Indication of Geological Structures and Tectonics in Geophysical Fields

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The anomalous gravity field of the Earth depicts density changes of subsurface parts of the Earth crust in a relative sensible way. These density changes reflect a petrographical diversity of rock environment and geometry of geological bodies. It is possible to find out indications connected with tectonics in gravity images, along which often occur horizontal and vertical movements.

On examples from a contact zone of the Bohemian Massif and the West Carpathians we present the gravity data processing by means of modern software tools which enable to detect and depict even less expressive or hidden indications too. Outputs of this modern data processing are maps with an outstanding ability to indicate and visualise structure and tectonic patterns of a studied region. These enable quite an easy and relatively objective interpretation which can be executed not only by geophysicists but also by not very experienced other collaborators in geologic or related branches. Modern data processing contributes to specification of the knowledge of the geological structure and in many cases may bring new information for final geological solutions.

Examples of Defining Chronology of Metamorphism in Metabasic Rocks of the Kaczawa Mts. and East Karkonosze Mts.

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The relative age, in other words the order of crystallisation, of minerals and mineral parageneses may be studied in the rocks mainly through microstructures such as zoned grains, inclusions, replacements, alteration as well as relationships of veins. Zoned grains, most commonly of amphiboles have been observed in metabasites of both the Kaczawa Mts. Complex and the East Karkonosze Mts. Complex. Zones from the centre to the margin indicate the order of crystallisation while the composition of the zones, analysed with the electron microprobe, allows to estimate the corresponding metamorphic conditions. This gives a chance of defining stages and/or events in the metamorphic history of the complex.

In medium grained diabases of the Świerzawa Unit in the Kaczawa Mts Complex the following zones, from the centre to the margin, have been noted (Smulikowski 1990); 1) clinopyroxene (salite) - kaersutite - crossite - glaucophane - actinolite, 2) kaersutite - riebeckite - glaucophane - magnesioriebeckite - actinolite (Fig. 1); 3) light brown hornblende - bluish green actinolitic hornblende - actinolite - crossite. The coexisting plagioclase is always albite, usually with epidote inclusions. Clinopyroxene, kaersutite and possibly also light brown hornblende represent original minerals of the igneous protolith. Glaucophane and crossite correspond to the glaucophane schist facies conditions (high P/T metamorphism stage) while actinolite, actinolitic hornblende as well as riebeckite/magnesioriebeckite correspond to greenschist facies. Most probably mineral zones in these composite grains represent various stages of the same metamorphic event (monometamorphism), but not in every zoned grain all the stages have their mineral representation.

In the Rudawy Janowickie (East Karkonosze Mts. Complex) olive high-Ti magnesiohornblende is common in most of the amphibolites of the Leszczyniec Volcanic Formation. No relics of clinopyroxene nor kaersutite are present. Most probably this hornblende originated from primary mafic basaltic minerals, mainly augite, in an early event of regional metamorphism, under conditions of the higher T part of amphibolite facies. Possibly this may be attributed to the ocean floor metamorphism.

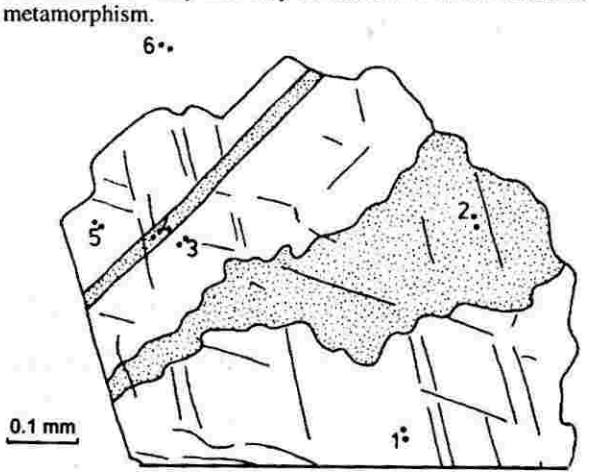

Fig. 1. Microscope image of the composite amphibole grain present in the metadolerite of Świerzawa Unit, N of Wojcieszów, Kaczawa Complex (after Smulikowski 1990). 1 - kaersutite; 2 - riebeckite; 3 - glaucophane; 4 - magnesioriebeckite; 5 - actinolite; 6 - chlorite. Dots represent analysed spots.

As a rule this olive hornblende is surrounded by the blue-green, low-Ti magnesiohornblende or ferrohornblende which

could have originated in another, probably much younger metamorphic event.

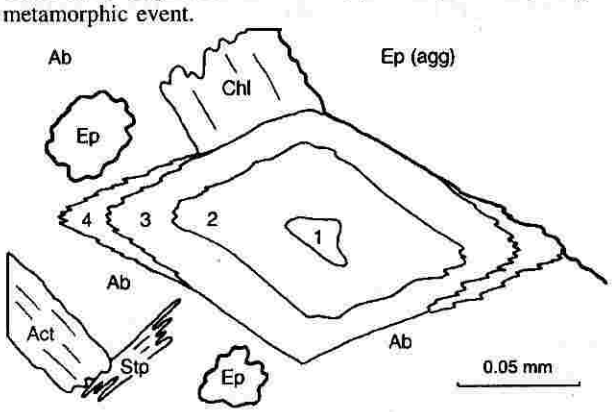

Fig. 2. Microscope image of the composite amphibole grain in the cataclastic Stp bearing FeActHbl-Chl-Ep-FeGln/Css-Ab gneiss from the E slope of the Lasocki Range near Kopina hill - E Karkonosze Complex (after Smulikowski 1995). 1 - subcalcic ferroactinolitic hornblende (FeActHbl); 2 - ferroglaucophane (FeGln); 3 - crossite (Css); 4 - Actinolite (Act). Ab = albite, Chl = chlorite, Ep = epidote, Stp = stilpnomelane.

To the south, in the Lasocki Range and Rýchory where alkali amphibole bearing rocks occur, the following zoned amphibole grains were observed: 1) subcalcic ferroactinolitic hornblende (or winchite) - ferroglaucophane - crossite - actinolite (Smulikowski 1995); 2) magnesioriebeckite - crossite; 3) glaucophane - subcalcic magnesiohornblende; 4) ferroglaucophane - subcalcic ferrohornblende; 5) ferroglaucophane - ferrobarroisite; 6) magnesiohornblende - barroisite - magnesioriebeckite; 7) actinolitic hornblende - winchite - riebeckite; 8) magnesioriebeckite - subcalcic actinolite. Coexisting plagioclase is always albite often with numerous epidote inclusions. Stilpnomelane, forming veins and nests, is observed in alkali amphibole bearing rocks as well as in low-Ti hornblende rich rocks. All mafic minerals were often replaced by chlorite. In some greenschists in the Lasocki Range and of the Poniklá Group in Rýchory crossite relics survived only as inclusions in larger albite grains.

The most complete record of the changing P-T conditions during metamorphism is represented by the zonation (1). It indicates the increase of pressure, to glaucophane-schist facies conditions, then the gradual decrease and ends up in the greenschist facies. The other examples of zonation correspond to various sections of the P-T-t path, some of the increasing and some of the decreasing pressure. The temperature variations may also be estimated. They may be rather interpreted as P-T changes during the same metamorphic event.

It is very probable that the low-Ti blue-green hornblende rims on high-Ti hornblende in amphibolites of Rudawy Janowickie and the alkali amphiboles in metabasites of the Lasocki Range and Rýchory are results of the same high P/T metamorphic episode corresponding to epidote-amphibolite facies and glaucophane-schist facies respectively. In both Kaczawa Complex and East Karkonosze Complex after the high P/T metamorphism greenschist facies metamorphism took place. It could correspond to the decompression stage of the same metamorphic event or to a separate, younger metamorphic event.

An important point made by Evans and Brown (1987) is that "depending on the whole-rock composition blueschist and greenschist lithologies can occur together at the same P and T". Local equilibria and variations of oxygen fugacity play also important roles in the formation of alkali amphiboles. This together with the selective survival of blueschist parageneses in the subsequent metamorphism of regional, contact and dislocation type may explain the very erratic and irregular distribution of the glaucophane schist facies rocks in the both complexes.

Maluski and Patočka (1996) with the $^{40}Ar/^{39}Ar$ method on phengite from the blueschists of Sněžný potok dated the glaucophane-schist facies metamorphic episode as ca. 360 Ma and the following greenschist facies episode as ca. 340 Ma. A similar attempt of Maluski and the present author on stilpnomelane from the Lasocki Range did not bring the results. In any case the regional metamorphism events were predating the contact metamorphism resulted from the intrusion of the Karkonosze granite.

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Variscan Metamorphism of the Devonian Quartzites from the NE Part of the Bohemian Massif (Strzelin Crystalline Massif, Fore-Sudetic Block, Eastern Sudetes)

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Geological setting

The Strzelin crystalline massif crops out in the eastern part of the Fore-Sudetic Block north of the Jesenik Mts. (SW Poland). The massif comprises the Upper Cambrian to Lower Ordovician orthogneisses (Oliver et al. 1993), mantled by mica schists and paragneisses of unknown, probably Neoproterozoic