Perple_X modeling of kyanite-andalusite gneisses from Thracian lithotectonic unit (Parvenets complex), Bulgaria

Introduction

The varied rocks of the former Parvenets complex (Ivanov et al., 1984) were attributed to different units with a regional extent: the Central Rhodope metamorphic terrain (Ichev, Pristavova, 2004), Thracian lithotectonic unit as part of the Thracian terrain (Sarov, 2012), and Srednogorie Zone (Naydenov et al., 2008). These rocks are affected by the Maritsa dextral strike-slip shear zone, and new structural and geochronological studies suggest a polymetamorphic history of the unit, with a high-grade (Hercynian?) metamorphism followed by greenshists Alpine metamorphic overprint (Naydenov et al., 2008). In this paper we present preliminary results on application of a Perple_X thermodynamic modeling (Connolly, 2009) for well-studied kyanite-andalusite gneisses collected near Hrabrino village, in order to connect the petrographic observation with bulk rock and mineral composition and to give some constrains on P-T evolution of the studied rocks.

Petrography

Previous studies on the kyanite-andalusite gneisses (Ichev, Pristavova, 2004; Naydenov et al., 2008) revealed the presence of two mineral assemblages. The relict association is garnet-kyanite-staurolite-plagioclase-quartz. Garnet is intensively cracked and fragmented, present both in the matrix and as inclusions in the andalusite. Kyanite was described only as inclusions in andalusite. Staurolite forms small prismatic grains orientated along the foliation planes, with a few or no features of replacement. Andalusite-biotite-plagioclase-muscovite-quartz ± chlorite ± K-feldspar is the later superimposed paragenesis (Ichev, Pristavova, 2004; Naydenov et al., 2008). Andalusite was described as syn- to post-kinematic porphyroblasts with inclusions of big garnet fragments and small prismatic kyanite, staurolite, biotite and muscovite, having orientation, which is different from the matrix foliation. According to our observations, the andalusite is clearly deformed and partly replaced. A few muscovite and chlorite flakes have shown clear post-kinematic growth oblique to the foliation. Intense static recrystallization of quartz and plagioclase in the matrix is common feature. The accessory minerals are present by large monazite and zircon grains mainly in the matrix. Andalusite, biotite and chlorite include abundant opaque mineral. In accordance with the previous authors, the two assemblages were formed during different metamorphic events and give clear evidence for the polymetamorphic history of the rocks.

Perple_X modeling

Perple_X model suppose a stable peak mineral assemblage of garnet-kyanite-biotite-white mica-feldspar-quartz-rutile-H2O at temperature from 620 to 685 °C and pressure from 1.25 to 0.7 GPa (Fig. 1). This P-T range corresponds to the maximum presence of kyanite (5.7 vol%), XMg0.24 of garnet (inclusion in andalusite) and plagioclase composition (An 25). This relict peak metamorphic assemblage indicates an upper-amphibolite facies metamorphism, very close to the wet melting reaction (T ~700 °C). The proposed by the previous author’s relict paragenesis of garnet-kyanite-staurolite-plagioclase is stable only in restricted area (T 630–660 °C, P 0.9 to 0.7 GPa, Fig. 1, not shown), hence we suppose that prismatic staurolite formed later, during the retrogression.

Andalusite is stable at moderate temperature (500–710 °C) and low pressure (>0.4 GPa). It was formed together with biotite (XMg0.5) and plagioclase with same the composition (An25), as well as with chlorite.
and white mica. Although the andalusite and garnet stabilities fields partly overlap, for the known garnet composition (XMg0.24), the cordierite is also a stable mineral phase. Hitherto, the cordierite was not identified in these rocks and we suggest that the abundant andalusite formation (max 6.7 vol%) took place under 600 °C. Further analyses of garnet composition will give more evidence for the possible presence of equilibrium garnet-andalusite assemblage. Post-kinematic crystallization of chlorite (max 15.6 vol%) and white mica should be assigned to greenschist facies conditions (under 480 °C).

Conclusions

The applied Perple_X modeling places some constraints on the P-T evolution of the studied rocks. The peak mineral assemblage (garnet-kyanite-biotite-white mica-feldspar-quartz-rutile-H2O) indicates upper-amphibolite facies metamorphism, while staurolite formed during retrograde P-T path. Andalusite crystallized at temperature below 600 °C and the presence of abundant chlorite and white mica points to greenschist facies conditions. By using the thermodynamic modeling, we can partly reconstruct the P-T paths of polymetamorphic rocks, but these preliminary results should be supported with more petrological observations, mineral chemistry and geochronological data.

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References

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