COMUNICACIONES Nº 50 (1999): 43-47

GEOCHEMISTRY OF GOLD GRAINS IN THE CERRO CASALE PORPHYRY GOLD DEPOSIT, MARICUNGA BELT, NORTHERN CHILE

C.PALACIOS[(1)], G.HERAIL[(2)], P.RIVAS[(1)], F.SEPULVEDA[(1)], B.TOWNLEY[(1)], V.MAKSAEV[(1)], A.LAHSEN[(1)] AND M. PARADA[(1)]

[(1)] Dept. of Geology Univ. Chile. P.O. Box 13518 Correo 21. Santiago-Chile.
[(2)] IRD, 209-213 Rue La Fayette, 75480 Paris Cedex 10, France

***KEY WORDS:** Geochemistry, gold grains, porphyry gold, northern Chile*

INTRODUCTION

Gold crystals from Cerro Casale gold porphyry were analyzed by electron microprobe to study their compositional variations within the deposit and relate them to the alteration/mineralization processes.

The middle Miocene gold Porphyry at Cerro Casale in the southernmost Maricunga belt, northern Chile (Sillitoe et al., 1991), consists of altered/mineralized sub-volcanic gronodioritic and dioritic stocks, and igneous/hydrothermal breccia complexes hosted by Miocene volcanics (Fig. 1). The orebody is columnar with a roughly circular section of 500 m in diameter and a vertical extent of >1,000 m, amounting 800 Mt at about 1 g/t Au and 0.15 to 0.30% Cu (geological resource of 20 MOz Au). The intrusive rocks include an early coarse-grained hornblende granodioritic porphyry and a late fine-grained microdioritic prophyry. Igneous and hydrothermal brecciation is widespread above the roof of the microdioritic porphyry and along the contacts with the early granodioritic porphyry, extending to the present-day surface (Rivas, 1999; Fig. 1).

A central K-silicate altered core at depth is surrounded by a chlorite-sericite hypogene alteration zone and both are associated with gold mineralization that occur as native metal in fine particles (5 to 20 μm) mainly within quartz grains (Sepúlveda, 1999). The early K-silicate alteration assemblage consists of biotite, K-feldspar, magnetite, hematite, quartz, anhydrite, and gold. A widespread stockwork of quartz veinlets with magnetite, hematite and gold is associated with the K-silicate core. Fluid inclusions in quartz from these veinlets reveal homogenization temperatures of about 500ºC and salinities from 40 to 50% Na Cl equivalent. The peripheral chlorite-sericite assemblage overprints the earlier K-silicate alteration and it is characterized by veinlets and dissemination of quartz, sericite, chlorite, pyrite, chalcopyrite, and gold. Fluid inclusions in quartz from this late alteration show homogenization temperatures from 200º to 260ªC and salinities from 6 to 15% NaCl equivalent. Intrusive and early hydrothermal vertical breccia pipes occur in the central part of the deposit, these include angular fragments of mineralized porphyries with a matrix dominated by the K-silicate alteration mineral assemblage. Late mineralized hydrothermal breccias occur in the highest section of the orebody, the late breccias include angular porphyry fragments within a matrix of sericite, quartz, chlorite, tourmaline, chalcopyrite, pyrite, and gold.

SAMPLING AND ANALYTICAL TECHNIQUE

The samples analyzed for this study (110 samples) were collected from diamond drill cores at different depths, in the porphyries and hydrothermal breccias. Analyzed gold grains correspond to those occurring within quartz in K silicate quartz stockwork, and in chlorite-sericite veinlets and matrix of hydrothermal breccias. Electron microprobe analyses for this study were performed on native Au using a CAMECA instrument with a Tracor Northern operating system at the University of Tolouse, France. A total of 6 elements were analyzed using wavelength dispersive spectrometry (WDS): Fe, Cu, As, Ag, Au and Bi. For most runs an accelerating voltage of 20 kV was used, with a beam current of 25 to 30 nμA and a spot size of about 2 μm. For all precious metal analyses a ZAF correction program was used, with pure metal standards. Counting time was 20 seconds on standards and 30 seconds on unknowns. All analyzed samples were observed using back-scattered electron imaging (BEI); significant compositional zoning was not found in native Au, as indicated by BEI and chemical analysis.

RESULTS

The geochemical study of the gold crystals in the Cerro Casale ore deposit, allows to outline the following results:

1. Ag and Cu are the elements that exhibit the main variation within gold crystals, in relation to the lithology and hydrothermal alteration (Figs. 2 and 3).
2. The gold crystals related to **K silicate alteration** present high abundances in Ag (8 to 28 wt.%) and low concentrations in Cu (0 to 0.24 wt.%). However, the composition of gold crystals deposited during the early stage of the hydrothermal activity differs in the granodioritic and microdioritic porphyries:
    i) Gold crystals recovered from the microdioritic porphyry present the higher abundances in Ag (17 to 28 wt.%) and the lowest concentrations in Cu (0 to 0.07 wt.%).
    ii) Gold crystals recovered from the granodioritic porphyry exhibit between 7 to 17 wt.% Ag and 0 to 0.24 wt.% Cu.

This patterns suggest that the K silicate precious metal mineralization occurs together with the intrusion of the microdioritic porphyry, and indicate a geochemical zonation in the composition of gold crystals.

3) The gold crystals deposited during the **chlorite-sericite alteration** evidence low concentrations in Ag (1 to 9 wt.%) and relatively high abundances in Cu (0.06 to 0.34 wt.%).
4) The gold crystals recovered from fragments of both porphyries included in the chlorite-sericite hydrothermal breccia maintain their original composition, evidencing that:
    i) during the retrograde alteration the K silicate gold was not dissolved and re-transported as has been modeled by Gammons and Williams-Jones (1997), and
    ii) the fluids that produced the chlorite-sericite alteration themselves carried a second input of gold.

ACKNOWLEDGMENTS

This study was supported by the Grant FONDEF 1033 from CONICYT, Chile.

REFERENCES

Gammons, C.H. and Williams-Jones, A.E. 1997. Chemical mobility of gold in the porphyry-epithermal environment. Econ. Geol., 92, 45-58.

Rivas, P. 1999. Geoquímica de cristales de oro del depósito Cerro Casale, Franja Maricunga, norte de Chile. Thesis. Department of Geology. Univ. of Chile. 100 p.

Sepúlveda, F. 1999. Control de variables intensivas y termodinámicas de los fluidos hidrotermales en la composición química del oro en el pórfido Cerro Casale, Norte de Chile. MSc Thesis. Department of Geology. Univ. of Chile. 118 p.

Sillitoe, R.H., McKee, E.H. and Vila, T. (1991). Reconnaissance K-Ar Geochronology of the Maricunga Gold-Silver Belt, Northern Chile. Econ. Geol., 86, 1261-1270.

Figure 1. Geologic cross section of the Cerro Casale porphyry gold deposit.

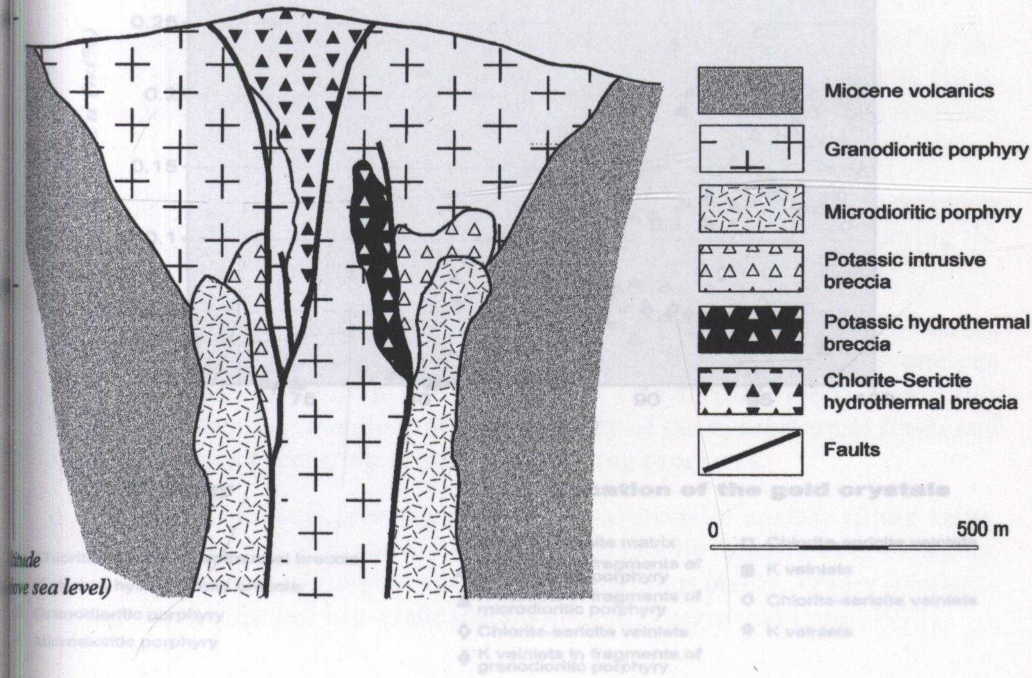

Figure 2. Ag concentrations in gold crystals

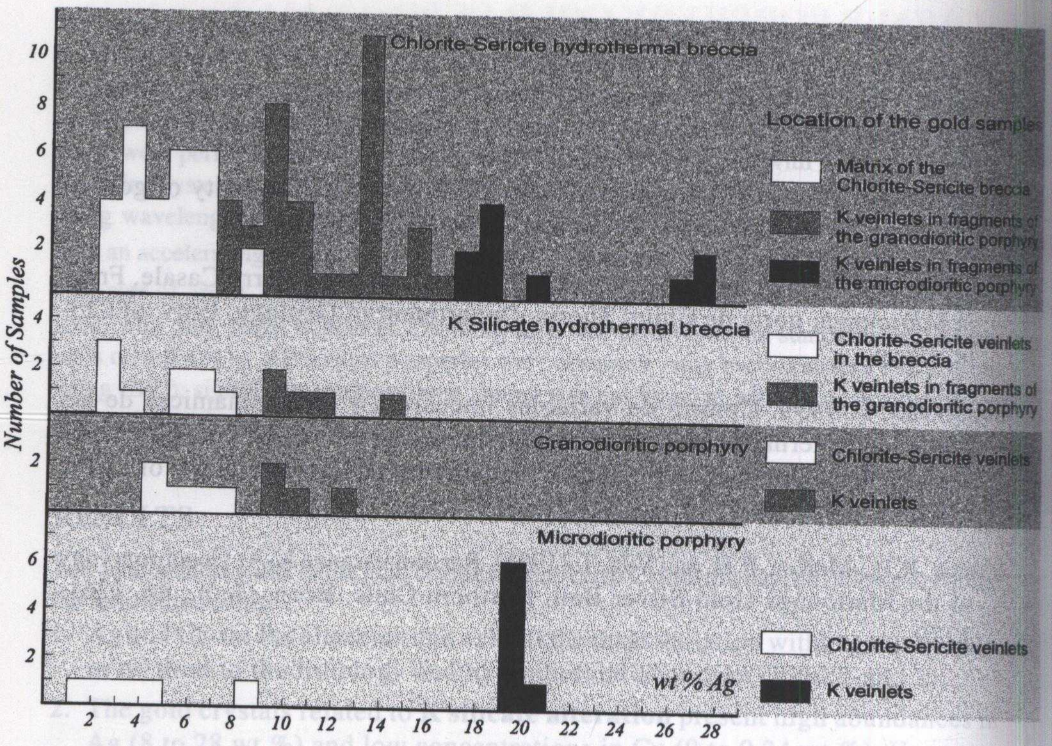

Figure 3. Cu-Ag and Cu-Au digrams