Forward Modelling of KTB Gravity Data

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Introduction
The aim of the project is the development of a structural model of the KTB region covering the extended area of the ISO 89 experiment. For that purpose integrated information is used: gravity (borehole and surface) / seismic / magnetic / geology.

Field Data - Borehole
Borehole gravity measurements were carried out as well in the pilot hole to the final depth of 4000 m (102 stations) as in the main hole from 650 m to 6000 m depth (109 stations). The spacing came up to 10 to 50 m.
The resulting Bouguer anomalies and the apparent density log in comparison with the cutting density log are presented in Fig. 1. The good correlation with the lithology, that is the alternating layering of gneisses and amphibolites, can be seen.The continously decreasing gravity below a depth of 3500 m (see Fig. 1a) suggests that the amphibolite/metabasite found down from a depth of 2650 m belongs to a massive body which is not drilled through as far as the profile end. The distinct lower apparent density (up to 0.15 g/cm³) in the same depth range (Fig. 1b) indicates that the borehole is located at the margin of this massive body. The comparison with the surface gravity shows that this body dips steeply towards NE.

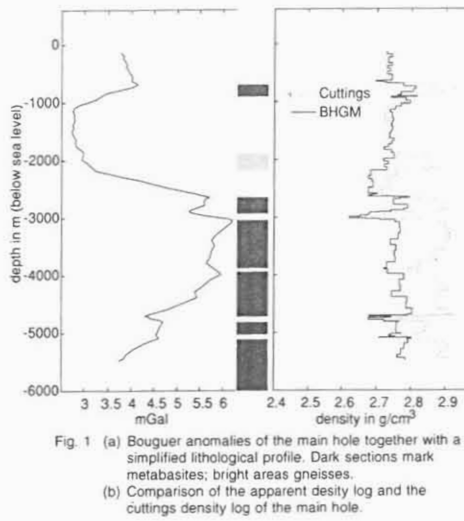

Fig. 1 (a) Bouguer anomalies of the main hole together with a simplified lithological profile. Dark sections mark metabasites; bright areas gneisses.
(b) Comparison of the apparent desity log and the cuttings density log of the main hole.

Field Data - Surface
The NLfB, the University Bochum, the University München and the University Berlin conducted a surface gravity survey to increase the station density. Now the gravity values of 1800 stations in an about 60 x 60 km large area are at hand. The average spacing is about 500 m in the inner area and about 2000 m in the outer area. Figure 2 shows the Bouguer map which reflects well the main geological units. The outstanding features are two connected maxima in the centre caused by the dense rocks of the ZEV. The extended minimum of Tirschenreuth east of the maxima corresponds to the less dense granitic areas.
The mesozoic sediments SW of the ZEV are characterised by rather constant gravity values.

Application of Potential Methods
The second vertical derivative map of the surface gravity data (Fig. 3) correlates very well with the outcropping geology. Within the ZEV the amphibolite zones can be clearly distinguished from the adjoining gneisses. Moreover the run of the Franconian lineament (FL) is distinctly marked by the narrow minima zone running from NW to SE. Besides that the map corresponds well with the anomaly map gained from aeromagnetic measurements.

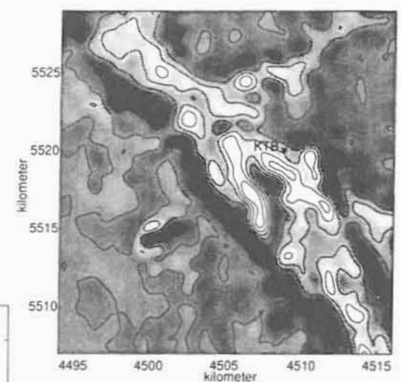

Fig.3 Map of the second vertical derivative of the surface gravity data.

Inversion
The present preliminary 2D model of the direct borehole vicinity (Fig. 4) follws in its general built-up the geologic model of Hirschmann (1994). It considers the drilling results concerning rock densities and lithological succession as well as the elements SE1 and SE2 determined from the ISO 89 data. The fit between the measured Bouguer anomalies and apparent density log and the calculated ones is very good (Fig. 5).
The 3D model will be developed for the 40 x 40 km large area marked by the frame in Fig. 1. It is devided into 39 vertical planes with a spacing of 1 km in the centre and 2 km in the periphery. The planes are oriented vertical to the general strike of the ZEV. The central plane of the present model across the drilling location is shown in Fig. 5. The main structural units are the Falkenberg granite in the NE, the ZEV in the middle and the sediments beyond the FL. In addition the "Erbendorfbody" is considered. The fit between measured und calculated Bouguer anomalies is very good, whereby it is necessary to suggest an extended body of higher density below the sediments.
Until now there are some discrepancies between the two models, eg. the allocation of the amphibolite bodies in the direct borehole vicinity and the run of the eastern granite margin. These discrepancies are probably caused by the 2D character of the borehole vicinity model.
Model calculations were carried out to evaluate the effect of a less denser cataclastic zone from 6200 m - 6400 m in the main hole, corresponding to the SE1 on the Bouguer anomalies and apparent density log down to a depth of 9000 m. Moreover the effect of the possible reverse faulting with a throw of about 2 km of the "Erbendorfbody" on the borehole gravity profile was calculated (Fig. 7). These model calculations show that it should be possible to separate these structures in a borehole gravity profile conducted from the present 6000 m to the final depth.

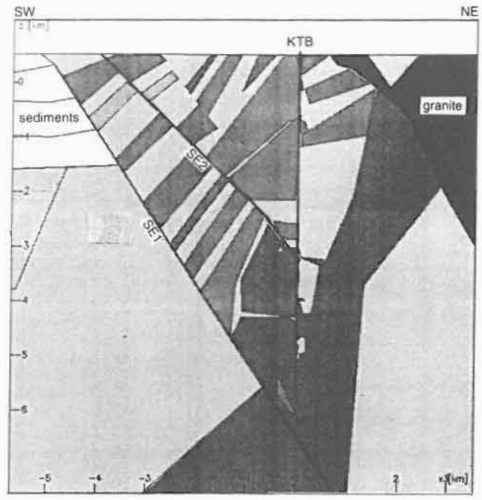

Fig. 4 2D model of the direct borehole vicinity. The sediments in the SW, the ZEV, onsisting of gneisses and metabasites and the granite in the NE can be distinguished.

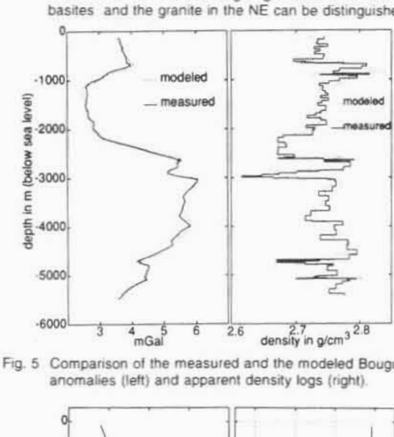

Fig. 5 Comparison of the measured and the modeled Bouguer anomalies (left) and apparent density logs (right).

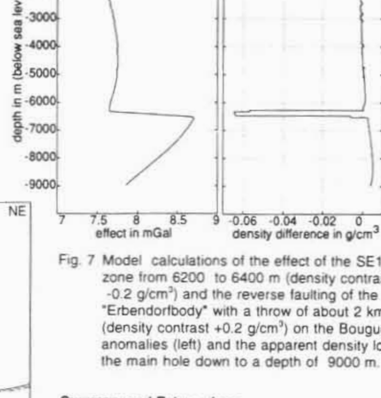

Fig. 7 Model calculations of the effect of the SE1 fault zone from 6200 to 6400 m (density contrast -0.2 g/cm³) and the reverse faulting of the "Erbendorfbody" with a throw of about 2 km (density contrast +0.2 g/cm³) on the Bouguer anomalies (left) and the apparent density log of the main hole down to a depth of 9000 m.

Summary and Future plans
The present outcomes of the forward modeling yielded geologic/geotectonic interpretable results. Discrepancies between the borehole and the surface model will be eliminated. The 3D model will be continously improved considering further geophysical and geological results. Concerning the deeper part of the model and the direct borehole vicinity the importance of the prolongation of the borehole gravity log was demonstrated above.

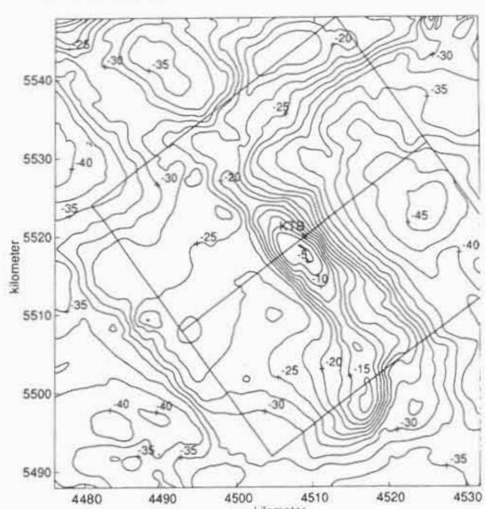

Fig. 2 Map of the Bouguer anomalies of the KTB area. The inserted lines mark the area of the model respectively the orientation of the model planes presented below.

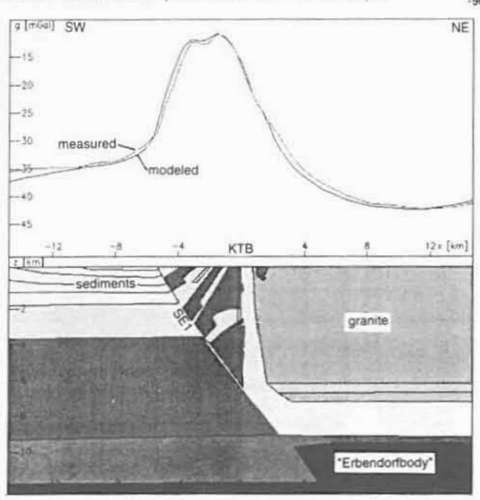

Fig. 6 Central plane across the drilling location of the 3D model. In addition to the structural units of the 2D model, the "Erbendorfbody" is considered.