BIOGEOCHEMISTRY
Discovery Using Metal Concentrations in Plants

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Bisbee (Cochise County, AZ)

Introduction

A structurally complex area approximately 20 miles south of the Bisbee porphyry copper mine was identified in the late 1980's for its gold potential. Exposed Cretaceous siliciclastics were mapped to the margins of Quaternary pediment gravels, which obscured what appeared to be the most structurally favorable areas. Because Mesquite and Acacia were widely distributed over the pediment, biogeochemistry was chosen for targeting the drilling program. Mesquite had been used in many earlier surveys with published results, and it was expected that if mineralization were present, Mesquite tissue would be enriched. However, there was no previous experience with White Thorn Acacia, which is the Acacia species with the widest distribution in this particular area.

Ground water was known to be 500 feet from the surface, yet the mineralization was presumed to be just 100-200 feet deep. This posed a serious problem for the biogeochemical survey because experience predicted that without ground water / mineral interaction only weak biogeochemical indications of deep mineralization could be expected.

Sample collection was done between October 26-27 and December 13-17, 1991. Samples from the October collection were analyzed by neutron activation (INAA), but it was observed that high salt concentrations (indicated by elevated Br concentrations) interfered with the accurate determination of Au at 0.1 to 0.8 ppb levels. Also, vital base metals were not reported by the INAA method. So, both the October and December samples were analyzed by ICP/OES for Au, Ag, Cu, Pb, Zn, As, and Sb.

Fig 1a. Location map of Bisbee vegetation survey (1991), relative to Tombstone and the Bisbee Mining Districts on a Google Earth image (2015).

Fig 1b. Detailed location map of Bisbee vegetation survey (1991), relative to the Bisbee Mining District and the historic Easter Sunday Mine on a Google Earth image (2015).

Geology

Cretaceous undifferentiated siliciclastics are exposed in the western half of the claim block where several south-striking thrust faults are mapped (age not indicated). A 1000 foot wide “fault zone” that strikes east-southeast and extends into the area covered by Quaternary pediment gravel postdates the thrust faults. At least one south-striking fault dips at a low angle to the east, but most southeast striking faults are high angle. There is only one mapped east-striking fault with some degree of strike-slip offset. Much later southeast-striking range faults exist under the pediment, which are revealed by gravity and magnetic data.

Quaternary pediment gravels cover the eastern half of the claim block and obscure what appear to be the most structurally favorable areas. Gravel thickness increases to the east to about 200 feet. Gold and silver mineralization under the pediment is related to a zone of southeast-striking faults that parallel the range faults. The biogeochemical data indicate several southwest structures, which were not mapped and may contribute to the structural complexity in the areas where mineralization was encountered by drilling.

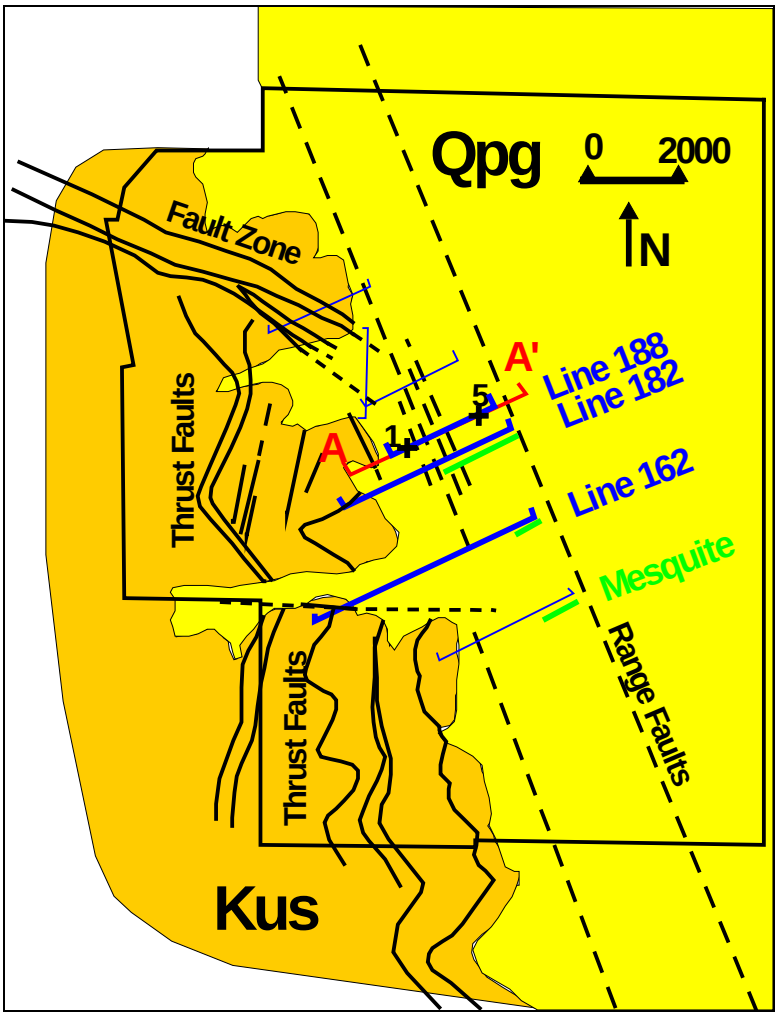

Figure 1. Geology in the area of the Bisbee biogeochemical survey (1991). Mapped faults in the exposed Cretaceous undifferentiated siliciclastics and those divined by magnetic and gravity geophysical surveys underlying Quaternary pediment gravels are shown. Heavy blue lines denote areas where Acacia data is anomalous (thin blue lines where Acacia data is not anomalous). Heavy green lines denote areas where Mesquite samples were taken instead of Acacia. Section A-A' depicted in following figures.

Biogeochemical Results

It was discovered that Mesquite and White Thorn Acacia accumulate comparable levels of metal in their tissues, revealing few if any "species effects". Targets were defined by enrichment of Au, Ag, As, and Sb, accompanied by depletion of Zn and halos of Br.

The area of best economic mineral potential as defined by the biogeochemical data lies northwest of Line 188, between Lines 188 and 182, and on the southwest end of Line 162. Gold mineralization on Line 188 seems to be zonationally related to Ag mineralization on Line 182. A north-south structure defined by the biogeochemical data runs through the mid-point of Lines 188 and 162. Mineral potential is confined to areas west of this structure on those lines. Mineralization in the middle of Line 162 is characterized by Au-Ag-Sb. A single Au concentration of 5 ppb in Acacia near an old adit on the west end of Line 162 is associated with minor concentrations of Ag, As, lesser Au concentrations and a depletion in Zn. Deeper precious metal zones predominate on the west ends of Lines 188, 182, and 162. Figures 2 through 4 show the relationship of trace metal concentrations in Acacia to the drill results. Relatively high gold concentrations of 0.4 to 0.8 ppb on Line 188 are replaced by relatively high Ag concentrations of 40 ppb on

Line 182. Arsenic concentrations halo the Au and Ag occurrences on both lines. Anomalies on other lines are associated with Pb, As, Sb, and Ba, but lack Au and Ag. This association characterizes the "Fault Zone".

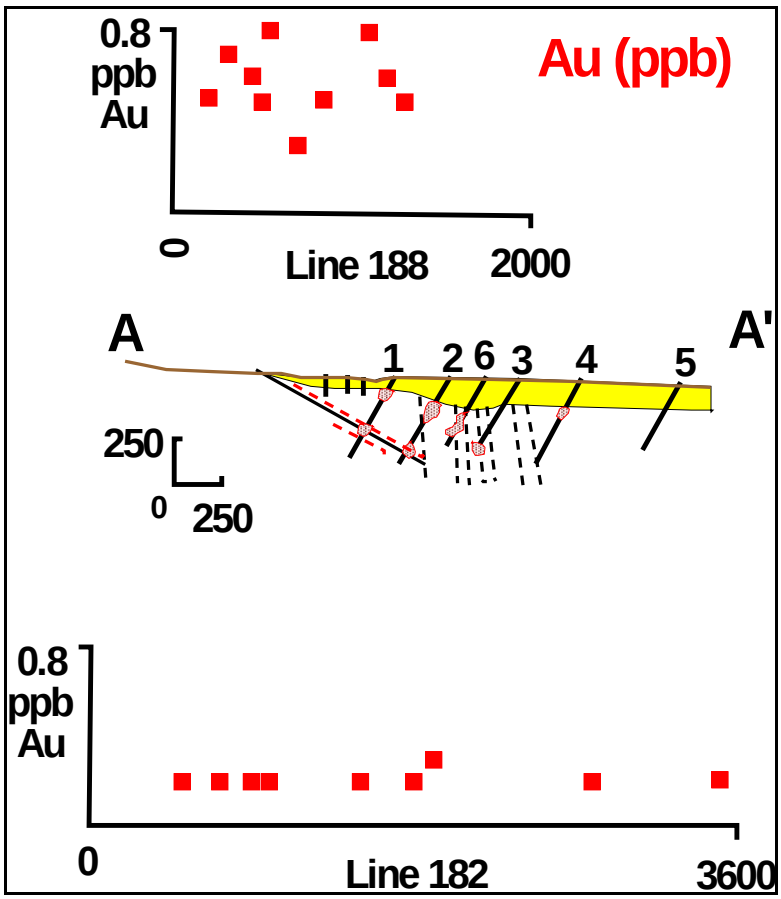

Figure 2. Gold concentrations in twigs (2nd year growth) of White Thorn Acacia on Lines 188 and 182. Section A-A' shows drilling attitude, depth, structures, relative pediment thickness, and "anomalous" Au mineralization on Line 188.

Drill Results

Biogeochemical results were used to target the drilling phase of this project. Ten core holes were drilled: five on Line 188, one about 100 feet northwest of Line 188, one on Line 182, and two on Line 162. A few holes were added to satisfy the whims and biases of the geologist, however all of these were barren.

Holes 1-4 encountered "anomalous" Au concentrations on Line 188 in a zone of several high angle faults, and one low angle fault. Hole 5 was outside the zone and was barren. Holes on other lines encountered very minor mineralization.

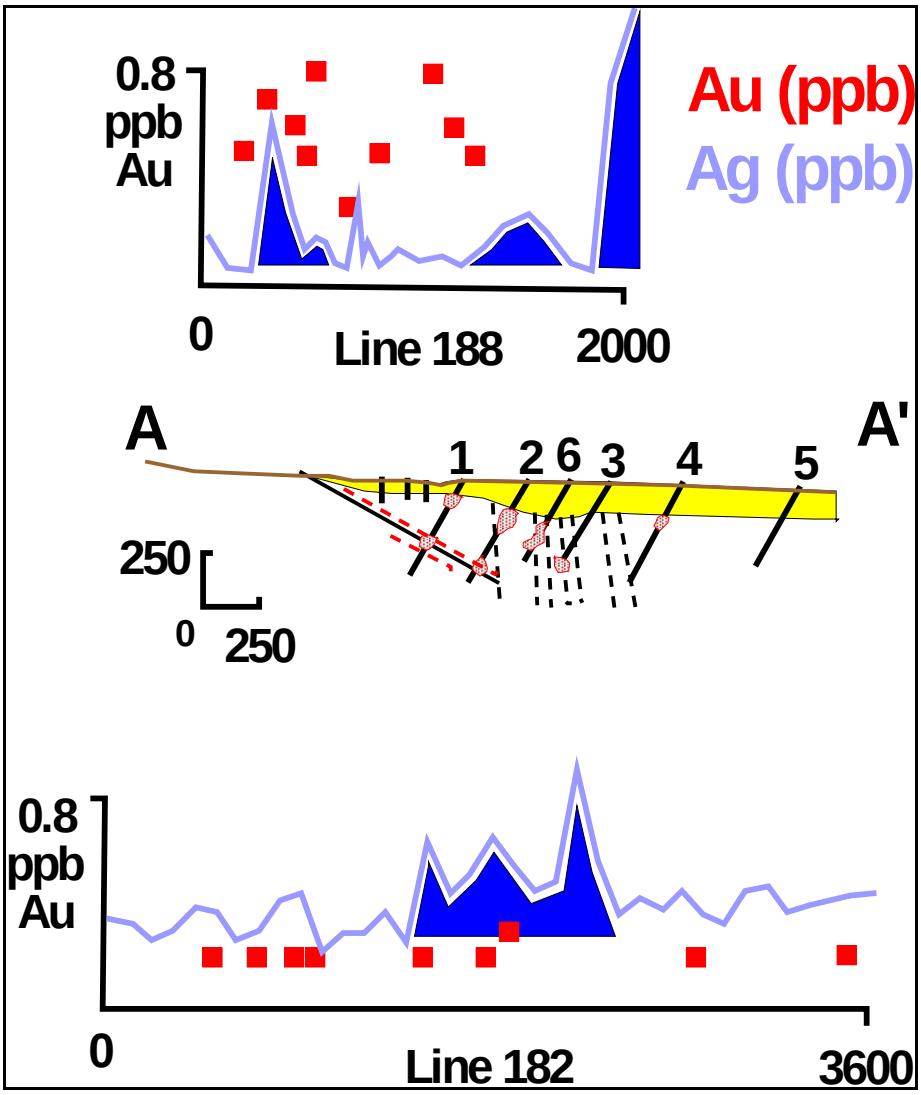

Figure 3. Silver and Au concentrations in twigs (2nd year growth) of White Thorn Acacia on Lines 188 and 182. Section A-A' shows drilling attitude, depth, structures, relative pediment thickness, and "anomalous" Au mineralization on Line 188.

Conclusions

Porphyry copper systems have recently been the targets for satellite precious metal deposits. The Bisbee Project was an early assault on this theme. Biogeochemistry was an easy choice for targeting the later drilling phase because of the wide distribution of Mesquite and Acacia in the area. However, White Thorn Acacia had never been used before, yet other common desert shrubs like Creosote, Paloverde, Sagebrush, and others had been used with exceptional success. Because ground water was not likely to be in contact with mineralization (to the drilling depth of 500 feet), subdued concentration profiles were anticipated during the interpretive phase and factored into the distinction between "anomalous" and "background" (based primarily on experience from biogeochemical results at the Pinson Mine, Nevada). Drilling results confirmed the biogeochemical anomalies and additionally found no mineralization in areas where the biogeochemical data predicted the bedrock to be barren.

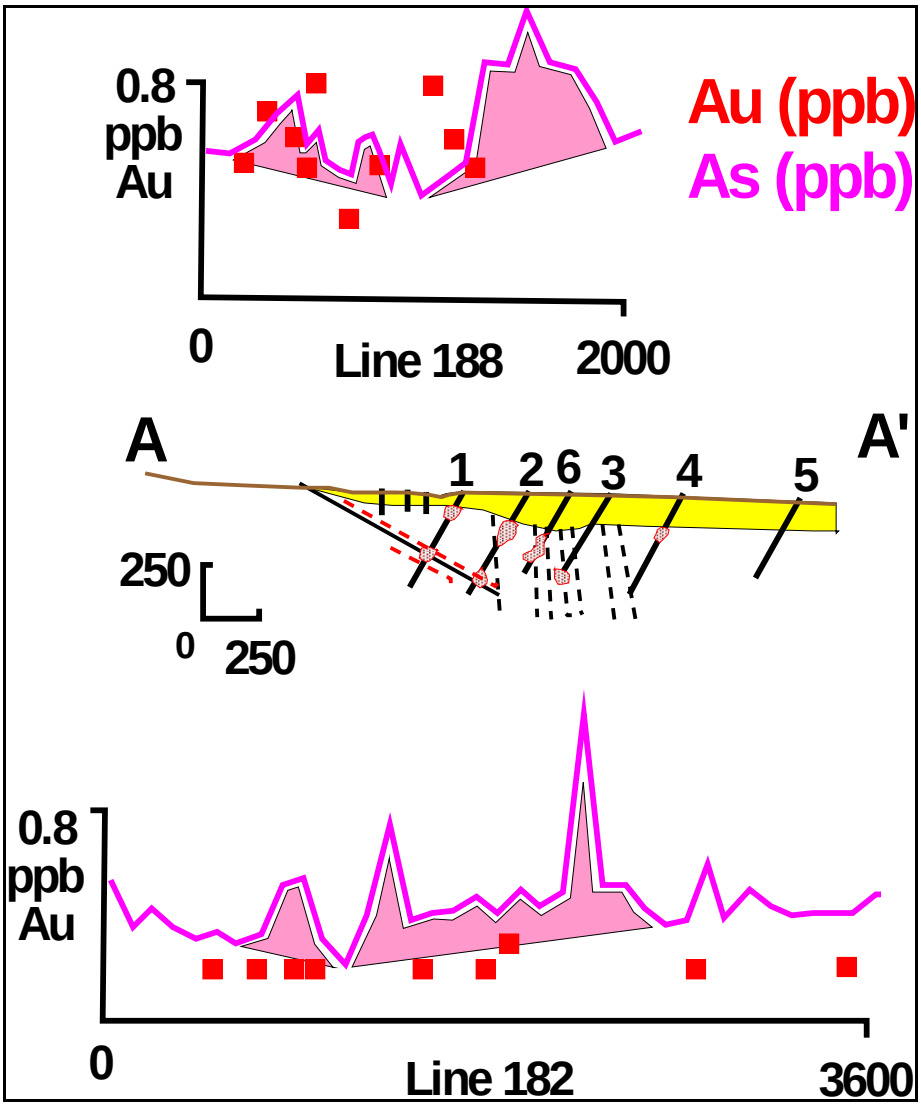

Figure 4. Arsenic and Au concentrations in twigs (2nd year growth) of White Thorn Acacia on Lines 188 and 182. The pattern indicates a structure and contact between two distinct lithologies. Section A-A' shows drilling attitude, depth, structures, relative pediment thickness, and "anomalous" Au mineralization on Line 188.

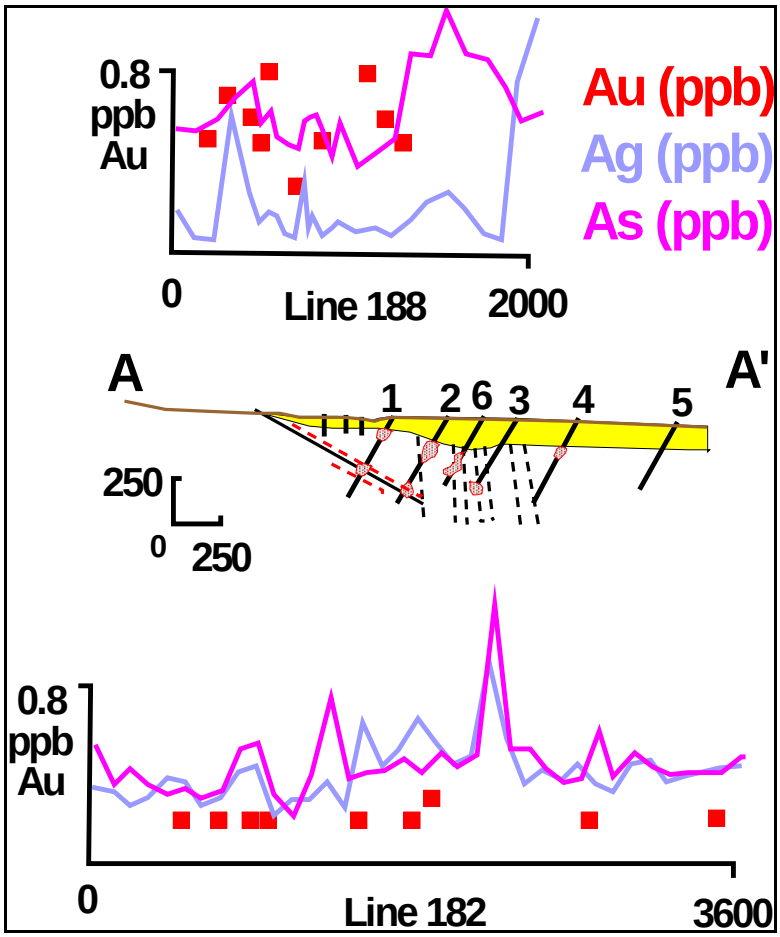

Figure 5. Arsenic, Au, and Ag concentrations in twigs (2nd year growth) of White Thorn Acacia on Lines 188 and 182. Note As and Ag halo Au concentrations. Section A-A' shows drilling attitude, depth, structures, relative pediment thickness, and "anomalous" Au mineralization on Line 188.

Acknowledgement

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