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Chapter 7

CASE HISTORY AND PROBLEM 1:

THE TONKIN SPRINGS GOLD MINING DISTRICT, NEVADA, U.S.A.

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Geochemical techniques played a major role in exploration of the Tonkin Springs district and ultimately led to discovery of economically significant bodies of gold mineralization. Using some of the information obtained during the exploration program, it is possible to review the geochemical environment, secondary dispersion processes and survey techniques used successfully in this part of Nevada.

The Tonkin Springs district is located in west-central Eureka County, Nevada, within the Simpson Park Range approximately 65 km northwest of the town of Eureka (Figure 7.1). Topography is typical of the Basin and Range structural province being characterized by long narrow valleys and north easterly trending mountain ranges with elevations varying between 1,700 and 3,100 m. Precipitation is in the order of 400 mm per year, the major portion of which occurs in the higher elevations during winter and spring. Soils are light brown to brown desert soils of residual origin in locations above the gravel-filled valleys and pediments. Vegetation consists of sagebrush and sparse grass in the valleys with juniper, pinyon and mountain mahogany in the higher country.

> From what you know of Nevada and its environment, can you make a statement as to the type(s) of secondary dispersion process that are operating here?
>
> What local features of the secondary environment are likely to cause problems in a soil survey?

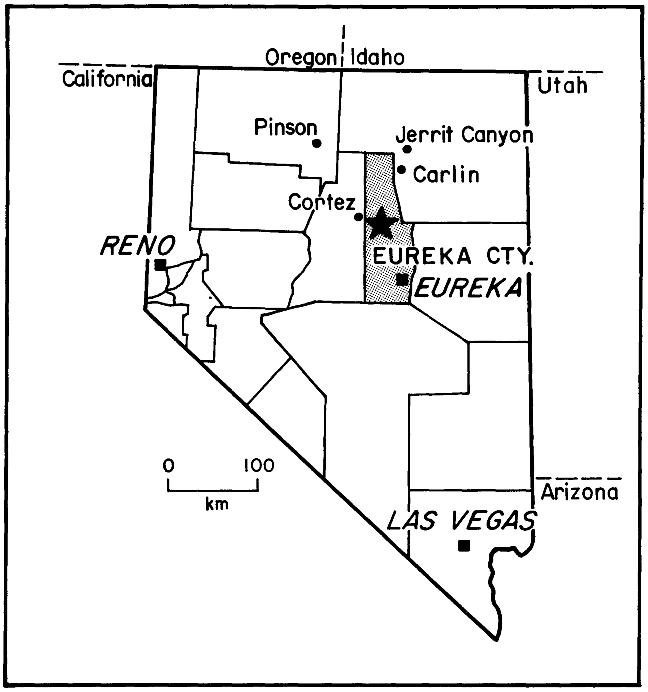

FIGURE 7.1—Regional location map, Tonkin Springs, Nevada.

The district is underlain by Lower Paleozoic sedimentary rocks and by Eocene–Oligocene rhyolite to andesite tuffs and flows (Merriam and Anderson, 1942) (Figure 7.2). The known economic mineralization at Tonkin occurs above the pediment at elevations of between 2,075 and 2,150 m and is localized within imbricate zones of the Roberts Mountain thrust (Roberts, 1966) intersected by high-angle faults. Ore is preferentially developed within silicified shaly carbonate rocks. Mineralizing fluids appear to have accessed the rocks via near-vertical faults and fractures while low-angled thrust faults and their associated breccias provided excellent lateral permeability. Anticlinal areas within the gently folded thrust system appear to have been the most favored sites for ore deposition particularly where the host rocks are overlain by relatively impermeable material such as clay-altered latite sills and rhyolitic ash flows.

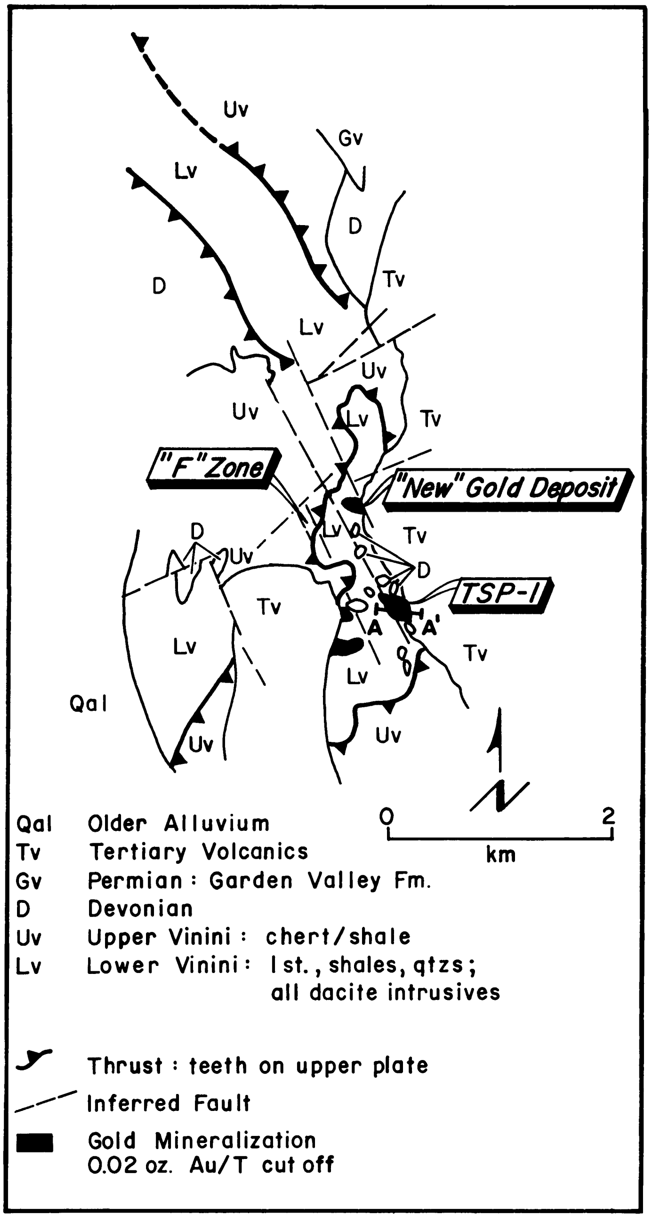

FIGURE 7.2—Geology and ore deposits, Tonkin District, Eureka County, Nevada.

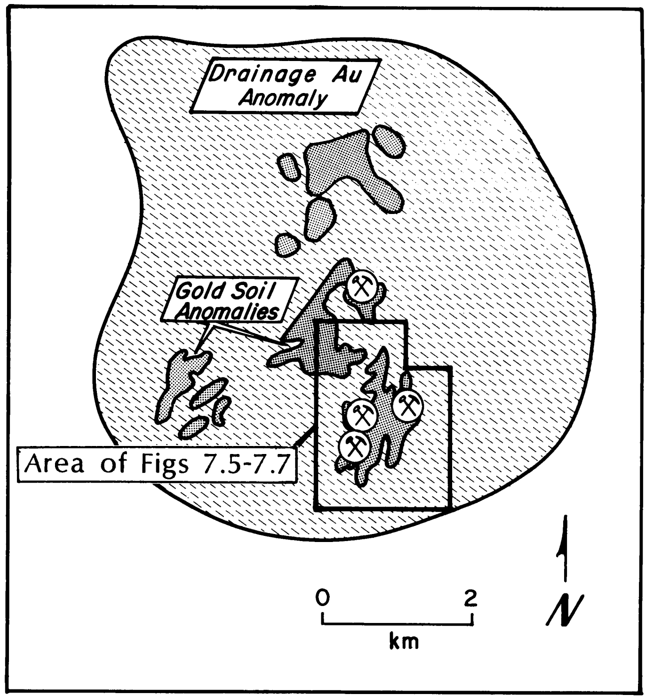

FIGURE 7.3—Distribution of gold in soils and drainage sediments within the Tonkin Springs District, Nevada.

Elevated concentrations of a number of elements related to the gold mineralization are detectable in rocks, soils and drainage sediments over several square kilometers around Tonkin Springs (Figure 7.3). This large surface geochemical expression is thought to reflect the scale of the hydrothermal (hot spring) system responsible for the precious metal mineralization of the district. It will be noted that the soil metal anomalies are enveloped by the drainage anomaly. Indeed it is this large drainage sediment dispersion pattern that allowed the initial appraisal of the Tonkin Springs district.

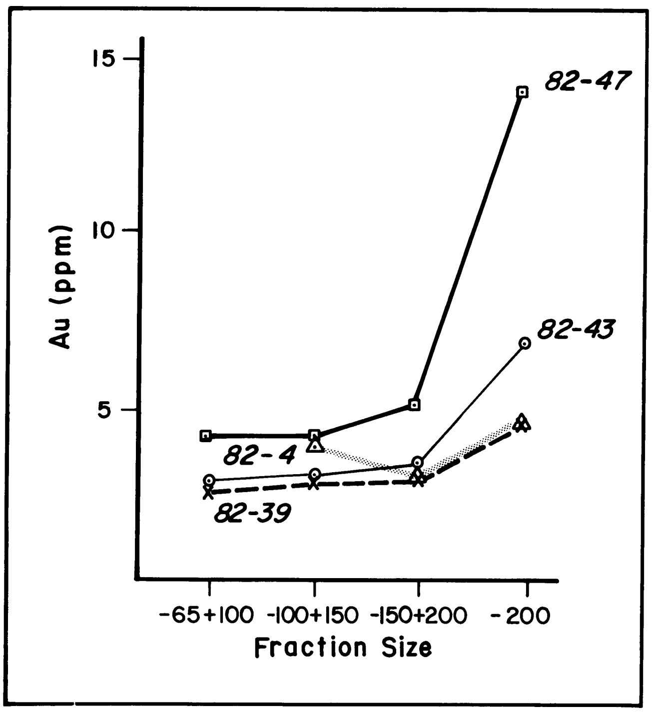

FIGURE 7.4—Gold distribution in oxide ore by fraction size.

TABLE 7.1—Metal distribution in the soil profile and underlying bedrock in weakly mineralized and ore-bearing localities, Tonkin Springs, Nevada. Soil samples are routinely collected at 20–40 cm depth. All results in ppm.

	Depth	Weakly mineralized[1]						Ore bearing[2]			
Horizon	(cm)	Au	Ag	Hg	As	Sb	Tl	Au	Hg	As	Sb
Residual soils											
Organic A	0–2	<0.02	<0.2	0.100	150	4	1.8				
Brown soil	2–20	0.03	<0.2	0.120	150	6	2.2				
Brown soil	20–40	0.05	<0.2	0.160	300	5	2.6	0.5	0.276	110	7
Brown soil	40–60	0.04	<0.2	0.115	500	7	3.3				
Bedrock											
	60–150	0.13						1.2		900	
	150–300	0.27						3.8		3000	
Average ore		4.5	3.4	3.6	900	28					

[1]Location 82-23 Figure 7.9
[2]Location 82-2 Figure 7.9

Stream sediment sampling led to recognition of the major mineralized areas, which were subsequently investigated by the soil survey described here.

In the unoxidized ore, gold occurs as submicron sized particles within framboidal pyrite accompanied by arsenic as orpiment and realgar and mercury in the form of cinnabar. Antimony occurs as small clusters of acicular stibnite. Oxidized ores contain free gold as finely divided particles with limonite and scorodite. Examination of the distribution of gold within various size fractions of crushed oxide ore confirms the association of gold with the minus 200 mesh fraction (Figure 7.4).

TABLE 7.2—Threshold values for Au, As, Sb and Hg in residual soils, 20–40 cm depth, Tonkin Springs, Nevada. Results in ppm.

Au	As	Sb	Hg
0.02	100	7	0.100

The character of the oxidized ore has some clear implications for the type of sampling and sample preparation that might be applied in an exploration soil survey program. Try to list these and also explain how the host rocks and local secondary environment may cause you to modify your approach.

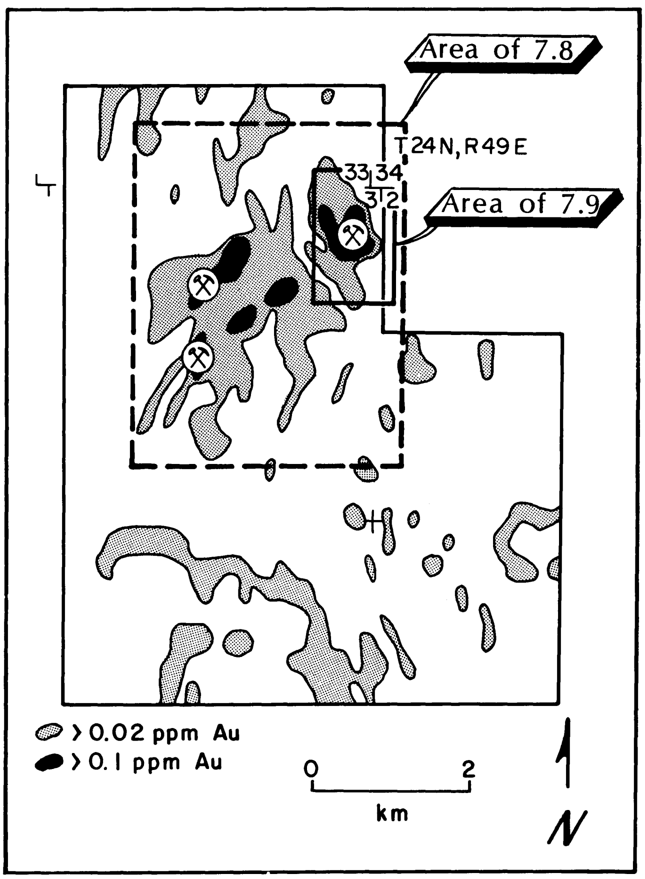

FIGURE 7.5—Distribution of gold in soils within the study area, Tonkin Springs.

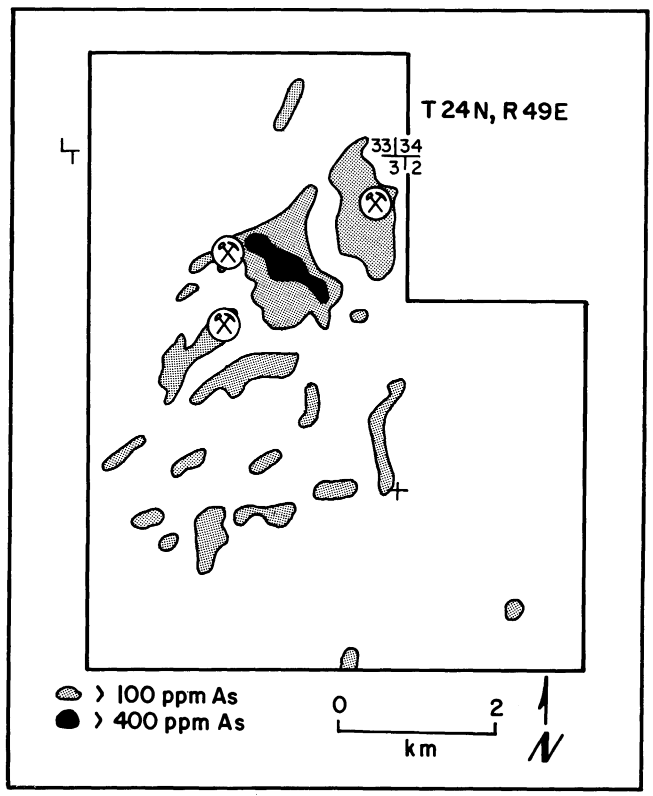

FIGURE 7.6—Distribution of arsenic in soils within the study area, Tonkin Springs.

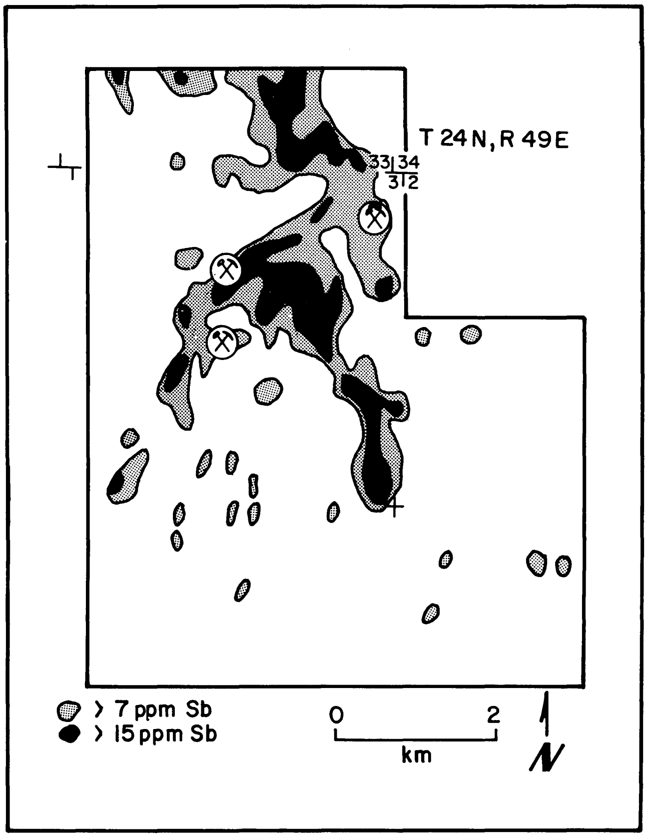

FIGURE 7.7—Distribution of antimony in soils within the study area, Tonkin Springs.

Above average concentrations of Au, Ag, Hg, As, Sb and Tl which characterize the Tonkin Springs mineralized zones, enter the residual soils upon oxidation and weathering. Limited data concerning the distribution of metals through the profile of the residual soil and near-surface bedrock are listed in Table 7.1 from weakly mineralized and ore-bearing areas. The results presented are for minus 80 mesh material analyzed for the contained metals following a hot mixed acid digestion. These data show a general but weak tendency for the metals to increase in concentration with depth in the soil profile and a rather abrupt increase from the soil to the mineralized near-surface bedrock. It is worth noting that the A organic-rich layer of the soil is impoverished in gold but generally indicative of mineralized bedrock, in terms of Hg and As values, when compared with threshold levels for these elements in routine soil samples (Table 7.2).

> The data presented indicate that an acceptable geochemical contrast can be obtained by routine sampling at a depth of 20–40 cm. Can you design an orientation study for this area that could quickly confirm the suitability of this procedure and also reveal any opportunity for further optimizing survey procedures?

> With the data available here can you suggest any supplementary or alternate procedures that would improve survey efficiency?

Detailed soil sampling at Tonkin Springs reveals the soil metal anomalies to be rather complex (Figures 7.5, 7.6, 7.7). One of these metal-rich locales occupies an area 1,000 × 2,000 m and consists of a number of composite Au, As, Sb, Hg anomalies (Figure 7.8). The high metal values tend to be aligned in two main directions; namely, NNW and NE, which closely approximate the two principal normal fault sets mapped in the bedrock. Except for Hg, composite metal soil anomalies are developed exclusively over limestones, shales and sandstones of the Lower Paleozoic. Mercury alone, however, is strongly enriched in soils over certain sections of the clay-altered Tertiary rhyolites and within a number of linear features over the Lower Paleozoic section.

> Can you give any explanation for the unique behavior of mercury?

In Figure 7.9, attention is focused on a portion of the soil metal anomaly where economic grades of gold have been located. Examination of the gold data indicates that the 0.1 ppm and 1.00 ppm isopleths in soils and surface bedrock, respectively, define the bounds of near-surface gold ore fairly accurately. In contrast, deeper ore zones overlain by barren rocks, although within the limits of the soil anomaly, are not clearly evidenced by the gold values in surface soils. Furthermore, when the other ore elements are considered, results are similarly inconclusive. Indeed, gold values in soils appear to be a more reliable guide to suboutcropping ore than does soil data for Hg, Sb or As.

> What does this information tell you about the mode of occurrence of gold in soils at Tonkin Springs?

> There are a number of possible reasons why gold might not be a reliable guide to suboutcropping ore. Can you describe any of them?

Ore grade gold values have been intersected in drilling at a number of localities within the 1,000 × 2,000 m soil metal anomaly described in this report. These ore pods are indicated by coincident Au, Hg, As, Sb soil anomalies, and all occur under minimal cover. Blind ore deposits cannot be discerned with any degree of confidence from the conventional soil geochemistry reported here.

> The large area characterized by raised concentrations of indicator elements (and gold) and the known structural complexity of the area suggest a very high potential for blind and buried gold ore bodies. Can you recommend any survey procedures that might be suitable for the search for such deposits in this geological/geochemical environment?

> Of the procedures you have identified, which do you feel would be most successful and which most cost effective? These may or may not be the same.

> What criteria would you use to select the appropriate survey procedure?

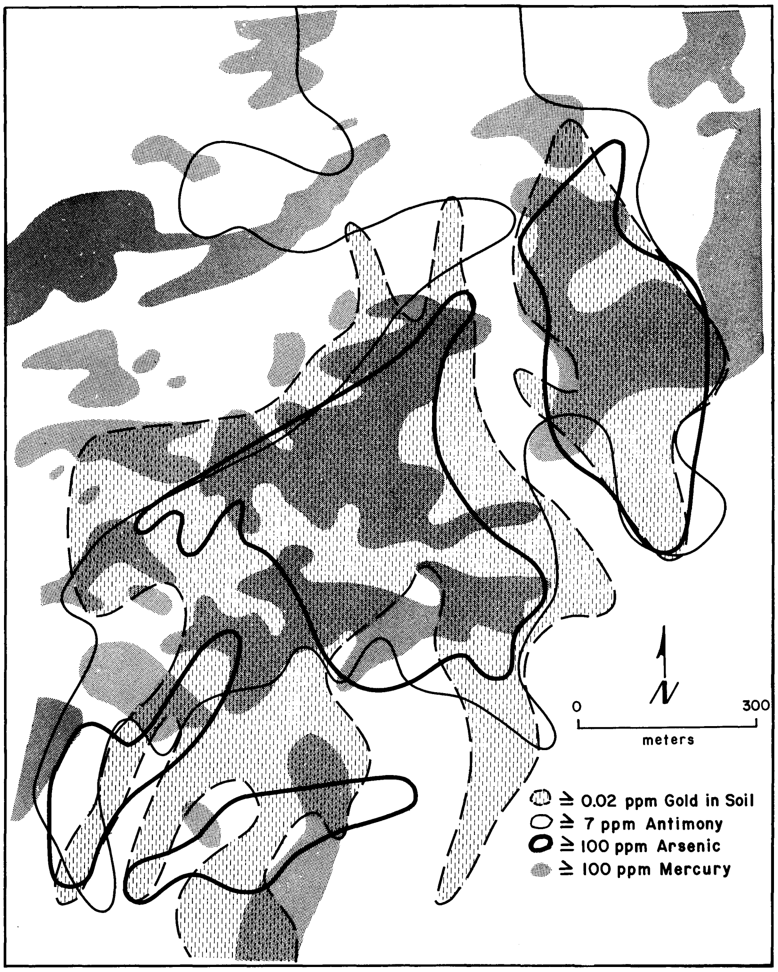

FIGURE 7.8—Distribution of gold, arsenic, antimony and mercury in soils within the detailed study area, Tonkin Springs.