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Reappraisal of Palaeomagnetism of the Colli Euganei and Monti Lessini Volcanics (Italy)*

J.E.T. Channell¹, V. De Zanche², and R. Sedeà²

¹ Institut für Geophysik, ETH-Hönggerberg, CH-8093 Zurich, Switzerland

² Istituto di Geologia dell'Università, I-35100 Padova, Italy

Abstract. New information on the age of the volcanics from Colli Euganei and Monti Lessini shows that the division made by Soffel (1972, 1974, 1975a) of palaeomagnetic directions from the two areas into Eocene and Oligocene groups is not valid. The difference in mean direction of these groups was thought to indicate a rotation of this part of northern Italy of 50° during the intervening time period. This rotation can not be substantiated.

Key words: Palaeomagnetism – Age of Volcanism – Rotation of Italy.

1. Introduction

Soffel (1972, 1974, 1975a and b) has carried out palaeomagnetic studies of the volcanic rocks of Colli Euganei and Monti Lessini. The principle tectonic conclusion from these studies was that this part of northern Italy rotated relative to Europe by about 50° between Late Eocene and Middle Oligocene. Both at Colli Euganei and at Monte Lessini the characteristic remanence directions were divided into two groups one of which was associated with an Oligocene eruptive cycle and the other with an older Eocene cycle. This division could not be made solely on the basis of radiometric and palaeontological ages. A more or less arbitrary value of declination was chosen which divided the data into two groups within the loose constraint of the available dating. The difference between the mean directions of these two groups (~50°) was interpreted as indicating an anticlockwise rotation of this magnitude between the eruption of the two cycles.

2. Colli Euganei

The first eruptions in the Colli Euganei have a Late Eocene age and are represented solely by basalts and basaltic breccias which are intercalated with marls allowing precise palaeontological dating (Dieni and Proto-Decima, 1963;

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De Vecchi and Sedeà, 1974; Massari et al., 1976). This type of volcanism only occurred during Late Eocene.

On the other hand, the rhyolitic, trachytic and latitic rocks from this district tend to be intrusive and are dated radiometrically (Borsi et al., 1969) and palaeontologically (Dieni and Proto-Decima, 1970) as Early-Middle Oligocene.

The genetic evolution of the Tertiary magmatism of western Veneto is considered to represent a classic province of intercontinental rifting (De Vecchi et al., 1974, 1976).

The mid-Late Eocene age attributed by Soffel (1974) to most of the differentiated rocks of the eastern part of the Colli Euganei is not consistent with the stratigraphic, palaeontological and petrogenetic evidence. The data indicate that the magmatism of Colli Euganei occurred in the following order: basalts, rhyolites then trachytes, and finally latites. The latites certainly occurred after the rhyolites but it is more difficult to confirm their relationship with the trachytes. The basalts are the only magmatic product in the Euganei which can be attributed to the Upper Eocene. This is demonstrated both by radiometric dating (Borsi et al., 1969) as well as micropalaeontology, the zones *Globorotalia cerroazulensis cerroazulensis* and *G. cerroazulensis cocoaensis* (Toumarkine and Bolli, 1975) being commonly associated with the basalts.

The differentiated products (rhyolites, trachytes, latites) are Middle-Early Oligocene in age. This is based on micropalaeontological and radiometric dating and on their stratigraphic relationship with the Middle Eocene/Lower Oligocene Euganei marls. In the western part of the region, Soffel (1974) attributed most of the sampled differentiated igneous rocks to the middle-Late Eocene. Evidence from these localities for a younger age is available:

(a) The rhyolitic breccias of Monte Nuovo have been shown by radiometric dating to have an age of 33 ± 1 m.y. (Borsi et al., 1969).

(b) The latite breccias of Monte Croce (site 10) can be assigned, according to Dieni and Proto-Decima (1970), to the *Globigerina tapuriensis* zone (Blow, 1969) of the Early Oligocene. The rhyolitic breccia of Monte Ceva is associated with the same palaeontological zone.

(c) The trachytic body of Monte Alto (site 12) is stratigraphically above and cuts rhyolitic breccias dated palaeontologically as Early Oligocene.

(d) The rhyolites of Monte Cimisella (site 13) cut marls of Early Oligocene age.

(e) The trachytes of Monte Lonzina (site 23) cut marls of Late Eocene age (zone *Globorotalia cerroazulensis cerroazulensis* of Toumarkine and Bolli, 1975) and were erupted after the rhyolite of Monte Brusà (called M. Lonzina by Borsi et al., 1969) which has been dated as Oligocene (33 ± 1 m.y.).

(f) Sites 3, 5, 16 were located at M. Castello di Calaone, M. Orsara and M. Rua. At all three of these localities the differentiated igneous rocks post-date marls and basaltic products of Late Eocene age.

(g) In the case of the differentiated rocks from sites 5, 22, 24 and 25, there is no direct evidence as to their age because the Tertiary sedimentary cover is lacking, and no radiometric ages are available. The connection of these sites with the central part of the Colli Euganei volcanic complex is obscured by alluvium.

The samples collected by Soffel (1972, 1974) from the Colli Euganei region were all reported to be rhyolites (=liparites), trachytes, or latites (=andesites). They are therefore *all* due to the younger Oligocene eruptive cycle. The sampling sites cannot be divided into two groups on the basis of age. Therefore the two mean directions have no meaning and the supposed 50° rotation of this part of Italy in Eocene/Oligocene cannot be substantiated.

Soffel (1974) has presented some conclusive arguments for the primary nature of the magnetization of these volcanics and secondary magnetizations do not appear to have caused the observed scatter of site mean directions. At most localities it is not possible to see the relationship between the igneous rocks and the original horizontal and the lack of good tectonic control may explain the dispersion of site mean directions.

3. Monti Lessini

In the case of Monti Lessini, Soffel (1975a) also divided his palaeomagnetic mean directions into two groups, one of which was considered to be Early-Middle Oligocene and the other Middle-Late Eocene. Again, this division could not be made solely on the basis of age determinations and an arbitrary declination value of 180° was used as a dividing line. Re-examination of the ages of the basalts of Monti Lessini indicates that the age of certain of Soffel's palaeomagnetic sites must be revised.

(a) Site 14: the age of these volcanics near Marosticano is Oligocene (Piccoli, 1967) with very rare occurrences of Paleocene volcanoclastics (Dal Prá and Medizza, 1965).

(b) Site 2 and 33: the age of these volcanics from Monti Berici is Late-Middle Eocene rather than Oligocene as they are overlain by Upper Eocene biocalcarenites. The same age is also apparent for the basalts (sites 22 and 23) of southern Trentino (Castellarin, 1966).

(c) Most of Soffel's palaeomagnetic samples came from the central-eastern part of Monti Lessini, where the basalts are largely Middle Eocene, with some Early Eocene and Paleocene occurrences. Dykes and lava plugs of Eocene or Oligocene age are also frequent. We consider that certain of these sites (no. 3, 4, 10, 27, 31), which were attributed by Soffel to the Oligocene, are Middle Eocene in age. The Middle Eocene rifting produced maximum thicknesses of volcanics in the valleys of T. Alpone, T. Chiampo and T. Agno (Piccoli, 1966; De Zanche and Conterno, 1972). Site 10 is immediately beneath the limestones of Roncá which contain *Nummulites brongniarti* (Uppermost Middle Eocene). The samples from sites 3, 4, and 27 are found between the Roncá limestones and limestones containing *Nummulites fabianii* of Late Eocene age. The samples from localities 31/1 and 31/2 are intercalated with the limestones of S. Giovanni Ilarione which contain *Nummilites millecaput* of Lutetian age, and with the Roncá limestones.

The remanence directions from Monti Lessini are plotted in Figure 1a showing the age according to Soffel (1975a). The difference in the mean declinations of the two groups (Fig. 1a) was considered to indicate a 50° anticlockwise

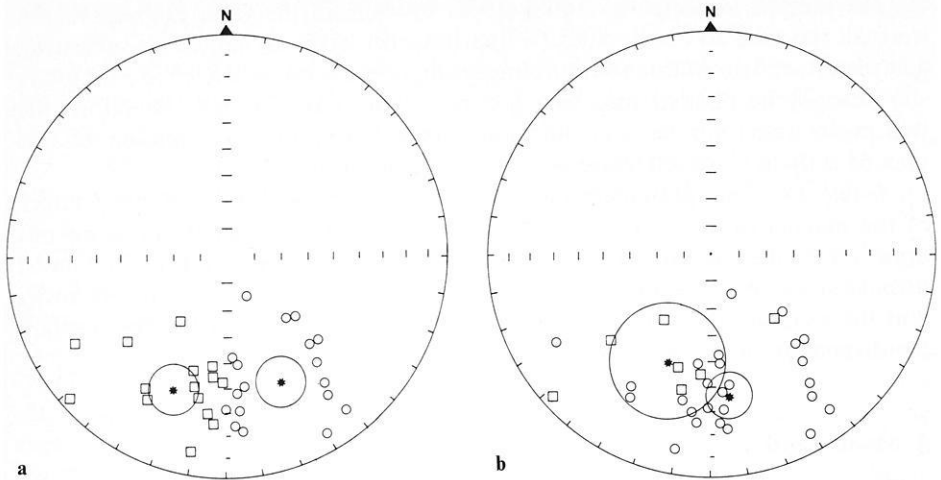


Fig. 1 a and b. Site mean directions from Monti Lessini (Soffel, 1975 a) showing the Eocene (circles) and Oligocene sites (squares) according to Soffel (a) and according to this paper, based on latest information (b). The stars represent the means for the Eocene and Oligocene sites, and circular approximations to α_{95} are shown. All inclinations are negative

rotation of this part of Italy during the time interval between the two volcanic cycles. Our re-classification of these ages (Fig. 1 b) illustrates that the difference between the Eocene and Oligocene mean directions is, in fact, not well-defined. As in the case of Colli Euganei, the data from Monti Lessini do not provide evidence for any rotation during this time interval.

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