Economic Geology, v. 101, pp. 281–310

Geology, Geochronology, and Hf and Pb Isotope Data of the Raúl-Condestable Iron Oxide-Copper-Gold Deposit, Central Coast of Peru

ANTOINE DE HALLER,[†,*]

University of Geneva, Mineralogy Department, rue des Maraîchers 13, CH-1205 Genève, Switzerland

FERNANDO CORFU,

University of Oslo, Department of Geosciences, Postbox 1047 Blindern N-0316 Oslo, Norway

LLUÍS FONTBOTÉ, URS SCHALTEGGER,

University of Geneva, Mineralogy Department, rue des Maraîchers 13, CH-1205 Genève, Switzerland

FERNANDO BARRA,

Department of Geociences, University of Arizona, Tucson, Arizona 85721, and Instituto de Geología Económica Aplicada, Universidad de Concepción, Concepción, Chile

MASSIMO CHIARADIA,

University of Geneva, Mineralogy Department, rue des Maraîchers 13, CH-1205 Genève, Switzerland

MARTIN FRANK,[**]

Institute for Isotope Geology and Mineral Resources, Department of Earth Sciences, ETHZ, NO F51.3, Sonneggstrasse 5, CH-8092 Zürich, Switzerland

AND JULIO ZÚÑIGA ALVARADO

Cía. Minera Condestable S.A., Calle Manuel Roaud y Paz Soldán 364, San Isidro, Lima 27, Peru

Abstract

Raúl-Condestable is a >32 million metric ton (Mt) iron oxide-copper-gold (IOCG) deposit located on the Peruvian coast, 90 km south of Lima. The ore occurs as veins, replacement "mantos," and disseminations consisting of a chalcopyrite-pyrite-pyrrhotite-magnetite-amphibole mineral association. The geology of the studied area comprises a series of superposed volcanic edifices of Late Jurassic to Early Cretaceous age, which are part of a larger volcanic island to continental arc system. Particularly good exposures of the tilted host sequence allow the mapping of the Raúl-Condestable IOCG deposit in a nearly complete oblique cross section, from its associated volcanic edifice down to a paleodepth of about 6 km.

U-Pb zircon ages indicate that in the deposit area felsic magmatic activity took place between 116.7 ± 0.4 and 114.5 ± 1 Ma, defining a new Raúl-Condestable superunit, the oldest so far, of the Peruvian Coastal batholith. This superunit is located west of the main part of the batholith and includes a dacite-andesite volcanic dome and a subvolcanic quartz-diorite porphyry sill-dike complex that were emplaced at 116.7 ± 0.4 and 116.4 ±0.3 Ma, respectively, followed by tonalite stocks and dikes emplaced between 115.1 ± 0.4 and 114.5 ± 1 Ma. All these rocks contain hornblende and/or biotite but no pyroxene and correspond to silica- and water-rich magmas following a calcic differentiation trend. Hf isotope data on zircons (ε_{Hf}(115 Ma) = 5.2–7.5) and Pb isotope data on whole rock, combined with lithogeochemical results, suggest that magmas were generated by partial melting of the upper mantle, enriched through hydrous metasomatism and/or melting of subducted pelagic sediments. The lack of zircon inheritance suggests that there was no direct involvement of continental crust.

The Raúl-Condestable IOCG deposit is connected in space and time with the magmatism of the Raúl-Condestable superunit. The mineralization was emplaced in the core of the dacite-andesite volcanic dome at a paleodepth of 2 to 3 km, surrounding two tonalitic intrusions formed at 115.1 ± 0.4 and 114.8 ± 0.4 Ma. The U-Pb age of hydrothermal titanite from IOCG veins at 115.2 ± 0.3 Ma indicates that the mineralization was coeval with (or more probably just followed) the emplacement of the tonalites. Re-Os geochronology on molybdenite did not yield reliable ages due to apparent Re loss. Copper ore is associated with a zoned alteration pattern, which surrounds the tonalite intrusions. It consists of a core of biotite alteration and quartz stockwork,

[†] Corresponding author: email, antoine.dehaller@terre.unige.ch

[*] The digital Appendix is available at <http://segweb.org/EG/papers/Abs 101-2_files/deHallerAppendix.pdf>.

[**] Present address: IfM-GEOMAR, Leibniz Institute for Marine Sciences at the University of Kiel, Wischhofstrasse 1-3, 24148 Kiel, Germany.

grading outward to actinolite (±magnetite, ±chlorite, ±titanite, ±scapolite, ±albite, ±epidote) and upward to sericite + Fe chlorite alteration. An upper distal alteration halo consisting of hematite-chlorite surrounds the sericite + Fe chlorite and actinolite alterations laterally. Most of the ore is spatially associated with the actinolite alteration and, to a lesser extent, with the sericite + Fe chlorite alteration.

The results of this study confirm that the 110 to 120 Ma age range was a productive time period for Andean IOCG deposits. The characterization of the hydrous intermediate magmatism related to the mineralization, as well as the subvolcanic position of the deposit and its related alteration pattern provides further criteria that may be used when exploring for IOCG deposits in a convergent plate tectonic setting.