Geophysical Imaging of the Roter Kamm Crater, Namibia, using the Transient Electromagnetic Method

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Introduction

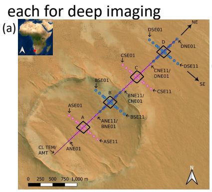
The Roter Kamm Crater is a 3.7-million-year-old meteoritic impact crater in the Sperrgebiet National Park in southern Namibia [1]. The sedimentary infill holds valuable information about the past climate, and thus the evolution of the surface and the biota. The geophysical exploration of the crater allows to provide information about its internal structure, especially as only a very limited number of geophysical studies had been carried out at this site. To be able to image sedimentary infill and basement of the crater, two electromagnetic methods were applied: the Transient Electromagnetic (TEM) and the Audiomagnetotelluric (AMT) method. TEM, which has already proven its capability imaging sedimentary deposits, is suited for investigations of shallow to intermediate subsurface (< 500 m). AMT, on the contrary, can reach large penetration depths down to a few kilometers depending on the subsurface conductivity.

Field Setup and Methods

Field Setup strongly influenced by environment
→ inside of crater only accessible on foot
→ Coincident and Fixed Loop setup (CL/FL)
CL: 64 stations along 2 profiles using 2 Tx Sizes
FL: 4 Transmitter loops with 21 receiver locations each for deep imaging

Setup	FL	CL
Transmitter	Zonge ZT 30	TemFast 48
Receiver	SMARTem24/KMS 820	
Sensors	Geonics/TEM 3 Coils	Loop
Tx Edge Length	200 m	50 m/100 m
Soundings	4 x 21 = 84	53/11

(a)



(b)

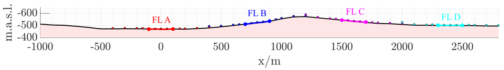


Figure 1: a) Map of the main profile and TEM fixed loop setup at the Roter Kamm Crater (Map Data: Earthstar Geographics [3]).
b) Topography along the main profile at the Roter Kamm crater [4].

Geology

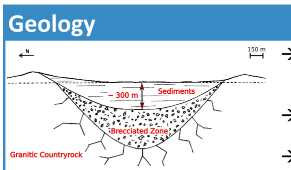


Figure 2: Hypothetical model based on various geophysical methods along the NS-profile (modified from [1])

→ Thickness of the sedimentary layer:
> 300 m
→ Bowel Shaped Infill [1,2]
→ Electrical Resistivities unknown

Method	Depth to Brecciated Zone („Basement“)	Depth of Granitic Countryrock
Seismics [1]	> 90 m	-
Gravimetry [1]	~ 300 m	Set to ~760 m
Magnetics [2]	-	~ 700 m

Fixed Loop Data

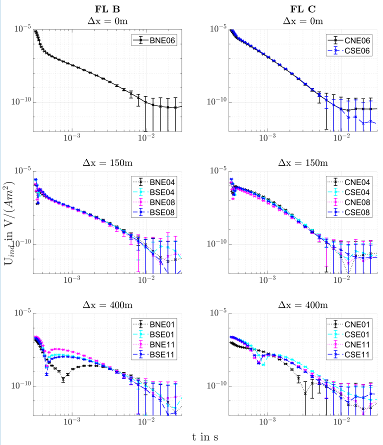


Figure 3: Transients (z-component) of selected receiver stations of fixed loops B and C.

Fixed Loop B and C:
- → Whole profile on the inside or outside slope of the crater (height difference B: ~90 m and C: 60 m along main profile)
- → Side profiles more or less parallel to crater rim (only 10 m height difference along both side profiles)
- → Differences between transients visible with increasing distance from the centre of Tx (main profile, Fig. 3)
- → Induced voltage decreases faster for transients of C (Fig. 3) → more resistive subsurface outside of crater

Main profile:
- → Each segment has a different behaviour (FL A to FL D, Fig. 4)
- → Clear difference between inside and outside of crater (Fig. 4)
- → 1D inversion of centre shows a similar model than TEM CL and AMT inversions (Fig. 5)

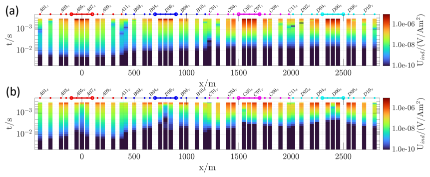


Figure 4: Fixed Loop Data. Transients along the NE profile. All loop positions and their respective receivers are indicated above of each panel. (a) presents the z-component, while (b) presents the x-component.

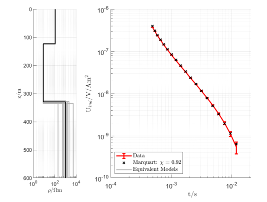


Figure 5: 1D Marquardt Inversion ANE06 (centre of the crater) using EMUPLUS

1D TEM Inloop and 2D AMT Inversions

1D TEM inversion using Emuplus (University of Cologne)
2D AMT inversion using MARE2DEM [6]

→ conductive Body in ~100 m depth
→ surface of conductor almost horizontal
→ max. thickness of ~300 m
→ conductive layer visible outside of crater

→ Small coincident loops cannot reach the lower boundary of the conductor near the centre
→ uncertainty of 1D models due to obvious 2D/3D (target geometry) and topographic effects

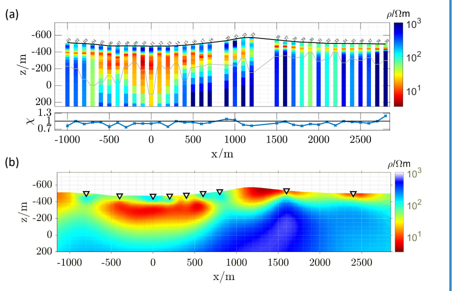


Figure 6: (a) 1D TEM Occam R1 inversion models presented in a 2D section along the main profile. The DOI after Spies [5] is indicated by a grey line. The lower panel shows the data fit χ. (b) 2D AMT inversion the downward facing triangles mark the sounding locations.

Conclusion & Outlook

- ➢ 1D TEM and 2D AMT inversions:
  - successful imaging of the crater infill despite the difficult conditions in the survey area
  - AMT worked well as a complementary method
  - presented results confirm the expectations
- ➢ Fixed Loop Data:
  - very consistent along the main and side profiles
  - behaviour of transients is different inside and outside of the crater
- ➢ Outlook:
  - 3D Inversion of FL Data

Acknowledgement & References

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[1] **Fudali, R.F.,** 1973, *Roter Kamm: Evidence for an impact origin*, Meteoritics, Vol. 8, No. 3
[2] **Brandt et al.,** 1998, *Geophysical profile of the Roter Kamm impact crater, Namibia*, Meteoritics & Planetary Science, 33, 447-453
[3] **Esri, Maxar, Earthstar Geographics, and the GIS User Community**, 2022, World Imagery [Data set], Accessed from https://services.arcgisonline.com/ArcGIS/rest/services/World_Imagery/MapServer/0
[4] **NASA JPL**, 2020, NASADEM Merged DEM Global 1 arc second V001 [Data set]. NASA EOSDIS Land Processes DAAC. Accessed 2022-08-29 from https://doi.org/10.5067/MEaSUREs/NASADEM/NASADEM_HGT.001
[5] **Spies, B.R.,** 1989, *Depth investigation in electromagnetic sounding methods*, Geophysics, 54 (7), 872-888
[6] **Key, K.,** 2016, *MARE2DEM: a 2-D inversion code for controlled-source electromagnetic and magnetotelluric data.* Geophysical Journal International, 207(1), 571–588. DOI: 10.1093/gji/ggw290.