Geophysical Research Abstracts
Vol. 17, EGU2015-12659, 2015
EGU General Assembly 2015

New observations on the Ni-Co ores of the southern Arburese Variscan district (SW Sardinia, Italy)

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Among the European Variscan regions, the Arburese district, located in the Paleozoic basement of SW Sardinia (Italy) is remarkable for its metallogenic complexity, and offers good opportunities to investigate time/space and genetic links between post-collisional Variscan intrusive magmatism and mineral deposits. The district hosts a large variety of mineral deposits and occurrences, which include the Pb-Zn (Cu, Ag) mesothermal veins of the Montevecchio Lode System, one of the largest and richest Variscan hydrothermal ore deposit of Europe, now exhausted. Ore deposits are genetically related to the emplacement of the Late Variscan (304$\pm$1 Ma) Arbus Pluton, a granitoid composite intrusion ranging from monzogabbroic to granodioritic and to peraluminous leucogranitic rock-types. After more than a century of geological studies in the area, several metallogenic issues are still unresolved; among them, the occurrence in the southern sectors of little known polymetallic Ni-Co-(Pb-Zn-Cu-Ag-Bi) veins, a kind of mineralization quite unusual for the Sardinian basement. These hydrothermal deposits are hosted by very low-grade metamorphic rocks at short distance from the intrusion, where contact effect generate also hornfels. Spatial, structural and textural characters of the hydrothermal system are coherent and in apparent continuity with those of the Montevecchio Lode System. Ni-Co ores are hosted by a system of parallel, 1-2 m thick high-angle veins that discontinuously follow the southwestern and southern contacts of the Arbus Pluton for about 7 km. They constantly dip SSW, sideways with respect to the pluton contact, and show a prevalence of fracture infilling (banded and brecciated) textures, with alternating quartz and siderite bands, cockades and frequent inclusions of wallrock fragments. Wallrocks are usually silicified, bleached and/or sericitized. Systematic studies of ore textures and parageneses from different veins along the system have been performed by standard ore microscopy and SEM-EDS. Ore minerals associations include Ni-Co (Fe, Sb) arsenides/sulfoarsenides (nickeline, rammelsbergite, skutterudite, safflorite, gersdorffite, breithauptite, lollingite, cobaltite), Pb-Zn-Cu-Ag-Bi sulfides (galena, sphalerite, chalcopyrite, tetrahedrite/freibergite, bismuthinite, proustite/pyrargirite, stephanite), native Bi and native Ag. Ore textures and mineral phases relationships allow to envisage the following paragenetic sequence: 1) deposition of quartz (I) and a Ni monoarsenide (nickeline), and antimonide (breithauptite) followed by 2) Ni-,Ni-Co, Co- and Fe- di-, tri-arsenides and sulfoarsenides (rammelsbergite, skutterudite, safflorite, löllingite, cobaltite), with bismuthinite and native Bi; 3) deposition of abundant siderite, with quartz (II), Pb-Zn-Cu-Ag sulfides and sulfosalts and rare native Ag, followed at last by 4) calcite. This sequence depicts a polyphased evolution with alternating gradual and abrupt changes of the physicochemical parameters of a mesothermal fluid initially characterized by Ni-As-(Sb) contents, subsequently evolved to higher contents of As, Co and Bi, and, finally, enriched in S, allowing Pb, Zn, Cu deposition as sulfides and sulfosalts.Thus, the fine alternating rims of pure nickeline (NiAs) and breithauptite (NiSb) in nickeline individuals, detected by SEM-EDS, may be explained by repeated compositional re-equilibrations due to variable As and Sb contents of the fluids; increases in As, and, moreover, the sudden appearance of siderite and sulfides after brecciations indicate further re-opening of the system, related to hydrothermal fracturing and syn-depositional tectonics.