

Superimposed Fabric Patterns in the Metamorphic Core of the
Apuan Alps (Northern Apennines)

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Summary

The Apuan Alps consist of nappes and wedges which were piled upon each other during several orogenic phases. Since the temporal sequence of the orogenic events and the correlation between the tectonic units is still controversial (see WUNDERLICH 1960, 1963; IPOLLITO 1950; HARTUNG 1966; WACHSMUTH 1966; HACCARD, LORENZ & GRANDJACQUET 1972; NARDI 1967; DALLAN-NARDI & NARDI 1974) we carried out a more detailed structural analysis using the methods of quantitative fabric analysis and microtectonics. The results show clearly that the single complexes have different patterns of tectonic stress. Furthermore they show different ages and degrees of metamorphism. We can therefore conclude that they belong to different tectonic tiers. A relation of this succession of tectonic events to a collision of plate margins seems to be very difficult because of still lacking data.

Structural Analysis

In the Apuan Alps the following tectonic complexes from bottom to top can be distinguished: 1) The autochthonous core ("Tuscanides I"), 2) The parautochthonous Massa Zone, 3) The parautochthonous schuppen zones of Stazzema and Isola Santa, 4) The parautochthonous Pania Unit, 5) The Tuscan nappe ("Tuscanides II") 6) The allochthonous Ligurian Units ("Ligurides I, II and III"). In ca. 40 outcrops in these tectonic units fabric elements such as fold axes, lineations, bedding planes and schistosity planes were measured and sphere diagrams were plotted for each type of fabric elements using a Fortran IV programme GELI (ADLER et al. 1968).

Linear Elements

In the sphere diagrams the linear elements show differences in the distribution of statistical maxima and submaxima. The main maxima correspond generally with macrotectonic axes (NW-SE direction predominant, N-S direction in the central part of the autochthonous, various directions in the deepest layers of the core, E-W directions in the eastern part). In the Massa Zone exists also a main maximum in the Apennine direction and a second accumula-

tion in the SW direction. But in contrast to the autochthonous, here a third system obviously exists forming a girdle distribution with another maximum at 336/56. Since it does not follow a small or great circle, these linears must be explained as the oldest system which exists only in the Massa Zone. Deviating orientations of the maxima were observed only in the parautochthonous schuppen (NNE-SSW). The submaxima in the lower tiers of the autochthonous often show great angles of divergence from the main maxima (NE-SW, ENE-WSW, NNE-SSW). This leads to the conclusion that the distribution is based on an older stress system (submaxima) which is superimposed by a younger folding (main maxima).

Planar Elements

In almost all measured exposures in the autochthonous and parautochthonous parts two systems of schistosity planes which intersect at an angle of about 30-40° could be observed. Within the allochthonous frame (Tuscan nappe), however, only one system of schistosity exists. Synoptic sphere diagrams of the poles of schistosity planes in the autochthonous prove a π -circle distribution around the Apennine direction of the fold axes. The poles of the bedding surfaces in the Tuscan nappe show the same orientation which proves that they belong to the same act of deformation.

Conclusions

On the basis of the results of structural analysis we can reconstruct the following succession of the orogenetic processes:

- 1) Folding with SW vergencies and metamorphism in the Massa Zone (14 mio.y., GIGLIA & RADICATI 1970).
- 2) Thrusting of the Massa Zone on the internal part of the autochthonous, primary folding (NE-SW) and metamorphism in the autochthonous, placement, folding and metamorphism in the parautochthonous schuppen (11 mio.y.).
- 3) Overthrust of the Tuscan nappe, placement of the parautochthonous Pania Unit and a second folding in the Apennine direction in all tectonic units. A second metamorphism leads to recrystallisation.
- 4) Arrival of the Ligurid nappes from the southwest.
- 5) Postorogenetic distractive tectonics during the Plio-Pleistocene, lifting of the entire Apuan Alps and generation of the present morphology. A relation of this succession of tectonic events to a collision of plate margins seems to be very difficult because of still lacking data.