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Tourmaline Composition of the Kışladağ Au Deposit, Uşak, Turkey

Gülcan BOZKAYA[1], Nurullah HANILÇI[2], Ivan A. BAKSHEEV[3], Vsevolod Yu. PROKOFIEV[3,4], David A. BANKS[5]

1 *Pamukkale University, Department of Geological Engineering, 20020 Denizli, TURKEY;*
2 *Istanbul University, Department of Geological Engineering, 34320 Istanbul, TURKEY;nurullah@istanbul.edu.tr;*
3 *Geology Department, Moscow State University, Moscow, Russia;*
4 *Institute of Geology of Ore Deposits, Petrography, Mineralogy, and Geochemistry, Russian Academy of Sciences, Moscow, 119017 Russia;*
5 *School of Earth and Environment, University of Leeds, Woodhouse Lane, Leeds LS2 9JT, United Kingdom*

The Kışladag Au deposit is classified as porphyry-type (Juars et al., 2010), and is located approximately 55 km southwest of Uşak, in western Turkey. Early to Late Tertiary volcanic complexes comprises the Elmadağ, İtecektepe and Beydağı stratovolcanoes around the Uşak region, due to the extensional tectonic regime in western Anatolia (Karaoğlu and Helvacı, 2012). The Kışladağ porphyry-Au deposit is related to intrusive and sub-volcanic rocks of the Beydağı volcanic complex composed of domes and intrusive bodies including andesite, latites, trachytes, dacites, ryhodacites and rare basalts (Karaoğlu and Helvacı, 2012). The Beydağı volcanics are dated at 12.15 Ma (Karaoğlu et al. 2010) and 13.1 Ma (Seyitoğlu, 1997).

The main lithologies of the Kışladağ Au deposit area are quartz-trachyte to quartz-latite flows and volcanoclastic rocks intruded by a series of nested subvolcanic porphyritic intrusives of alkali affinity (Juars et.al. 2010). Mineralization is related to two different stages of sub-volcanic intrusives of quartz-syenite to quartz-monzonite composition.

Gold mineralization includes traces of Mo, Zn, Pb and Cu. Gold is associated with four phases of partially overlapping stockwork veins and brecciation. These are intense quartz-tourmaline stockwork veining, hydrothermal breccias (±gold), multiple phases of quartz-pyrite veining with gold, and late sulfide rich quartz veining with traces of molybdenite, sphalerite, galena and tetrahedrite (± gold) (Juars et.al. 2010).

Argillic alteration is represented by alunite overprinting tourmaline and the occurrence of mixed-layer chlorite-smectite (corrensite) replacing mafic minerals (e.g., amphibole, biotite). Potassic alteration is characterized by the occurrence of fine-grained biotite and K-feldspar in the plutonic body referred to as the advanced alteration stage for porphyry copper gold deposits.

Tourmaline occurs as radial aggregates of small crystals (up to 50 μm in length and up to 10 μm across). Four generations of tourmaline were established. Tourmaline I occurs as the largest crystals; tourmaline II overgrows tourmaline I and forms isolated crystals and aggregates; tourmaline III is observed as rims on earlier crystals of tourmaline II; and tourmaline IV forms rims on tourmaline III. The first-generation is enriched in Ca (0.3-0.4 apfu) and in Fe^{3+} as indicated by the Fe^{3+}/Fe_{tot} value (ca. 60%) calculated from charge balance constraints. The small size of the grains impedes the use of Mössbauer spectroscopy. This tourmaline is characterized by the greatest $Fe_{tot}/(Fe_{tot}+Mg)$ value 0.5-0.6 amongst all the tourmaline generations studied here. The second generation of tourmaline is also enriched in Ca (0.3-0.5 apfu), but it is characterized by much lower Fe^{3+} (calculated Fe^{3+}/Fe_{tot} value is ca. 10%). The $Fe_{tot}/(Fe_{tot}+Mg)$ value in this tourmaline is also lower ranging from 0 to 0.4. Tourmaline III is similar in composition to tourmaline II. The fourth generation of tourmaline is depleted in Ca (0.1-0.2 apfu) and is characterized by the lowest $Fe_{tot}/(Fe_{tot}+Mg)$ value of the tourmaline generations studied here (ca. 0.1). The calculated Fe^{3+}/Fe_{tot} value ranges from 0 to 20%. This tourmaline is distinguished by the highest proportion of *X*-site vacancy (ca. 0.6). According to the available data and the classification of Henry et al. (2011) tourmaline I is classified as a Ca-rich and Fe^{3+}-rich dravite, although if Mössbauer spectroscopy were possible this might change to oxy-dravite; tourmalines II and III are classified as Ca-rich dravite; tourmaline IV is referred to as a magnesio-foitite. Thus, the data obtained indicate that tourmaline evolves from dravite (or oxy-dravite) to magnesio-foitite. The trend differs from other trends typical of tourmalines

* Corresponding author. E-mail: gbozkaya@pau.edu.tr

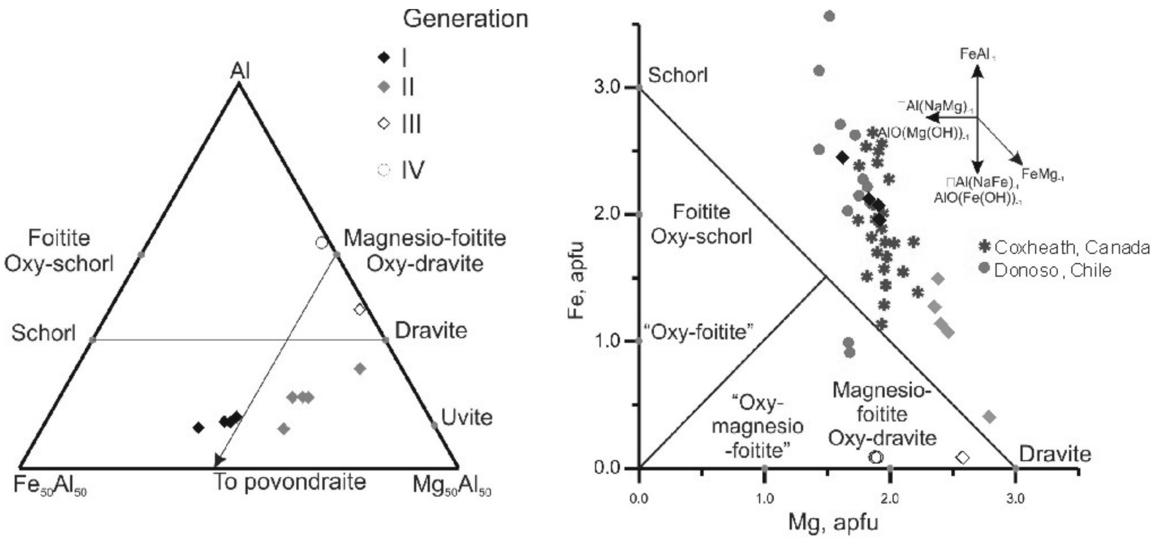

Fig. 1. An Fe-Al-Mg ternary and Fe_{tot} versus Mg plots for tourmaline data of Kışladağ gold deposit, Coxheath (Canada) and Donoso (Chile) porphyry-Cu deposits.

from porphyry-style deposits (Baksheev et al., 2012) (Fig. 1).

Thus the evolution trend of the Kışladağ deposit differs from that of typical porphyry deposits. The likelihood is that the Kışladağ deposit experienced a different evolutionary process to other porphyry systems. Even though the evolution trend of the Kışladağ deposit differs from that of typical porphyry deposits, the Fe_{tot} versus Mg plots of Kışladağ tourmalines overlap on the data of Coxheath porphyry Cu-Mo-Au and the Donoso porphyry Cu deposits. This overlap indicates that the initial tourmaline chemstry evolved as other deposits and can be valid as an exploration tool for porpyhry type deposits. The departure from the expected trend occurred during the 3rd and 4th generations of tourmaline deposition and further work will determine the processes responsible and what if any significance this has for Au-mineralisation.

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