

*Short Communication*

**Palaeomagnetism of Permo-Triassic Red Sandstones  
From the Northern Calcareous Alps**

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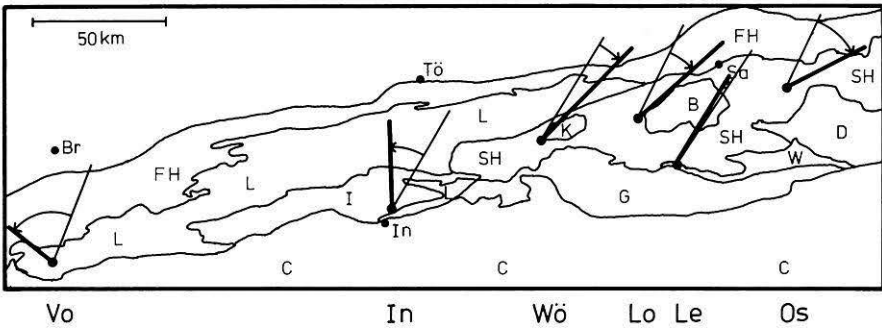
**Key words:** Northern Calcareous Alps – Permo-Triassic sandstones.

**1. Introduction**

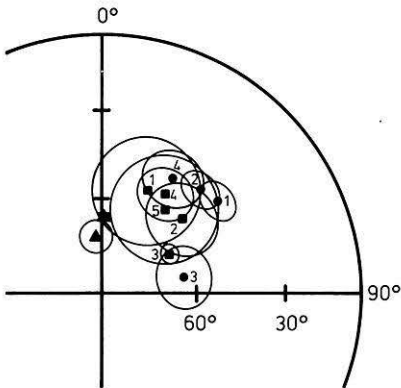
It is generally agreed (Gwinner, 1971) that the Northern Calcareous Alps (together with the Northern Grauwackenzone) rest allochthonously on top of a Penninic basement and have been transported into their present position from the South after Upper Eocene. Their complicated structure is characterized by a series of nappes of various lateral extensions and thicknesses. A sketch map of the Western part of the Northern Calcareous Alps (Fig. 1) shows the main nappes (after Gwinner, 1971).

Earlier palaeomagnetic measurements on rocks from the Northern Calcareous Alps gave contradictory results. Hargraves and Fischer (1959) studied Liassic red limestones and radiolarites near Lofer (Lo) and deduced a slight ( $20^\circ$ ) clockwise rotation with respect to Central Europe. A much larger clockwise rotation ( $40^\circ$ ) was concluded by Mauritsch and Frisch (1978) from the study of Upper Jurassic red limestones of the Osterhorngruppe (Os). However, an anticlockwise rotation ( $60^\circ$ ) was deduced by Soffel (1975) from the palaeomagnetism of Upper Permian to Lower Triassic effusives in Vorarlberg (Vo). None of these data seem to have a general validity for a rotation of the Northern Calcareous Alps as a whole during their transport by gravity gliding.

Along the southern margin of some of the nappes, Permo-Triassic (Skythian) red sandstones are exposed which are in some places in an undisturbed tectonic context with overlying Triassic limestones and dolomites. Several localities of these brown to violet coloured fine grained sandstones have been sampled. (In: Innsbruck, Rumer Spitze, 1 site, 10 samples; Wö: Hopfgarten near Wörgl, 5 sites, 36 samples; Le: Leogang near Saalfeld, 4 sites, 29 samples.) All localities and their corresponding position within the different nappes are shown in Fig. 1.



**Fig. 1.** Western part of the Northern Calcareous Alps. *L* Lechtaldecke; *I* Inntaldecke; *SH* Staufen-Höllengebirgsdecke; *K* Kaiserdecke; *B* Berchtesgadener Schubmasse; *W* Werfener Schuppenzone; *D* Dachsteindecke; *G* Grauwackenzone; *FH* Flysch, Helvetikum; *C* Kristallin, Schieferhülle. *Br* Bregenz; *Tö* Bad Tölz; *Sa* Salzburg. For sampling localities see text. Measured remanence directions (*thick*) and reference directions with regard to Central Europe (*thin lines*). *Arrows* indicate rotation.

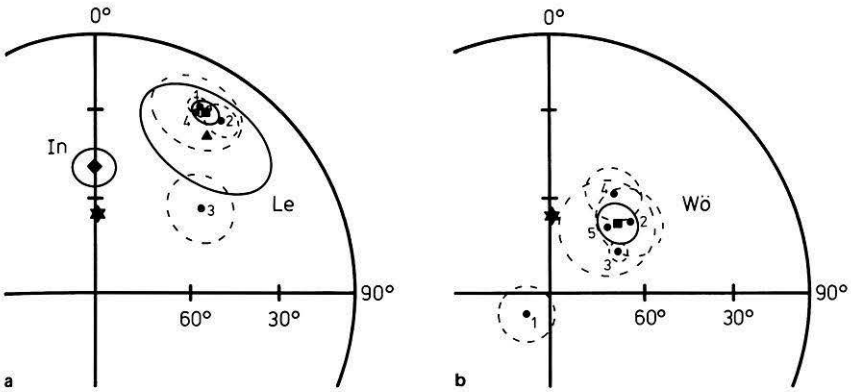


**Fig. 2.** NRM directions in equal area projection. *Star*: present geomagnetic field direction. *Triangle*: site In. *Squares*: sites Wö. *Dots*: sites Le

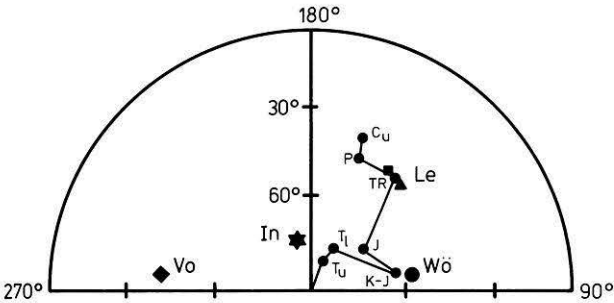
## 2. Palaeomagnetic Results

Figure 2 shows the NRM directions, all being normal. For meaning of the symbols see legend. With exception of site In, all directions differ significantly from the present local geomagnetic field direction (star). AF demagnetization up to 2,000 Oe and thermal demagnetization up to 650° C revealed the presence of two antiparallel remanence components in all three localities: a reversed component which could be destroyed with AF fields up to 100 Oe and thermal treatment up to 300° C, and a normal component stable up to 2,000 Oe and thermal treatment up to 560° C. At higher temperatures the directions scattered randomly and revealed no indication of a consistent component with higher blocking temperatures. Largest precision parameter was obtained for thermal demagnetization at 300° C.

Figure 3a and b show the site mean and locality mean directions after thermal cleaning and tectonic correction in equal area projection. For details see legend. The locality means are as follows: In:  $N=10$ ,  $R=9.82$ ,  $D=359.0^\circ$ ,



**Fig. 3a and b.** RM directions after thermal cleaning with 300° C and tectonic correction. *Star*: present geomagnetic field direction. **a** *Diamond*: site In. *Square*: sites Le, 3 closely grouped. *Triangle*: sites Le, all. **b** *Square*: sites Wö, 4 closely grouped



**Fig. 4.** Pole positions and part of European polar wander path. For details see text. *Diamond*: Vorarlberg after Soffel (1975); *Star*: Innsbruck; *Square*: Leogang, 3 closely grouped sites; *Triangle*: Leogang, all sites. *Full circle*: Wörgl

$I=49.9^\circ$ ,  $k=50.1$ ,  $\alpha_{95}=6.3^\circ$ ; Wö:  $N=4$ ,  $R=3.97$ ,  $D=44.3^\circ$ ,  $I=59.2^\circ$ ,  $k=102.7$ ,  $\alpha_{95}=6.9^\circ$  (omitting site 1 because of uncertain tectonic position); Le:  $N=3$ ,  $R=2.995$ ,  $D=31.5^\circ$ ,  $I=19.6^\circ$ ,  $k=414.8$ ,  $\alpha_{95}=4.0^\circ$  (omitting site 3 because of too large deviation from the remaining group). The corresponding pole positions are: In:  $194.5^\circ$  E,  $73.4^\circ$  N; Wö:  $98.9^\circ$  E,  $57.6^\circ$  N; Le:  $147.0^\circ$  E,  $44.1^\circ$  N. The mean geographic coordinates are  $12^\circ$  C,  $47.5^\circ$  N, however the exact coordinates were used for the computation of the pole positions. They are shown in Fig. 4 together with a part of the European polar wander path after McElhinny (1973). The Jurassic pole is from Heller (1977), the Lower Cretaceous-Upper Jurassic pole was taken from Schweitzer (1975).

### 3. Discussion and Conclusions

The presence of two almost exactly antiparallel remanence components (with fortunately not too much overlapping coercivity and blocking temperature spec-

tra) indicates a complicated magnetization history of these sandstones. The too steep inclinations for rocks of Early Triassic age (except for site Le) suggests a later overprint, perhaps during Upper Cretaceous or Lower to Middle Tertiary (early stage of the alpine orogeny). On the other hand, the presence of a third magnetization component with shallower inclination could not be found during the demagnetization experiments. From polished section studies the carrier of remanence seems to be detrital magnetite to some degree oxidized to hematite. From the petrology of the rocks there is no evidence for major mineralogical changes or reheating. The exact age of remanence of sites In and Wö remains therefore uncertain. Only the Leogang sandstones have a pole position which agrees with the Triassic pole for Central Europe indicating no rotation during the transport. Supposing an at least pre-Oligocene age of remanence of the two other sandstone sites, a slight clockwise rotation ( $15^\circ$ ) must be assumed for the Wörgl and a small anticlockwise rotation ( $20^\circ$ ) for the Innsbruck sandstones. The amounts of rotation are indicated in Fig. 1, where the corresponding rotations from Vorarlberg (Vo), Lofer (Lo) and Osterhorngruppe (Os) are also shown. The pattern of rotations (anticlockwise in the West, clockwise in the East) does in my view not reflect any bending of the Northern Calcareous Alps. Unless more data from the whole extent of the Northern Calcareous Alps are available I tend to regard the observed rotations as local effects which may be typical for a specific nappe or a part of it. They seem to reflect the sense and amount of relative rotation of the different units during their post Eocene northward transport by gravity gliding.

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