

## Block, thrust and escape-related rotations in the Central Northern Calcareous Alps

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The Northern Calcareous Alps (NCA) belong to the Upper Austroalpine units (Eastern Alps) and represent one of the largest structural units of the Alps. The application of paleomagnetic methods in this part of the orogen started very early and was focused on the reconstruction of the thrust system evolution, in paleogeographical reconstruction's or in large-scale interpretations after the appearance of the escape hypothesis. However, the extension of the NCA together with their complex geological evolution contrasts with the amount and distribution of data available (less than one hundred sites) and the diversity of interpretations. Data with adequate quality (statistically) based on new instrumentation and precise age control of the magnetization (proved by stability test) are essential in any single structural unit. Structural units must be treated independently to isolate and separate the vertical axis rotation related with the thrust or block systems arrangement (relative rotation among units) from large scale movements and/or inherited paleogeographical configurations.

In this work, we present data from more than 100 paleomagnetic sites located in the Salzkammergut area. Stratigraphic distribution spans from Lower Triassic to Lower Cretaceous and all of them are situated in Tirolic units. About 70 new sites (including 4 long magnetostratigraphical sections) have been joined to almost 40 sites from previous studies. A great diversity of magnetic behaviors allows us to define up to three magnetic directions mostly carried by low coercivity minerals

with unblocking temperatures of 350° (J1), 500° (J2) and 680° (J3), respectively. J1 and J2 have always positive inclinations and J3, when present (only a few sites), shows two polarities. The whole set shows good results and reveals three main observations: A systematic clockwise rotation which fits with previous observations. J2 or J3 display always higher rotation values than J1. When appear together (most cases), J1 displays constant inclinations everywhere but J2 shows different inclinations depending on the structural position of the sites (north or southwards dips).

Taking into consideration the fold test results (applied separately in the North and South sectors), J1 and J2 can be interpreted as pervasive post and syn-folding remagnetizations respectively. In most cases the original information (J3) has been completely reset. They show different degrees of rotation in the different blocks. J3 can be considered as primary (two polarities). In view of the geodynamic evolution and the observed inclinations, the second remagnetization event (J1) could have taken place much later than the final configuration of the Tirolic system and around the age of both the thrusting of the NCA over the Flysch and the Tauern window uplift. From this moment on, the NCA behaved like a unit and J1 would record the main stage of rotation (60° in average) associated with the collision and the extrusion. J2 would have been acquired during the Tirolic thrusting and then, the differences between J2 and J1 (15° in average) would be the rotations related with the lateral differences of shortening of this system.

### A paleomagnetic cross section through the Eastern Northern Calcareous Alps: preliminary data in the Mariazell meridian

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More than eighty new paleomagnetic sites have been investigated in the Eastern Northern Calcareous Alps. The sites are located in the Mariazell meridian (about 15° 30' East longitude) and span from Scheibbs in the North to Kapfenberg in the South. From the structural point of view, these sites cover mainly the Northern Calcareous Alps (NCA) nappes but some sites were also taken in the

Helvetic and Penninic flysch units as well as in the Greywacke Zone. At least 5 sites (8 to 10 oriented cores) per thrust sheet or nappe were obtained in order to check properly the age of the magnetization by means of fold tests: Frankenfelds, Lunz, Sulzbach and Reisalpen nappes (Bajuvarikum); Ötscher, Göller, Rotwald-Gindelstein nappes (Tirolikum); Mürzalpen, Proles, and

Schneeberg nappes (Juvavikum) were sampled in detail mostly in Mesozoic rocks.

Thermal demagnetizations were applied to unravel the magnetic history of these rocks. Pilot data confirm the stability of the magnetic directions which are carried by soft magnetic minerals (presumably magnetite). Unblocking temperatures between 350 and 575° C usually display well-defined paleomagnetic directions.

A preliminary interpretation of pilot data, based on the separated application of the fold test in any studied unit, shows nicely that the magnetization is not always primary (acquired at the time of the sedimentation) and then has to be related with remagnetization processes associated with the structural and geodynamic history. This fact correlates very well with the new view of previous and new paleomagnetic data in the Central NCA

(Salzkammergut area). A general view of the whole set reveals a general increase of the degree of rotation southwards. A southwards gradient of remagnetization is also detected, this means that evidences of primary (two polarities and pre-folding magnetizations) are only present in the North. Southern positions usually display syn- or post-folding remagnetizations. After considering the results of the fold test it can be inferred that the flysch units do not show any significant rotations (if compared with the present north). Bajuvaric units hardly show significant rotations. Tirolic and Juvavic sheets display clockwise rotations ranging between 30 and more than 90°. Future work should be done with the aim of building reliable fold tests and concentrating paleomagnetic sites unit by unit and age by age.

## **Strukturkontrollierte Edelmetall-Vererzungen im Altenbergtal, Lungau, Salzburg**

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Im östlichen Tauernfenster treten in den Metasedimenten der Silbereck Formation und im unterlagernden Zentralgneis strukturegebundene Edelmetallvererzungen auf. Die wichtigste Einzellagerstätte ist Rotgülden, wo Bergbau auf Gold und Silber, später auf Arsen umging. Eine Vielzahl spätmittelalterlicher Einbaue und Schürfe konnte neuerdings im Altenbergtal und am Silbereck SE-Grat, 3 km S der Lagerstätte Rotgülden, im Detail montangeologisch untersucht werden. Bei einem Großteil der Einbaue handelt es sich um natürliche Karsthohlräume, die von den Bergleuten aufgrund ihrer Gold- und Silbervererzung mittels Feuersetzen und handgeschämter Strecken erweitert wurden.

Im Raum Altenbergtal/Silbereck SE-Grat konnten drei Vererzungstypen nachgewiesen werden: 1) metasomatische Verdrängungserze, die auf die Marmore beschränkt sind; 2) Erze in Dehnungsklüften, die in den Marmoren, am Gneis-Marmor-Kontakt oder im Zentralgneis auftreten; und 3) edelmetallführende Vertalkungszonen in den Marmoren, die einen neuartigen Vererzungstypus (Typus 3) darstellen. Charakteristisch für den Typus 3 ist das Auftreten von silberarmem Gold gemeinsam mit Bismuthinit, Tetradymit, Vertretern der Lillianit-homologen Serie und weiteren Ag-Pb-Bi-Sulfosalzen (Cosalit, Pavonit, Giessenit, Matildit).

Vier Vererzungsphasen können unterschieden werden. Phase 1 ist durch die Abscheidung von Arsenopyrit, Pyrit und Pyrrhotin bei Temperaturen von ~ 360-380°C charakterisiert. Während der zweiten Phase wurden Hochtemperatur-Chalkopyrit, Bismuthinit-Derivate, Ag-Pb-Bi-Sulfosalze und ged. Gold abgeschieden. Die Kristallisation von Chalkopyrit, Sphalerit, Galenit und Fahlerzen (Tetraedrit-Tennantit) kennzeichnet die dritte Phase. Den Abschluss des Mineralisationsprozesses bildet Galenit mit Einschlüssen von Ag-Tetraedrit, Polybasit, Bournonit und Hessit.

Erste Ergebnisse der Untersuchung von Flüssigkeitseinschlüssen in Quarz und Dolomit liefern Hinweise auf Bildungstemperaturen deutlich über 300°C (Mittelwert 342.2°C) für die zweite Vererzungsphase im Zentralgneis und um 250°C für die dritte und vierte Phase im Marmor.

Die Untersuchungen wurden im Rahmen eines von der Kommission für Grundlagen der Rohstoffforschung der ÖAW initiierten Projektes „Stoffmobilitäten und die Bildung von Minerallagerstätten in den Ostalpen während der alpidischen Orogenese“ (Teilprojekt: Genese strukturkontrollierter Goldmineralisationen in der Habach Gruppe und Silbereck Formation) gefördert.