Gondwana Breakup: The South American, African and Indian plate movements and remaining problems.

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Summary The reconstruction of Gondwana deals to a great extent with the geological history of Antarctica's rifted margins. All continents on the southern hemisphere had common boundaries with what is today Antarctica. Geophysical investigations of the last decades have discovered the first order geophysical and geological features, which are important to reconstruct the pre-breakup Gondwana plate positions back to 160 Ma. Continuous geoscientific research provided solid constraints on the movements of the major plates. In this contribution the current knowledge will be reviewed and the remaining problems will be highlighted. New marine magnetic investigations in the Mozambique Basin and across the Mozambique Ridge shelf allow to better constrain the movements between Africa and Antarctica. Furthermore, the new data allow to interpret the Mozambique Ridge as volcanic construct, which formed during the separation of both plates. Finally, first results from investigation of the Indian-Antarctic sector will be presented and discussed

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Geological mapping and geophysical data indicate that the geological history of the East Antarctic between Berkner Island in the west and Enderby Land in the east faced several geological events, which are not fully understood. The main information on the sub-ice geology is provided by aerogeophysical investigations. However, these surveys are somehow logistically limited to a region, which is parallel to the coast line. Thus, large parts of the inner Antarctic continent are only sparsely surveyed due to the lack of long-range aircrafts, which can operate also in these remote areas. As a consequence geological units, which are identified in the coastal or near coastal mountain ranges, cannot be followed into the interior. Thus, most of the models, which predict the continuation of the geological features from the surrounding continents into the Antarctic craton are still highly speculative. Thus, we concentrate in this contribution on the aero/marine magnetic investigations, which aim to further constrain the plate movements since 160 Myr, and thus provide a good fit. This might facilitate at a later stage the correlation of geological units across the continents, if there is any continuation. The areas and remaining problems from our perspective are described (Abbreviations: SAM-South America, ANT-Antarctica, FRS-Filchner-Ronne Shelf, EANT-East Antarctica, WANT-West Antarctica, AFR-Africa, IND-India):

South America-Antarctica

According to the latest models SAM was situated deep in the southern Weddell Sea. The break-up with the formation of oceanic crust started some 148 Ma (König and Jokat, 2006) with spreading rates around 1-2 cm/yr. Slow to ultra-slow spreading rates dominated the documented drift history of ANT and SAM. The magnetic anomalies in the southwestern Weddell Sea are –for unknown reasons- not well developed. A short high resolution magnetic survey along the Larsen rifted margin did not show any continuous magnetic anomalies, which would allow to better describe the evolution of this area. It is questionable, if a further densification of the existing data will provide better constraints than the existing ones.

Filchner-Ronne Shelf-EastANT/WestANT

We consider the FRS to consist mainly of highly stretched continental crust. However, in the centre of this huge sedimentary basin, some indications for the existence of oceanic crust can be deduced from deep seismic sounding profiles. This is supported by aeromagnetic data, which show at least four more or less continuous magnetic anomalies. They can be interpreted as edge or spreading anomalies. In our current geodynamic model we have introduced some moderate extension of the FRS to account for this observation.

Falkland Plateau (FP)
The distance between the Falkland islands and the easternmost part of the FP, the Maurice Ewing Bank, is almost 800 km. The nature of the underlying crust is speculative. It might consist either of stretched continental or oceanic crust or a mixture of both. Since the early geophysical investigations no critical new geophysical data were gathered to constrain the size of the FP in a pre-breakup configuration.

Mozambique Ridge
This ridge in the Indian Ocean is almost 700 km long, and is located almost parallel to the East African coast. Recent magnetic and seismic investigations show that the ridge might be of volcanic origin, and might have been formed during the separation of AFR and ANT. Magnetic anomalies in the strike of the ridge show high amplitudes, and are partly continuous within the survey area. The current model on the origin of the ridge is not unique due to the limited geophysical data sets. In any case, evidence for a large amount of volcanic material erupted between 130-100 Ma exists. If true, this region would have faced much more post break-up volcanism than previously expected.

Africa
The spreading system between AFR and ANT moved twice as fast as the SAM-ANT plate system. This might be an indication for separate "spreading cells", which received independently largely different volumes of mantle material to drive the plate drift. Recent conjugate magnetic investigations in the Riiser Larsen Sea and the Mozambique Basin confirmed models, which predicted a 155 Myr old spreading system. According to König and Jokat (2006) this area together with the Somali Basin was the first true oceanic basin, which formed within Gondwana.

India and Madagascar
Numerous models are published on the base of a growing geophysical data set. However, due to the line spacing of the magnetic data their interpretation is not unique. Furthermore, the role of the Kerguelen Plateau as a large oceanic plateau is questioned. Deep drilling has recovered continental rocks.
Currently a Japanese/German project tries to derive additional constraints on the separation of IND and ANT. The first results indicate that at least in the area close to the Gunnerus Ridge the oceanic crust has a different age than predicted in published models. A dense aeromagnetic grid indicates a lack of Mesozoic magnetic anomalies north of 67°S. One prominent magnetic anomaly is could be mapped close to the rifted margin of ANT. Therefore, the following interpretations are possible:

- This anomaly represents M0. This would shift the break-up of IND and ANT to much younger times than in published models.
- The magnetic anomaly is of continental origin
- It is an anomaly of the M-series, but the other anomalies are beyond the survey area. In this case the ANT/IND plates must have moved significantly faster than any model predicted.
- The survey is still located within the continent-ocean transition, and M-anomalies are located more to the north.

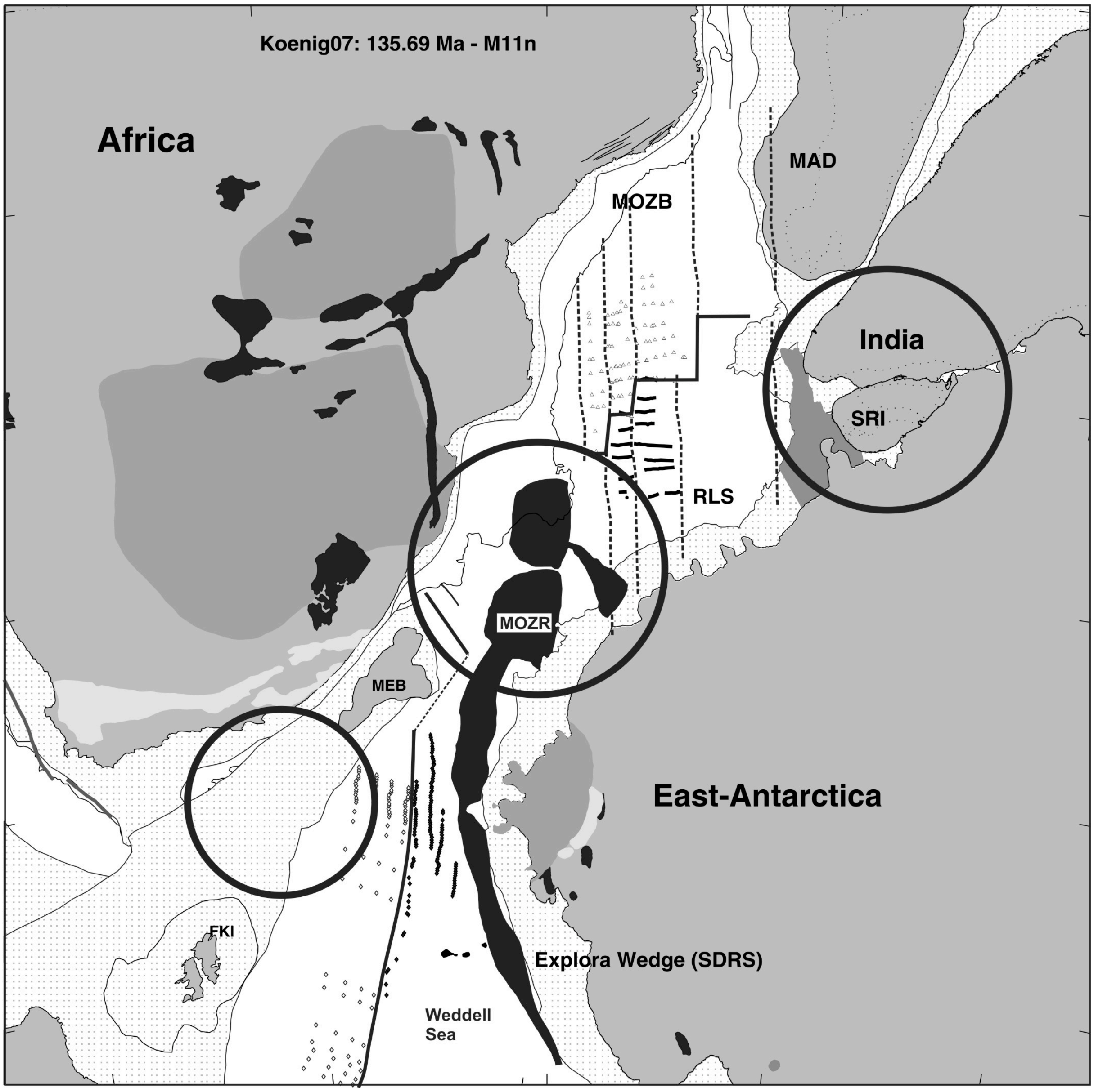

Figure 1: Gondwana Reconstruction at M11n time. The circles indicate the areas, which will specifically discussed in this study. FKI-Falkland Islands, MAD-Madagascar, MEB-Maurice Ewing Bank, MOZB-Mozambique Basin, MOZR-Mozambique Ridge, RLS-Riiser Larsen Sea, SRI-Sri Lanka, SDRS-volcanic seaward dipping reflectors

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