STUDIES RELATED TO WILDERNESS

The Wilderness Act (Public Law 88-577, September 3, 1964) and related acts require the U.S. Geological Survey and the U.S. Bureau of Mines to survey certain areas on Federal lands to determine the mineral values, if any, that may be present. Results must be made available to the public and be submitted to the President and the Congress. This report presents the results of aeromagnetic surveys of the Mazatzal Wilderness and Contiguous Roadless Areas, Tonto and Coconino National Forests, Gila, Maricopa, and Yavapai Counties, Arizona. The Mazatzal Wilderness (NF3048) was established by Public Law 88-577, September 3, 1964. The Mazatzal Wilderness Contiguous Roadless Areas (3-016) were classified as further planning areas during the Second Roadless Area Review and Evaluation (RARE II) by the U.S. Forest Service, January 1979.

INTRODUCTION

The Mazatzal Wilderness and contiguous roadless areas are located in Tonto and Coconino National Forests, west and southwest of Payson, and are almost exactly in the geographic center of Arizona. This is a region of relatively small mining districts and few mines, but occurrences of many different metals are widespread.

The Mazatzal Mountains constitute the dominant physiographic feature of the wilderness. The eastern slopes of these mountains rise steeply from about 3,500 ft in altitude along the valley of Rye Creek east of the range, to 7,903 ft at Mazatzal Peak. To the west, the range slopes steeply from the crest then more gently along the lower flanks to the Verde River, one of the main drainage channels of Arizona. In the northern part of the wilderness, the East Verde River, a tributary of the Verde, occupies a deep canyon that separates the Mazatzal Mountains from mesas to the north. The lowest parts of the wilderness have altitudes of about 2,200 ft and are located near Bartlett Reservoir in the southwestern part of the area studied.

Two aeromagnetic surveys were flown and interpreted to aid in the delineation of subsurface lithology and structure: one survey was flown at a low level (1,000 ft above ground) and the other at a high level (9,000 ft above sea level). In addition, the results of a small-scale electromagnetic (EM) survey are briefly discussed; the surface EM survey took place in an area of copper concentrations and past exploration activity to look for evidence of massive sulfide mineralization.

Studies of the geology, geochemistry (Marsh and others, 1983a,b; Erickson, 1984), mines and prospects (Ellis, 1982), and mineral resource potential (Wrucke and others, 1983) of the Mazatzal Wilderness and contiguous roadless areas have been published elsewhere.

GEOLOGY

Proterozoic rocks that are exposed in the Mazatzal Wilderness and contiguous areas are overlain by local cappings of Paleozoic strata and by an extensive cover of Tertiary volcanic and sedimentary rocks. The Proterozoic rocks include stratigraphic sequences of Early Proterozoic age that are largely fault bounded and have an aggregate thickness of 61,000 ft. The oldest rocks in the area probably are in a structurally fragmented layered sequence exposed on the east side of the Mazatzal Mountains and along the East Verde River. This sequence contains mafic volcanic rocks, a variety of clastic sedimentary rocks, and subordinate amounts of rhyolite tuffs and flows, and has close lithologic similarities to the Yavapai Series that occurs in the Jerome-Prescott region. The layered sequence along the East Verde River has been intruded in turn by diorite and gabbro, and by alkali granite, all of Early Proterozoic age. The granite crops out in the central part of the area. The alkali granite also intruded a sequence of rhyolite flows and tuffs that are considered as possibly the comagmatic extrusive equivalent of the granite. Strongly foliated volcaniclastic rocks and rhyolite of the Alder Formation of Early Proterozoic age occur to the south of the alkali granite and are thought to be younger than the gabbro and diorite and older than the alkali granite. A quartz monzonite porphyry body exposed immediately west of the wilderness and contiguous areas appears to intrude the alkali granite; however, the relative ages of the quartz monzonite porphyry and the alkali granite have not been established, and it is not known if the quartz monzonite porphyry is Proterozoic. The youngest stratigraphic sequence of early Proterozoic age consists of rhyolite intruded by alkali granite and overlain by quartzite and shale. Porphyritic quartz monzonite of Middle Proterozoic age crops out at the southwestern corner of the area. Most of the known mineral occurrences in the Mazatzal Wilderness, the roadless areas, and the immediately surrounding terrane are found in rocks of Early Proterozoic age.

Sedimentary rocks consisting of the Tapeats Sandstone of Cambrian age, the Martin Formation of Devonian age, the Redwall Limestone of Mississippian age, and the Naco Limestone of Pennsylvanian age form scattered exposures in the northern third of the area. Miocene and Pliocene rocks include basalt flows and minor amounts of dacite tuff and flows interlayered with sandstone, limestone, and conglomerate in a composite section 2,000 ft thick.

AEROMAGNETIC SURVEY SPECIFICATIONS AND MAPS

Aeromagnetic surveys flown at different heights above the ground provide mutually complimentary data. Data obtained from low-level surveys are superior for the detailed delineation of rocks and structures at shallow depth, whereas data obtained from high-level surveys generally reflect large deep-seated bodies. Anomalies from small, shallow-seated bodies are also more strongly attenuated by high-level surveys. The low-level aeromagnetic map (map A) was flown and compiled in 1978-79 for the U.S. Geological Survey on contract by LKB Resources Inc. Terrain clearance of the survey was nominally 1,000 ft in draped mode. The high-level aeromagnetic map (map B) is from Sauck and Sumner (1970). Flight altitude was constant at 9,000 ft above sea level.

Magnetic anomalies are numbered on the maps and keyed to the discussion. Numbers appended with LL are anomalies denoted on the low-level survey and numbers appended with HL are anomalies denoted on the high-level survey. Both maps A and B display the anomaly numbers from the companion map in parentheses to illustrate spatial relationships.

LOW-LEVEL AEROMAGNETIC SURVEY (MAP A)

Anomaly OLL, a magnetic low in the west-central part of the wilderness, is part of an alternating series of north-trending lows and highs that probably reflect faulty field data or faulty data processing. These anomalies appear to be related to about 8 flightlines; the anomalies are most prominent near OLL where alkali granite (Pg) crops out and where magnetic relief might normally be low. True anomalies related to geology are probably distorted in a zone 8 flightlines wide, possibly extending across the map in the north-south direction, with distortion being least obvious where magnetic relief from geologic sources is strongest.

Complex densely spaced anomalies, generally less than 1 mi in the smallest dimension, characterize the magnetic expression of the Tertiary basalt on the low-level aeromagnetic map. Anomalies reflecting the basalt predominate in the northern and the southwestern parts of the map area, and are scattered in the west-central part of the area where remanents of basalt (Tb) cap the alkali granite (Pg). The strong, complex low-level anomalies which reflect the basalt effectively conceal some anomalies of units beneath the basalt; an example of this is high-level aeromagnetic anomaly 1AHL which is difficult to recognize on the low-level aeromagnetic map because of the basalt.

The low-level aeromagnetic data suggest that high-level anomaly 2HL is incorrectly contoured, that it does not actually extend as far southeast as anomaly 2LL. The low-level data also indicate that the northern, broader part of anomaly 2HL is a composite anomaly arising from multiple bodies, some lying beneath Tertiary rocks north of the East Verde River. Immediately northeast of anomaly 2HL, a magnetic depression about 9 mi long, which trends northwest-southeast, approximately follows the trace of the East Verde fault. This magnetic depression is thought to be associated with the negative topography of East Verde Canyon, and thus indirectly with the fault, which partly controls topography.

At Knob Mountain the east-trending axis of anomaly 2LL occurs near the contact between alkali granite (Pg) and mafic volcanic rocks (Pmv). Computer models (fig. 1) indicate that part of the source of the anomaly lies within or beneath the granite south of the contact. Anomaly 2LL may relate to the mineral resource potential of the area based on an analogy with the subsidiary magnetic high trending northeast from its west end. The subsidiary high is aligned with and overlaps Bullfrog Ridge where mineral deposits occur (Ellis, 1982). Like anomaly 2LL, the subsidiary high occurs at a mafic volcanic rock contact. There is some question of whether the highs simply reflect an edge of a mafic volcanic rock plate, or whether they partially reflect anomalously magnetized material, possibly secondary magnetite, near the contact. A conclusive answer to this question cannot be found in the magnetic data alone. Although the model section of figure 1A depicts one particular configuration of mafic volcanic rocks which could cause the magnetic anomaly, such a configuration is not the only interpretation of the data. Figure 1B, for example, illustrates how a similar magnetic anomaly could be caused by two bodies with different magnetic susceptibilities, which have a composite form similar to that of the source in figure 1A. Exhaustive efforts were not made to match the observed magnetic data exactly, or to include details of mapped lithology and structure for the models on figure 1 because any solution in final analysis is not totally unique. Susceptibility measurements were not obtained on rock specimens, therefore, within moderate limits, the thickness of the model body could be changed simultaneously with inverse changes in susceptibility of the body, without degrading the anomaly fit.

Anomaly 4LL marks the west margin of anomaly 4HL of the high-level aeromagnetic map. It defines the edge of a body of diorite and gabbro (Pdg) near the Payson mining district which has small precious-metal and copper deposits (Ellis, 1982).

Anomaly 5LL, a linear magnetic high southeast of the wilderness, has three maxima. It is in the Sunflower mining district (Ellis, 1982), where its northeast trend coincides with the strike of the steeply dipping Alder Formation. Of the numerous layered sedimentary and igneous members of this formation, a dacite breccia member correlates most closely with the anomaly, and is likely its source.

The northwest trend exhibited by anomaly 5HL on the high-level aeromagnetic map is not apparent on the low-level aeromagnetic map; it may be that anomaly 5HL is contoured incorrectly, or that the near-surface magnetization of the Alder rocks is sufficiently strong to mask the northwest trend at the low level.

On trend southwest of anomaly 5LL, a yet stronger multiple-peak linear magnetic high (5ALL) probably traces the magnetized Alder Formation member beneath Tertiary sedimentary and volcanic rocks. Although hills of basalt may contribute to the anomaly, they alone cannot explain its sharply defined trend.

A northeast-trending magnetic low, anomaly 7LL, is believed to correlate with a less strongly magnetized member of the Alder Formation that is locally overlain by dacite tuff (Tdt) and intruded by dacite (Tid), both of which are only weakly magnetized.

Anomaly 8LL is a magnetic high parallel to anomaly 7LL, that is thought to be caused by a second magnetized member of the Alder Formation. Largely underlain by volcanic rocks, some of which are mafic (C. M. Conway, unpub. data, 1983), anomaly 8LL includes an area with a mineral prospect where an electromagnetic survey was made in the Copper Camp Creek area. Anomaly 8LL extends northeast to and beyond the magnetic peak of 51,317 gammas, strongly suggesting that Alder Formation rocks extend across the Sheep Mountain fault and are present beneath Proterozoic rhyolite ash flows (Pr).

HIGH-LEVEL AEROMAGNETIC SURVEY (MAP B)

Alkali granite (Pg) is widely exposed in the central part of the wilderness and correlates generally with low magnetic intensity indicating that the granite is only weakly magnetized. The granite may occur at depth in broad areas of low magnetic intensity although other rocks occur at the surface. Anomaly OHL, a magnetic trough which crosses the map area diagonally from northwest to southeast, is believed to correlate with the alkali granite. The magnetic trough (OHL) extends southeastward to the boundary of the map area. Presumedly it traces the alkali granite beneath outcropping Proterozoic clastic sedimentary rocks (Pcs), rhyolite (Pr), Alder Formation rocks (Pa), and Tertiary sedimentary and volcanic rocks (Tsv). To the northwest the trough is intersected by a northeast-trending ridge-like anomaly which spatially correlates with alkali granite in a horst; the source of this anomaly, however, is interpreted to be quartz monzonite rocks (Pqm), beneath the granite in the horst rather than the granite and is discussed with the interpretation of anomaly 1HL.

Alkali granite at depth is regarded as a plausible source of several other features seen on the high-level aeromagnetic map. Among these are the following features: (1) the east-west-trending magnetic depression separating highs 1AHL and 6HL in the southern third of the map area, (2) the north-south-trending depression between anomalies 2LL and 4LL in the east-central part of the map area, and (3) the northwest-trending magnetic depression in the northeast quadrant of the map area.

Anomalies 1HL, 2HL, 3HL, 4HL, 5HL, and 6HL are prominent magnetic highs on the high-level aeromagnetic map. Each anomaly suggests the presence of plutons that are more strongly magnetic and more mafic than the alkali granite.

Outcrops of unit Pqm near the west border of the map area are interpreted to be part of a mostly concealed quartz monzonite porphyry body which causes magnetic high 1HL. Two magnetic contour ridges suggest that the quartz monzonite porphyry extends beneath cover into the roadless area and the wilderness: one ridge trends northeast and was discussed previously with the interpretation of anomaly OHL; the second ridge trends southeast and is labelled as anomaly 1AHL. Geochemical anomalies associated with both the quartz monzonite porphyry and the faults that bound the horst imply the presence of a concealed porphyry molybdenum system (S. P. Marsh, written commun., 1983).

Anomaly 2HL has a strong northwest trend in the north-central part of the map area which we attribute to Proterozoic diorite and gabbro (Pdg), with possible contributions from metavolcanic rocks or their sedimentary derivatives (Pvs). High-level data contours are not tightly controlled because of the 3-mi flightline spacing; this, together with disparate low-level data, places the size and shape of anomaly 2HL, as drawn, in doubt. We believe that data from more closely spaced flightlines would resolve anomaly 2HL into two anomalies; the present anomaly would be foreshortened on the southeast, and a second anomaly would be seen southeast, correlating with anomaly 2LL on map A.

The source of anomaly 3HL in the northern part of the map area is concealed by Tertiary sediments and basalt (Tsv). Proterozoic diorite and gabbro (Pdg) is a plausible source of the anomaly considering proximity of the northwest extension of anomaly 2HL.

Diorite and gabbro rocks (Pdg) mapped near the east border of the map area are believed to be exposures of a large body causing magnetic anomaly 4HL. The same rocks are also associated with a magnetic low just north of anomaly 4HL. The low may be a reflection of alkali granite at shallow depth, or it may indicate a local, less magnetic phase of the diorite.

Anomaly 5HL in the southeast corner of the map area may be a reflection of an intrusive body concealed by layered Proterozoic rocks. The northwest extension of the concealed body implies a possible genetic association with known gold-silver-lead or mercury mineralization in the Sunflower mining district (Ellis, 1982) although it may, in turn, be an artifact of incorrect contouring, as discussed with the interpretation of anomaly 5LL.

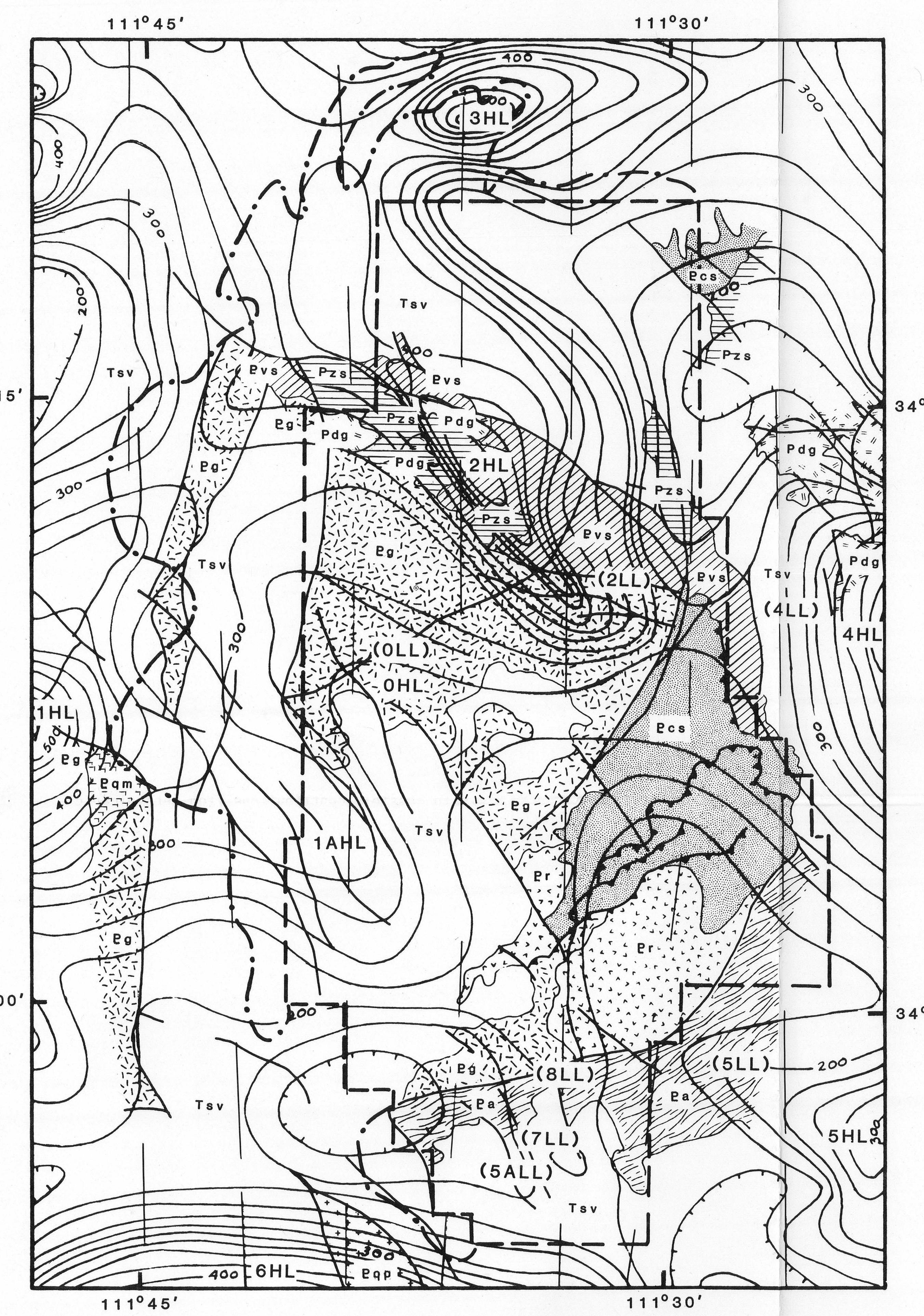
The source of anomaly 6HL is believed to be a pluton which increases in intensity south of the map area. Granitic rocks (Ppg) cropping out southwest of the wilderness are regarded as probable exposures of the source body.

ELECTROMAGNETIC SURVEY

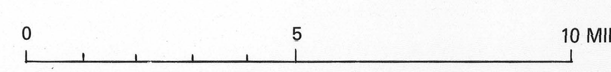
A mineral prospect believed to have potential for volcanogenic massive sulfide mineralization (Wrucke and others, 1983) was the site of a surface electromagnetic survey on Copper Camp Creek in the southern part of the wilderness (map A). The survey employed a Sirotem[1/] pulse-transient EM instrument capable of substantial depth penetration for massive sulfide deposits. Measurements were made using a coincident transmitter-receiver loop 500-ft square. North-south traverses were conducted with 250-ft station increments.

The electromagnetic measurements (C. K. Moss, unpub. data, 1982) were degraded by instrumental offset making quantitative analyses difficult, however, a large conductive sulfide deposit is not believed to be present within a depth of a few hundred feet (F. C. Frischknecht, oral commun., 1983). The electromagnetic measurements do suggest that rocks significantly more conductive than those at the surface occur within a depth of several hundred feet, possibly reflecting lithologic differences across a thrust fault.

1/ Any use of trade names is for descriptive purposes only and does not imply endorsement by the USGS.



Magnetic map from Sauck and Sumner (1970). Generalized geology from C. T. Wrucke and C. M. Conway (unpub. data, 1983)



MAP B.-HIGH-LEVEL AEROMAGNETIC MAP

EXPLANATION FOR HIGH-LEVEL AEROMAGNETIC MAP

- **2HL** — HIGH-LEVEL AEROMAGNETIC ANOMALY
- **(2LL)** — LOW-LEVEL AEROMAGNETIC ANOMALY
- CONTOURS OF TOTAL MAGNETIC FIELD INTENSITY--Hachures on closed contours bounding areas of lower intensity. Contour interval 25 gammas
- FLIGHTLINE--Flight elevation, 9,000 ft above sea level; flight direction, north-south; flightline spacing, approximately 3 mi
- APPROXIMATE BOUNDARY OF WILDERNESS
- APPROXIMATE BOUNDARY OF ROADLESS AREAS

LIST OF MAP UNITS FOR HIGH-LEVEL AEROMAGNETIC MAP

Tsv	SEDIMENTARY AND VOLCANIC ROCKS (TERTIARY)
Pzs	SEDIMENTARY ROCKS (PALEOZOIC)
Pqp	PORPHYRITIC QUARTZ MONZONITE (MIDDLE PROTEROZOIC)
Pqm	QUARTZ MONZONITE PROPHYRY (PROTEROZOIC)
Pg	ALAKALI GRANITE (EARLY PROTEROZOIC)
Pcs	CLASTIC SEDIMENTARY ROCKS (EARLY PROTEROZOIC)
Pr	RHYOLITE (EARLY PROTEROZOIC)
Pa	ALDER FORMATION (EARLY PROTEROZOIC)
Pdg	DIORITE AND GABBRO (EARLY PROTEROZOIC)
Pvs	VOLCANIC AND SEDIMENTARY ROCKS (EARLY PROTEROZOIC)

- CONTACT
- NORMAL FAULT
- THRUST FAULT

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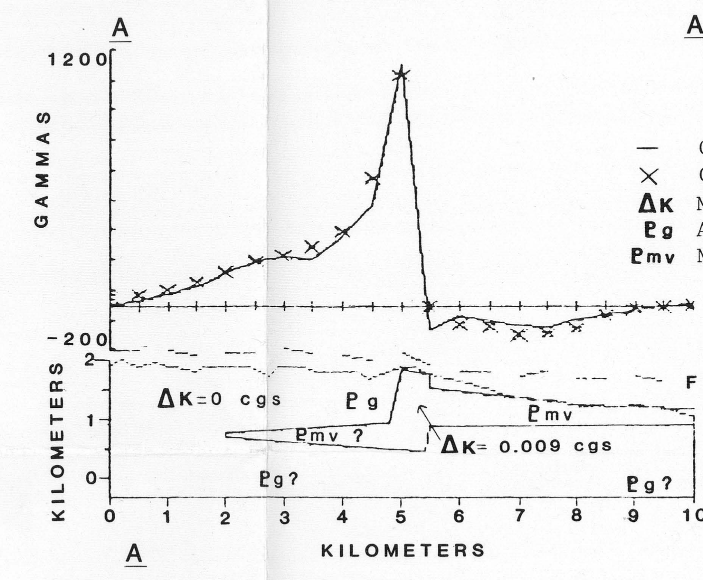

EXPLANATION

- — Observed magnetic profile
- × Calculated magnetic profile
- ΔK Magnetic susceptibility contrast
- Pg Alkali granite (Early Proterozoic)
- Pmv Mafic volcanic rocks (Early Proterozoic)

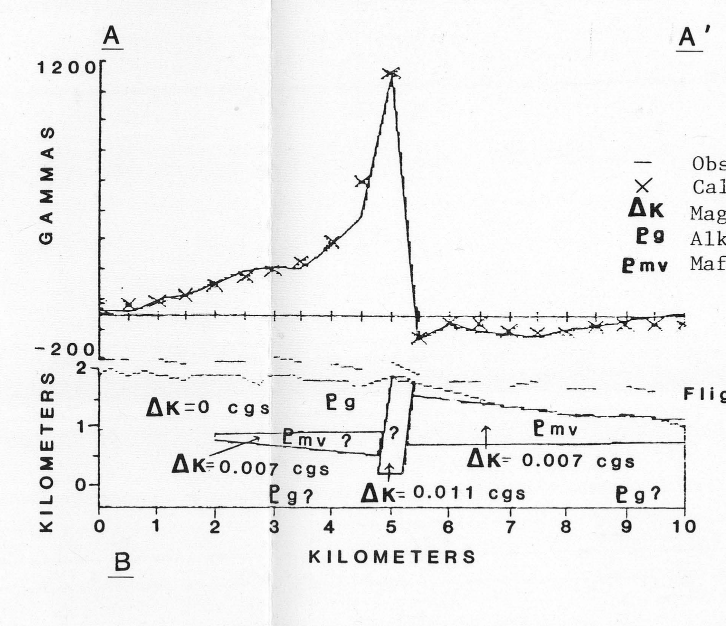

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Figure 1.--Computer model of area along profile A-A' at Knob Mountain (Map A.).
A, source body has single susceptibility contrast.
B, source body has multiple susceptibility contrast.
Model by G.A. Abrams using computer programs by Campbell (1983). Total field, 51,000 gammas; inclination, 61°; declination, 14°E; infinate-strike length, two-dimensional body.

AEROMAGNETIC MAPS OF THE MAZATZAL WILDERNESS AND CONTIGUOUS ROADLESS AREAS, GILA, MARICOPA, AND YAVAPAI COUNTIES, ARIZONA

By
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