Directional correlation of petrophysical anisotropy patterns with rock deformation during alpine tectonic evolution (Eastern Alps, Austria)

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Introduction

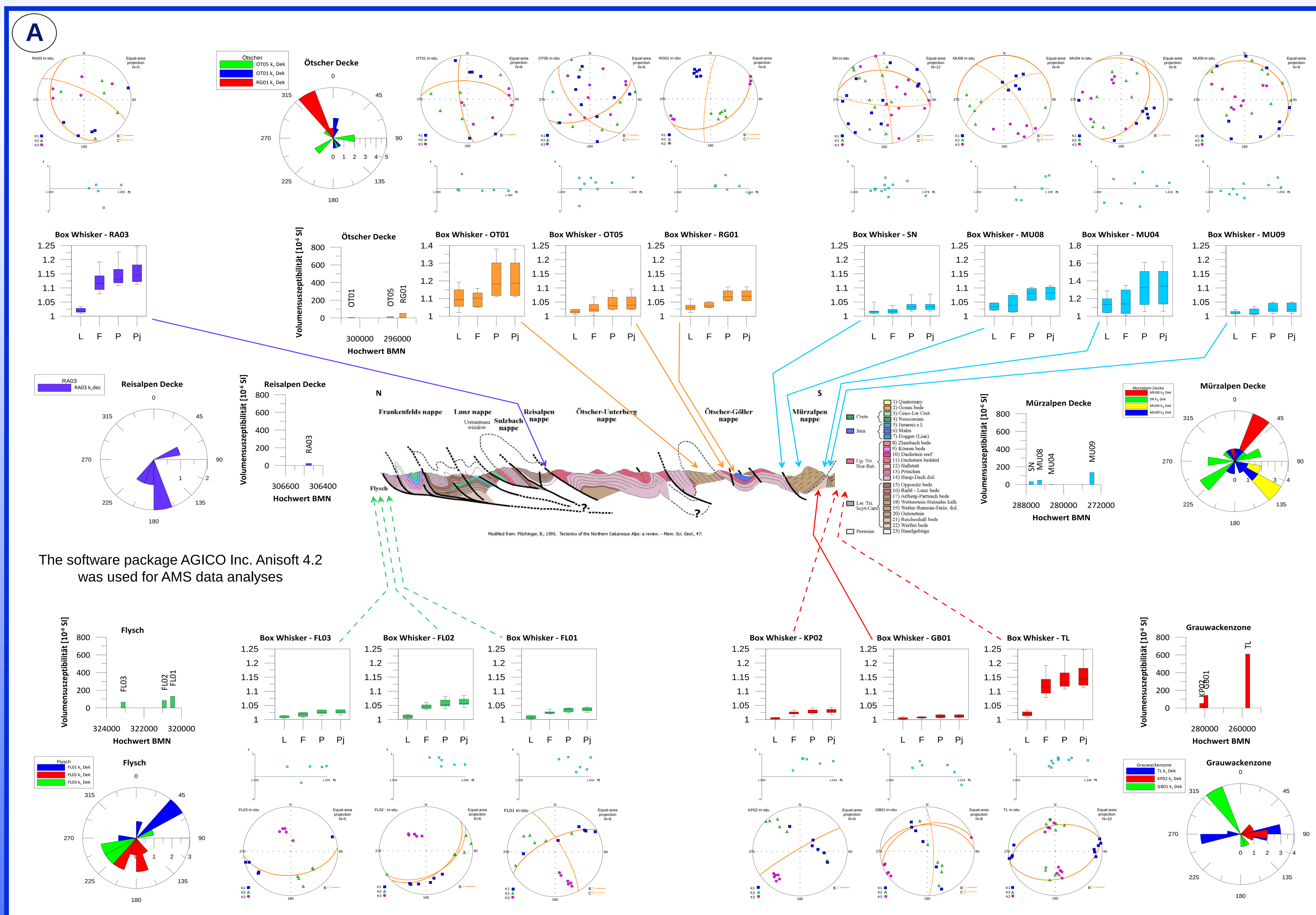
Recent geodynamic investigations in the Eastern Alps and surrounding areas gave rise for large neotectonic movements, which are dated younger than 5 Ma. The main objective of the study involves petrophysical analyses of textures in Alpine rocks in order to observe changes of the regional deformation pattern.

Measurements of anisotropy of magnetic susceptibility (AMS) were carried out on samples from 34 sites collected in the Eastern Alps. Samples spanning an age range from U. Permian to Mesozoic were taken along a North-South transect from Scheibbs in the North to Kapfenberg in the South, comprising Helvetic and Penninic Flysh units, most of the Northern Calcareous Alps (NCA) nappes, as well as the Greywacke zone.

AMS analysis was carried out on two to six sites per thrust sheet or nappe for a structural investigation of the relationship between magnetic fabrics and tectonic strain in the investigated area. The study focuses on the directional correlation of the AMS axes patterns.

The palaeostress results of Peresson & Decker (1997) give evidence of six tectonic events during alpine evolution which we use as reference frame for our strain correlation:

- T1: NW – SE compression (post – Early Eocene)
- T2: N – S compression (Early to Middle Miocene)
- T3: NE – SW compression (Middle Miocene)
- T4: E – W extension (Middle Miocene)
- T5: E – W compression (Late Miocene, Pannonian)
- T6: N – S extension (Late- to post-Miocene).



Anisotropy of magnetic susceptibility

Particularly within the NCA, AMS is inapplicable on most rocks for strain analysis as they are diamagnetic and/or isotropic. Even so, some sites are anisotropic and yield oblate and triaxial magnetic fabrics. In some cases even tendency to prolate magnetic fabrics can be observed. The AMS data of the research area show three main characteristics of magnetic fabrics related to strain. In the Flysh units and Greywacke zone, the AMS principal axes document a weaker tectonic deformation than in the NCA.

Figure A:
AMS parameter, rose diagrams displaying the mean direction of the maximum susceptibility axes (k_{max}) and susceptibility values are presented along a North – South profile of the eastern NCA.

Rock and paleomagnetic results

Isothermal Remanent Magnetization (IRM) measurements and stepwise thermal demagnetization of 3-component Isothermal Remanent Magnetization (3D I_ST) identify magnetite and haematite as well as goethite as the main magnetic minerals.

Figure B: IRM and 3D I_ST of a sample from the Ötscher nappe yielding magnetite as magnetic carrier mineral.

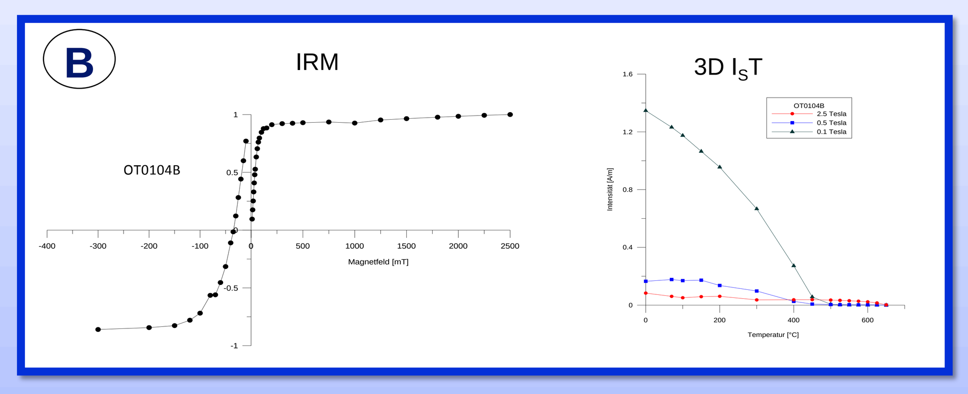
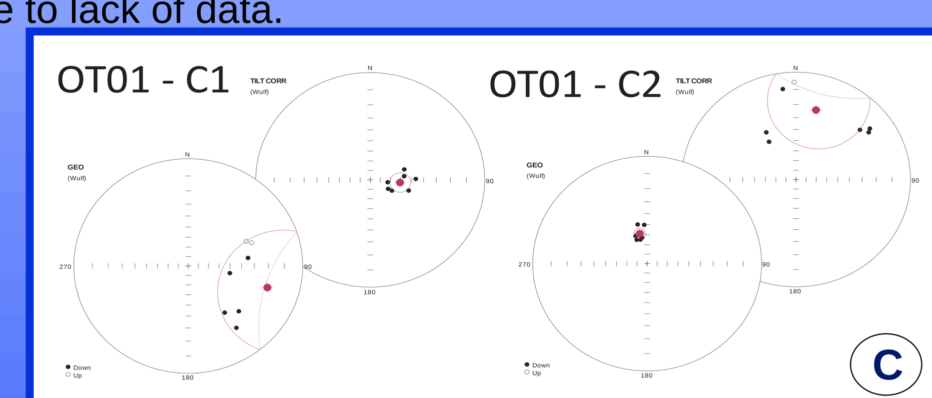


Figure C:
Stepwise thermal demagnetization defines two magnetic directions carried by phases with low coercivity and low unblocking temperatures: C2, 250°C and C1, 580°C. Clockwise and anticlockwise vertical axes rotation (Middle - Late Miocene) with values ranging from 2° to 57° were recorded by the remanence vector C2 (**Figure D**). The remanence vector C1 also documents an older blockrotation with higher rotation values than C2 but the remagnetization and rotation ages cannot be given due to lack of data.



Northern Calcareous Alps

Figure A:
Some sites reveal weakly deformed magnetic fabrics with very low susceptibility values and the directions of k_{max} vary locally. Oblate to triaxial magnetic fabrics are dominant. In some samples prolate magnetic fabrics are observed.

Figure D:
During NE-directed compression (T3 - Middle Miocene) k_{max} was aligned parallel to σ_3. NW – SE directed reverse faults and sinistral ENE – WSW directed strike-slip faults are significant for phase T3 (Peresson and Decker, 1997). After restoration of the pre-Miocene situation k_{max} displays a more suitable correlation with σ_3.

Flysh units

Figure A:
Oblate fabrics are dominant with a quite low bulk susceptibility. In-situ orientations of k_{max} are well aligned in a subhorizontal NE – SW direction with a separate cluster in the South. The magnetic fabrics differ slightly from sedimentary fabrics which indicates a weak stage of deformation.

Figure D:
The magnetic fabrics indicate a relationship to the tectonic event T1 – NW-SE compression but direct comparison is not possible due lack of strain data in the Flysh units.

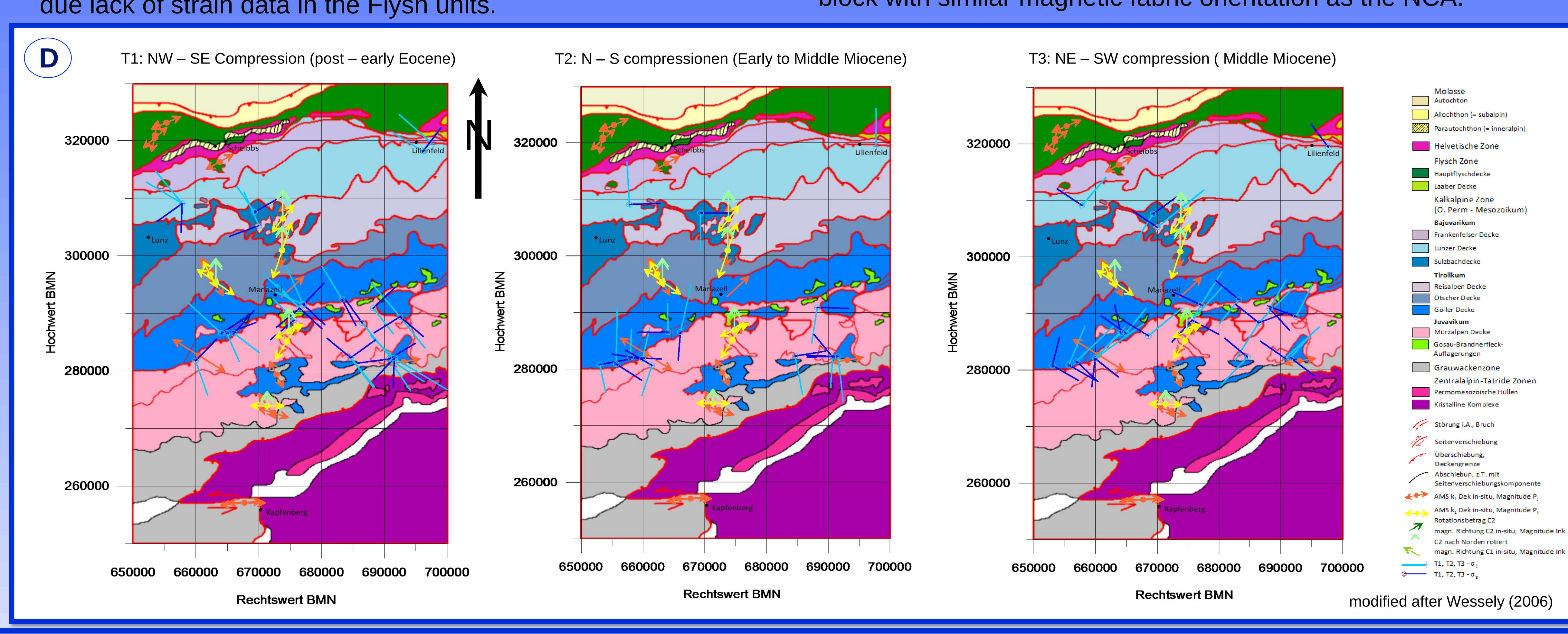
Greywacke zone

Figure A:
Oblate magnetic fabrics are dominant. The in-situ orientation of k_{max} yields two groups: (1) k_{max} scattered around a NW – SE trending girdle normal to the bedding and (2) k_{max} is aligned in a E – W direction. The bulk susceptibility reaches its highest values in the transect.

Figure D:
In group (2) the alignment of k_{max} can be related with the N-directed compression (T2) during Early to Middle Miocene (Peresson and Decker, 1997). Group (1) represents a tectonic block with similar magnetic fabric orientation as the NCA.

Conclusion

All sampled lithologies of the Flysh units and Greywacke zone yield well defined AMS patterns whereas in the NCA only carbonatic sediments accumulated in sub-oxic and reducing environments with terrigenous influence are suitable.
The magnetic fabrics document weak deformation. The orientations of the susceptibility tensor can be correlated to strain directions during neotectonic events from Early to Middle Miocene. Remagnetization vectors record very young (< 5 Ma) vertical axes blockrotations within the NCA.



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