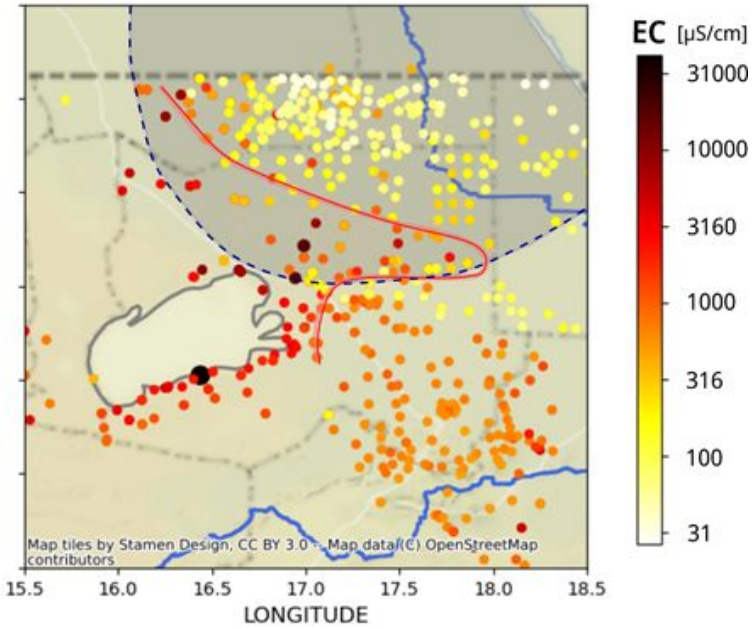


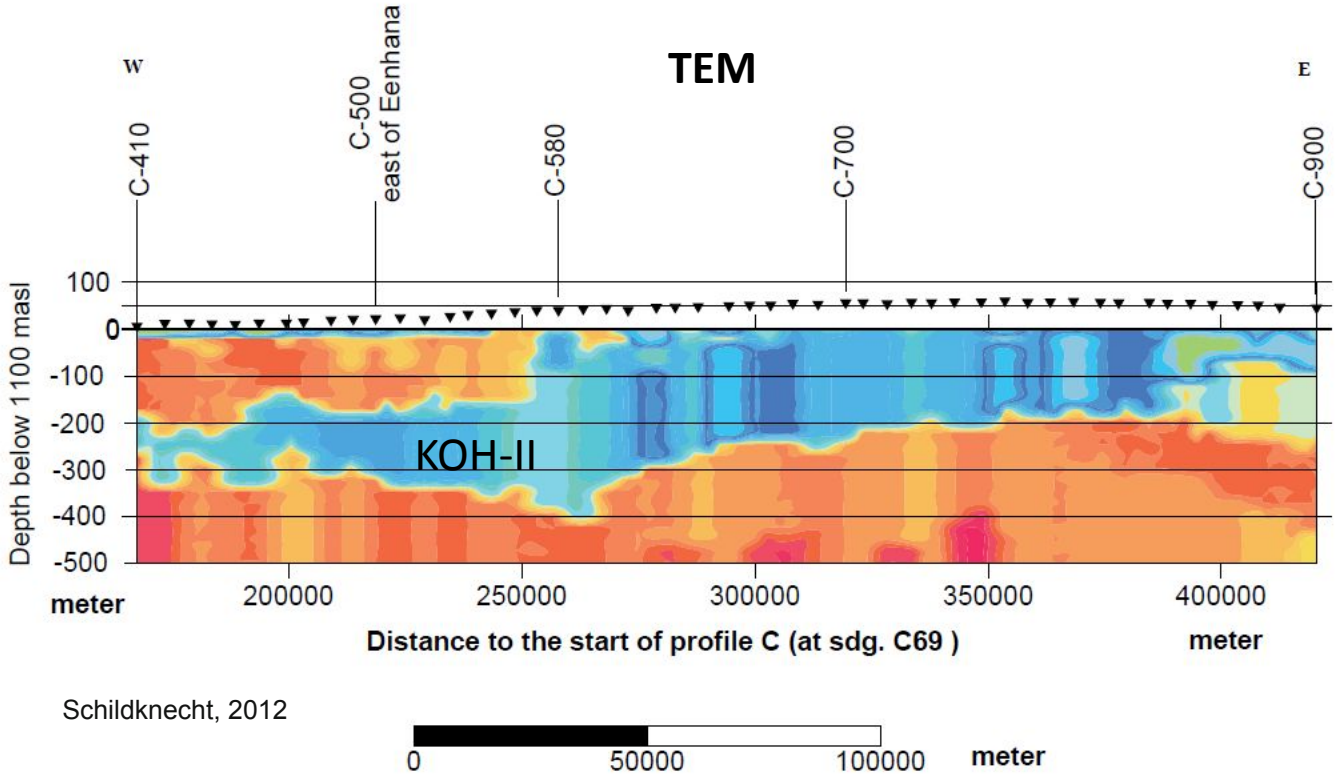
Recharge in mountain ranges and foothill areas, but overall poorly understood



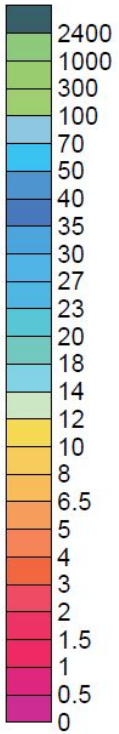
Bäumle, 2024

SeeKaquA – Cuvelai Etosha Basin





Schildknecht, 2012



Key (Geophysical) Research Questions:

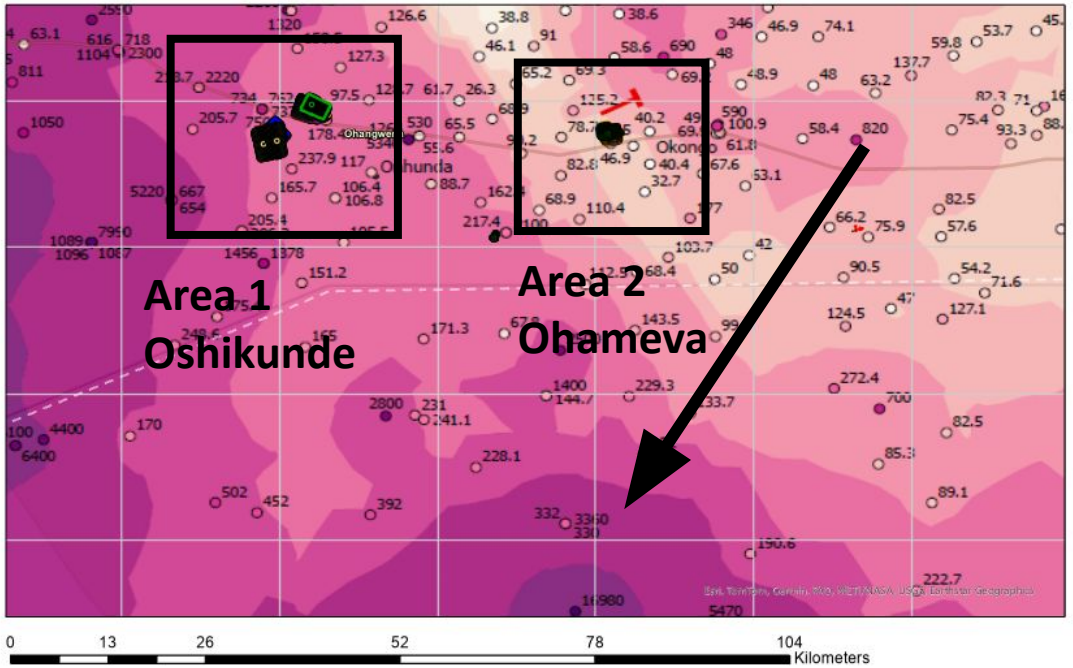
I) Identification of confining layer between KOH I and II, how are they distinguished & Depth extension of KOH-2

II) Investigation of fresh-saltwater boundary

III) Lateral extend of Perched Aquifers

Field Survey August-September 2025





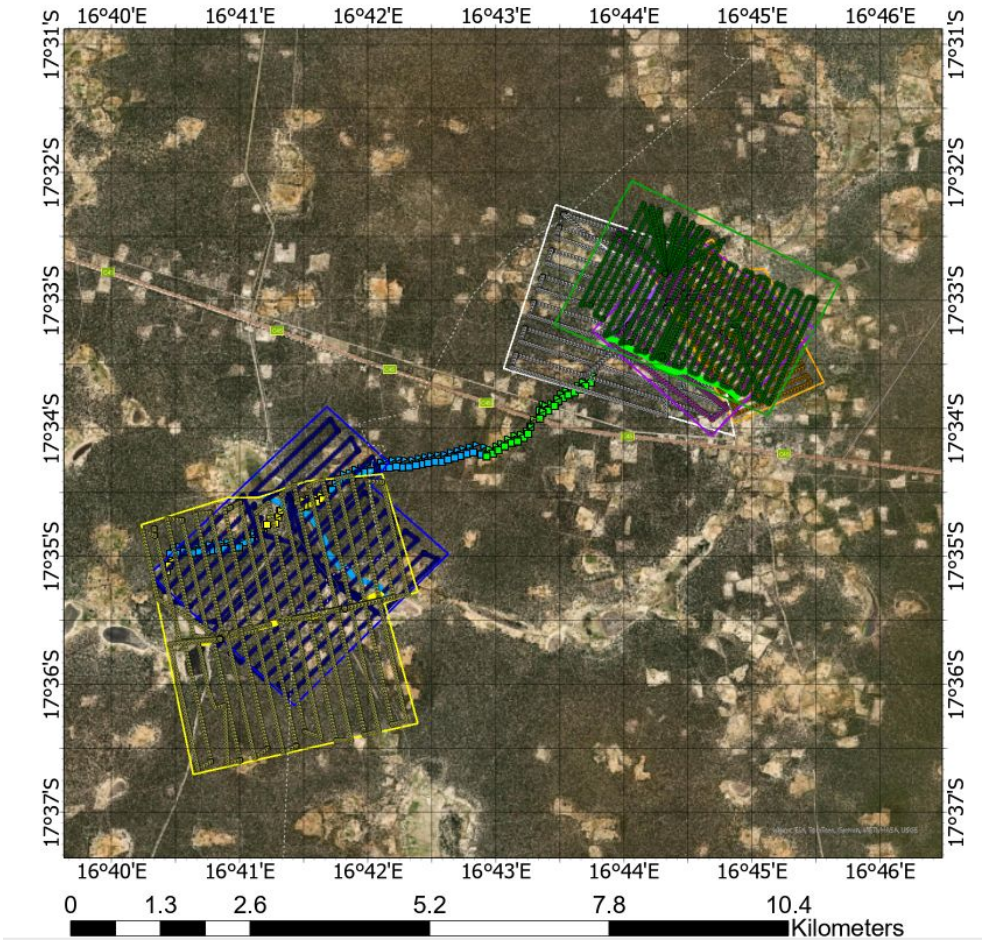
Bäumle et al

Increasing electrical conductivty/ Salinization To South/West

Geophysical Methods

- SAEM for spatial investigation of Saltwater boundary
- TEM/ SAEM for investigation of perched Aquifers

Area I: Oshikunde



- SAEM
  - Several overlapping flight areas with 2 different sensors
  - Estimated depth of investigation between 20 m – 800 m
- Ground Based Geophysics
  - TEM, ERT (shallow investigation down t 150-400 m)
  - CSEM (20 m- 600 m)

SAEM/CSEM: Transmitter & Ground Based Receiver













SAEM: UAV Systems & Sensors





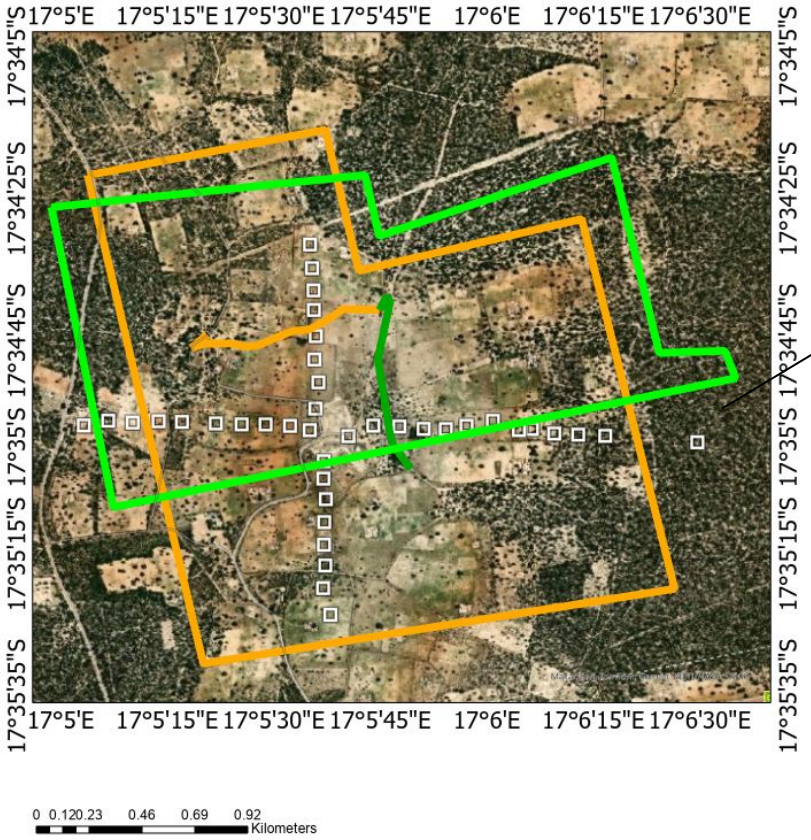




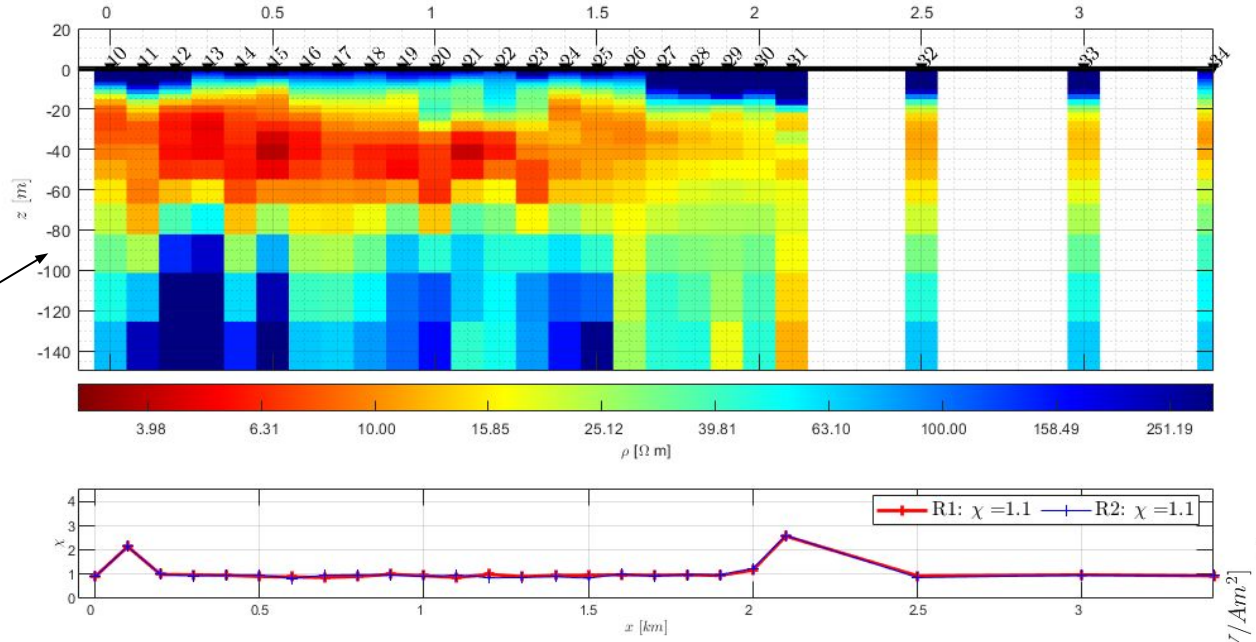


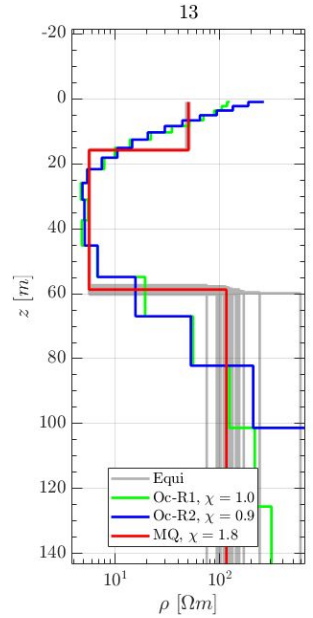


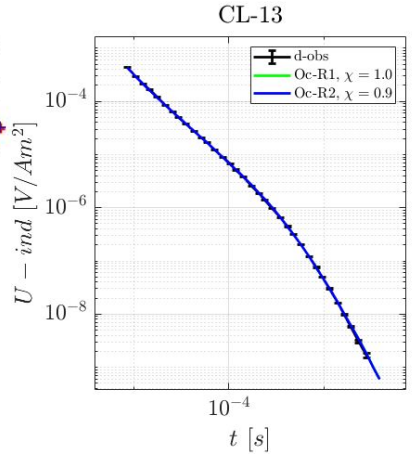
Area II: Ohameva



Transient Electromagnetics, 1D Inversion Models



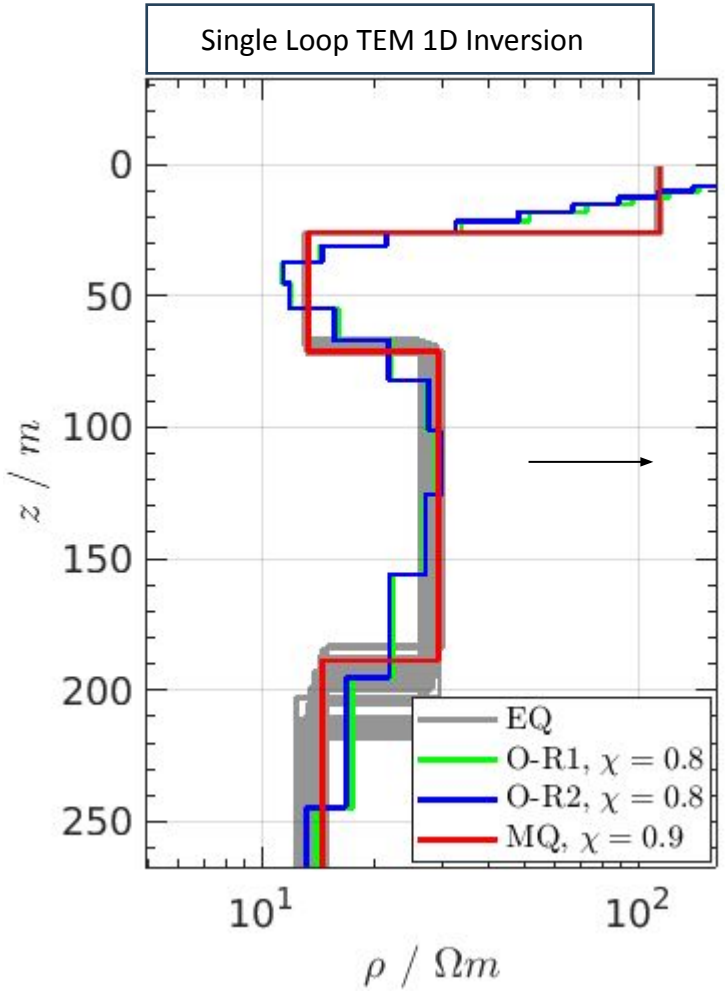




Identification of shallow conductive body in investigation area

Area III: Ekoka – Transient Electromagnetics





Zone of increased electrical resistivity

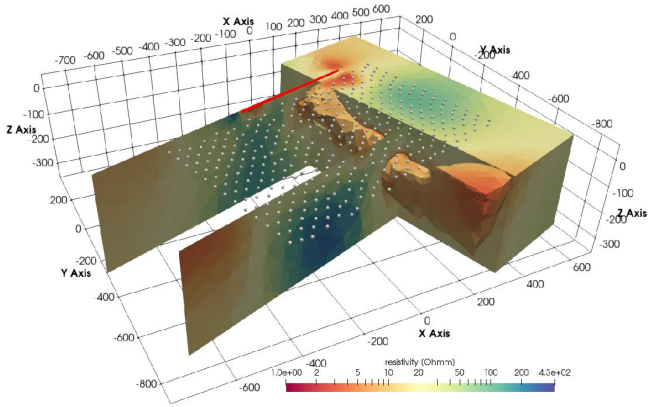
Large Loop Survey dor investigation depth of 400 m

Next Steps

Cuvelai-Etosh Basin

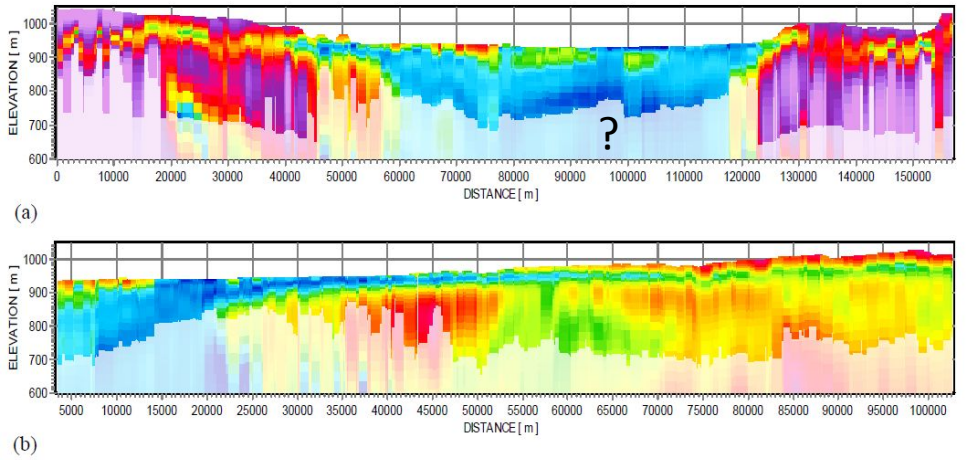
- Extensive UAV/Fixed Loop/TEM/ERT Dataset & Hydrogeological Sampling

- Derivation of 3D Conductivity Subsurface Model



Machile Zambesi Graben

- AMT/TEM Survey ans SAEM Surveys planned
- Enhancing geological understanding of the subsurface
- Identifying potential drilling locations
- Is there a deep Aquifer smilar to KOH-II ?



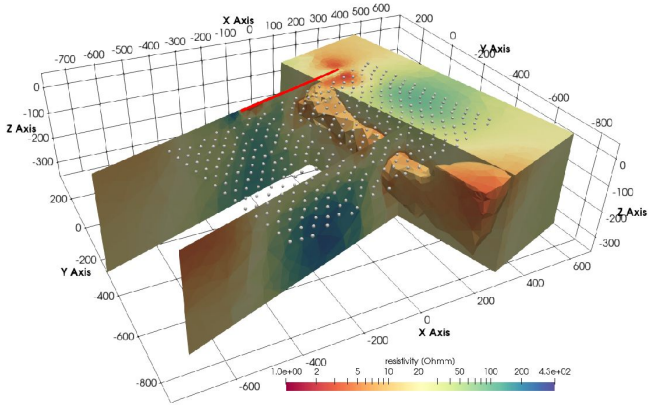
Chongo et al, 2015

Next Steps

Cuvelai-Etosh Basin

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Machile Zambesi Graben

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SAEM Presurvey in MZB and AMT/TEM Survey scheduled for 1.11-16.11 2025

Long-term Vision

Cuvelai-Etosh Basin

- Understanding the current salinity distribution within the KOH-II aquifer
- Recommendations for exploitation of KOH-II aquifer as part sustainable groundwater management
- Methods applied here can be extended to the wider Kalahari Basin.

Machile Zambesi Graben

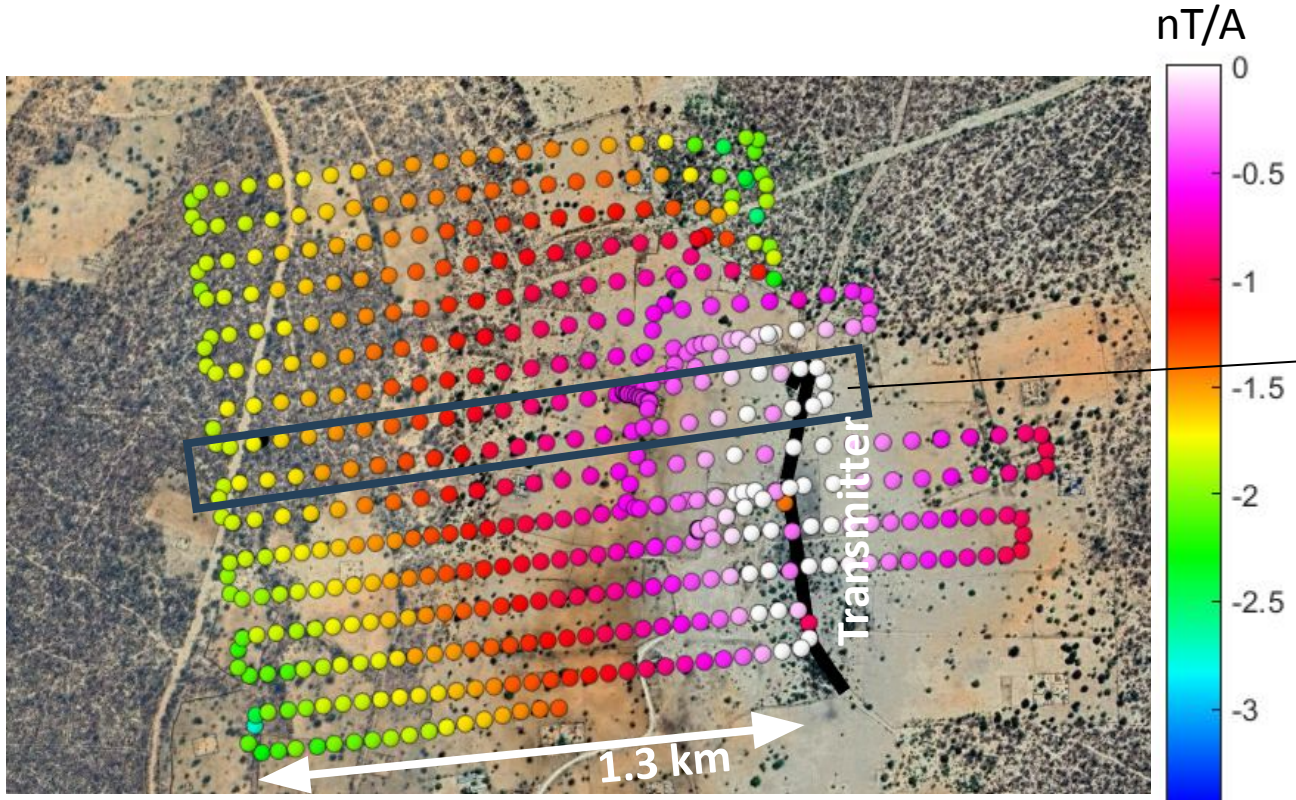
- Expand the deep geophysical resistivity models beyond the pilot transects in 3D
- Improve hydrological flow model, Investigate trace elements

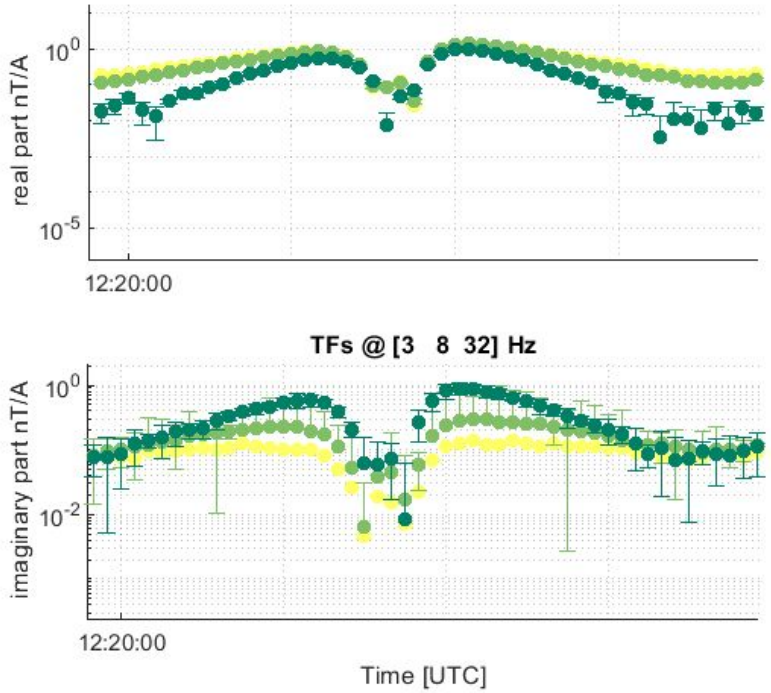
☐ Recommend drilling locations to make deep groundwater resources part of sustainable water supply concept

Thank You for the Attention

Project Coordination: Dr. Raphael Rochlitz, LIAG (Raphael.Rochlitz@liag-institut.de)
African Consortium Speaker: Dr. Josefina Hamutoko, UNAM

Data Example SAEM





High Data Quality also for low frequencies/deep investigation down to several hundred meters!