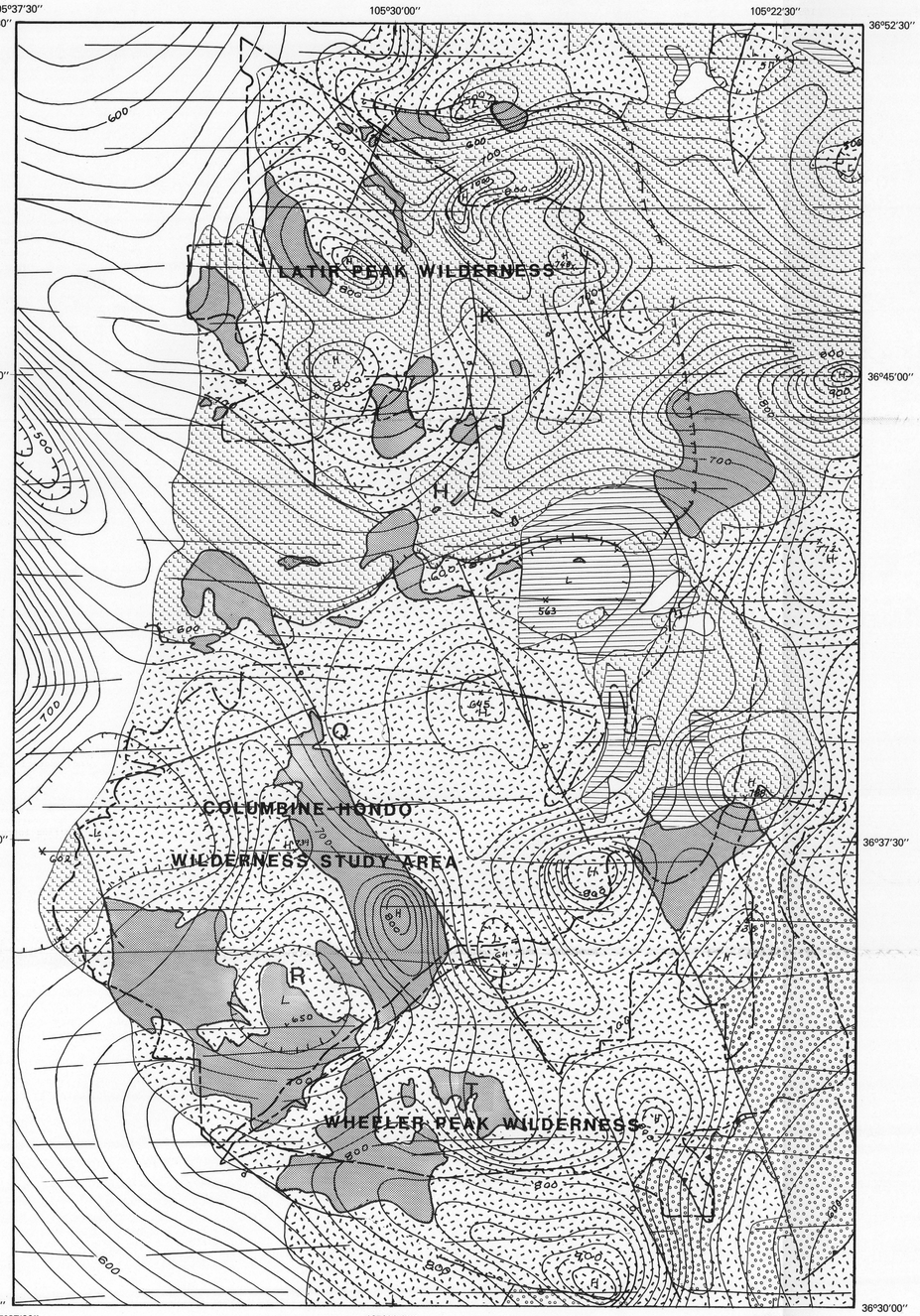
DEPARTMENT OF THE INTERIOR
U.S. GEOLOGICAL SURVEY



Aeromagnetic data from U.S. Geological Survey (1975). Geology generalized from Reed and others, 1983

SCALE 1:100 000

1 ½ 0 1 2 3 4 5 MILES

1 .5 0 1 2 3 4 5 KILOMETERS

EXPLANATION FOR MAP C

- MAGNETIC CONTOUR--Contour interval 20 and 100 nanoteslas; hachures indicate closed areas of lower magnetic intensity; flight altitude, 13,000 ft barometric. International Geomagnetic Reference Field updated to November 1975 and 1,000 nanoteslas added
- K — MAGNETIC ANOMALY DISCUSSED IN TEXT
- FLIGHT LINE
- MAGNETIC HIGH--Showing intensity in nanoteslas
- MAGNETIC LOW--Showing intensity in nanoteslas
- QUATERNARY SEDIMENTARY AND VOLCANIC ROCKS OF THE RIO GRANDE RIFT
- TERTIARY ROCKS OF THE LATIR VOLCANIC FIELD
- Volcanic rocks
- Granitic and rhyolitic intrusive rocks
- Intrusive quartz latite
- PALEOZOIC ROCKS
- PROTEROZOIC ROCKS
- CONTACT
- CALDERA WALL
- NORMAL FAULT--Ball and bar on downthrown side
- THRUST FAULT--Saw teeth on upper plate

MAP C. RECONNAISSANCE AEROMAGNETIC MAP

AEROMAGNETIC MAPS OF THE LATIR PEAK AND WHEELER PEAK WILDERNESSES AND THE COLUMBINE-HONDO WILDERNESS STUDY AREA, TAOS COUNTY, NEW MEXICO

By

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1985

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 their mineral resource potential. Results must be made available to the public and be submitted to the President and the Congress. This report presents the results of a geophysical survey of the Latir Peak Wilderness, the Wheeler Peak Wilderness, and the Columbine-Hondo Wilderness Study Area, all in the Carson National Forest, Taos and Colfax Counties, N. Mex. The Latir Peak Wilderness was established by Public Law 96-550, December 19, 1980. The Wheeler Peak Wilderness was originally established by Public Law 88-577, September 3, 1964; the present boundary, incorporating additional area, was established by Public Law 96-550, December 19, 1980. The Columbine-Hondo Wilderness Study Area was classified as a further planning area during the second Roadless Area Review and Evaluation (RARE II) by the U.S. Forest Service, January 1979, and designated a Wilderness Study Area by Public Law 96-550, 1980.

LOCATION AND SETTING

The Latir and Wheeler Peak Wildernesses and the Columbine-Hondo Wilderness Study Area comprise areas of approximately 42, 31, and 66 mi^2 respectively in the Carson National Forest in Taos County, N. Mex. (Fig. 1). The study areas all lie in the Sangre de Cristo Mountains, a narrow and rugged mountain uplift that extends for more than 200 mi north and northwestward from Glorieta Pass east of Santa Fe, N. Mex., to Poncha Pass southwest of Salida, Colo. The areas lie entirely within the Taos Range, which includes some of the most spectacular alpine topography in northern New Mexico, including Wheeler Peak, the highest peak in the state.

INTRODUCTION

This report interprets data from a helicopter-borne magnetic survey to help delineate subsurface geology. Such data, acquired near the ground, reflect greater magnetic detail than do data acquired at higher altitude. Data from a high-altitude reconnaissance aeromagnetic survey (U.S. Geological Survey, 1976) are used selectively to assist in the interpretation of the helicopter data.

Interpretations are chiefly empirical, wherein magnetic anomalies characterizing known geologic features in the region are used as interpretive criteria for identifying such features where they are concealed. Identifying geologic environments favorable for mineral deposits is a primary objective of this report.

Geophysical interpretations of a broader and more general scope are made from other geophysical data by Cordell and Jones (in press).

SURVEY SPECIFICATIONS

The helicopter magnetic survey was flown under contract by QEB, Inc. (a subsidiary of High Life Helicopters, Inc.) in 1980. Flight lines were draped and were flown at a nominal terrain clearance of 500 ft; lines were flown north-south, spaced 1/2 mi apart in area A (see fig. 2) and 1/3 mi apart in area B.

Altitude of the reconnaissance aeromagnetic survey was constant at 13,000 ft, and flight lines were flown east-west, spaced 1 mi apart.

MINERALIZATION AND GEOLOGY

Stockwork molybdenum deposits, three of economic tenor and large size, occur adjacent to Red River canyon between the Latir Peak Wilderness and the Columbine-Hondo Wilderness Study Area (see map B). Numerous, small, inactive, precious- and base-metal mines and prospects occur within the study areas (Briggs, 1982). Most mineral occurrences are believed to be of middle Tertiary age, with some of Precambrian age.

From Reed and others (1983):

"In the map area the Taos Range is composed largely of Precambrian rocks partly mantled by mid-Tertiary volcanic rocks and invaded by in part coeval and cogenetic intrusive rocks in dikes, dike swarms, plugs, and plutons. Paleozoic rocks are widespread in parts of the range to the east and south.*** Widely exposed granitic intrusions and associated porphyro-aphanitic rocks that form dikes, sills, and laccoliths are thought to represent phases of a large composite batholith emplaced during and after the volcanic activity of the Latir field. At the deepest exposed structural levels, in southern parts of the map area, the granitic rocks are massive and relatively coarse grained (quartz monzonite of Rio Hondo; granite of Lucero Peak). To the north within the caldera, finer-grained granite, granite porphyry, aplite porphyry, and rhyolite porphyry are more abundant and are thought to represent higher structural levels of the same magmatic system. Mineralized plutons along the Red River are interpreted as representing cupolas on a massive irregular ring intrusion along the south margin of the Questa caldera, localized where regional northwest-trending faults intersect the caldera margin. Granitic rocks north of Cabresto Creek and in the Rito del Medio area are interpreted as representing late magmatic pulses in the resurgent core of the Questa caldera."

TERRAIN-RELATED MAGNETIC ANOMALIES AND REMANENT MAGNETISM

Elevations within the study areas span a range of about 5500 ft, and strong local relief is prevalent. In general, magnetized rocks having topographic relief will cause anomalies whether data are obtained by draped flight lines or by flight lines of constant altitude. Examples of anomalies calculated for draped lines crossing a butte-like feature are shown in figure 3A and 3B. The anomaly caused by a vertical tabular body is shown in figure 3C.

Corrections for terrain (topography) cannot be rigorously applied to magnetic data because the magnetism of the rocks is not known. Anomalies not due to terrain can most readily be distinguished where they are strong, and where their size, form, and orientation do not correlate with terrain. A deep-seated body (fig. 3C), produces a stronger and wider anomaly than does a butte-like feature having less vertical extent (fig. 3A). Surface rocks of the study areas are commonly magnetic, and careful qualitative analyses of anomalies are necessary to determine whether they are caused by topographic relief in magnetically uniform surface rocks, or by bodies of contrasting magnetism extending to depth.

Paleomagnetic studies of Tertiary igneous rocks of the study areas (Hagstrum and others, 1982) indicate that remanent rock magnetism is mostly of normal polarity. Reverse polarity identified in the Red River pluton (no. 5 on map B) and in Tertiary andesite (unit Ta on map A) is a factor to be considered in interpreting anomalies where these rocks occur.

MAGNETIC ANOMALIES AT KNOWN RED RIVER CANYON MOLYBDENUM DEPOSITS

Magnetic data at Red River canyon, between Latir Peak Wilderness and Columbine-Hondo Wilderness Study Area, were examined for anomalies characterizing the geologic environment of the known molybdenum deposits. Magnetic anomalies might reflect either intrusive rocks, hydrothermal alteration, or structure associated with mineralization. Anomalies caused directly by molybdenum mineralization would not be expected.

Magnetic Anomalies Associated with Tertiary Intrusive Rocks Having Molybdenum Mineralization

The Bear Canyon pluton (no. 3 on map B) south of Red River canyon correlates with a magnetic low. The intense, northeast-curving part of the low reflects the negative dipole field from magnetic rocks to the south and may in part be terrain related. Moly mine pluton (no. 4 on map B) also correlates with a magnetic low, one that approximately outlines its complex shape. Three molybdenum deposits are associated with these two plutons (see map B): one deposit each is associated with the Bear Canyon pluton and the Moly mine pluton and a third deposit, comprised of two parts lies between the plutons and coincides with a magnetic low.

In broader view, the magnetic lows that are associated with the Bear Canyon and Moly mine plutons are part of a larger, sinuous, east-trending magnetic low that approximately follows the south wall of the Questa caldera toward the Red River pluton (no. 5 on map B). This magnetic low is interpreted as grossly reflecting prominences in the ring intrusion described by Reed and others (1983).

Unlike the Bear Canyon and Moly mine plutons, the Red River pluton (no. 5 on map B) does not correlate with a magnetic low. Although the low at A (see map B) suggests weakly magnetic rocks marginal to and possibly within that pluton, a significant part of the pluton is substantially magnetized.

A spatial association between magnetic highs and the molybdenum deposits can also be observed. Magnetic highs at C, D, and E (see map B) are each adjacent to a molybdenum deposit. Rocks causing the highs cannot be identified with certainty. Andesite (unit Ta), occurs at each site, but it may not be the source of the magnetic anomalies. The causative magnetic bodies lie at the caldera wall, and at C and E they appear to extend a few thousand feet southward beneath Proterozoic granite (unit Xg). It is not known if the bodies are related to the molybdenum deposits. Two additional somewhat similar highs are also present near Red River canyon, one at F and the other at G. The area of the first is underlain by Proterozoic mafic rocks (unit Xm); the area of the second by Tertiary intrusive latite (unit Tqi).

Magnetic Anomalies Associated with Hydrothermal Alteration

Areas of intense hydrothermal alteration (potassic, argillic, pyritic, and silicic) are shown on map B after Clark and Read (1972) and McKinlay (1957). In theory, hydrothermal destruction of accessory magnetite may cause magnetic lows with attendant implications for associated mineralization. In the Red River canyon area, however, alteration occurs with little evidence of correlative magnetic lows; thus, magnetic lows are not judged to be a useful guide for alteration in the region. Although a well defined magnetic low correlates with alteration between the Bear Canyon pluton and the Moly Mine pluton, this low is interpreted to be caused by poorly magnetic plutonic rocks rather than by alteration.

Magnetic Anomalies Associated with Structure

Magnetic indications of structure(s) that may be genetically associated with molybdenum deposits in the Red River canyon area were not identified.

MAGNETIC INTERPRETATION OF LATIR PEAK WILDERNESS

Limbs from the magnetic low, discussed earlier, reach north and south from the Moly Mine pluton (no. 4 on map B). The north limb, beginning at H (see maps A and B), divides into east and west branches at I. These branches rejoin approximately 3 mi north at K, where a magnetic low, possibly representing a separate source, extends westward. The magnetic low is particularly intense between H and J. Over this interval and to K, the low is strongly reflected in the high-altitude reconnaissance magnetic data on map C, indicating a substantial, deep-seated source body. This trend crosscuts volcanic and topographic grain. The northeast-trending segment of the west branch of the magnetic low from L to K correlates with a canyon and may be terrain related.

Broad correlations between exposures of the Cabresto Lake pluton (no. 7 on map B) and branches of the magnetic low suggest that rocks of the pluton, either exposed or concealed, contribute to the low. On the other hand, detailed, strong correlations between exposures of the Cabresto Lake pluton and magnetic anomalies are lacking. Specific explanations are not suggested here, but, in general, where intrusive exposures are much smaller in area than an associated anomaly, the causative body may be only partially exposed. Where a magnetic high correlates with part of the pluton, a more strongly magnetized phase of the pluton may be indicated, or the body may be locally thin, allowing an anomaly from underlying rocks to be observed. Ultimately, the accuracy of the magnetic contour map itself is a factor, because contours between flight lines are not tightly controlled, and small positional errors in data plotting may also exist.

North of the Cabresto Lake pluton, a broad magnetic low occurs at K and LL (see maps A and B); terrain effects clearly contribute to this magnetic low, but weak magnetization in underlying rocks may be the dominant cause. This magnetic low also extends west from K through M to N and diagonally crosses topography and diverse volcanic rocks, implying a coherent concealed source. It may be significant that this magnetic low is parallel with the magnetic low along the the Red River that is continous with the magnetic low associated with the Cabresto Lake plutdn. This magnetic low terminates near the southern tip of the Rito del Medio pluton (no. 6 on map B). Neither the Rito del Medio pluton nor the pluton to the southwest is outlined by a distinctive anomaly. The data suggest that the plutons do not have steep contacts, but join beneath cover as part of a single, broad pluton.

Two other prominent magnetic lows are present in the Latir Peak Wilderness. One magnetic low crosses the northwest tip of the wilderness along the west projection of the north caldera wall at O (see map A), where Proterozoic gneissic granite (unit Xgg) and amphibolite (unit Xa) underlie it, and Tertiary intrusive rhyolite (unit Tri) borders it. The granite and/or the intrusive rhyolite are plausible causes of this magnetic low. The other magnetic low, near the southwest boundary of the wilderness at P, is bordered on three sides by faults. Surface rocks in this area are Tertiary andesite (unit Ta), Tertiary lithic tuff (unit Tt), and Proterozoic granitic rock (unit Xg). The magnetic low may be caused by these rocks, but a concealed intrusive body could also cause it.

MAGNETIC INTERPRETATION OF COLUMBINE-HONDO WILDERNESS STUDY AREA AND WHEELER PEAK WILDERNESS

The magnetic low extending southward from Moly Mine pluton (no. 4 on map B) suggests possible continuity of the pluton beneath Proterozoic rocks. Terrain effects along Columbine Creek accentuate the magnetic low for a distance of approximately 3 mi north and 3 mi south of Q. This magnetic low also occurs on the reconnaissance aeromagnetic map (map C), except that an east-trending magnetic-low segment, as shown on map B, is absent. That segment lies mostly between flight lines of the reconnaissance survey and would not have been recorded.

The Rio Hondo pluton (no. 1 on map B) and the Lucero Peak pluton (no. 2 on map B) are the major Tertiary intrusive bodies in the southern two study areas. Rocks of the Rio Hondo pluton are quartz monzonite (unit Tqm) with subsidiary granite (unit Tg).

In contrast to the plutons at Red River canyon, plutons in the Columbine-Hondo Wilderness Study Area and in the Wheeler Peak Wilderness are substantially magnetized as shown by survey data. However, the data also indicate local occurrences of granitic rocks having low magnetization, and an effort is made here to outline those rocks, because the Tertiary rocks associated with molybdenum mineralization at Red River canyon have low magnetization (see map B).

A magnetic high shown on both map B and map C trends northwest from the eastern exposures of the Rio Hondo pluton (no. 1 on map B), suggesting that the Rio Hondo pluton extends to the Bear Canyon pluton (no. 3 on map B) beneath Proterozoic granite (unit Xg). Also, a lobe of the magnetic high trends southwest from the eastern exposures of the Rio Hondo pluton, suggesting that the pluton is continuous (beneath various Proterozoic rocks) with western exposures. Weakly magnetized rocks of the Rio Hondo pluton are indicated at R, and molybdenum mineralization occurs in the extreme west at Mo.

A prominent magnetic low at S, immediately north of the western part of the Rio Hondo pluton, is in an area of Proterozoic quartzite (unit Xq) and amphibolite (unit Xa); however, neither these rocks nor the prevailing terrain provide an adequate explanation for this magnetic low. A concealed, weakly magnetic intrusive body may be the source of this magnetic low or, in part, the low may reflect the negative dipole field of the western part of the Rio Hondo pluton.

Tertiary granite (unit Tg) of the Lucero Peak pluton (no. 2 on map B) is generally less magnetic than the quartz monzonite (unit Tqm) of the Rio Hondo pluton (no. 1 on map B). The most intense positive anomalies at the Lucero Peak pluton reflect Proterozoic amphibolite (unit Xa), which caps granite ridges and peaks. A weakly magnetic phase of the granite is interpreted in eastern-most outcrops, where its approximate contact with a more strongly magnetic phase is near a molybdenum occurrence at T (Luddington, 1981). The contact is also indicated by a steep magnetic gradient at T, on map C. Two shallow extensions of weakly magnetic granite are suggested, one trending north from U, the second east from V. The north-trending magnetic low loses identity at a deep, east-west-trending magnetic low north of the magnetic high at BB.

The Relica Peak plug or laccolith (no. 8 on map B) lies at the eastern border of the Columbine-Hondo Wilderness Study Area.

From Reed and others (1983):

"Large body of intrusive rhyolite near Relica Peak at head of the Red River is interpreted as a single large plug or irregular laccolith."

This body of rock is only weakly magnetic. A magnetic high at W, associated with phyllite (unit Xp), projects northeast across the northwest lobe of this body of rock, suggesting that phyllite occurs beneath it in this area. This relationship is compatible with the preceding geologic description.

MAGNETIC INTERPRETATION: PRECIOUS-METAL MINERALIZATION

Most known precious-metal deposits in the study areas (Briggs, 1982) have no related magnetic expression. Exceptions are precious-metal deposits associated with magnetite-specularite iron formation in Proterozoic phyllite (unit Xp); such deposits are known at magnetic highs W and X. A magnetite-precious-metal association also occurs at Y; however, rocks there are granite (unit Xg) and amphibolite (unit Xa), and mineral paragenesis is not known.

Iron formation may be the source of magnetic highs at Z, AA, and BB. Proterozoic felsic volcanic rocks (unit Xf) crop out at Z, but the magnetic high there may be caused by concealed phyllite containing iron formation. Phyllite occurs at AA, and iron formation is a plausible source of the magnetic high there. Rocks causing the two magnetic highs at BB are mostly concealed: the southeast high correlates in part with phyllite but must in part have a source within or beneath tonalite (unit Xt); and surface rocks at the northwest high are amphibolite (unit Xa), but iron formation in phyllite may be present in the subsurface.

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