tive gold, electrum, bournonite, dismuthinite, silver-bismuth sulfosalts, stibnite, and base-metal sulfides. Gangue minerals are quartz, pyrite, barite, siderite, rejalgar, and orpiment. Hydrothermal fluid temperature range from 270° to 325° (Caudalosa) and from 295°C to 325°C (Julcani). Salinities are 4-18 (Caudalosa) and 5-24 (Julcani) wt percent NaCl equiv. The deposits are associated with: 1. The resurgent caldera at Nevado Portuguesa (Rosario in Atunsulla); 2. Stratovolcanos (Ccarhuaraso and Palla Palla); 3. Volcanic domes at Julcani and Castrovirreyna (Caudalosa, Candelaria, and Bonanza); and 4. Faults (Cerro Anta in San Juan de Lucanas). Radiometric ages are: Julcani (9.8 Ma) and Ccarhuaraso (1.2 Ma).

The deposits are located at distinct lineaments or fault zones. Precious metal ore in both types of deposits occurs chiefly in well defined veins, although some ore is in hydrothermal breccia bodies (Santa Bárbara, Ccarhuaraso, Caudalosa, and Anta in San Juan de Lucanas). The veins strike N25°-40°W, N40°-75°E, and E-W. The range from 200 m to 4 km in length, and are generally a few tens of centemeters to 1.5 m in width.

The Caudalosa Candelaria-Bonanza vein system in the Castrovirreyna district has an exceptional length of 9 km, whereas the Calera vein in the Orcopompa district and San Cristobal vein in the Caylloma distric have exceptional maximum widths of 10 and 25 m, respectively. Gold and silver ores extend to relatively shallow depths and gold increases with depth in some veins. Ruby silver ores give way to polymetallic base-metal ores at depths of 300-400 m (San Juan de Lucanas, Caylloma, San Genaro, Reliquias, Condoroma, San Antonio de Esquilache (they are zoned, and tetrahedrite persists at depths in the Julcani and Castrovirreyna districts.

HYDROTHERMAL SYSTEMS RELATED TO A PALEOGENE CALDERA COMPLEX IN NORTHERN CHILE; EL GUANACO, CACHINAL DE LA SIERRA AND EL SOLDADO MINING DISTRICTS, ANTOFAGASTA REGION

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The epithermal precious metal deposits El Guanaco (Au, Cu), Cachinal de la Sierra (Ag) and El Soldado (Ag) are aligned along 69°32'W for a distance of 27 km between 24°52.1' and 25°06.5'S. They are genetically related to a Paleocene-Eocene volcanic arc that formed after a major reorganizing tectonic phase in middle Cretaceous (Subhercynian) time, as a first intracontinental arc after a fore-arc, arc, back-arc system of Late Triassic to Early Cretaceous time. The Paleogene volcanic rocks are subalkaline, ranging in composition from basalts to rhyolites, but with andesites and dacites predominant. Eroded eruptive centers showing volcanic necks or subvolcanic bodies with radial dikes have been recognized in this unit. A two-resurgent caldera model is proposed as the source of the volcanic sequence that crops out in the area between El Soldado and El Guanaco districts. This model is supported by detailed geologic mapping, by petrographic studies, and by K-Ar dating of 26 mineral concentrates of hydrothermally altered and unaltered volcanic rocks of the area.

The El Guanaco, Cachinal de La Sierra, and El Soldado deposits are in rocks of the caldera complex and were formed by hydrothermal systems related to the final phase of the caldera evolution. El Soldado, in the northern part of the area, consists of veins along faults striking N15°W. Silver and minor amounts of gold have been mined from 0.5-3.0 m wide and 600 m long quartz veins containing argentiferous galena, sphalerite, chalcopyrite, cerusite, proustite, argentite, pearceite, calcite, siderite, native gold, and copper oxides. The Cachinal de La Sierra deposit, to the south, consists of at least 14 veins having vertical ore shoots in a zone 20 m wide and 200 m long, which extends to a depth of 120 m. Hydrothermal alteration is

of the adularia-sericite type; ash-flow tuff host rocks are silicified. Hypogene minerals consist of argentiferous galena associated with quartz-adularia-fluorite gangue. Supergene specularite, anglesite, cerusite, limonite, pyrargyrite, chalcocite, and covellite are found in the near-surface oxide zone. Veins at El Guanaco are related to an E-W fracture zone in intensively silicified volcanic rock surrounded by an irregularly distributed, advanced argillic alteration (quartz, alunite, kaolinite, dickite) zone. Outside this central zone of intense alteration, the rock shows weak chloritic alteration. Supergene ores have been mined in ore shoots up to 50 m in diameter consisting of fracture-filling veins of native gold, barite, hematite, and alunite. Hypogene mineral assemblages consist chiefly of pyrite, enargite, luzonite, and minor chalcopyrite, which are similar to assemblages for acid-sulfate or enargite-gold type deposits.

The Cachinal de La Sierra and El Guanado deposits are at the western margin of a caldera, called the Cachinal caldera, of which only the western part has been preserved. The El Soldado deposit is at the intersection of this caldera and the 7 Ma younger, 8 km diameter El Soldado caldera to the north. It consists of veins distributed radially along the rim of El Soldado caldera. Rocks associated with the older Cachinal caldera include a diorite porphyry stock, called the Cachinal diorite, and coeval, petrologically similar pyroxene andesite lavas; radiometric ages are 62-60 Ma. These rocks crop out to the east of El Guanaco and to the north of Cachinal de La Sierra. The Cachinal-Guanaco tuff unit, a major ash-flow sheet having a K-Ar age of 61-60 Ma, is interfingered with the youngest lavas, but overlies older lavas of this unit. This tuff unit extends throughout the area and westward for about 40 km. The Peñafiel Fracture, a remarkable N-S structure extending from Cerro La Isla to Cerro Campana, marks the ring fracture zone of the caldera. The resurgent dome lies to the east of this fracture, where the uplifted floor of the caldera shows dacitic dikes and laccolithic stocks (Cerro Islote). Dacitic domes were emplaced along the Peñafiel Fracture. Some of these domes show a vitrophyric chill margin. Paleofumarolic zones and hydrothermal breccias are present at places along the margins of the domes. The emplacement of the domes was asynchronous from north to south (59-56 Ma), and the magnitude of caldera collapse also changes from north (Cachinal de La Sierra) to south (El Guanaco). The caldera sedimentary fill consists of green conglomerates and sandstones cropping out east and south of the mine areas. The veins at Cachinal de La Sierra and El Guanaco are controlled by the local fractures, which at El Guanaco are parallel to a major ENE structure truncating the caldera in the south, whereas the veins at Cachinal de La Sierra are controlled by the Peñafiel Fracture. The mineralization is genetically related to the youngest dacitic domes as indicated by the age (59 Ma) of sericite from two different veins.

THE EL INDIO AND EL TAMBO GOLD DEPOSITS, CHILE

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The El Indio and El Tambo gold deposits are located several kilometers apart in the Chilean Andes, approximately 180 km east of La Serena. These deposits are the first major gold operation in Chile in which gold is not a relatively minor by-product of copper ores. Full scale mining operations began in 1981 from both underground and surface workings.

The deposits are hosted by Tertiary volcanic rocks that form a prominent N-S belt between thrust faults. Volcanism changed between 8.2 and 11.4 Ma (Araneda, 1982) from extensive andesite flows to the rhyolitic and dacitic pyroclastic tuffs that are the principal host rocks of the deposits. The tuffs show the effects of intense hydrothermal alteration and contrast sharply with the dark, propylitically altered andesites. Argillically altered tuffs which are most prevalent, contain abundant kaolinite, sericite, and dickite