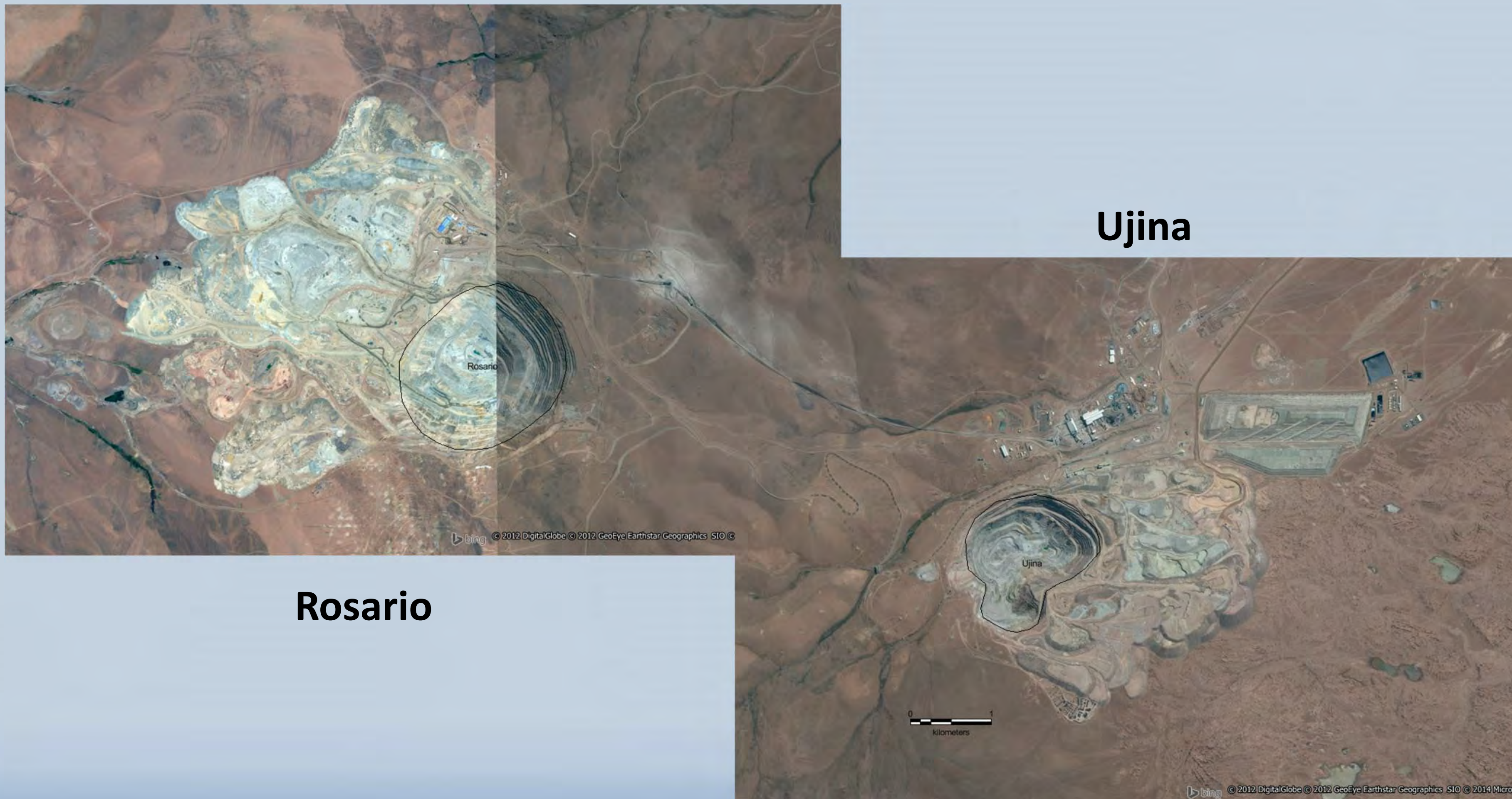
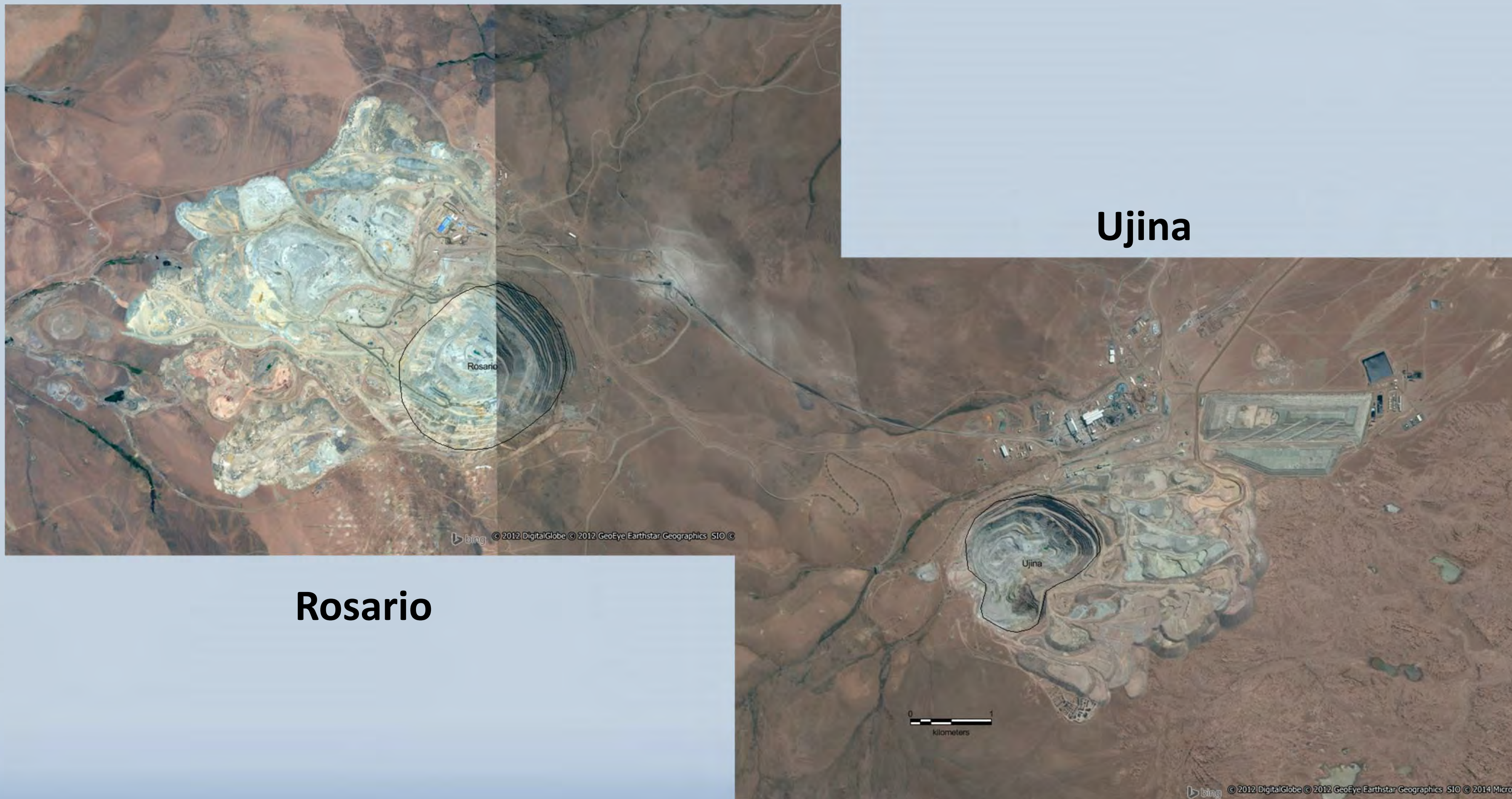
WIP-Collahuasi-Chile



WIP=Work in Progress

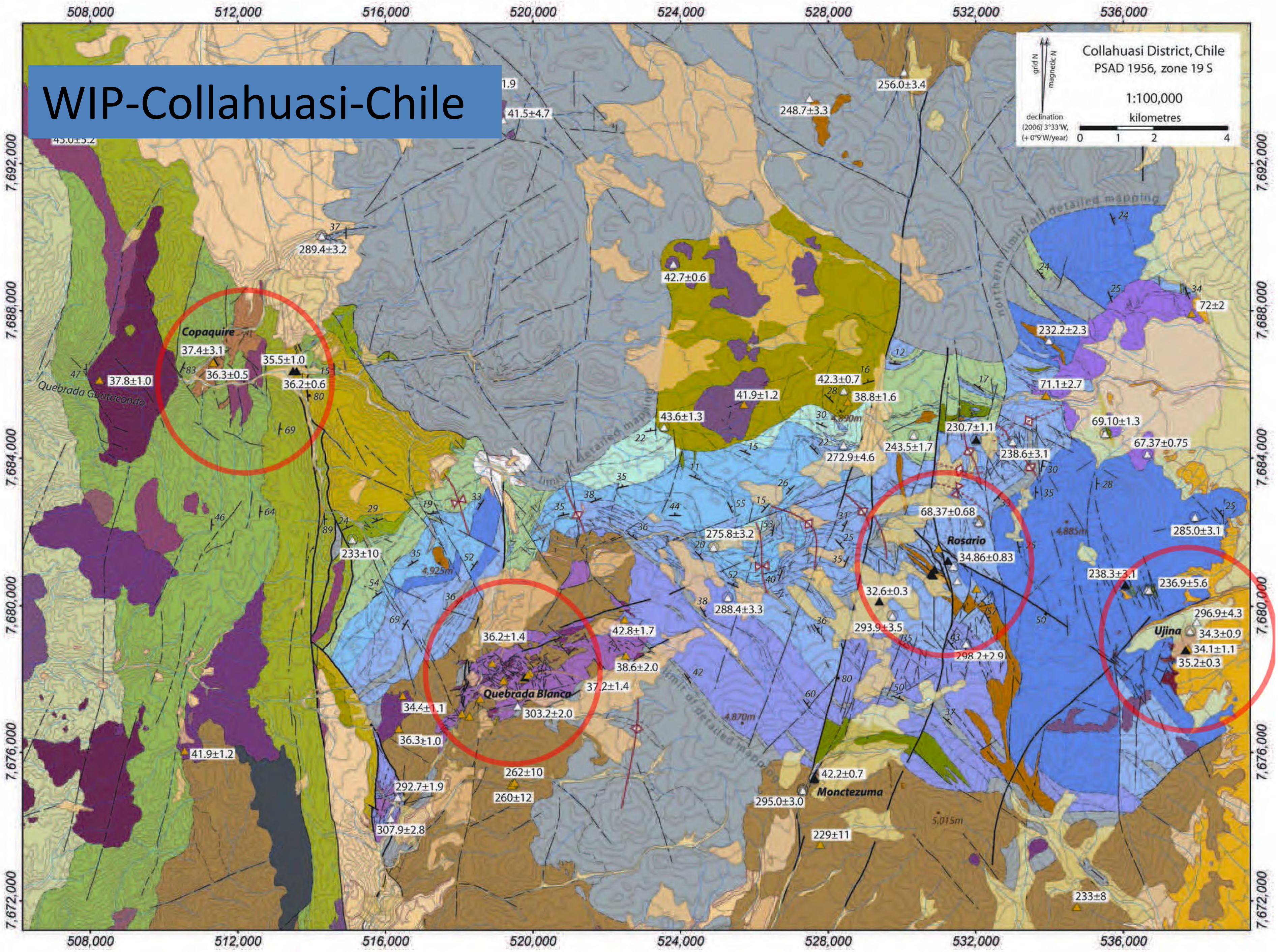
WIP-Collahuasi-Chile

Ujina



Rosario

WIP-Collahuasi-Chile



WIP-Collahuasi-Chile

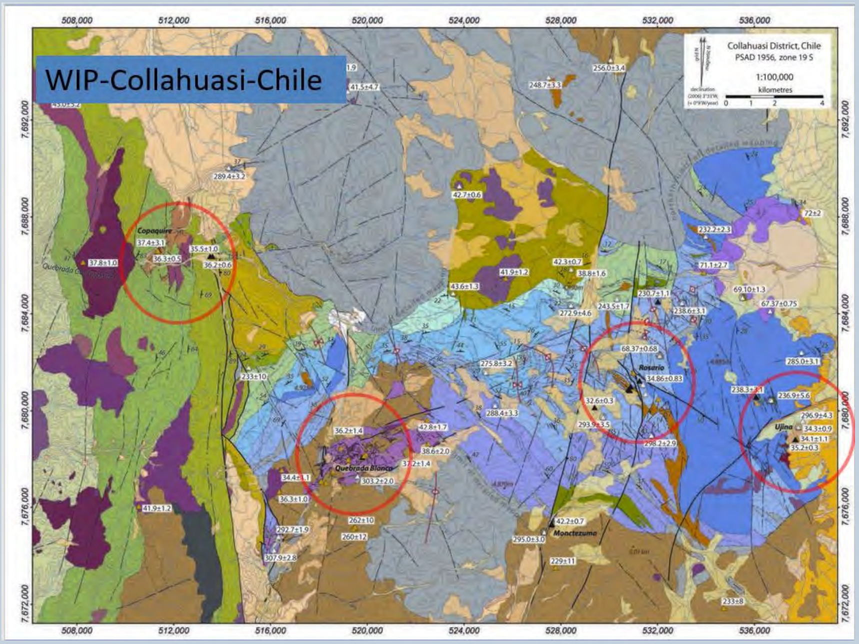
Four main porphyry bodies have been defined in the Collahuasi area: the Rosario Porphyry (34.4 ±0.3 Ma), the Collahuasi porphyry (59 Ma), the Ujina porphyry and the Inés porphyry. The weakly mineralized Inés porphyry is interpreted to have intruded the Ujina porphyry.

The Rosario and Collahuasi porphyries have been described as feldspar–quartz–biotite porphyries. The Rosario porphyry center was emplaced near a NW trending fault transecting volcanic and sedimentary units of the Collahuasi Formation. The highest hypogene Cu grades are associated with the Ujina porphyry. The Ujina porphyry center is hosted by a thick andesite sequence, overlain by rhyolite and sedimentary breccia, representing the lower part of the Collahuasi Formation. It lies along the SE prolongation of the lineament that transects the Rosario deposit. The quartz monzonitic syn-mineralisation Ujina porphyry (35.01 ±0.3 Ma) is intruded by the late and weakly mineralized quartz latitic Inca porphyry (34.8 ±0.3 Ma). Several epithermal vein systems have been described in the district. The most important occur in the vicinity of the Rosario mineralized system. High-sulphidation systems dominate, the most important being the La Grande vein system. Recent geochronological data for the La Grande and Rosario veins show that they formed simultaneously 1.8 Ma after porphyry-style mineralisation at Rosario. The most significant low-sulphidation veins in the district occur in the Moctezuma area.

Alteration: There are defined four main alteration stages in the Rosario, Collahuasi, and Ujina porphyries: pre-mineralisation albite–magnetite alteration; early-stage hydrothermal biotite–K-feldspar; intermediate-stage hydrothermal sericite–chlorite–quartz; and late-stage hydrothermal pyrophyllite–alunite adjacent to a high-sulfidation vein or sericite–quartz halo.

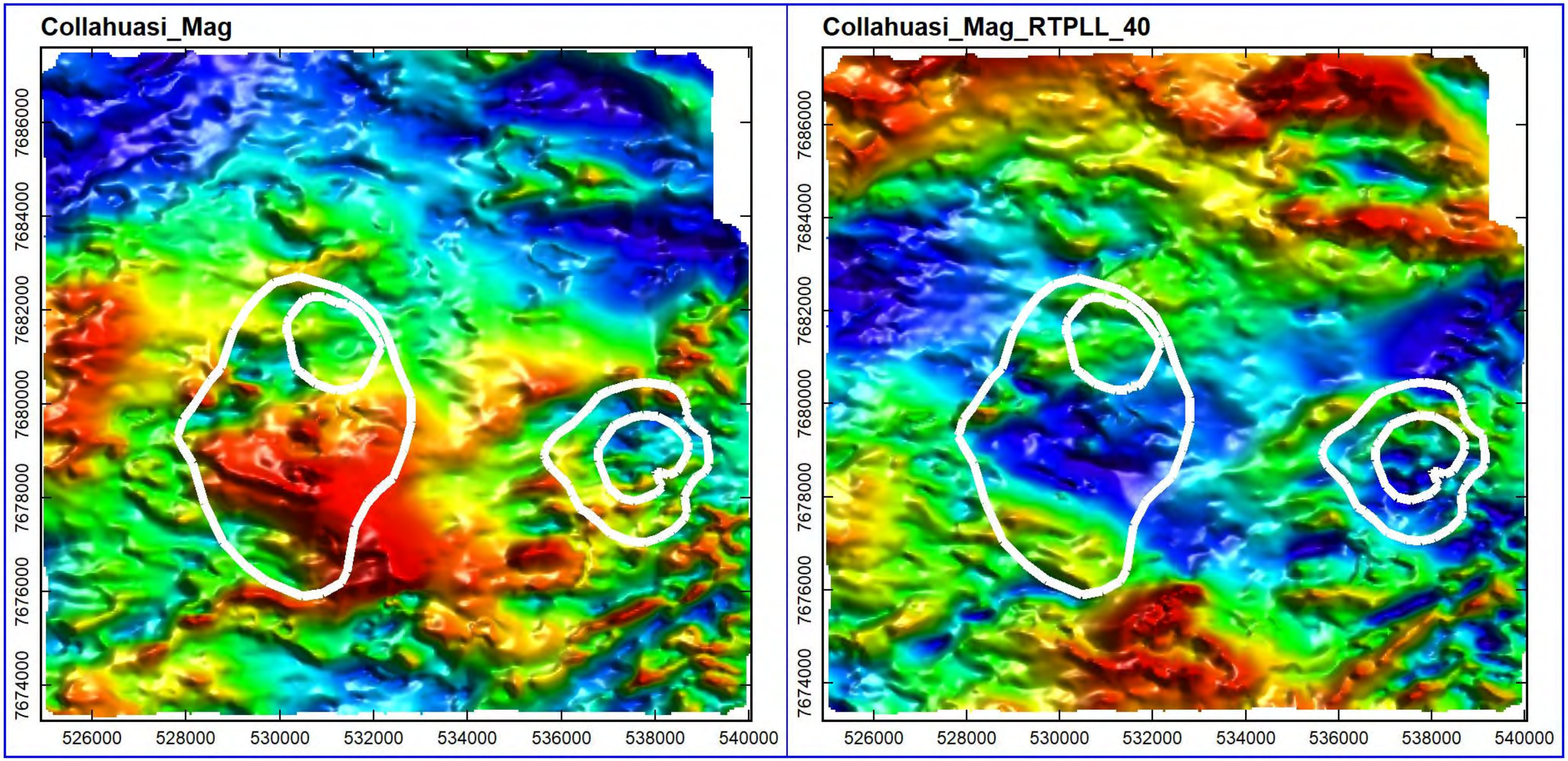
Sulphide and alteration assemblages are concentrically zoned about the Ujina porphyry. The orthoclase-biotite alteration core is overprinted by sericite–chlorite alteration and a chlorite–epidote halo. All veins in the Ujina porphyry exhibit advanced argillic envelopes grading outwards to epidote–chlorite alteration.

Mineralisation: Supergene mineralisation occurred over the Rosario and Ujina porphyries, represented by high-grade chalcocite and Quaternary gravels cemented by chrysocolla and copper wad. Hypogene mineralisation occurs in all three porphyries, but the grades decrease outwards from the contacts of the Rosario porphyry with the Collahuasi and Inés porphyries



Hypogene mineralisation includes chalcopyrite and lesser bornite. In the Ujina porphyry, the highest Cu grades form an annulus around the sulphide-poor potassic core, and coincide with the cylindrical contact between the Ujina porphyry and the volcanic host rocks.

WIP-Collahuasi-Chile

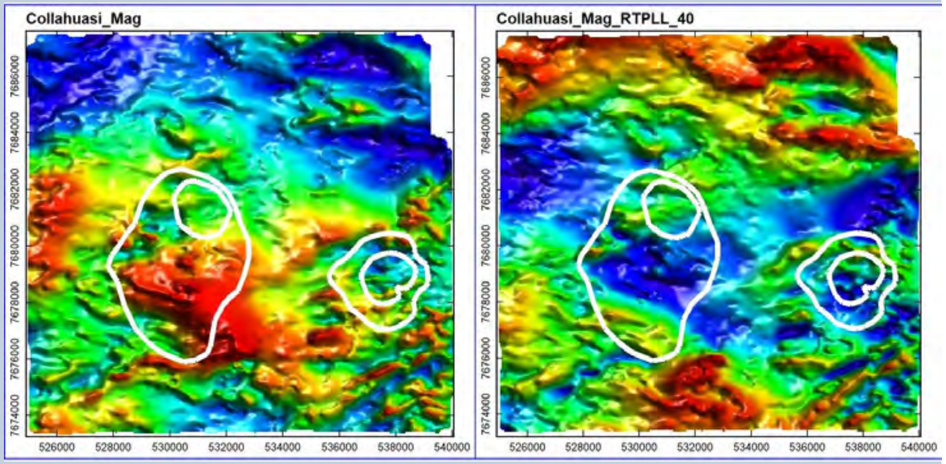


WIP-Collahuasi-Chile

Aerodat flew the area in 1991. Using plan maps produced for marketing purposes, the magnetic contours were digitized and a grid produced of the TMI results.

Due to the low magnetic latitude, carrying out a pole reduction was challenging. The result shown here was derived from Encom PA using their PPL approach to pole reduction. This part of the data assessment is continuing.

At this stage, the RTP results suggest that the Rosario and Ujina systems are associated with magnetic lows.



WIP-Collahuasi-Chile

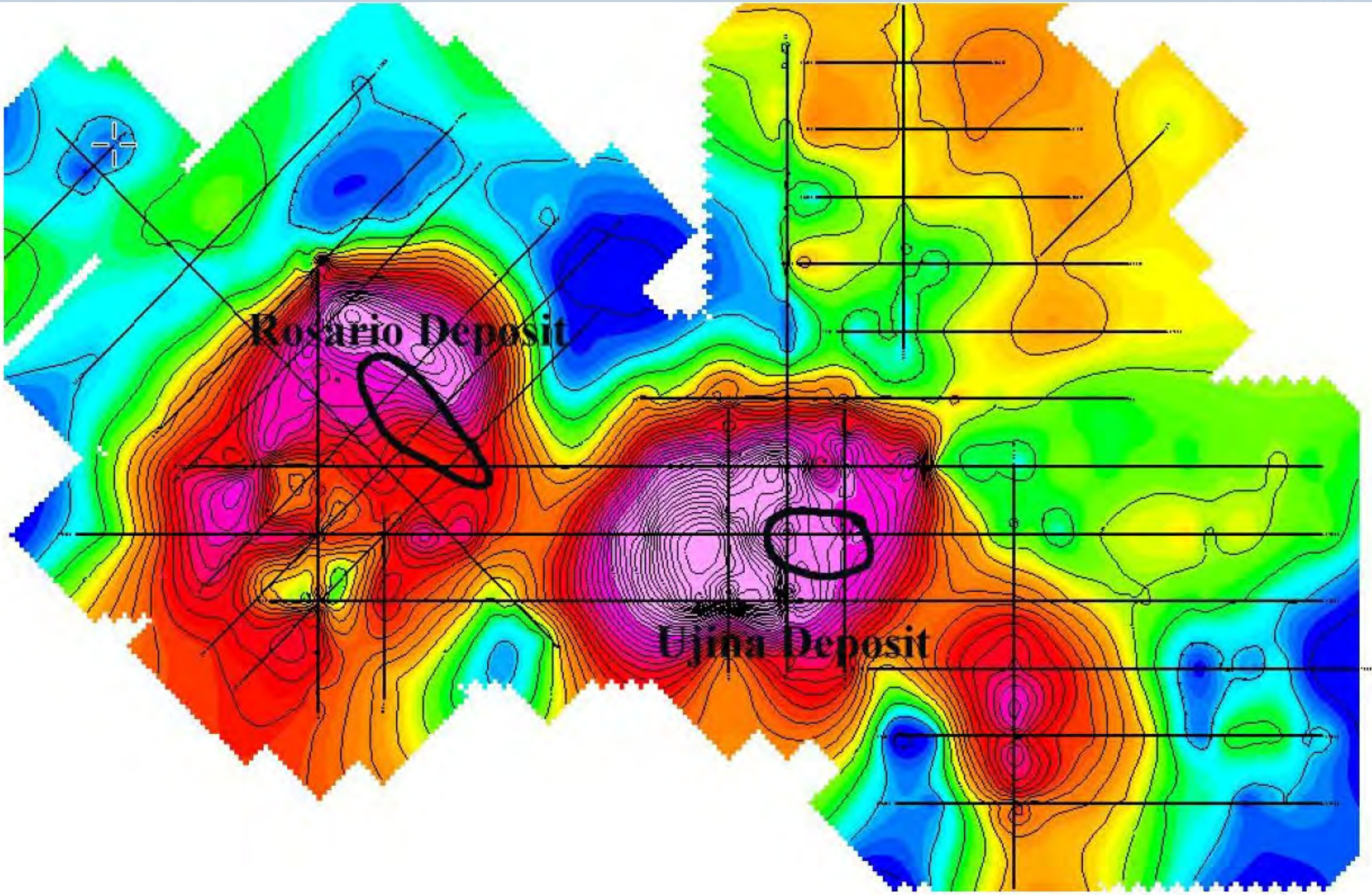


Figure 4: Plan Map of 1990 IP survey, a-300m, n=2

WIP-Collahuasi-Chile

We understand there were several campaigns of IP as outlined in 2002 SExG expanded abstract by Watts. For both Rosario and Ujina, the deposits are located within a large zone of high IP. This is a variant of two modes of IP response; the sulfide (pyrite) halo where the Cu-rich deposit sits inside an IP anulus and the model where the Cu zone correlates directly with the IP high.

The next figure shows the IP response for Quebrada Blanca, a major deposit considered to be part of the Collahuasi system, located ~12 km SW of Rosario. The response here is complicated with the deposit appearing (again) to be associated with a portion of a large zone of IP high.

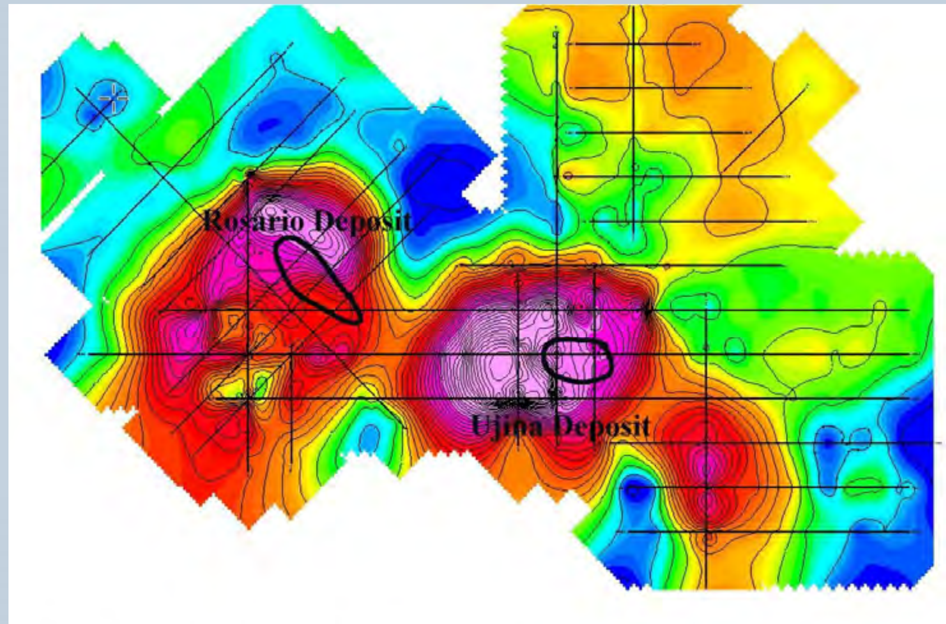


Figure 4: Plan Map of 1990 IP survey, a-300m, n=2

WIP-Collahuasi-Chile

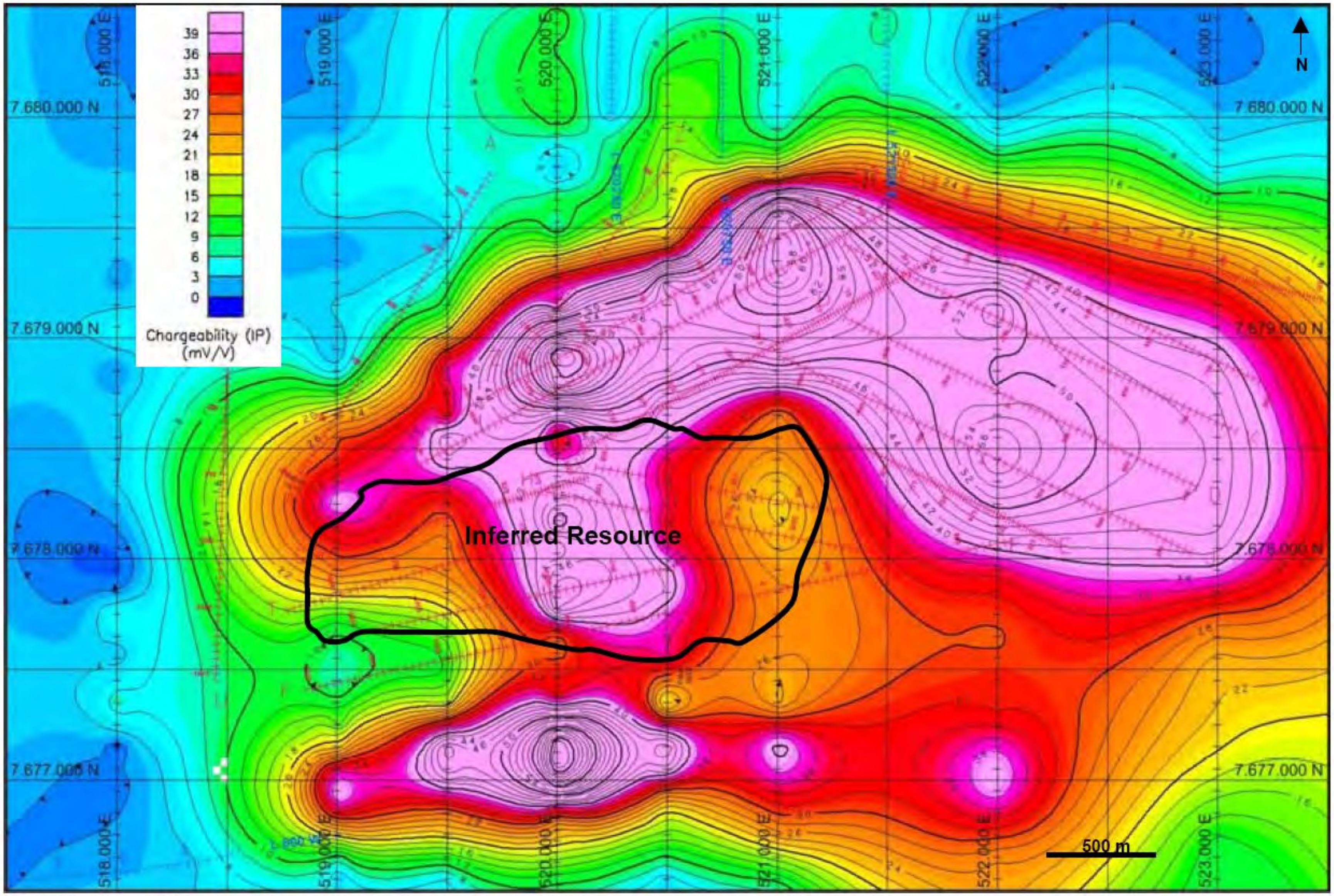
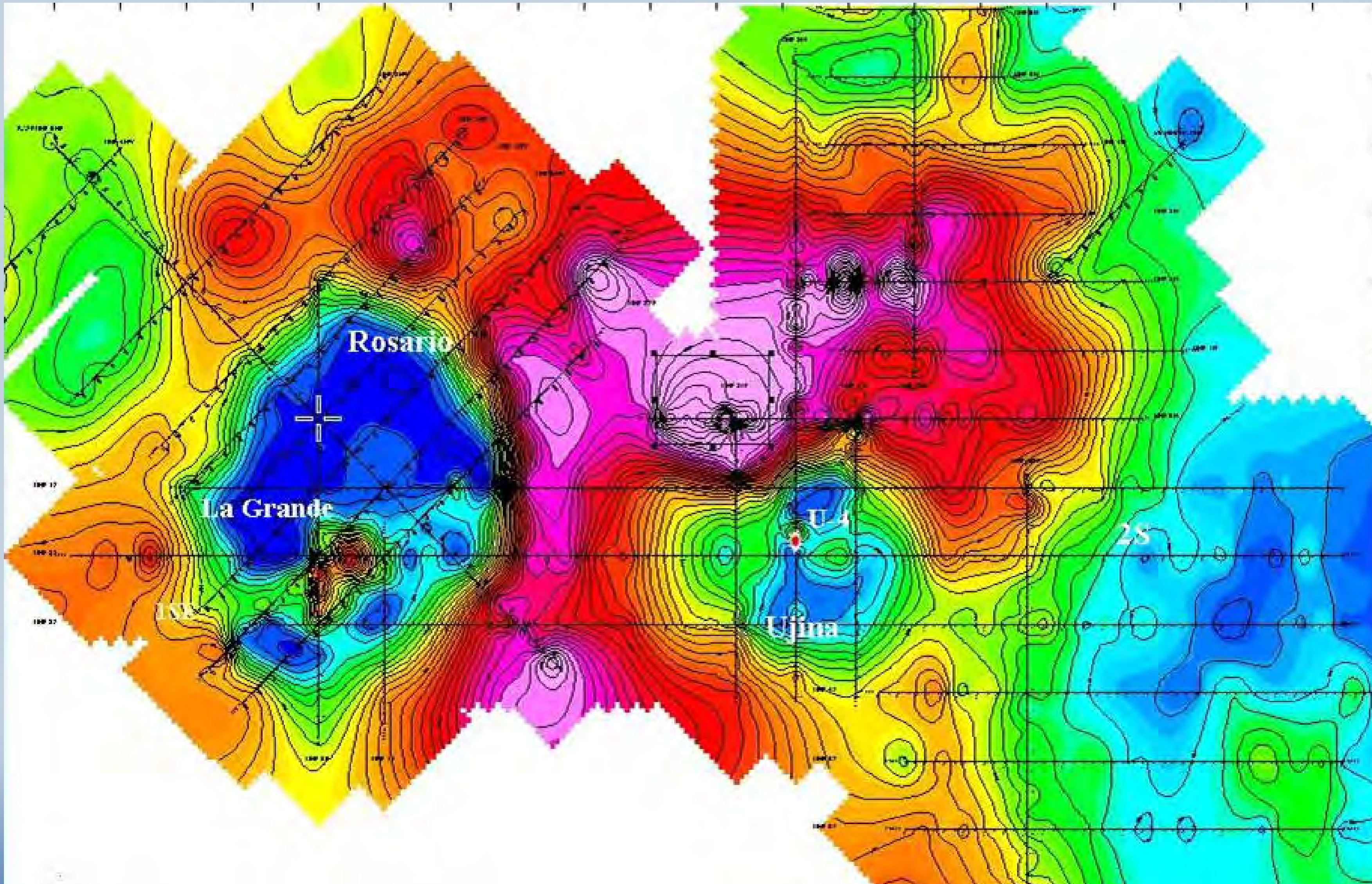


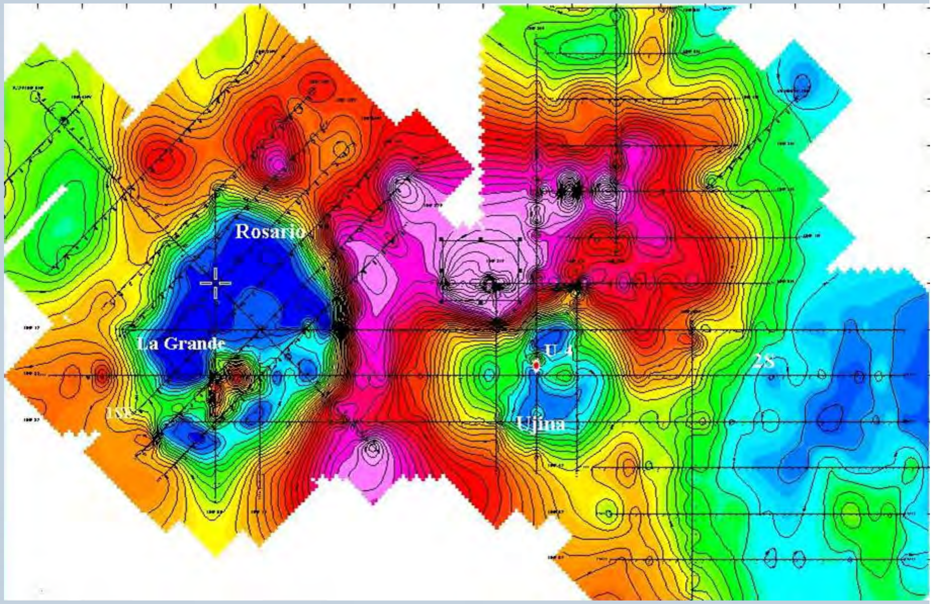
Figure 9. QB chargeability anomaly at 4100 meter elevation.

WIP-Collahuasi-Chile

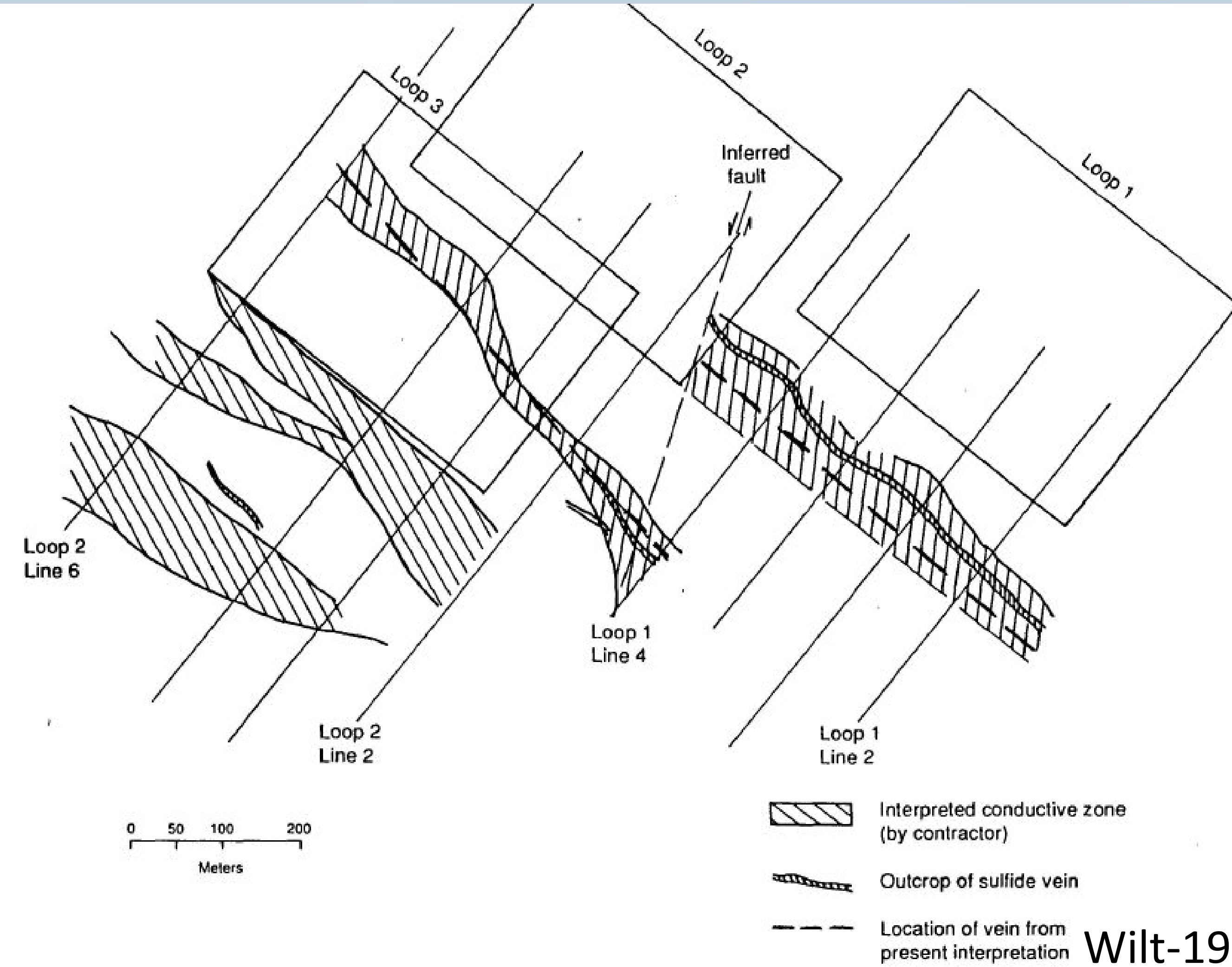


WIP-Collahuasi-Chile

The Rosario deposit shows a clear low resistivity (blue) whereas the Ujina response while low, is not as intense as that apparent at Rosario. The reasons for this are unclear.



WIP-Collahuasi-Chile

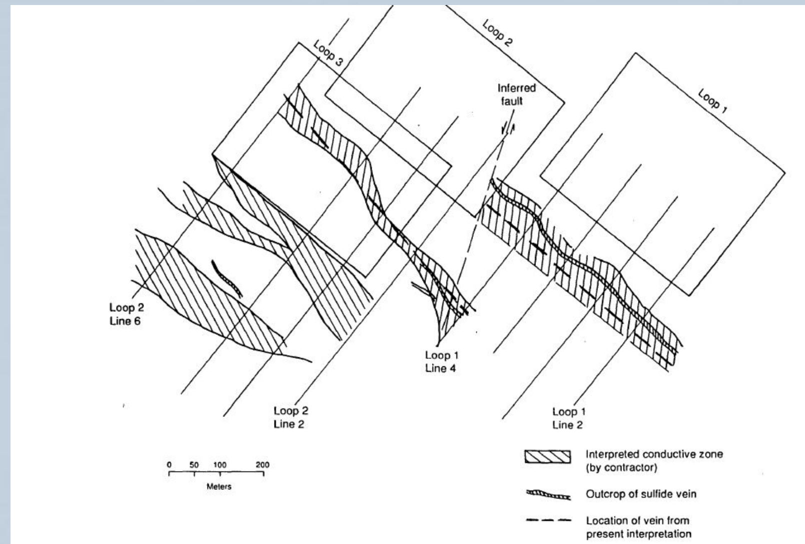


Wilt-1991

WIP-Collahuasi-Chile

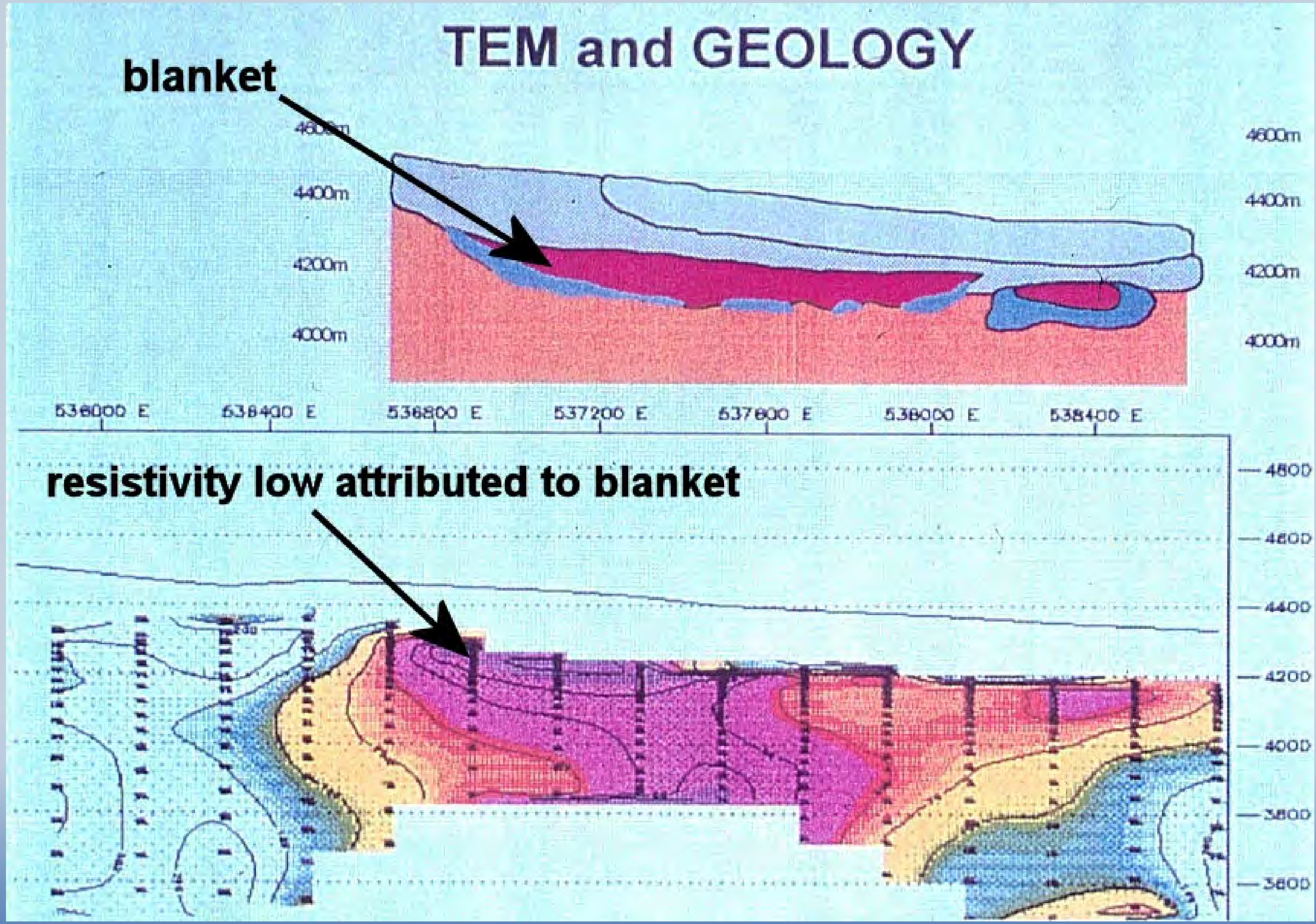
The use of TEM at Collahuasi spanned >15 years with the first surveys reported to be carried out in the late 1980s using Crone Geophysics (Wilt 1991) and then Chevron carrying out work in the same area with their in-house EM-60 in 1989-1990.

The focus of this work was to map near surface veins in the Ponderosa area, SE of the center of the Rosario deposit. The vein system is discussed in a number of geology papers indexed at the end of this note.



WIP-Collahuasi-Chile

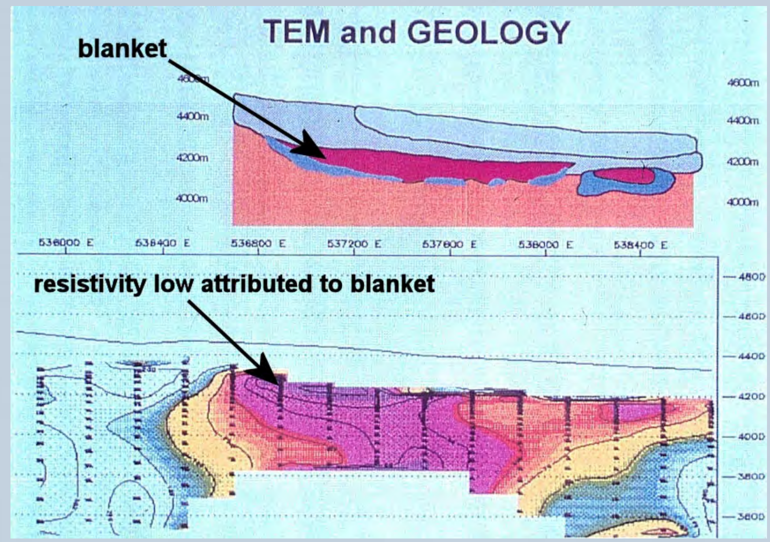
Ujina



WIP-Collahuasi-Chile

In 1993, Quantec (Nickson per com 2014) undertook a EM-37 survey over the Ujina deposit after earlier IP-resistivity surveys showed that the supergene blanket present was very conductive (<2 ohm-m). This survey showed that TEM could effectively map the supergene blanket.

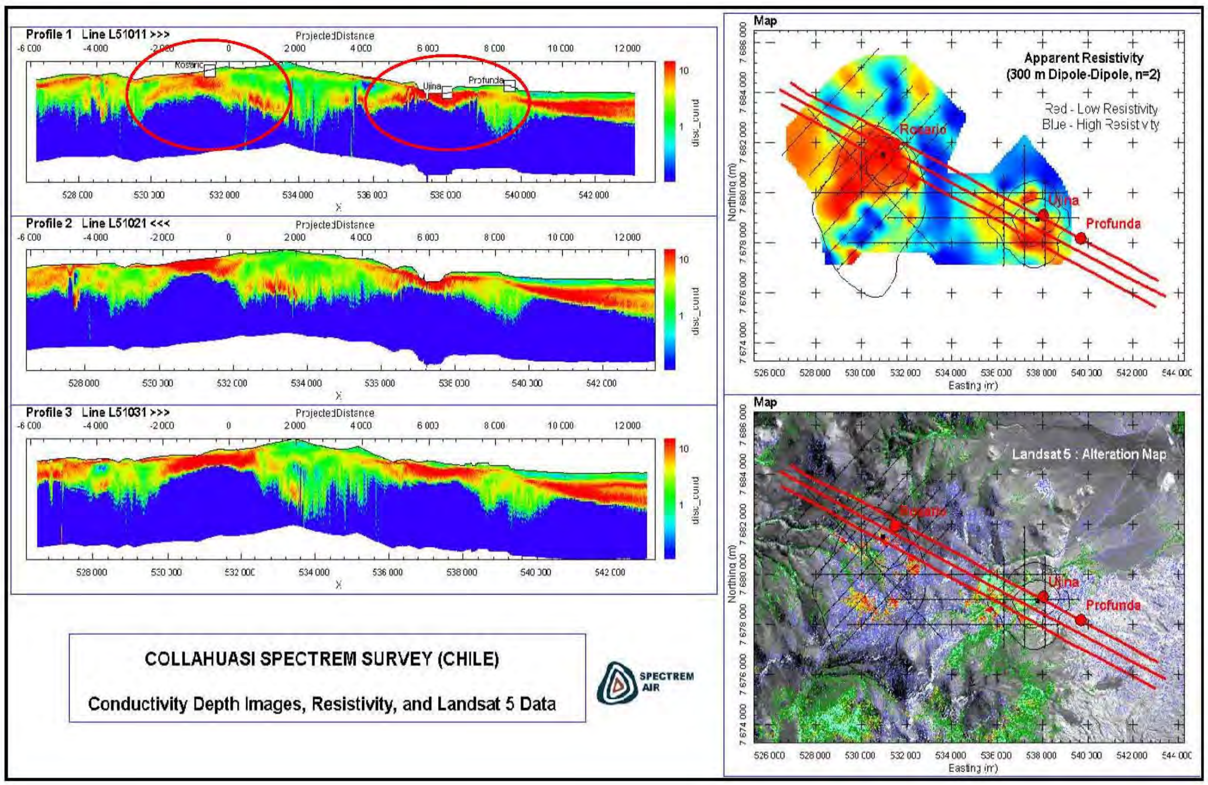
While a supergene blanket is also present at Rosario, it is not as well developed as at Ujina and as well, Ujina lacks to sulfide vein system present at Rosario.



WIP-Collahuasi-Chile

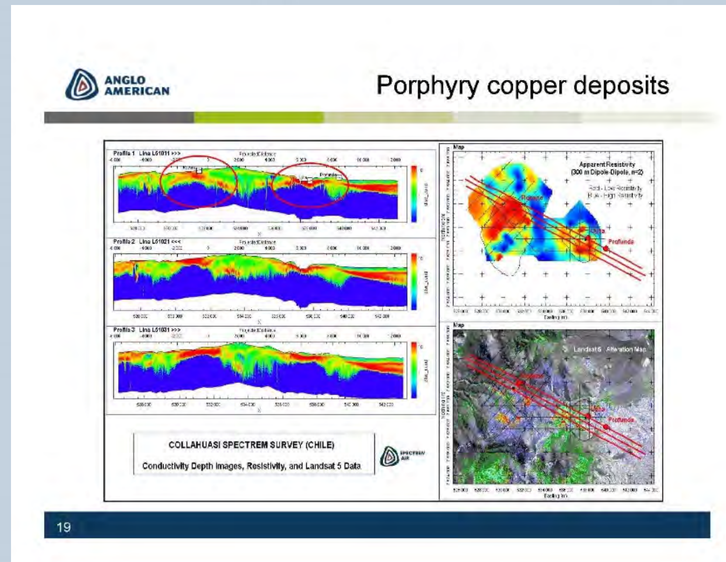
ANGLO AMERICAN

Porphyry copper deposits



WIP-Collahuasi-Chile

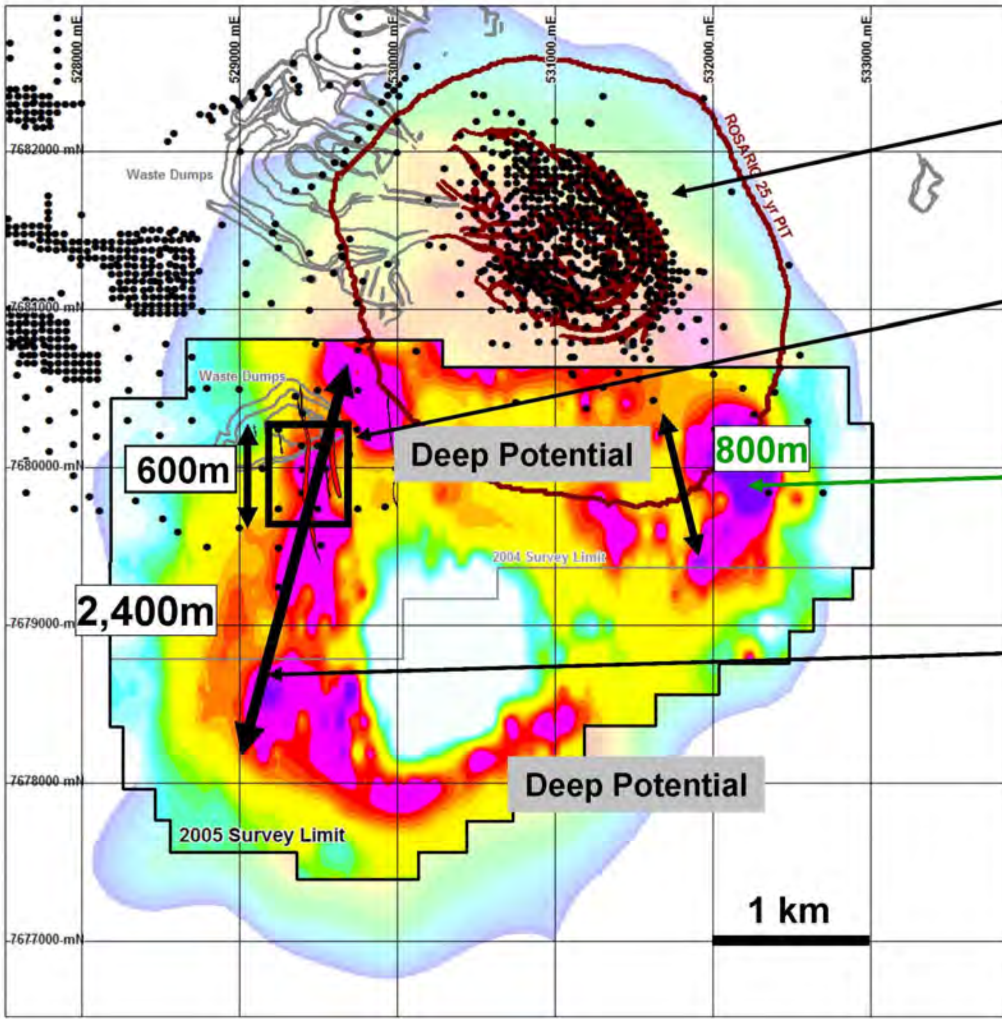
Anglo flew Spectrem, their in-house airborne EM system over Collahuasi in 2000. Conductive zones were defined at both Rosario and Ujina but the these results did not define the geometry of the conductive zones in any definitive way. An extensive conductive zone at a shallow depth east of Ujina was also indicated.



WIP-Collahuasi-Chile

The Greater Rosario Potential

xstrata
copper



Rosario Reserve:
1,062 Mt @ 1.02% Cu

Rosario Oeste
Inferred Resource:
>500 Mt @ 1.00% Cu

Poderosa
Exploration Potential:
300 Mt ???

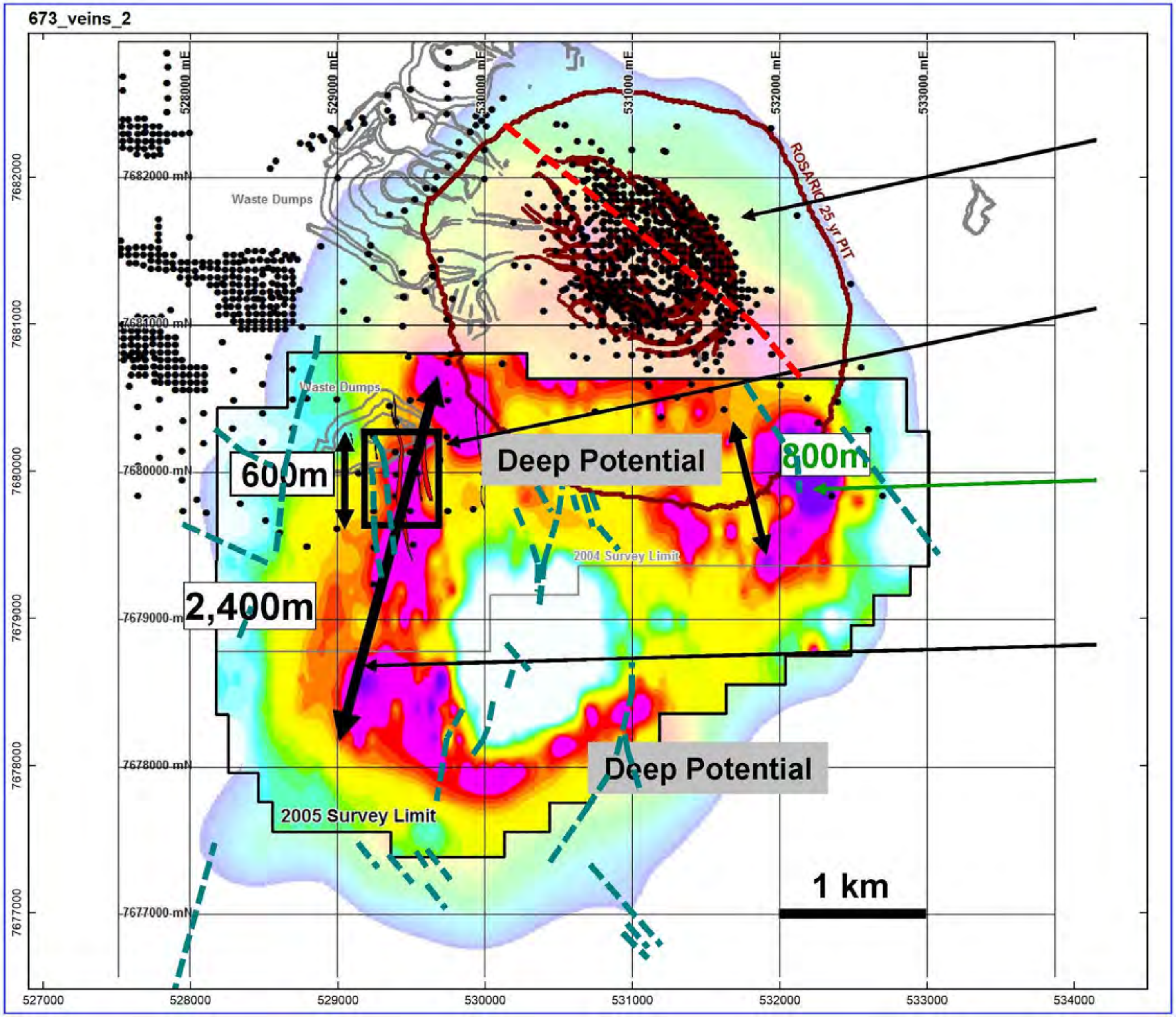
Rosario Oeste
Exploration Potential:
4 X 248 Mt ???

Plus Deep Potential

400m Depth Slice

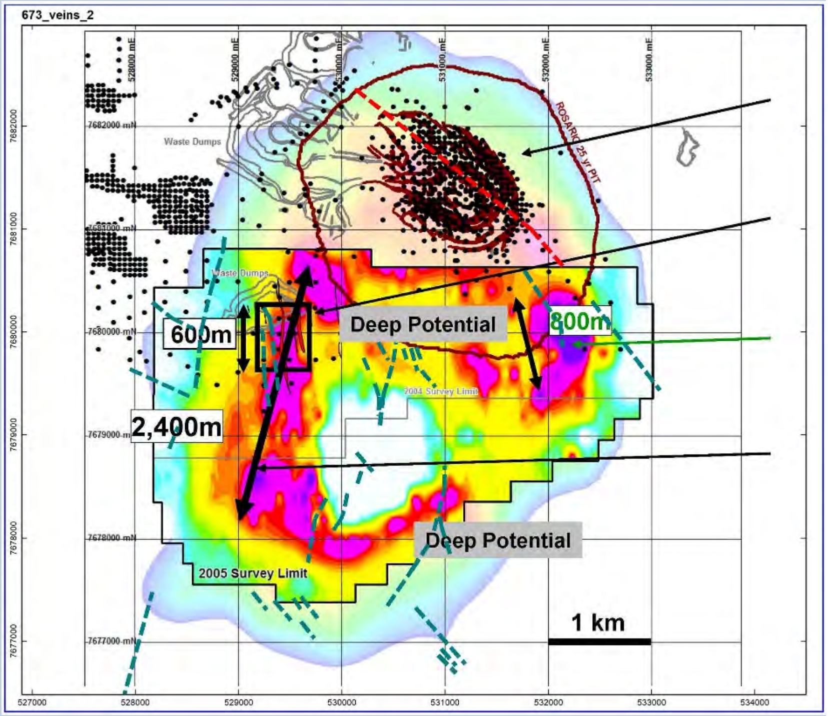
WIP-Collahuasi-Chile

This image summarizes the ground TEM surveys carried out by Xstrata in 2004-2005. In this image, the mapped veins have been added as dashed green lines.

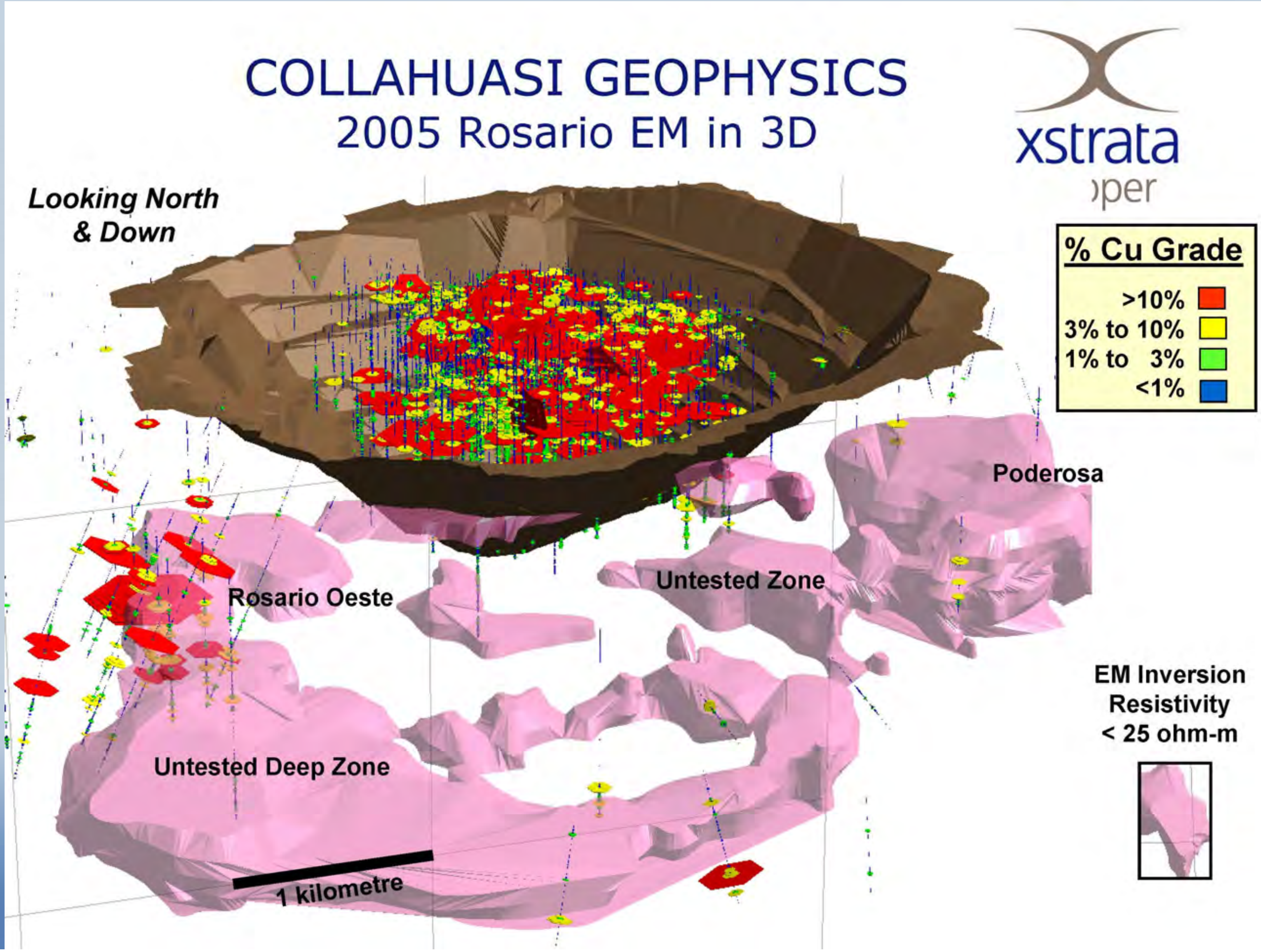


WIP-Collahuasi-Chile

There is a reasonable correlation between the mapped veins and the conductive zone at depth but the conductor at depth appears more continuous than the veins as surface would suggest. The reasons for this are not understood at this time.

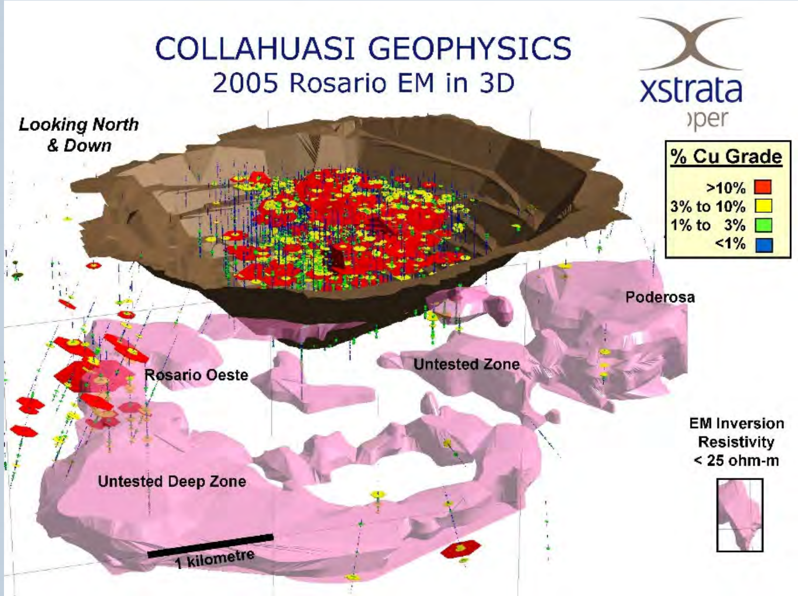


WIP-Collahuasi-Chile

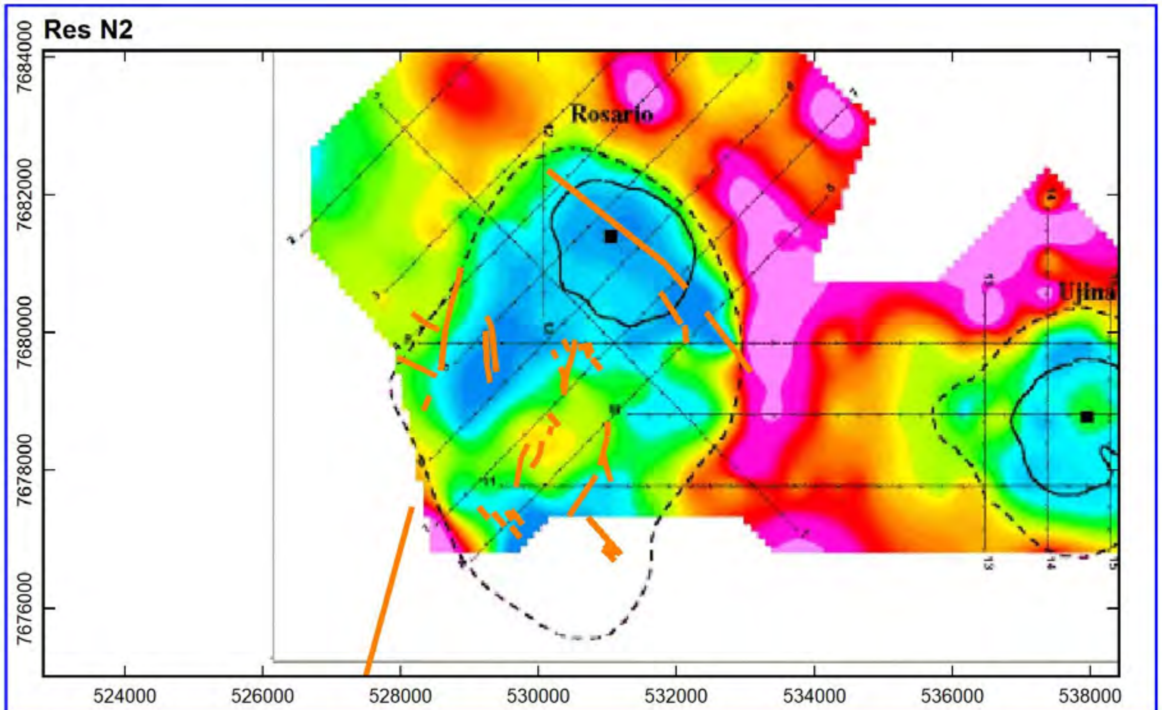


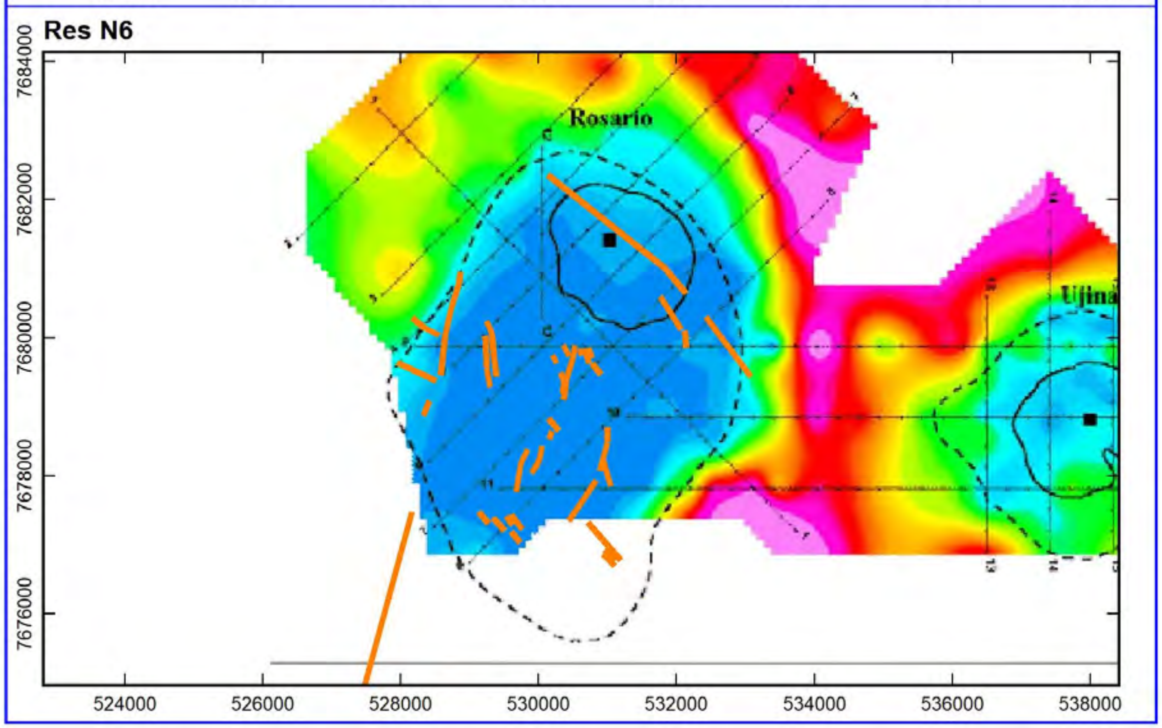
WIP-Collahuasi-Chile

This image suggests good copper grade zones are located close to but no necessarily directly associated with the EM iso-surface (pink body). Also, the EM iso-surface appears to be a roughly circular toroidal shape and how sheet-line veins system seen at surface would be so imaged at depth is not clear. Possibly the nature of the massive sulfide veins changes with depth.



WIP-Collahuasi-Chile

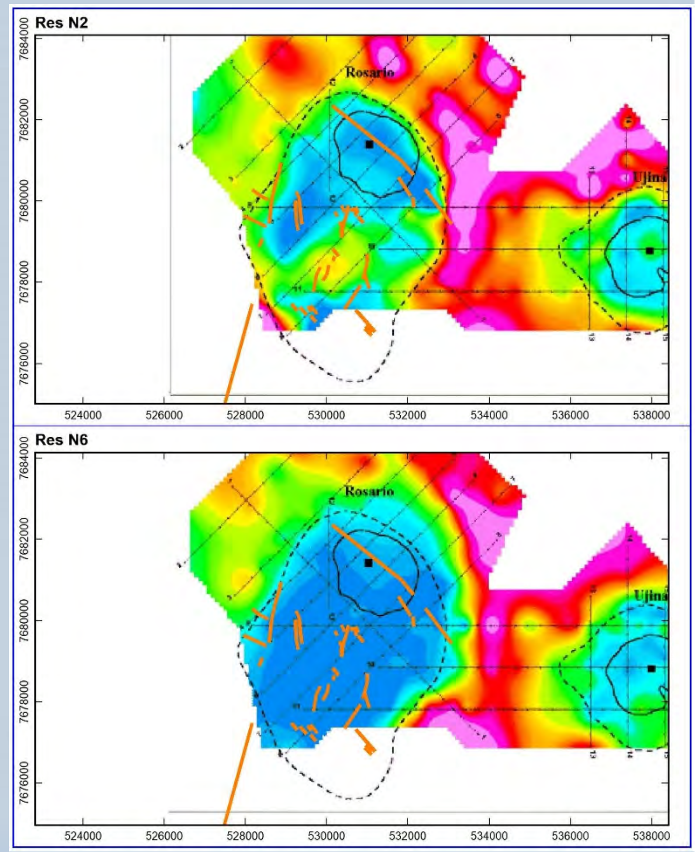




WIP-Collahuasi-Chile

The strong resistivity low at Rosario is mapped very well in the 1991 survey. The major sulfide veins are noted through the area mapped as low resistivity but the veins distribution lacks the overall elliptical shape apparent in the resistivity low. As the IP DC resistivity survey is more sensitive to a volume response (compared to EM which is more sensitive to conductive surface distribution), the DC resistivity low is felt to most likely caused by alteration/disseminated sulfides.

What remains unclear is what happens going from near-surface to 300-400 m depth regards the vein system. The outline of the mapped veins and the shape of the TEM isosurface at a depth of 400 m is quite different. It is hoped the various geological papers might shed some light on how to reconcile these two sets of information.



WIP-Collahuasi-Chile

The Collahuasi porphyry system shows two distinctive modes of conductive response; at the Rosario deposit, massive sulfide veins are believed to be the primary source for the pronounced conductivity low/EM response mapped out with four different EM surveys over a 16 year period. This said, some of the alerted rocks also have extremely low resistivity responses and could be contributing to the observed response.

The adjacent Ujina deposit also shows a conductive response but it is reasonably clear this is due to the supergene blanket located at a shallow depth.

The authors of the SEG Newsletter in 1994 (Dick et al., 1994) cite several other deposits with veins present. By inference, it is believed these could as well have shown an EM response had such a technique been applied. The Butte Montana deposit is one such system as well as the Superior/Magma deposit. Condor has access to a ZTEM survey over the Magma deposit area.

KEW June 28/2019