BIOGEOCHEMISTRY
Discovery Using Metal Concentrations in Plants

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North Silver Bell

The Silver Bell District was recognized for its copper potential in the mid-1950's. North Silver Bell is a 64 Ma (Laramide age) quartz monzonite porphyry-centered system like its immediate neighbors to the south, El Tiro and Oxide. Supergene ores are the result of at least two alteration cycles, and consequently these three deposits of the Silver Bell District are known for their classic leached cap and enrichment blanket. It is estimated that 60-75% of production has come from the non-porphyry wall rock which is predominantly altered dacite porphyry (Lopez, 1995).

In 1974, a reconnaissance biogeochemical survey was done around the operating Oxide and El Tiro pits to demonstrate that trace metal concentrations in mesquite could identify the district. Samples of mesquite twigs were taken from trees growing in dry washes with a sample spacing of approximately one per $3Km^2$. Mesquite are known to have deep tap roots (phreatophytes) and predominate in fracture controlled drainages where deep ground water approaches the surface. It has been demonstrated that riparian trees and shrubs are good surrogates for stream sediment samples, especially in arid climates.

Molybdenum is known to have exceptional mobility in alkaline-dominant terrains. The Mo distribution identified by these 60 mesquite samples shows anomalous concentrations in plant tissue as far as 17 Km from the deposits. The anomalous range is 12 ppm to greater than 45 ppm Mo. Figure 7 shows the anomaly, and offers a strong suggestion that further exploration should proceed in a WNW and NNE direction. As a regional exploration tool, molybdenum in mesquite is an excellent choice.

In 1996, a detailed survey involving over 1000 sample locations was undertaken in the area east and west of the Silver Bell district. At each station, samples of either creosote or paloverde, and soil were taken. Figure 7 shows the location of this survey relative to the 1974 mesquite survey, and Figure 8 shows the extent of the survey west of the El Tiro pit. The colored line segments identify where paloverde, rather than creosote, were sampled. Sample spacing is 100 meters on line-pairs that are 100 meters apart. Most of the line-pairs run north-south and are separated by approximately 830 meters. The total survey area covers approximately 17 Km west to 17 Km east of the Silver Bell District. The results from this large survey are still being studied for mineral potential, however the area is being considered for withdrawal by the Federal Government as the Ironwood National Monument.

One area of particular interest is the North Silver Bell ore body where Asarco started opening a pit in 1999. The 1996 soil and biogeochemical survey includes two line-pairs over what is now the active North Silver Bell Mine. Figure 9 summarizes the results from the local biogeochemical survey, while Figure 10 summarizes the soil data. What we are offered by the plots is a classic trace metal zonation around the Cu-Mo porphyry system.

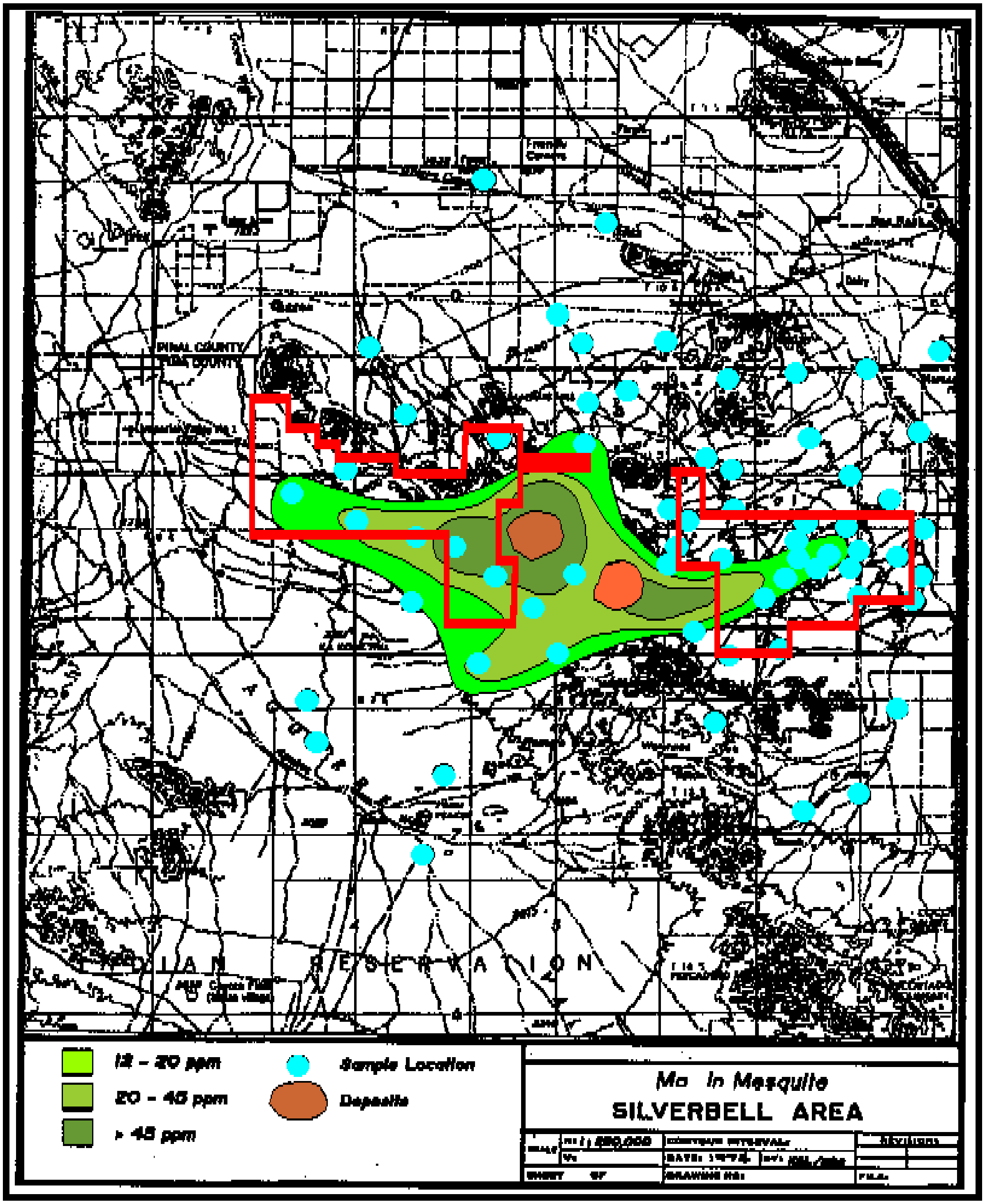

Figure 7. Results from a mesquite survey done in 1974 the Silver Bell Mining District, showing Mo concentrations around the Oxide and El Tiro pits (courtesy of K.A. Lovstrom). In 1996, a detailed creosote and paloverde survey was done in the two areas outlined in red (Courtesy of James A. Briscoe, JABA).

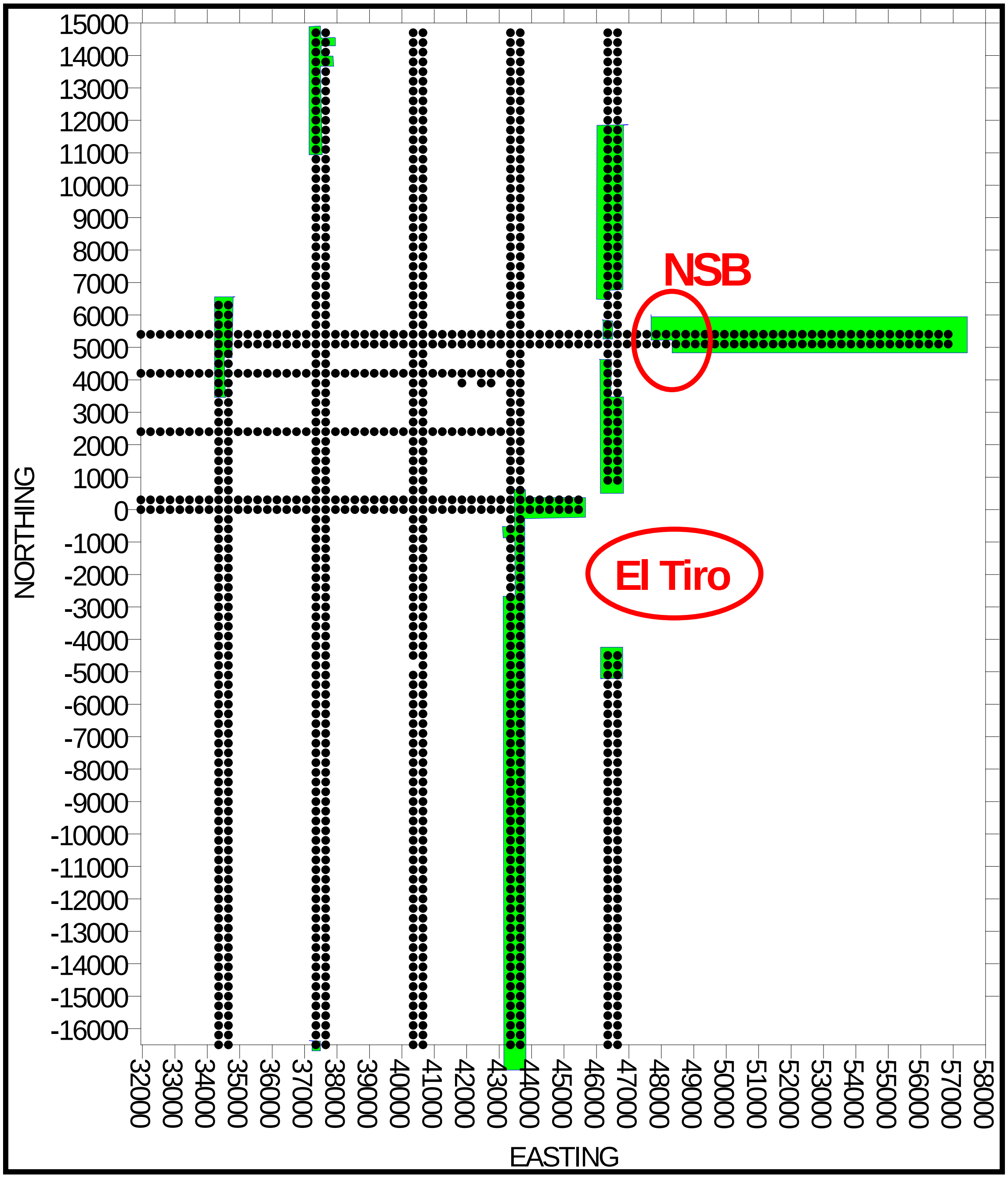

Figure 8. Regional location map for the creosote and paloverde survey conducted in 1996 around the North Silver Bell Mining District, Pima County, Arizona. Shaded area is the location of paloverde samples (Courtesy of James A. Briscoe, JABA).

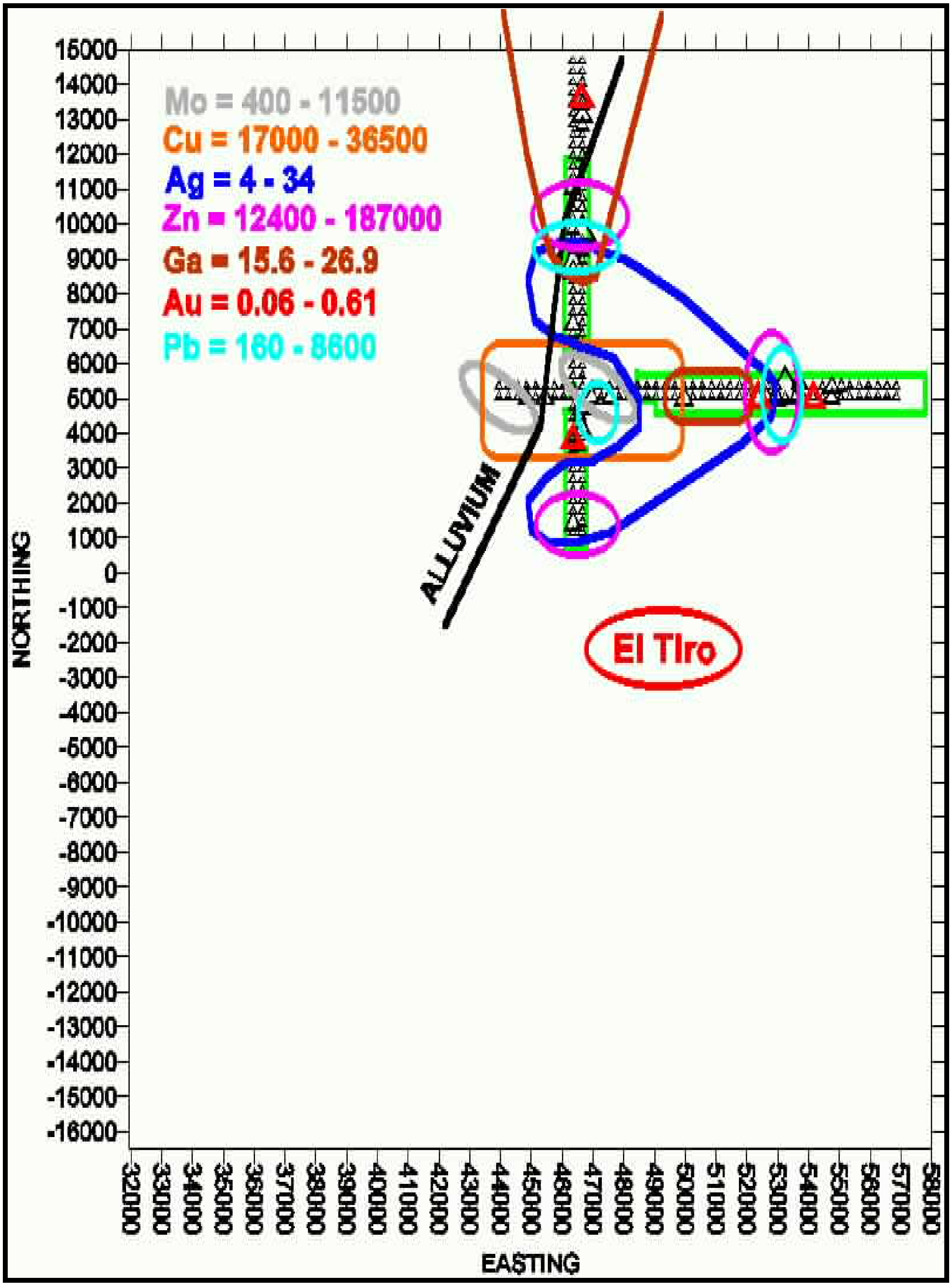

Figure 9. Summary map of metal concentrations (ppb) in creosote and paloverde from the 1996 survey around the El Tiro pit, North Silver Bell Mining District, Pima County, Arizona. Green rectangular area is the location of paloverde samples (Courtesy of James A. Briscoe, JABA).

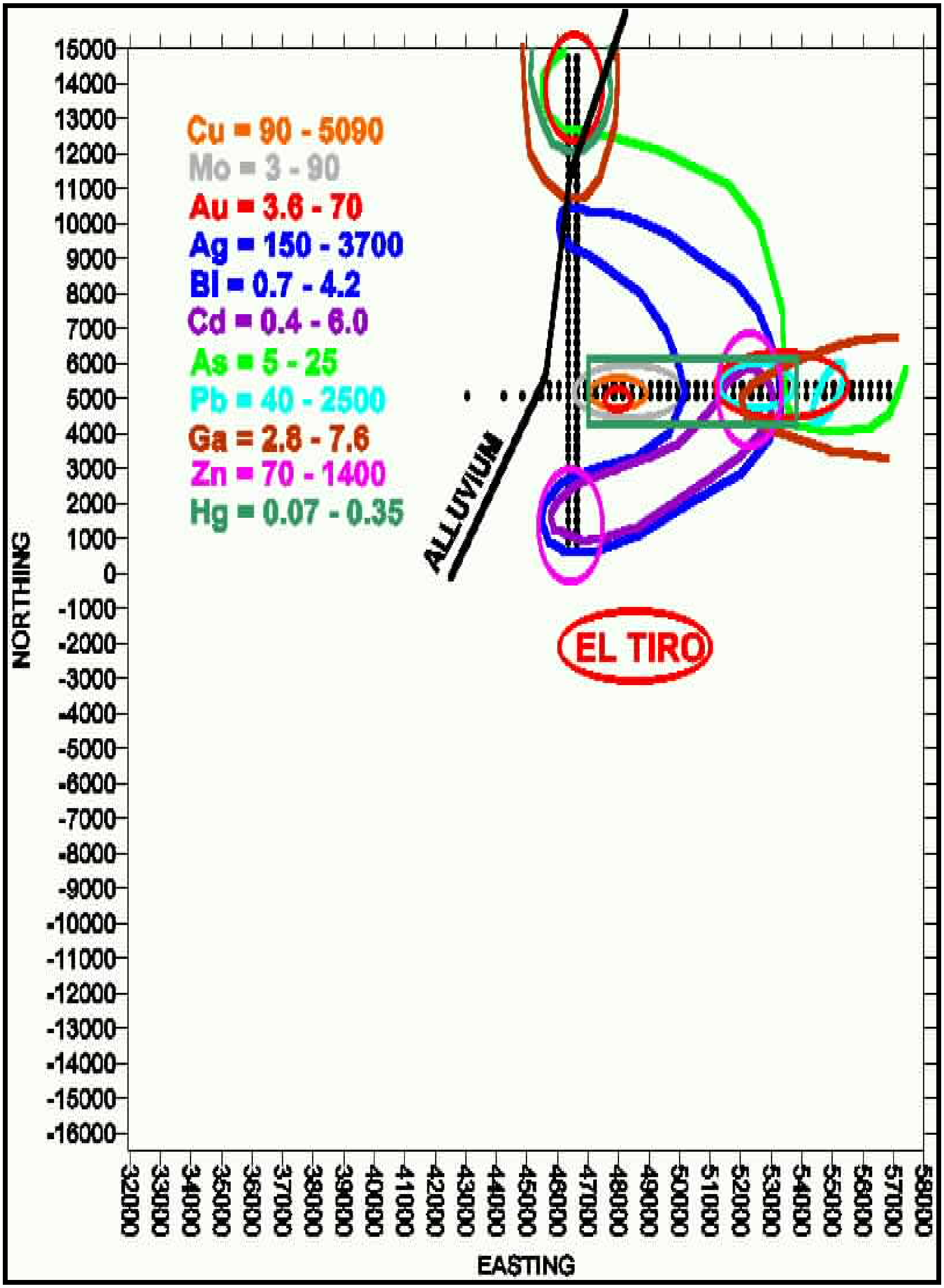

Figure 10. Summary map of metal concentrations (ppm) in soil from the 1996 survey around the El Tiro pit, North Silver Bell Mining District, Pima County, Arizona. Green rectangular area is the location of paloverde samples (Courtesy of James A. Briscoe, JABA).

The soil zonation is (moving outboard): Cu (Au)-Mo-(Ag-Bi-Cd-Hg)-Se-Te-(Zn-Pb)-Sb-(Ga-As)-Au-Hg. This zonation transcends (moving outboard): the potassic (biotite-(chalcopyrite-quartz)-(K-feldspar-quartz)), the Phyllic (quartz-sericite-pyrite), and the Propylitic (epidote, chlorite, calcite) alteration zones. This zonation extends up to 3 Km from the porphyry center.

The biogeochemical patterns are complicated by species effects in paloverde related predominantly to Zn, but also discernible in the Ag and Sb data. Species identification during collection is absolutely necessary where it is likely more than one shrub species will be included in the survey. To get coverage over the North Silver Bell porphyry, paloverde had to be taken since no creosote was growing in the area. To interpret the data and effectively avoid the "species effect" trap, the simple solution was to plot the trace metal data over colored areas that identify where the odd shrub species was collected. Patterns that transcend the transition from one species to the next can be presumed to have little or no "species effect". Elements that display "species effects", yet pattern within one species zone are legitimate and can be tied to patterns that have developed wholly within the other species zone.

After these precautionary measures, we see that the biogeochemical zonation is very similar to the soil zonation, but with some significant enhancements. Most importantly, the copper anomaly is six times larger in areal extent, and indicates mineralization through increasingly thick alluvium (west of the North Silver Bell stock). The highest Mo concentration in creosote is very near the Atlas Fault which is likely a mapable member of the regional left-lateral Cemetery Fault system. There is no corresponding soil anomaly in this alluvial covered area. A strong indication of gold metallization farthest from the stock is provocatively suggested by a very consistent and robust halo of high Ga concentrations in the biogeochemistry data. The Ga pattern in soil is much less convincing.

It is anticipated that in the larger survey area, biogeochemical patterns will indicate mineral potential in alluvial covered terrains. This is where soil data will likely fail to indicate bedrock mineralization.

The North Silver Bell example demonstrates the effective use of reconnaissance and detailed biogeochemical methods as applied to a classic porphyry copper system. Early exploration phases are well served by using a riparian mesquite population for the location of district-sized occurrences. Shrub populations that are widely distributed, like creosote and paloverde, are useful for detailed chemical characterization of the entire system even to the extremities that might reveal associated precious metal deposits. Soils of course are effective where mineralized bedrock is eroding near the surface, but vegetation can be equally effective in these exposed terrains as well as in deeply buried terrains where soils will not be at all effective.