TOTAL-INTENSITY MAGNETIC-ANOMALY MAP OF THE RENO 1° by 2° QUADRANGLE, NEVADA AND CALIFORNIA

By

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INTRODUCTION

This map is part of a folio of maps of the Reno 1° by 2° quadrangle, Nevada and California, prepared under the Conterminous United States Mineral Assessment Program. Each product is designated by a different letter symbol, starting with A, in the U.S. Geological Survey Miscellaneous Field Studies Map MF-2154 folio.

AEROMAGNETIC DATA AND REDUCTION TECHNIQUES

Data used in compilation of this map were collected during two separate surveys (U.S. Geological Survey, 1971; 1972). Measurements in the northern two-thirds of the quadrangle were obtained at a constant barometric elevation of 2,744 m along east-west flight lines spaced about 3.2 km apart. The survey that included the southern one-third of the quadrangle employed two flight elevations; 2,744 m, east of long 119°51', and 3,354 m, west of long 119°51'. The increased flight elevation in the southwestern part of the study area was necessary because of surface elevations in excess of 2,744 m in this region. Survey flight lines in the southern survey were spaced at intervals of 1.6 km in east-west directions. An aeromagnetic map of the Reno 1° by 2° quadrangle, using these data, has previously been published by the Nevada Bureau of Mines and Geology (1977).

Data for the present map are from a compilation and reduction of aeromagnetic measurements of the State of Nevada by Kucks and Hildenbrand (1987). Because aeromagnetic readings were collected at different times, flight line spacings, and elevations, a consistent data set for the State of Nevada was created in order to provide uniformity to the final map production (Hildenbrand and Kucks, 1988). The reduction procedure is cited as follows.

For most individual aeromagnetic surveys, the total-intensity data were gridded in units of decimal degrees at a grid interval of 0.0083 degrees (30") of latitude and longitude using a computer program (Webring, 1982) based on minimum curvature (Briggs, 1974).* * *. The geomagnetic reference fields appropriate for the date and location of the surveys were subtracted from the total-intensity grids to produce the residual total-intensity grids. The particular geomagnetic reference field removed depended on the year in which a given survey was flown and included the International Geomagnetic Reference Field of 1965 prior to 1965, the Provisional Geomagnetic Reference Field between 1965 and 1980, and the International Geomagnetic Reference Field of 1980 after 1980 (Peddie 1982a and b). The residual anomaly grids were then projected to the Lambert conic conformal projection (standard parallels at 33° N and 45° N and central meridian at 117° W) on a 1-km grid.

A new technique called "chessboard", developed by Cordell (1985), was used to drape data taken at constant elevation onto a surface 305 m (1,000 ft) above ground. Data originally observed on a level surface were continued onto ten levels by the conventional level-to-level continuation using the Fast Fourier Transform (computer program by Hildenbrand, 1983). Two levels were selected slightly both above the highest and below the lowest point of the datum surface. The remaining six levels were equally spaced (internal <340 m) between these maximum and minimum points. To remove short-wavelength noise enhanced by the downward continuation process, a low-pass filter was applied to the data. As the amount of downward continuation (*h*) increased, a larger value for the wavelength cutoff (*wl*) was selected using $wl=1.25.(h+2.\text{grid spacing})$. The calculated field on the lowest of the ten levels, therefore, was filtered the most while those upward continued from the original observational level were not filtered. The field, now known on the stack of ten levels, was evaluated at any point on the datum surface (305 m above terrain) by least-square interpolation in the vertical direction.

Before merging data sets, we adjusted the magnetic field values of each survey by a datum shift, if required, to minimize discontinuities at survey boundaries. The data sets were then merged using the one-dimensional splining techniques described by Bhattacharyya and others (1979).

The resulting data set was computer contoured for the present map presentation. This map is a representation of the total-intensity magnetic field, 305 m above ground in this portion of Nevada. A note of caution should be made however; some short-wavelength information has been lost in the filtering, gridding, and contouring processes. Persons interested in applying analytical techniques to individual anomalies should refer to the original survey data and reserve the present map for such qualitative purposes as identification of magnetic trends and approximate locations and amplitudes of major individual anomalies. For a comparison of magnetic and geologic features readers should refer to the companion geologic map of Greene and others (1991).

DISCUSSION

REGIONAL SETTING

The Reno 1° by 2° quadrangle is located, for the most part, in the extreme western part of the Great Basin section of the Basin and Range physiographic province; only the southwest corner of the quadrangle is part of the Sierra Nevada section of the Sierra-Cascade province (Fenneman, 1931) (fig. 1). Topographically and structurally the Reno quadrangle is bisected along a northwest-trending line that separates two different magnetic regions.

In the northeast half of the quadrangle, the topographic and dominant structural grain trend north-northeast, which is reflective of Tertiary Basin and Range topography and structure. This structural grain is superimposed on a subordinate and older (Mesozoic) northwest trend. The northerly structural and magnetic character is representative of most of northwestern Nevada south of the extensive basalt province of extreme northwestern Nevada and southeastern Oregon.

The southwest half of the quadrangle is part of a large area of western Nevada and east-central California lying immediately east of the Sierra Nevada in which the major structural features are a number of blocks characterized by west-northwest striking, right-lateral, strike-slip faults. Large blocks typified by the right-lateral faults are broken by areally subordinate zones, in which complex east to northeast, mainly left-lateral, faults predominate. The composite region has been termed the Walker Lane belt (Carr, 1984; Stewart, 1988) and nine individual structural blocks have been identified as comprising the belt (Stewart, 1988). Within the Reno 1° by 2° quadrangle, parts of three blocks are present; Pyramid Lake in the northwest, Carson in the west-central and southwest, and Walker Lake in the south-central (fig. 1). The Pyramid Lake and Walker Lake blocks are two of the blocks characterized by major northwest-striking, right-lateral, strike-slip faults and minor north-trending normal faults. The Carson section is typified by zones of northeast-striking faults of known or presumed left-lateral displacement. The origin and tectonic implications of features of the Walker Lane belt are a matter of some discussion in the geologic literature (see Stewart, 1988 for summary). Tectonic activity, reflected in the blocks, may have begun as early as the Late Triassic forming structural features that were reactivated in late Cenozoic time.

The magnetic character in the Walker Lane belt reflects the structural orientation; west-northwest-trending magnetic ridges, troughs and alignment of isolated highs typify the region. This magnetic grain results from a combination of structurally controlled topography, emplacement of plutonic rocks, and (or) juxtaposition of rocks of differing magnetization along transcurrent faults. Stewart and others (1977) have described anomalies in the Walker Lane belt as arcuate or slightly sigmoidal and suggest a possible genetic relation with a series of west-trending magnetic features in eastern Nevada and western Utah.

Most positive magnetic features in the Reno quadrangle and environs appear to be related to a series of Mesozoic and late Tertiary intrusive bodies of varying composition. Extensive Tertiary basalt and andesite flow sequences also produce positive anomalies on this map although amplitudes are much less than those interpreted as resulting from intrusive sources. Negative magnetic features in the region appear to arise from a variety of sources; deep sediment-filled basins, relatively thick sequences of Paleozoic(?) and Mesozoic metamorphic rocks, thick deposits of Tertiary pyroclastic material, plutonic rocks with a strong reversed remnant magnetic component, and dipolar lows associated with positive anomalies.

Analysis of the magnetic field of Nevada by Blakely (1988) suggests that the depth to the Curie isotherm (the temperature at which magnetite becomes paramagnetic) may vary in the Reno quadrangle from less than 10 km in the north-central to more than 20 km in the south. Also, a north-trending zone of shallow depth to the Curie isotherm is located immediately east of the quadrangle. This zone may reflect active extensional and strike-slip faulting in the region (Blakely, 1988), an interpretation supported by historic earthquake activity (Ryall and others, 1966), anomalous crustal seismic proprieties (Eaton, 1963; Catchings, 1987; Thompson and others, 1988), and high heat flow (Lachenbruch and Sass, 1978). Depth to magnetic basement (depth to the top of magnetic sources) within the Reno quadrangle is variable, ranging from the surface in most mountainous areas to 2 to 3 km in the Carson Sink and Dixie Valley regions (Smith, 1968; Speed, 1976; Okaya and Thompson, 1985). The effects of a shallowing Curie isotherm are a reduction in the amplitude of a given anomaly and a subtle, but determinable, change in the spectral properties of the general magnetic field when viewed over a large area. The effects of substantial changes in the depth to magnetic basement are not only a large variation in the amplitudes of anomalies but also a significant difference in the gradients associated with the anomalies. Given two bodies of similar shape and composition, which are at different depths, the increased distance to magnetic basement of the deeper source would result in a reduction of the amplitude and lengthening of the gradients associated with that body. In this light, the horizontal length of the maximum magnetic gradient along the edge of an isolated anomaly is one parameter used to estimate the maximum depth to the top of the source and is used, in a limited extent, in the following discussion.

ANOMALIES WITHIN THE RENO QUADRANGLE

Residual total-field magnetic values vary in the Reno quadrangle from a high of approximately +1,200 nT (nannotesla) in the northwest corner of the map (Dry Valley) to isolated lows of about -750 nT in the central and north-central areas. Very low values are also located along the western margin of Carson Valley in the southwest corner of the map. The total relief of the residual field within the quadrangle is about 2,000 nT, which when combined with the associated steep magnetic gradients, is reflective of the highly variable magnetic character of the near-surface rocks of the region. Areas of subdued anomalies and low gradients are associated with large sediment-filled basins of the Carson Sink, Dixie Valley, and Mason Valley. These magnetically "flat" regions reflect the increased depth to source and possibly nonmagnetic character of basement rocks flooring the valleys. Because the data presented on this map are residual values, anomalies fluctuate from an average of about 0 nT, as would be expected. The extreme maximum and minimum anomalies are areally restricted and reflect local magnetic sources as opposed to a more regional variation. In the following discussion descriptions of magnetic anomalies as they pertain to physiographic features or regions are presented, beginning in the northeast corner of the map.

Stillwater Range and Carson Sink

The residual magnetic field in this part of the quadrangle can be divided into three areas on the basis of amplitudes and spatial relations of anomalies. In the northern Stillwater Range and Carson Sink (northeasternmost corner of the quadrangle), circular positive anomalies appear to be related to Jurassic basic intrusive rocks of the Humboldt lopolith (Speed, 1976). Positive anomalies here are in the range of 300 to 750 nT and are centered over outcrops of gabbro. Other anomalies in the area suggest that sources are very near surface or, in the northern Carson Sink, form the floor of the depression.

The Humboldt lopolith underlies an area of about 1,000 km^2, in and directly adjacent to, the northeast corner of the Reno quadrangle (fig. 1). It is elliptical in plan view with the semi-major axis extending in a northwest direction from the Clan Alpine Mountains in the southeast to the West Humboldt Range to the northwest, a distance of about 50 km. The width is approximately 25 km. The Humboldt lopolith is a gabbroic dish or spoon-shaped intrusion displaying well-defined igneous layering and foliation near its lateral margins, and grading upward, in the interior, from gabbroic to sodic rocks within 100 to 300 m of the roof. The intrusion was emplaced at shallow crustal levels in Middle Jurassic time and presently represents the upper plate of concomitant Jurassic thrusting (Speed, 1976). Dilek and others (1988) have posed an alternate interpretation for the Humboldt complex, in which they suggest that the igneous rocks represent lower Mesozoic ophiolitic basement preserved as thrust nappes. This interpretation, however, apparently conflicts with certain age and structural relations (D.A. John, written commun., 1990). From magnetic modeling, the maximum thickness of the intrusion is estimated to be nearly 3 km near its center (Smith, 1968; Speed, 1976). The magnetic field over the intrusive complex is quite variable with both high and low closures noted within the confines of the body. Discrete highs occur near the margins of the body and over outcrops of the intrusive rocks. Magnetic low closures may have a variety of sources including; extensive deuteric alteration of the gabbroic rocks in the areas of the magnetic lows, burial of the gabbroic rocks beneath post-Mesozoic deposits, and thinning of the magnetic source rocks by Mesozoic and (or) Cenozoic erosion or extensional faulting. From laboratory analysis of a limited number of samples, Smith (1968) indicates that the gabbro, altered gabbro, and associated mafic rocks of the Humboldt lopolith have a wide range of magnetic properties (table 1). Susceptibilities of these rocks fall into the range of 20x10^{-6} to 4,120x10^{-6} EMU (electromagnetic units). The variability of susceptibility is dependent on the iron content of the sample (primarily magnetite) and the oxidation state of the iron. Of the values listed by Smith (1968), there is not a clear contrast between the susceptibilities of altered and unaltered(?) samples. This would suggest that at least some of the large variability in magnetic properties measured in these samples may result from segregation of the iron during the intrusive process rather than deuteric or post magmatic alteration. Iron (magnetite) endoskarns are associated with the Humboldt lopolith (John and Sherlock, 1991) and represent massive and vein replacement of the gabbro and associated basalt by magnetite, commonly associated with scapolite and albite alteration. On the magnetic map, the iron endoskarns are generally associated with magnetic highs (for example, Copper Kettle Canyon-Buena Vista mine; northeast corner of map) and may contribute to the high anomalies but do not appear to be the primary source. The lateral extent and gradients of the Copper Kettle Canyon anomaly suggest the source occupies a much larger volume than is indicated by the exposed skarn deposits.

Magnetically, the area south of the Humboldt lopolith is characterized by subdued anomalies and gradients forming a distinct west-northwest-trending trough. This magnetic depression continues east of the Reno quadrangle for about 45 km across the Dixie Valley and into the Clan Alpine Mountains, where it takes a sharp bend to the south (Hildenbrand and Kucks, 1988). This trend is perpendicular to the topographic grain of the region and crosses both the Stillwater Range and Clan Alpine Mountains at a sharp angle. Pre-Tertiary rocks exposed in these mountains, where the magnetic trough crosses, are primarily Triassic and Jurassic metasedimentary clastic rocks (Greene and others, 1991), which may attain a thickness in excess of 5 km (Speed, 1978). The great thickness and nonmagnetic character of these rocks (table 1) would be sufficient to explain the low residual values. The data that indicate the trend continues across the southern Dixie Valley and Carson Sink and that isolated anomalies are absent suggests that the metasedimentary units form the basin floors and the magnetically low area has not been invaded by later intrusions.

To the south of this magnetic trough is a large area dominated by a positive, regional magnetic anomaly. This area of relatively high values forms a prominent northwest-trending "block" evident on the statewide compilation (Hildendrand and Kucks, 1988). Its dimensions are approximately 100 km in length and 25 km in width, extending from the southwestern margin of the Carson Sink southwestward to the Desatoya Mountains some 25 km east of the Reno quadrangle. Within this block are a number of high and low closures. Comparison of anomalies and exposures in the southern Stillwater

Range (Greene and others, 1991) strongly suggests a correlation between magnetic highs and Cretaceous and Tertriary granitoid bodies. Little correspondence exists between magnetic highs and Tertiary surficial flow and pyroclastic sequences. These observations suggest that magnetic basement in this block is composed largely of Cretaceous and Tertiary granitic rocks, and the metasedimentary units seen immediately to the north are scarce or nonexistent within the block. Positive anomalies in the block that do not have an obvious source exposure (burial beneath late Cenozoic sediments or volcanic units) probably reflect the presence of granitoid plutons in the subsurface. This interpretation is based on a similarity of the lateral extents, amplitudes, and gradients of anomalies in areas of exposed and unexposed source rocks. Gradients suggest that the top of magnetic sources are not more than about 1 km in depth.

Three Tertiary tuff-filled calderas have been identified in the southern Stillwater Range (John and McKee, 1991; John and Silberling, 1991) and one along the east Reno quadrangle border in the southern Clan Alpine Mountains (Hardyman and others, 1988). Postcaldera tectonic activity resulted in dismemberment and tilting of the calderas and associated ash-flow tuffs to a nearly vertical position. The northern two of the three in the Stillwater Range (near lat 39°37.5' ; long 118°15') contain as much as 3 km of primarily rhyolitic tuff and are associated and comagmatic with a body of granodiorite that appears to be the source of a +200- to +300-nT, three-peaked circular anomaly (fig. 1). The other caldera in this area is not evident on the magnetic map.

If structurally intact and not affected by later igneous events, silicic, tuff-filled calderas are commonly reflected in the magnetic field as circular negative anomalies. These magnetic lows result from a combination of removal or disruption of the country rock (assuming it had a measurable induced and remanent magnetic component), infilling of the cauldron with pyroclastic material that had cooled below the Curie point prior to deposition (that is, randomizing of remanent magnetism), hydrothermal alteration associated with the magmatism, and frequently a lower magnetic susceptibility (lower induced magnetization) of the explosive source material compared to the country rock. Inasmuch as caldera-type eruptions occurred in the southeastern part of the Reno quadrangle in Oligocene to Miocene time (John and McKee, 1991), a study of the magnetic map in this region revals several anomalies that could be related to these explosive events.

The first of these are a pair of circular magnetic lows in the south-central part of the Carson Sink, about 25 km northeast of Fallon (fig. 1). Both of these negative anomalies are somewhat elliptical (elongate to the north) and average nearly 4 km in diameter. The larger (amplitude) of the two is nearly -600 nT with gradients suggesting the top of the source is at a depth of about 1 km. Whether these anomalies are related to calderas or not is speculative. Arguing for the presence of calderas are the shape and amplitudes of the magnetic anomalies and the proximity of the anomalies to the estimated location of an eruptive center in the Carson Sink that was the source for some of the widespread ash-flow tuffs in the Reno quadrangle (Best and others, 1989). Arguements against calderas are an apparent lack of associated gravity anomalies (Erwin and Berg, 1977) and a similarity in shapes and amplitudes with other magnetic anomalies in the western Reno quadrangle that are not associated with calderas. Another possible source for these anomalies would be negatively polarized stocks (probably intermediate in composition) with a large component of remanent magnetization. Other possible caldera associated magnetic anomalies in the southeastern part of the quadrangle are discussed below.

Southeastern section
(Fairview Peak, Sand Springs Range, and Cocoon Mountains)

The magnetic field in this part of the quadrangle lacks well-defined linear trends and is variable, ranging from intense anomalies with short wavelengths in the Fairview Peak region to subdued anomalies in Fairview Valley and Fourmile Flat. Many of the anomalies in this area are located over Tertiary pyroclastic deposits or Quaternary alluvium and obvious source rocks are not exposed. Two or more possible calderas may be located in this area (D.A. John, written commun., 1990). One is located near Fairview Peak, in an area of extensive deposits of Tertiary tuff; however, the location of the actual volcanic center is not straightforward. Intense positive anomalies here suggest a large, highly magnetic plutonic body is located immediately east of Fairview Peak (fig. 1) and may represent the intrusive source for the pyroclastic rocks. Short wavelengths associated with this anomaly indicate that the top of the causative body is shallow, probably less than 0.5 km below the surface. Circular positive anomalies to the west and south of this prominent magnetic high are lower in amplitude and are, in some cases, related to bodies of Cretaceous granitic rocks. Other possible volcanic centers may be located in the southeast corner of the Reno quadrangle, but again their locations are problematical (D.A. John, written commun., 1990). Magnetic lows in this area may reflect calderas but further studies and analyses would be required to substantiate this relation.

The northern Sand Springs Range is characterized by a large body of Cretaceous granitic rocks that are bounded on the north and south by Mesozoic metasedimentary rocks. The corresponding magnetic field over the granitic terrane is typical of a normally polarized body that has a positive susceptibility contrast compared to adjacent units, that is, a positive peak over the southern margin of the plutonic body sloping down to the north and a magnetic low north of the body. A steep down-to-the-southwest magnetic gradient along the southern margin of the granitic mass suggests a steep contact between metasedimentary rocks to the southwest and the plutonic rocks. This gradient also appears to be a part of a continuous magnetic lineament that marks the boundary between the Basin and Range and Carson-Walker Lake structural blocks of Stewart (1988). The areally extensive negative anomaly in the northern Sand Springs and southernmost Stillwater Ranges may reflect Mesozoic basement consisting predominantly of metasedimentary rocks. The positive magnetic anomaly associated with the Sand Springs granitic rocks continues to the northwest, crossing the southern Fourmile Flat and into the Cocoon and Bunejug Mountains suggesting a continuation of granitic basement in these areas.

South-central section (Mason/Churchill Valleys and Desert/Dead Camel Mountains)

The magnetic character in this region consists of a series of southerly concave, west-northwest oriented ridges and troughs that extend from the Carson fault zone in the northwest for at least 100 km beyond the quadrangle boundary to the southeast. In this area magnetic ridges generally correspond to positive topographic features (Desert, Dead Camel, and Terrill Mountains and Calico Hills). Magnetic ridges also extend across intervening alluvial valleys indicating that the anomalies do not result solely from terrain differences. Magnetic peaks atop the ridges appear to be associated with isolated outcrops of Mesozoic granitic and dioritic rocks and relatively thick accumulations of Tertiary basalt and andesite flows (Greene and others, 1991), which interpretation is supported by analyses of magnetic properties of rocks in the region (table 1). The circular +700-nT magnetic high along the Desert Mountains trend in the Calico Hills (south boundary of the map; fig. 1) suggests the presence of a magnetite-rich pluton at a depth of 1 to 2 km. Iron skarn deposits in the area may result from hydrothermal leaching of a Jurassic(?) intrusion and magnetite replacement in overlying Mesozoic carbonate units. Modeling suggests that magnetic basement in, and to the north of, the Desert Mountains (Churchill Valley) is primarily granitic. Northeast of the Desert Mountains a segmented magnetic trough, extending from Churchill Valley southeast to Black Eagle Hill (fig. 1), may represent a narrow zone (~4 km wide) of Mesozoic metasedimentary and metavolcanic rocks that has been intruded by stock-size plutons, although none of these rocks are exposed. South of the Desert Mountains, a more continuous magnetic trough extends from the Pine Nut Mountains about 100 km to the south-southeast (30 km beyond the Reno quadrangle boundary; fig. 1). Where exposed, pre-Tertiary basement along the trend is mainly a complex mixture of highly altered sedimentary and volcanic units of the Pine Nut terrane (Greene and others, 1991). Samples collected during this study for magnetic analyses indicate the nonmagnetic character of these rocks (table 1) and modeling suggests that the sequence may attain a thickness of 3 to 4 km in the northern Mason Valley. South of this trough is a magnetic ridge that cuts the topographic grain of the northern Buckskin and Singatse Ranges, crosses Mason Valley, and continues into the Wassuk Range (fig. 1). Outcrops of granitic rocks along this ridge suggest they are the sources of the positive anomaly.

This area of the Reno quadrangle consists of parts of the Walker Lake and Carson structural blocks of Stewart (1988). Magnetically, the northwest oriented features of the Walker Lake block appear to continue well into the Carson block, terminating or being offset along the Carson fault zone. A southerly bending of the west end of the Mason Valley magnetic ridge appears to be spatially related to the northeast-trending Wabuska fault zone (fig. 1), suggesting either structural control of the magnetic source rocks or lateral offeset along the fault. The northeasternmost magnetic ridge in this section (herein called the Dead Camel-Blow Sand trend; fig. 1) apparently marks a fundamental boundary in the basement complex. Northeast of the Dead Camel-Blow Sand trend, magnetic lineaments are not as well developed and the residual magnetic values are at a slightly reduced level compared to those to the southwest. This magnetic trend also corresponds to both the Lahontan Reservoir structural and volcanic zone (D.A. John, written commun., 1990) and an abrupt change in the regional Bouguer gravity anomaly (Erwin and Berg, 1977). The Lahontan Reservoir structural and volcanic zone is located near the northwest end of the magnetic trend and is a well-defined broad zone of east-southeast striking faults, a concentration of rhyolitic lava flows and flow domes, and an elongate east-southeast distribution of basalt and andesite lava flows. Faults and volcanic rocks within the zone are Cenozoic in age and probably are not the sources of the magnetic anomaly. Instead, distribution of structural and volcanic features within the zone may represent reactivation of older (Mesozoic) structures, which also controlled emplacement of Jurassic and Cretaceous plutons that are the suggested sources of the magnetic anomaly. A similar relation may exist along the Desert Mountains magnetic trend and structural-volcanic zone (D.A. John, written commun., 1990). Gravity values to the northeast of the Dead Camel-Blow Sand trend, in the Basin and Range block, are about 20 mGal higher than those in the Carson block. This sharp change in the Bouguer gravity anomaly values extends across the entire Reno quadrangle in a somewhat sinuous pattern, from the Virginia Mountains west of Pyramid Lake to the southern Sand Springs Range. Increased gravity values in the Basin and Range block could result from a combination of density contrasts, ranging from changes in upper mantle density and (or) crustal thickness to upper crustal inhomogenities. The correspondence of the gravity and magnetic lineations suggests, however, that part of the source of the gravity variation lies within the upper 15 km of the crust.

The Carson lineament is a zone defined by alignment of valleys and ranges and contains numerous northeast striking faults. It is presumed, from comparison with the Olinghouse zone to the north, to represent the site of pre-mid-Cretaceous, left-lateral offset (Rodgers, 1975) extending into the Holocene. The Carson lineament extends from the vicinity of Carson City on the southwest to about Lahontan Dam near the center of the quadrangle (fig. 1). Clearly, the strong northwest-oriented magnetic anomalies in the south-central part of the quadrangle are terminated or offset where they intersect the lineament. If initial development of the lineament predated intrusion of the magnetic source rocks, the zone may have controlled emplacement of plutons, or if initial tectonic activity postdated plutonic activity, source rocks may have been laterally separated along the transcurrent faults. In either case, the Carson lineament marks the northwest terminus of the magnetic ridges in the Walker Lake and southern Carson structural blocks.

Sierra Nevada section

This area is located in the southwest corner of the map (fig. 1) and includes Lake Tahoe, the Carson Range, and the Carson and Washoe Valleys. Magnetic anomalies in this section appear to be related to pre-Tertiary basement rocks that are predominantly granitoids of the Sierra Nevada batholith but including a sequence of Triassic and (or) Jurassic metavolcanic rocks along the west margin of Carson Valley. The Carson Range displays a north-trending, generally positive anomaly while lows are located over Lake Tahoe and along the west margins of Carson and Washoe Valleys. The prominent north-trending magnetic high near Genoa Peak (south boundary of the map; fig. 1) probably reflects an highly susceptible component of the batholith, whereas the low immediately to the east appears to correspond to Mesozoic metavolcanic rocks. Gradients between these two anomalies suggest a steeply dipping contact and the continuation of the low into Carson Valley may reflect a metavolcanic floor although topographic effects may also contribute to the low. Sources of the low magnetic values in Washoe Valley and adjacent Carson Range are not evident from the surficial geology but probably represent either a part of the batholith with low magnetization or a wedge of metamorphic rocks beneath the granitic rocks and valley fill.

The Virginia Range

Located in the Carson structural block, between the Olinghouse and Carson fault zones, the northeast-trending Virginia Range (fig. 1) is typified by extensive exposures of Tertiary volcanic rocks and restricted exposures of Jurassic(?) and Cretaceous granitoids. A distinctive Tertiary dacite unit (the Kate Peak Formation) is present as lava flows, flow and laharic breccias, and intrusive rocks in much of the area. Of the 55 samples collected for magnetic analyses during this study, a sample of Cretaceous granite along the south margin of the Virginia Range had the highest values of susceptibility (~ 3,000 x 10^{-6} EMU). This granite crops out at the northwest end of the Desert Mountains magnetic ridge and is interpreted as one of the sources of the anomaly. Outcrops of the intrusive rocks of the Kate Peak Formation also are associated with positive magnetic anomalies. Although the exposures occupy a much smaller area than the corresponding highs they are thought to be, at least in part, the source rocks of the anomalies. Other extensive anomalies in areas of sedimentary or volcanic cover in the Virginia Range probably reflect either pre-Tertiary plutons or dacite intrusions of Kate Peak Formation.

Intense negative anomalies are found in several locations in the Virginia Range. The largest of these is located in the eastern Virginia Range 5 km north of Silver Springs (fig. 1), has an amplitude of -600 nT, and is about 6 km in diameter. The source of this anomaly is not evident in the topography or exposed rocks but, from its geometry, a shallow negatively polarized body is suspected. If this is the case, the magnetic low indicates that the intrusion has a negative remanent component that is significantly larger than the induced magnetism. This anomaly lies near the intersection of the southerly projection of the Pyramid Lake (right-lateral) and Carson (left-lateral) fault zones, suggesting premagmatic or comagmatic structural control of the location of the intrusion. Also, this anomaly is along the major gravity gradient that marks the boundary of the Basin and Range and Carson structural blocks.

North-south elongated magnetic highs and lows are found near the Lyon-Storey County line in the vicinity of Tibbie Peak (fig. 1). The easternmost of these is a 300-nT low that appears to be associated with exposures of a series of pre-Tertiary granitic and metamorphic rocks. This anomaly is mentioned because of its proximity to the Dayton and Iron Blossom iron skarn deposits, which are 5 and 10 km southeast of Tibbie Peak respectively (John and Sherlock, 1991), and may represent the intrusive source of the mineralization. The Tibbie Peak anomaly consists of a north-trending 400- to 500-nT central high flanked on the east and west by 250-nT lows. The high is situated over a relatively extensive exposure of dacite belonging to the Kate Peak Formation but the magnetic pattern is atypical of a uniformly polarized, homogeneous intrusion. Sources of the flanking lows are not obvious but could arise from several situations: (1) intrusion of the dacite into a wedge of low susceptibility metamorphic(?) rocks, (2) fault-controlled alteration of the east and west margins of the dacite, or (3) multiple episodes of intrusion and cooling under both normal and reversed magnetic fields. A similar pattern is noted in other locations in the northwest quadrant of the map, that is a northerly elongate magnetic high flanked on the east and west by lows. In these locations, as well as Tibbie Peak, lows appear to be spatially related to north-striking Basin and Range normal faults that bound or cut intrusions. Alteration of high-susceptibility intrusive rocks along the faults may be indicated in these locations.

Pyramid Lake structural block

A portion of this structural division of Stewart (1988) occupies a majority of the northwest part of the Reno quadrangle (fig. 1). This block is bounded by Pyramid Lake and the Pyramid Lake fault zone on the northeast and the Olinghouse fault zone to the south. The structural block continues to the northwest into California. Prominent structural features within this block, in the map area, are the northwest-striking, right-lateral Pyramid Lake and Warm Springs Valley transcurrent faults, and a series of north-striking Tertiary normal faults. Surficial geology in this section includes Jurassic and (or) Cretaceous dioritic intrusions of Petersen and Freds Mountains, Cretaceous granitoids north and west of Reno, the Pah Rah Range, and Dogskin Mountain, wide-spread late Tertiary flow sequences and related rocks, late Tertiary ash-flow tuffs, and Quaternary alluvial valley fill.

The magnetic field is reflective of these basic geologic units and is quite variable in this region, ranging from intense highs over exposures of dioritic rocks and a granitoid at the northwest corner of the map, to both oval and trough-shaped lows. In general, magnetic highs are found over exposures of Cretaceous granitic rocks (which range in magnetic amplitude from about 200 nT to as much as 500 nT) and dioritic rocks with anomalies with as high as 1,300 nT. As mentioned in the previous section, magnetic lows flanking positive anomalies on the east and west sides are found at several locations (fig. 1). These negative anomalies do not represent dipolar lows resulting from magnetic induction in the inclined field but, in all likelihood, reflect either the presence of east and west flanking nonmagnetic country rock or alteration of the positive source rock along north-striking faults or fault zones. Isolated magnetic lows in the Pah Rah Range (near and to the south of Spanish Springs Peak; fig. 1) are found over an extensive basalt-andesite terrane and could possibly be caused by thick accumulations of reversely polarized extrusive rocks and (or) reversely polarized intrusive rocks. Magnetic troughs are located along the Pyramid Lake and Warm Springs Valley fault zones and may reflect alteration associated with the faults. A large area of negative magnetic anomalies is located over Pyramid Lake and the Truckee River valley southeast of the lake. Over Pyramid Lake the low magnetic anomaly is caused, at least in part, by the increased sensor to source distance (water depth plus sediment fill), while in the lower Truckee River valley negative anomalies may be associated with a sequence of Paleozoic or Mesozoic carbonate rocks that may be extensive in the subsurface.

Truckee and Trinity Ranges

Located in the north-central part of the Reno quadrangle, this region is characterized by an extensive Tertiary basalt-andesite terrane in the southern Truckee Range, and an area of granitic and volcanic rocks in the northern Truckee and Trinity Ranges. Intrusive rocks, in the northern terrane, range in composition from gabbroic to granitic (Greene and others, 1991) and are Jurassic and Cretaceous in age.

Despite the wide-spread occurrence of intrusive bodies in this northern area, isolated magnetic anomalies are at a reduced level when compared to other such regions of the quadrangle, averaging less than about 200 nT. One area displaying a large amount of magnetic relief in this region is North Valley in the central Truckee Range (fig. 1). Here a circular 600- to 700-nT low (7 km in diameter) is found over the valley, while the surrounding mountains produce a 100- to 200-nT high ring. Because topographic effects have been largely accounted for in the magnetic reduction procedure this anomalous area probably does not reflect just terrain differences. The striking correspondence of the magnetic pattern and topography, however, suggests lithologic or structural control of the terrain. Source rocks of the magnetic low are not exposed in the valley but, because of the circularity and amplitude of the anomaly, an intrusive body is suspected. Gradients suggest the top of the source less than 2 km below the surface.

The magnetic field over the basalt-andesite terrane of the southern Truckee Range is complex, displaying large amplitude high and low closures. A distinct pattern of these anomalies is not evident, although the anomalous region appears to be centered in the topographically highest part of the Truckee Range, near Two Tips peak (fig. 1) along the Churchill-Washoe County line. Both near-surface and deep sources are suggested by the anomaly gradients. Surficial volcanic deposits (to 1 km in thickness), when combined with the effects of subvolcanic intrusions (Two Tips peak is a known young volcanic center), could account for the observed anomalies. If this is the case, magnetic lows indicate that parts of the volcanic units are either reversely polarized or have a lower susceptibility than units corresponding to positive anomalies.

SUMMARY

Values displayed on this map simulate the residual total field that would be observed about 305 m above the ground. Corrections and adjustments have been applied to the original survey data, which was flown at constant barometric elevations, in order to simulate a "draped" survey and merge measurements of adjacent surveys and survey levels.

Regionally, the Reno quadrangle occupies parts of two physiographic terranes; the Great Basin and the Sierra Nevada. The magnetic character is reflective of these divisions. A horst-graben terrain typical in the Great Basin is noted in northeastern quarter of the quadrangle and is characterized by poorly developed north to northeast and west to northwest trending magnetic anomalies. North and northeast trends reflect late Tertiary Basin and Range tectonic development while northwest-trending magnetic anomalies are related to Mesozoic structural and magmatic events. Major anomalies or anomalous areas in this section generally reflect pre-Tertiary basement lithologies. Positive anomalies are located over areas where basement is composed primarily of intrusive rocks of varying age and composition and negative anomalies are found over Paleozoic or Mesozoic metamorphic basement. Tertiary volcanic rocks apparently have only minor effects on the magnetic field, as presented on this map.

The northwest-trending Walker Lane belt occupies most of the southwestern part of the quadrangle and is represented by three structural blocks; the Walker Lake, Carson, and Pyramid Lake. Northwest-trending magnetic ridges and troughs in this region reflect both juxtaposition of rocks having different magnetic susceptibilities and structural control of the emplacement of intrusive bodies. Prominent northwest anomalies are terminated or offset along the northeast-striking Carson and Wabuska fault zones. Analyses of samples collected in the southern part of the quadrangle indicate the highly variable magnetic susceptibilities of some of the outcrop units; this variability is sufficient to account for the observed anomalies. As in the northeastern part of the quadrangle, magnetic highs and ridges appear to be related to intrusive basement, while regionally continuous magnetic troughs correspond to thick wedges of metamorphic rocks. Narrow magnetic troughs also appear to be related to some of the faults and fault zones in this section and may reflect extensive alteration. Intense, circular magnetic lows may indicate the presence of reversely polarized, stock-size intrusions in this region.

The Sierra Nevada occupies the southwest corner of the quadrangle. Here the residual magnetic anomalies are generally positive although negative anomalies are located over known or suspected remnants of pre-batholithic metamorphic units. The Carson Range displays a north-trending, variable magnetic character indicating a heterogeneity in the iron content of the intrusive rocks.

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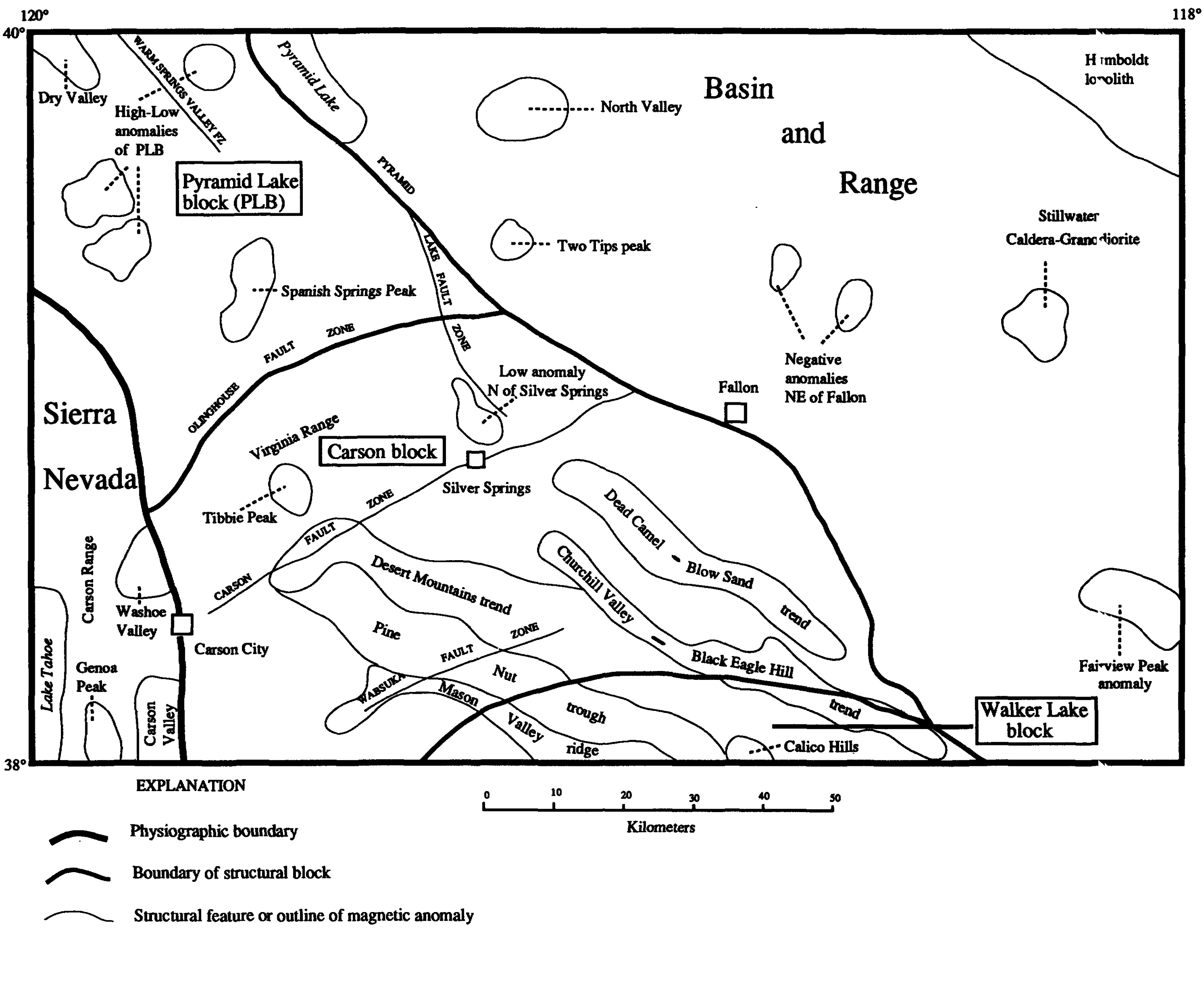

Figure 1. Physiographic and structural divisions of the Reno 1° by 2° quadrangle and locations of selected structural features and magnetic anomalies.

Table 1. *Magnetic susceptibilities of samples from the Stillwater Range (Smith, 1968) and south-central section of the Reno 1° by 2° quadrangle, Nevada and California.*
[Geographic coordinates for samples from the Humboldt area are not available (NA). Susceptibilities in EMU (electromagnetic units)]

Rock type	Number of samples	Average susceptibility X 10^6 EMU	Age	Location	Coordinates Latitude; longitude
Humboldt lopolith and vicinity					
Latite	2	505	Tertiary	Stillwater Range	NA
Welded tuff	1	930	Tertiary	Stillwater Range	NA
Gabbro	5	1582	Jurassic	Humboldt lopolith	NA
Scapolitized gabbro	1	3330	Jurassic	Humboldt lopolith	NA
Diabase	1	3570	Jurassic	Humboldt lopolith	NA
Albitized gabbro	1	20	Jurassic	Humboldt lopolith	NA
Anorthosite	1	2790	Jurassic	Humboldt lopolith	NA
Peridotite	1	2790	Jurassic	Humboldt lopolith	NA
Altered gabbro	1	3700	Jurassic	Humboldt lopolith	NA
Hydrated basalt	1	420	Jurassic	Humboldt lopolith	NA
South-central section					
Granite	3	3014	Cretaceous	Southern Virginia Range	39°19.60';119°28.30'
Diorite	3	2219	Jurassic	Desert Mountains	39°15.40'; 119°15.10'
Basalt	3	1547	Tertiary	Desert Mountains	39°16.40'; 119°11.50'
Basalt	3	1449	Tertiary	Desert Mountains	39°13.40'; 119°09.55'
Greenstone	3	1402	Triassic	Mason Valley	39°09.80'; 119°06.95'
Granodiorite	2	1316	Jurassic	Long Valley	39°04.40'; 118°47.85'
Basalt	1	1315	Tertiary	Desert Mountains	39°13.60'; 119°09.20'
Basalt or andesite	3	1118	Tertiary	Desert Mountains	39°12.95'; 119°08.85'
Granodiortie	3	1005	Jurassic	Desert Mountains	39°12.50'; 119°04.15'
Basalt or andesite	3	991	Tertiary	Desert Mountains	39°13.50'; 119°08.40
Granite	3	954	Cretaceous	Churchill Butte	39°19.55'; 119°17.10'
Dacite	2	939	Tertiary	Desert Mountains	39°16.40'; 119°11.95'
Dacite	3	905	Tertiary	Fort Churchill	39°17.80'; 119°16.70'
Granodiorite	2	836	Jurassic	Long Valley	39°07.20'; 118°48.70'
Dacite	3	389	Tertiary	Desert Mountains	39°16.45'; 119°14.05'
Rhyolite	3	387	Tertiary	Desert Mountains	39°15.30'; 119°05.25'
Rhyolite	3	89	Tertiary	Desert Mountains	39°16.35'; 119°02.30'
Metavolcanic	3	49	Triassic	Mason Valley	39°11.55'; 119°04.70'
Greenstone	3	40	Triassic	Parker Butte	39°07.45'; 119°03.50'
Altered diorite	3	26	Jurassic(?)	Desert Mountains	39°14.80'; 119°16.60'

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