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SOLID-SAMPLE GEOCHEMISTRY STUDY OF WESTERN DIXIE VALLEY, CHURCHILL COUNTY, NEVADA -- PART II, SOIL GEOCHEMISTRY

Russell W. Juncal[1] and Elaine J. Bell[2]

[1]Geothermal Development Associates
251 Ralston Street
Reno, Nevada 89503

[2]Mackay School of Mines
Mackay Minerals Research Institute
University of Nevada
Reno, Nevada 89557

Abstract

Numerous thermal springs present in northern Dixie Valley, Nevada, are the surface expression of a deep-seated geothermal system. The strucural setting, a complex asymmetric graben controls the location of surface springs and migration of thermal fluids to the surface. The distribution of arsenic and mercury in the soils of the valley correlates well with the occurrence of structures which may be in communication with the underlying geothermal system. Generally anomalous arsenic values occur along structures near the playa where fine-grained sediments and a high water table occur. Mercury values are uniformly low near the playa but are typically anomalous along structures in the coarser fan deposits.

The complementary geochemical signatures of arsenic and mercury which arise from basic differences in elemental chemical behavior have been useful in delineating the structural trends of the valley. The structural model indicated by the geochemistry and results of drilling suggest future targets should be selected east of the Dixie Meadows fault, within the "inner graben".

Introduction

A general association of mercury (Hg) and arsenic (As) with geothermal activity has been demonstrated by many workers. The purpose of the present study was to determine the soil geochemical distribution of these two elements in a portion of northern Dixie Valley and to relate the observed distribution patterns, where possible, to the geothermal influence. The approximate extent of the study area and general background information are given in a companion paper (Bell and Juncal, this volume).

The complex structural setting of Dixie Valley has made the geothermal system difficult to characterize. Many structures serve or have served as preferential conduits for fluid migration as evidenced by alignments of springs, seeps and fumaroles, and the subsurface and surface concentration of intense hydrothermal alteration along these features. This is best seen along the range front fault where very intense localized alteration is observed, associated with fumaroles and the presence of hot water within 30 m of the surface, as indicated by drilling.

Water chemistry data show major differences between hot spring systems at Sou, Hyder and Dixie Meadows, implying a lack of communication between structures. The exact heat source and precise structural or stratigraphic factors controlling the system have not yet been defined.

Broad scale sampling (730 m x 305 m grid) outlined specific areas for more detailed work. Additionally, high density sampling (30 - 180 m) was performed in the vicinity of two exploratory wells and across specific structural features.

Soil samples were collected from a depth of 25 to 30 cm. This depth was chosen on the basis of randomly selected vertical soil profiles from the three major soil environments: upper alluvial fan slopes, fan piedmont and playa. The profiles indicated Hg and As values generally increased with depth, with a zone from 15 to 25 cm where values tended to increase substantially and then level off. These results were taken as representative of the study area, indicating much higher As and Hg values roughly corresponding to the B horizon. Because identification of specific soil horizons is difficult in many places and considering the study of Klusman and Landress (1978) which showed that variation of secondary soil parameters did not mask significant geothermal mercury anomalies, a standard sampling depth was chosen.

Soil mercury concentrations were determined by AAS using borohydride generation methods while arsenic analyses were performed using colorimetric techniques. Replicate samples were analyzed for temporal and analytical variance; however, neither of these variances were significant.

Results

The results of the broad grid sampling of mercury are depicted by geochemical contours in Figure 1. This geochemical surface reveals some important aspects of the distribution of mercury in Dixie Valley. Most notable are the isolated high at the Dixie Comstock Mine and the somewhat broader high to the north near a group of fumaroles. Both areas exhibit metallic mineralization along the range front. Also apparent is the trend toward lower mercury values away from the range front closer to the playa.

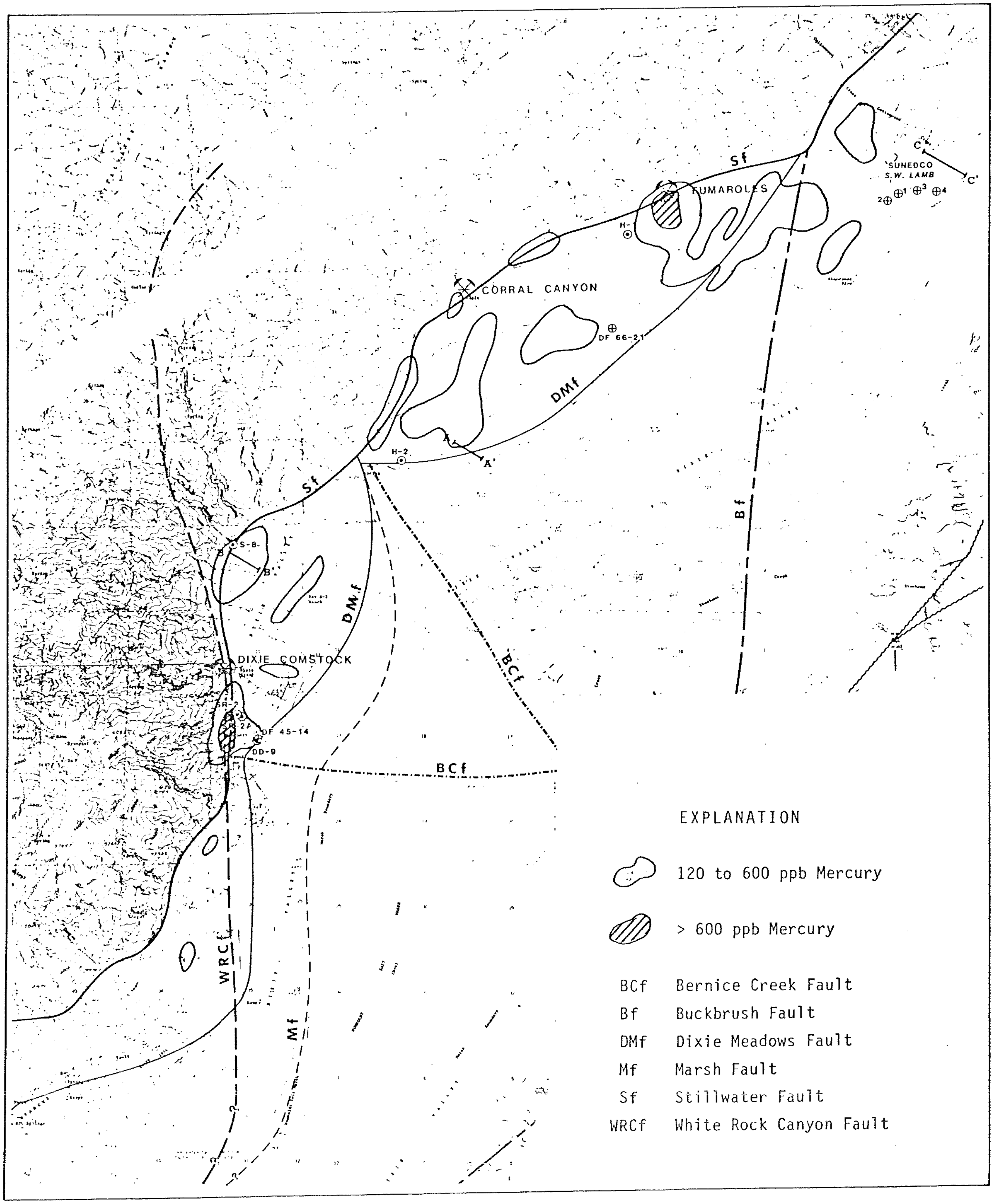


Figure 1. Mercury geochemical surface.

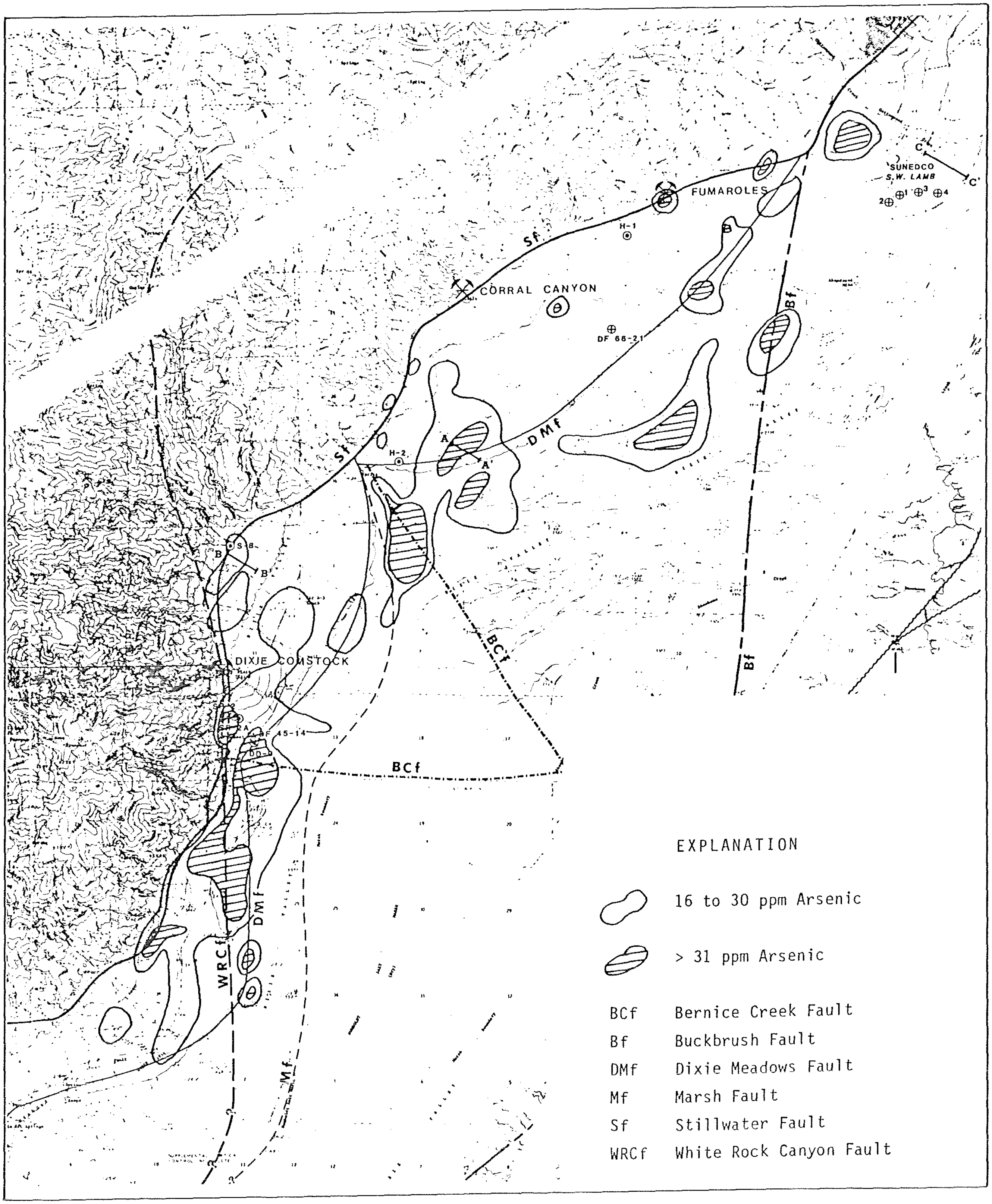
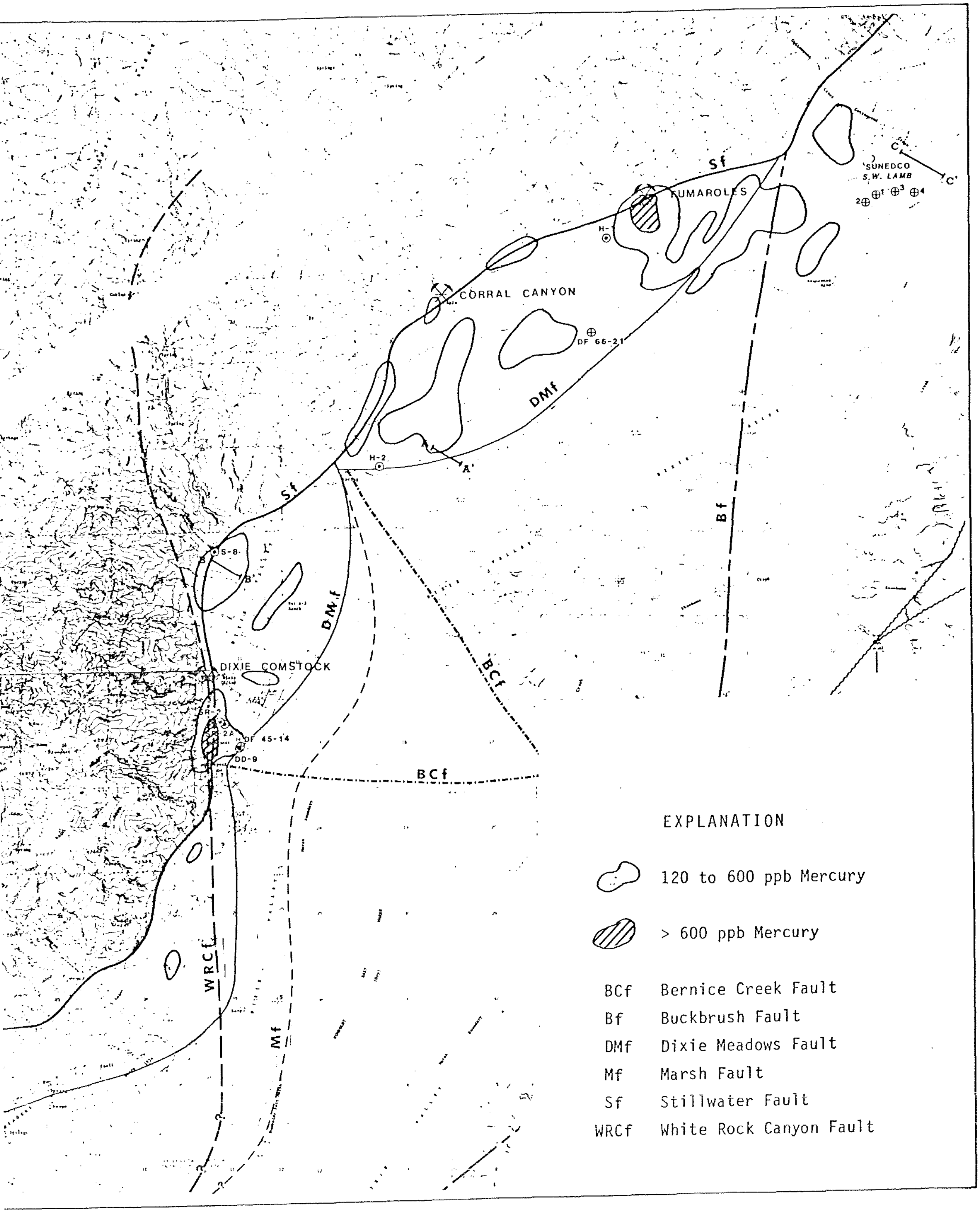


Figure 2. Arsenic geochemical surface.



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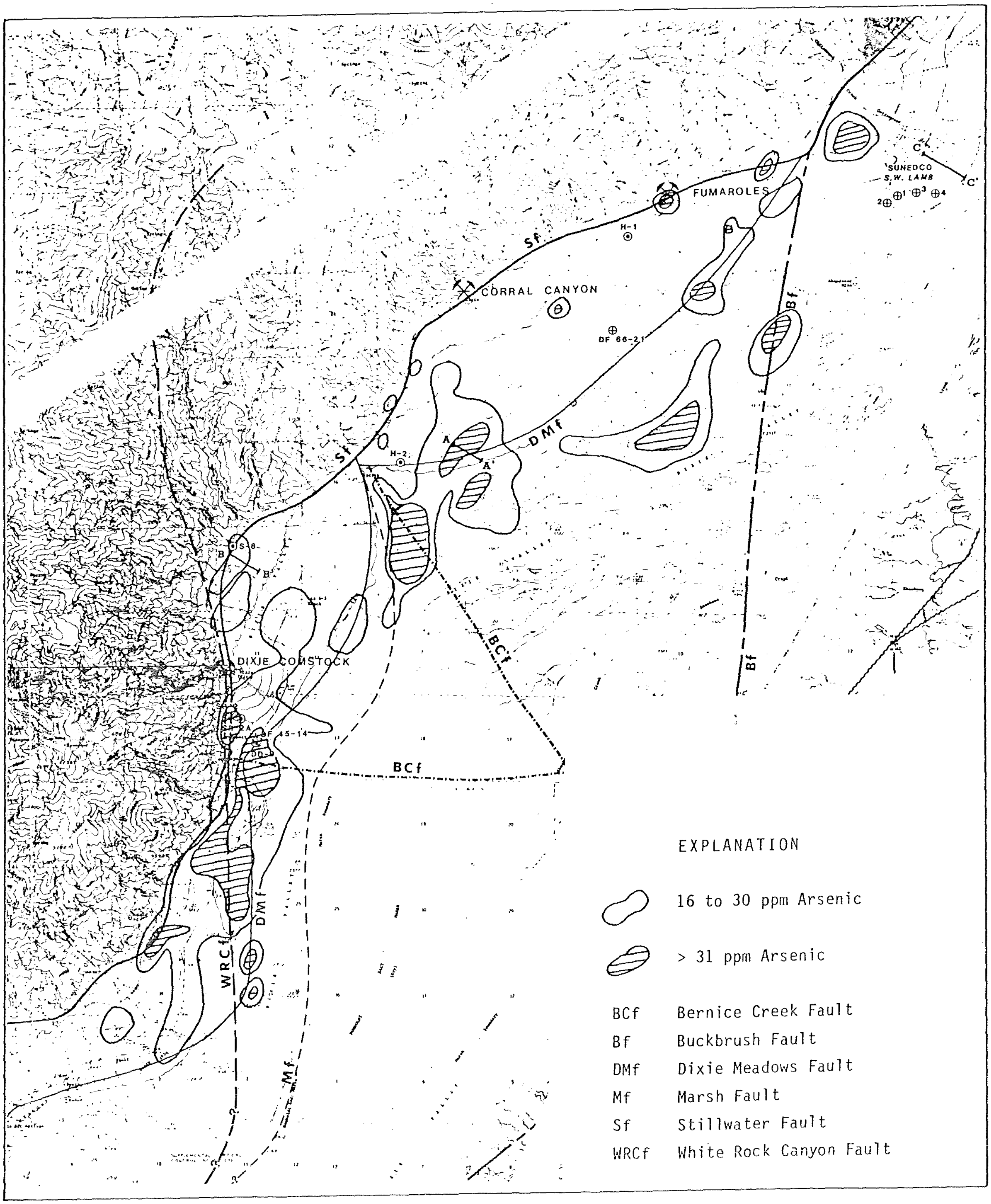

Figure 2. Arsenic geochemical surface.

Log probability graphs of the mercury data suggest the presence of three lognormally distributed populations. These three groups probably arise from three separate sources and/or dispersion mechanisms, tentatively identified as: background (<20 ppb), a geothermally influenced population (20 - 600 ppb), and a mineralized population (>600 ppb). The background and intermediate populations of mercury values overlap considerably, while the values of the highest population, exclusively associated with areas of mineralization, exhibit considerably less overlap.

The arsenic geochemical surface is depicted on Figure 2. Arsenic highs occur near the Dixie Comstock Mine and fumarole area to the north, but are not as strongly anomalous as the mercury. In contrast to the mercury distribution, high soil arsenic levels are more prevalent towards the playa, particularly right at the playa margin.

A log probability graph of the arsenic values indicates an apparent bimodal distribution with a large population ranging from 5 ppm to approximately 35 ppm and a smaller population of values greater than 35 ppm. Unlike the mercury data, the highest population of arsenic is not as clearly associated with mineralization. However, many of the high values are associated with drainage from mineralized areas and may be hydromorphic dispersion halos. This is consistent with the affinity of arsenic for the liquid phase, particularly in comparison with mercury. At least four relatively high arsenic values are associated with springs, and another possibly with drillhole discharge during well testing. Thermal fluids from drillholes DF 45-14 and DF 66-21 showed rather high As contents (0.59 and 2.1 ppm, respectively; Bohm and others, 1980) making source implications for these latter anomalies clear.

Discussion

The rather poor correlation between mercury and arsenic values for the broad grid sampling (Pearson's r = 0.14) is indicated by the distinct distribution patterns shown in Figures 1 and 2, and is a reflection of their differing geochemical behaviors in the surface environment. Arsenic is capable of forming strong hydromorphic anomalies such as those along the playa margin. However, mercury anomalies will not tend to coincide with these since it is sparingly soluble, particularly in waters typical of Dixie Valley, and vapor anomalies commonly formed by mercury are limited by the great vertical extent of fine-grained playa sediments.

With the above considerations in mind, a correlation between geochemical anomalies and geologic structure becomes more apparent. The strongest correlation occurs along the Dixie Meadows fault, with numerous zones of high anomalous arsenic and mercury along its trend. High anomalous arsenic values along the apparently structurally controlled playa margin, including several associated with springs, suggest some communication with arsenic-rich thermal waters at depth. Low anomalous values of mercury and arsenic also occur along the trace of the Buckbrush fault in the northern portion of the study area, at least partly associated with a group of structurally controlled springs. Geochemical trends west of the the Dixie Meadows fault also suggest some structural control. The association of geochemical anomalies with the more easterly fault traces is significant. Two low-production wells have been drilled to the west of these 'inner' faults, whereas at least five productive wells have been drilled basinward of them.

Although anomalous arsenic and mercury values do occur along the Stillwater (range front) fault, they are generally associated with mineral deposits and are more difficult to interpret. Based on the available data it appears that the geothermal reservoir in Dixie Valley lies east of the Dixie Meadows fault and that communication via the Stillwater fault and other structures to the west is generally poor, perhaps due to sealing by mineral deposition. Where follow-up sampling at 30 m intervals has been performed, a correlation with structures has been observed, particularly along the Dixie Meadows fault.

Because the nature of the Dixie Valley geothermal system is still not completely understood, it is difficult to evaluate the effectiveness of mercury and arsenic soil geochemistry as an exploration tool. Tentatively it appears that soil sampling together with previous structural interpretations has provided a plausible explanation for much of the observed drilling data. It would also appear as though the broad grid sampling with follow-up work in close center could be useful in selecting drilling targets. Clearly, it rests with further deep drilling to confirm, modify or possibly contradict the conclusions of this work.

References

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Acknowledgement

Support for this work was provided by Southland Royalty Company under U. S. Department of Energy contract DE-AC08-79ET27006.