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5.2. First Attempt of Gravity Map Stripping in the South-Eastern Bohemian Massif

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With 6 Text-Figures

Abstract

In this paper first results of gravity map stripping are presented considering both the gravity effect of the crust–mantle boundary and the low density of the Molasse sediments in Lower Austria. It can be shown that anomaly patterns at the eastern margin of the Bohemian massif are markable changed. This especially is valid for the NNE–SSW striking positive anomaly near Hollabrunn which decreases by about 10 mGal compared with the absolute Bouguer maximum of the Austrian part of the Bohemian massif situated in the Raabs–unit.

1 Introduction

Since 1990 a new detailed gravity map is available, which completely covers the Austrian part of the Bohemian massif and the adjacent parts of the Molasse zone in Upper and Lower Austria (MEURERS et al., 1990). The map is based on about 5500 gravity stations evenly distributed with a station interval of at most 3 km. In some regions of local interest a much higher station density was established. The gravity net was tied to several first and second order absolute gravity stations to guarantee the correct datum. Bouguer anomalies were determined using the geodetic reference system 1980 and the mean Adriatic sea level as reference plane. Normal gravity and vertical gradient formulas considering also the second order terms were applied. Mass corrections were calculated spherically up to a distance of 167 km applying a reduction density of 2670 kgm^{-3}. This value is near to the mean density of the surface rocks in that region. The quality of the data is very good due to the generally smooth topography and using exclusively stations with precisely determined coordinates. Small errors far below 0.1 mGal can be expected in Bouguer gravity determination.

Compared with the old regional map published by the Bureau Gravimetrique International (BGI) in 1964 already the Bouguer gravity (Fig. 1) shows an unexpected highly structured anomaly pattern also in areas where the cristalline rocks are covered by low density sediments of the Molasse basins. In the eastern transition zone to the Molasse basin between Retz and Hollabrunn the gravity effect of the sedimentary filling with increasing thickness towards the East is obviously masked by deep reaching basement structures (MEURERS & STEINHAUSER, 1990). The gravity field here is partly caused by the relatively low density of the socalled Thaya batholite which extends near Retz in NNE–SSW direction. This gravity low is followed in the East by a marked zone of positive anomalies striking in the same direction. In this way an interesting negative-positive anomaly couple is formed which dominates the gravity effects of the Molasse sediments.

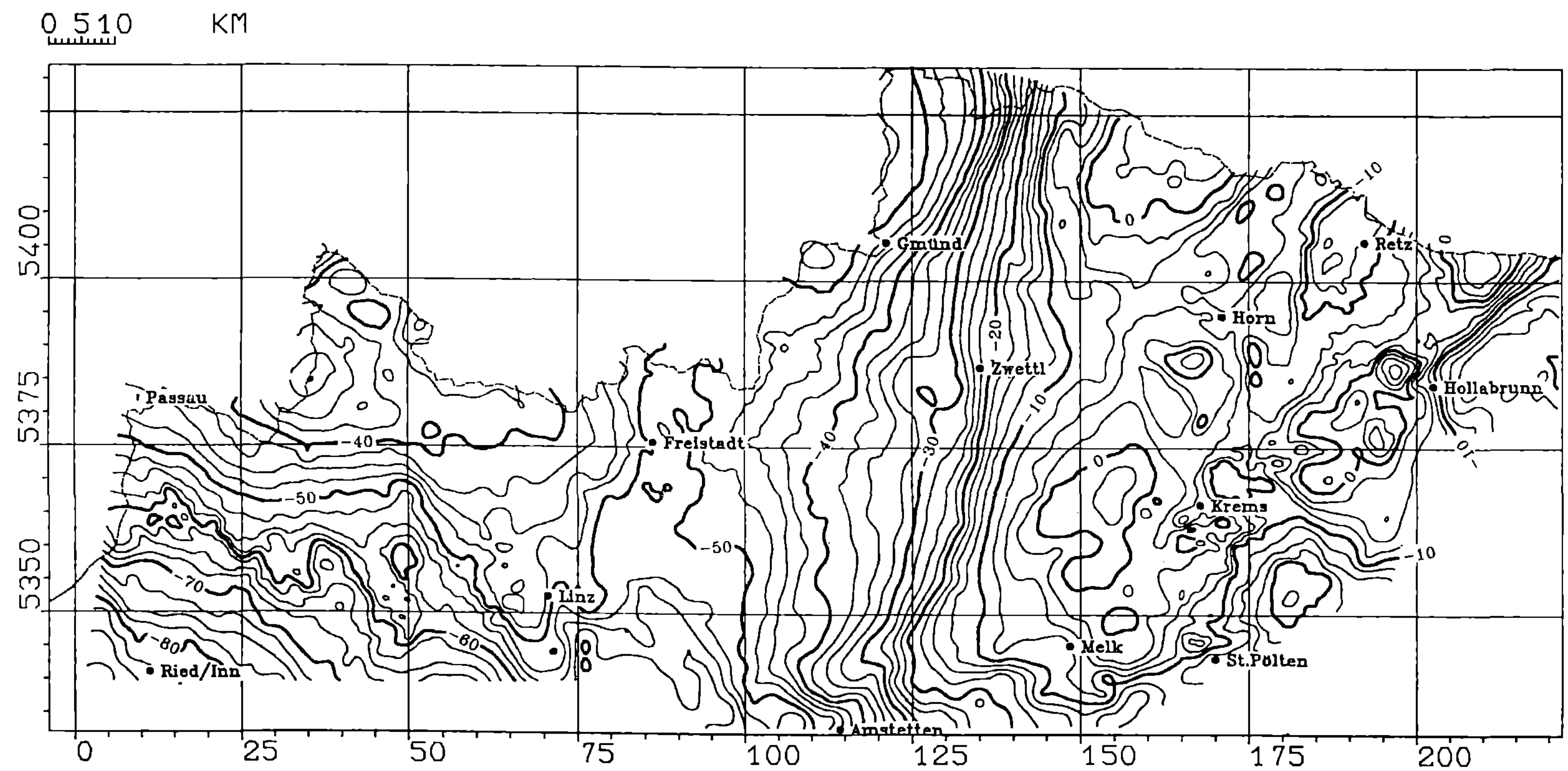

Figure 1: *Bouguer gravity map of the southern Bohemian Massif (*MEURERS *et al., 1990) contour interval: 2.5 mGal*

The margin of the Bohemian Massif in general is marked by a high gradient zone including several short wavelength anomalies caused by rim synclines. Only in the western part of the map the regional trend of the Bouguer anomaly seems to be guided by the gravity effect of the Mohorovičić–discontinuity, while beginning in the region near Linz the upper crustal structures become dominant more and more.

2 Gravity effect of the Mohorovičić–discontinuity

A first it is of special interest to estimate the gravity effect of the crust–mantle boundary. The depth of the Mohorovičić–discontinuity is well known in the territory of the CSFR, Hungary and beneath the main crest of the Eastern Alps (ALBU et al., 1989). For the region of Southern Germany a corresponding map is available published by GIESE & PRODEHL (1986) which fits very well to the results of Albu et al. Unfortunately the Moho depth is not well defined beneath the Bohemian Massif in Austria. In that area a boundary model can only be interpolated assuming that no local variations of the Moho depth exist (MEURERS, 1990). Under this assumption a flat ridge structure can be expected in the western and central part followed by a boundary slightly ascending towards the East (Fig. 2).

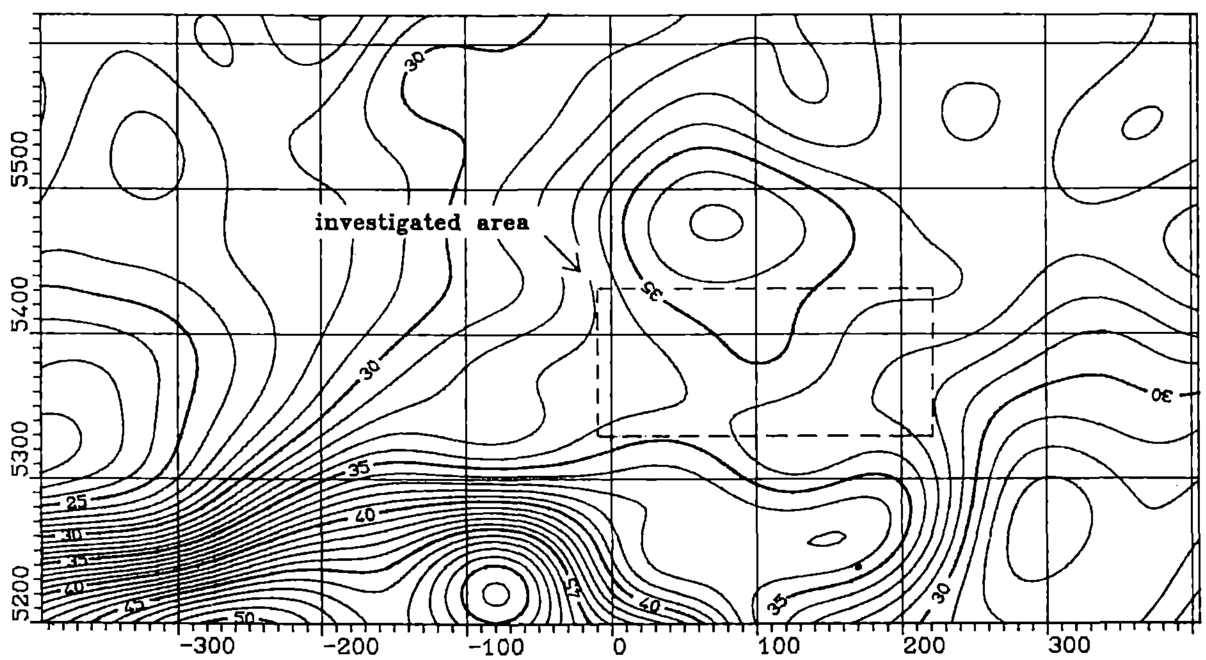

Figure 2: *Model of the Mohorovičić–discontinuity beneath the Bohemian Massif based on the maps of* ALBU *et al. (1989) and* GIESE & PRODEHL *(1986)*

The gravity effect of the crust–mantle boundary was calculated applying the well known discrete Fourier transformation–method of PARKER (1972). It has to be emphasized that this method assumes a plane approximation and does not consider the curvature of the earth surface. Due to this algorithm an off–set effect occurs and it can be possible that a small regional trend remains in the gravity distribution. A constant density contrast of 400 kgm^{-3} between lower crust and upper mantle material was assumed corresponding to seismic results in that region. Fig. 3 shows the residual gravity determined by subtracting the Moho–effect from the Bouguer anomaly and correcting the off–set to keep the same gravity mean value as in the original map.

Remarkable differences between both maps can be observed. Especially this refers to the NNE–SSW striking high gravity zone in the West of Hollabrunn, where the anomaly diminishes by about 10 mGal relative to the gravity maximum connected with the Raabs–unit in the Northwest of Horn due to metamorphic rocks with an high content of amphibolites. That means the Bouguer gravity increasing towards the East can partly be explained by the undulation of the crust–mantle boundary.

The stripped gravity map can be compared with an the isostatic residual field calculated by determinition of the gravity effect of an Airy–Heiskanen root which is based on the same digital topographic height model as applied for terrain corrections of the zone far away from the gravity stations. Again the PARKER–formulas have been applied. The resulting anomaly pattern is very similar to the stripped gravity map. This agreement indicates a more or less isostatic compensation in the region of the Bohemian massif. The main part of the residual anomalies are obviously caused by upper crustal structures.

3 Gravity effect of the Molasse sediments

A second step consists in determining the gravity effect of the low density Molasse sediments. The question how far the Bouguer map is influenced by these effects is especially interesting at the eastern margin of the Bohemian massif, where the negative–positive anomaly couple is masking the gravity of the sediments with increasing depths towards the East. The results shown in this paper can only be considered as a first attempt, because till now not all informations available about the basement structure and density distribution could be evaluated for this purpose. The calculations are based on the Molasse basement relief map of BRIX et al. (1979), which covers the region between Steyr and the northern part of the Viennese basin. A map of the complete Molasse zone in Upper and Lower Austria is just under construction, therefore gravity map stripping concerning the Molasse sediments can only be performed for the eastern part of the Bohemian massif. The gravity effect was determined applying PARKER's formula assuming a density contrast of 300 kgm^{-3}, that corresponds to a surface density of the Molasse sediments between 2400 and 2500 kgm^{-3}, which is quite realistic.

The basement model stops in the South, where overthrusting by the Alpine units is beginning. Along of this tectonic lineament the model assumes a more or less vertical boundary. A vertical fault gravity effect has to be expected there, which of course is not realistic. But because of the large distance this problem does not disturb the anomaly pattern at the margin of the Bohemian massif and therefore can be neglected. The parker algorithm may only be applied if the lower and upper surface limiting the density inhomogeneity can be described by single valued functions. Therefore vertical fault structures within the basement area can not be modelled exactly in this method.

Fig. 4 shows the basement depth distribution compiled by digitizing the map of BRIX et al. (1979) and interpolating a 4 km $\times$ 4 km grid. The contour lines describe the basement depth below Adriatic sea level. In Fig. 4 the outcrop line of the cristalline rocks at the northern margin is symbolized by stars. For interpolation of the basement surface mean topographic heights from a high resolving digital height model of Austria (STEINHAUSER et al., 1984) have been used here. Additionally all digitized data points defining the interpolation surface are shown in Fig. 4. The resulting gravity effect amounts up to more than 20 mGal in the deepest parts of the area under investigation, but deminishes very fast towards the inner part of the Bohemian massif as clearly

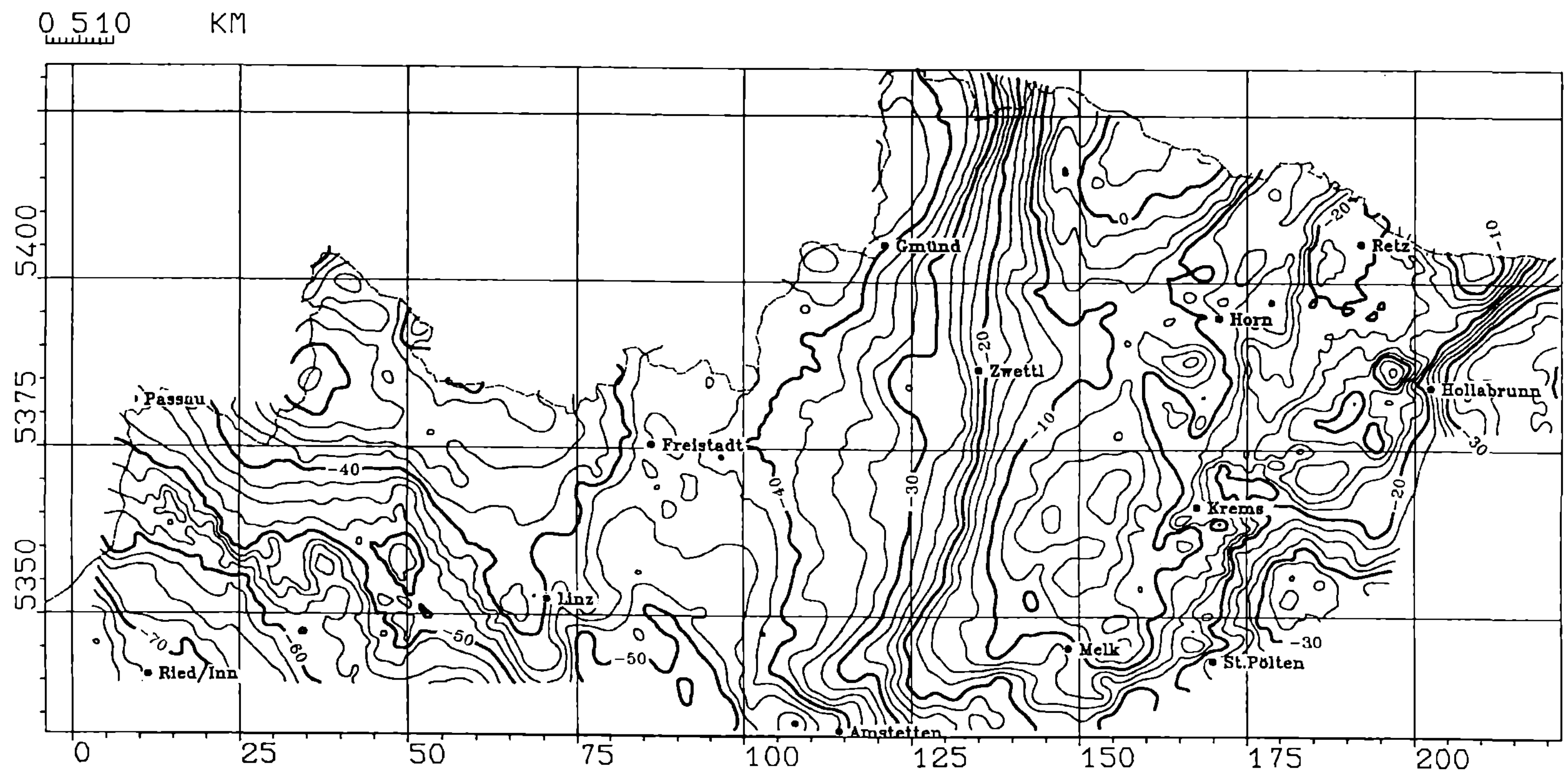

Figure 3: *Stripped Bouguer gravity map of the southern Bohemian Massif (Moho gravity effect subtracted), contour interval: 2.5 mGal*

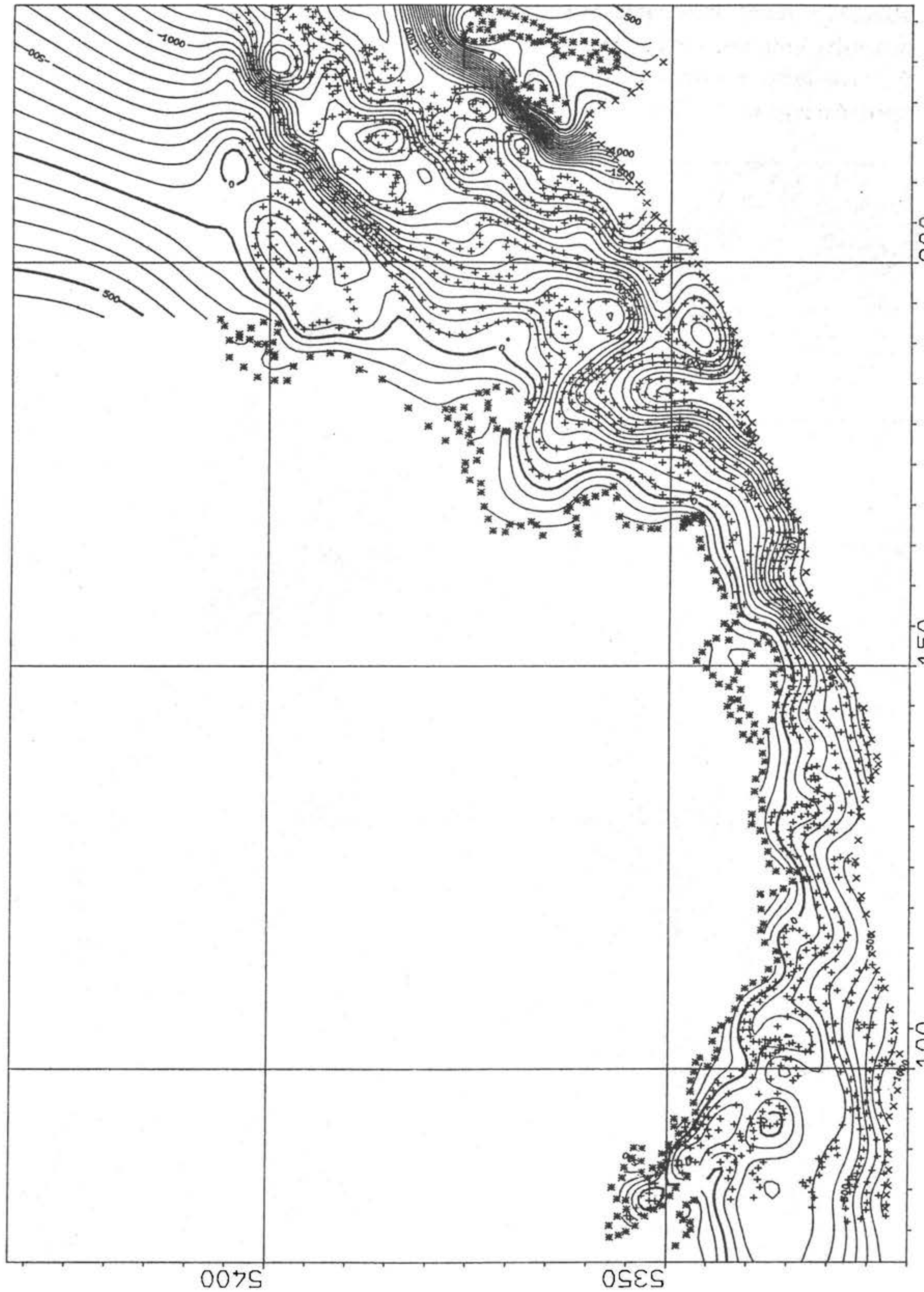

Figure 4: *Basement of the Molasse in Upper Austria (after* BRIX *et al. (1979)*
**, ×: northern resp. southern margin of the Molasse zone*
contour interval: 100 m

can be observed in Fig. 5. The high gradient zone in the South marks the southern end of the Molasse model. As mentioned above this anomaly pattern has no geological meaning. The same is true for the region north of Gauss–Krüger x–coordinate 5420 km, where the Molasse model is not defined.

The preliminary result after subtracting the gravity effect of the crust–mantle boundary and the low density sediments of the Molasse zone is presented in Fig. 6. The high gradient zone connected with the course of the Mailberg fault near Hollabrunn is almost removed. The negative anomaly remaining in the East after correction shows the same order of magnitude as the

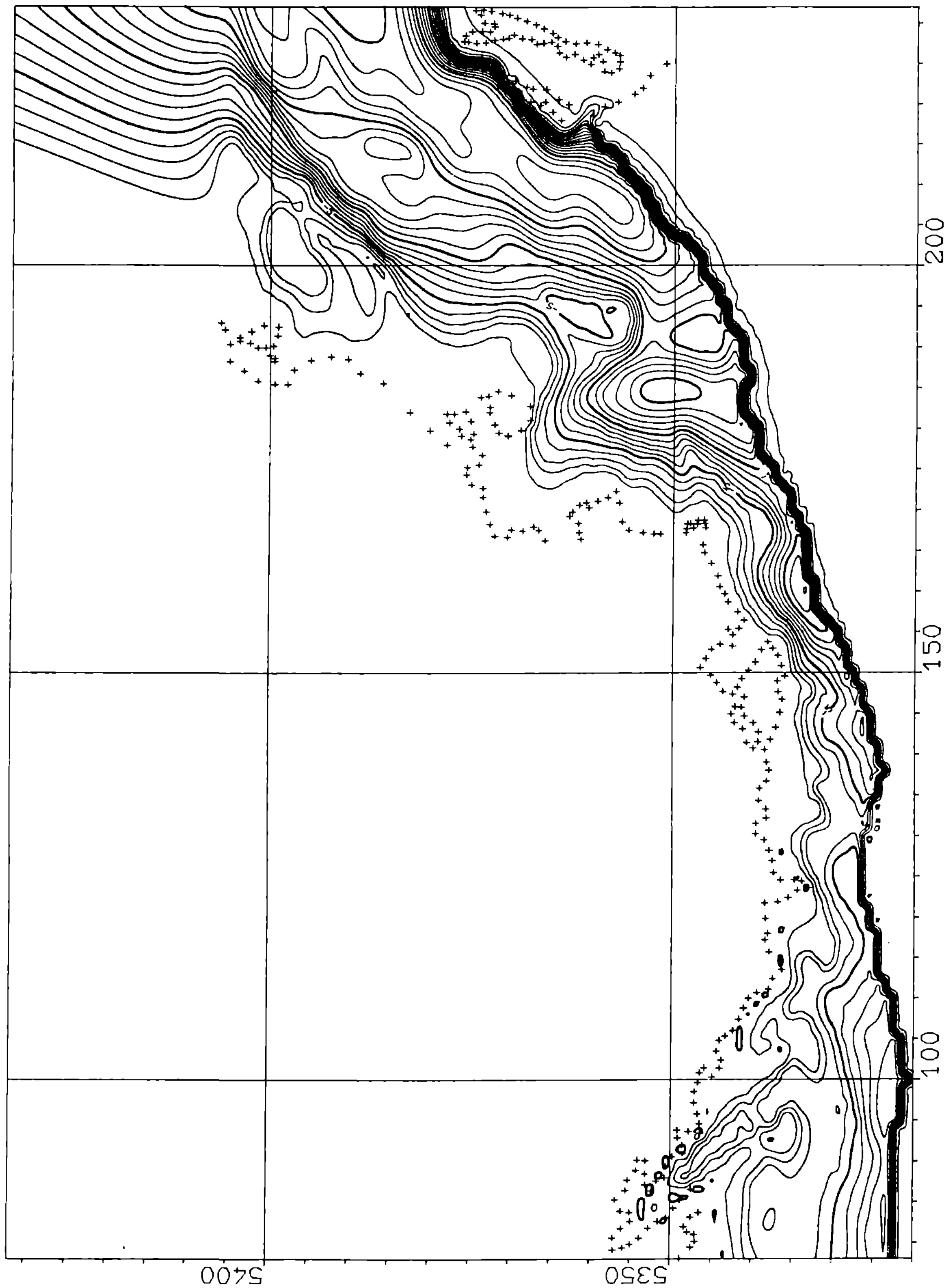

Figure 5: ***Gravity effect of the Molasse sediments in Upper Austria***
density contrast: 300 kgm^{-3}, contour interval: 1 mGal
+: northern margin of the Molasse zone

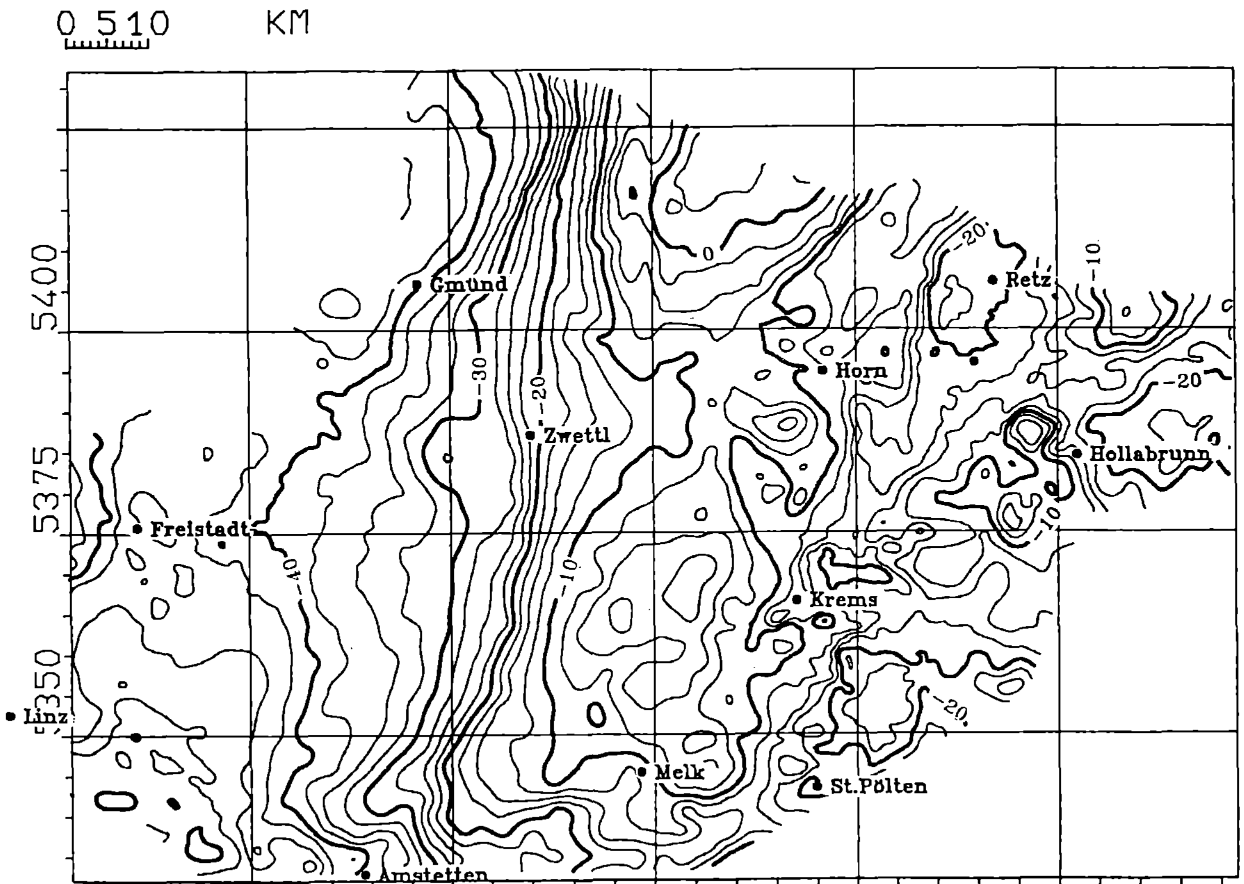

Figure 6: *Stripped Bouguer gravity map of the southern Bohemian Massif (gravity effect of Molasse sediments and Moho subtracted) contour interval: 2.5 mGal*

negative anomaly near Retz which is caused by the Thaya batholite. This is also true for the anomaly pattern near Herzogenburg. These anomalies enclose a NNE–SSW striking zone of positive gravity. In the original Bouguer map very high gravity values similar to the situation in the Raabs–unit could be observed here. In contrast the stripped gravity map shows anomalies in that area, which are reduced by about 10 mGal, and therefore the absolute gravity maximum of this map is now situated within in the Raabs–unit.

Of course this result is only a preliminary one. As clearly can be seen in Fig. 4 a better resolution of the basement structures especially at the margin of the Bohemian massif is necessary. Some recent seismic investigations at the eastern margin (Retz, Röschitz, Herzogenburg) give valuable contributions and will be considered in a new basement map. With additional informations about the density distribution of the Molasse sediments model calculations assuming a density exponentially increasing with depth (GRANSER, 1987) will be performed, which is much more realistic than using a constant density contrast.

4 Conclusions

The comparison of the stripped gravity map after elimination of the crust–mantle boundary effect and the residual isostatic anomaly with the standard Bouguer gravity field show that the anomaly pattern is mainly caused by upper crustal structures in the Austrian part of the

Bohemian Massif. Due to the crust–mantle boundary only a flat regional field can be estimated with a gravity distribution slightly increasing eastwards. Especially at the eastern margin of the Bohemian Massif marked density inhomogenities are obviously extending far into the basement of the adjoining Molasse basin. After subtracting the effect both of the Mohorovičić–discontinuity and the Molasse sediments the NNE–SSW striking positive anomaly in the West of Hollabrunn is surrounded by flat negative anomalies with more or less equal amplitudes, which at least partly are caused by the Thaya pluton. Its maximum is reduced by about 10 mGal compared with the absolute maximum of the Raabs–unit.

The results have to be considered as preliminary, because more detailed resolution of the basement structures especially at the margin of the Bohemian massif is necessary and will be considered together with better informations about the density distribution of the Molasse sediments. Further results will be obtained by applying gravity map stripping on the Bouguer anomaly calculated under consideration of the surface rocks density distribution for all mass corrections.

Acknowledgement

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