Three-dimensional geophysical modelling of Kiejo-Mbaka geothermal field, Tanzania

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Introduction

- The Kiejo-Mbaka geothermal field is located inside the Karonga basin (Tanzania)
- The area is located in the Rungwe Volcanic Province, near the Rukwa, Usangu, and Karonga triple junction
- Karonga rift is dated late Miocene/Pliocene; volcanics younger than 8 Ma (Ebinger et al., JGR, 1993)
- Elton plateau, Livingstone fault, Poroto mountains main physiographic elements
The survey area: geology

- Precambrian Basement (MIT) outcrops in the central area, shallow more recent volcanics overlying it
- Main manifestations: Kilambo-Kajala hot springs and Lufundo gas vent
The geophysical survey

- Goal: definition of the geothermal prospect structure
- MT/TEM and gravity surveys in September/October, 2016, funded by ICEIDA/NDF
- 76 MT/TDEM stations acquired, 8 profiles. St. spacing: 750 m.
- 108 gravity stations, 9 profiles. St. spacing: 700 m
- 25 sparse additional gravity stations, 20 km-far MT station for RR processing
The MT/TDEM survey: methods

- MT mean record length 21 hrs
- RR Robust MT processing, allowing to very good results
- TDEM stations acquired by 100-200 m central loop, 10 to 20 A
- MT static shift effect corrected by means of TDEM/MT phase joint inversion
The MT data

- YX phase-out-of-quadrant for all the MT station lying in the central region. Possible strong current channelling (*see e.g. Ichihara, 2009, G.J.Int.*)

- 3D conditions are however ubiquitous --> 3D modelling necessary
MT 3D inversion: discretization

• 92 x 92 x 55 cells; width: 300m x 300m x 25m

• Inversion of broadband full-tensor MT impedance and geomagnetic tipper (300-0.001 Hz)

• Topography (from SRTM DEM) is included

• MT out-of quadrant data reasonably explained
MT 3D inversion: slices and sections

- Four distinct conductive anomalies (1-5 Ohm m).
- One wide conductor in the plain area, two in the ridge sector. C4 related to Lufundo.
- Two planes (D1,D2) depict the tilted block
- The Mbaka fault foot wall is plausibly altered
MT 3D inversion: isoresistivity surfaces analysis

- Iso-100 Ohm m: main structure (asymmetric and different-trending Mbaka and Livingstone planes).
- Iso-10 Ohm m: shape of the anomalies
- C1 thickens toward SW; C2 and C3 are thin and sub-horizontal
Gravity survey: methods

- Lacoste-Romberg G-series gravity meter, with error of 0.013 mGal (1σ). Vertical position error of 11.6 cm (differential GPS positioning)

- Estimated BA density is 3000 kg/m³ (MIT basement) by rock samples and Parasnis method

- Reference absolute gravity from mean value of the World Gravity Map over the survey area (977717.536 mGal)
Gravity: residual BA

- Regional field calculated from «regional» stations
- Central residual BA high (>20 mGal) related to MIT basement.
- Horizontal derivatives reveal four trends: Mbaka, Livingstone, Karonga rift-related, E-W. These are coherent with RS analysis
Gravity: 2D forward modelling

- Two-media models (2500 and 3000 kg/m³) are suitable
- Gravity high related to MIT basement, lows to the plain and NE of it
- Very thick low-density region in the graben plain
Gravity: 3D inversion

- 3D fixed density layer inversion of residual Bouguer Anomaly data. Density contrast of -500 kg/m³
- High-density layer top surface deepens SW and NE
- Low-density layer beneath the plain (SW) is 1200-1500m thick
Integrated interpretation

- Gravity bedrock high related to resistive core: MIT; lows related to conductive zones: sediments

- The relatively conductive zone close Lufundo not related to low density → likely basement alteration
Conclusions

Geophysics identified:

i) MAIN TECTONICS. Two planes delimiting the tilted MIT block

ii) POTENTIAL FLUID PATHWAYS. Besides the Mbaka fault, N-S discontinuities can act as a pathway for fluids coming from Mt.Kiejo or intercept fluids from Elton Plateau

iii) ALTERATION. The Mbaka fault plane, and near Lufundo

iv) CAP ROCK. The sediments beneath the plain can act as a cap rock at their top

v) RESERVOIR. The sediments beneath the plain can act as a cap rock at depth
Thank you

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