We want to thank the anonymous reviewer for the useful comments on our manuscript.

## Reviewer 1:

### The major comment from referee #1 is that we "should more clearly try to relate the observations to the continent-ocean-transition. Along line 1 the HVLC is an integrated part of the oceanic crust, i.e. this is anomalously thick oceanic crust related to higher than normal mantle temperatures, whereas on line 3 the HVLC is beneath continental crust."

This is a very good point and this is why we stated "This challenges the concept of a simple extrusive/intrusive relationship between seaward dipping reflector sequences and HVLC, and it provides evidence for formation of the HVLC at different times during the rifting and break-up process." However, this comment motivated us to further expand this issue in the manuscript and we added the following paragraph in chapter 5.2 "Relationship of high velocity lower crust and seaward dipping reflector sequences":

We do not have the advantage of densely spaced OBS stations as e.g. Mjelde et al. (2007) but we consider the inner SDRs sequences as being emplaced predominantly over extended continental crust (Hinz, 1981). This has led Planke et al. (2000) to argue that the arcuate, diverging reflection pattern in the inner SDRs are related to more numerous and thicker lava flows towards the rift axis where the largest accommodation space was created. The southernmost HVLC on the western South Atlantic margin likely lies below stretched continental crust but there is no corresponding SDR sequence. We consider this HVLC to represent intrusions into stretched continental crust, where magmas extrusion failed to take place or was so minor as not to show up seismically. The HVLC intrusions on this profile may have occurred before break-up and seafloor spreading. In the central portion of both conjugate margins, the HVLC likely represents a combination of lower crustal intrusions beneath the inner SDR sequences and later underplating that extends farther seaward. The proportion of magmatic underplating vs. crustal intrusion increases to the north, and in the northern margin segment underplating predominates. There, a major part of the HVLC was emplaced in the oceanic domain, leading to considerably thickened oceanic crust which is clearly of post-breakup age.

### A SDR sequence must have a ponding system in the lower crust, i.e. a corresponding HVLC, but a ponding system in the lower crust may not necessarily lead to extrusions

We agree that surface lavas, which the SDRs are intepreted to be, must have an intrusive equivalent, but this is not necessarily at the base of the crust in the observed HVLC. In fact, petrologic studies of the CFB basalts require low-pressure fractionation and thus high-level ponding. And yes, it is possible that magmas only intrude the crust and do not erupt at surface. That may be the explanation for HVLC without SDRs in the southern profile of South America. The proportion of intrusive to extrusive magmas is certainly complex and depends on many factors of crustal lithology, rheology and stress, all of which may change with time and along strike in an active rifting system.
Our point, and one main result of our study is that the SDRs and HVLC in the South Atlantic do *not* show the expected relations for simple extrusive / intrusive equivalents of the same magmatic event. Each SDR wedge may have a feeder and ponding system, but that is clearly not what the HVLC represents in many cases. The HVLCs on northernmost sections 1, 4 and 5 extend far seaward of the COB, and are therefore at least partly of postrift age, which would exclude a genetic relationship with the SDRs. On the other hand, the SDRs and HVLC in the central margin segments (sections 2,

6 and 7) do align vertically at the continent-ocean transition, and here they may be parts of the same magmatic event at break-up.

The authors should more clearly distinguish between rifting processes and processes related to the Tristan Plume.

This is a non-trivial problem because it is very likely that both processes took place together, at least in the northern segments and it is difficult to separate their effects. The presence of a hot spot at the present latitude of the Walvis Ridge is indicated by geologic and geochemical-petrologic studies of the magmatic record on both margins, not to mention the age-progressive hot spot track of the Walvis Ridge. It is also clear that there is major increase in the volume of HVLC from south to north toward the suggested hot spot position. While geologic and geochemical-petrologic studies of the magmatic record on both margins may indicate the presence of a hot-spot, the 4-fold difference in HVLC volumes across the margins is at least of similar magnitude as the along-margin variations, and this cannot be explained by variable proximity to the hot spot. The Paraná flood basalts are in fact more voluminous than their counterparts in the Etendeka province on the African side. This east-west contrast in HVLC is almost certainly related to the rifting process, and we have proposed a simple-shear scenario of rifting to explain it (see below).
If we accept that the northward increasing volumes of HVLC are related to the hot-spot, then the lateral position of the HVLC indicates that the influence of the latter became distinct only after rifting and breakup.

All minor comments have been addressed and corrected in the main text.

Minor comments:

Fig. 2, d: Your modelling seemed to have missed two significant arrivals; a strong middle/lower crustal refraction (10-25 km), and Pn (30-40 km). Could you please try to include these phases?

We added the missing Pg-phase on OBH2.1 (see updated Fig. 2d, middle and lower panel). This slightly increased the ray coverage in this area - so we updated Fig. 3b accordingly. We have not used the Pn phases for our tomography. Our approach allows only refracted waves above the reflector (Moho) and reflected phases from the Moho. This method is in detail described by Korenaga et al. 2000.

Fig. 8b: Could the black bodies be interpreted as something else than intrusions?
The "black bodies" are almost certainly intrusions. First, their seismic p-wave velocities are greater than their surroundings, they have a radially symmetric and coincident positive gravity and magnetic anomaly, and they lie directly under surface-exposures of Early Cretaceous gabbro intrusions (Messum, Cape Cross). These are described in detail by Bauer et al. (2003).

Line 332: You should mention that velocities above 7.2 km/s usually are related to anomalously high temperature in the melt, leading to higher Mg content (as described by White etc).

The reviewer is thanked for pointing this out, and we have added the following text to line 332:
It is important to note that the p-wave velocities in HVLC bodies on the northern margin segments are considerably higher than the value of 7.2 km/s which is typical for ocean layer 3, i.e., gabbro of

MORB composition. It has long been recognized (e.g. Keleman and Holbrook, 1995) that the higher Vp velocities of HVLC can be explained by magmas richer in Mg than MORB, which are the consequence of melting at anomalously high potential temperature. Trumbull et al. (2002) suggested from petrophysical models that the HVLC intrusions on profiles 4 and 5 have 14 to 18 wt.% MgO, consistent with melting at 150 to 200°C excess temperature compared with average MORBs.

## Reviewer 2:

The authors should describe in more detail how the crustal structures used in gravity modelling (Figs. 5 and 6) have been obtained. Note that the seismic data presented in Figs. 2 and 3 are far to reproduce the fine structure of the upper-middle crust depicted in gravity modelling.

The upper crustal structures were obtained from reflection seismic data. This includes the subdivision of the postrift sediments, the basement the SDRs as well as the synrift graben. The referee is absolutely right in stating that there is no basis for a subdivision of the gravity model into an upper and a lower crustal unit. We could have modeled the crust with an average density or guess the approximate position of the boundary between upper and lower crust. Both approaches have their limitations. Most important in our view is the fact that either approach has no effect on the results and conclusions obtained.

The northern part of the study region is clearly affected by the Tristan plume (Parana-Etendeka margins), which is responsible for anomalously high potential mantle temperature and magma generation (flood basalts and anomalously thick oceanic crust). The effects of Tristan plume superpose to those related to passive extension and rifting.

This is a non-trivial problem because it is very likely that both processes took place together, at least in the northern segments and it is difficult to separate their effects. While geologic and geochemical-petrologic studies of the magmatic record on both margins may indicate the presence of a hot-spot, the 4-fold difference in HVLC volumes across the margins is at least of similar magnitude as the along-margin variations, and this cannot be explained by variable proximity to the hot-spot. In addition this is in sharp contrast to the Paraná flood basalts which are in fact more voluminous than their counterparts in the Etendeka province on the African side. This east-west contrast in HVLC is almost certainly related to the rifting process, and we have proposed a simple-shear scenario of rifting to explain it. If we accept that the northward increasing volumes of HVLC are related to the hot-spot, then the lateral position of the HVLC indicates that the influence of the latter became distinct only after rifting and breakup.

One of the main conclusions raised is that the South Atlantic margins obey to a simple shear mode of deformation. Perhaps the authors can add some discussion about. Definitely, a scheme or cartoon showing a lithospheric cross-section with the polarity of the simple-shear mechanism would help very much in understanding the proposed model.

Thank you for this suggestion. We added a cartoon (Figure 10) showing the supposed westward-dipping major detachment fault and the mechanism that may explain the major asymmetry in the HVLC across the margins.

All minor comments have been addressed and corrected in the main text.