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Palaeomagnetic and Rockmagnetic Properties of the Permian Volcanics in the Western Southern Alps*

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Abstract. A palaeomagnetic and rockmagnetic investigation has been carried out in the western Southern Alps. At 31 sites in the Permian volcanics from four regions 349 samples were drilled: 1. the region of Arona (SW of Lago Maggiore), 2. the porphyry district of Lugano and Ganna, 3. the Valle Brembana (N of Bergamo) and 4. the Auccia volcanics (N of Brescia).

AF-cleaning as well as continuous and progressive thermal demagnetization reveal, in most of the igneous rocks studied, the presence of a stable characteristic remanent magnetization (ChRM) representing the magnetization acquired at the time of formation of these rocks. Microscopic observations, IRM-acquisition curves and Curie point measurements indicate the ChRM to be carried by Ti-poor magnetite and titanohematite. Stable secondary magnetizations due to oxidation may be present. Their directions, however, are very similar to the primary thermoremanent magnetization (TRM). Therefore it is inferred that the oxidation probably took place shortly after acquisition of the primary TRM.

The magnetization directions within individual sites are well grouped (α_{95} usually $< 10°$), but the site mean directions are dispersed, due to regional and local tectonic complications. At Arona, Ganna and Auccia a suitable tilt correction can be made. Since the consistent directions from these sites are very similar to the well defined results from the Bolzano porphyries (Zijderveld et al., 1970), it is suggested that the western and eastern Southern Alps have, on a large scale, behaved as a single tectonic unit. The Southern Alpine block has been rotated anticlockwise by about 50° relative to extra-alpine Europe since the Early Mesozoic.

The Permian Southern Alpine palaepoles are situated close to the Permian part of the African polar wander path. Therefore the palaeomagnetic data support geological and sedimentological arguments which consider the Southern Alps as originating on the southern margin of Tethys and forming a parautochthonous extension of the African plate since the Early Mesozoic.

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1. Introduction

For more than a decade the Alpine and Mediterranean area has been of much interest for palaeomagnetic studies. Earlier investigations in the Southern Alps – the region to the South of the Insubric Line (Fig. 1) – give palaeomagnetic evidence for tectonic rotations (e.g. Zijderveld and Van der Voo, 1973). Most of the palaeomagnetic data from the Southern Alps however, come from regions to the east of the Giudicaria fault and concentrate on the Bolzano quartz-porphyries. Many of these data are based on purely palaeomagnetic work with little or no examination of the magnetic mineralogy.

The aim of the present palaeomagnetic and rockmagnetic study was to obtain more evidence related to the large scale tectonic history of this area.

2. Geological Outline

The northern and western margins of the Southern Alps are sharply defined by the Insubric fault line. The Po and Venetian plains represent the southern boundary. The tectonic style, with folds, small 'nappes' and faults contrasts markedly with the 'nappe'-style characteristic of the Alps north of the Insubric Line. In terms of Alpine tectonic units they represent the 'autochthonous' hinterland of the Austro-Alpine nappes, from which they have been separated by the Late Alpine Insubric fault.

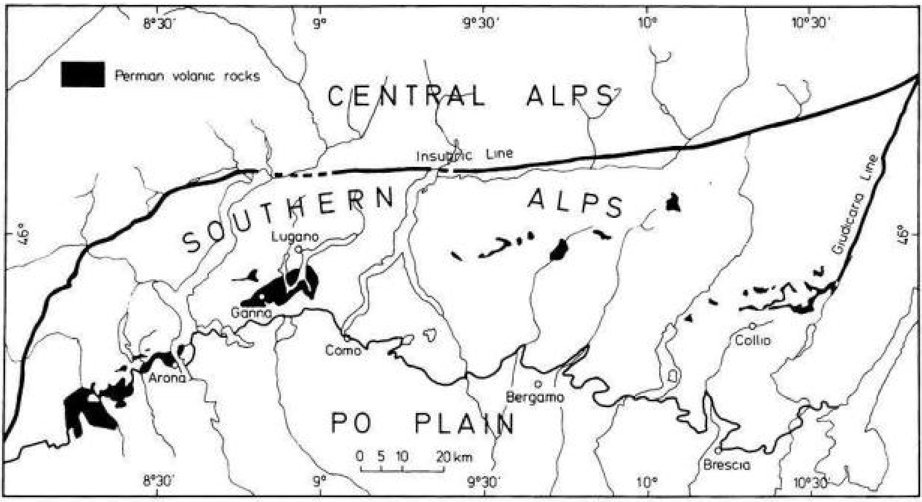


Fig. 1. Geographic situation of the four sampling regions and main outcrops of Permian volcanics in the western Southern Alps

The stratigraphic sequence of the Southern Alps comprises Hercynian and Pre-hercynian crystalline basement rocks, Palaeozoic sediments and volcanics and a highly differentiated Mesozoic-Tertiary sedimentary sequence.

The Permian volcanics and sediments, together with the Triassic formations, constitute the lower part of the sedimentary sequence. They rest unconformably on a basement that was subject to Hercynian orogenesis in Carboniferous time.

With the exception of the Bolzano quartz-porphyries (eastern Southern Alps) all the main outcrops of the Permian volcanics are situated to the west of the Giudicaria Line. The Bolzano quartz-porphyries have been thoroughly investigated geologically (cf. Pichler, 1959) as well as palaeomagnetically (Zijderveld et al., 1970), and their palaeomagnetic results will be compared with those from the western Southern Alps.

Geological data from the Permian igneous rocks from the western Southern Alps are sparse. There are no radiometric ages for the volcanics. However, the Baveno granite which is considered to be genetically equivalent to the Lugano volcanics, has been dated to 270 to 290 m.y. (Jaeger and Faul, 1959).

On the basis of stratigraphic evidence, the Bolzano quartz-porphyries can be considered to be of Permian age (Pichler, 1959). In the case of the Lugano porphyries and those from the region of Arona, the Lower Permian age follows from their stratigraphic position which is younger than the Westphalian of Manno (Graeter, 1952) and older than the Upper Permian 'Verrucano Alpino' of the Bergamasc Alps.

The volcanic sequencies are most completely preserved in the region of Lugano where they have been examined in detail by Kuenen (1925) and De Sitter (1939). The most complete petrological study of the Arona sampling area is given by Kaech (1903) and for the Bergamasc Alps by De Sitter and De Sitter-Koomans (1949). For the Auccia volcanics it is referred to the studies of Cassinis (1966; 1968).

Petrologically all these Permian igneous rocks show a large variety of porphyries, porphyrites, quartz-porphyries, and tuffs. In all sampling areas the rocks show varying degrees of alteration due to weathering. The primary mineralogical composition often cannot be reconstructed in detail. As a consequence unambiguous identification of the rock type is sometimes not possible.

The tectonic situation differs from sampling area to sampling area and sometimes even from site to site within each area. This deserves much attention, because only a reliable tectonic correction of the remanence directions allows for a palaeomagnetic interpretation of the results.

3. Natural Remanent Magnetization

Between 5 and 13 cores were drilled at each of 31 sites in the Permian volcanics (cf. Table 1). Each gave 1 to 5 cylindric specimens, 2.54 cm i.d. and 2.2 cm high. The resultant ratio of height to diameter of 0.85 gives an optimal reduction of sample shape anisotropy (Porath et al., 1966). Altogether 349 samples were investigated to establish the palaeomagnetic and rock magnetic properties of the Permian volcanics.

Table 1. Mean direction of ChRM before and after tectonic correction

Region Site	ChRM after demagnetization					Tectonic Reference		Tectonically corrected direction of ChRM			
	n	D	I	α_{95}	kF	Az	Dip	D	I	α_{95}	kF
Auccia											
AU1	14	133.2	−44.7	6.9	34.2	304–320	18–42	131.3	−26.8	6.9	34.3
AU2	25	138.3	−22.5	3.0	96.5	8	18	141.2	−12.1	3.0	96.5
AU3	9	142.9	−20.7	3.5	215.7	300	10	141.8	−11.5	3.5	215.7
AU4	13	140.4	−21.4	2.7	237.4	320	8	139.4	−12.0	2.7	337.4
AU5	13	142.7	−16.2	1.0	>1 000	4	12	144.0	− 8.2	1.0	>1 000
Mean	74	139.4	−25.1	2.6	39.9			139.8	−14.1	2.2	54.7
Regional mean ($N=5$):								139.7	−14.1	8.2	88.8
Valle Brembana											
BR2	12	209.4	−36.3	2.6	276.3	(330	50)	(193	−2	2.6	276.3)
BR3	8	197.0	−49.7	4.8	131.7			(178	−9	4.8	131.7)
BR6	10	209.0	−38.5	11.5	15.4			(191	−4	11.5	15.4)
Mean	30	206.4	−40.4	4.7	32.4			(189.5	−5.4	4.7	32.4)
BR7	7	238.7	−26.8	17.3	13.2	(120–150	3	255	−21	17.3	13.2)
BR8	8	222.2	18.4	5.3	111.4	–	–	–	–	–	–
Lugano											
1	11	108.7	34.5	3.6	158.0	–	–	–	–	–	–
2a	3	125.1	16.3	7.9	247.3	–	–	–	–	–	–
2b	15	92.6	32.4	2.8	191.7	–	–	–	–	–	–
3a	4	125.9	22.4	10.3	80.4	–	–	–	–	–	–
3b	12	102.2	39.1	6.5	45.4	–	–	–	–	–	–
4	10	120.0	−36.4	14.1	16.4	–	–	–	–	–	–
5	56	106.6	21.7	3.8	25.8	–	–	–	–	–	–
6	6	131.5	−2.8	11.6	34.2	–	–	–	–	–	–
Ganna											
GA1	13	147.1	26.7	8.4	25.6	150	45	147	−22	8.4	25.6
GA2	11	151.6	5.2	4.6	99.2	150	30	151	−25	4.6	99.2
VHZ1	3	135.8	31.4	8.6	207.3	146	42	137	−11	8.6	207.3
VHZ2	4	135.0	30.3	7.0	171.7	154	56	137	−23	7.0	171.7
Mean	31	146.3	20.1	5.5	22.9			146.3	−20.5	4.3	36.5
Regional mean ($N=4$):								142.9	−20.4	10.4	78.5
GA3	10	189.9	−4.0	5.0	95.5	–	–	–	–	–	–
GA4	7	169.7	−4.0	5.8	109.8	–	–	–	–	–	–

Table 1 (continued) Mean direction of ChRM before and after tectonic correction

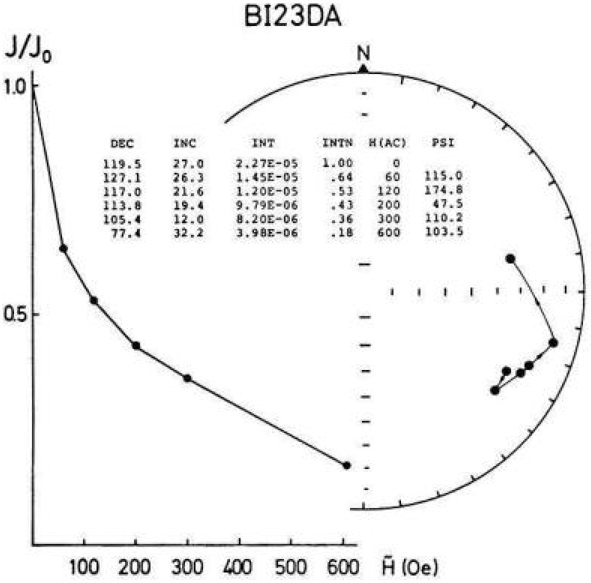
Region site	ChRM after demagnetization					Tectonic reference		Tectonically corrected direction of ChRM			
	n	D	I	α_{95}	kF	Az	Dip	D	I	α_{95}	DkF
Arona											
AR1	11	138.3	41.4	2.9	254.0	140	45	140	−5	2.9	254.0
AR3	7	146.9	22.0	6.7	83.0	145	35	146	−13	6.7	83.0
AR4	3	124.8	27.9	12.9	92.0	145	35	128	−16	12.9	92.0
BI21	11	124.1	29.8	10.4	20.4	130	52	125	−22	10.4	20.4
Mean	32	134.2	32.3	5.1	26.0			134.8	−11.1	5.8	19.9
Regional mean ($N=4$):								134.9	−14.2	13.6	46.5
AR2	3	116.7	58.9	15.9	60.8	(140	45	130	16	15.9	60.8)
BI23	8	102.4	22.1	12.1	22.1	–	–	–	–	–	–
BI24	22	106.9	10.9	4.1	41.6	(50	20	105	0	4.1	41.6)

Az, Dip: Azimuth and dip of tectonic reference plane used for correction
n: Number of specimens
N: Number of sites
α_{95}: Semi angle of Fisher's 95% cone of confidence (Fisher, 1953)
kF: Fisher precision parameter
Directions in brackets are not used for palaeomagnetic interpretation

The characteristic remanence (ChRM), acquired at the time of formation of the volcanics, has been evaluated by means of stepwise alternating field demagnetization as well as continuous and progressive thermal demagnetization. About 90% of the samples were AF-cleaned, the remainder was demagnetized by thermal methods.

The intensities of the initial NRM and of the ChRM are distributed over wide ranges. They were measured with a Digico complete results magnetometer (Molyneux, 1972) and with a ScT cryogenic magnetometer (Goree and Fuller 1976). The mean value of initial NRM-intensity of all samples investigated is $6.03*10^{-5}$ Gauss, the mean value after optimum demagnetization is $2.95*10^{-5}$ Gauss. On average the ChRM intensity represents about half the initial NRM intensity. No correlation between intensity-distribution and rock type or sampling area was found.

The ChRM is taken to be the most stable remanence component, as determined with the aid of a palaeomagnetic stability index obtained by computing the change of direction of the remanence vector for each demagnetization step. The minimum directional change is associated with the most stable direction and is tabulated in Fig. 2 for a representative sample together with plots of remanence intensity and a stereographic projection of the direction. For this example the characteristic remanence direction is found at AC-field amplitudes between 120 and 300 Oe where the smallest changes in direction occur. The optimum field is chosen at 200 Oersted because the index parameter PSI is minimum and amounts to only about 47 mdeg/Oe. Because the rock magnetic



DEC	INC	INT	INTN	H(AC)	PSI
119.5	27.0	2.27E-05	1.00	0	
127.1	26.3	1.45E-05	.64	60	115.0
117.0	21.6	1.20E-05	.53	120	174.8
113.8	19.4	9.79E-06	.43	200	47.5
105.4	12.0	8.20E-06	.36	300	110.2
77.4	32.2	3.98E-06	.18	600	103.5

Fig. 2. Change of direction (PSI, in millidegrees per Oersted) and normalised intensity (INTN) of natural remanent magnetization (NRM) of a porphyry sample during AF-demagnetization

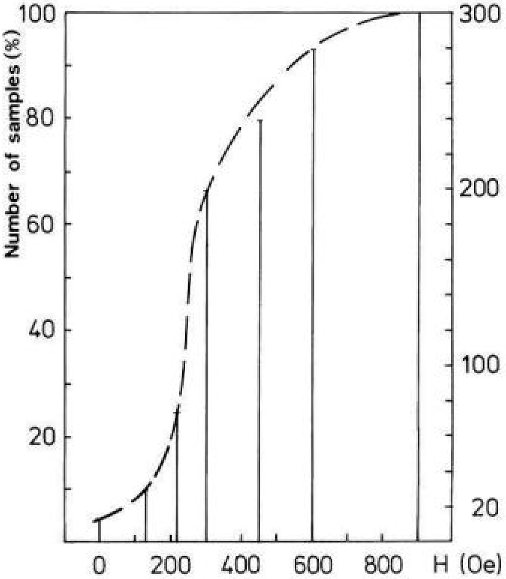


Fig. 3. Cumulative frequency distribution of maximum coercivities of the 'unstable' component of the Permian volcanics

properties of the volcanics vary not only from region to region, but also from site to site, it was necessary to demagnetize all specimens in at least three steps in order to determine the optimum demagnetizing field.

In about 40% of all demagnetized samples the characteristic remanence is found after demagnetization with 300 Oersted; 5% show an initial NRM

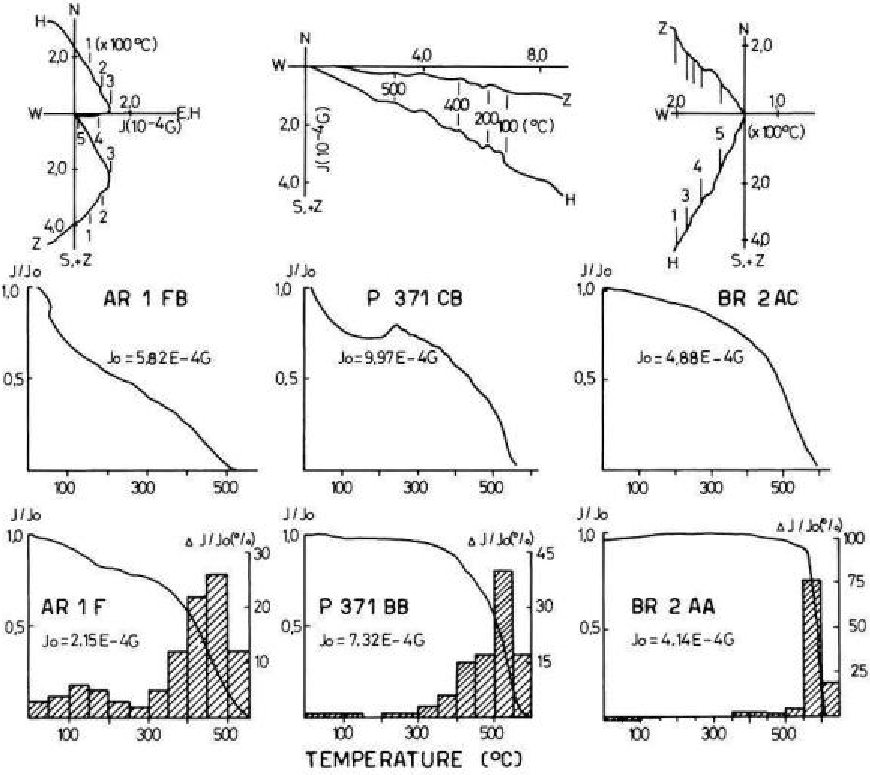


Fig. 4. Results of thermal demagnetization of three rock samples. *Top*: Orthogonal projections of the NRM directions as a function of temperature. *H* denotes the horizontal magnetization component, defined by N-S and E-W axis. *Z* is the projection of magnetization vector on the E-W vertical plane. *Middle*: Corresponding normalised intensity in terms of initial remanence. *Bottom*: Normalised intensity and histogram of blocking temperatures of progressive thermally demagnetized samples from the same core

direction practically identical to that after demagnetization with high fields, whereas another 5% achieve a stable direction only upon cleaning in fields between 600 and 900 Oe. For the total of the samples tested the non-characteristic remanence is mainly carried by coercivities between 200 Oersted and 300 Oersted, as can be seen from the steepest part in the graph of Fig. 3.

To examine the directional distribution of the stable components and to get an idea about the blocking temperature distribution of the remanence, both continuous and progressive thermal demagnetizations have been carried out. For the latter a special spinner magnetometer was built to record continuously the direction and intensity of the remanence vector during heating (Heiniger and Heller, 1976).

The vector plot of the directions (Fig. 4) sometimes shows an initial secondary component which is removed below 300° C. However, above 300 °C the remanence decreases towards the origin along an almost straight line.

This observation is valid for the continuous as well as for the progressive thermally demagnetized samples. Therefore we conclude that, if secondary remanence directions are present in the high blocking temperature range, they do not differ from any primary directions.

The most striking feature of the progressive thermal demagnetization curves of many samples is the extreme stability at lower temperatures (Fig. 4: samples P371BB and BR2AA). The blocking temperature spectra are often restricted to temperatures between 400 °C and 600 °C. In the case of sample BR2AA the remanence is partly carried by a mineral fraction with blocking temperatures above 580 °C. These high values together with the square shaped intensity vs. temperature curve may indicate that titanohematite is the main carrier of remanence. In sample P371CB the peculiar NRM intensity increase without change of direction around 200 °C during continuous thermal demagnetization may also be caused by the presence of titanohematite (cf. Heller and Egloff, 1974). In the case of samples AR1F and AR1FB the blocking temperatures are distributed over a much wider range and reach maximum values of only 500 °C to 550 °C. Also the stability is less pronounced. Therefore the NRM may be carried mainly by Ti-poor magnetite.

4. Magnetic Mineralogy

About 25 polished sections have been studied. Ore minerals occur only accessorily. Their concentration is always smaller than one percent by volume. Both hematite and magnetite have been identified. Paramagnetic ore minerals such as rutile and pyrite are rare, but they have been observed in samples from the Valle Brembana region. The ore minerals are generally observed along large grains of hornblende and pyroxene. Often they also are clustered in small (former) cracks. Very small opaque grains with diameter around 1 μm occur in the rock matrix originating from altered mafic minerals. The grain diameters vary from about 200 μm down to submicroscopic size. Magnetite can be observed in idiomorphic, primarily crystallized grains but also as a pseudomorphic product of pyroxene. Ilmenite exsolutions within the magnetite grains are frequently found. Magnetite grains are also observed in the neighbourhood of titanohematite which shows exsolution lamellae of ilmenite. These exsolutions indicate high temperature oxidation of the original hemoilmenite.

The temperature dependence of spontaneous magnetization of powdered rock samples confirm the results of thermal demagnetization; Curie points characteristic for titanohematite and Ti-poor magnetite have been detected.

Following Dunlop (1972), acquisition curves of isothermal remanent magnetization (IRM) can be used to establish the distribution of coercivities in a rock sample by plotting the increment of change of magnetization ΔJ against change of applied dc-field ΔH. Using superconductive coils magnetic fields of up to 50 kOe can be produced. This is sufficient to saturate most of the rockforming ferromagnetic minerals. Dunlop's method allows the identification of these minerals by determining their complete coercivity-spectrum without causing irreversible chemical changes of mineralogy, which is an ever present danger during thermal demagnetization.

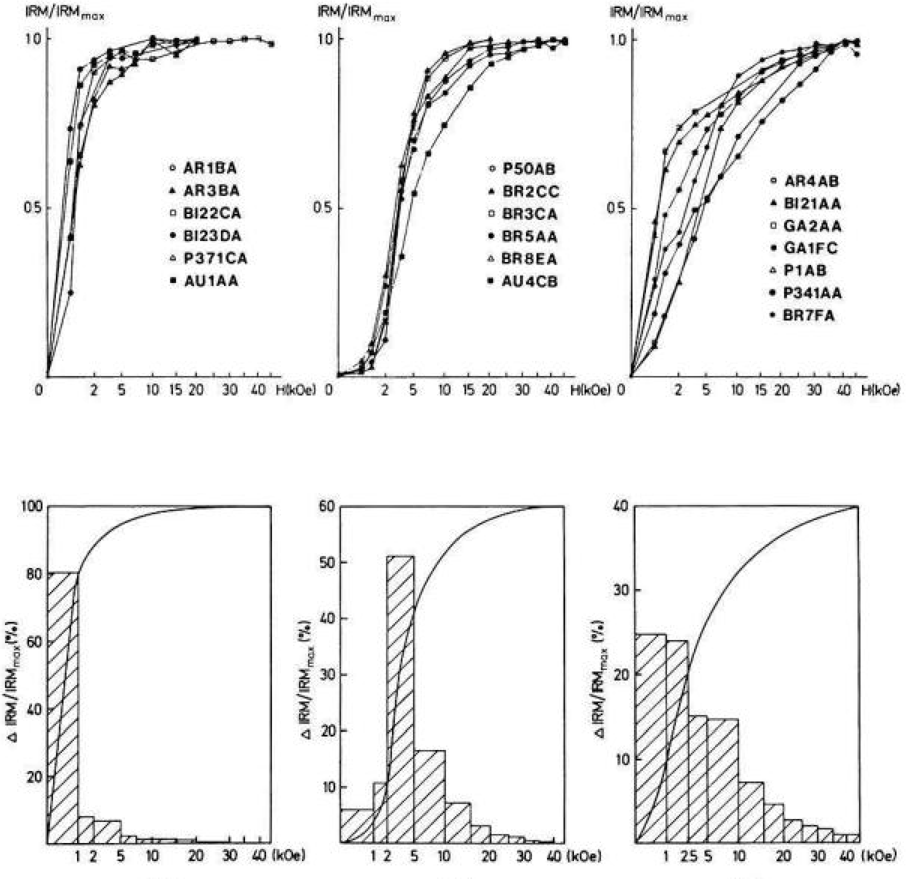


Fig. 5a–c. *Top*: Representative isothermal remanence acquisition curves of the Permian volcanics. Three different types (**a**), (**b**), and (**c**) can be distinguished. *Below*: Generalised coercivity distribution for each type

From most of the sampling sites one to two samples have been investigated using this method. The IRM acquisition curves and the results of the AF-cleaning experiments show that many of the Permian volcanics contain a considerable amount of high coercivity NRM-components. Three different types of coercivity spectra can be distinguished (Fig. 5). The first group consists of samples with predominantly low coercivity components (Fig. 5a). These are dominated by magnetite. The second group consists of samples without low coercivity components below 2 kOe and saturating between 10 kOe and 20 kOe. At H = 5 kOe only two third of the saturation remanence is acquired. These samples contain predominantly titanohematite (Fig. 5b). A third group (Fig. 5c) comprises samples containing low- as well as very high coercivity components. The low coercivity magnetic minerals are again magnetite, but the high coercivity fraction is more difficult to identify from such data. On the basis of the minerals

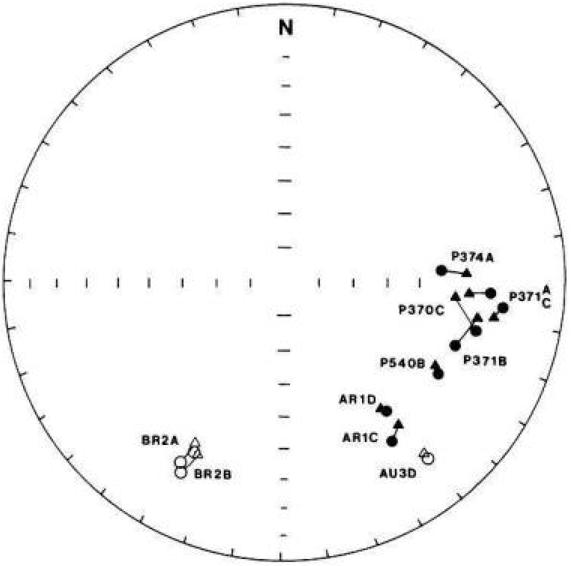


Fig. 6. Comparison of the directions of stable remanence of thermally demagnetized samples (●) with those of corresponding AF-demagnetized samples (▲). *Open symbols* denote negative inclination (upper hemisphere); full symbols denote positive inclination (lower hemisphere)

identified microscopically and by Curie-temperature measurement, the most likely mineral is titanohematite. The nature of the ferromagnetism and magnitudes of the spontaneous magnetization, anisotropy and magnetostriction constants are rather poorly known for natural hematite. However, Roquet (1954) has reported experimentally determined coercivities up to 30 kOe in hematite.

5. Palaeomagnetic Directions

A comparison of thermally cleaned samples with corresponding AF-cleaned samples from the same core (Fig. 6) shows that the cleaned directions are very similar with both methods, whether the magnetic properties are due to magnetite or titanohematite. Therefore, the ChRM directions are considered to be representative for the primary NRM also in those samples which contain a large titanohematite fraction and which have been shown to be very stable against AF-demagnetization, e.g. from the Valle Brembana sampling area and also from the Lugano porphyry district.

As the thermal and alternating field demagnetization show only one single stable directional component, the direction of any stable secondary magnetization must be similar to those of the characteristic primary remanence, and may therefore also have been acquired in the Permian.

The mean ChRM directions within individual sites are well grouped. The semi angle α_{95} of Fisher's cone of confidence is mostly smaller than 10°. The site mean directions, however, are dispersed, due to local and regional tectonic complications (Table 1).

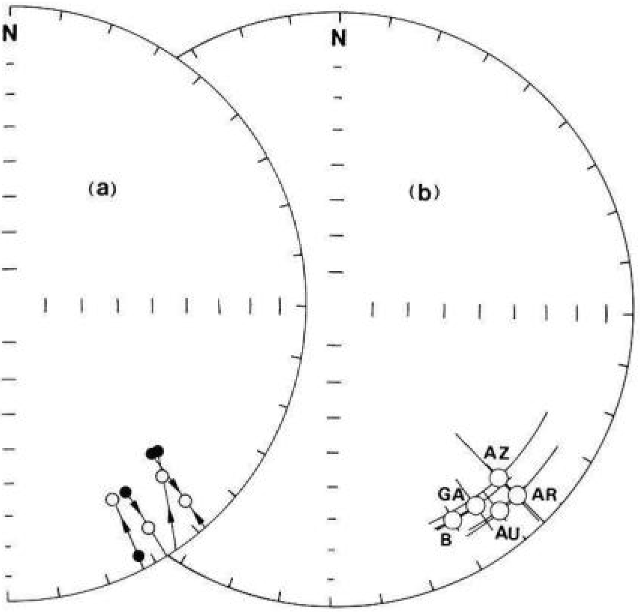


Fig. 7. a Stereographic projection of site-mean directions of ChRM for the sampling area of Ganna before and (*arrow*) after tectonic correction. For symbols see Fig. 6. **b** Regional mean directions after tectonic correction with main axes of the α_{95}-confidence oval. *AR*: Arona; *GA*: Ganna (western part of the Lugano sampling area); *AU*: Auccia volcanics compared with (*AZ*) the results given by Zijderveld and De Jong (1969) and (*B*) the Bolzano quartz porphyries (Zijderveld et al., 1970)

The (Alpine) tectonic movements have considerably affected the relative position of the Permian volcanics. At some places geological data do not allow a reconstruction of the tectonic movements. This is especially the case for the volcanics at the upper Valle Brembana and also for those from the Eastern part of the Lugano district, where the local tectonic situation has turned out to be more complicated than expected.

The usual dip correction about horizontal fold axes fails in these two regions. It would require unrealistically steep dip angles (between 80° and even more than 180°) to get site mean directions characteristic for the Southern Alps (as e.g. Bolzano, Fig. 7b). At the Valle Brembana region there is no coincidence of the observed orientation of stratification planes (cf. Table 1) and the hypothetically required unfolding. In the eastern part of the Lugano porphyry district, a lack of sediments or recognizable stratification due to erosion and weathering again does not allow a reliable tectonic correction. In both cases several phases of differential (Alpine) tectonic movements may have caused the strongly dispersed site mean directions within these regions and prevent a simple dip correction.

At Arona, Ganna, and Auccia the tectonic situation can be accounted for. The mean remanence directions for the sites around Ganna are plotted in Fig. 7a before and after tectonic correction. The correction was done by unfold-

Table 2. Mean direction of ChRM of the sampling areas with palaeomagnetically relevant remanences. Basis of statistic calculation: *N*; (cf. Table 1)

Region	Mean site pos.		Direction of ChRM after tectonic correction						Virtual palaeomagnetic pole position			
	Lat.N	Long.E	N	n	D	I	α_{95}	kF	Lat.N	Long.E	dm	dp
Auccia	45.8	10.4	5	74	139.7	−14.1	8.2	88.8	38.1	244.9	8.4	4.3
Ganna	45.8	8.8	4	31	142.9	−20.4	10.4	75.5	42.7	242.6	10.9	5.7
Arona	45.7	8.5	4	32	134.9	−14.2	13.6	46.5	35.4	248.0	13.9	3.1

ing the SE dipping overlying layered Triassic dolomites. Before correction all site means have a positive inclination; after unfolding, the inclinations become negative as expected for Permian rocks in this region. The data confirm the results of an early study carried out by Van Hilten and Zijderveld (1966). In the region of Arona most site mean directions can again be tectonically corrected by means of the bedding orientation of the overlying Triassic dolomites. The site mean directions of the Auccia volcanics were tectonically corrected by means of the bedding orientation of the underlying Collio formation. The mean directions of these three sampling areas after dip correction are shown in Fig. 7b. The data agree with those given by Zijderveld and De Jong (1969) and also with those from the Bolzano quartz-porphyries (Zijderveld et al., 1970) although this area is on the eastern side of the Giudicaria fault line.

6. Discussion

At all sites where the local tectonic situation allows a correction of the characteristic site mean directions by means of simple unfolding of formerly horizontal boundary surfaces, there is an improvement of their grouping. Moreover, there is not only a reduction of dispersion of a certain sampling area; there is also a close grouping of these corrected mean directions between each sampling area (Table 2). Besides a fold test, carried out by Pavoni et al. (1969) in the Lugano area, this may be considered as further evidence that the ChRM directions represent a stable initial remanence of the volcanics and therefore record the direction of the Permian geomagnetic field at the sampling sites.

The tectonically corrected remanence directions of all the volcanics investigated in the western Southern Alps (cf. Table 2) can also be compared with those of the Bolzano porphyries and with Upper Palaeozoic directions from extra-Alpine Europe (Fig. 8). The similarity of the mean directions of all these Permian volcanics suggests that the western Southern Alps have, on a large scale, behaved as a single tectonic block.

As the directions coincide with the well defined results from the Bolzano porphyries (eastern Southern Alps), it can be concluded, that the Southern Alpine area as a whole constitutes one single crustal block since the Permian.

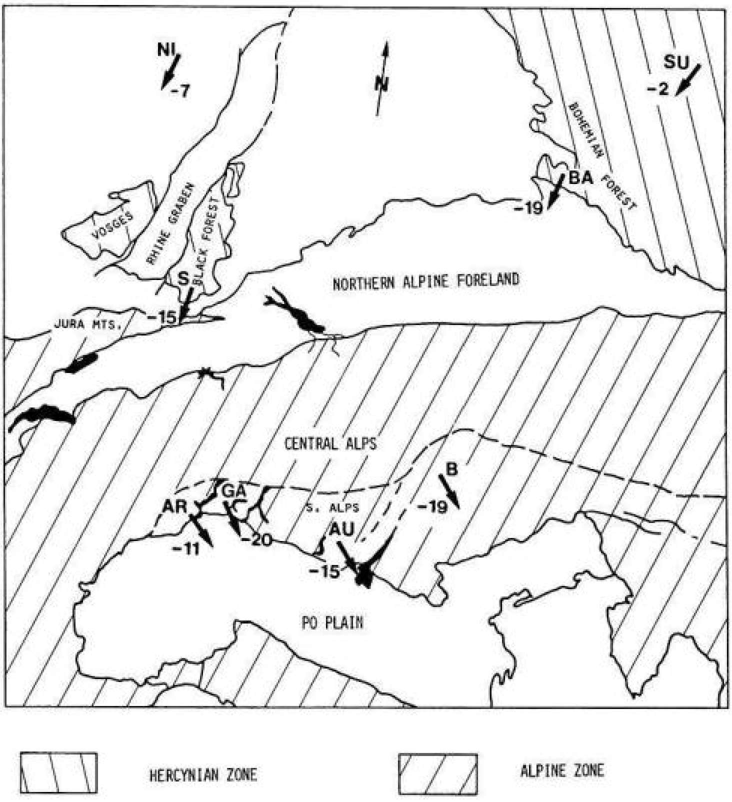


Fig. 8. *Arrows* show the remanence declinations of Southern Alpine Upper Palaeozoic rocks compared with those of the same age from extra-Alpine Europe (numbers denote the appropriate site mean inclinations). *AR*: Arona, *GA*: Ganna and *Au*: Auccia (cf. Table 2); *B*: Bolzano (Zijderveld et al., 1970); *Ni*: Nideck (Nairn, 1957); *S*: Black Forest (Konrad and Nairn, 1972); *BA*: Bavarian Forest (Heller, personal communication); *SU*: Inner Sudetic Basin (Birkenmajer et al., 1968)

The magnetization directions are very different from extra-alpine European directions. The declinations indicate that this block has been rotated by about 50° anticlockwise relative to extra-Alpine Europe since the Early Mesozoic.

In fact the Southern Alpine directions are very similar to African directions for that period. The Permian Southern Alpine palaeopoles are situated close to the Permian part of the African polar wander path of Van der Voo and French (1974) and nowhere near the polar wander path of stable Europe (Fig. 9). The palaeomagnetic data support other geophysical and sedimentological arguments that the Southern Alps may be considered a parautochthonous extension of the African plate since the Early Mesozoic (Channell and Horváth, 1976). Therefore, it seems realistic to assume that the Southern Alpine region has moved together with the African lithospheric plate which has rotated anticlockwise by about 50° relative to the European plate since the Early Mesozoic.

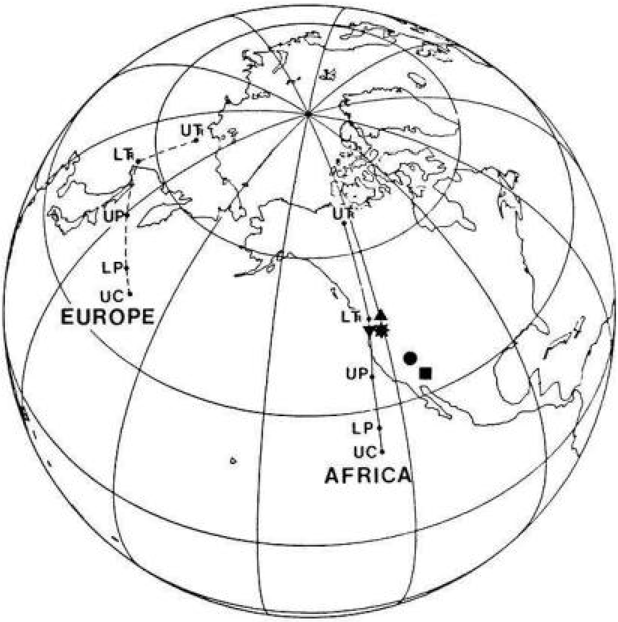


Fig. 9. Virtual palaeomagnetic pole positions for Auccia (●), Ganna (★) and Arona (■) as listed in Table 2, compared with the African and European polar wander path from Upper Carboniferous (*UC*) to upper Triassic (UT_R) from the data of Van der Voo and French (1974), and the Southern Alpine pole position of Bolzano (▼, Zijderveld et al., 1970) and the (Upper Triassic) Dolomites (▲, Manzoni, 1970). Modified after Channell et al. (1979)

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