UNIVERSITÀ DEGLI STUDI DI TRIESTE

DMG dipartimento di matematica e geoscienze

esa

PERLA
Paranà-Etendeka Regional Lithospheric Analysis

B685

GOCE OBSERVATIONS AND GEOPHYSICAL CONSTRAINTS TO BETTER UNDERSTAND THE LITHOSPHERE AND GEODYNAMICAL PROCESSES UNDER THE PARANA'-ETENDEKA REGION: PRELIMINARY RESULTS OF PERLA PROJECT

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1) GEOLOGICAL INTRODUCTION

The Paranà-Etendeka region is a part of a Large Igneous Province (LIP) that foreran the opening of the South Atlantic Ocean. This volcanic region was the south-western part of Gondwana, which belonged to one supercontinent, the **Pangea**, before the opening of the South Atlantic Ocean that lead to the creation of the South American and the African continents.
The shallow layers are relatively well known, in contrast to the deeper lithospheric layers and concerning the magmatic orgin of the LIP event. Here the lithosphere is investigated.

2) GOAL

Use the GOCE data and geopotential methodology to better understand the lithosphere under the **Paranà-Etendeka region** (South America, W-Africa).
Increase the knowledge of the lithosphere dynamic under this LIP.

3) METHODOLOGY

- ☐ Calculate the gravity anomaly from GOCE using two different heights of calculation, here only 10 km is shown. The global model developed in spherical harmonics is adopted (TIMR4, Pail et al. 2011).
- ☐ Gravimetric data is integrated with the geophysical data focusing on lithosphere.
- ☐ Make a forward modeling to compute the gravity effect of known layers (sediment isopachs, Moho).
- ☐ Calculate the Bouguer residual and use it during the inverse modeling.
- ☐ Make the inverse modeling to define the geometry (thickness and depth) of unknown layers inside the lithosphere.

4) GEOPHYSICAL DATA

A) TOPOGRAPHY

ETOPO1 (Amante and Eakins, 2009) resolution of 1 arc-minute (Fig.1).

B) GOCE GRAVITY DATA

Thanks to the good quality of GOCE data it is now possible to study wide areas, crossing several states and continents; the resolution is 80 km (Fig. 2).

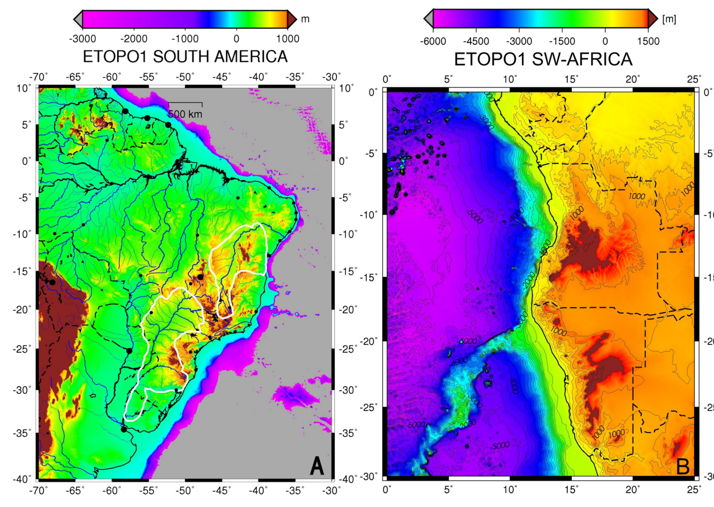


Fig. 1 Topography for the studied area, sampling of grid 0.01667° (1').

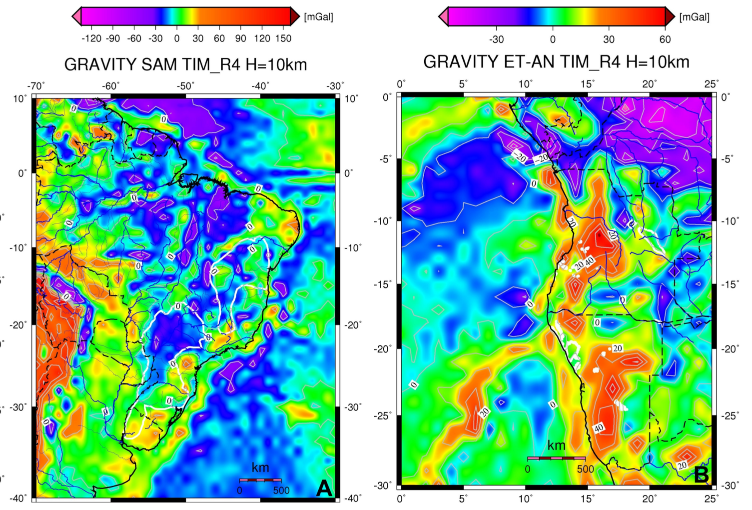


Fig. 2 Gravity anomaly with GOCE TIM4 model (Pail et al., 2011), height of calculation 10 km.

C) SEDIMENT ISOPACHS

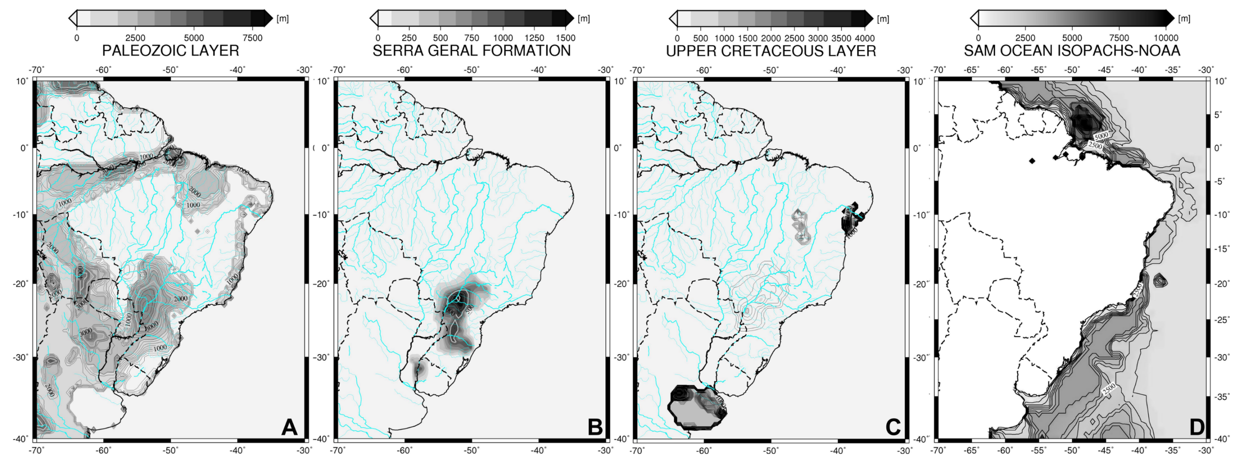


Fig. 3 Sediment thickness onshore and offshore in SAM continent (A, B, C); in D: SAM offshore according to NOAA dataset (Divins et al. 2003).

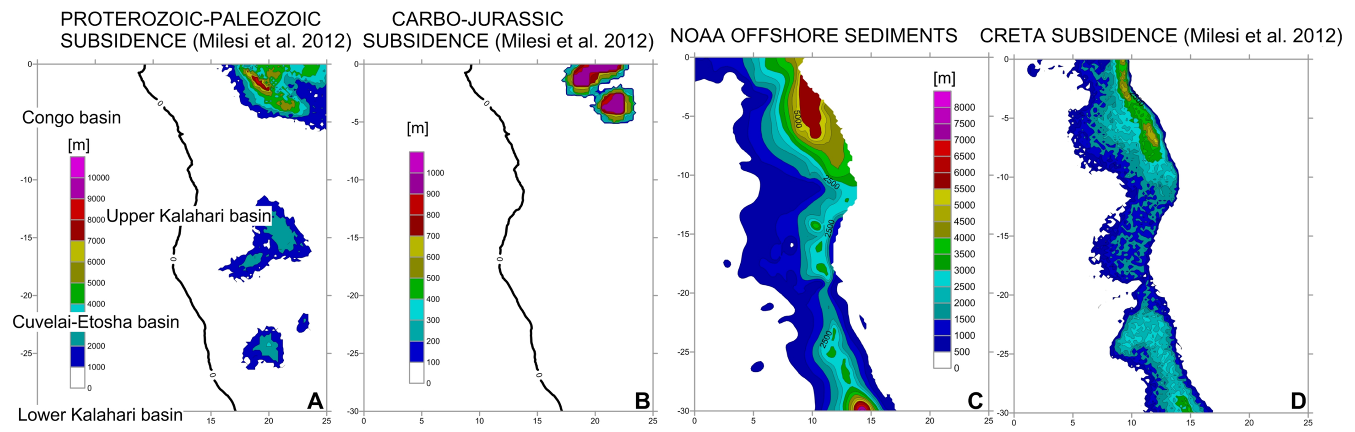


Fig. 4 Sediment thickness in Africa, according to Milesi et al. (2012).
A: Proterozoic-Paleozoic isopachs. B: Carbo-Jurassic layers. C and D: Comparison between offshore isopachs; C: NOAA sediment thickness and D: Milesi et al. (2012) filled contours with same color chart.

D) FORWARD MODELING OF SEDIMENT ISOPACHS

Thanks to the geological constraints it has been possible to compute the gravity effect of the singular known layers. Here the total gravity effect is provided (Fig. 5)

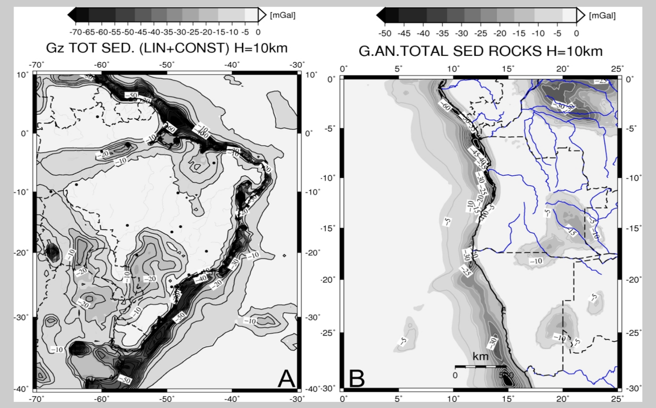


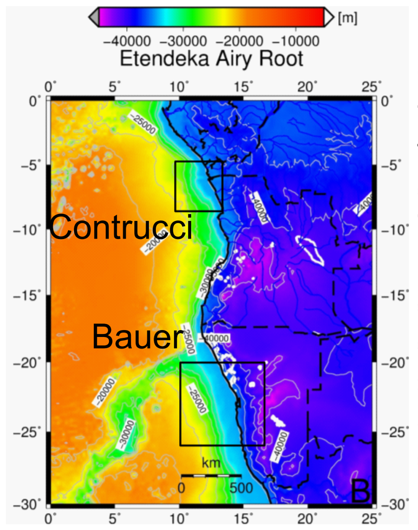
Fig.5 Forward modeling of known layers. A: SAM; B: S-W Africa.

Tab. 1 Density values in SAM and Africa sedimentary rocks.

		SW_AFRICA		SAM		
Compaction law	Rock type Age	Depth [m]	Density [kg/m³]	Rock type Age	Depth [m]	Density [kg/m³]
Linear	Sed. Proteroz.	0-250 250-2000 2000-3500 >3500	2200 2300 2400 2600 2670	Pre-volcanic sed. Paleoz.	0-3500	2400-2600
Constant	Sed. Carbo-Jurassic	2500	2300	Volcanic Lower Creta		2850
PARAMETERS EXPONENTIAL LAW: Decay: 0.0006 1/m; Water density: 1030 kg/m³; Grain density: 2670 kg/m³; Initial Porosity: 65%				Post-volcanic sed. Upper Creta		2200

E) SEISMOLOGICAL-SEISMIC MOHO AND AIRY MOHO IN SW AFRICA AND SAM

@ In South America seismological models of Moho are available (a review in Mariani et al., 2013).
@ In the oceanic area the geophysical constraints are given by Isostatic Airy model (Fig. 6).
@ In Etendeka a comparison between seismic and isostatic data is shown in Fig. 7.



Outlook: In the future the reference depth for the oceanic area could be decreased. The choice of the new values could be estimated with the agreement of singular Moho seismological depth in SAM and seismic point depth in Etendeka.

Fig. 6 Airy root Etendeka. The root is calculated using a density contrast of 530 kg/m3, and a reference depth of 35 km.

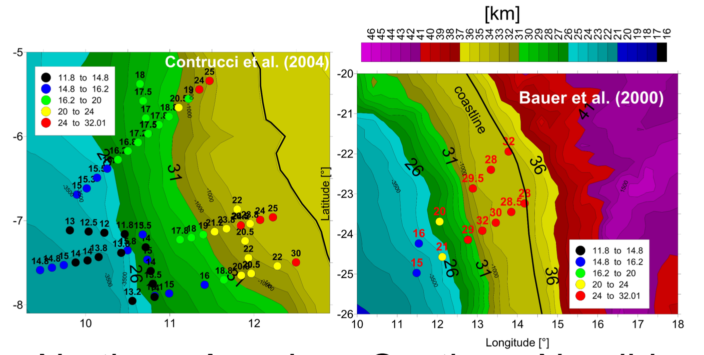


Fig. 7 Comparison between seismic Moho depths and Airy root along the Etendeka coastline.

5) INVERSE MODELING

Gravity inversion models are offered to quantify the residual gravity anomaly as unknown body.
The gravity anomalies are classified in two types:
1) POSITIVE → denser masses respect to normal crust, or normal mantle
2) NEGATIVE → less dense masses respect to normal crust

@ The positive gravity anomaly can be due to a magmatic activity connected to the Paranà-Etendeka province, and the negative to the presence of the sedimentary basins.
@ To perform the inversion, the fmincon function (Matlab) is applied.
@ At the state of art: the anomaly under the Paranà basin is preferentially inverted (SAM).
@ Positive area has almost the same location according to the three residual Bouguer anomaly models, with a range respectively from 125-75 mGal.
@ Deeper Moho belongs to Assumpção et al. (2013). Shallower belongs to Feng et al. (2007).
@ Wider positive area is localized in the northern part of rio Paraná (e.g. Assumpção).
@ We are going to model the anomaly as denser mass at different crustal depths under the Paraná region (Fig. 8).
@The choice of reference depth is done according to Moho depth.

5-1) MODELING IN CONTINENTAL AREA OF SAM

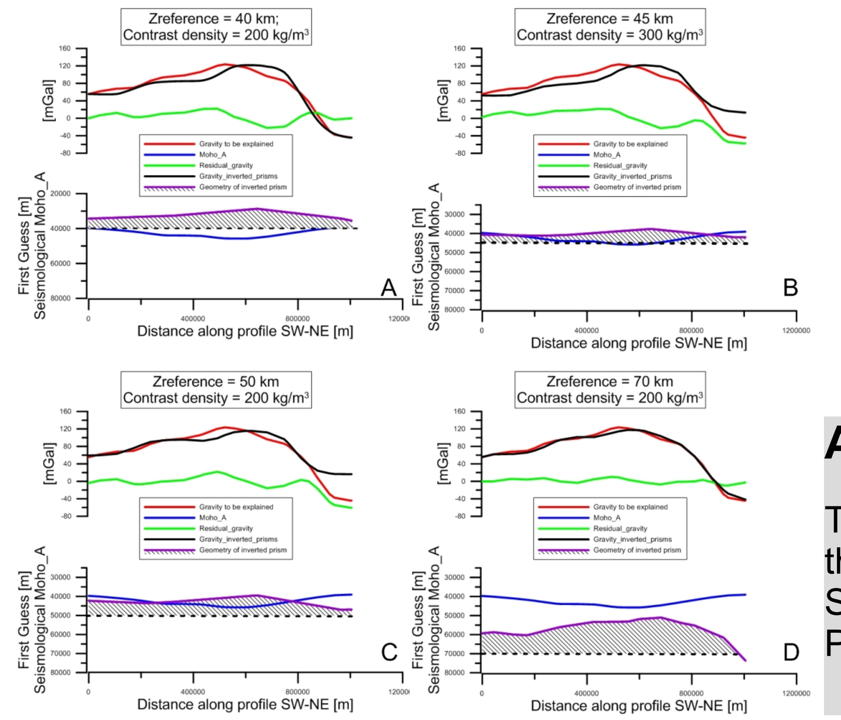


Fig. 8 The residual Bouguer anomaly, where the first guess is the Moho of Assumpção et al. (2013). The prisms define the density anomaly body.
Reference depth (Zref.) is 40 km (A); 45 km (B), 50 km (C), 70 km (D).

Acknowledgements

This work is supported by the ESA through the PERLA project (« Changing Earth Science Network Call for Research Proposals 2012»).

5-2) MODELING IN OCEANIC AREA OF ETENDEKA

ANGOLA PASSIVE MARGIN	NAMIBIA PASSIVE MARGIN
Magma-poor margin	Magma rich
Margin is dominated by tectonic processes without magmatic activity Thinned continental crust underlines a serpentinised and/or exhumed continental mantle	Volcanic activity, Seaward Dipping Reflectors, high velocity into the lower crustal bodies → magmatic underplating
von Nicolai et al., 2013, Blaich et al., 2011; Reston, 2009; Péron-Pinvidic and Manatschal, 2009; Reston, 2010.	von Nicolai et al., 2013; Fernandez et al., 2010; Bauer et al., 2000;

But in the Angola margin there are sampled rocks of rift-related magmatic activity, with the occurrence of dykes and intrusion (Jackson et al. 2000; Marzoli et al., 1999).

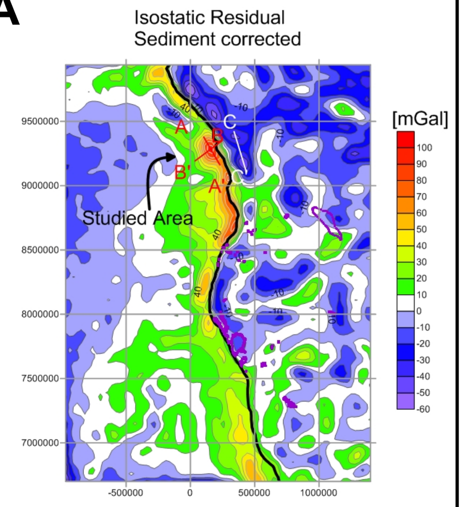


Fig. 9 Location of studied profiles. Purple lines: occurrence of the alkaline-carbonatite complexes (Milesi et al., 2012).

@ Focus on the possibility of an ancient volcanic margin activity along the Angola coastal sector: it could be the continuation of the coastal volcanic activity of Angola-Etendeka province, but the gravity high could be due to mantle densification.
@ The widest and the longest positive area is located along the passive margin of Angola and Namibia (Fig. 9).
@ The analyzed profiles A-A' and C-C' are shown in Fig. 10-11.

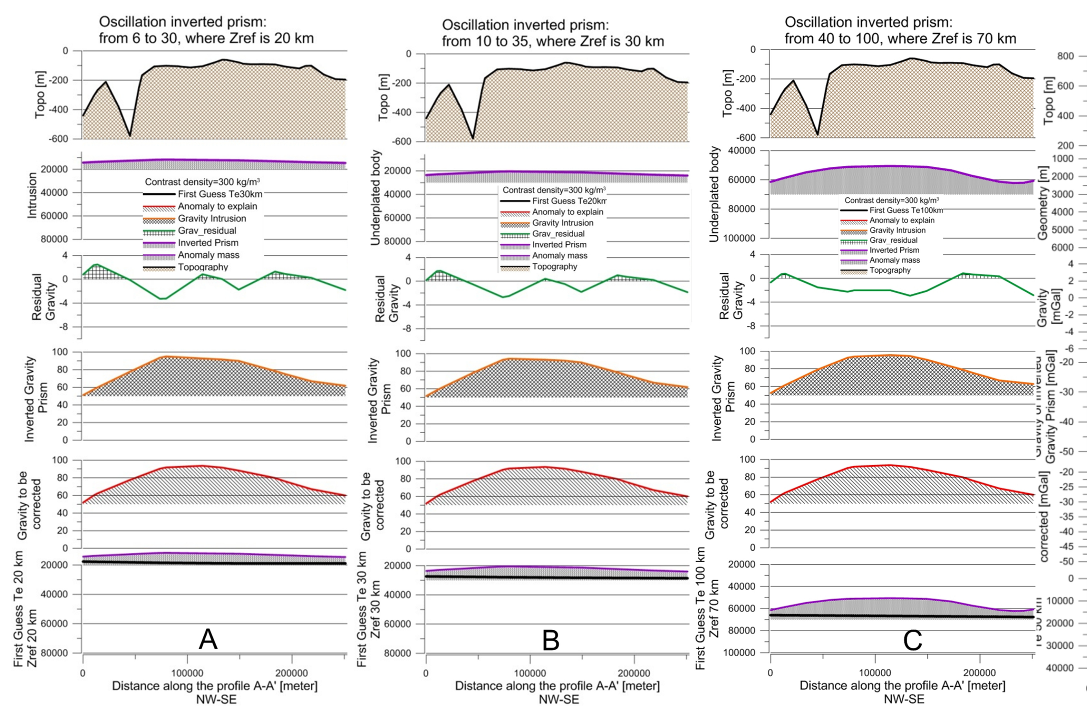


Fig. 10 Inverse modeling in the northern Angola basin. The model simulated in A: a mass intrusion, in B an underplating between crust and mantle, the Zreference is respectively: 20 and 30 km, and the contrast density is 300 kg/m³. In C the model simulates a mantle densification.

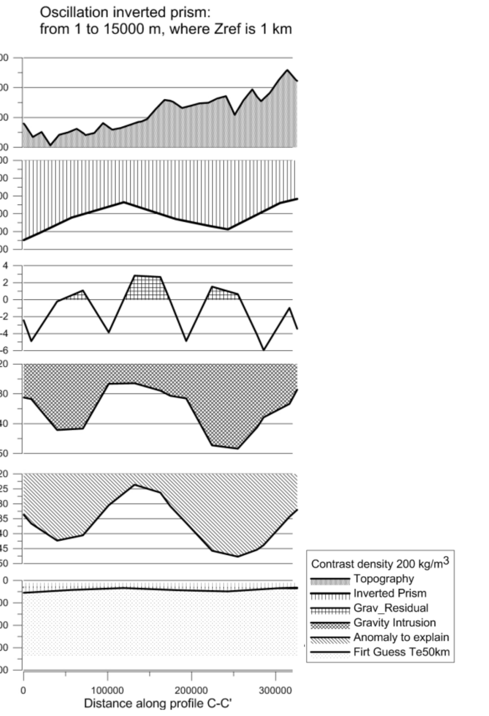


Fig. 11 Inverse modeling of a sedimentary basin, near Congo basin. The model simulates a sedimentary basin on land land, that was not integrated during the forward modeling. Contrast density -200 kg/m³.

6) PRELIMINARY RESULT

@ The gravity inverse modeling suggest missing mass inside the lithosphere under the Paraná-Etendeka province.
@ **Paraná**: we suggest the presence of underplating but also an anomalous mantle could explain the anomaly.
@ **Offshore area of Etendeka** positive gravity anomaly:
In the southern margin → underplating has already been considered,
In the northern margin it is clear that an anomalous body is concealed, maybe an → serpentinized mantle, as suggested in literature.
@ **SAM margin** again a positive anomaly.
@ NB: the layer of *volcanic LIP offshore* and saline domes are not integrated in the models.
@ The inclusion of saline dome could increase the positive anomaly.
@ More investigations to confirm our hypothesis have to be done in future.

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