

# Ore Deposits of the Andes: A Compilation 1919–2011

Search

SEG Compilations Volume 6

Preface

Volcanogenic Massive Sulfide (VMS) Deposits

Epithermal Deposits

Regional Metallogeny

Polymetallic Ag-Sn-W Deposits

Porphyry Breccia Pipe Manto Deposits

Misc. Deposits

Skarn Deposits

Iron Oxide Copper-Gold (IOCG) Deposits

Sedimentary Base Metal Deposits

[www.segweb.org/store](http://www.segweb.org/store)

© 2012 Society of Economic Geologists, Inc.



[www.segweb.org](http://www.segweb.org)

## Ore Deposits of the Andes: Preface

Thomas Felts, Department of Geological Sciences, University of Colorado, Boulder, CO  
80309, USA

Stuart F. Simmons, Hot Solutions Ltd, PO Box 32-125, Devonport, Auckland 0744, New  
Zealand

&

Richard J. Goldfarb, USGS, Box 25046, MS973, Denver Federal Center, Denver, CO 80225,  
USA

The precious and base metal endowment of the Andes is enormous, hosting some of the largest hydrothermal copper, gold, and silver deposits in the world. The styles of mineralization are diverse, although porphyry Cu (Mo-Au), epithermal Au-Ag, and iron oxide copper-gold (IOCG) predominate. New discoveries are sustaining intense exploration activity throughout the region. This Society of Economic Geologists Compilation contains more than 100 years of classic papers on ore deposits of the Andes, from 1905 to 2010. These include the manuscripts published in *Economic Geology*, Special Publications, Economic Geology Monographs, SEG Newsletters, and *Economic Geology 100<sup>th</sup> Anniversary Volume*.

The compilation is divided into nine sections reflecting eight different sub-types of ore mineralization and one section on regional metallogeny. Given their prominence in the region, it is not surprising that the majority of papers are on porphyry Cu (Mo-Au) deposits, including breccia pipes and mantos. Among the classic papers are those describing Agua Rica, Bajo de la Alumbrera, Los Bronces-Rio Blancos, Chuquicamata, Collahuasi, Escondida, El Teniente, Los Pelambres, Potrerillos, and Rado Tomic, representing some of the largest and most important copper deposits in the world. Listed by country, the porphyry papers included in the compilation are as follows:

### *Argentina*

Agua Rica: Landtwing et al., 2002

Bajo de Alumbrera: Ulrich and Heinrich, 2001; Ulrich et al., 2001, 2002; Proffett, 2003;  
Harris et al., 2006

### *Chile*

Andacollo: Reyes, 1991; Oyarzun et al., 1996

Cerro Colorado: Bouzari and Clark, 2002; 2006

Chuquicamata: Lopez, 1939; Jarrell, 1944; Sillitoe et al., 1996; McInnes et al., 1999;  
Tomlinson et al., 2001; McInnes et al., 2001; Rivera and Pardo, 2004; Campbell et al.,  
2006; Rivera et al., 2009

Collahuasi: Hunt, 1985; Dick et al., 1994; Masterman et al., 2004; 2005

El Abra: Campbell et al., 2006

El Salvador: Gustafson and Hunt, 1975; Field and Gustafson, 1976; Sheppard and Gustafson, 1976; Gustafson and Quiroga, 1995; Mote et al., 2001; Gustafson et al., 2001, Watanabe and Hedenquist, 2001; Bissig and Riquelme, 2009  
El Teniente: Lindgren and Edson, 1922; Clark et al., 1983; Skewes et al., 2002; Maksaev et al., 2004; Stern et al., 2007; Vry et al., 2010  
Escondida: Lowell, 1991; Richards et al., 1999; Richards et al., 2001; Padilla Garza et al., 2001; Padilla Garza et al., 2004  
Esperanza: Perello et al., 2004  
La Fortuna: Perello et al., 1996  
Los Bronces-Rio Blanco: Warnaars et al., 1985; Serrano et al., 1996; Vargas, 1999; Davidson and Kamenetsky, 2001; Davidson et al., 2005; Deckart et al., 2005; Frikken et al., 2005; Irarrazaval et al., 2010  
Pelambres: Sillitoe, 1973; Atkinson, 1996  
Potrerillos: Marsh et al., 1997; Bissig and Riquelme, 2009  
Radomiro Tomic: Patricio and Gonzalo, 2001; Brimhall et al., 2001; Acuri and Brimhall, 2003  
Toki: Rivera and Pardo, 2004

#### *Colombia*

La Colosa (Columbia): Lodder et al., 2010

#### *Peru*

La Granja (Peru): Schwartz, 1982

Morococha (Peru): Nagell, 1957, 1960; Eyzaguirre et al. 1975

Toquepala (Peru): Laughlin et al., 1968; Clark, 1990; Clark et al., 1990

---

The next section, on polymetallic-Ag-Sn-W deposits, reflects the diverse metal inventories of hydrothermal deposits occurring mainly in Peru and Bolivia. The important deposits comprise Casapalca (McKinstry and Noble, 1932; Rye and Sawkins, 1974), Cerro de Pasco (Graton and Bowditch, 1936; Kruger and Lacy, 1949; Johnson, 1955; Ward, 1961; Einaudi, 1977; Baumgartner et al., 2008, 2009), Cerro Rico (Bartos, 2000; Rice et al. 2005), Colquijirca (Lindgren, 1935; McKinstry, 1936; Vidal and Ligarda, 2004; Bendezu and Fontbote, 2009), Julcani (Goodell and Petersen, 1974; Scherckenbach and Noble, 1984; Shelnutt and Noble, 1985; Lueth et al., 1990; Deen et al., 1994), Llallagua (Ahfeld, 1931, 1936; Turneure, 1935a & b), and Pasto Bueno (Landis and Rye, 1974, 1975; Hollister et al., 1975; Norman and Landis, 1983). Cerro Rico, which is the largest silver deposit in the world, as well as Colquijirca, Cerro de Pasco, and Julcani share similarities with high sulfidation epithermal mineralization, but their metallogenic signature warrants a distinct grouping.

The important deposits of the epithermal section are mainly high sulfidation deposits, occurring in Peru, Chile, and Argentina. The principal deposits are El Indio-Pascua Lama (Jannas et al., 1999; Bissig et al., 2002; Deyell et al., 2004; Chouinard et al., 2005), La Coipa (Oviedo et al., 1990), Veladero (Charchafle et al., 2007), and Yanacocha (Gustafson et al.,

2004; Mallette et al., 2004; Teal and Benavides, 2010; Longo et al., 2010). Jeronimo, also known as Hueso, is listed in the porphyry deposits section (Thompson et al., 2004; Bissig and Riquelme, 2009). The two notable intermediate to low sulfidation epithermal deposits are El Peñón (Warren et al., 2004, 2008) and Esquel (Sillitoe et al., 2002; Soechting et al., 2008).

The IOCG deposits are found mainly in Chile, where there has been much debate regarding the origin of the El Laco magnetite deposit (Park, 1961; Frutos and Oyarzun, 1975; Rhodes et al., 1999; Rhodes and Oreskes, 1999; Sillitoe and Burrows, 2002, 2003; Henriquez et al., 2003). Candelaria (Marschik and Fontbote, 1996, 2001; Arevalo et al. 2006), Mantoverde (Vila et al., 1996; Benavides et al., 2007; Rieger et al., 2010), Mina Justa (in Peru), and Rau-Condostable (de Haller et al., 2006; de Haller and Fontbote, 2009; Chen et al., 2010), however, are the major deposits of this section.

The last four sections on specific ore deposit type cover skarns, sedimentary rock-hosted base-metal deposits, volcanic massive sulfide deposits, and other miscellaneous deposits (e.g., diamonds, fluorite, nitrates, iron ore, platinum group elements, orogenic gold, placer gold). Among the skarns, Antamina (Mckee et al., 1979; Love et al., 2004) and Tintaya (Maher, 2010) are important; Aguilar (Spencer, 1950; Gemmell et al., 1992) is a sedex deposit overprinted by contact metamorphism; and Haerberlin et al. (2004) discuss the orogenic gold deposits of the Eastern Cordillera of Peru in the miscellaneous grouping.

The last section contains papers on regional metallogeny in the Andes, featuring several overview papers on ore deposits, magmatism, and tectonics (Kay et al., 1999; Petersen, 1999; Sillitoe, 2004; Sillitoe and Perello, 2005). Other papers deal with isotopic constraints (Kontak et al., 1987, 1990; Gunnesch et al., 1990; Mukasa et al., 1990; Macfarlane et al., 1990; Sillitoe et al., 1991; Kamenov et al., 2002; Chiardia and Paladines, 2004). Lastly, there are the mineral provinces and belts occurring in Bolivia (Turneaure and Welker, 1947; Kelly and Turneaure; 1970; Turneaure, 1971; Arce-Burgoa and Goldfarb, 2009), Chile (Fuller and Ericksen, 1962; Sillitoe, 1991; Espinoza et al., 1996), Ecuador (Goossens, 1972; Gemuts et al., 1992), and Peru (Stoll, 1961; Petersen, 1965; Benavides, 1990; Clark et al., 1990; Petersen and Vidal, 1996; Noble and McKee, 1999).