Geophysics of terrestrial impact structures:
new data and modeling

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Impact studies?

Mass extinctions...and Recovery of life (with different species)!

Source of early life development?

Economic interest (ore minerals)

Planetology

Geological heritage
Geophysics?

- can reveal buried and/or altered craters
- can remotely detect syn- and post-impact processes, like hydrothermalism
- signals can be compared to similar signals over planetary surfaces
Geophysics?

- density contrasts → gravimetric anomalies
- magnetization contrasts → magnetic anomalies
- electrical conductivity contrasts → electrical anomalies
Terrestrial impact craters

~208 confirmed

Tunnunik

Rochechouart

Chicxulub

: in this study
Tunnunik

Diameter: ~25 km
Age: ~480 Ma
Type: complex
Target: sedimentary cover

~10 to 15 km / day in 2.5 weeks
Tunnunik

Correlation with ‘shatter cones’ area

Today: fractured zone of ~1 km thickness → how large was the erosion?

2D numerical model constrained by mag/gravi data + sample analyses

Quesnel et al., M&PS, 2020
Rochechouart

Diameter: ~23 km
Age: 205 Ma
Type: complex
Target: crystalline

- Lateral extent of drilled formations?
- Diameter?
- Crater floor?
Rochechouart

Drilling campaign in 2017
More than 510 m of cores!
All impactite lithologies observed in Rochechouart
Rochechouart

- Correlation between stratigraphic log and resistivity layers
- Melt-rich suevite layer - on top of topography - stores groundwater
- Suevite/gneiss and MR/MP suevite contacts are not flat (at local scale)

Quesnel et al., GGG, 2021
Conclusions

*Impact Craters/structures*

- concern many (all?) geoscientific topics
- ground truth for planetological studies
- 1 in France!

*Geophysics*

- powerful because of erosion/burial
- potential-field methods: anomalies...or not..but in all cases we must explain: due to target lithology? impactor size? erosion? post-impact hydrothermalism? → modeling (with constraints from samples)
Impact?

Impact at cosmic velocity

\( V > 11 \text{ km/s} \)

Increasing Crater Diameter

- **Pit**
  - 10 um
- **Simple crater**
  - Moltke (1 km)
- **Complex crater**
  - Euler (28 km)
- **Peak ring basin**
  - Schrödinger (320 km)
- **Multi-ring basin**
  - Orientale (970 km)

[Diagram showing various stages of crater formation and the resulting features such as fractured and brecciated target rocks, shocked target rocks, and impact melt rocks and breccias.]
Haughton

Diameter: 23 km
Age: 24 Ma
Type: complex
Target: 1.8 km sedimentary cover

Magnetization source?
Haughton

2013: local study + drilling

Predicted by modeling Quesnel et al., 2013

Impactite "anormale" : ~0.2
F2

Impactite "normale" : ~0.04
F3

Post-impact hydrothermal alteration

Zylberman et al., MAPS, 2017
Annex Haughton

Core samples showing anomalous magnetization with hydrothermal alteration

Post-impact hydrothermalism, and erosion, and accumulation

Zylberman et al., MAPS, 2017
Ground magnetic field survey at high spatial resolution (0.5 m) + ERT line

Intense magnetic anomalies are observed → suevite/gneiss contacts?

→ confirms gneiss/suevites geological contacts in this area

Rochechouart

Model resistivity with topography
Elevation: iteration 7, abs. error = 4.2

Mag mapping

NNE

Suevites

Gneiss quarry

SSW

U1-Melt bearing lithic breccia

U2-Gneiss, fractured

SC4

0 m

10 m

187 m

180 m-Crater floor

176.5 m

Severe alteration
Vesicles
Schliren, red matrix
Microgranite