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Stream-sediment geochemical anomalies in the Doonerak Area, Wiseman quadrangle, Brooks Range, Alaska

by

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INTRODUCTION

The results obtained from reconnaissance geochemical studies in the 1° x 3° Wiseman quadrangle, Alaska (fig. 1) under the Alaska Mineral Resource Assessment Program (AMRAP) were found to be extremely variable (Cathrall and others, 1987). The variability of the geochemical results was found to be correlated with distinct lithologic units. When the Wiseman quadrangle was divided into six areas containing significantly different geochemical populations, geochemical signature suites, and bedrock lithologies, a better statistical evaluation and interpretation of the geochemical results could be made for each area. We designated these areas as "geochemical lithologic subdivisions." The boundaries of the subdivisions follow important geologic contacts that coincide with geochemical changes (fig. 1).

The most conspicuous of these subdivisions is the Doonerak subdivision (figs. 1 and 2), a structural window that exposes a doubly plunging anticlinorium composed mostly of Lower Paleozoic rocks. Although this area comprises less than 10% of the Wiseman quadrangle, it has yielded from 55% to 80% of the anomalous stream-sediment samples with the highest 5% of concentrations of Zn, Cd, Ag, Mo, and Sb in the quadrangle and 30% of the anomalous samples with the highest Cu (Cathrall and others, 1987). If all the stream-sediment samples in the quadrangle are viewed as a single population, clusters of sample localities with anomalies in these metals clearly define the anticlinorium.

When the samples from each geochemical lithologic subdivision are treated as separate populations, geochemical data and mineral occurrences of gold, barite, sphalerite, chalcopyrite, galena, arsenopyrite, cinnabar, and pyrite, delineate two anomalous areas within the Lower Paleozoic rocks in the Doonerak window (fig. 2) and a third anomalous area within the Devonian and younger rocks of the Endicott subdivision in and adjacent to the window. The geochemical suites and their association with the mineral occurrences, the geologic environment, and geophysical features suggest that a potential for sediment-hosted submarine exhalative Cu-Zn and volcanogenic massive sulfide mineral deposits exists in the Doonerak window and this part of the Endicott subdivision.

In this paper, under the heading Doonerak Area, we briefly describe the geology and geophysical features of the Doonerak subdivision and of the small part of the Endicott subdivision which contains related anomalies. We then discuss the anomalous geochemical suites as they relate to the geological environments of the two geochemical lithologic subdivisions.

STRUCTURAL SETTING

The Doonerak Area occupies a unique position in the Central Brooks Range. Its peaks are higher and consist of rocks older than any known rocks immediately to the north or south. The Doonerak Area is thought to represent a mid-Paleozoic structural high as demonstrated by the unconformable occurrence of Mississippian rocks on Silurian and older strata in the core of the anticline and by an unconformity beneath Devonian rocks in the thrust plates surrounding the antiform (Dutro and others, 1976). The boundary of the Doonerak Area follows thrust faults that bound the structural window, except in the northeast, where it lies a few miles within the window and excludes unconformably overlying Mississippian through Triassic rocks (T Cs) composed mostly of carbonate rocks that have been grouped with similar rocks in the Endicott area (figs. 1 and 2). Lower Paleozoic and unconformably overlying

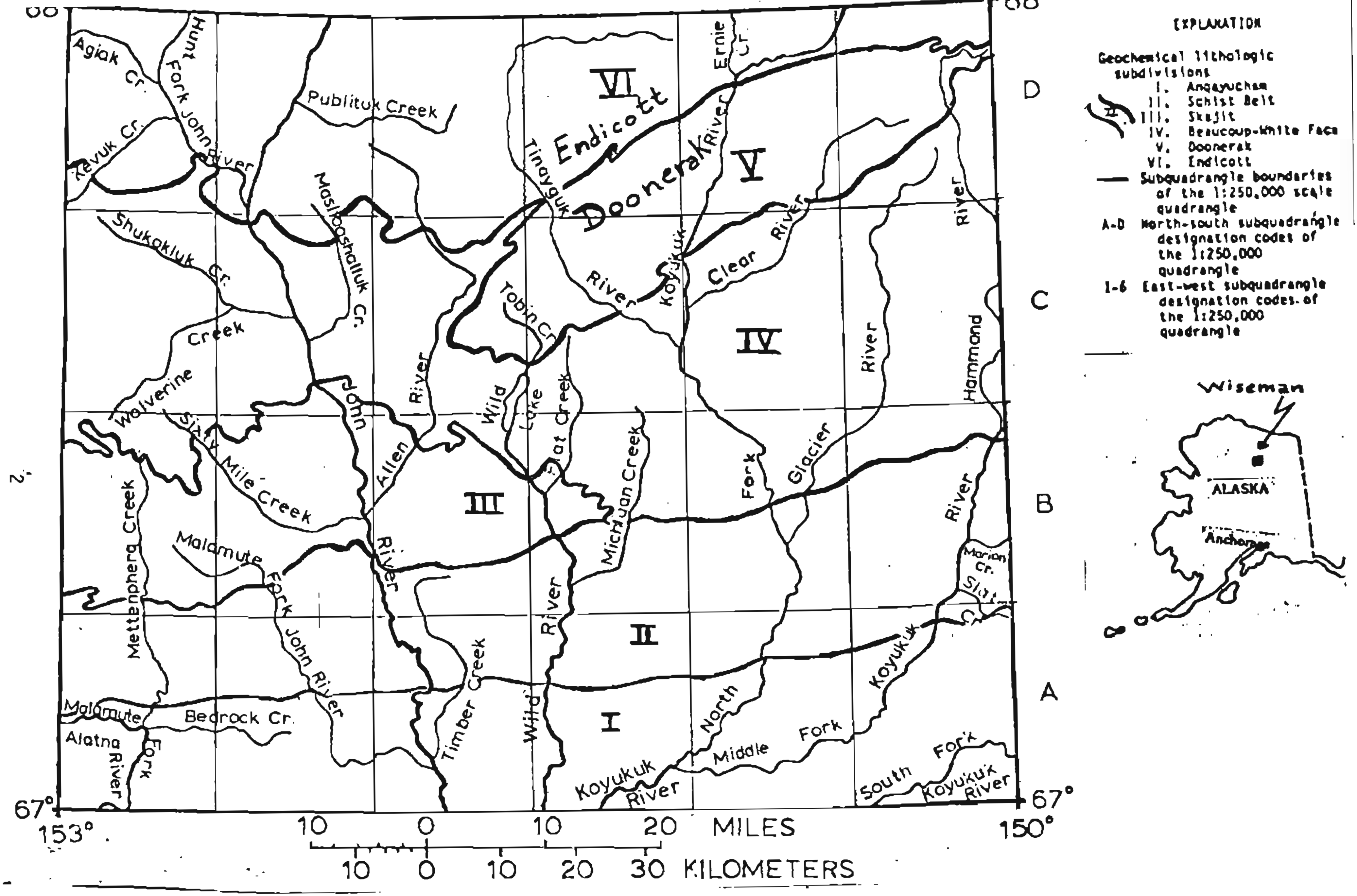

Figure 1.--Map showing the location of the Doonerak (V), Endicott (VI), and other geochemical lithologic subdivisions (I-IV) of the Wiseman quadrangle, Brooks Range, Alaska.

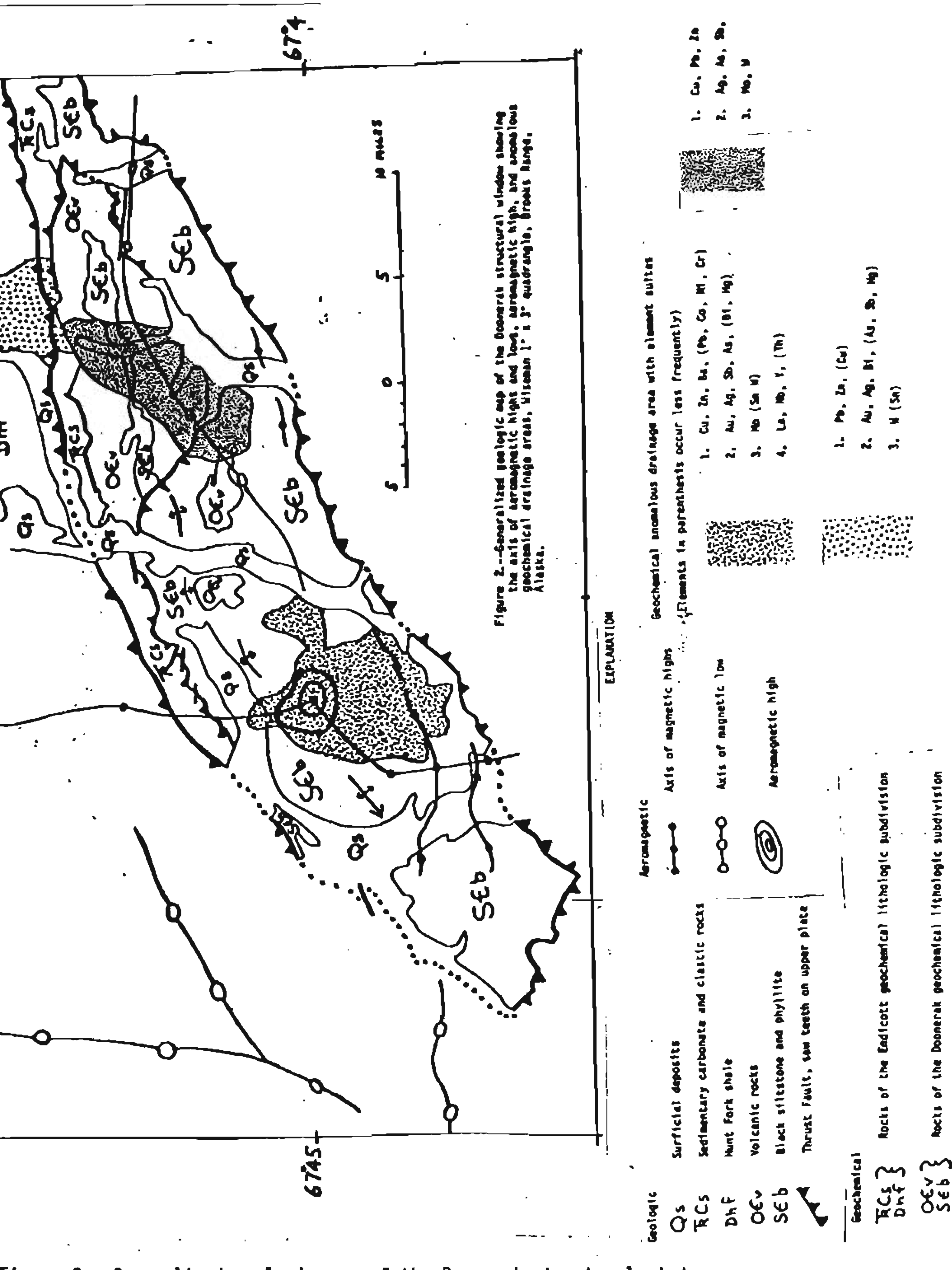

Figure 2.--Generalized geologic map of the Doonerak structural window showing the axis of aeromagnetic highs and lows, aeromagnetic high, and anomalous geochemical drainage areas, Wiseman 1° x 3° quadrangle, Brooks Range, Alaska.

upper Paleozoic through Triassic rocks are correlated with rocks in the North Slope subterrane (Silberling and Jones, 1984). The southernmost exposure of the North Slope subterrane is at the Doonerak fenster.

GEOLOGY, LITHOLOGY, AND METAMORPHIC FACIES

A linear belt of slightly metamorphosed Upper Devonian to Triassic sedimentary rocks strikes east to west across the northern quarter of the Wiseman quadrangle, Brooks Range, Alaska. These rocks are part of a folded thrust system that forms the north front of the Brooks Range. A few key units of this linear belt can be traced across the quadrangle. South of this linear belt, the continuity of rock units and thrust plates in the middle half of the quadrangle is disrupted by a broad arch that trends diagonally across the quadrangle from SW to NE, and by two large synforms on the flanks of the arch. Broad folding of thrust plates on these dip reversals has produced a large structural arch--the Doonerak antiform (fig. 2).

The rocks in the core of the southeastern portion of this structural window consist mostly of black phyllite and metasiltstone, minor quartzite, graywacke, red, green, and purple phyllite, green chert, siliceous metatuff, and thin limestone beds of Cambrian through Silurian age, and abundant metabasite mafic sills of Devonian(?) age (SCb, fig. 2). The protoliths of these rocks were composed of approximately 90% black shale and siltstone; 5% sandstone, quartzite, and conglomerate; and 5% mafic rocks.

The rocks in the core of the northeastern portion of this structural window consist of rocks (SCb) like those found in the southwestern portion, plus a large area of andesitic to basaltic volcanoclastic rocks and local tuffaceous phyllite, gabbro, and diabase, and black phyllite of Cambrian(?) through Ordovician age (OCv, fig. 2). These rocks were originally composed of approximately 25% black shale and siltstone and 75% mafic to intermediate volcanic rocks.

Some of the volcanic rocks in the northeastern core of the anticline were partly metamorphosed to prehnite-pumpellyite facies, whereas the metasedimentary rocks in the southwestern core of the anticline were metamorphosed to lower greenschist facies (Dusel-Bacon and others, in press). They contain white mica and locally identifiable shelly fossils and graptolites. The Devonian(?) sills within the metasediments contain stilpnomelane and actinolite and were also metamorphosed to lower greenschist facies.

In the northeast, carbonate rocks (approximately 80% grey cherty limestone, dolomite, and marble) of Mississippian and locally Pennsylvanian age and minor amounts of Mississippian to Triassic clastic rocks (approximately 20% black shale and siltstone and quartzite) which contain minor amounts of felsic tuff, occur in a narrow band within the Doonerak window (T Cs, fig. 2). These rocks lie between the unconformably underlying Lower Paleozoic rocks of the Doonerak subdivision to the south and the structurally overlying organic rich Hunt Fork Shale (approximately 80% black shale and siltstone and 20% sandstone, quartzite and conglomerate) outside the window to the north. Quartz-chert pebble sheared conglomerate, quartzite, and limestone of the Beaucoup Formation(?) (which contain minor amounts of felsic tuff) occurs locally along the fault beneath the Hunt Fork. The Hunt Fork and the younger rocks structurally below the Hunt Fork are polymetamorphic phyllite and slate.

GEOPHYSICAL FEATURES

Aeromagnetic data shows an area of low magnetic intensity and low magnetic relief that coincides with unmetamorphosed and (or) slightly metamorphosed and gently folded Cambrian through Triassic sedimentary rocks in the northern half of the Wiseman quadrangle. This magnetic quiet zone is interrupted by a magnetic high that trends north across the Doonerak fenster (fig. 2). This trend, which is oblique to the Doonerak fenster, suggests that it is related to rocks beneath the lower Paleozoic rocks of the fenster. The width of this high suggests that it may be caused by an uplift of magnetic basement on a north-trending, fault-bounded belt of magnetic rocks within the basement. Along the south side of the Doonerak (fig. 2) fenster, a linear NE trend of short wave magnetic highs may be caused by the many observed but unmapped metabasite mafic sills of Devonian(?) age.

DISCUSSION OF ANOMALIES

In the southern portion of the Doonerak structural window, geochemically anomalous suites of elements, heavy-mineral suites, permissive host rocks, a favorable sedimentary and tectonic environment, and aeromagnetic features suggest a potential for sediment-hosted submarine exhalative Cu-Zn deposits and (or) epithermal precious-metal deposits. Concentrations of zinc are exceptionally high in this area exceeding 1,700 parts per million at several localities (Cathrall and others, 1987).

Three geochemical suites, in stream sediments and nonmagnetic heavy-mineral concentrates from stream sediments, Cu, Zn, Ba (Pb, Co, Ni, Cr); Au, Ag, Sb, As, (Bi Hg); and Mo, (Sn, W) outline areas favorable for the occurrence of sediment-hosted submarine exhalative Cu-Zn deposits in permissive rocks of the metasedimentary unit, SCb. These rocks are composed of approximately 90% black organic-rich shales and siltstone, 5% minor quartzite, graywacke, purple phyllite, green chert, limestone, and siliceous tuff; and 5% metabasalts. Median contents of Zn, Cu, Ag, Mo, and Sb in 75 grab samples of bedrock of unit SCb from throughout this area are less than the average of metals in black shales worldwide (Rose and others, 1979). We interpret the lithology and geochemical data to represent a sapropelic, euxinic facies in a closed marine basin. Aeromagnetic features (fig. 2) support a hypothesis of uplift of a north-south-trending, fault-bounded belt of magnetic rocks within the basement that may provide a conduit for mineralizing fluids.

Within the same drainage area, the geochemical anomalous suite of La, Nb, Y, and (Th) appears to reflect the presence of a felsic pluton. This geochemical suite and the anomalous elements Au, Ag, As, Sb, (Bi, Hg), Mo, (Sn, W) are commonly associated with felsic mesothermal to epithermal precious-metal deposits. The aeromagnetic high (fig. 2), found coincident with the anomalous drainage area, further supports the presence of a felsic pluton.

Within the northeastern portion of the Doonerak structural window favorable element suites, heavy-mineral suites, permissive host rocks, and a depositional environment suggest a potential for volcanogenic massive sulfide deposits. Sphalerite, arsenopyrite, chalcopyrite, galena, barite, and pyrite identified from panned nonmagnetic heavy-mineral concentrates and three geochemical anomalous suites of elements Cu, Pb, Zn; Ag, As, Sb, (Hg); and Mo and W occur in drainage areas containing rocks permissive for volcanogenic massive sulfide deposits. These are mainly Cambrian through Ordovician rocks of andesitic to basaltic composition with local tuffaceous phyllite, gabbro and diabase, and black phyllite. These rocks are partly in the prehnite-pumpelleyite facies. Dutro and others (1976) report that some of these basaltic and andesitic mafic volcanic rocks have compositions like those of a typical island arc listed by Rogers and others (1974). The approximate lithology of these rocks is 25% black shale and siltstone and 75% mafic to intermediate rocks.

Three anomalous suites of elements Pb, Zn, (Cu); Au, Ag, Bi, (Sb, As, Hg); and W (Mo) outline a third anomalous area. This area, which has the potential for vein-type deposits and sediment-hosted Cu-Zn deposits, exists in rocks belonging to the Endicott geochemical lithologic subdivision (figs. 1 and 2) within and adjacent to the Doonerak structural window.

The rocks within the anomalous area consist of Mississippian to Triassic age carbonate rocks, minor amounts of clastic rocks containing minor amounts of felsic tuff, and the structurally overlying Devonian Hunt Fork shale which lies outside the Doonerak structural window to the north. Quartz-chert pebble sheared conglomerate, quartzite and limestone containing minor amounts of felsic tuff, and unmapped diorite intrusive rock were observed along the fault beneath the Hunt Fork. Visible gold and cinnabar were observed in heavy-mineral concentrates from drainages associated with the thrust faults that bound the northeast boundary of the structural window. Binocular microscopic examination of the nonmagnetic heavy-mineral concentrates from stream sediments revealed the presence of gold, cinnabar, barite, chalcopyrite, stibnite, pyrite, galena, and sphalerite locked with galena altering to cerussite.

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