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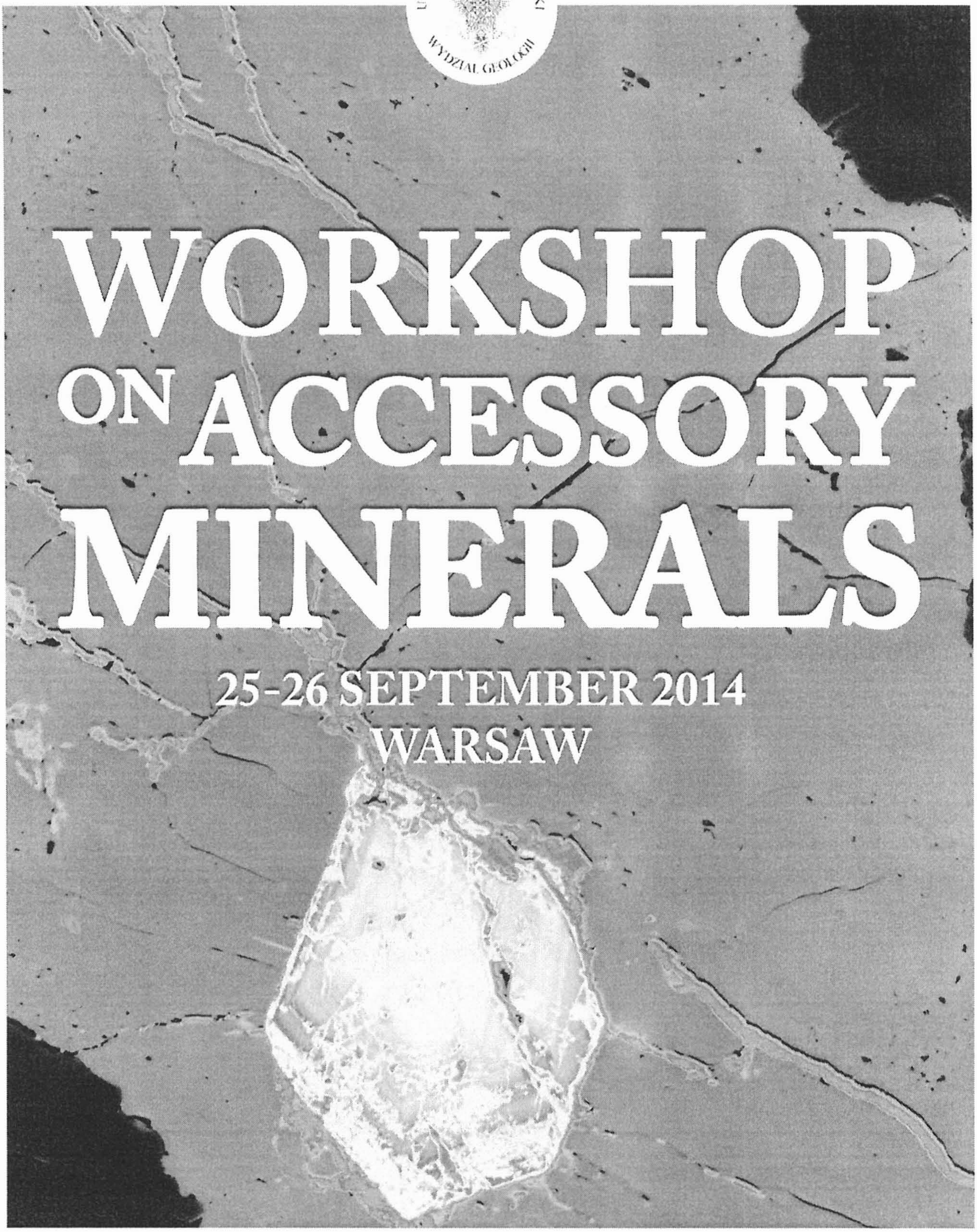

WORKSHOP ON ACCESSORY MINERALS

25-26 SEPTEMBER 2014
WARSAW

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Cover photo: A euhedral, oscillatory zoned, primary monazite has been altered at the rims and along cracks to an allanite-apatite-xenotime assemblage. The host mineral is feldspar. Granite, Strzegom Massif.

Workshop on accessory minerals,
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Chevkinite → allanite reaction relationships in silicic rocks

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Allanite and chevkinite are among the most important REE, particularly LREE, carriers in granitic and related rocks and thus control the main LREE budget in many magmatic systems. In the Neoproterozoic 'A-type' Graciosa Province, S-SE Brazil, and in several similar worldwide magmatic provinces, allanite is the typical LREE-rich primary mineral in metaluminous to marginally peraluminous *subsolvus* biotite syeno- and monzo-granites from the so-called aluminous association. In contrast, primary chevkinite is the only LREE-rich primary phase in *hypersolvus* metaluminous to peralkaline alkali-feldspar syenites and peralkaline alkali-feldspar granites from the alkaline association, which was formed in relatively reduced crystallizing conditions. Post-magmatic, hydrothermal, allanite and other epidote-group minerals appear in both associations.

However, in a number of syenitic and granitic varieties from some plutons both primary allanite and chevkinite do appear. Rock textures indicate that allanite crystallized late and substituted for chevkinite, with chevkinite often appearing partially corroded and mantled by allanite (Figure 1); discrete ilmenite grains occur in allanite mantles, suggesting a peritectic-like reaction relationship such as *chevkinite* + $melt_{(1)}$ → *allanite* + *ilmenite* + $melt_{(2)}$. The structure of a crystal fragment from the Farinha Seca Pluton was refined in C2/m [R_1 = 0.0505 for 775 Fo > 4σ(Fo)] and gave **a** = 13.490(3), **b** = 5.757(1), **c** = 11.132(3) [all in Å], **β** = 100.592(4)°, which agrees well with a typical chevkinite unit cell.

These rocks are characterized by structural and textural features which suggest mingling and local mixing processes involving two contrasting magma types, one silicic and the other basic-intermediate. So, in spite of some previous experimental data suggesting that such reaction may be a normal peritectic in a silicic crystallizing system, in the studied cases the geological evidence points to a reaction triggered by mixing processes which change the silicic melt compositions, introducing, among other elements, Ca, Al and Fe.

Similar reaction relationships were observed in a unique sample of peralkaline alkali-feldspar granite collected close to the Papanduva Pluton contacts with older migmatic-gneissic rocks. In this case, however, there is no evidence of mingling; rock magnetic susceptibilities are anomalously high and both textures and associated minerals (*e.g.*, almost pure albite, fluorite) suggest late- to post-magmatic or hydrothermal substitution.

Total REE contents in chevkinite are higher (*ca.* 48-50 wt% oxide) than in allanite (*ca.* 22-27 wt% oxide) but their REE patterns are similar and highly fractionated, with a high fractionation in the LREE range as well as of the LREE over the HREE (*eg.* 2 < La_N/Nd_N < 5 and Ce_N/Yb_N up to 500) and a strong negative Eu anomaly (0.02 < Eu/Eu* < 0.07). Figure 2 depicts the main gain-loss trends due to the substitution of chevkinite for allanite as determined for an analyzed reaction pair from Sample GRA-16A (Farinha Seca Pluton). This diagram shows that, relative to chevkinite cores, allanite mantles are enriched in Si, Al, Fe, Ca (and OH-F, not shown), as well as in Mn, Mg, LILE (Rb, Sr, Ba), Zn, Sn and Pb; allanite mantles are depleted in Ti and also P, Ga, HFSE (Zr, Hf, Nb, Ta), Mo, REE (especially the HREE, Sc and Y), Th and U. These characteristics may be accounted for by a basic-intermediate input into silicic melts and partial mixing as well as by the interaction of primary chevkinite with relatively Ca-, Al- and Fe-rich late- to post-magmatic fluids.

In silicic systems, allanite is a stable mineral in magmatic and hydrothermal environments, so it may substitute for chevkinite in both situations, depending only on the composition of the reference system, including (OH) activity. It is difficult to precisely evaluate the fO_2 effect, but it is suspected that allanite is favored by relatively high oxidizing conditions.

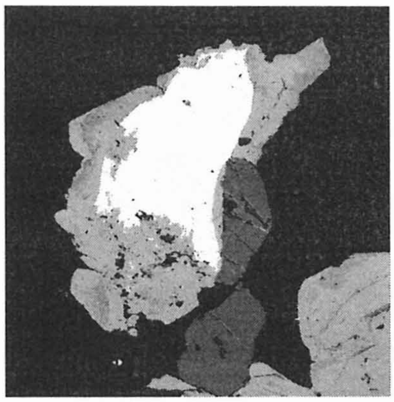

Fig. 1. BSE image showing a typical mantle texture involving chevkinite and allanite. Sample 16A, syenite, Farinha Seca Pluton, Graciosa Province.

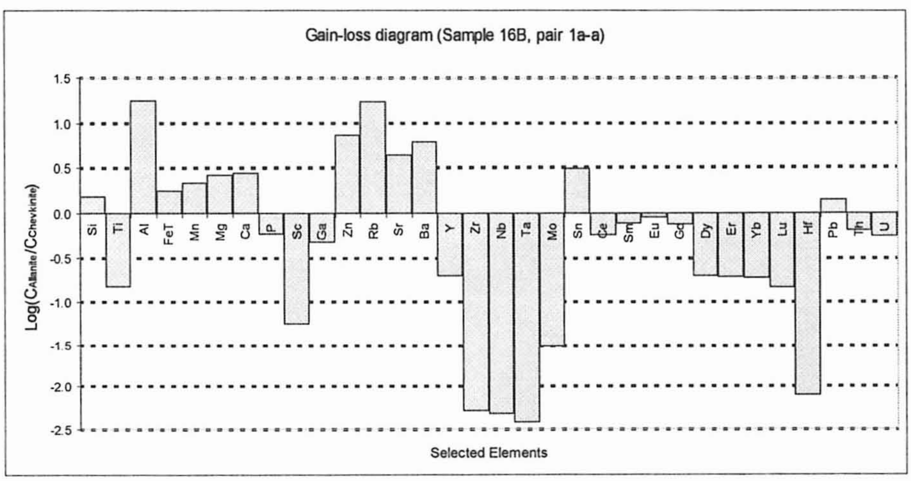

Fig. 2. Elemental budget due to the substitution of chevkinite for allanite (EPMA and LA-ICPMS data). Sample GRA-16B, syenite, Farinha Seca Pluton, Graciosa Province.