MECHANISMS AND MICROSTRUCTURAL ELEMENTS OF THE EARLY, DUCTILE DEFORMATION PHASE IN LIMESTONES OF THE NE BÜKK MOUNTAINS, HUNGARY

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According to field investigations (e.g. CSONTOS, 1999), the "main schistosity" in the NE Bükk is a generally recognised feature. It constitutes the axial plane of the early folds formed by ductile deformation of the Late Palaeozoic-Triassic sequence. The ductile deformation elements are best observable in beds where limestone alternates with seams or lenses of materials with different competence, e.g. in cherty limestone.

It was supposed that the early, ductile deformation took place during the Alpine low-grade metamorphism (ÁRKAI, 1973, 1983). According to these investigations, the conditions of the peak metamorphism can be characterised by 300-350 °C temperature and 200-300 MPa pressure. They already pointed out that there is no correlation between the pressure of metamorphism and the stratigraphic position (burial), the metamorphic event is proved to have mainly a dynamothermal character. The later deformation phases took place under lower temperature (DUNKL *et al.*, 1994), where ductile deformation in the limestones cannot be formed.

In the present paper different microstructural elements of limestones were studied which could have developed during the ductile deformation phase but were not overprinted by the later phases. The position of the samples in an early fold was also considered: samples both from the hinge and limb zones of folds were investigated. The following microstructural elements were examined:

- grain shape preferred orientation (SPO) of the fine-grained (10-20 μm) matrix, examined by quantitative image analysis.
- shape of the intercrystalline boundaries in the matrix.
- crystallographic preferred orientation (CPO) by constructing inverse pole figures.
- formation and further deformation of calcite twins in large (150-200 μm) pre-kinematic crystals.

No correlation was found between the stratigraphic position and the occurrence and intensity of these microstructural elements. Conversely, it was detected that they depend on the position of the sample relative to different fold elements formed during the early deformation phase.

The SPO of the matrix was weak in the hinge zones, while it was intensive on the limbs. The strongest SPO values were detected on samples from the limbs on sections cut normal to shear direction. The sections cut parallel to shear direction had more moderate SPO values.

The intercrystalline boundaries of the fine-grained matrix were predominantly serrate in specimens from hinge zones. On the other hand, the grains of the matrix of samples from limbs had a fair proportion of straight (plain) boundaries. Planar grain boundaries with polygonal texture dominated the sections cut parallel to shear direction, while they were less frequent in the normal sections.

According to inverse pole figures, the sample from a hinge zone had no CPO. Conversely, a weak but definite CPO was detected on samples from the limb zones. They showed a "c-axis fibre type" CPO (LEISS & ULLEMEYER 1999) having a simple c-axis maximum normal to the main schistosity. The slight CPO and the predominance of straight boundaries in the matrix indicate that the limestones in limbs of the early phase folds could deformed by "superplastic creep" (SCHMID *et al.*, 1977).

The deformation twins within and the grain boundary zones around the large, pre-kinematic calcite crystals from the intensively sheared limbs were dynamically recrystallized: these elements were replaced by aggregates of small, isometric calcite grains with dominantly straight boundaries. Conversely, the large calcite crystals from the hinge zones showed only serrated grain boundaries and straight, undeformed twins.

These features indicate that the differential stress during the early, ductile phase was relatively weak (about 20 MPa) in the hinge zones, the limestones here deformed by diffusion mass transfer (pressure solution). The additional shear stress on the limbs rose the differential stress (up to 35-60 MPa) thus dynamic recrystallization and superplastic creep could take place.

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