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RARE EARTH ELEMENTS CHARACTERISTIC OF CARBONATE ROCKS FROM THE KŁODZKO METAMORPHIC UNIT

GEOLOGICAL SETTING AND PETROGRAPHY

The Kłodzko Metamorphic Unit (Sudetes) is composed of metasedimentary and metaigneous rocks metamorphosed at greenschist to amphibolite facies conditions (Wojciechowska, 1990). In the upper part of the Kłodzko Metamorphic Unit there are metamorphic rocks that include marbles with corraline fauna of Givetian age (Hladil et al., 1999). They are unconformably covered by unmetamorphosed late Frasnian pelagic limestones of the Bardo Mountains Unit. The lenses of the marbles appear in the lower (Bożków) and in the upper (Łączna) formation of the Kłodzko Metamorphic Unit. These formations are composed mainly of phyllites and chlorite schists and they are probably in the tectonic contact (Mazur & Kryza, 1999).

The marbles are fine- to medium grained, distinctly laminated. As follow from the thin section observations, they are composed of calcite and dolomite laminas in varying proportions, with quartz, muscovite, chlorite and opaque grains (pyrite). Dolomite has a fine grained (0.1 to 1 mm) and calcite has a coarser grain size (1 to 3 mm). The calcite prevails over the dolomite.

METHODS

Rare earth elements (REE) concentrations in samples of marbles and schists from the Kłodzko Metamorphic Unit were determined by neutron activation analysis (NAA) at Activation Laboratories Ltd, Ontario, Canada. Rare earth elements (La, Ce, Nd, Sm, Eu, Tb, Yb, Lu) concentrations in marble samples are very low and concentration of Tb is below detection limit. In REE distribution patterns contents of this element were calculated by linear interpolation.

The samples of the marbles and schists were collected from the Łączna and Bożków formations.

RESULTS

The REE contents of the marbles and schists were normalized (REE_N) to Post-Archean Australian shale (PAAS) (Taylor & McLennan, 1985). The schists (samples K6, K716, K1516) and the marbles of the Kłodzko Metamorphic Unit reveal similar

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REE_N patterns (Fig. 1), and they are characterized by very low REE contents and a nearly flat light REE_N (LREE) patterns. They are showing relative enrichment in heavy REE (HREE), slight negative Ce anomaly in some marble samples and slight positive Eu anomaly. The slight negative Tb anomaly is noticed in the schist and distinctly negative Tb anomaly is observed in the marbles patterns.

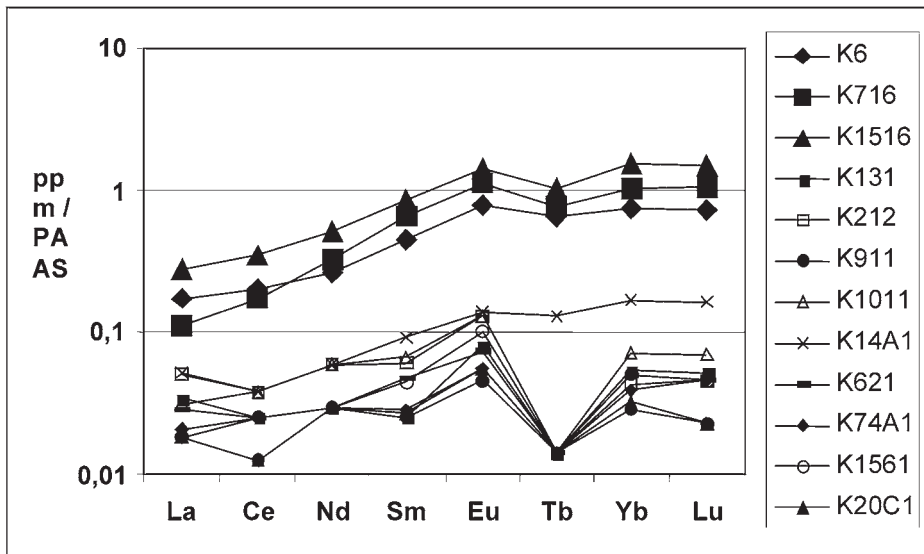


Fig. 1. REE diagram for selected schists (K6, K716, K1516) and crystalline carbonate rocks of the Kłodzko Metamorphic Unit, normalized to the PAAS (average 23 post-Archean shale from Australia /Taylor & McLennan, 1985/).

DISCUSSION

Marine water commonly possesses a negative Ce anomaly (Hu et al., 1988) which is then inherited by carbonates formed in equilibrium with seawater in marine environment. Absence of the Ce anomaly in some marble samples of Kłodzko Metamorphic Unit suggests diagenetic and/or metamorphic overprint which is most likely the reasons for some minor deviation of some REE_N patterns from the ideal marine signature.

The Eu anomaly in sedimentary rocks may be result of enrichment of plagioclase contents, sedimentation in alkaline pore water of anoxic marine conditions or interaction of the rocks with the magmatic fluids (McLennan, 1989). In diagenetic conditions, below 100 °C, the Eu in aqueous solutions is dominant by trivalent state (Sverjensky, 1984). Slight positive Eu anomaly in the marbles of Kłodzko Metamorphic Unit suggests that changes in REE contents of the sediments could not be attributed to diagenetic processes, but they might be connected with the interaction of magmatic or metamorphic fluids. The marbles protolith from Kłodzko Metamorphic Unit were

deposited rather in normal redox conditions with only small changes in REE distributions connected to plagioclase contents.

The reason of the negative Tb anomaly is not clear.

The flat shape in $HRRE_N$ distributions (apart Tb anomaly) indicates no influence of the heavy mineral contents on the REE_N patterns of metasediments of the Kłodzko Metamorphic Unit (McLennan, 1989). The similarity of the REE_N distributions in both marbles and schists from Kłodzko Metamorphic Unit suggest that these rocks were formed in the same sedimentary basin and probably in quite similar geochemical conditions.

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REFERENCES

- HLADIL J., MAZUR S., GALLE A., EBERT J., 1999: Revised age of the Mały Bożków limestone in the Kłodzko metamorphic unit (Early Givetian, Late Middle Devonian): implications for the geology of the Sudetes. *N. Jb. Geol. Palaeont., Abh.*, 179, 275-284. Stuttgart.
- HU X., WANG Y. L., SCHMITT R. A., 1988: Geochemistry of sediments on the Rio Grande Rise and the redox evolution of the South Atlantic Ocean. *Geochim. Cosmochim. Acta*, 52, 201-207.
- MCLENNAN S. M., 1989: Rare earth elements in sedimentary rocks: influence of provenance and sedimentary processes. In: Lipin B. R. & McKay G. A. Ed.: *Geochemistry and Mineralogy of Rare Earth Elements*. Mineral. Soc. Am., *Rev. Mineral.*, 21, 169- 200.
- MAZUR S., KRYZA R., 1999: Preliminary report on the metamorphosed melange in the Kłodzko metamorphic complex (west Sudetes, SW Poland). *Mineral. Society of Poland. Special Papers*, 14, 102-104.
- SVERJENSKY D. M., 1984: Europium redox equilibrium in aqueous solutions. *Earth Planet. Sci. Lett.* 67, 70-78.
- TAYLOR S. R., MCLENNAN S. M., 1985: *The Continental Crust: Its Composition and Evolution*. Blackwell, Oxford, 312 p.
- WOJCIECHOWSKA I., 1990: Geology of the Kłodzko Metamorphic Unit (Sudetes, Poland). *N. Jb. Geol. & Palaeont., Abh.*, 179, 189-195.