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The Permian-Triassic of the Gartnerkofel-1 Core (Carnic Alps, Austria): Magnetostratigraphy

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With 13 Text-Figures and 1 Table

Carinthia
Carnic Alps
Permian/Triassic Boundary
Magnetostratigraphy
Anisotropy
Cretaceous Overprint

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Zusammenfassung

In einem Profil Oberperm (Bellerophon Formation) – Untertrias (Werfen Formation) in den Karnischen Alpen wurden paläomagnetische Untersuchungen durchgeführt. Dazu wurden 594 Proben aus dem 330 m langen Bohrkernprofil Gartnerkofel-1 und 218 Proben aus dem Reppwandprofil analysiert. Die Studie umfaßte die Messung der natürlichen Remanenz (NRM, Deklination, Inklination und Intensität), der magnetischen Suszeptibilität sowie deren Anisotropie, die Aufnahme von induzierter remanenter Magnetisierung (IRM) und der Bestimmung der Koerzitivfeldstärke sowie das Abmagnetisierungsverhalten der NRM.

Die gesteinsmagnetischen Untersuchungen zeigen Magnetit als dominierendes Trägermineral der remanenten Magnetisierung. Der Magnetit weist eine große Streuung in der Partikelgröße auf und wird häufig von Pyrrhotin begleitet. Die charakteristische remanente Magnetisierung (ChRM) ist fast überall von Effekten von Goethit und Hämatit überlagert, die ihre Magnetisierung zum Teil im gegenwärtigen Erdfeld und zum Teil in einem kretazischen normalpolarisierten Feld erhalten haben. Der Hämatit wurde durch Oxidation aus diagenetischem Pyrit gebildet. Profilabschnitte mit niederer Suszeptibilität zeigen den Hämatit als dominierendes Mineral.

Für alle Profilintervalle beider Profile gilt, daß sie in einem normal polarisierten Feld überprägt wurden und nirgends glaubhafte Perm–Trias-Richtungen zeigen.

Diese Ergebnisse stehen im Gegensatz zu Ergebnissen von HEINZ, H. & MAURITSCH, H. J. (1980) und MANZONI, H., et al. (1989) aus dem unterlagernden Karbon. In beiden Arbeiten konnten paläomagnetische Pole aus dem Karbon für das gleiche Gebiet der Karnischen Alpen isoliert werden.

Die magnetische Überprägung könnte bei einer Mineralisierung in Zusammenhang mit einer späten Dolomitisierung passiert sein.

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Abstract

A paleomagnetic study in the Upper Permian (Bellerophon Formation) and Lower Triassic (Werfen Formation) dolostone section in the Carnic Alps was made on 594 samples from 330 m of the Gartnerkofel-1 core and 218 samples from 48 m of the nearby outcrop on the Reppwand cliff. The studies included measurements of low-field magnetic susceptibility, magnetic intensity and declination and inclination of remanent magnetization during stepwise thermal demagnetization. Coercivity was determined by measurement of IRM generated in unheated samples by fields of up to 1.5 T.

The studies of rock magnetism showed that the dominant carrier of characteristic remanent magnetization was magnetite in a variety of grain size, possibly supplemented by some pyrrhotite. However, the ChRM was pervasively overprinted by the effects of goethite and hematite formed by oxidation of diagenetic pyrite in both the recent Earth field and apparently also during the Cretaceous normal interval. In intervals of low magnetic susceptibility hematite occurs dominant. All intervals were overprinted in a normal field, obscuring any reversal pattern of a Permian ChRM. Thus neither of the paleomagnetic profiles provided a believable Permian-Triassic reversal stratigraphy, although a Permian direction (140/–20) could be separated on some cases. These results are in contrast to success in determining paleopoles for underlying Carboniferous limestones of the Auernig Formation from this same area of the Carnic Alps (H. HEINZ & H. J. MAURITSCH, 1980, M. MANZONI et al., 1989).

This magnetic overprint is related to Alpine tectonic deformation, as shown by magnetic anisotropy, and may have been generated by mineralization accompanying the late-stage dolomitization.

1. Location, Geological Setting, Stratigraphy

A core drilling at Gartnerkofel-1 provided an opportunity to study in detail the magnetostratigraphy across the Permian/Triassic boundary. Both the core and a section in the Reppwand outcrop were studied (Text-Figs. 1,2).

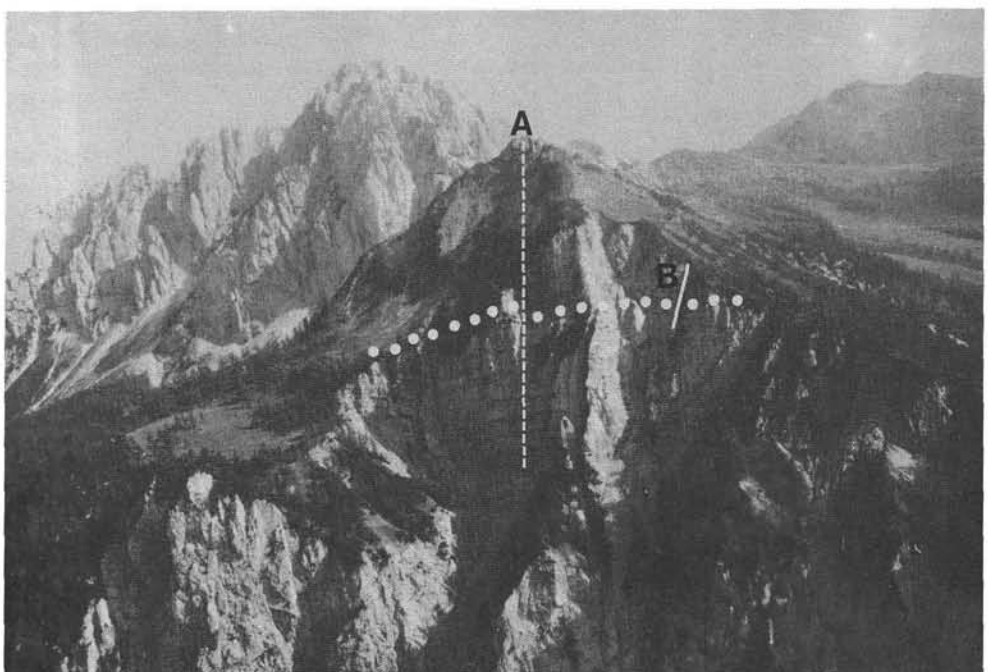
The Reppwand-Gartnerkofel section is located in the eastern part of the Carnic Alps, in southern Austria at the Italian border. The geology of this area was described in detail by F. KAHLER & S. PREY (1963); a new map showing the site of the drilling program was published by H. P. SCHÖNLAUB (1987).

Traditionally, the middle part of the Reppwand-Gartnerkofel section has been divided into three formations: the upper part of the Upper Permian Bellerophon Formation, the lower part of the Lower Triassic Werfen Formation (Seis member), and the upper part of the Werfen Formation (Campil Member). In the Dolomites west of the Carnic Alps the Werfen Formation has been divided into 9 lithostratigraphic units based on transgressive-regressive sedimentary features (C. BROGLIO-LORIGA, 1983). In ascendig order above the Upper Permian Bellerophon Formation these are: Tesero Horizon, Mazzin Member, Andraz Horizon, Seis Member, Gastropod Oolite Member, Campil Member, Val Badia Member, Cencenighe Member and San Lucano Member.

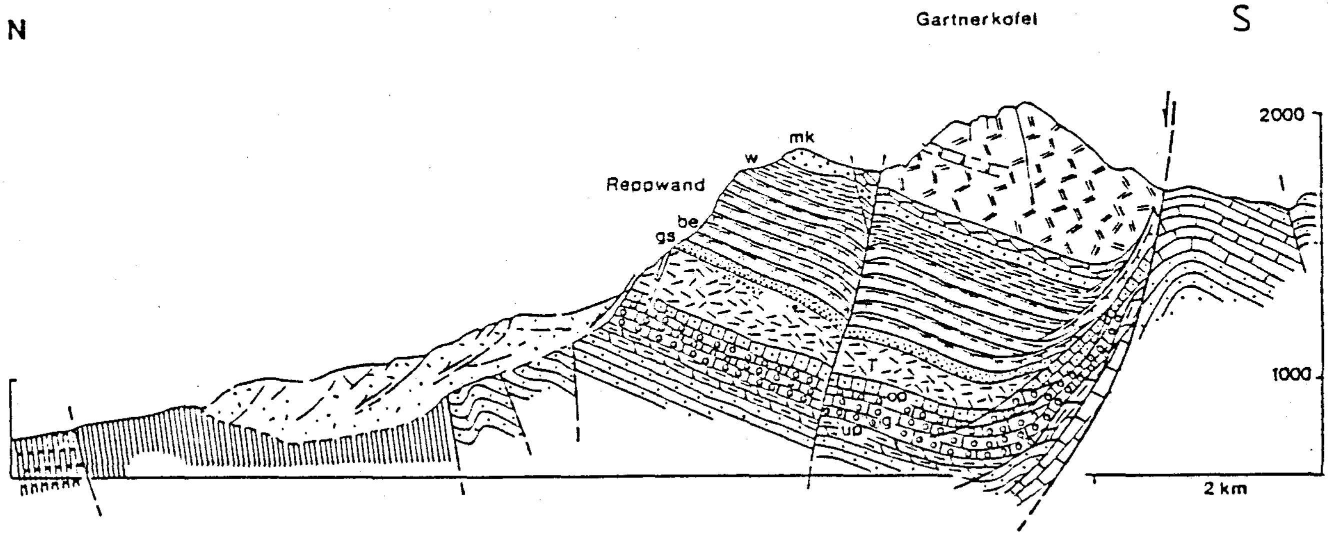
Recently, K. BOECKELMANN (1988) successfully applied part of this subdivision to the area east of the Dolomites. In this more basinward position he identified the following units that are encoutered in study of the Permian/Triassic boundary (see contributions by K., BOECKELMANN, this volume; H. P. SCHÖNLAUB, this volume).

1.1. Bellerophon Formation

Depth: 330–231.04 m in the core; on the Reppwand outcrop section 13 m were sampled for paleomagnetic studies, of these the upper 4.4 m were also sampled for paleontological and geochemical studies.



Text-Fig. 1.
Aerial photograph from the north of the Reppwand with the Gartnerkofel (2195 m) in the background.
A: Drill site on Kammleiten (1998 m); B: Top of the outcrop section. Dotted line indicates the Permian–Triassic boundary between the Bellerophon Formation (below) and the Werfen Formation above. Photo: G. FLAJS, Aachen.



Text-Fig. 2.
Geological profile of the Reppwand/Gartnerkofel area (F. KAHLER & S. PREY, 1963).

Lithology: Well-bedded greyish dolomites which comprise completely dolomitized mud- and wackestones with Stromatactis-like fenestral fabrics. Locally these dolomites are very fossiliferous and strongly bioturbated. Terrigeneous influence by clastic debris is insignificant.

1.2. Tesero Horizon

Depth: 231.04–224.50 m in the core; lowermost 4 m of the Werfen Formation in the Reppwand outcrop section.

Lithology: this unit conformably overlies the uppermost beds of the Bellerophon Formation. It consists of fine-to medium-grained dolomite which in thin section comprises oolitic and bioclastic grainstones that contain fossils. Thin marly and clayey interlayers are common. The Permian/Triassic boundary lies somewhere within the basal meter of this member (H. P. SCHÖNLAUB, this volume).

1.3. Mazzin Member and Seis Member

Depth: 224.50–95 or 82 m in the core; 4–59.70 m of the studied Reppwand outcrop section.

Lithology: All samples – except a few with relict calcite – are completely dolomitized and consist of fine- to medium-grained dolomite. Consequently, sedimentary structures and fossil remains are difficult to recognize. The lower and strongly bioturbated part is probably equivalent to the Mazzin Member; the upper part is characterized by increasing oolitic horizons, tempestites and grain- and packstones resembling the typical lithology of the Seis Member. Clastic input occurs as silty angular quartz dispersed in the carbonates or enriched in thin shaly layers.

1.4. Campil Member

Depth: 95 or 82–57 m in the core; in the Reppwand outcrop section the equivalents of this member have not yet been sampled.

Lithology: In the core the boundary between the Seis and the Campil Members is not sharp. Color gradually changes from grey to red, fossil content decreases and clastic interlayers become more abundant. The Campil member is composed of mixed dolomitic and siliciclastic beds with few intercalated mollusc shell layers. Most rocks are altered to dolomite of varying grain size.

In the Gartnerkofel-1 core (and as well in the outcrop and its surroundings) the Campil Member is disconformably overlain by the Muschelkalk Conglomerate of early Anisian age suggesting deep erosion of parts of the Werfen Formation.

2. Paleomagnetic Sampling

The sedimentation rate deduced from the paleontological dating is about 7 mm/1000 a (pers. comm. K. BOECKELMANN). In order that the resolution be 10^5 a or better, the paleomagnetic cores were taken from the Reppwand as well as from the Gartnerkofel-1 core at short intervals, down to 0.2 m.

The aim of this work was to get information about the magnetic polarity pattern, especially near the P/Tr boundary. Therefore two profiles were sampled:

a) The Reppwand outcrop section, from the upper 13 m of the Bellerophon Formation into the lower part of the Seis Member (total about 48 m, 218 samples),
and
b) the 330 m core Gartnerkofel-1, on the Kammleiten, some 400 m southeast of the Reppwand section. The core included part of the Campil Member, the underlying Seis Member, the Tesero Horizon, and the upper part of the Bellerophon Formation (594 samples). The outcrop section was sampled with a portable drill; the Gartnerkofel-1 core was reoriented and sampled in the laboratory. A total of 812 samples, yielding more than 1550 specimens, were obtained for the rock magnetic and paleomagnetic studies.

The Reppwand and Gartnerkofel-1 sections complemented each other, for comparison of the azimuth and verification of the polarity pattern.

3. Methods

Natural Remanent Magnetization (NRM) measurements were done in Gams with a Digico spinner magnetometer and all low-level measurements were made on the cryogenic magnetometer of the ETH-Zürich.

All rocks of the Reppwand outcrop and Gartnerkofel-1 sections were subjected to measurements of low-field magnetic susceptibility $\varkappa$ before heating and after each heating step. The $\varkappa$ vs. T plots demonstrate mineralogical changes induced in the specimens during heating. Information indicating the carrier minerals was determinded from the behaviour of the remanence and the susceptibility on heating, as well as by techniques like IRM acquisition, geochemical and thin section analysis.

Thermal demagnetization was usually done in 10 or 12 steps up to 700°C using a TSD-1 Thermal Specimen Demagnetizer (Schoenstedt Instrument Company, Virginia). During cooling the samples were shielded (from the Earths's magnetic field) down to less than 5 nT. Data of the experimental analysis for each specimen were plotted using orthogonal and stereographic projections of the vector end points after each demagnetization step. The behaviour of the vector of remanent magnetization (RM) is represented in I/I_0 vs. T curves together with Zijderveld diagrams.

AF-cleaning was attempted in a two axis tumbler installed in three pairs of Helmholtz coils, but did not offer reliable results.

4. Rock Magnetism

During demagnetization of Bellerophon rocks the curves of I/I_0 vs. T in Text-Figure 3a show that the intensity significantly diminishes (30 %–85 %) at 100°C. This indicates goethite as the carrier of this secondary magnetic component, which is mostly aligned to the recent Earth's magnetic field. The remaining component, carried by magnetite and pyrrhotite with a wide range of blocking temperatures, follows the normal or reversed direction of the paleofield (Text-Fig. 3a, b).

Pyrite is common in the Reppwand dolostones especially in the Bellerophon Formation and in the Seis Member, and it can oxidize to an unwelcome late goethite (W. Lowrie & F. Heller, 1982).

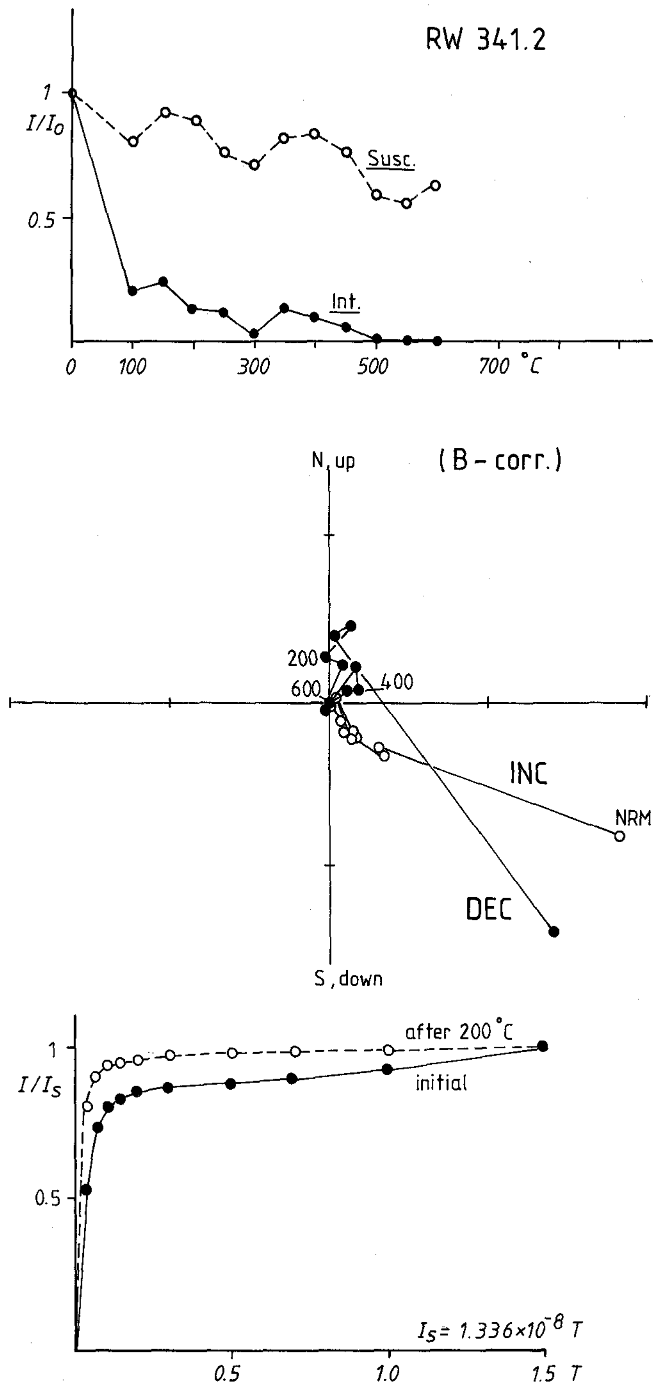
In the range from 100–300°C the RM-directions in the orthogonal and stereographic projections often become erratic due to the oxidation of the iron sulfides. After heating to 300–500°C the remaining component of NRM is so weak that its vector is rather indefinite.

Demagnetization of Werfen rocks was hindered by the high coercivity of geothite and hematite pigment (Text-Fig. 4c) as the prevailing minerals in several specimens, especially of the Campil Member. Therefore Af-demagnetization couldn't be applied. The demagnetization curve of a typical sample from the Campil Member (Text-Fig. 4a) shows a primary hematite, which is also characterized by multicomponent magnetization (Text-Text-Fig. 4b).

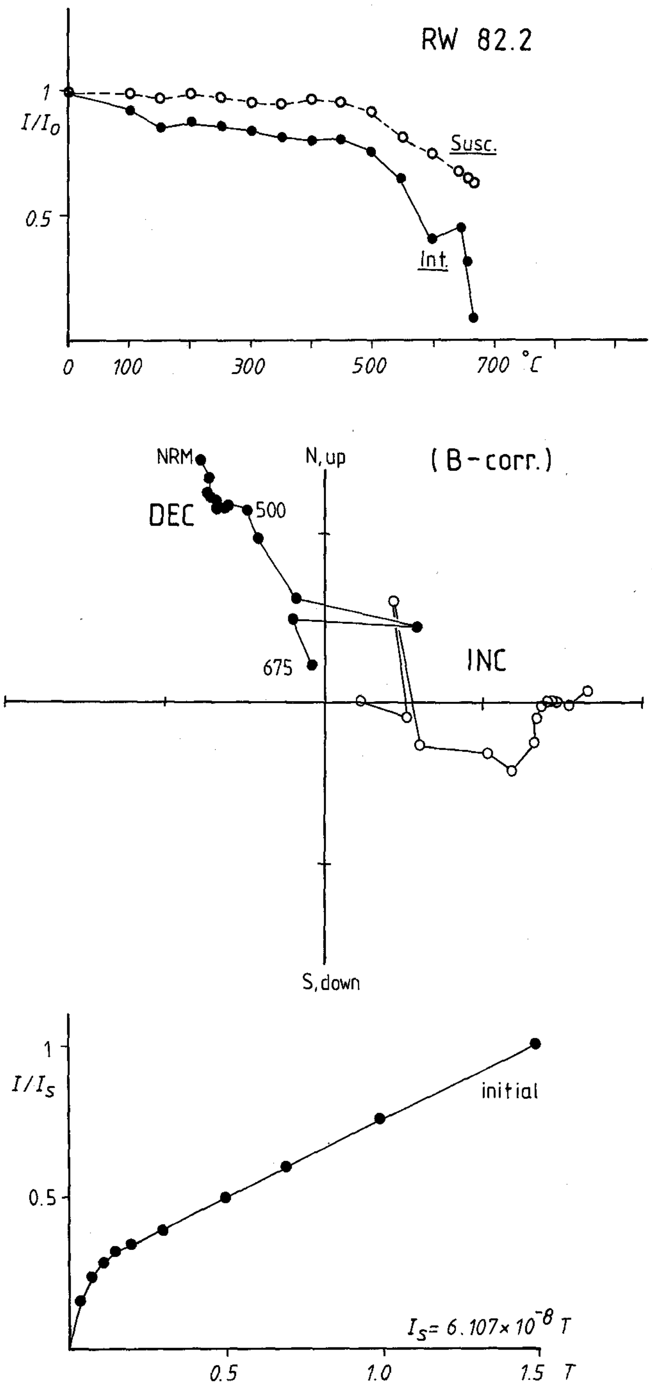
In view of the results for the Seis Member (Text-Fig. 5a) its NRM is argued to be carried by both pyrrhotite and magnetite. At quite low temperatures (100–300°C) the intensity increases in accordance with mineralogical changes (Text-Fig. 5a).

Unheated samples were given an IRM in progressively increasing magnetizing fields up to 1.5 T with an electromagnet. The IRM acquisition curves were used to calculate the total coercivity spectra of the samples (Text-Figs. 3c,4c,5c).

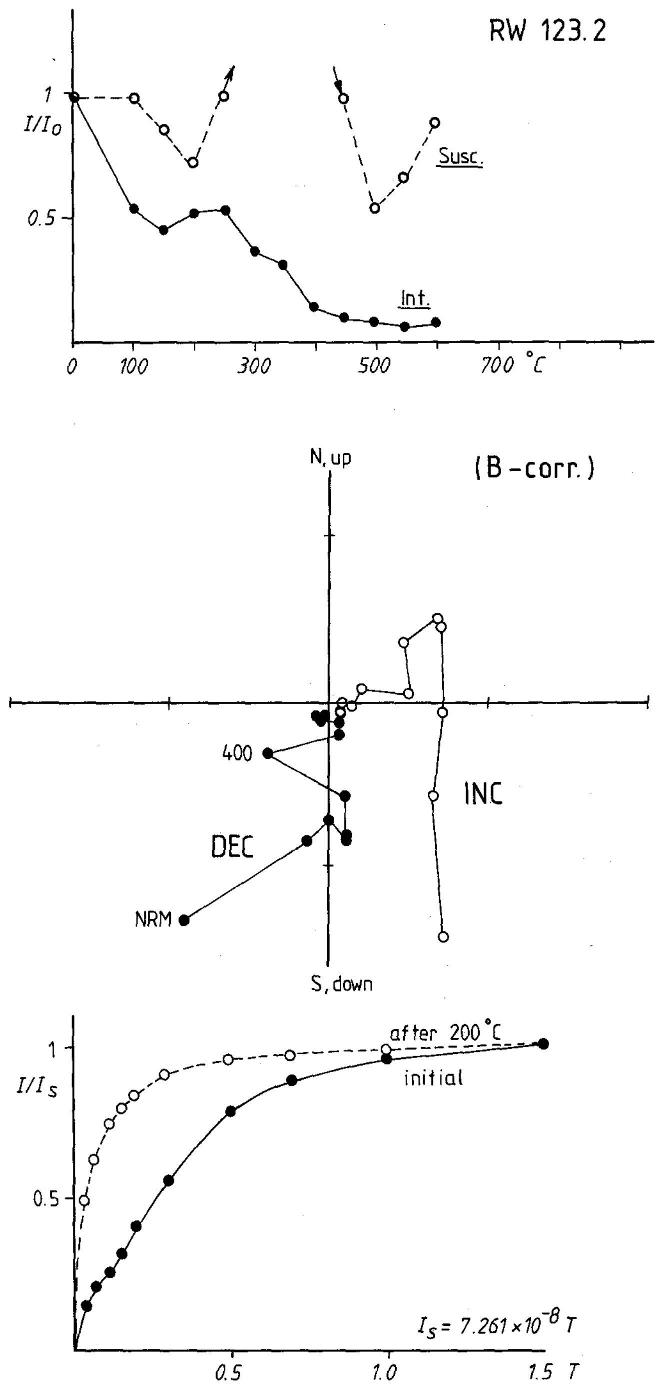
The samples from the Upper Bellerophon Formation reached saturation IRM at about 0.25 T (Text-Fig. 3c).



Text-Fig. 3.
Example of rock magnetic data from the Bellerophon Formation, GK-1.



Text-Fig. 4.
Example of rock magnetic data from the Werfen Formation (Campil Member), GK-1.



Text-Fig. 5.
Example of rock magnetic data from the Werfen Formation (Seis Member), GK-1.

In contrast, several of the lower Werfen Formation (Seis Member) samples showed saturation IRM only after applying fields of about 1.0 T (Text-Fig. 5c). The high coercivity component of these samples is probably a hematite signal (Text-Fig. 5c) in the presence of magnetite and goethite.

Text-Fig. 3c is an example where both magnetite and hematite are revealed, by steep rise to about 0.2 T (magnetite), a sharp kink at that point and a slow rise beyond this to about 1.5 T (hematite). They also show a strong influence of goethite by heating to 200°C before inducing IRM (Text-Figs. 3c, 5c).

Susceptibility of all samples were monitored at room temperature after stepwise heating to high temperatures and the results demonstrate that the magnetic mineralogy changed with heating at temperatures between 100°C and 300°C and up to 500°C.

The magnetic low-field susceptibility before heating for most samples is positive and low – it does not exceed $1.4 \cdot 10^{-4}$ SI. The $\varkappa$ vs T plots (Text-Figs. 4a, 5a) show a large scatter between 100°C and 300°C, probably a result of transformation of iron sulfides. The decrease of the susceptibility between the 400°C–500°C heating step shows the oxidation from iron sulfide to hematite. After heating to 500°C $\varkappa$ begins to rise, up to 10 times, indicating the formation of secondary magnetite during heating.

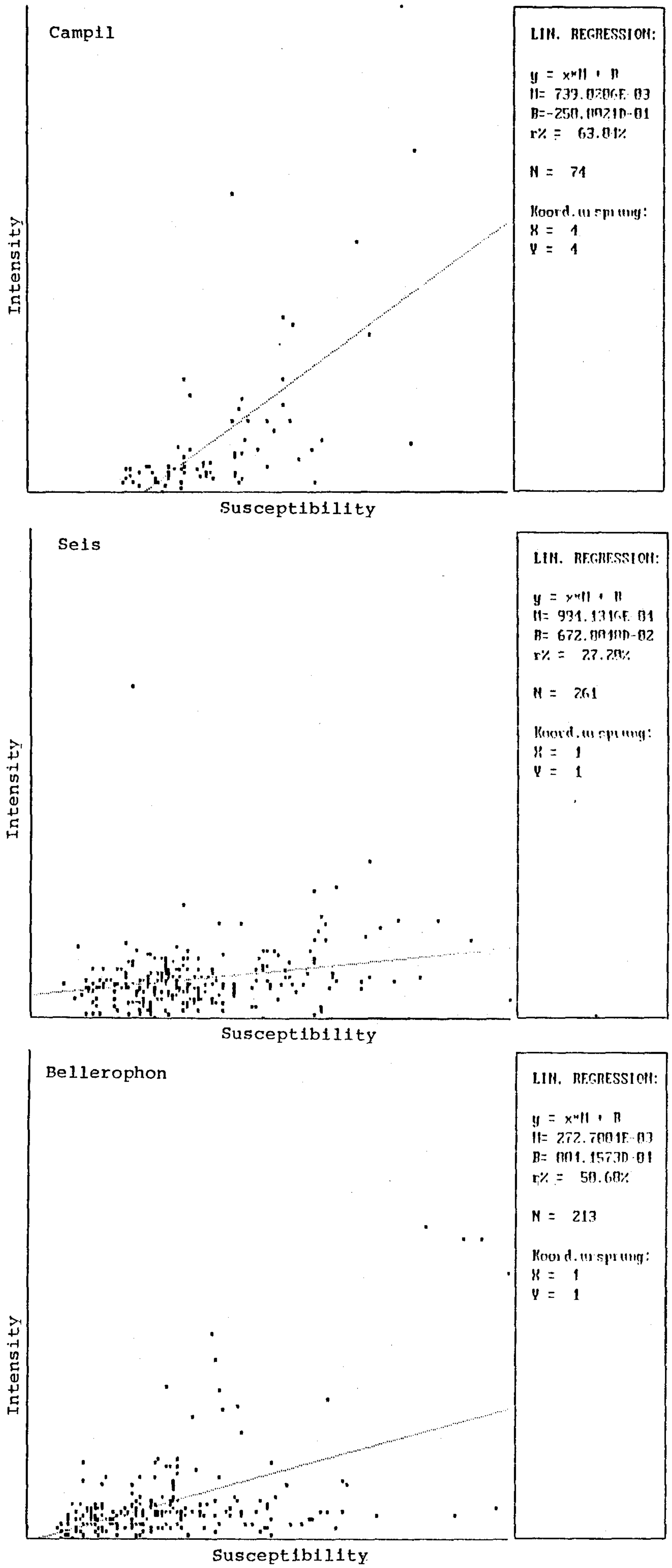


Fig. 6.
Crossplots between susceptibility (ϰ) and intensity (I) of all formations of the Gartnerkofel core GK-1:
a) Campil.
b) Seis.
c) Bellerophon.

The dominant magnetic mineral seems to be magnetite of various grain sizes, with participation of iron sulfides (pyrite, pyrrhotite). Contributions from hematite especially in the Campil Member and goethite are observed in nearly all parts of the profile.

The natural remanent magnetization intensities mostly range from 1.0×10^{-3} to 1.0×10^{-4} A/m. In some parts of the section the intensities are weaker than 1.0×10^{-4} A/m because of a lower magnetite content.

For each formation regression crossplots between susceptibility (abscissa) and NRM-intensity (ordinate) were computed, to investigate the influence of lithology on magnetization. The best correlation (r = 63.8 %) is found in the Campil Member, mainly owing to the fine-grained hematite dispersed in the homogeneous micritic limestones (Text-Fig. 5a). The most poorly fitting correlation coefficient (r = 27.2 %, essentially uncorrelated) of the Seis Member (Text-Fig. 6b) may be controlled by a varying magnetic mineralogy of this section, compared to the more homogeneous Bellerophon Formation, which has a much better correlation (r = 50.7 %) between susceptibility and intensity (Text-Fig. 6c).

5. Analysis of Characteristic Remanent Magnetization

In order to isolate the characteristic component of natural remanence (ChRM), the demagnetization results were improved by plotting mixed remagnetization circles (D.W. COLLINSON, 1983). To get reliable results the points plotted in the stereogram of Text-Figure 7 were taken from all normal intervals of the Reppwand section. The mean (345/+15) of all points of intersection between pairs of great circles (11 plots) is in good agreement with the Permian/Triassic reference pole (H. M. MAURITSCH & M. BECKE, 1984) for this region.

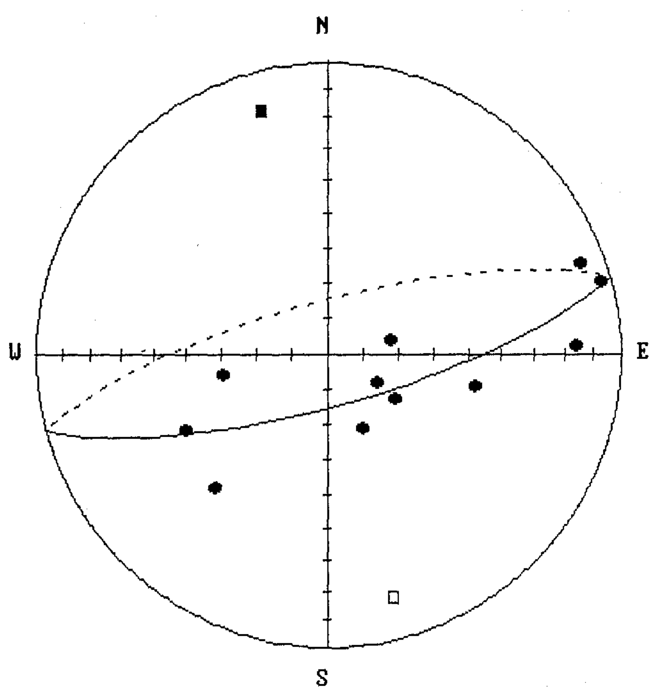
The difference in tectonic parameters, however slight, allowed us to apply the tilt-(fold) test (D. H. TARLING, 1983) to the two sites. The overall mean calculated before and after tectonic correction, suggests a pre-tectonic origin of the ChRM in some small parts of the profile (upper Campil, upper Seis) in view of a better grouping after correction (Text-Fig. 8).

As the study of the Reppwand and Gartnerkofel-1 samples progressed the tightest grouping was attained by thermal cleaning. Specimens from each site were subjected to thermal demagnetization in steps from 300°C to 450°C and in a few cases where the intensity was high enough, up to 600°C. Text-Fig. 9 illustrates the temperatures of thermal cleaning were applied to each bed that resulted in a tighter grouping of vectors and in a more distinct separation of normal and reversed polarity.

The ChRM vectors represent both normal and reversed polarities, which form more or less well-clustered (BKorr.), almost antipodal groups. Almost one-half of the specimens (47 %) in the Campil Member and 62 % in the Bellerophon Formation is reversely magnetized. The ChRM was taken as the first measurement after the direction stopped changing during thermal demagnetization. The susceptibility was monitored after each heating step, and remanence measurements were stopped if a marked susceptibility increase was accompanied by increasing directional scatter.

The mean ChRM intensities are 4.4×10^{-5} A/m, 3.2×10^{-5} A/m, 2.9×10^{-5} A/m in the Bellerophon Formation, Seis Member and Campil Member, respectively.

The paleomagnetic directions were grouped according to age, (Campil, Seis, Bellerophon) and to polarity (normal and inverse), and averaged statistically (R. V. FISHER, 1953; Table 1).

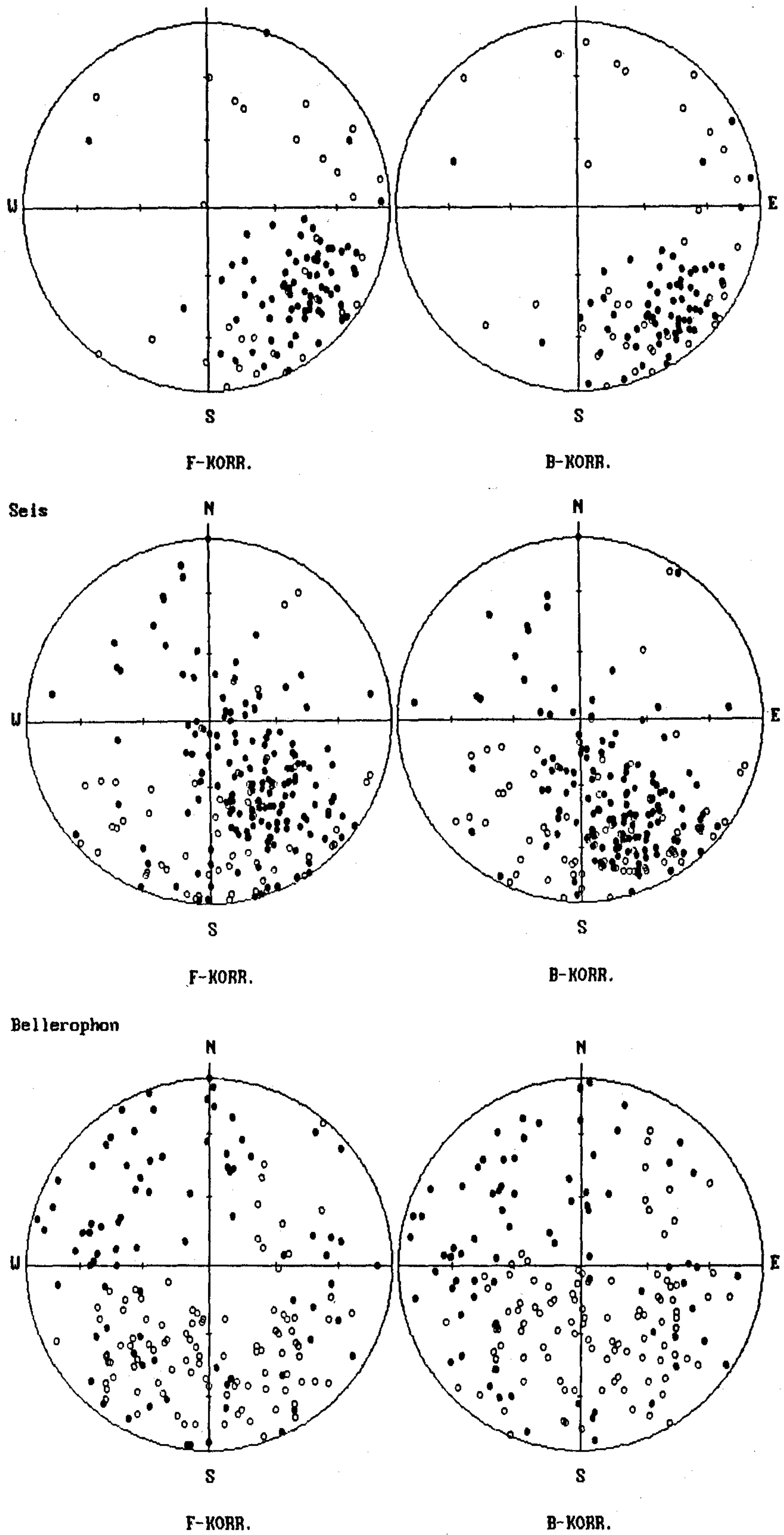


Text-Fig. 7.
Isolation of a primary magnetization (345/+15, N = 11) by mean of great circle distribution.

6. Anisotropy

Anisotropy of the "low-field" susceptibility was measured in the samples of the Gartnerkofel-1 drill core, giving reliable results despite the very low susceptibility ($59–81\cdot10^{-6}$) of all carbonates. The equal-area density plots of the distribution of maximum ($\varkappa_{max}$) and minimum ($\varkappa_{min}$) susceptibility axes demonstrate a non-primary magnetic fabric (Text-Fig. 10). Various shadings indicate the percentage of points per unit percent area (MORD = Multiples Of Random Distribution, Random Distribution = area/number of data). The $\varkappa_{min}$ axes of each part of the section were plotted in Text-Fig. 11 to demonstrate the considerable scatter in these magnetic values. This may arise from the weak susceptibilities of the samples, for a primary pre-deformational source or from local inhomogenities in strain on a scale smaller than that over which the strain data were collected.

With respect to the often recrystallized matrix the $\varkappa_{min}$ axes are grouped in a shallow NE–SW direction (Text-Fig. 10b) while the $\varkappa_{max}$ axes indicate a steep NW–SE direction (Text-Text-Fig. 10a). This strain is in



Text-Fig. 8.
Grouping of the ChRM directions before FKorr and after BKorr tectonic correction:
a) Campil.
b) Seis.
c) Bellerophon.
Open symbols = inverse; closed symbols = normal.

remarkable agreement with the local tectonic compression directions during the Alpine orogeny.

The most plastic rocks (P = 1.089, $\varkappa_{max}/\varkappa_{min}$), those of the Bellerophon Formation, show the most preferred orientation of Alpine deformation (144/–16, $\varkappa_{min}$) for this area, which is in good agreement with the data of J. S. RATHORE & M. BECKE (1980).

7. Magnetic Stratigraphy

Text-Fig. 11a, b exhibits the sequence of formations in the Gartnerkofel-1 drill core and their magnetic values. Paleodeclination and paleoinclination are smoothed with a bandwidth of 5 data points. The strike direction was extrapolated from nearby outcrops. Some typical lithological markers (e. g. stylolotization) are also plotted in Text-Fig. 13a to evaluate whether any magnetic overprint was related to such changes in lithology.

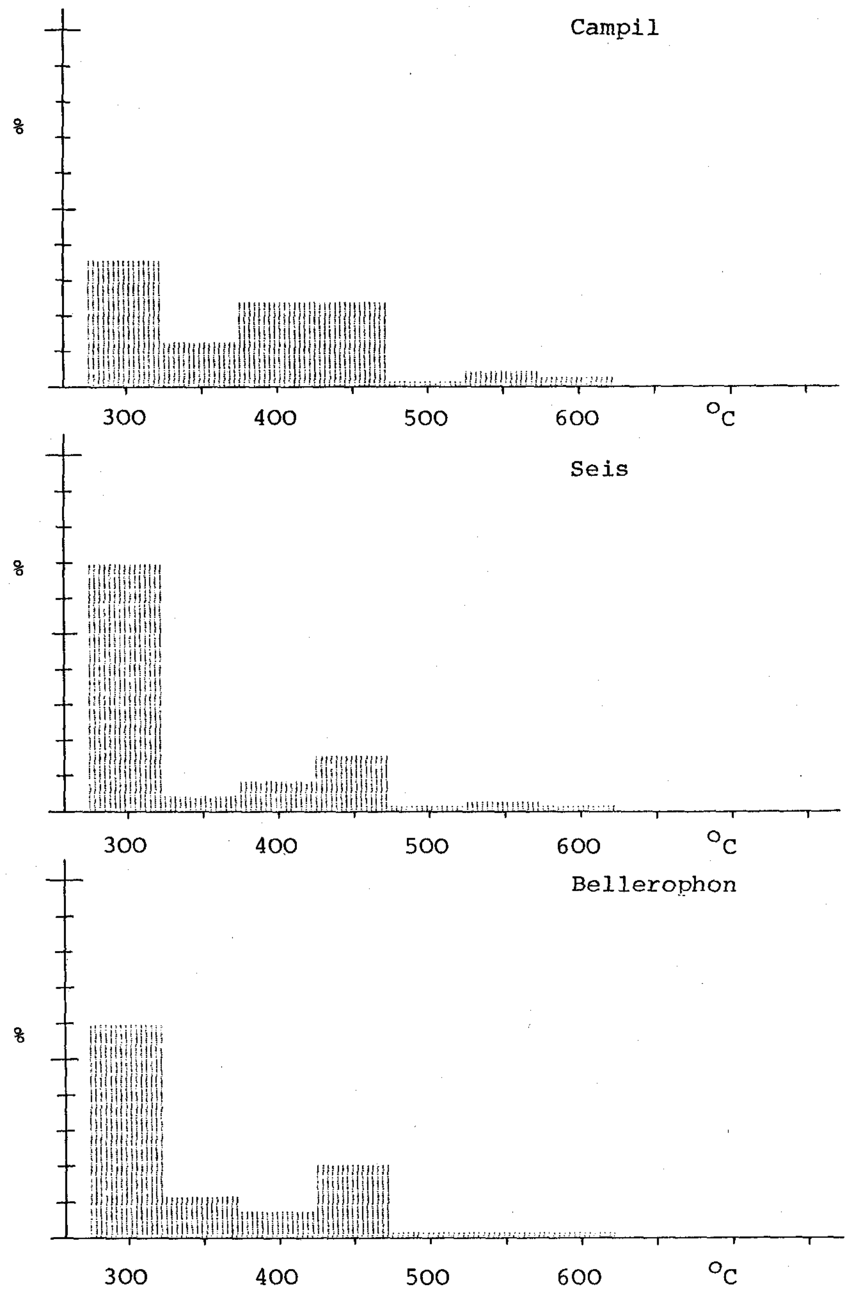
The ChRM directions define discrete stratigraphic zones of declinations and inclinations (Text-Fig. 12a). Many of the magnetic polarity reversals involve synchronous changes in declination and inclination. Coincident changes in the remanent intensity (ChRM) and especially the susceptibility (ChRM) (Text-Fig. 12b) suggest lithological control.

For example, the susceptibility increases by an order of magnitude in the beginning of the gradual transition from the Seis Member to the Campil Member (120 to 110 m) (Text-Fig. 12b). This part of the Seis Member is characterized by dolomites veined with fine-grained hematite. In the Campil Formation itself a shallow inverse inclination and a declination of about 150° suggests a primary magnetization with a characteristic south Alpine Permian direction, but samples were mostly overprinted by most probably Cretaceous magnetic field directions.

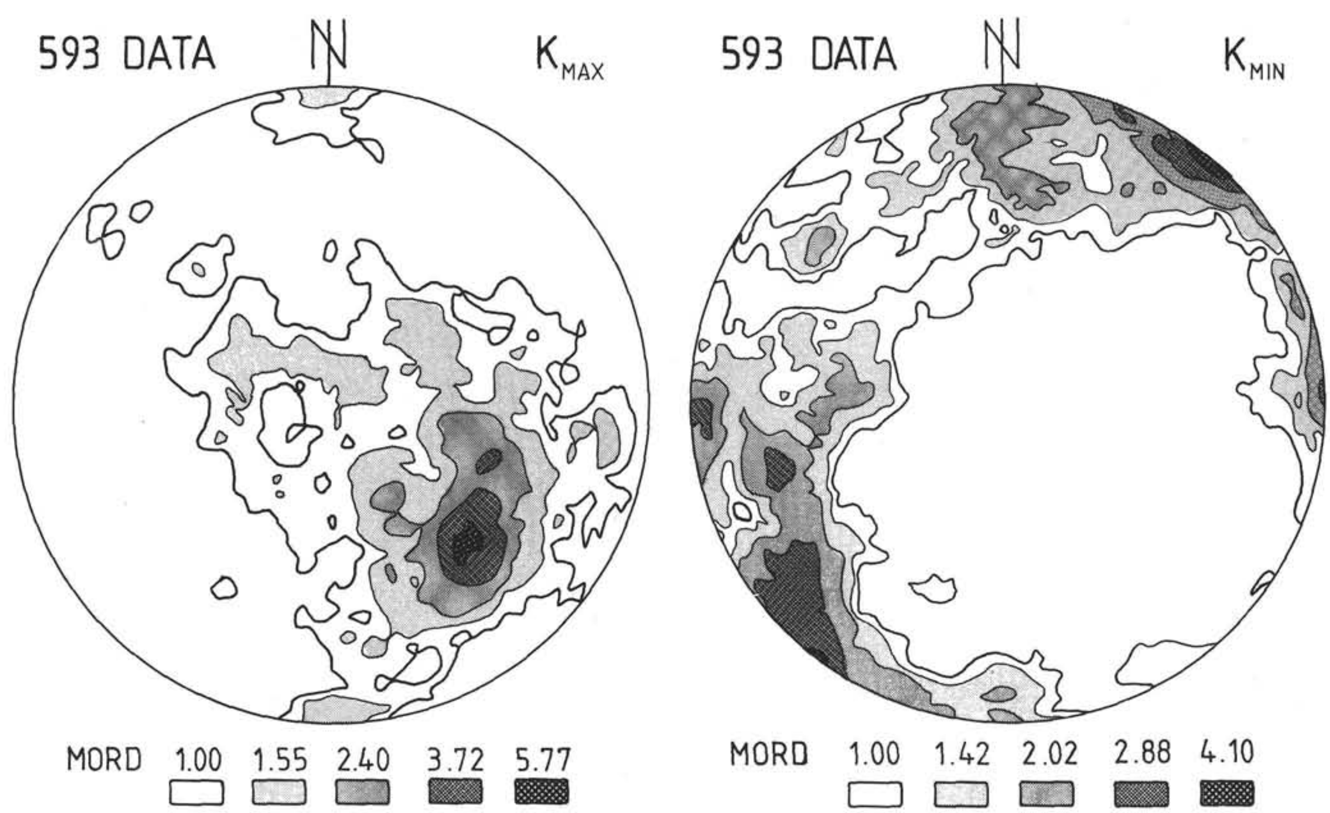
Just below the Mazzin/Tesero boundary near 225 m a minimum of susceptibility corresponds to a zone rich in fine-grained pyrite, partly altered to goethite and hematite (W. T. HOLSER, this volume).,

In the Gartnerkofel-1 core zones of tectonic movements (110–116 m, 150–160 m, 207–211 m, see K. BOECKELMANN & M. MAGARITZ, this volume) with more coarse-grained dolomite and higher concentration of pyrite and hematite can be correlated with susceptibility minima. In the outcrop section all pyrite seems to be oxidized to goethite or hematite.

In the Gartnerkofel-1 (Unit 1) and in the overlying Tesero Horizon (Unit 2) rock magnetic studies show magnetite with induced remanent magnetization (IRM) saturation at about 0.5 T (Text-Fig. 3c) and maximum blocking temperatures between 300°C and 500°C (Text-Fig. 3a). In some intervals a minimum in the sus-



Text-Fig. 9.
Distribution of the cleaning temperature versus percentage of the samples of a) Campil, b) Seis and c) Bellerophon.



Text-Fig. 10.
Equal-area density plot of the distribution of maximum $\varkappa_{max}$(10a) and minimum $\varkappa_{min}$ (10b) axes of the susceptibility anisotropy in GK-1.
Different shading = MORD (Multiples Of Random Distribution).

ceptibility plot probably indicates hematite-bearing samples.

Some of the intervals of low susceptibility and high hematite content also have normal polarity suggesting that these reversals could be lithologically controlled by Cretaceous mineralization during the Alpine orogeny. The inclination in this part of the section is very steep (40°–50°, Text-Fig. 11a), which would correspond to a magnetic field direction for Cretaceous time. The distribution of $\varkappa_{min}$ axes (Text-Fig. 10b) also indicates that the mineralization was contemporaneous with the NE–SW compression along the Periadriatic Line.

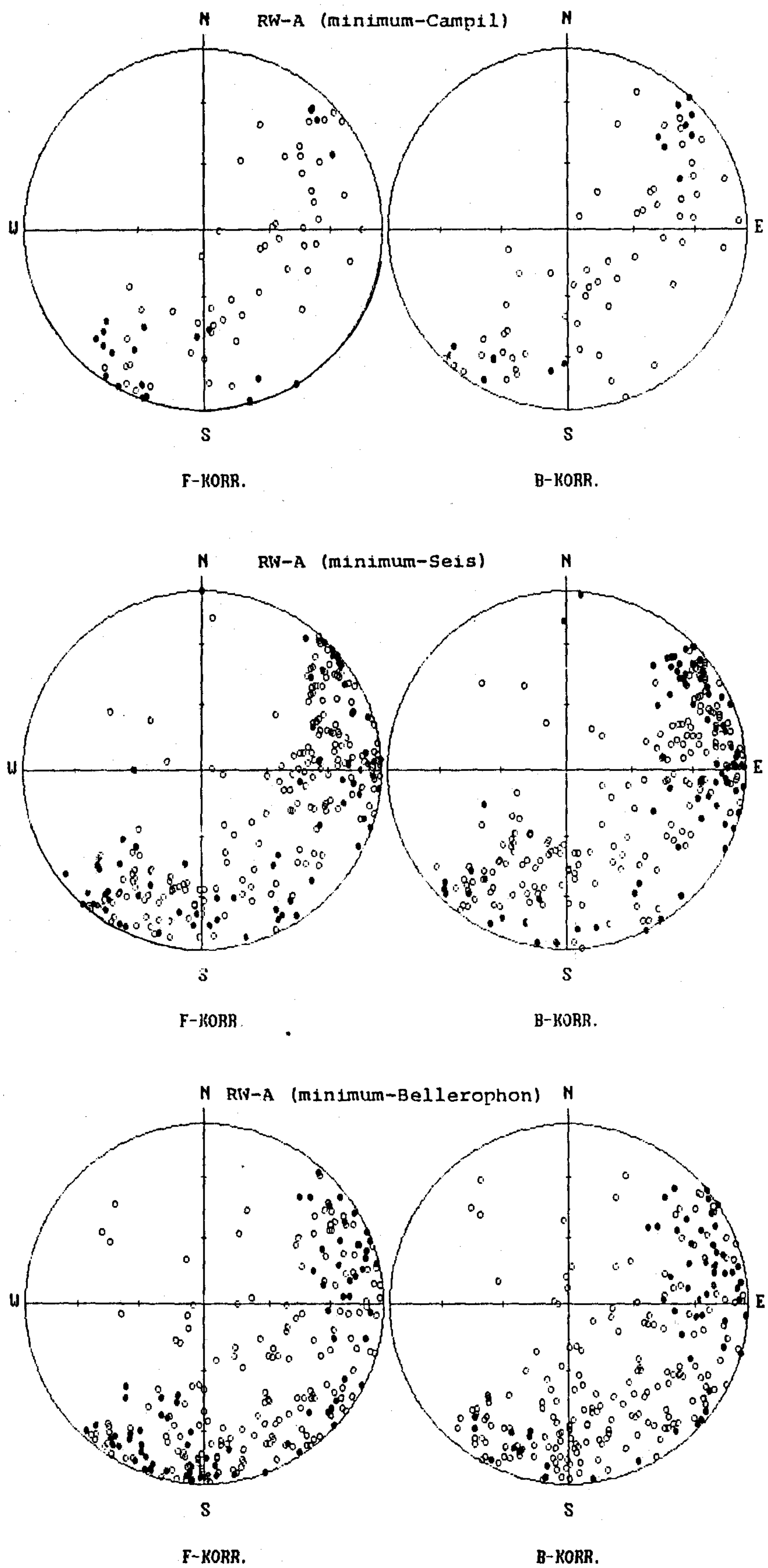
8. Discussion and Conclusion

According to the results of the section on rock magnetism the Reppwand and Gartnerkofel-1 core profiles demonstrate a multicomponent magnetization of all limestones and dolomites. Using thermal demagnetization, Permian (148/–20) and Cretaceous (312/+46) paleomagnetic directions could be isolated in part. Probably all of the polarity changes indicate random distributions on great circles between Permian and Cretaceous remanence vectors. This is characterized by Table 1, which shows the paleomagnetic mean directions (FKorr/BKorr) of each formation. The distribution of the vectors, indicating a varying contribution of a Cretaceous overprint, is probably lithologically controlled.

The magnetostratigraphy of the outcrop section does not correlate with that of the Gartnerkofel-1 core (Text-Fig. 13). We also conclude that the magnetostratigraphy of neither profile is a reliable measure of the paleofield of Permian/Triassic time. The lower part of the outcrop section follows the recent Earth's magnetic field direction, as a consequence of present-day pyrite oxidation (K. Boeckelmann, 1988). In contrast some sections of the upper part (above about 27 m) exhibit a shallowing inclination with a synchronous shift in declination, suggesting a possible primary magnetization. But because the inclination is shallow, and of positive

Table 1.
Paleomagnetic Mean Directions before (FKORR) and after (BKORR) Tectonic Correction.
N = number of samples; $\varkappa$ = precision parameter; α_{95} = half angle of confidence.

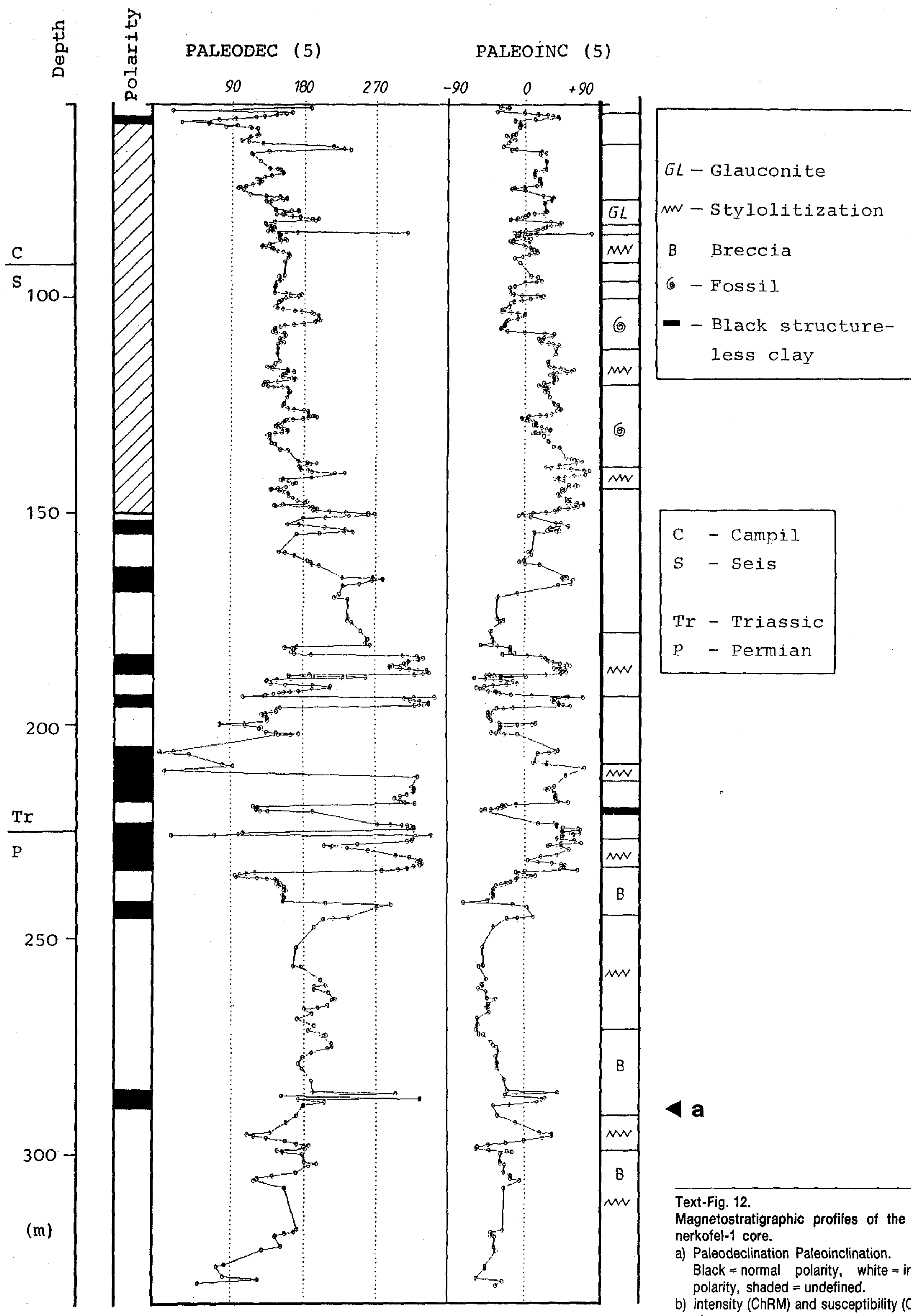
			DEC/INC	N	K	α_{95}
Campil Member		FKORR	130/+27	109	7.4	10.5
		BKORR	136/+20	109	7.5	10.3
Seis Member	Positive Inclination	FKORR	147/+45	261	8.3	7.1
		BKORR	160/+31	261	8.7	6.7
	Negative Inclination	FKORR	160/–33	34	7.3	8.8
		BKORR	155/–22	34	7.9	8.7
Bellerophon Formation	Negative Inclination	FKORR	202/–56	214	5.8	14.9
		BKORR	191/–59	214	5.9	14.8
	Positive Inclination	FKORR	329/+34	44	4.9	15.3
		BKORR	312/+45	44	5.7	14.9



Text-Fig. 11.
Demonstration of the scatter of the $\varkappa_{min}$ axes in each part of the section GK-1.
Open symbols = inverse, closed symbols = normal.

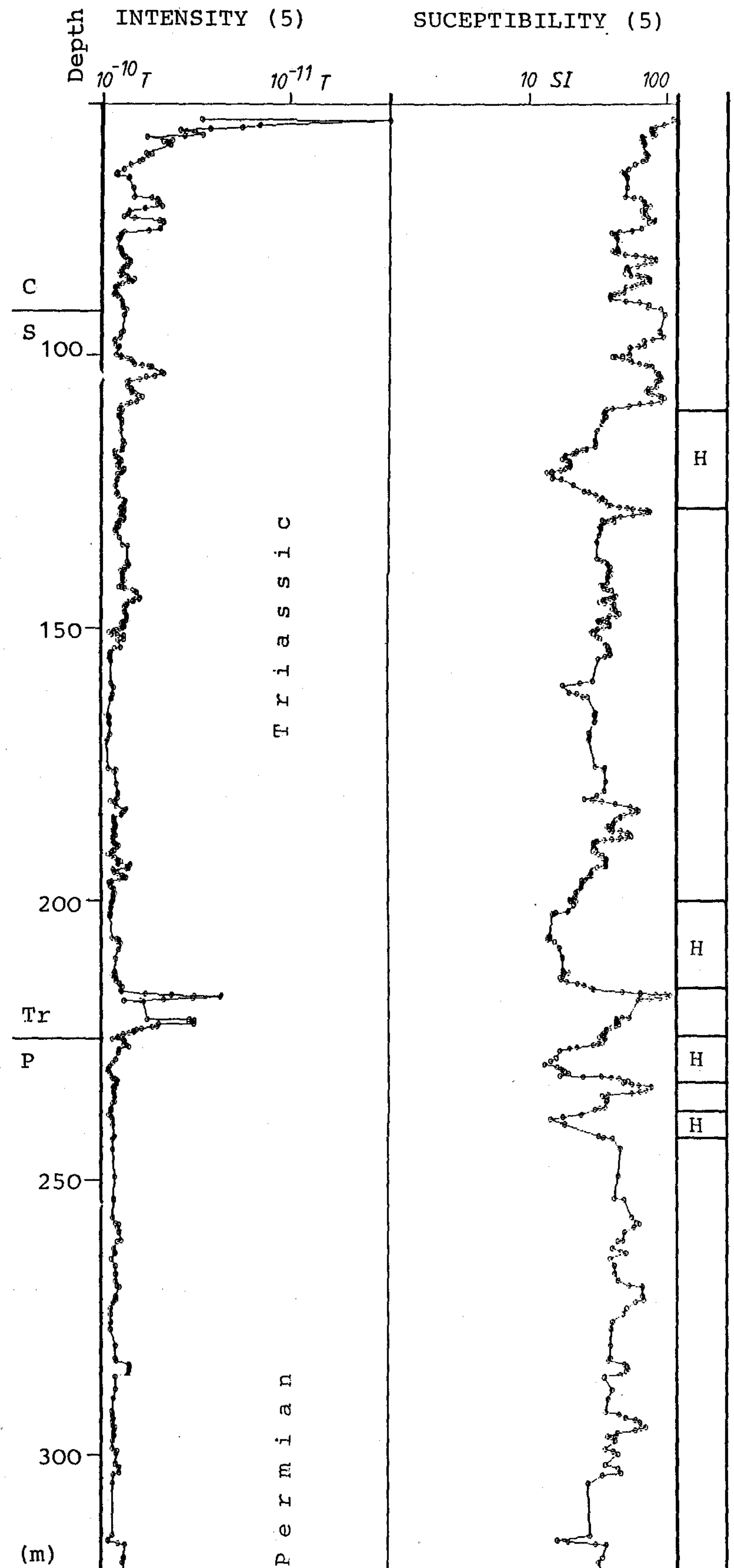
instead of inverse inclination, indicates a remaining Cretaceous overprint. Primary and secondary magnetization are apparently equally resistant to cleaning.

The drill core Gartnerkofel-1 is characterized by different polarity changes: The lower part of the Seis Member as well as that in the Bellerophon Formation shows synchronous changes of declination and inclination, while the Campil Member has a very homogeneous declination and only varies in inclination. In the Seis Member most of the inclinations are steep



Text-Fig. 12.
Magnetostratigraphic profiles of the Gartnerkofel-1 core.
a) Paleodeclination Paleoinclination.
Black = normal polarity, white = inverse polarity, shaded = undefined.
b) intensity (ChRM) and susceptibility (ChRM) plots

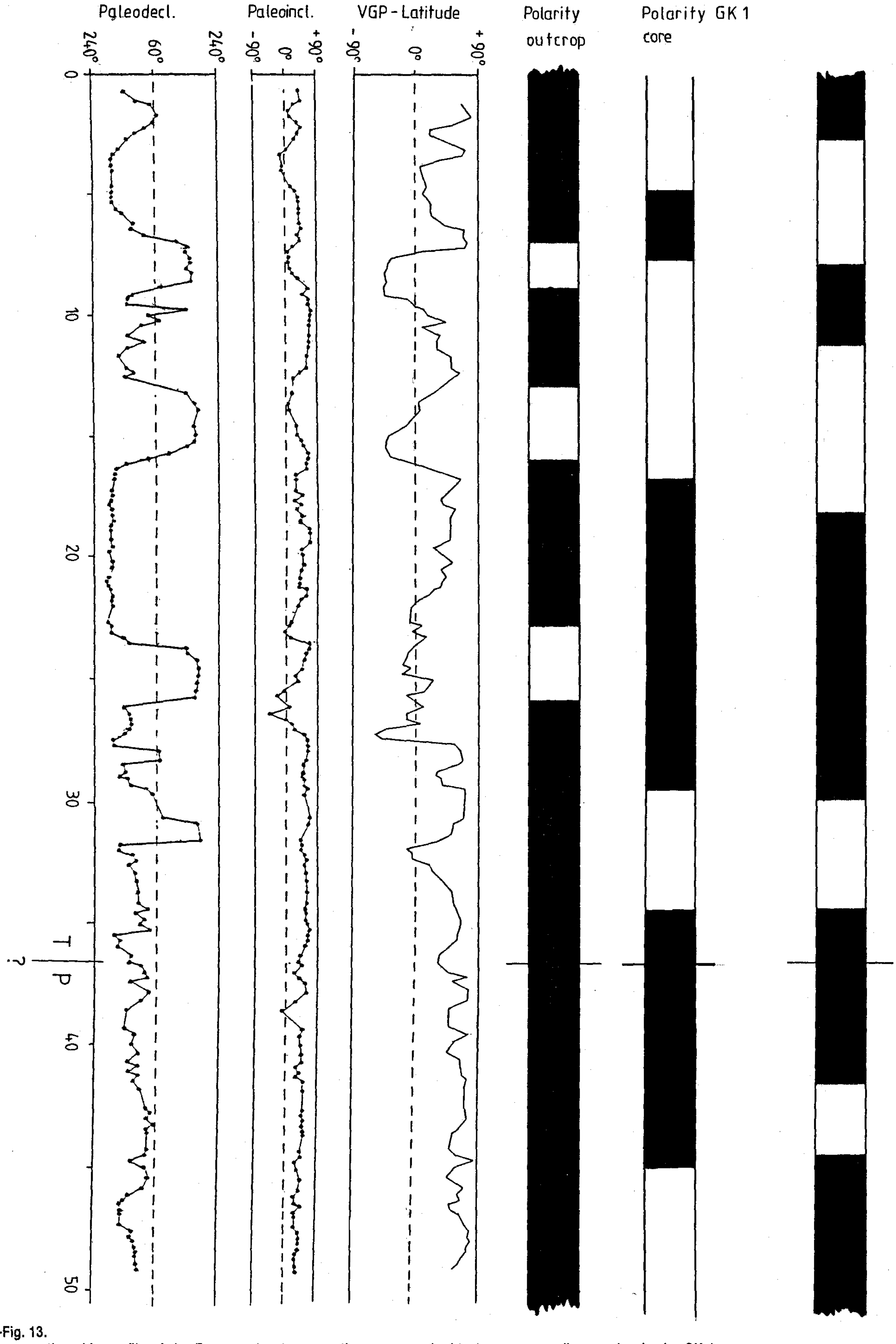
H = Hematite



Depth
INTENSITY (5)
SUCEPTIBILITY (5)
10^{-10} T
10^{-11} T
10 SI
100
C
S
100
150
200
Tr
P
250
300
(m)
Triassic
Permian
H
H
H
H

b ▶

MAGNETOSTRATIGRAPHIC PROFILE "REPPWAND" - P/T-BOUNDARY



Text-Fig. 13.
Magnetostratigraphic profile of the Reppwand outcrop section, compared with the corresponding section in the GK-1 core.
Black = normal polarity; white = inverse polarity.

(40°–50°), probably indicating a Cretaceous or younger overprint. In contrast to the outcrop section a primary magnetization (345/+15) could be isolated in a few parts of the sections by means of a great circle distribution (Text-Fig. 7).

The strain measured from the degree of the anisotropy of the susceptibility shows a NE–SW directions, which can be correlated with the local tectonic compression direction during the Alpine orogeny (J. S. RATHORE & H. J. MAURITSCH, 1983). This NE–SW strain corresponds to a sinistral movement direction on the Periadriatic Line, causing a clockwise distortion. The Permian direction computed by great circle distribution (345/+15) is in good accordance with the results of the anisotropy, also indicating a clockwise rotation.

To summarize all these results, we conclude that the outcrop section as well as the profile of the drilling core are overprinted by recent and Cretaceous Earth's field directions, in varying amounts. Mainly normal directions seem to be acquired during this overprinting, so the remagnetization is presumed to have occurred during a normal polarity event. Possibly this alteration of magnetic minerals accompanied one of the two stages of dolomitization to which the whole section has been subjected (K. BOECKELMANN & M. MAGARITZ, this volume). These paleomagnetic results are in contrast to success in determining paleopoles for the underlying Carboniferous limestones of the Auernig Formation (see Text-Fig. 2) from this same area of the Carnic Alps (H. HEINZ & H. J. MAURITSCH, 1980; M. MANZONI et al., 1989).

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