POLSKIE TOWARZYSTWO MINERALOGICZNE – PRACE SPECJALNE
MINERALOGICAL SOCIETY OF POLAND – SPECIAL PAPERS
Zeszyt 23, 2003; Volume 23, 2003

Sławomir ILNICKI[1], *Thomas M. WILL*[2]

CALCULATED MINERAL EQUILIBRIA IN THE SYSTEM NA_2O-CAO-FEO-MGO-AL_2O_3-SIO_2-H_2O (NCFMASH): PRELIMINARY RESULTS FOR AMPHIBOLITES FROM THE STARA KAMIENICA BELT, THE IZERA-KARKONOSZE BLOCK, WEST SUDETES

INTRODUCTION

One of the principal aims of metamorphic petrology is to decipher the pressure-temperature (PT) conditions experienced by the rocks and to construct relevant PT paths to infer the sequence of tectonometamorphic events within an orogen. Conventionally, this is achieved by applying thermodynamic equations defining geothermobarometers in which chemical compositions of minerals, which constitute equilibrium assemblages, are used. Alternatively, pressures and temperatures of metamorphism are estimated with petrogenetic grids (for a detailed review see Will 1998). Especially those calculated by using internally-consistent thermodynamic data and providing phase diagrams for systems involving solid solutions are of the utmost petrological importance. If phase diagrams are calculated for a given bulk composition of rocks (PT-*pseudosection*) which define PT stability fields of mineral assemblages and compared with petrographic observations, segments or entire PT path may be inferred. This approach is particularly efficient if PT paths are otherwise either difficult or, because of the lack of suitable conventional geothermobarometers, even impossible to obtain.

RESULTS

In the present study the petrogenetic grid of Will et al. (1998) was applied. The pseudosections were generated using the computer program THERMOCALC (Powell and Holland 1988) with the thermodynamic database of Holland and Powell (1990). The selected sample of amphibolite collected near Czerniawa Zdrój (CRK 2a) is composed mainly of Fe-tschermakite, plagioclase (An_{27-39}), quartz, ilmenite and accessory small blasts of garnet, chlorite and epidote. Based on several geothermobarometric calibrations, average temperatures of c. 570-590 ^{0}C at pressures of 8.6 and 8.0 kbar, respectively, were estimated by Ilnicki (2000). In the present study, investigations on the amphibolites were extended to infer the PT path associated with the metamorphic evolution of the amphibolites.

[1] *Warsaw University, Institute of Geochemistry, Mineralogy and Petrology, al. Żwirki i Wigury 93, 02-089 Warszawa, Poland; e-mail: ssi@geo.uw.edu.pl*
[2] *Institut für Mineralogie, Universität Würzburg, Am Hubland, 97047 Würzburg, Germany*

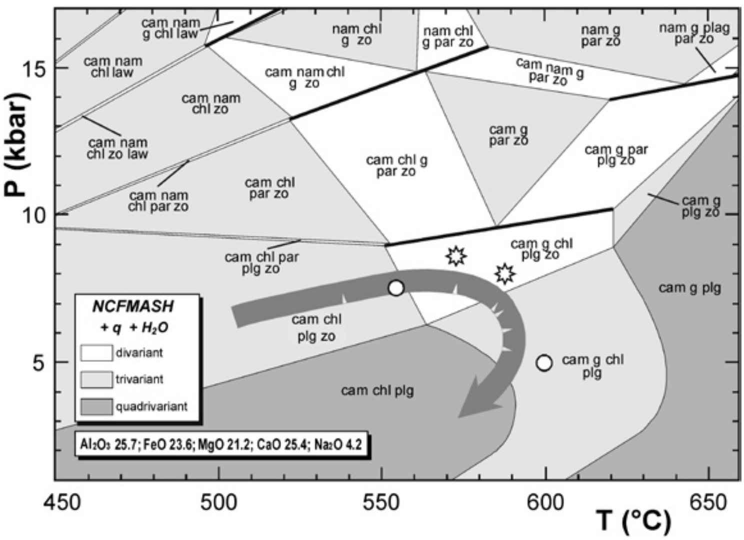

Fig. 1. PT pseudosection calculated for sample CRK 2a of amphibolite from vicinities of Czerniawa Zdrój (the bulk composition is expressed as normalized mole-proportions). The heavy line shows most probable PT path for the sample (this study), stars and circles denote PT conditions of metamorphism obtained from the conventional geothermobarometry for the sample and amphibolites from the Stara Kamienica belt, respectively (Ilnicki, 2000). Abbreviations: cam – Ca-amphibole, chl – chlorite, ga – garnet, law – lawsonite, nam – Na-amphibole, par – pargasite, plg – plagioclase, zo – zoisite/epidote.

The calculated NCFMASH PT pseudosection for sample CRK 2a (Fig. 1) consists of di-, tri- and quadrivariant fields that define stability of mineral assemblages typically occurring in medium-pressure – medium-temperature and high-pressure – medium-temperature metabasites. The fields at pressures below 10 kbar correspond very well to the mineral assemblages found in the studied rock. By contrast, di- and trivariant fields with paragonite and sodic amphibole or even lawsonite and omphacite are irrelevant due to the absence of these minerals in the sample.

Comparing the microscope observations with the calculated pseudosection, the PT path associated with the series of changes that occurred in the rock is inferred. In the starting assemblage cam-plg-chl-zo garnet appeared on entry into the divariant field cam-plg-chl-zo-ga. Epidote/zoisite must have reacted out after entry into the trivariant field cam-plg-ga-chl because the sample is almost free of epidote and its rare and tiny relicts are spatially related to garnet crystals. Most probably the quadrivariant field cam-plg-ga was not entered since small blasts of chlorite are ubiquitous in the sample. Instead, the quadrivariant field cam-plg-chl must have been entered, which led to the predominance of these three minerals and to disappearance of garnet, as indicated by the observed textural relationships in the sample. It is therefore assumed that peak conditions of metamorphism of c. 560-570 ^{0}C at pressures about 8 kbar were followed by slight temperature increase to about c. 590 ^{0}C at pressures of 5-6 kbar and a subsequent decrease towards greenschist facies conditions. The derived PT trajectory is similar to the one for amphibolites of the Stara Kamienica belt (Ilnicki 2000).

CONCLUSIONS

Preliminary though they are, the results presented here show that limitations of conventional geothermobarometry can be successfully circumvented by the phase diagrams approach. In the case of sample CRK 2a, calculation of an appropriate PT pseudosection enabled to infer the metamorphic conditions experienced by this rock and showed that there is no substantial discrepancy with PT path derived for other amphibolites from the Stara Kamienica belt. Undoubtedly, further calculations of mineral isopleths for the rock CRK 2a and phase diagrams modelling for other amphibolites samples will provide valuable tools to investigate the metamorphic evolution of the northern part of the Izera-Karkonosze block.

The scholarship from the German Academic Exchange Service (DAAD) for S.I. is greatly acknowledged. The study was partly financed by the grant from the Faculty of Geology, Warsaw University BW No. BW1567/18.

REFERENCES

HOLLAND T., POWELL R., 1990: An enlarged and updated internally consistent thermodynamic dataset with uncertainties and correlations. J. Metam. Geol. 8, 89-124.

ILNICKI S., 2000: Genesis of amphibole rocks and metabasites from the Stara Kamienica metapelitic belt and from selected adjoining parts of the Izera block (in Polish). Ph. D. thesis manuscript. Warsaw University, 265 p.

POWELL R., HOLLAND T., 1988: An internally consistent thermodynamic dataset with uncertainties and correlations (part 3). J. Metam. Geol. 6, 173-204.

WILL T. M., 1998: Phase Equilibria in Metamorphic Rocks – Thermodynamic Background and Petrological Applications. Lecture Notes in Earth Sciences 71, Springer Verlag, Berlin, Heildelberg, New York, 315 p.

WILL T. M., OKRUSCH M., SCHMÄDICKE E., CHEN G., 1998: Phase relations in the greenschist-blueschist-amphibolite-eclogite facies in the system Na_2O-CaO-FeO-MgO-Al_2O_3-SiO_2-H_2O (NCFMASH), with application to metamorphic rocks from Samos, Greece. Contrib. Mineral. Petrol. 132, 85-102.