Mineralogical and Geochemical Study of the Contact Aureole of the Sithonia Plutonic Complex, Elia Area, Chalkidiki Peninsula, N. Greece

A. Stamatiadis[1], L. Papadopoulou[1], A. Koroneos[1], T. Soldatos[1]

(1) Department of Mineralogy-Petrology-Economic Geology, School of Geology, Aristotle University of Thessaloniki, Thessaloniki 541 24, Greece, arisstam17@gmail.com

The extensive magmatic activity that took place in the area of northern Greece during the Tertiary is represented by numerous igneous rocks that are found at the regions of the Rhodope Massif, the Serbo-Macedonian Massif and the Circum-Rhodope Belt (Christofides et al., 2001). The Sithonia Plutonic Complex is a part of that magmatic activity and is located at the Sithonia Peninsula, which constitutes the middle “leg” of the “three-legged” Chalkidiki Peninsula. This intrusion occupies the largest part of the Sithonia Peninsula, except for the central-western and the southernmost parts, where the magmatic body intrudes into the rocks of the Serbo-Macedonian Massif and the Circum-Rhodope Belt. It consists of various petrographic types, including granite and granodiorite, but also pegmatite and aplite dykes that interrupt both the magmatic body and the country rocks. This pluton has caused contact aureole phenomena to the country rock of these regions, forming a narrow belt about 100 m width.

At the area of Elia, which is the study area, two-mica granite and leucogranite are found to be in contact with the meta-sediments of the Mellisochori Formation (former Svoula Flysch) that mainly consists of dark phyllites (metapelites) passing upward into calcareous siltstones and (meta-) sandstones, whereas the most common lithology is formed by platy to massive calcareous (meta-) sandstones and minor quartzites (Meinhold et al., 2013). The studied rocks consist of yellowish to brownish calcareous metapsammites with intercalations of grey metapelites.

The metamorphic mineral assemblages are located in sites between metapsammites and metapelites, or inside the former, as lenticular, “boudinage” bodies possibly indicating that the thermal content was transferred from the pluton to the country rocks through a fluid flow mechanism (Fig. 1).

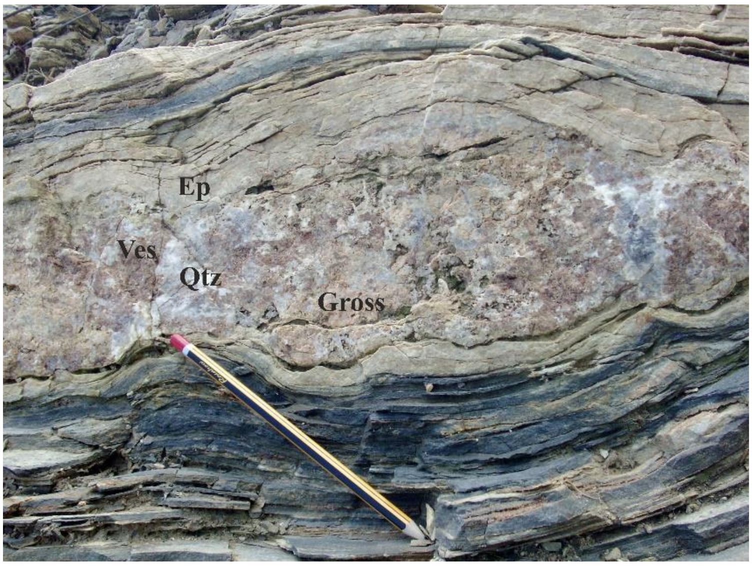

Figure 1. Lenticular body developed among metapsammite layers. Qtz=Quartz, Ves=Vesuvianite, Gross=Grossular, Ep=Epidote.

The mineralogy assemblage consists of quartz, clinozoisite, epidote, garnet, pyroxene, vesuvianite, calcite, titanite and plagioclase, while amphibole, zircon, K-feldspar, apatite, chlorite, biotite, allanite and opaques are also present. Garnet is characterized as grossular, containing an andradite component $[(Ca,Na,Mg)_3(Al,Fe,Mn)_2(Si,Al)_3O_{12}]$ and no obvious chemical difference in composition was recognized from core to rim. Vesuvianite is represented by the chemical formula $[(Ca_{18.8},Na_{0.4},K_{0.1})_{19.2}(Al_{10.1},Fe^{+}_{21.7},Mg_{0.7},Ti_{0.2},Mn_{0.1})_{12.8}Si_{17.9}O_{68}(OH)_{10}]$. It is characterized as high-grade metamorphosed, P4/nnc symmetry vesuvianite and is often found with garnet. Pyroxenes’ composition corresponds to diopside $[En_{27.9}Fs_{22.8}Wo_{49.4}]$, while amphiboles’ composition to ferroedenite. Plagioclase’s composition ranges from andesine to bytownite $[Or_{0\text{-}6.3}Ab_{23.8\text{-}56.6}An_{40.9\text{-}75.8}]$ and K-feldspars are found in small quantity, with composition $[Or_{96.2}Ab_{3.2}An_{0.6}]$. Minerals of the epidote-group, mostly clinozoisite, are present in most parts of the entire contact aureole (Fig. 2).

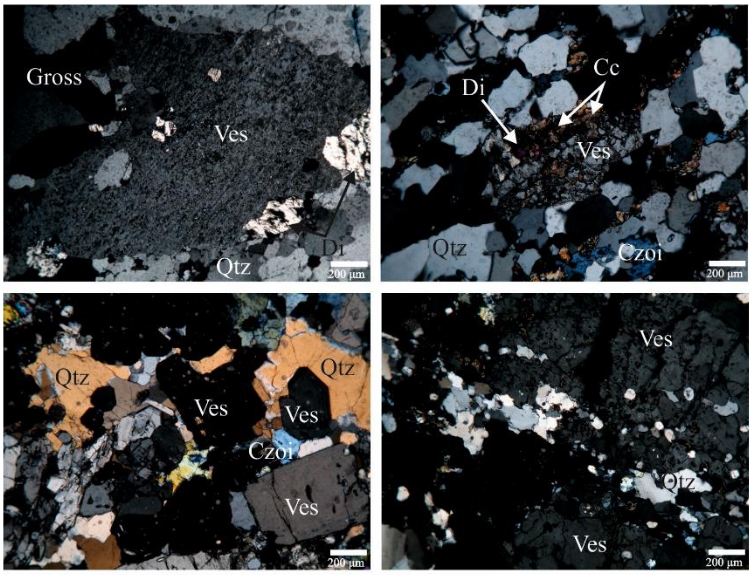

Figure 2. Representative microscopic images of the mineral assemblages (Nicols +). Qtz=Quartz, Ves=Vesuvianite, Gross=Grossular, Czoi=Clinozoisite, Di=Diopside, Cc=Calcite.

According to Kockel et al. (1977) the conditions under which the contact aureole was developed ranged from 500 to 540°C, based on mineral assemblages. The participation of calcsilicate minerals, especially vesuvianite, in the paragenesis of the contact aureole rocks is an indication of fluid-present processes. Another notable observation is the absence of wollastonite, a common calcsilicate mineral in thermal metamorphosed rocks, leading to the assumption that the temperature of the studied paragenesis did not exceed 600ºC which is the critical value for the stability of wollastonite-bearing assemblages (Timon et al. 2007). On the other hand, the vesuvianite-bearing assemblages are stable in temperatures above 480ºC, so a temperature range of 500-600ºC at pressures not exceeding 6 kbar (Trommsdorff 1968, Bogoch et al. 1997), with the participation of H_2O-rich and CO_2-poor fluids as formation conditions could be acceptable. Also, the presence of mineral assemblages at specific sites and the lenticular shape of the metamorphic bodies could reveal the possible pathways of fluids deriving from the magmatic body as well as the places where metamorphic reactions occurred.

In addition, Christofides et al. (2007) have determined for the two-mica granite, which is the plutonic type that intrudes into the studied metamorphic rocks, a crystallization depth of about 15 km, corresponding to a pressure of 4,5 kbar. Such calcsilicate rocks containing vesuvianite, but not wollastonite, are common constituents of many medium-grade contact aureoles. Actually, the observations of this study are in agreement with other studies that deal with the conditions of the Sithonia Plutonic Complex emplacement.

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