Ore Deposits of the Andes: A Compilation 1919–2011

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

© 2012 Society of Economic Geologists, Inc.
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 100th 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; Scherkenbach and Noble, 1984; Shelnutt and Noble, 1985, Lueth et al., 1990; Deen et al., 1994), Llallagua (Ahfeld, 1931, 1936; Turneare, 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 (Charchaflie et al., 2007), and Yanacocha (Gustafson et al.,
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-Condestable (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 Haeberlin 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).