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Intrusion, skarn and vein paragenesis of the Ferrobamba Cu-Mo porphyry-skarn deposit, Las Bambas porphyry cluster, Peru

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The Eocene-Oligocene Ferrobamba deposit in southern Peru is the largest deposit in the Las Bambas Porphyry Cluster, and is owned by Minera Las Bambas (62.5% MMG Limited). Mining commenced in 2015 from the Ferrobamba deposit which has a resource of 1.47 Bt @ 0.64% Cu and 179 ppm Mo, totalling 9.35Mt of contained Cu.

The Ferrobamba deposit formed late in the magmatic evolution and emplacement of the 38 – 34 Ma Ferrobamba Intrusive Complex into Cretaceous platformal limestones. The early Pioneros (quartz diorite, MZB in mine site terminology) and Taquiruta stocks (diorite porphyry, MBF) form wall rocks to porphyry stockwork mineralisation and have minor skarn halos at their contacts. Ccomerccacca (monzodiorite, MZM) irregular stocks, dikes and sills have variable thicknesss of contact skarn. Two Jahuapaylla stocks and several sets of Jahuapaylla dikes (monzodiorite porphyry, MZH) occur in the centre of the deposit, and are overprinted by numerous late quartz monzodiorite dikes (MZQ).

Exoskarn intervals extend from <1m to 40m from the intrusive contacts and are dominated by multiphase andraditic garnet with variable crystal sizes (up to 5cm wide), colours, and crystal habits. Complex compositional and textural zoning in the garnets indicate formation through both progressive growth and by replacement of early formed garnet. The assemblage of bornite – chalcopyrite – chalcocite - molybdenite is hosted in the interstitial pockets between garnet crystals and is the product of multiple overprinting skarn and hydrothermal events, accompanied by calcite, dolomite, quartz, specular hematite, mushketovite, chlorite, green biotite, diopside and accessory epidote, pale garnet, actinolite, talc, tremolite, and a low temperature clay assemblage. Garnet crystal faces are locally dissolved by the pocket assemblage, and variably altered by pyroxene, calcite and sulphides. Pyroxene-dominated skarns are variably developed outboard of the garnet skarn zones, and pass outwards to altered marble. Sulfide assemblages vary from absent to abundant in the garnet and pyroxene skarns, suggestive of metal introduction as a discrete paragenetic event postdating the formation of the skarn.

In total 15 vein stages in 7 main groups have been identified at Ferrobamba, with most of the Cu and Mo in late stage porphyry style quartz-sulfide (± biotite, magnetite) veins. Lower grade porphyry-style mineralisation occurs in all the intrusions, and has highest vein density in the Jahaupaylla stock and dike margins, particularly adjacent to the higher grade exoskarns. The late quartz monzodiorite dikes also locally have well-developed marginal veins. Potassic, calc-potassic and calc-sodic alteration is centred on the Jahuapaylla stocks and passes outwards to distal propylitic alteration.

The 34.45 Ma average age of 9 Re-Os Mo samples spans a total range of 1.3 m.y., which overlaps with the U-Pb ages of the Ccomerccacca, Jahuapaylla and late quartz monzodiorite dikes. Vein-hosted and pocket-hosted molybdenite present overlapping ages. Geochronological,

petrographic, and textural evidence suggests that the early prograde skarns were formed during multiple intrusive events, however the introduction of sulfides into the skarns was synchronous with mineralised vein formation which accompanied intrusion of the Jahuapaylla stocks and dikes, and to a lesser degree the late quartz monzodiorite dikes.