GOCE gravimetric data and geophysical constraints to better understand the lithosphere under the Paraná-Etendeka region

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Introduction

• PERLA project: Paranà-Etendeka Regional Lithospheric Analysis

• Petrography and geochemical affinity on Paranà (South America → Brazil) and Etendeka (SW Africa → Angola and Namibia)
GOALS

• Aiming at the goal of better understanding the lithosphere under the Paraná-Etendeka conjugate margins (Brazil, and Angola-Namibia).

• Focus: Investigate on the magmatism unveil into the crust of Etendeka region

• Forward and Inverse Modeling: gravity anomaly → unveiling body masses
Methodology

• The proposed a methodology integrates the considerable progress made by gravimetric technology with the geological and geophysical information about the thickness and the density of main known geological layers
• e.g. sedimentary layers, crustal thickness and mantle inhomogeneities of deep layers
• NB: Geophysical data in Africa is scarce and private (oil companies)
Geophysical database at the state of art

- Topography: ETOPO1
- GOCE TIM_R4 Gravity field
- Shallow sedimentary layers
  - Sedimentary rock layers
  - Volcanic rock layers
- Medium layers:
  - Moho crustal layers:
- Deep layers: still under construction
Africa topography and geology
African sediment layers

Isopachs provided by:

• PLATES global model (Divins, 2003)
• Milesi et al. (2013): regional analysis with subsidence timing (GIS dataset)
• NOAA global off-shore dataset
Shallow layers
Database crustal thickness

- Crust 1.0, Crust 2.0 (Bassin et al. 2000; Laske et al. 2013)
- Airy root
Middle layer: Crustal thickness
Gravity Anomaly

(Pail et al., 2011)
Gravity effect of Sediment layers

- Constant density law
- Linear compaction law
- Exponential law
Linear compaction of sediments

<table>
<thead>
<tr>
<th>Depth [m]</th>
<th>Density [kg/m³]</th>
</tr>
</thead>
<tbody>
<tr>
<td>0-250</td>
<td>2200</td>
</tr>
<tr>
<td>250-2000</td>
<td>2300</td>
</tr>
<tr>
<td>2000-3500</td>
<td>2400</td>
</tr>
<tr>
<td>&gt;3500</td>
<td>2600</td>
</tr>
</tbody>
</table>

Mesozoic-Cenozoic sediment density:
2000 kg/m³ (Downey and Gurnis (2009))
2250 (Kadima et al. (2011b)).
Contrast density: 670-550-420 kg/m³
2670 at 8 km depth (linear decreasing: Buiter et al. 2012)
Exponential decay of sediment density

- \( \Phi_0 = 0.65 \) (initial porosity of the sediment)
- \( \rho_f = 1.030 \) (fluid density);
- \( \rho_s = 2.670 \) (rock, grain density);
- \( d = 0.0006 \) (exponential decay);
- \( z = \) depth

\[
\rho(z) = \Phi_0 \cdot e^{-d \cdot z} \cdot \rho_f + (1 - \Phi_0 \cdot e^{-d \cdot z}) \cdot \rho_s
\]
Exponential decay

<table>
<thead>
<tr>
<th>SAM EXPO [1/m]</th>
<th>Min Gravity effect mGal</th>
</tr>
</thead>
<tbody>
<tr>
<td>0.003</td>
<td>-17</td>
</tr>
<tr>
<td>0.0009</td>
<td>-50</td>
</tr>
<tr>
<td>0.0006</td>
<td>-72</td>
</tr>
<tr>
<td>0.0003</td>
<td>-130</td>
</tr>
</tbody>
</table>
Gravimetric total effect of sedimentary rock layers

- Total effect:
  1) Exponential decay for the ocean 0.0006;
  2) Linear compaction for PP
  3) Constant density C-J
Bouguer Anomaly and BA sediment corrected
Isostatic anomaly and Isostatic anomaly sediment corrected
Modeling

Positive anomaly →
- rocks denser than normal crust
  - Intrusion into the crust
  - Mass in underplating: anomalous body at the level of Moho layer

Negative anomaly →
- rocks less dense than normal crust
  - Sedimentary basin
  - Salt layers
Inversion modeling
Intrusion into the crust
Underplating case

Oscillation inverted prism for underplating: from 10 to 40, where Zref is 30 km

Contrast density=200 kg/m³
- First Guess Te30km
- Anomaly to explain
- Gravity Intrusion
- Residual Gravity
- Inverted Prism
- Crust1.0
- Topo
- Anomaly mass

Contrast density=300 kg/m³
- First Guess Te30km
- Anomaly to explain
- Gravity Intrusion
- Residual Gravity
- Inverted Prism
- Crust1.0
- Topo
- Anomaly mass
Oscillation inverted prism: from 1 to 15000, where Zref is 1 km
Conclusion remarks

• The western passive margin of Africa: Namibia is considered as volcanic margin underplating, while Angola is non-volcanic (Fernandez et al., 2009)

• Is the Angola passive margin also a volcanic margin too? (Tectonic Coastal Basin: Torquato, 1979, Alberti et al., 1992)
Thank you for your attention