SHORT COMMUNICATIONS

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PALEOMAGNETISM OF SOME LATE PALEOZOIC AND TRIASSIC ROCKS FROM THE EASTERN LOMBARDIC ALPS, ITALY.

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ABSTRACT

The directions of magnetization of five volcanic units of the Late Paleozoic rock sequence from the Eastern Lombardic Alps, each sampled at one site, display small within-unit dispersion and rather large between-unit dispersion. They yield a mean direction of $D = 135^\circ$, $I = -21^\circ$ ($\alpha_{95} = 20^\circ$), which is as divergent from the Late Paleozoic paleomagnetic field in the Alpine Foreland as the directions of contemporaneous rocks in other places in the Southern Alps. The characteristic magnetization direction of the Middle Triassic porphyrite of Valle di Scalve is $D = 161^\circ$, $I = -21^\circ$. It is remarkably similar to the Late Paleozoic results and rather different from other Triassic paleomagnetic directions from the Southern Alps.

Both the Late Paleozoic and the Triassic paleomagnetic directions indicate a counterclockwise rotation of the Southern Alps with respect to the Alpine Foreland (about 50°). There is no clear paleomagnetic evidence of large translational megatectonic movements between the Southern Alps and the Alpine Foreland.

INTRODUCTION

Paleomagnetic directions obtained from Late Paleozoic and Triassic rocks from the Southern Alps are found to deviate from those of contemporaneous rocks from the Alpine Foreland.* These deviations have been explained as the result of megatectonic movements of the Southern Alps with respect to the Alpine Foreland (v a n H i l t e n, 1960, 1962, 1964;; v a n H i l t e n and Z i j d e r v e l d 1966; d e B o e r, 1963, 1965, 1965; G u i c h e r i t, 1969). Paleomagnetic research in the Southern Alps and the Alpine Foreland is being carried out in order to verify this hypothesis. In this note the results are given of a reconnaissance study of some Late Paleozoic and Triassic volcanics and sediments from the Eastern Lombardic Alps.

The natural remanent magnetization (N.R.M.) and the susceptibility (K) of the handsamples was measured with astatic magnetometers, and the remanent magnetizations were analysed by the standard procedure of alternating field demagnetization at the Paleomagnetic Laboratory of Utrecht (A s, 1966, a and b; Z i j d e r v e l d, 1966.). All azimuthal directions in this note are given in degrees east of true north.

GEOLOGY

In the Western Lombardic Alps the oldest rocks on the crystalline basement are conglomerates of Westphalian age (V e n z o, 1951), which are generally considered to precede the volcanic cycle to which the Lower Collio Volcanics belong. The Collio sediments contain fossil plants which are probably Early Per-

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*) The expression Alpine Foreland is used for the area of Europe, west and north of the Alpine mountain chain; the part of the continent not involved in the major Alpine folding movements. This region is also referred to as Stable Europe, Meso Europe and extra-Alpine Europe.

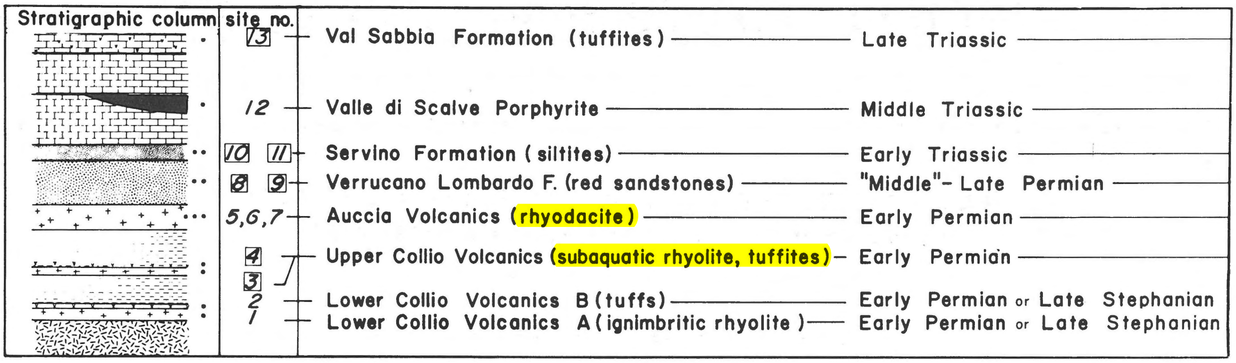

Figure 1.
Stratigraphic column showing the distrubtution of sites in the late Paleozoic and Triassic sequence of the Eastern Lombardic Alps, sampled for paleomagnetic research. Sampling sites with a square around the number yielded no usable paleomagnetic results.

mian, but they might also be Late Carboniferous (C a s s i n i s, 1966a). The Auccia Volcanics are covered by red sandstones of "Middle" and Late Permian age (C a s s i n i s, 1966b). Thus the Lower Collio Volcanics are Latest Carboniferous, perhaps Early Permian and the Auccia Volcanics are most probably Early Permian.

The porphyrite of Valle di Scalve rests on Anisian limestones, and it is older than the capping Upper Ladinian dolomite (A s s e r e t o and C a s a t i, 1965). So its age must be Early Ladinian (Middle Triassic).

All sampling sites are situated in moderately or low dipping rocks sequences without nappe structures. The dip of the volcanic flows has been determinated from the dip of the layered rocks immediately below and above.

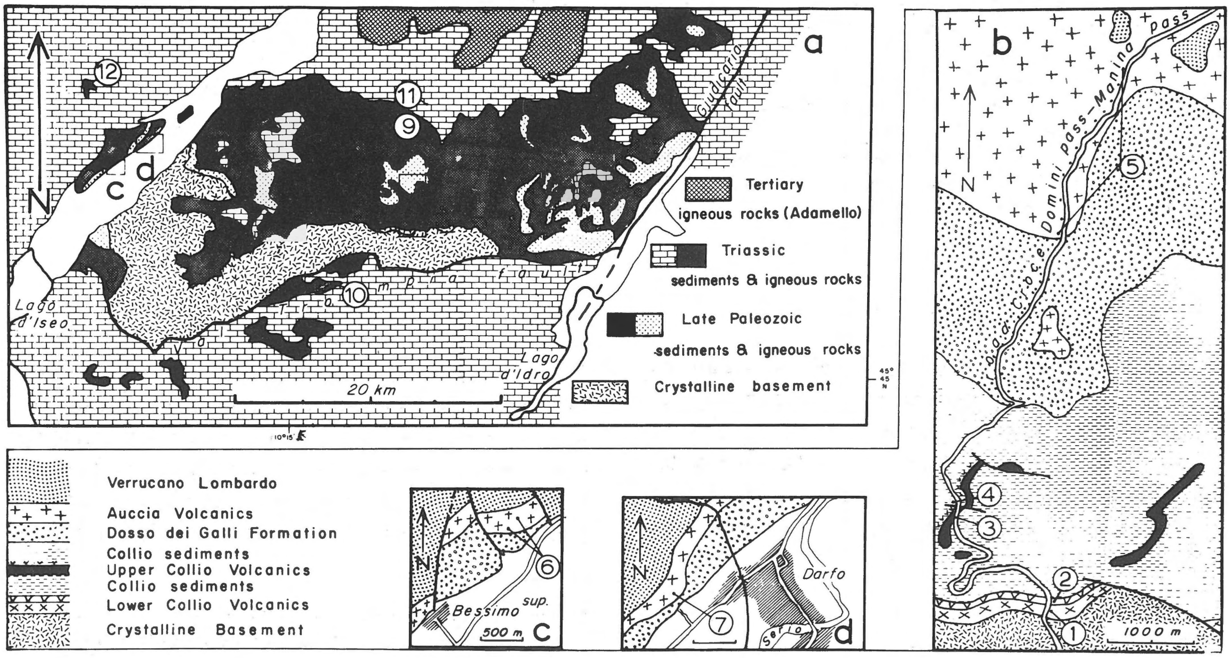

Figure 2.
Geological index maps of the Eastern Lombardic (compiled with data from Cassinis, 1966 a and b; Assereto and Casati, 1965; Boni, 1963) with the location of sampling sites 1-7 and 9-12. The location of sampling sites 8 and 13 are described in the appendix.

PALEOMAGNETIC RESULTS

The N.R.M. of all sampled sediments (sites 8, 9, 10, 11 and 13) had intensities of about 10^{-6} e.m.u./cm^3 and directions *in situ* close to the present dipole field. As it was very unlikely that from these sediments any original remanence could be isolated with sufficient accuracy, they were discarded. Also

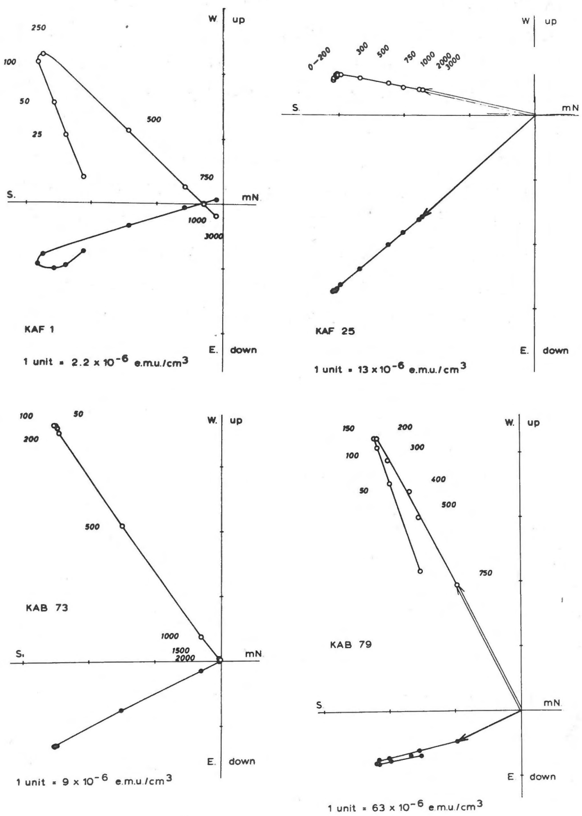

Figure 3.
Demagnetization diagrams of 4 samples, resp. from the Lower Collio rhyolite (A), from the Auccia rhyodacite "Maniva – Croce Domini road" (B), and from the porphyrite of Valle di Scalve (C and D). The plotted points represent orthogonal projections of the successive positions of the terminus of the resultant magnetization vector during progressive demagnetization by a.c. magnetic fields. The numbers denote the intensities of these fields in Oersteds. Open symbols indicate projections on the north-south vertical plane; full symbols indicate projections on the horizontal plane.

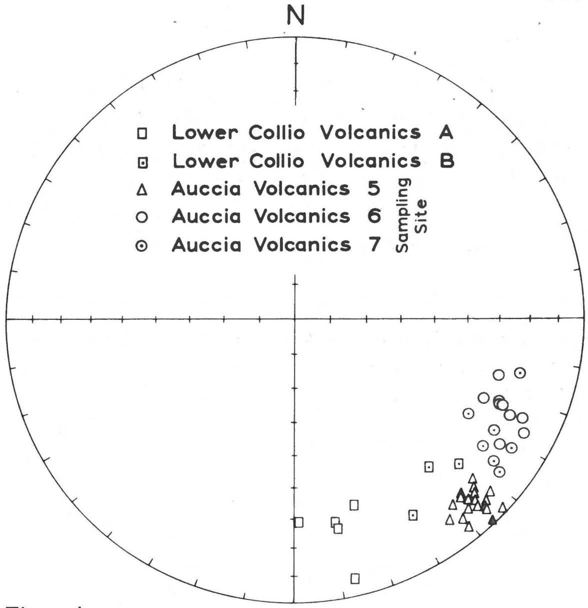

Figure 4.
Directions of magnetization of the Lower Collio and Auccia Volcanics, after partial demagnetization and with respect to the bedding planes.
Open symbols denote north-seeking poles pointing up; full symbols denote north-seeking poles pointing down.

the samples of the rhyolite and the tuffites from the Upper Collio Volcanics (sites 3 and 4) proved to contain practically no natural magnetic remanence. Only the Late Paleozoic Lower Collio and Auccia Volcanics (sites 1, 2 and 5, 6, 7) and the Triassic porphyrite of Valle di Scalve (site 12) yielded usable paleomagnetic results.

Lower Collio and Auccia Volcanics

Progressive demagnetization with a.c. magnetic fields up to 3000 Oe (peak value) of some pilot samples showed that the total N.R.M. of most porphyries was practically singular in direction and for the larger part very hard (figure 3B). Only samples of the Lower Collio rhyolite contained next to this characteristic remanent magnetization a second and soft remanence with a recent direction (figure 3A). In all samples the secondary remanent magnetization could be eliminated with a.c. magnetic fields of 250 Oe.

For the direction of the Characteristic N.R.M. is taken in the majority of samples the direction of the N.R.M. remaining after treatment with 1000 Oe and in some cases the direction of the N.R.M. eliminated with the higher alternating magnetic fields (fig. 4).

Porphyrite of Valle di Scalve

The intensity of the N.R.M., very low in the centre of the porphyrite, increases towards its lower and upper border (Table 1). Irrespective of the intensity, the N.R.M. directions of the upper five samples were consistent, whereas the N.R.M. directions of the lower three samples were strongly dispersed.

TABLE 1

Variations in the intensity of N.R.M., susceptibility and Q-ratio through the porphyrite of Valle di Scalve.

No. Sample KAB	$J_0 \times 10^6$ e.m.u./cm^3	$K \times 10^6$	Q-ratio
80	180	1700	0.24
79	170	2300	0.17
74	35	80	1.0
73	40	24	4.0
71	0.2	24	0.02
72	10	28	0.8
75	0.5	17	0.07
76	90	38	5.5

Progressive demagnetization of the consistent samples showed that the N.R.M. of some of these samples was singular (figure 3C); but that the N.R.M. of some others of these samples contained a soft secondary component, which was eliminated with a.c. magnetic fields of 200 Oe (figure 3D). From these demagnetization experiments it was concluded that the direction of the remaining N.R.M. after 500 Oe treatment could be taken as characteristic for these five samples. This Characteristic N.R.M. direction is not substantially different from various Permian paleomagnetic directions from the Southern Alps (e.g. Lower Collio Volcanics). Its inclination is distinctly lower than the inclinations of all other Triassic rocks from the Southern Alps reported so far (G u i c h e r i t, 1964).

Progressive demagnetization of the two stronger magnetic samples out of the lowermost group with the scattered initial directions did not decrease the dispersion of their N.R.M. directions. (figure 5.).

Samples from the carbonatic sediments immediately below and above the porphyrite contained only

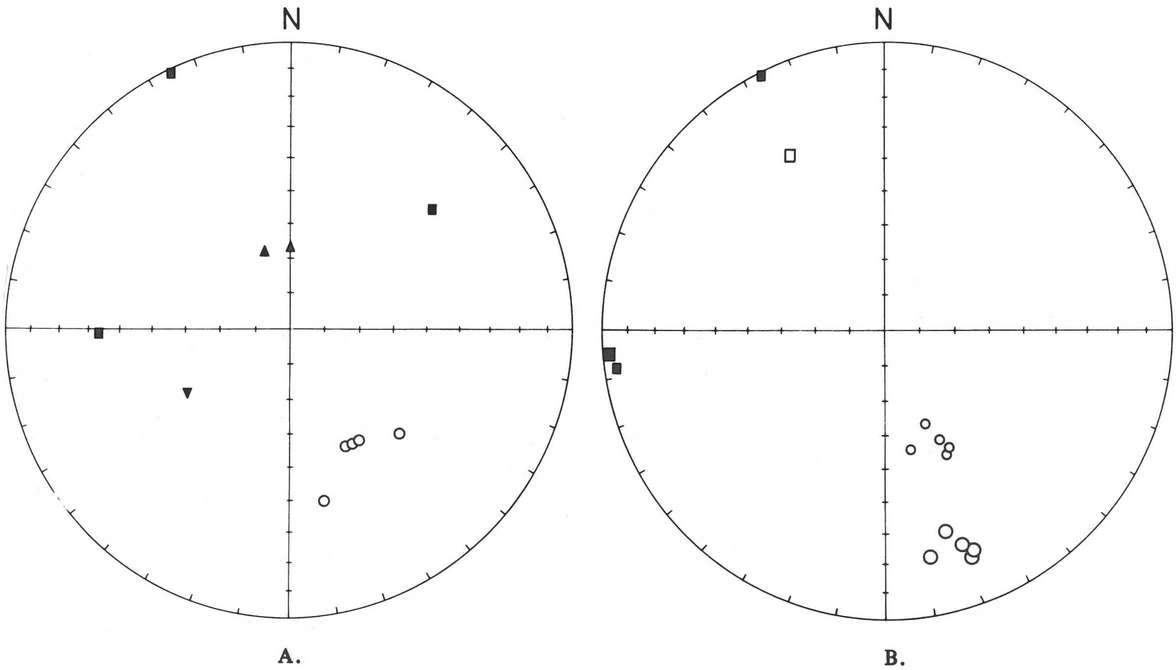

Figure 5.
Directions of magnetization of the porphyrite of Valle di Scalve. A: initial results, with respect to the present field position. B: after partial demagnetization, with respect to the present field position (small symbols) and with respect to the bedding planes (large symbols). Open symbols denote north-seeking poles pointing up; full symbols denote north-seeking poles pointing down. Squares = lower part of the porphyrite. Circles = upper part of the porphyrite. Triangles = underlying limestone and overlying dolomite.

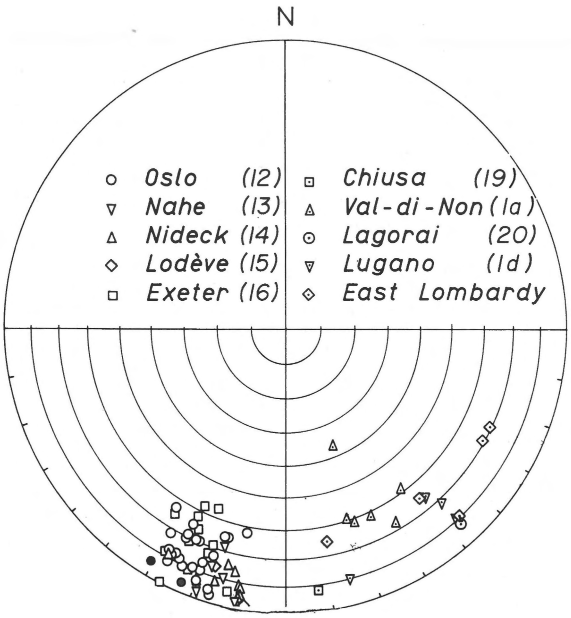

Figure 6.
Early Permian (Late Carboniferous?) paleomagnetic data from the Southern Alps and the Alpine Foreland. The symbols represent the geomagnetic directions for the present-day position of the East Lombardic Alps, computed from the ancient virtual pole positions. The Directions are obtained from single stratigraphic units. Open symbols denote north-seeking poles pointing up; full symbols denote north-seeking poles pointing down.

extremely weak N.R.M. with steep downward directions. This N.R.M. seems to be for the larger part of recent origin. Its low intensity prevents any further analysis.

DISCUSSION

The Characteristic N.R.M. directions of the sampled rocks from the Eastern Lombardic Alps represent spotreadings of the paleomagnetic field in this region. The dispersion of the five N.R.M. directions from the Collio and Auccia Volcanics is rather large, and it is more present in the declination than in the inclination. The difference in direction between the N.R.M. from the Auccia rhyodacite (Croce Domini – Maniva road) and the other Auccia Volcanics might be attributed to secular variation.

Paleomagnetic directions of Late Paleozoic rocks from the Southern Alps have been compared with paleomagnetic directions from the Alpine Foreland in figure 6. At the present stage we may note

1) The dispersion of the South Alpine paleomagnetic directions is much larger than the dispersion of the directions of the Alpine Foreland.

2) The inclinations of the N.R.M.'s of South Alpine rocks are generally high in comparison with the inclinations of rocks from the Alpine Foreland (the difference between the inclinations of the two tentative direction means is about 5°). According to the present authors it is difficult to interpret this inclination difference as strong *paleomagnetic* evidence for

TABLE 2
Summary of paleomagnetic data from the Eastern Lombardic Alps

	Total N.R.M.		Characteristic N.R.M.						
	range of intensity $\times 10^6$ e.m.u./cm^3	range of Q-ratio	Samples used/collected	Direction of N.R.M. without tectonic correction			Strike and dip of bedding	Direction of N.R.M. after tectonic correction	
				D	I	α_{95}		D	I
Middle Triassic									
Valle di Scalve porphyrite	0.2 – 180	0.02 – 5	5/8	156°	–54.5°	5.5°	260 – 34°	161.5°	–21.5°
Late Carboniferous – Early Permian									
Auccia rhyodacite (Darfo)	2 – 12	0.4 – 3	9/9	115°	–45°	6°	220 – 25°	119°	–21°
Auccia rhyodacite (Bessimo)	2 – 20	1 – 5	7/7	112.5°	–30°	6°	225 – 10°	114.5°	–21°
Auccia rhyodacite (Maniva – Croce Domini)	50 – 150	15 – 40	19/19	135.5°	–18.5°	2°	243 – 8°	136°	–11°
Lower Collio tuff (Maniva – Croce Domini)	20 – 30	4 – 5	3/3	138.5°	–29°	15°	270 – 5°	140.5°	–25°
Lower Collio rhyolite (Maniva – Croce Domini)	4 – 15	1 – 1.5	5/5	163°	–43°	12°	285 – 20°	169.5°	–25°

large translational megatectonic movements between the Southern Alps and the Alpine Foreland. Since (a) the inclination difference is less than has been assumed hitherto (van Hilten, 1960, 1962, 1964, van Hilten and Zijderveld, 1966, de Boer, 1963, 1965, Guicherit, 1964), (b) on the Alpine Foreland inclinations corresponding with the higher ones in the Southern Alps have been observed, and (c) closer age correlations are lacking.

3) The deviation between the mean declination of the N.R.M.'s of the South Alpine rocks and that of rocks from the Alpine Foreland amounts to circa 50°, and can be taken as an established fact. It indicates a post-Permian counterclockwise rotation of the Southern Alps with respect to the Alpine Foreland.

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APPENDIX

Location of the sampling sites (figure 2).

Site 1-5: Pass-road Maniva – Croce Domini; at site 5, samples were taken at regular distances from the lower 90 meter of the Auccia rhyodacite. The upper 10 meter of tuffaceous rock were not sampled. Site 6a and 6b: Tunnel behind house about 75 m above highway, and small abandoned quarry SW of the house. Site 7a and 7b: Abandoned large quarry, which is visible from the highway, and along the road which leads to this quarry from above. Site 8: East from Moico de Calve along the highway from Roncobello to Martino. Site 9: Along the pass-road Maniva – Croce Domini. Site 10: North of the bridge across the Mella di Serla along the highway. Site 11: Along the pass-road Maniva – Croce Domini. Site 12: Samples taken at regular distances along the outcrop of the porphyrite at km stone 62 of highway Angolo – Dezzo di Scalve. Site 13: 1 km north of S. Giovanni Bianco along the highway of the Valle Brembana.

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