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GEOLOGY OF THE ARIZARO AND LINDERO PROSPECTS, SALTA PROVINCE, NORTHWEST ARGENTINA: MID-MIOCENE HYDROTHERMAL Fe-Ox COPPER-GOLD MINERALISATION

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Abstract – The Arizaro and Lindero prospects are possibly the youngest recognised examples of the hydrothermal iron oxide-copper-gold class of deposits in the world. These two prospects, and numerous other iron-oxide manifestations, form a newly discovered district within northwest Argentina. The Arizaro and Lindero prospects are hosted within mid-Miocene, calc-alkaline, dominantly andesitic, volcanic complexes that formed within a convergent plate margin tectonic setting. This descriptive paper presents observations from surface geology and petrographic studies.

Alteration at the Arizaro prospect is zoned from distal calcite-epidote-chlorite alteration (propylitic) inwards to actinolite-potassium feldspar-magnetite-biotite ± diopside-albite alteration (calcic-potassic) and finally to a central core of intense potassium feldspar-magnetite-biotite alteration (potassic). Weak hydrolytic alteration (quartz-sericite-clay) occurs on the periphery of the system and overprints other alteration types. Alteration at Lindero forms near-complete, concentric rings that are zoned from a central chlorite-calcite core, outwards into potassic alteration (potassium feldspar-magnetite-biotite), into hydrolytic alteration (quartz-sericite-clay-limonite), and finally to an outer propylitic alteration zone (epidote-calcite). Both prospects contain magnetite-rich, pyrite-absent assemblages with Cu-Au and elevated Pd and REE concentrations (La-Ce-Nd). Sulphides are largely restricted to zones of strong to intense potassic alteration and consists of disseminated chalcopyrite and minor bornite.

The interplay between extensional tectonics, magmatism, and thermal convection of saline basinal brines is probably critical for the development of the Arizaro - Lindero alteration systems.

Introduction

The Arizaro-Lindero prospects were discovered by Mansfield Minerals S.A. in 1999 and 2000 respectively and form part of a newly discovered, extremely young (ca 15 Ma), hydrothermal iron oxide copper-gold district within the Puna Plateau of northwest Argentina (Figure 1). Prospects within the district are hosted within both the cores of mid-Miocene, calc-alkaline, dominantly andesitic, volcanic complexes (eg. Arizaro, Lindero, Rio Grande) and within Miocene-age(?), high-angle splays off major structural lineaments (eg. El Camino, La Sarita) (Figure 2). These prospects formed within a convergent plate margin tectonic setting. The Arizaro-Lindero prospects represent a unique opportunity to further our understanding of the iron oxide-copper-gold class of deposits, primarily due to their youth (14 to 15.5 Ma), absence of post-mineralisation alteration or deformation, and location within a tectonic and regional geological setting that is well-constrained relative to other global districts. This paper focuses on description of the surface geology and includes petrographic information on alteration assemblages. Additional laboratory studies to constrain the genesis of mineralisation of these prospects is currently underway.

Regional Geological Setting

The Arizaro-Lindero prospects are located at the southern limit of the Salar de Arizaro, one of the largest salars in South America (Figure 2). The salar occupies the western third of a large 100x100 km intra-arc basin, which is referred to as the Arizaro Basin within this paper. The Arizaro Basin is bounded by major normal, strike-slip and reverse/thrust fault systems and is interpreted to contain approximately 4000 m of sedimentary fill (Jordan and Alonso, 1987). The basin is bounded to the north by the northwest-trending Calama-El Toro Transverse Zone, in the south by the northwest-trending Archibarca Transverse Zone and in the west by the NNE-trending 'East Fissure' Longitudinal Zone (Figure 2). These three structural zones controlled the emplacement of large volumes of mid-Miocene to recent intrusive and extrusive igneous rocks. The eastern extent of the basin is bounded by a NNE-trending reverse/thrust fault structural zone that is currently un-named. The major NNE-trending structures probably represent terrane boundaries, whereas northwest-trending structures were possibly initially established during Triassic extension of the Pangea super-continent. These large basin-bounding structural zones are surface expressions of deep-

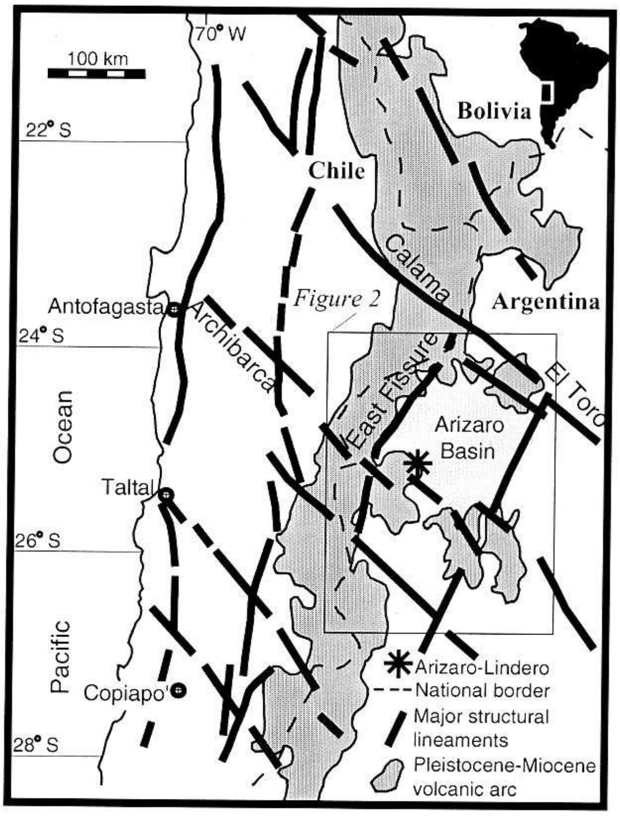

Figure 1: Location map of the Arizaro and Lindero prospects in the Puna area of northwest Argentina. The map indicates the location of the Pleistocene-Miocene Andean volcanic arc, major structural lineaments and the Arizaro Basin (modified after Richards, 2000).

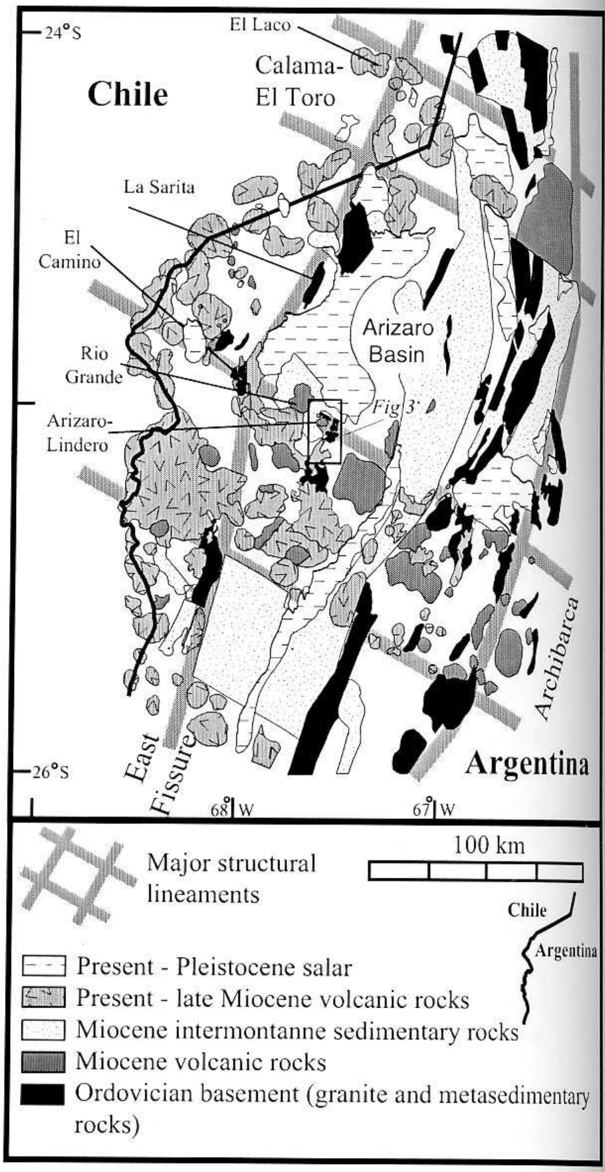

Figure 2: Regional geology of northwest Argentina showing the location of major crustal lineaments, the Arizaro Basin and key geological units. Note that Cretaceous to Late Oligocene arkosic sedimentary rocks are not defined on this map, due to poor regional mapping. Arkosic sedimentary rocks of Cretaceous through Late Oligocene age are believed to underlie most of the Miocene intermontane strata (modified after Richards, 2001).

crustal structures and have been periodically reactivated since at least the early Tertiary (Richards, 2000). Episodic movement along these structures, related to subduction of the Pacific oceanic plate below the South American continent, created high-permeability tensional and transtensional tectonic regimes.

The basement of the Arizaro Basin comprises Early to Middle Ordovician granitic plutons and Precambrian through Paleozoic volcanic and sedimentary sequences (Amengual, et al., 1979, Vandervoort, 1993). This basement is unconformably overlain by Cretaceous - latest Oligocene continental arkosic sedimentary rocks. Oligocene strata accumulated in a foreland depositional basin of low relief in which clastic playa, aeolian, and fluvial depositional environments predominated (Jordan and Alonso, 1987). The regional extent of the Oligocene strata clearly distinguish them from the much less extensive Neogene and younger sedimentary rocks (Vandervoort, 1993).

Initiation of Puna Plateau development, at approximately 16-17 Ma (Jordan et al., 1997, Vandervoort et al, 1995), imposed significant changes on the depositional environment and tectonic-structural framework of this region as well as coinciding with the establishment of an extremely arid environment. This plateau is 1800 km long and 300-400 km wide and has an average elevation of greater than 3000 m. The plateau is characterised by numerous structurally-controlled, internally-draining basins (eg. Arizaro) that probably started forming around the time of initial plateau development.

Plateau uplift occurred due to subduction-related crustal thickening produced by horizontal shortening of a thermally softened crust (Allmendinger et al, 1997). Rapid uplift promoted high erosion rates and resulted in accumulation of thick sequences of immature clastic and evaporitic sediments within internally-draining basins. Measured sections in the Arizaro Basin indicate greater than 1500m of evaporitic sediments (Vandervoort, 1993) with an interpreted thickness of up to 4000m (Jordan and Alonso, 1987, Vandervoort, 1993). The Arizaro Basin stratigraphic package consists of first generation red beds and evaporitic halite deposits.

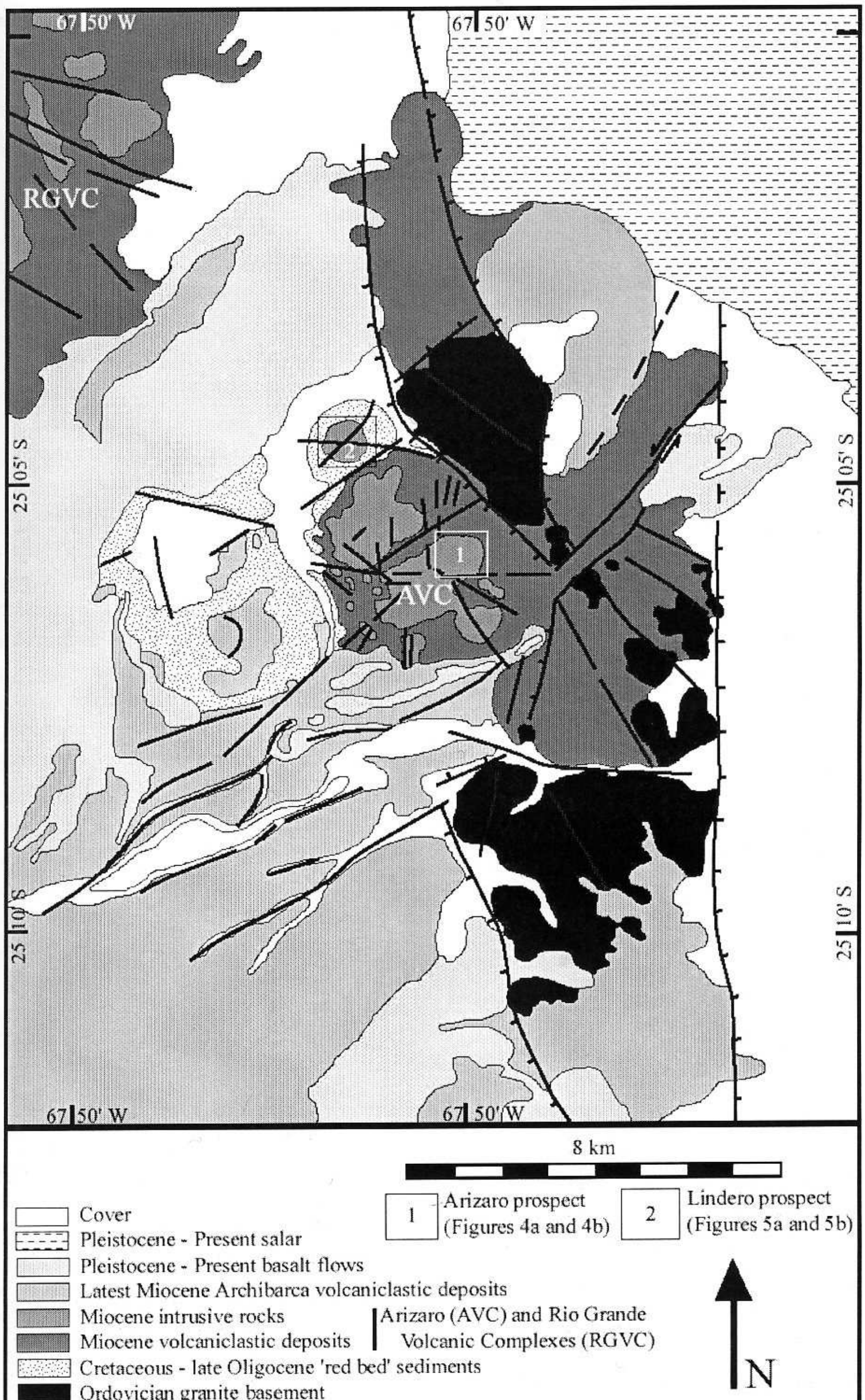

Figure 3: Geology map of the broader Arizara Volcanic Complex.

Mid-Miocene to recent igneous rocks occur along the modern Andes magmatic arc, and within northwest-trending 'magmatic fingers' (Figure 2) which coincide with northwest-trending structural lineament zones. At least four distinct ages of igneous rocks have been identified within the broader Arizaro-Lindero area including: porphyry copper intrusions at Cerro Samenta and Taca Taca (28-30 Ma, Rojas et al, 1999), the Arizaro and Rio Grande volcanic complexes (16-17 Ma, Dow, 2001), Archibarca Volcano (<5 Ma ?) and very young basalt dykes and lava flows (2 Ma-present).

Local Geology

The Cretaceous to late Oligocene red arkosic sandstones are unconformably overlain by mid-Miocene volcanic flows and volcaniclastic sediments and are cross-cut by intrusive rocks. These mid-Miocene igneous rocks comprise the Arizaro volcanic complex which covers an area of approximately 6x4 km. Lithologically similar rocks to the northwest make up the area around the Rio Grande prospect (Figure 3). Mid-Miocene volcaniclastic rocks also outcrop north, northeast and east of the Arizaro volcanic complex, although, it is unclear where these deposits originated. The Arizaro volcanic complex consists of three zones containing abundant calc-alkaline intrusive rocks which are each surrounded by lava flows and volcaniclastic rocks. These extrusive rocks are cut by calc-alkaline dykes which extend radially away from each of the intrusive centres.

The intrusive rocks are generally porphyritic although minor equigranular phases are also present. Porphyritic minerals are dominated by medium-grained plagioclase and hornblende with minor augite. The groundmass of the intrusive rocks consists dominantly of plagioclase and potassium feldspar. Extrusive rocks immediately adjacent to the intrusive units are generally weakly hornfelsed. Relatively unaltered intrusive rocks from the Arizaro prospect have yielded an $^{40}Ar/^{39}Ar$ age of 16.35±0.35 Ma while relatively unaltered intrusive rocks from the Lindero prospect yield an $^{40}Ar/^{39}Ar$ age of 16.75±0.35 Ma.

The lava flows and volcaniclastic rocks surrounding the intrusive centres are typically slightly more felsic than adjacent intrusive rocks. Lava flows are subordinate to volcaniclastic rocks. The volcaniclastic rocks are dominated by mass-flow units consisting of blocks of andesite and/or dacite in a fine- to medium-grained, crystal-rich, andesitic matrix. The volcaniclastic rocks also contain minor thin-bedded ashfall deposits.

The Arizaro complex appears to be a series of partially dissected volcanic edifices. The Arizaro prospect is located in a relatively large zone of intrusions while the Lindero prospect occurs in a small intrusion that forms a prominent hill. The largest volcanic edifice is located to the south of the Arizaro prospect and appears to be unmineralised.

Igneous rocks of the Arizaro complex are unconformably overlain by late-Miocene (?) volcanic rocks which are believed to be derived from the Archibarca volcanic complex 15 km to the southwest of Arizaro. In the Arizaro area, these Archibarca volcanic rocks comprise white, poorly lithified, pumice flows and heterogeneously coloured volcaniclastic massflow deposits. The youngest volcanic rocks in the area are Quaternary basalt flows and dolerite dykes.

The Arizaro prospect area is cut by northeast-, north-northeast-, and northwest-trending, high angle faults. Most faults occupy covered valleys. Maximum displacement on the faults is probably several hundred metres. The Arizaro area is bound to the northeast by a northeast-trending, left-lateral strike-slip fault zone.

Geology of the Arizaro Prospect

The Arizaro prospect is located within an intrusive centre of the Arizaro volcanic complex. The intrusive core is surrounded by volcaniclastic breccias which are cut by radial dykes (Figure 4a). The prospect area is cut by a number of northeast-trending valleys that are interpreted to mark the location of high angle faults. The southern limit of the prospect is a major northeast-trending valley which separates the prospect from the main intrusive centre of the Arizaro volcanic complex.

Sulphides were discovered at Arizaro in 1999 through prospecting. Mineralisation occurs in both intrusive and extrusive igneous rocks of the Arizaro volcanic complex. Early grab samples for the prospect returned an average grade of 0.36% Cu and 0.73g/t Au. Distinctive alteration zones similar to the previously discovered Rio Grande system quickly highlighted the similarities between these two prospects. This initial work was followed-up with the excavation of two small trenches over the best exposed mineralisation, which returned assay values of 22m @ 0.63% Cu, 1.12 g/t Au and 8m @ 0.8% Cu, 1.44 g/t Au. During late 2000, a 1400x1200 m soil survey, at 100x50 m spacings, was completed and identified a moderate sized anomaly of 600x400 m @ >800 ppm Cu and >300 ppb Au (Figure 4b). A second trenching program was completed in early 2001 to confirm the continuity of the identified soil anomaly. This trenching program confirmed the continuity of the alteration and mineralisation system, although it also highlighted the low grade nature of the exposed system. The two longest trenches returned assays of 636m @ 0.13% Cu, 0.22 g/t Au and 516m @ 0.13% Cu, 0.24 g/t Au. These and most other trenches intersected small and discontinuous higher grade zones (ie. >15m @ 0.4% Cu, 0.8 g/t Au). Copper-gold ratios typically range from 1:2 to 1:1.5 (ie. 0.5%Cu:1g/t Au to 0.5% Cu : 0.75 g/t Au).

Hydrothermal Alteration

Hydrothermal alteration at Arizaro (Figure 4b) is zoned from distal calcite-epidote-chlorite alteration (propylitic) inwards to actinolite-potassium feldspar-magnetite-biotite ± diopside-albite alteration (calcic-potassic) and to a central core of intense potassium feldspar-magnetite-biotite alteration (potassic). Weak hydrolytic alteration (quartz-sericite-clay) occurs on the periphery of the system and overprints other alteration types. The central potassic and calcic-potassic alteration zones have a strike length of almost 2 km. Propylitic alteration extends from the edge of the central alteration zone to the limit of exposures of the Arizaro volcanic complex.

Potassic Alteration

Three distinctive styles of potassic alteration are observed: potassium feldspar flooding with magnetite veins, biotite vein breccia, and biotite spots. Alteration is generally pervasive and results in the destruction of primary igneous texture. Altered rocks are primarily cream to dark brown coloured.

Potassium feldspar flooding with magnetite vein zones is the dominant potassic alteration style observed at Arizaro. This alteration style is characterised by massive potassium feldspar with variable amounts of disseminated magnetite and biotite. These zones are cut by chaotic magnetite veins which locally give the rock a brecciated appearance. Magnetite veins within these zones have irregular shapes, are angular and discontinuous. Zones with well-developed breccia texture are typically round in shape with diameters

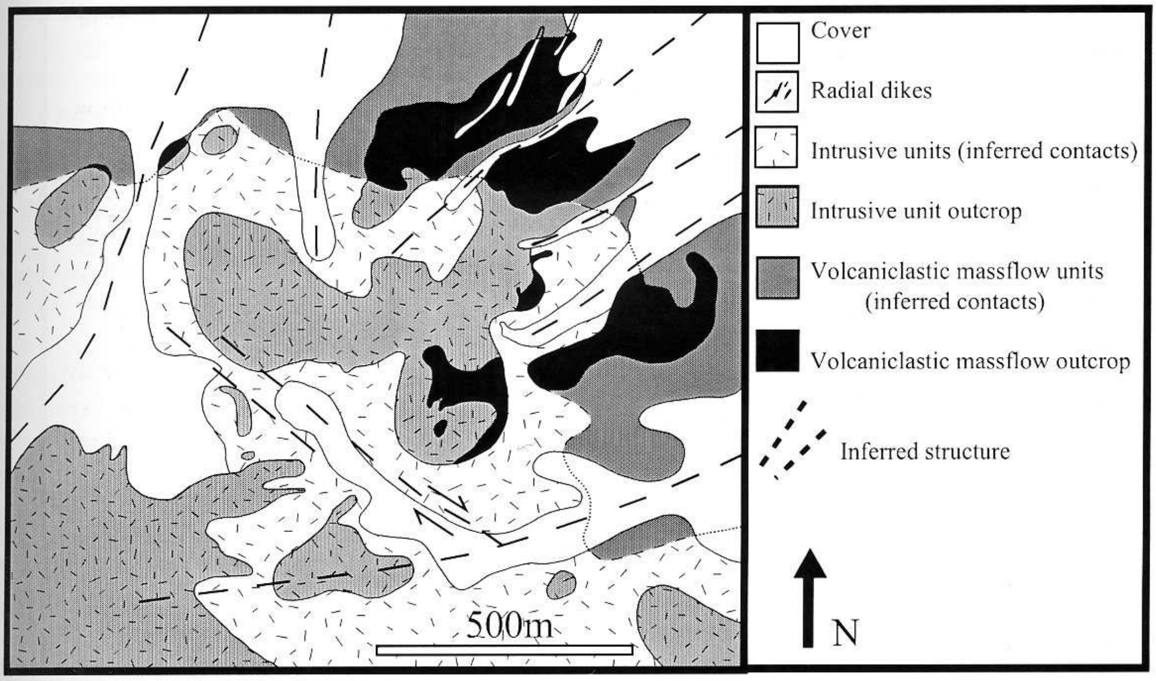

Figure 4a: Outcrop geology map of the Arizaro prospect

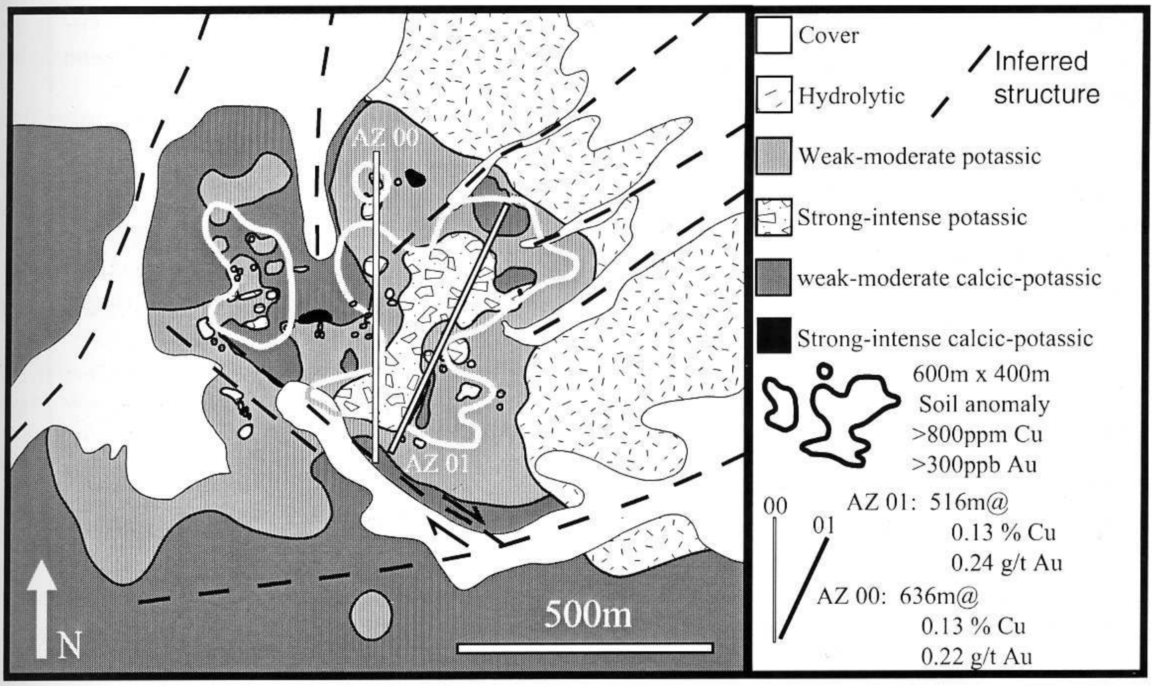

Figure 4b: Alteration and mineralisation map of the Arizaro prospect

that range in size from 3 to 40 m. Wallrock alteration decreases in intensity with increasing distance from breccia zones. Magnetite veins outside of the breccia zone generally display a rectilinear geometry.

Biotitic alteration is characterised by thin (<1 mm) biotite ± potassium feldspar-magnetite veins that locally coalesce to form a breccia texture. Biotite veins typically have a straight to curvilinear morphology. Individual biotite veins commonly have potassium feldspar-biotite-magnetite alteration halos. In zones with abundant biotite veins the wallrock may be pervasively replaced by a biotite-potassium feldspar-magnetite assemblage. Biotite from a thoroughly biotitically altered area yielded an $^{40}Ar/Ar^{39}$ age of 15.46 ± 0.11 Ma.

Biotite spots represent the least common form of potassic alteration. This textural style of alteration is present in rocks which have been pervasively altered to potassium feldspar. The biotite spots are 2-5 mm in diameter, and are amoeboidal to tube-like (up to 50 mm long) in shape. The spots generally consist of a central biotite-potassium feldspar ± chalcopyrite core surrounded by a biotite-magnetite rim. This alteration style is observed in both intrusive and extrusive protoliths indicating that the texture is not lithologically controlled.

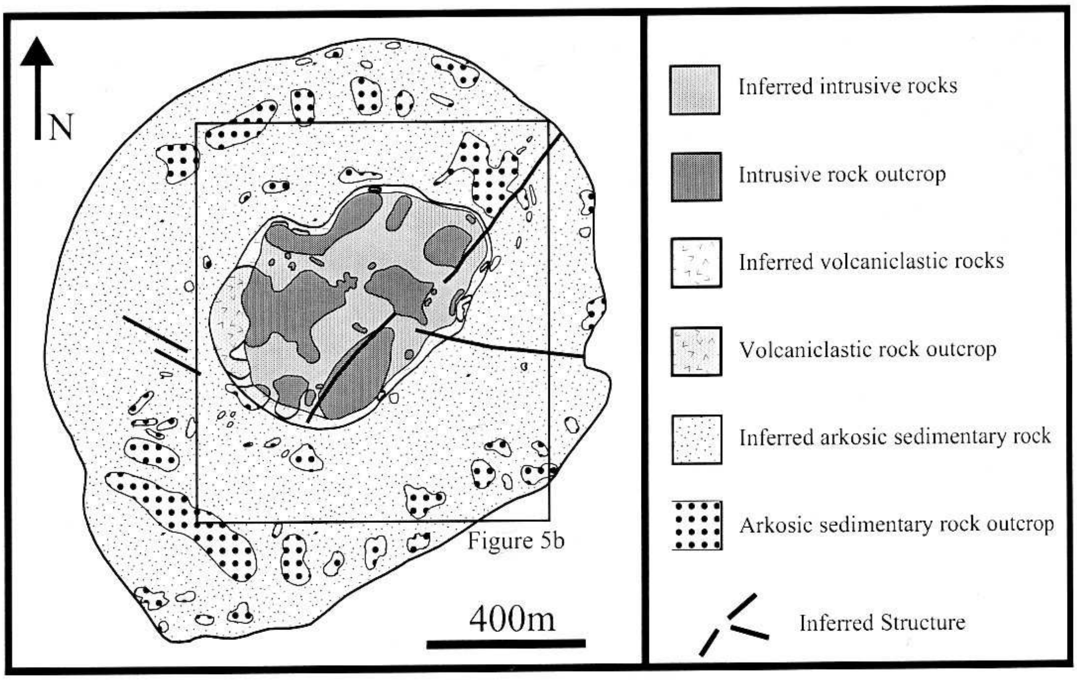

Figure 5a: Outcrop geology map of the Lindero prospect.

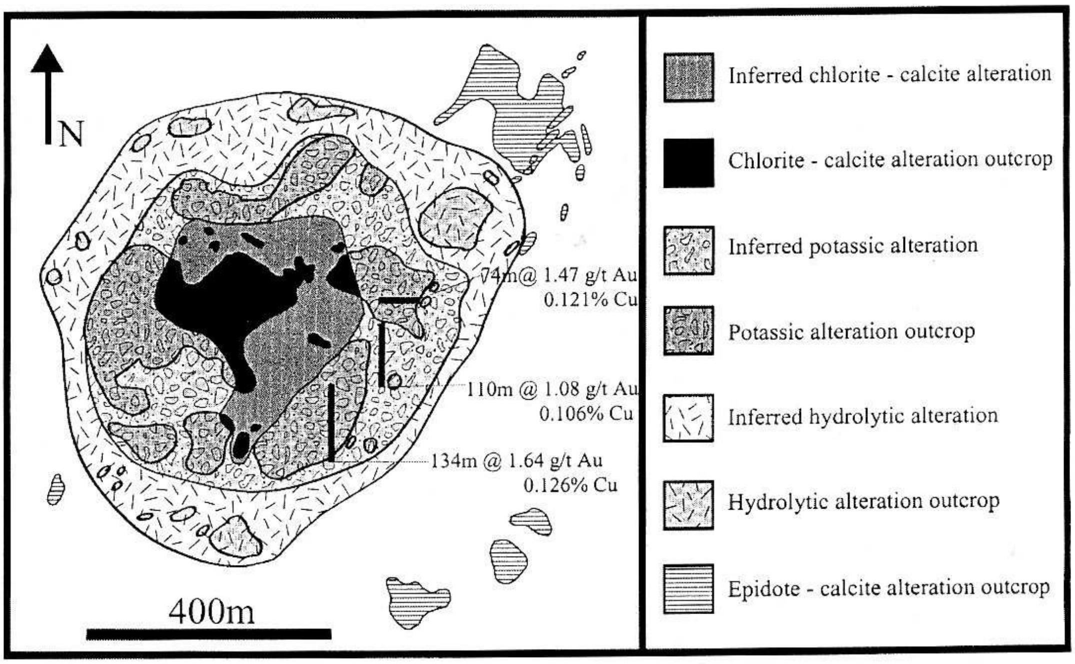

Figure 5b: Alteration and mineralisation map of the Lindero prospect.

Calcic-potassic Alteration

Calcic-potassic alteration is poorly developed relative to potassic alteration. Altered outcrops typically have a green colour, display well preserved primary igneous textures, and megascopically appear unaltered. Alteration mineralogy and intensity, outcrop colour and texturally non-destructive nature of alteration allow for easy mapping distinction between this alteration type and potassic alteration zones. Calcic-potassic alteration occurs primarily as an envelope around the central potassic alteration zone (Figure 4b).

Calcic-potassic alteration is characterised by vein and vein stockworks which have selvages and halos containing similar alteration minerals. Vein mineralogy is dominated by actinolite-magnetite ± quartz-potassium feldspar-biotite-chalcopyrite. Outside of the veins, actinolite generally replaces igneous hornblende and augite, while potassium feldspar, magnetite, and biotite replace the finer-grained groundmass.

Age relationships between the calcic-potassic and potassic styles of alteration are unclear. However, in the northeast and central portion of the prospect, actinolite is locally replaced by biotite, suggesting that calcic-potassic alteration may predate potassic alteration.

Two zones of strong to intense, calcic-potassic alteration are shown in Figure 4b. The northern outcrop comprises a zone of diopside-albite-biotite-magnetite vein breccia. The southern outcrop consists of an intensely developed, massive potassium feldspar-actinolite-magnetite ± biotite vein with strong actinolite-magnetite replacement of adjacent wallrock. Massive potassium feldspar from this vein returned an $^{40}Ar/Ar^{39}$ age of 13.98 ± 0.38 Ma, significantly younger than the alteration age from biotite in the potassic zone. This age relationship contrasts with the petrographic evidence that actinolite is replaced by biotite.

Propylitic Alteration

Propylitic alteration is characterised by weak to strong calcite and weak epidote alteration of plagioclase phenocrysts and groundmass and weak chlorite alteration of mafic phenocrysts. Alteration is typically controlled by calcite micro-veinlets. Propylitic alteration intensity gradually decreases away from the central potassic core and affects most of the Arizaro volcanic complex.

Hydrolytic Alteration

Hydrolytic alteration is present around the north, northeast and eastern parts of the prospect in the volcaniclastic rocks which surround the intrusive core. Hydrolytically altered rocks are generally light cream to white in colour, and contain a quartz-sericite-clay mineral assemblage.

Mineralisation

Exposed mineralisation at Arizaro is dominated by supergene, copper oxide minerals which replace chalcopyrite and minor bornite. Chalcopyrite is generally fine-grained (<0.5 mm), is commonly associated with bornite and intergrown with magnetite. Micron-sized gold (±Pd) grains occur with chalcopyrite-copper oxide accumulations, although chalcopyrite-gold intergrowths have not yet been identified. The highest copper and gold grades are contained almost exclusively within the strong to intense potassic alteration zone. Sulphides are primarily disseminated but also occur within magnetite veins. Copper-gold anomalies are strongly coincident, suggesting that the two metals share a similar fluid transport and precipitation mechanism. Mineralised samples show minor enrichments in silver (<6.5 g/t), zinc (<0.2%) and lanthanum (<50 ppm) relative to unaltered samples.

Geology of the Lindero Prospect

The Lindero prospect was discovered by the senior author during completion of 1:20 000 scale mapping of the Arizaro Volcanic Complex during late 2000. Since discovery, the prospect has been soil sampled and trenched. The soil sampling program led to the discovery of a large, partially covered gold soil anomaly at the southern end of the prospect (500x300 m, >1g/t Au). An 1100 m trenching program, started in early 2001, confirmed the bedrock source for the large soil anomaly. Unfortunately, significant areas of cover limited testing of the anomaly. Nevertheless, 1100 m of trenching returned an average of 0.66 g/t Au and 0.13% Cu. These assay results define a semi-circular mineralised zone approximately 900 m long and >70 m wide.

Outcrop Geology

The Lindero prospect forms a semi-circular mineralised halo around a steep hill containing an intrusive core (Figure 5a and 5b). The hill is isolated from the main Arizaro Volcanic Complex by a northeast-trending valley. The Lindero hill comprises a central intrusive core consisting of at least four individual andesite intrusive bodies. One of these intrusions has yielded an $^{40}Ar/Ar^{39}$ age of 16.75 ± 0.12 Ma. These intrusive rocks cross-cut both Oligocene(?) arkosic sedimentary rocks and volcaniclastic rocks of the Arizaro volcanic complex. The volcaniclastic rocks display both monolithic and polylithic breccia textures and have been classified as both mass-flow deposits and intrusion-related breccias. These deposits form a thin ring that separates the central intrusive complex from the host rock arkosic sediments. The hill is cross-cut by two andesite radial dykes that are aligned parallel to the main observed structural trends (northwest and NNE).

Hydrothermal Alteration

Alteration types at Lindero are similar to those observed at Arizaro. However, calcic-potassic alteration has not been identified at Lindero and the core of the Lindero system contains calcic (chlorite-calcite) alteration. Alteration at Lindero forms near-complete, concentric rings that are zoned from a central chlorite-calcite core, outwards into potassic alteration (potassium feldspar-magnetite-biotite), then hydrolytic alteration (quartz-sericite-clay-limonite), and finally to an outer propylitic alteration zone (epidote-calcite). The contact between potassic and propylitic alteration is obscured by a >100 m wide ring of colluvial cover. Biotite from the potassic alteration zone has recently been dated by $^{40}Ar/Ar^{39}$ methods at 15.21 ± 0.11 Ma.

Chlorite-calcite Alteration

The central intrusive core of the Lindero hill is weakly to moderately altered to a chlorite-calcite alteration assemblage. Chlorite replaces igneous hornblende and augite. Calcite is present as minor veins and disseminated throughout the porphyry groundmass.

Potassic Alteration

Potassic alteration forms a ring around the intrusive centre and has a length of 1500 m with an average width of 150 m. The strongest potassic alteration is located along a linear northeast-trending ridge in the southwest portion of the prospect. Potassic alteration appears to extend under cover to the south and east of this ridge. The potassic alteration within this ridge has an abrupt western contact with the central chlorite-calcite alteration zone, a feature most easily explained by a fault offset. Potassic alteration at Lindero is typically more intense than that observed at Arizaro. The potassic zone contains four distinct assemblages: early magnetite-biotite ± quartz rectilinear veins, potassium feldspar-magnetite-biotite breccias, magnetite vein breccias, and late quartz-magnetite vein stockworks.

Early magnetite-biotite ± quartz veins are rectilinear and have thin potassium feldspar-magnetite-biotite alteration selvages. These veins are also accompanied by weak to moderate potassium feldspar-magnetite-biotite alteration of adjacent wallrock. This early alteration event is crosscut by massive potassium feldspar-magnetite-biotite breccia zones which contain weakly to moderately altered wallrock clasts in a potassium feldspar-magnetite-biotite matrix. These breccias make up the majority of the potassic alteration zone.

These breccias are cross-cut by magnetite veins which locally form stockwork breccias. The magnetite veins have moderately developed potassium feldspar-magnetite alteration selvages. The veins commonly have unfilled (open) centres. Magnetite veins are locally cross-cut by late quartz ± magnetite veins.

Hydrolytic and Propylitic Alteration

Hydrolytic alteration is developed around the entire intrusive body. This alteration type is typically cream to tan coloured. The rock is weak to moderate clay altered with minor quartz-sericite development. Yellow limonite is commonly observed. Epidote-calcite alteration (propylitic) forms the most distal alteration type. Epidote veins cross-cut the host 'red bed' sediments and weak epidote-calcite forms a pervasive alteration of the matrix.

Mineralisation

Rock chips, soils and trenching confirm the presence of a mineralised zone that is 900 m long, >70 m wide and has an average grade of 0.66 g/t Au and 0.13 % Cu. This mineralised zone contains significant widths with higher grades: 134 m @ 1.65 g/t Au, 0.126% Cu; 110 m @ 1.08 g/t Au, 0.106% Cu; and 74 m @ 1.47 g/t Au, 0.121% Cu (Figure 5b). High copper and gold values at Lindero are restricted to the potassic alteration zone. Mineralisation is strongest along a northeast-trending zone in the southeast part of the prospect. Mineralisation at Lindero is dominated by copper oxides; chalcopyrite is rarely observed. The highest copper concentrations occur within potassium feldspar-magnetite-biotite breccia zones.

Summary

The Arizaro and Lindero prospects are believed to be extremely young examples of the iron oxide-copper-gold class of deposits (Hitzman 2000). Both prospects contain magnetite-rich, pyrite-absent assemblages with significant Cu-Au and elevated REE concentrations (La, Ce, Nd). Both prospects are characterised by intense potassic alteration (potassium feldspar-biotite). The rocks display veinlet-controlled, disseminated and pervasive styles of alteration. Iron oxide-copper-gold systems typically display zoning from a deep sodic zone upward to potassic and hydrolytic alteration zones (Hitzman et al, 1992). Although sodic alteration has not been recognised at Arizaro and Lindero, the nearby Rio Grande prospect (Figure 2) does contain a sodically altered core. It is probable that sodic alteration is present at depth below the potassic zone at Arizaro and Lindero.

The Arizaro and Lindero prospects are hosted within the cores of mid-Miocene (≈ 16-17 Ma), calc-alkaline andesitic volcanic complexes. Geochronology suggests that these two prospects may be the youngest currently recognised examples of the hydrothermal iron oxide copper-gold deposit class in the world. Geochronology also indicates a significant time gap (≈ 1 Ma) between the age of host rock intrusions and hydrothermal alteration. These data strongly suggest that the observed host rocks are not the direct source of hydrothermal fluids. In addition, the preliminary geochronology suggests hydrothermal alteration may have occurred during a 1.5 million year period. Work is ongoing to better constrain the duration of the hydrothermal event.

The development of the Arizaro Basin and the emplacement of the Arizaro volcanic complex coincided with uplift of the Puna Plateau. It is probable that the Arizaro Basin was an active depocentre during hydrothermal alteration processes at Arizaro-Lindero, however, what is unclear is the size, depth and nature of contained sediments and basinal fluids. The dominance of magnetite and the sulfur-deficient nature of the two systems is not typical of a magmatic-fluid dominated hydrothermal system (Barton and Johnson, 1996, 2000). It is probable that an oxidised, saline fluid was required to form the observed alteration at Arizaro and Lindero. The interplay between tensional tectonics, magmatism, and induced thermal convection of saline basinal brines is probably critical for the development of the Arizaro - Lindero alteration systems and the multitude of other iron-oxide manifestations observed surrounding the Arizaro Basin.

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