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Palaeomagnetic Investigations on Hematite Pigmented Magnesites of the Western Graywacke Zone, Austria

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With 5 figures

Schlüsselwörter

Ostalpen
Paläomagnetismus
Magnesite: hämatitpigmentiert
Grauwackenzone (westliche)

Abstracts

Based on the early work of HANUS and KRS (1963) on haematite pigmented magnesites of Bankov (Czechoslovakia) and on the need of additional information about the diagenesis of the magnesite, palaeomagnetic investigations in the Entachen area were started in 1977. The chosen sampling area was east of Saalfelden in the western graywacke zone. The sampled materials were haematite pigmented magnesites and dolomites. The rockmagnetic investigations established the recristallized haematite as carrier of the natural remanent magnetisation (NRM). The material was cleaned at 400 Oe, and alpidic directions of characteristic remanent magnetisation (ChRM) for the three sampling areas Entachen, Fuchspalven and Pfanneggkogel were found.

Introduction

Since the early thirties a lot of investigations have been carried out to study the problem of diagenesis of magnesites (MOSTLER, 1973). KRS and HANUS (1963) studied the haematite pigment in magnesite by the palaeomagnetic method and suggested it as a tool for investigating such problems. The object of this study was to try this method on the magnesite deposits in the western graywacke zone of Austria, not only for diagenetic purposes but also to try and establish an alpidic virtual magnetic poleposition for the eastern alps. The fieldwork was started in the area of Saalfelden on the Fuchspalven near Dienten, on the Entachen Alm and on the Pfanneggkogel (Fig. 1). The samples were drilled in the field and oriented with a magnetic compass. The bedding planes were also measured with geological magnetic compass but had to be sometimes statisticly calculated because of the rough surface of the bedding planes.

Rockmagnetic Investigations

The rockmagnetic investigations were undertaken to find the carrier of the magnetic properties and to determine the correct cleaning procedure.

As shown in Fig. 2 temperature and ac-field demagnetisations were carried out. In Fig. 2a it can be seen that the ac-demagnetisation effects the intensity of magnetisation

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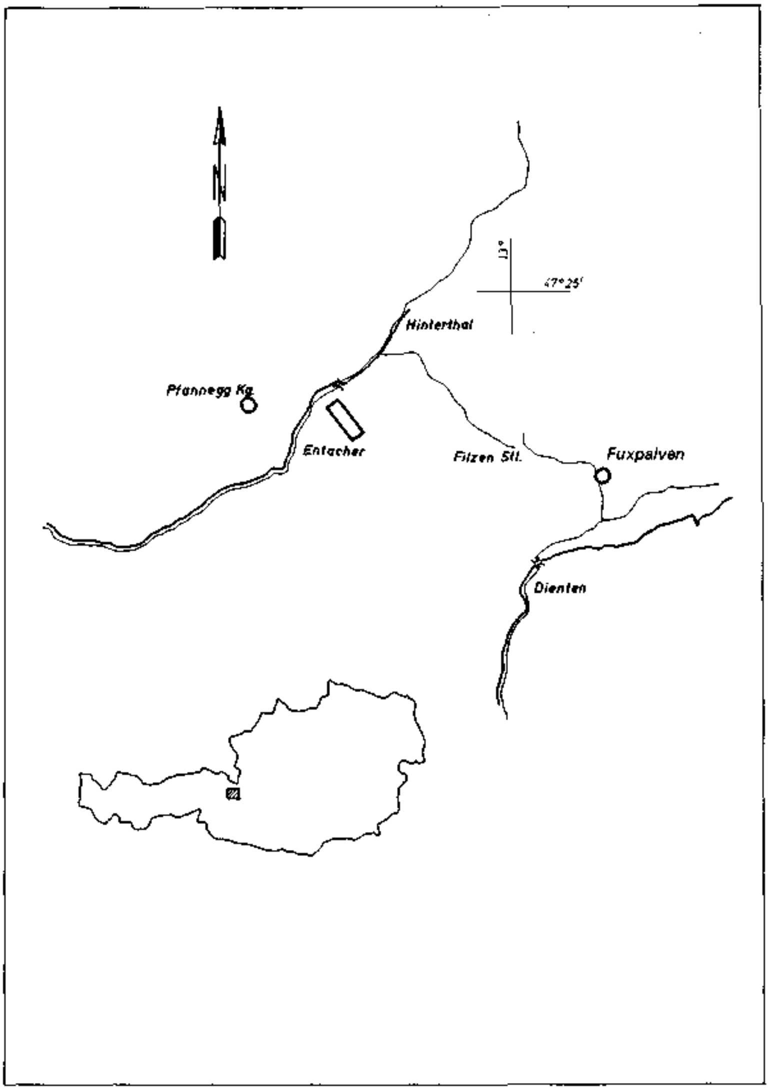

Fig. 1: Sketchmap of the sampling areas.

(NRM) up to about 500 Oe after which it remains stable. Up to 100 Oe demagnetising fieldstrength there is a small change in the direction of the NRM and the usual decrease in magnetic intensity. Between 100 and 450 Oe demagnetising peakfield the ChRM remains stable in direction. The ChRM is defined in this case as the cleaned NRM above 100 Oe.

In Fig. 2b the results from the high temperature experiments are shown. The two kinds of material, the un-pigmented and the pigmented magnesite are generalised by the result for samples E 2c and E 9a respectively. The intensity of sample E 2 decreases above 300° C to show a blocking temperature of at least 500° C which seems to be due to magnetite. There is a high increase in the susceptibility above 400° C. This increase and the increase of the susceptibility of all the pilots above this temperature is one of the most interesting phenomenon which was found. The most suitable explanation is the reduction of parts of the haematite pigmented under the influence of the CO_2 to magnetite during the heating procedure. The decrease in magnetic intensity of samples E 9a 2 and E 9a 4 with respect to the small plateau of sites E 9a 5 and E 2c between 450 and 500° C seems to show that the reduction process is possibly interrupted or overlapped by an oxidation effect. In Fig. 2c the saturation behaviour of two pilots is shown and can be seen that the curves show a haematite behaviour. In Fig. 2d the IRM and ARM properties of the material are shown. The IRM is as expected hard and the ARM shows a multidomain behaviour.

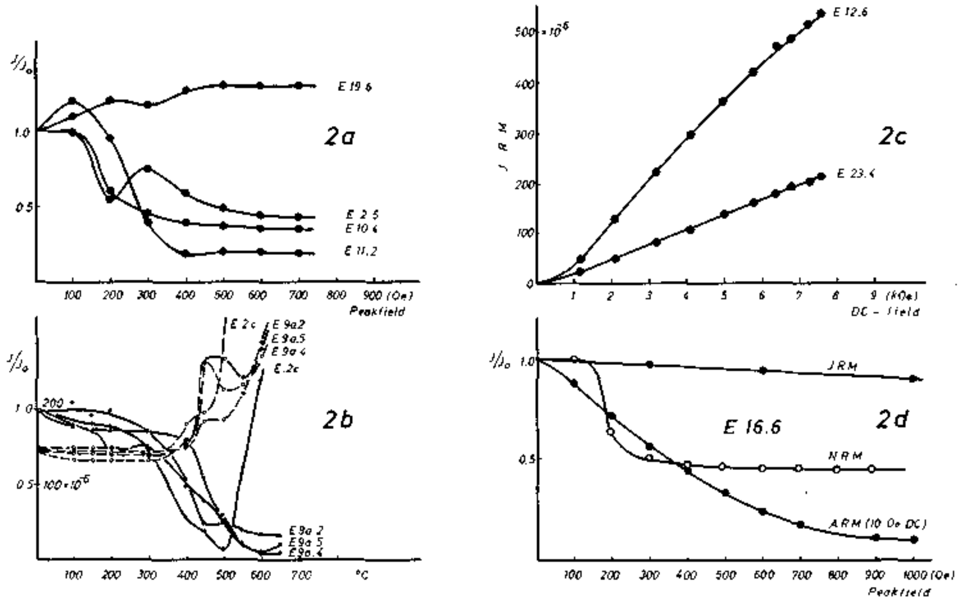

Fig. 2: Rockmagnetic results.

a) AC-demagnetisation behaviour of four characteristic samples
b) High temperature experiments; fully drawn curves show the change of the intensity with the increase of temperature, broken curves the susceptibility belonging to it
c) Increase of the IRM with increase of DC-fieldstrength
d) IRM, NRM and ARM characteristic of a dark red coloured sample. The ARM were formed in a 10 Oe DC-field.

Summarizing it can be pointed out that the carrier of the magnetic properties is mainly the haematite pigment which seems to be slightly influenced by small amounts of magnetite especially in the grey layers. The influence of the initial magnetite is not detectable in the direction analysis because this magnetite was probably formed during the metamorphism. Very strong geological evidence exists for this alpine metamorphism and Schramm (1977) and personal communications suggests a metamorphic temperature of 300–350° C. This relatively lowforming temperature of the ChRM could be the reason for the directional unstability above 450–500 Oe. Even high field and temperature experiments between 450 and 1000 Oe and 500° C and 680° C could not prove a stable remanence. Taking all these results into acount, one has to come to the conclusion that the haematite pigment must be overprinted (martitisized?). Another reason will be discussed later.

Results

The results are discussed in detail on the example of the Entachen Alm were the largest part of the sampling was carried out. The sampling was started near the footwall of the deposit which in this case is build up of black silicified shales, followed by lydites alternating with black dolomites. The black dolomites change into grey dolomites and finally into red

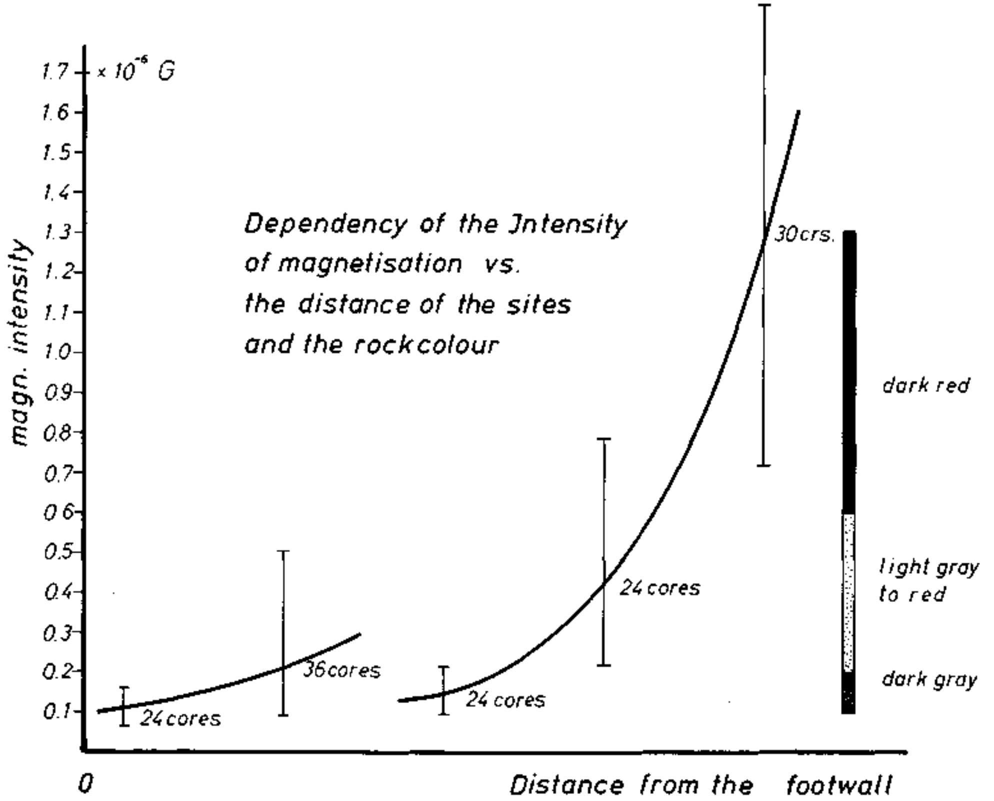

Fig. 3: This figure shows the distribution of the magnetic intensity depending on the distance of the sites from the footwall and the colour of the samples. The interruption in the durve is clear to unterstand because in this position we went back to the footwall for topographic reasons.

nodulous limestones. The magnesite first occurs in the horizon of the black nodulous dolomites which are interlayered with the lydites and continue throughout of the whole profile (Mostler, 1973). Since the dip of the beddings in the magnesite is steeper than the topography the sampling was done from the footwall to the hangingwall of the sequence. In Fig. 3a comparison of the magnetic intensity, distance of the outcrops from the footwall and the colour of the material is shown. There is strong indication for haematite being the carrier of the remanence (NRM) because the magnetic intensity increases with the darkness of the red colour. This argument on its own has to be handled carefully because in a lot of sediments the haematite pigment occurs in a superparamagnetic particle size, however, with the rockmagnetic results in this particular case one can take it as additional evidence for the recristalized haematite being the remanence carrier.

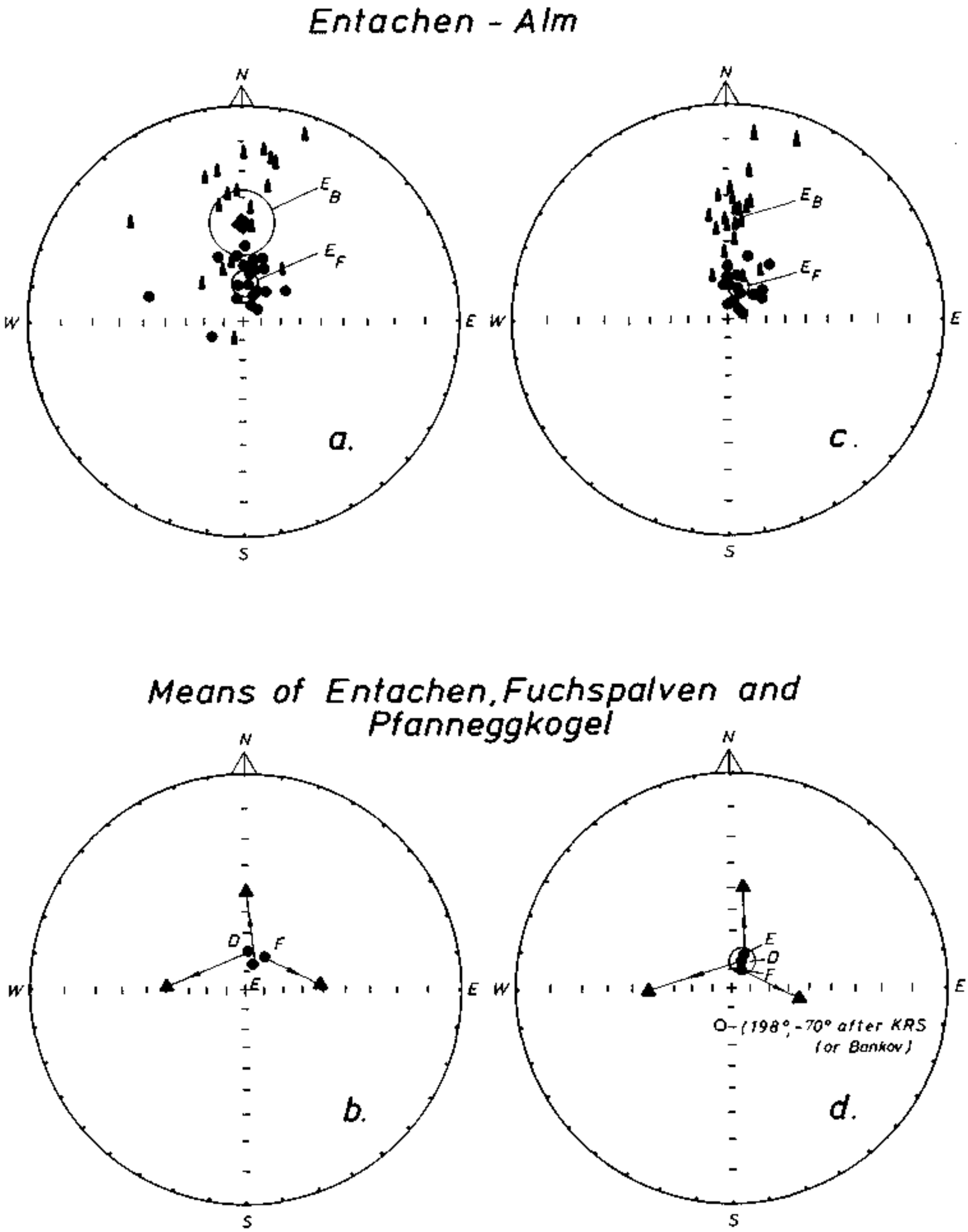

Fig. 4: a) Initial distribution of the site means for the Entachen Alm (E_F mean after field orientation, E_B mean after bedding correction with coni of confidence).

b) Area means for Fuchspalven (F), Entachen Alm (E) and dolomite of the Pfanneggkogel (D) before (full circles) and after (triangles) bedding correction.

c) Site means after 400 Oe demagnetisation (E_F mean after fieldorientation, E_B after bedding correction).

d) Area means after field correction (full circles) after bedding correction (triangles). The open circle shows the direction for Bankov.

The samples were measured with a spinner magnetometer (MOLYNEUX 1971) and the site mean orientations were plotted on a stereogramm (Fig. 4a). The grouping after the reorientation with the fieldorientation data is very good (table 1). The initial mean direction for Entachen Alm is Dec. = 003.9; Inc. = 69.7. After the tectonic (bedding) correction the

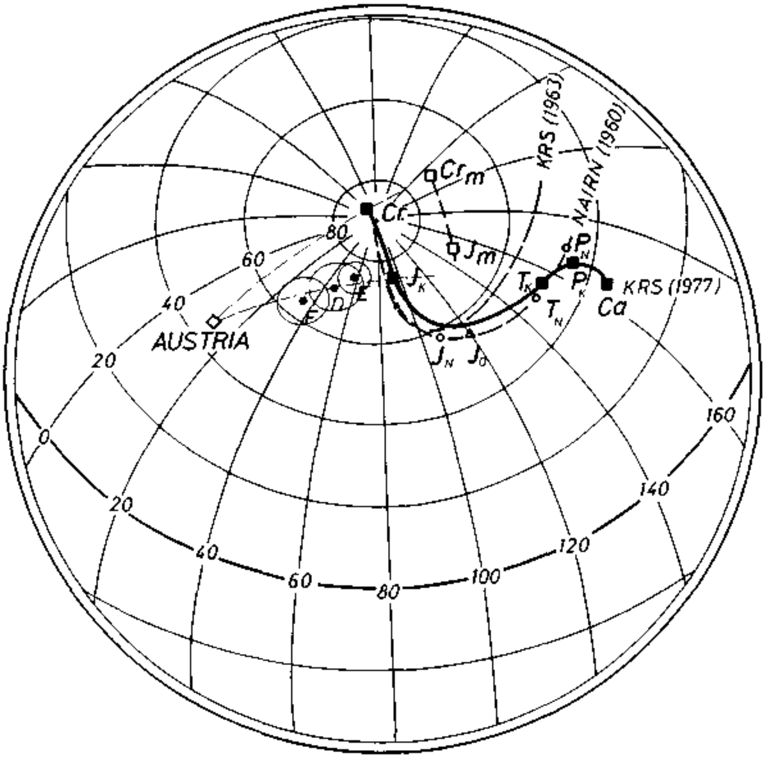

Fig. 5: Polar wandering path for stable Europe after KRS (1963, broken line), NAIRM (1960 brocken line with open circles and the footnote (N)) and KRS (1977 with footnotes [K]). (J_o) marks the Jurassic pole after OPDYKE and C_{rm} and J_m the virtual pole position for mobile Europe. (E, D, F) – virtual poles for Entachen Alm (E), dolomite (D) and Fuchspalven (F).

scatter was very high and the more or less meaningless mean direction became Dec. = 000.8; Inc. = 42.1. This is a typical case of a negative fold test. The reason for the relatively good grouping even after the tectonic correction is that the inclination coincides, to an extent, with the dip of the beddings. The same procedures were carried out for the other two sampling areas the Fuchspalven and the Pfanneggkogel. In Fig. 4b the mean directions for all three sampling areas are shown and the negative fold test is much more noticeable than it is in one area. After the initial measurements the whole material was cleaned at 400 Oe peakfield. It is clearly seen that the secondary effects had been successfully removed (Fig. 4c) and, in table 1 the statistic parameters are remarkably better than before the cleaning with a better grouping of the site means. As before in Fig. 4d the mean direction of the sampling areas were plotted to show again the negative fold test after cleaning. Once again the grouping of the field oriented mean values in satisfactory. After the tectonic correction one gets the same meaningless scatter. This negative fold test proves that no magnetisation direction was produced during sedimentary processes. If we assume that the haematite is detrital (and the red colouration of the surrounding limestones [Saubergerkalke] speak for this fact) we have to conclude that the magnetisation direction must be an overprinted direction. Furthermore one can see in Fig. 4d that the magnetisation directions of the three sampling areas show deviations form each other. These deviations can easily be explained by tectonic movements between the three sampling areas. The mean direction of the ChRM for the whole area gives a Dec. = 021.7 and an Inc. = 75.2. This means that during metamorphism the haematite pigmented magnesites must have been in a more flatlying position than present. Compared with the present inclination of the earth magnetic field in this area and, assuming that the deposit was not very far from the present day position during the Alpidic metamorphism, a tilting correction of at least 8° has to be assumed. The further south the deposits lie the larger will be the necessary tilting correction. In the model of FRISCH (1977) there is no doubt that the sampling area was originally further to the south of the present position during the time of metamorphism. As seen in Fig. 4d there is good agreement of these results with the directions of HANUS and KRS for the area of Bankov (Czechoslovakia).

For the age determination of the magnetisation direction the pole wandering paths after KRS (1963) (for Czechoslovakia) and NAIRN (1960) were taken and modified after KRS (1977). One can see in Fig. 5 that the mean direction for the whole investigated area fits better to the Jurassic poleposition for stable Europe than to the Cretaceous poleposition. This, at first irritating result, has to be seen in connection with the present position of the sampling area and its associated rotation with respect to the Cretaceous direction of stable Europe. If we rotate the magnetisation vector over approximately 20°–25° counterclockwise then we get a very good agreement with Cretaceous poleposition.

Discussion

After all these results the questions asked at the beginning of this paper should be discussed. Firstly the question concerning the diagenesis of the magnesite and secondly the Alpidic magnetisation direction.

If we assume that the Fe and Mg occured at the same time, which seems to have been proven by microscope analysis (intergrowths of haematite in magnesite SIEGL (personal comunication) and further assume that the distribution of the haematite pigment shows a strong increase from the footwall to the hangingwall (Fig. 3) or in other words from the footwall to the permeability plane, then one gets the impression of a metasomatic process which formed the magnesite and the haematite pigment. If we combine these mineralogical facts with the palaeomagnetic results we have to come to the conclusion that the magnesite was formed by an alpidic (early) metasomatism.

J. M. SCHRAMM (1973) found sub-angular magnesite components in the basal breccia (Permian) hence, the age of the magnesites is variscian under the assumption that the magnesite in the different localities are from the same age. Taking these facts into account one must conclude an Alpidic metamorphism as the cause for the direction of magnetisation. This second possibility is very strongly supported by the metamorphism investigations by J. M. SCHRAMM (1977).

The Alpidic (Cretaceous) magnetisation direction shows a clockwise rotation of approximately 12° in comparison to the palaeopolposition for the Cretaceous of stable Europe (KRS 1977). This clockwise rotation is in very good agreement with the fact, that the Northern Calcareous Alps with the Greywackezone rotated clockwise during the alpine orogeny (MAURITSCH & FRISCH 1978, in press, SOFFEL 1977 personal comm. HARGRAVES & FISCHER 1959, FRISCH 1977). Therefore we have to assume that the magnesites and dolomites investigated were in a more southerly position during the metamorphism. If that is correct then one gets a larger tilting correction, which fits without problems, in the reconstruction in Fig. 5 and also in the models of MAURITSCH & FRISCH and FRISCH 1977.

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