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Magnetic Data from Western Hungary and Eastern Austria and Their Interpretation

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With 8 Text-Figures

Ungarn
Transdanubisches Mittelgebirge
Aerogeophysik
Aeroelektrische Messungen
Prospektion

Inhalt

Magnetische Daten aus Westungarn und Ostösterreich und ihre Interpretation

Zusammenfassung

Für eine Analyse der magnetischen Signatur im östlichen Teil der Alpen (Rechnitz/Bernstein/Güssing) wurde versucht, die österreichischen und ungarischen Magnetfelddaten auszugleichen, um die magnetischen Anomalien in Zusammenhang mit den geologischen Befunden interpretieren zu können. Die Quellen der magnetischen Anomalien sind ultrabasischen Gesteinen zuzuordnen, die zu ophiolitischen Folgen gehören, die vom westlichen Teil der Ostalpen (Unterengadiner-, Tauernfenster) bis hierher verfolgbar sind; sie werden als Reste der ozeanischen (südpenninischen) Entwicklung aufgefaßt. Das betrachtete Gebiet nimmt eine Schlüsselposition für das Verständnis der Verbindung des Ostalpen-, Westkarpaten- und pannonischen Raumes ein, da das magnetische Muster eine Bifurkation der ozeanischen Tröge indiziert.

Földmágneses adatok Nyugat-Magyarországról és Kelet-Ausztriából, és azok értelmezése

Összefoglalás

A szerzők az Alpok legkeletibb része (Rohonc, Bernstein és Güssing) és Nyugat-Magyarország mágneses jellegeit vizsgálták. A két mágneses térképet az összehasonlítást lehetővé tevő szintre hozták és megkísérelték a mágneses jellegek földtani értelmezését.

A legfontosabb eredmény, hogy az ofiolitos összlet ultrabázitjaitól származó mágneses jellegek, melyek a Keleti-Alpok nyugati és központi részének pennini ablakaitól (Unterengadini és Tauern) nyomozhatók, a dél-pennini óceáni térség maradványait jelölik.

A vizsgált terület az alp-kárpáti kapcsolatok kérdéseinek megoldása szempontjából kulcsfontosságúnak látszik, minthogy itt az óceáni kéregmaradványok elágazódása (triple junction) tapasztalható.

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Abstract

The magnetic pattern of the easternmost part of the Alps (Rechnitz/Bernstein/Güssing; Burgenland/Austria) and Western Hungary has been analyzed. Attempts have been made to transform both magnetic maps into a common level to interprete the magnetic signature due to geological terms. An outstanding result is the magnetic pattern being due to ultrabasites of an ophiolitic sequence which is traceable from the Penninic windows of the western and central part of the eastern Alps (Unterengadin and Tauern) marking the remnants of a Southern Penninic oceanic realm.

The area is crucial for solving some problems of the Alpine/Carpathian/Pannonian junction as there is indicated a bifurcation of the oceanic domain of the Southern Penninic.

1. Introduction

Main target of this study has been to obtain a geological interpretation of the anomalous magnetic pattern which is dominating the eastern margin of the Eastern Alps (cf. SEIBERL, 1991).

This pattern continues into the territory of western Hungary.

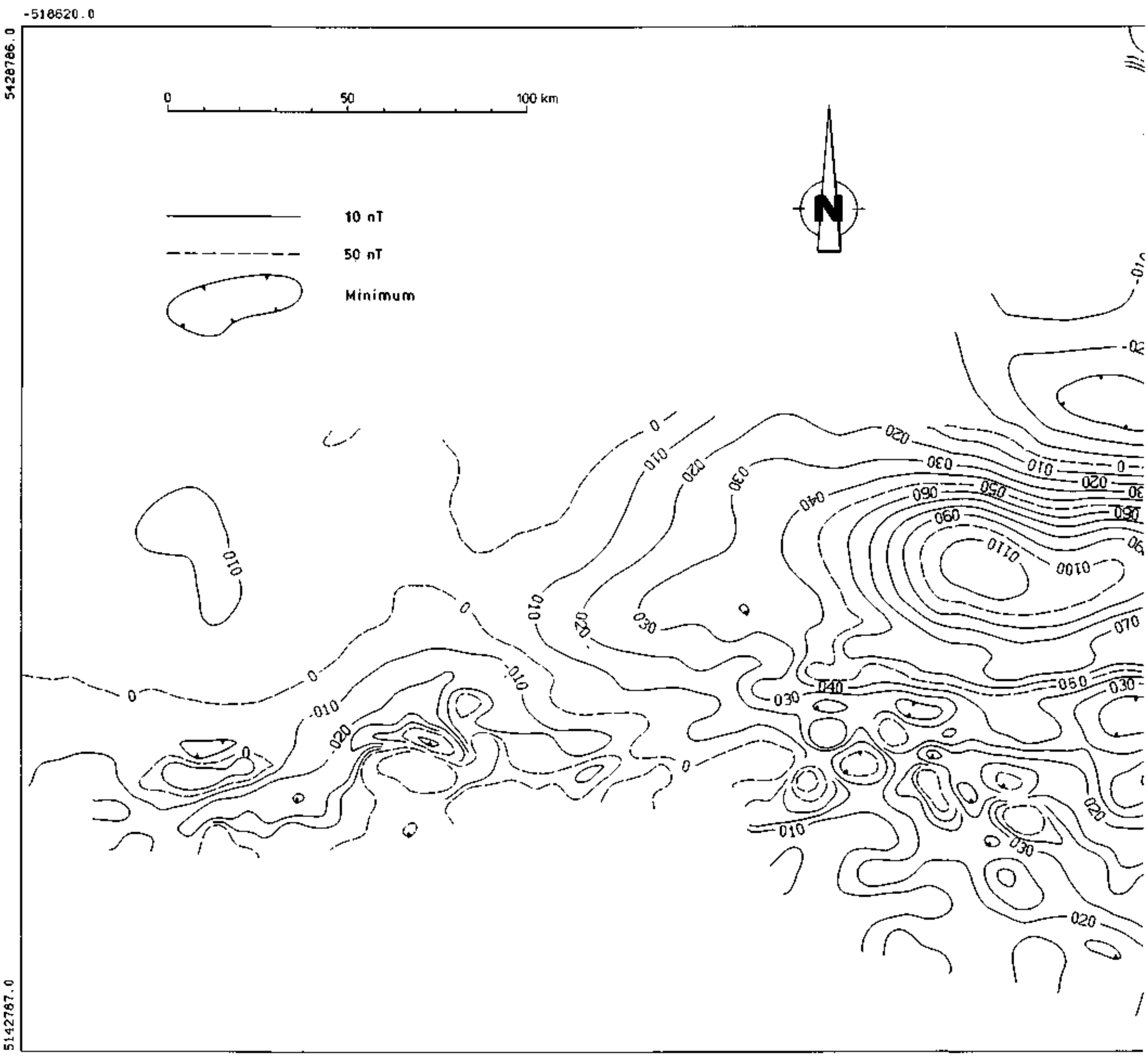
For this purpose the attempt has been made to fit together both the aeromagnetic map of Austria (ΔT [SEIBERL, 1991]) and the map of the vertical intensity ΔZ of Hungary (HAAZ & KOMÁROMY, 1966).

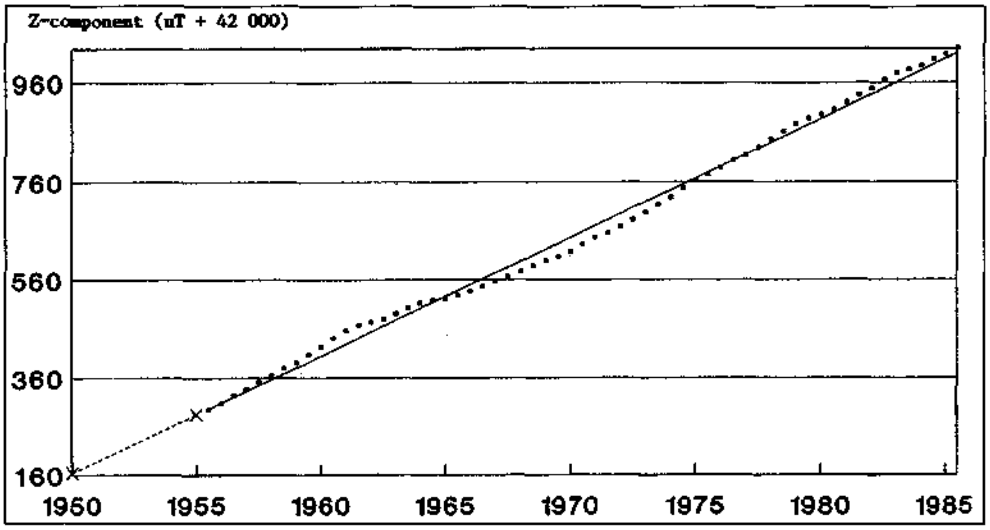
Comparing the maps we have to consider that

- they do not correspond in respect of units and reduction levels;
- for this study no complementary measurements have been done;
- no data have been available from the Hungarian reference observatory.

Therefore recent papers are based on new investigations and measurements (e.g. HOFFER et al., 1991).

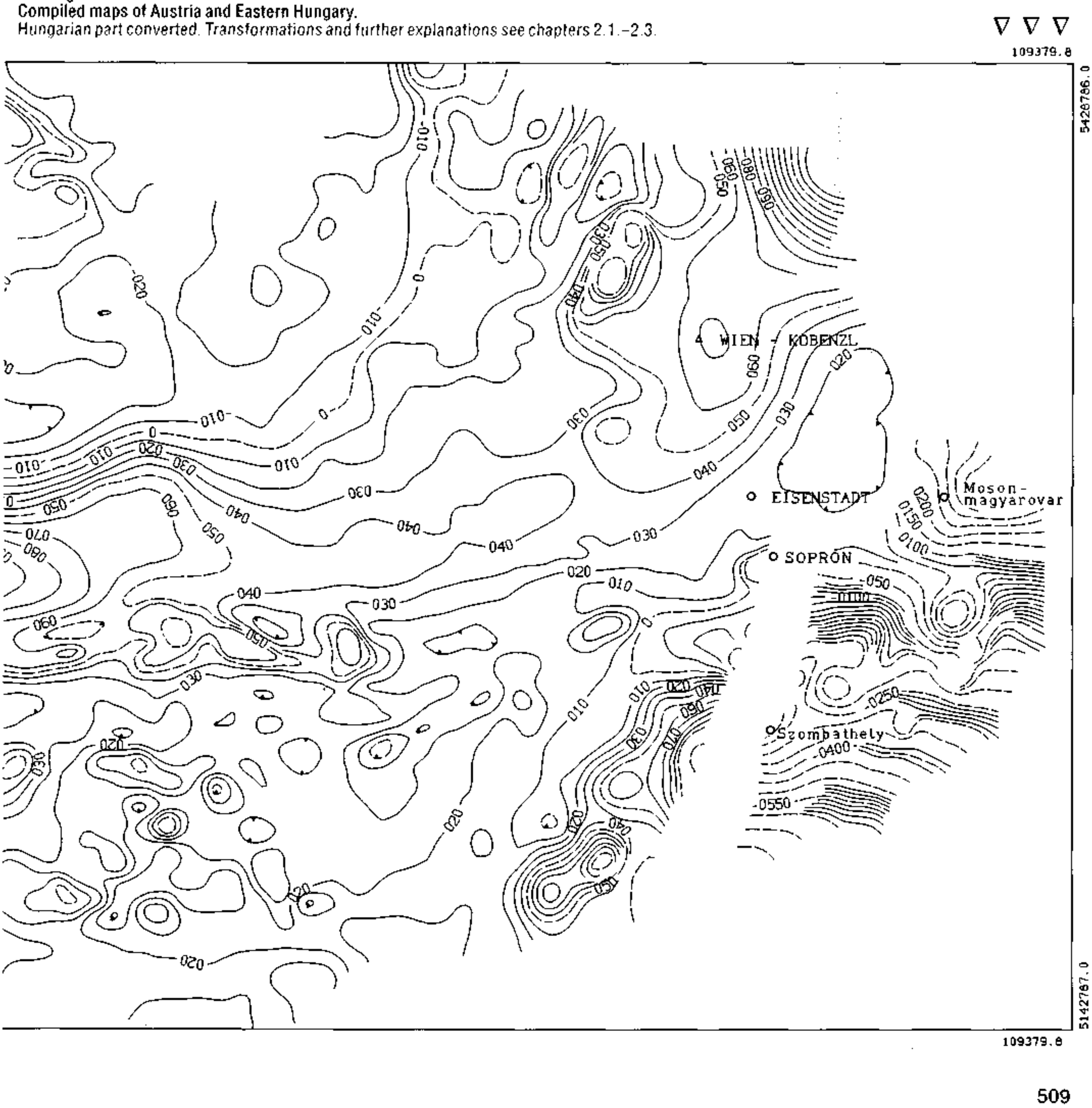
Consequently geological interpretations are restricted to anomalies with high amplitudes which are less affected by inaccuracies of measuring levels.



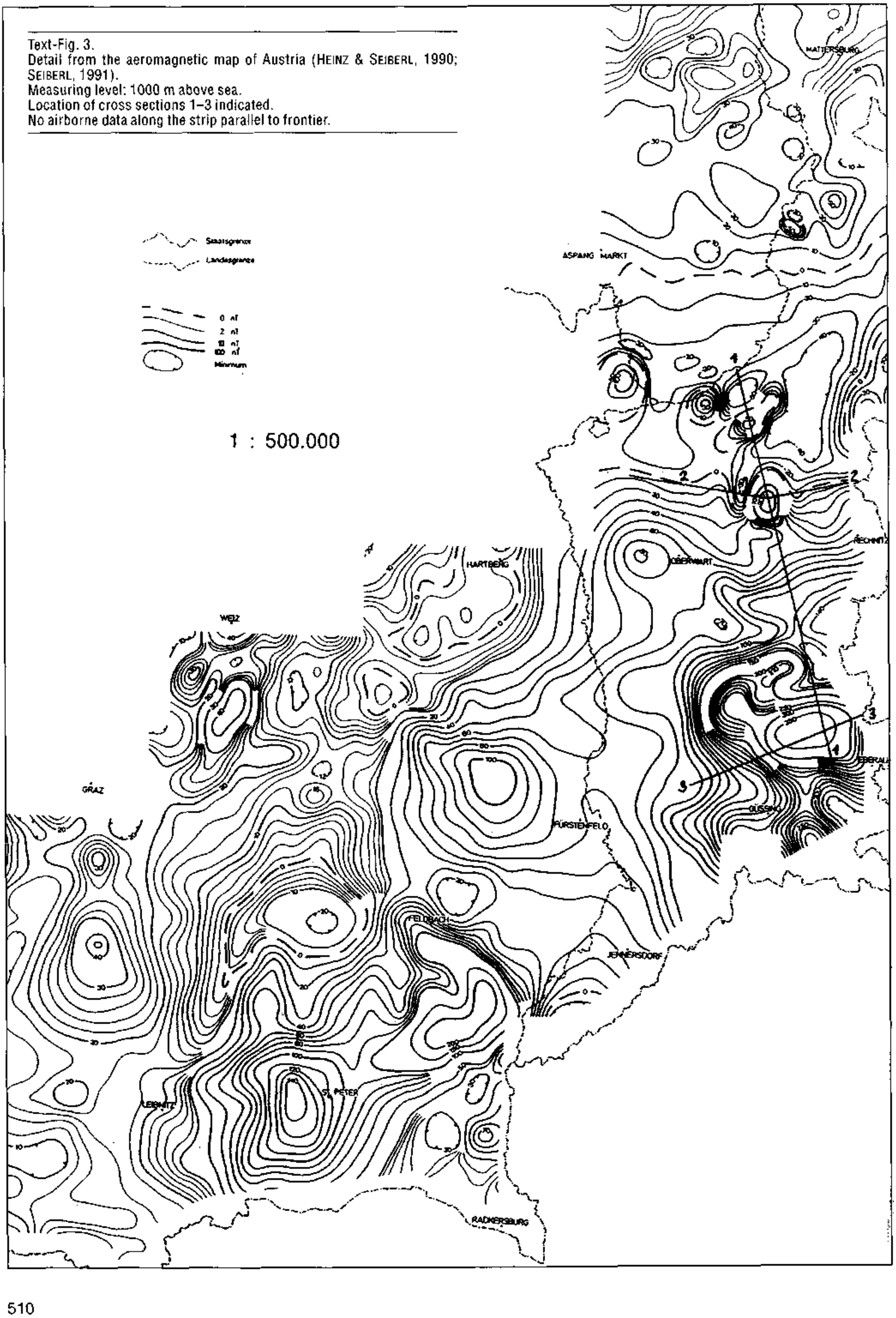


Text-Fig. 1.
Secular variation of earth's magnetic field (Z-component), Wien Kobenzl.
From: Zentralanstalt für Meteorologie und Geodynamik (1988).
Values increase from 42.294 nT (1955,0) to 42.830 nT (1977,5; starting of aeromagnetic survey).
Dotted line: extrapolation of linear regression. Latitude: 48,265°N, Longitude: 16,318°E. Elevation: 400 m.

Text-Fig. 2.
Compiled maps of Austria and Eastern Hungary.
Hungarian part converted. Transformations and further explanations see chapters 2.1.–2.3.



Text-Fig. 3.
Detail from the aeromagnetic map of Austria (HEINZ & SEIBERL, 1990; SEIBERL, 1991).
Measuring level: 1000 m above sea.
Location of cross sections 1–3 indicated.
No airborne data along the strip parallel to frontier.



2. Methods

2.1. Comparison of Magnetic Maps

2.1.1. Aeromagnetic Map of Austria

The aeromagnetic map of Austria (SEIBERL, 1991) represents a compilation of maps of the residual field measured in different flying levels. A common level of 3000 m (above sea level) has been selected (BLAUMOSER, 1991). The calculated reference level is useful for interpreting supraregional structures by low-pass-effect of the magnetic field data at lower flying-levels (in the area of eastern Austria: 800–1000 m above sea). System of coordinates: Gauß-Krüger. Reference meridian: M 31, converted for the area studied into M 34. Data reduction: IGRF, epoch 1977,7. Gradient: 2,67 nT/km (direction N), 0,74 nT/km (direction E), constant value of 47.093,3 nT subtracted.

2.1.2. ΔZ-Map, Hungary

The measurements have been carried out 1951–1961. Reduced values are referred to epoch 1950,0. They are determined (as well as the values for the ΔZ normal field) in mOe. According to HAHN (1985) the unit 1 Oe [cgs] is equivalent to 10^{-4}T [SI]. Therefore: 1 mOe ≈ 100 nT. The residual field of the western part of the map has been digitalized (G. HÜBL and K. MOTSCHKA, Vienna), transformed into the Gauß-Krüger coordinates (M 34) and recalculated using the isodynames of the main field (derived from the map).

2.2. Transformations Applied to the Hungarian Map

The residual map ΔT of the aeromagnetic survey of Austria (reference level: 3000 m above sea) has been reduced to the observatory Wien-Kobenzl (φ = 48,265°, λ = 16,318°). Considering the secular variation of the magnetic field for Kobenzl observatory (elevation: 400 m) it is obvious that there is an increase of the value of the ΔZ-component in the order of 536 nT (Text-Fig. 1).

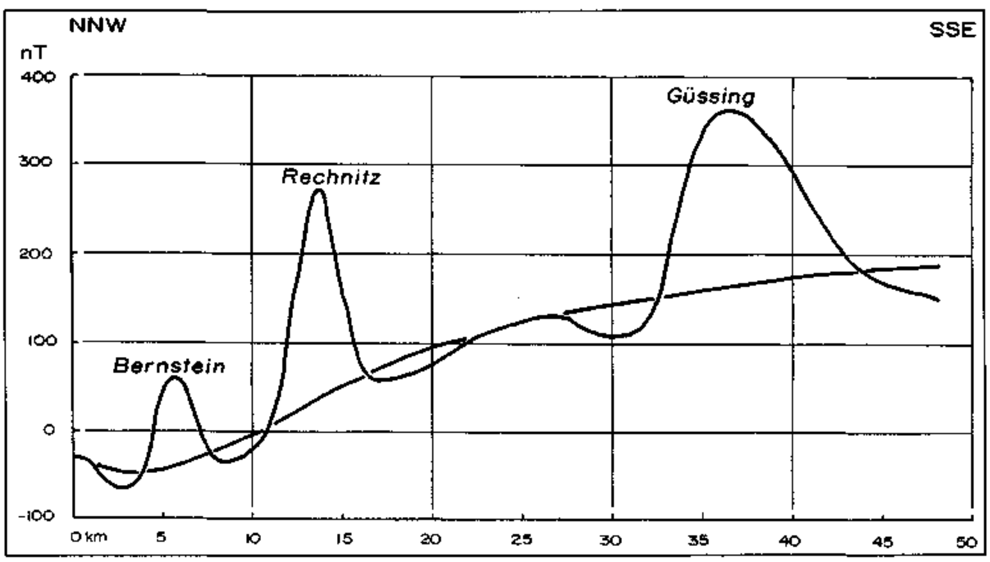
Extrapolating the linear regression of the observation period of the Hungarian maps we get a Z-component value of 42.140 nT (1950,0). The difference of 690 nT (compared with 1977,5) has been considered adjusting both maps. The local dependence of the reference field (IGRF) has been corrected by a plane whose gradients were calculated by

$$T_r = 47141{,}48 + 55{,}5\,(\gamma-13{,}5°) + 296{,}67\,(\varphi-47{,}5°)$$

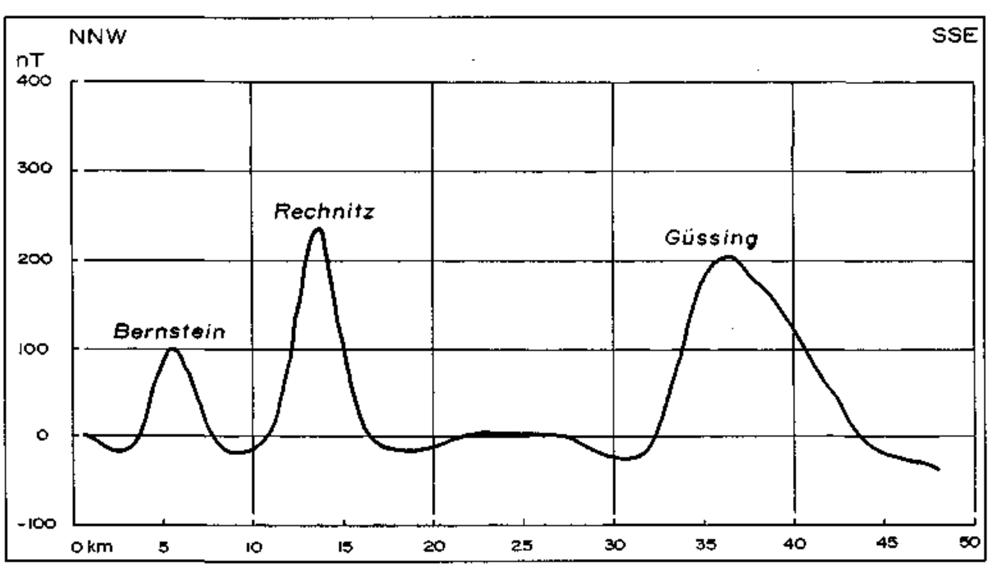
This reference field T_r (according to GUTDEUTSCH & SEIBERL, 1987) has been subtracted from the Hungarian data after correction.

The declination D and the inclination I for Wien-Kobenzl 1955,5:
D: –0°52'2, I: 64°10'4.

Considering the variations due to location and time the values D = –1°20' and I = 63°40' have been used for the area of Western Hungary.



Text-Fig. 4.
Data not trend reduced along the cross section 1 in Text-Fig. 3.



Text-Fig. 5.
Trend reduced data along cross section 1 (Text-Fig. 3).

The digitized map was interpolated on a square grid by means of an algorithm developed by BRIGGS (1974). The ΔZ map as a result of this procedure has been transformed to ΔT using FFT-filtering considering values of D_{1950} = –1,333° and I_{1950} = 63,667°. The transformation was carried out by a suitable Fortran-program of the US Geological Survey (HILDENBRAND, 1983), which has been adapted for the Geological Survey of Austria (Geologische Bundesanstalt) by BLAUMOSER & HÜBL (1991). For theoretical details see STRAUSS (1983).

The result of the transformation was continued upward from the mean measuring level of 200 m up to 3000 m (above sea) to obtain an immediate comparison with the aeromagnetic map. The accuracy of the transformations has been controlled at the overlaps of the grid.

2.3. Restrictions

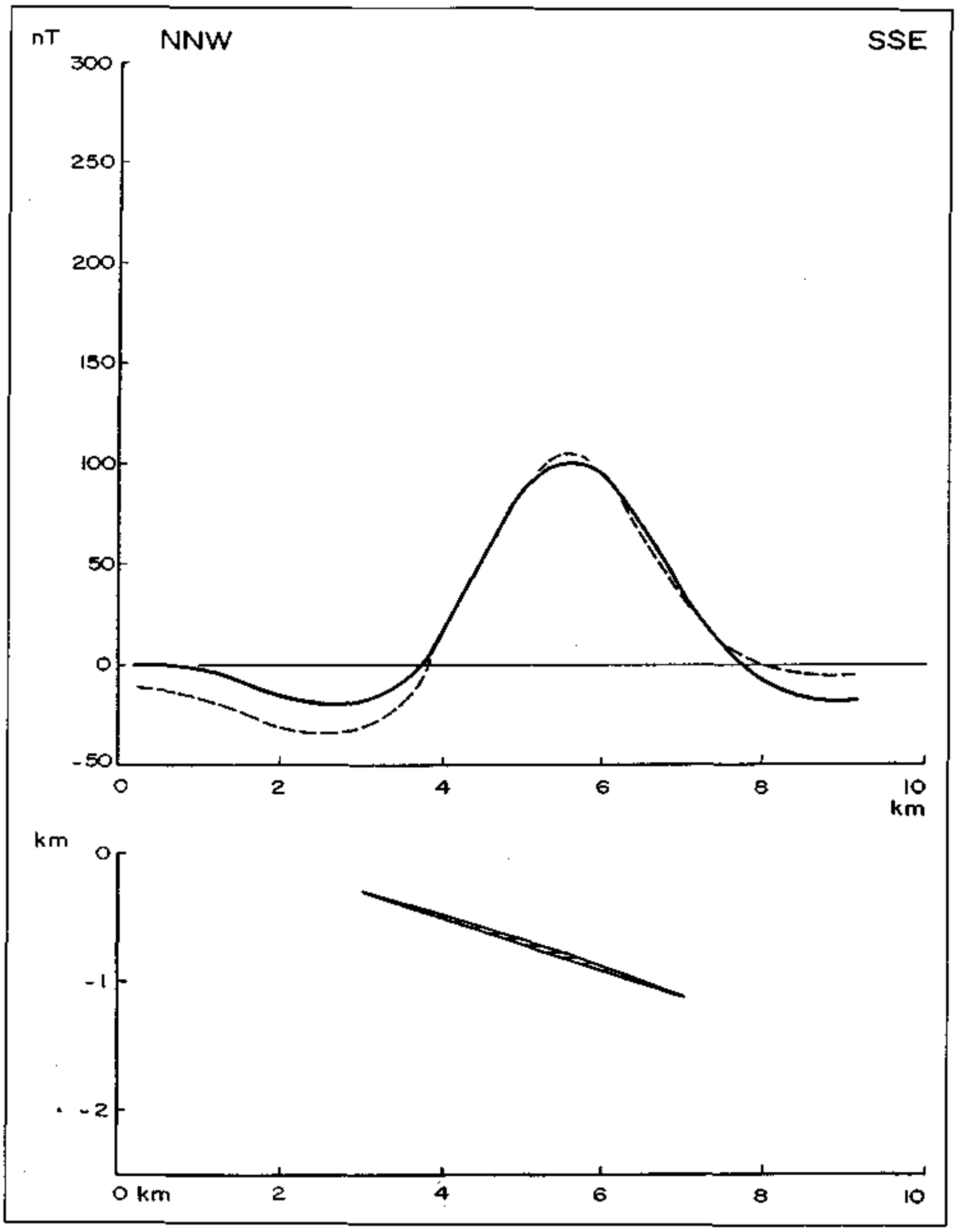
Scrutinizing all the procedures mentioned above it became obvious that there is a N–S gradient of the magnetic field in the Hungarian map which is neither reducible nor explainable by the transformations applied and which is not observable in the magnetic field due to the aeromagnetic map. We therefore assume that some transformations or descriptions of the main field which would explain this anomalous field gradient (in comparison with the Austrian map) are not published or accessible in respect of the Hungarian depiction. Due to those uncertainties the map in Text-Fig. 2 has been divided strictly into a western and an eastern part. However in spite of the regional gradient the geologically significant anomalous structure remained visible and interpretable.

3. Results

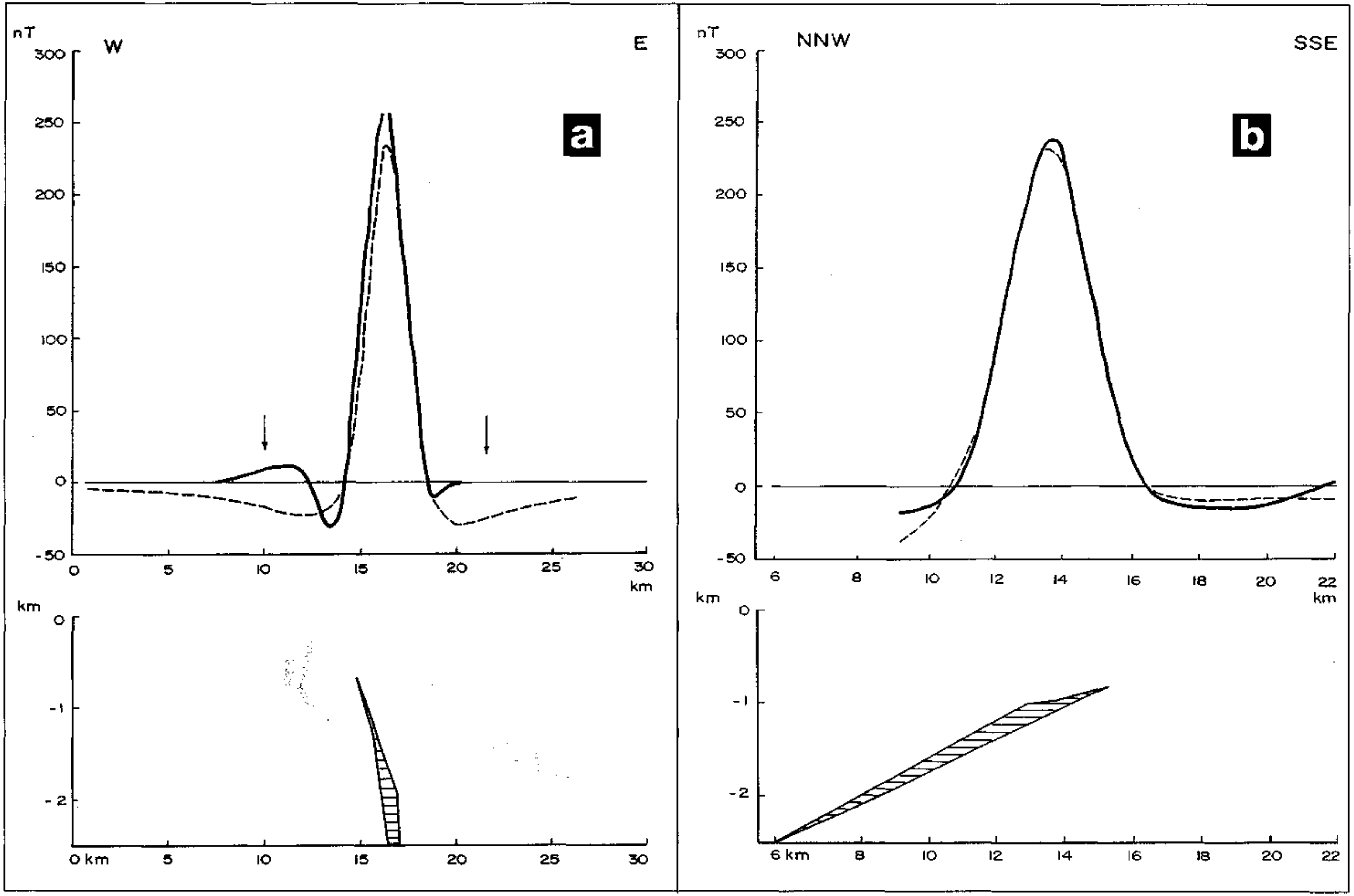
The magnetic pattern of Eastern Austria is depicted in Text-Fig. 3. The western (southwestern part) has been described and analyzed in detail by KRÖLL et al. (1988). Characteristic magnetic anomalies in this area are mainly due to the volcanic activity during the Tertiary. However, east of the line Hartberg – Fürstenfeld the magnetic pattern becomes dominated by magnetic structures with high gradients and amplitudes (>350 nT) as well as short wavelengths. This anomaly group extends into Hungarian territory (Szombathely, Köszeg, Servar [?]) but seems to be cut off west of the Raba-lineament. The Austrian part has been investigated by HEINZ et al. (1987) and HOFFER et al. (1991) (frontier crossing).

The most prominent structures are grouped along a N–S line, according to Text-Fig. 3. All of those anomalies are superposed by a regional trend which had to be eliminated: see cross sections in Text-Figs. 4 and 5.

Three sections across modelled source bodies have been calculated ("Bernstein", "Rechnitz" and "Güssing"), using the algorithms developed by LEVENBERG (1944), MARQUART (1963) and TALWANI & HEIRTZLER (1964) (Text-Figs. 6, 7 and 8; *generally the full line represents measured values, trend corrected*). The anomalies near Rechnitz and Güssing have been investigated additionally by almost E–W directed sections (Text-Fig. 3, cross sections 2, 3). Considering the shape of the structure and the



Text-Fig. 6.
Anomaly near Bernstein. Location: see Text-Fig. 3 (northern part of cross section 1).
Full line = measured; dashed line = calculated.
Data: Susceptibility: 25×10^{-3}[SI]; inclination: 63°; declination: 1°.
Main field: 47.600 nT.



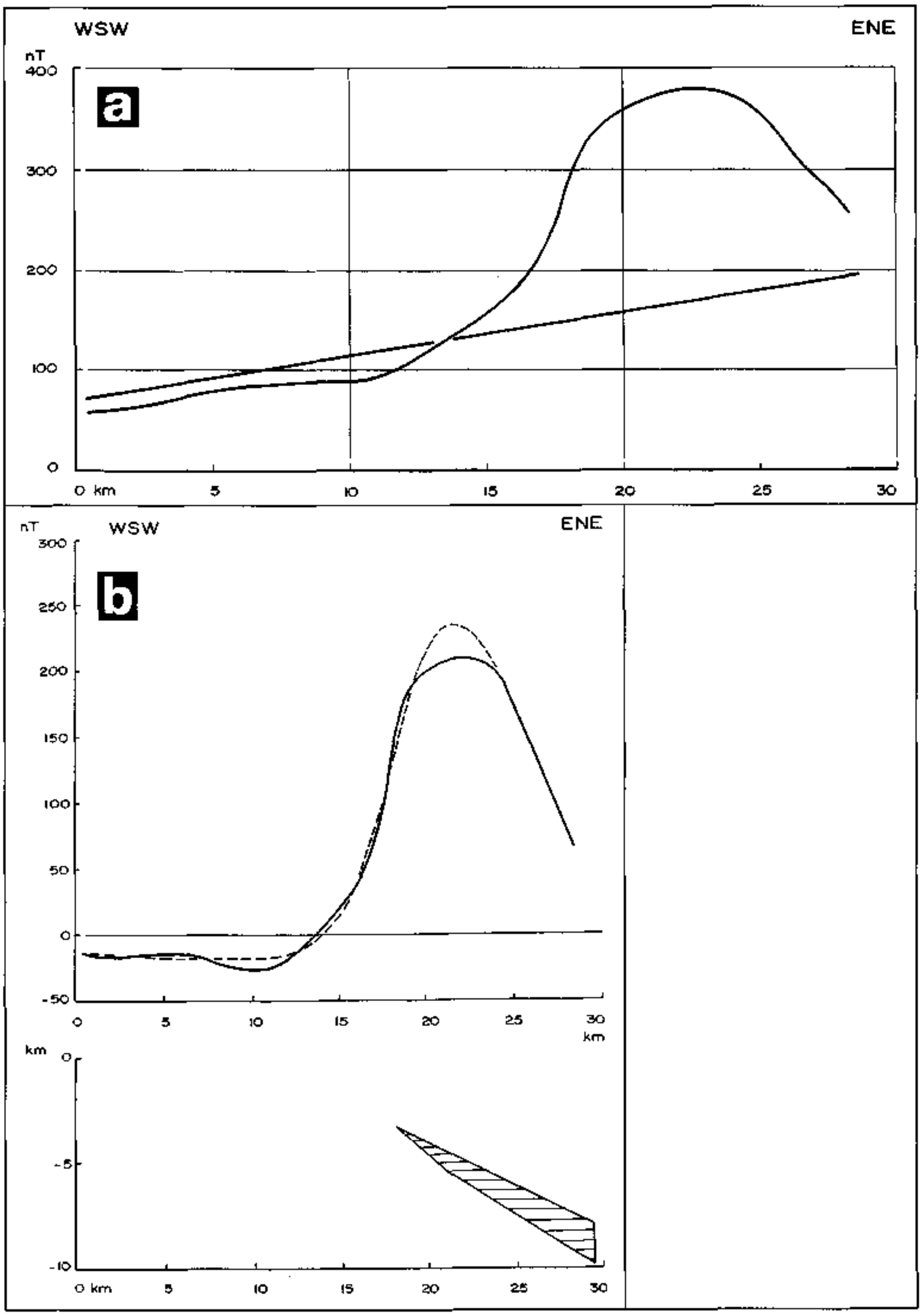
Text-Fig. 7.

Anomaly near Rechnitz.

a) Cross section 2 (Text-Fig. 3).
Full line = measured; dashed line = calculated. Data: Susceptibility: 15×10^{-3}[SI]; inclination: 63°; declination: 1°. Main field: 47.600 nT. Arrows indicate influences of superimposed adjacent structures.

b) Cross section 1 (central part; Text-Fig. 3).
Full line = measured, trend reduced; dashed line = calculated. Data: cf. Text-Fig. 7a.

Text-Fig. 8.
Anomaly near Güssing.
a) Cross section 3 (Text-Fig. 3). The straight line marks the linear trend in this area.
b) Cross section 3 (Text-Fig. 3). Full line = measured; dashed line = calculated. Susceptibility: 25×10^{-3}[SI]. Inclination: 63°. Declination: 1°. Main field: 47.600 nT.



direction of the regional trend – slightly bent to the south – it has been tried to fit the cross section to the main direction of the regional trend (Text-Fig. 7a; as the cross section has been digitalized approximately parallel to the zero contour line: not trend reduced). Serious difficulties in computing and interpreting the source of the structure arose from superposition of the anomaly near Bernstein located in the N. In Text-Fig. 7b the cross section along the N–S extension of the Rechnitz structure (trend reduced) is represented.

The anomaly near Güssing has been analyzed by an E–W cross section as well (Text-Fig. 8a, 8b).

WEBER et al. (1983) published average susceptibility values from basites of the easternmost Alps (36×10^{-3}[SI]). In this paper minor values have been used for the models "Güssing" and "Rechnitz": due to increasing depth the degree of serpentinization will change. A higher value has been selected for model "Bernstein" according to its shallow depth (see chapter 4).

4. Conclusions

The presented cross sections reflect the complicated tectonic and structural conditions of the Penninic system of the Eastern rim of the Alps which are delineated in numerous papers. All of the source bodies are due to ultrabasites (serpentinites) of the tectonic windows. The "Rechnitz"-structure is obviously due to a serpentinite which is located near a subduction zone postulated by PAHR (1984), HERRMANN & PAHR (1988), KOLLER (1985) etc. and marked by occurrences of blueschists. The interpretation of the source body as a NNW-dipping slab fits quite well in the regional tectonic concept developed by PAHR (1984) and especially by HERRMANN & PAHR (1988). All three models coincide with the subduction zone sensu PAHR (1984) which might be projected to the surface as a NNW–SSE directed characteristic stripe. The sources of the "Bernstein" anomaly partly even are exposed (serpentinite; HERRMANN & PAHR, 1982). According to PAHR (1977) those rock complexes are dipping to the SE (cf. Text-Fig. 6).

However, the most striking feature of the Bernstein – Rechnitz – Güssing anomaly group is the fact that they do not continue either into the Pannonian basin nor into the Western Carpathian realm (cf. HAÁZ & KOMÁROMY, 1966; this paper; GNOJEK & HEINZ, 1993). It seems to be indicated that a continuation to the south exists which, however, can not be proved as there are no sufficient data from Slovenia and Croatia available up to now.

Anyway, there is strong evidence that this anomaly type (short wavelengths, high amplitudes, high gradients) is traceable from the area Bernstein/Rechnitz/Güssing to the west (Tauern Window, Central and Western Alps) and may be parallelized with remnants of a Southern Penninic crust (HEINZ, 1989; HEINZ & SEIBERL, 1990; HEINZ, 1992).

The anomalies of same type accompanying the southeastern margin of the Bohemian Massif in Austria ("Dunkelstein-Moldanubian belt" sensu GNOJEK & HEINZ [1993]) could be of the same origin. A direct continuation however is revealed by the Vienna basin and superposition of structures of the Bohemian Massif s.s.

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