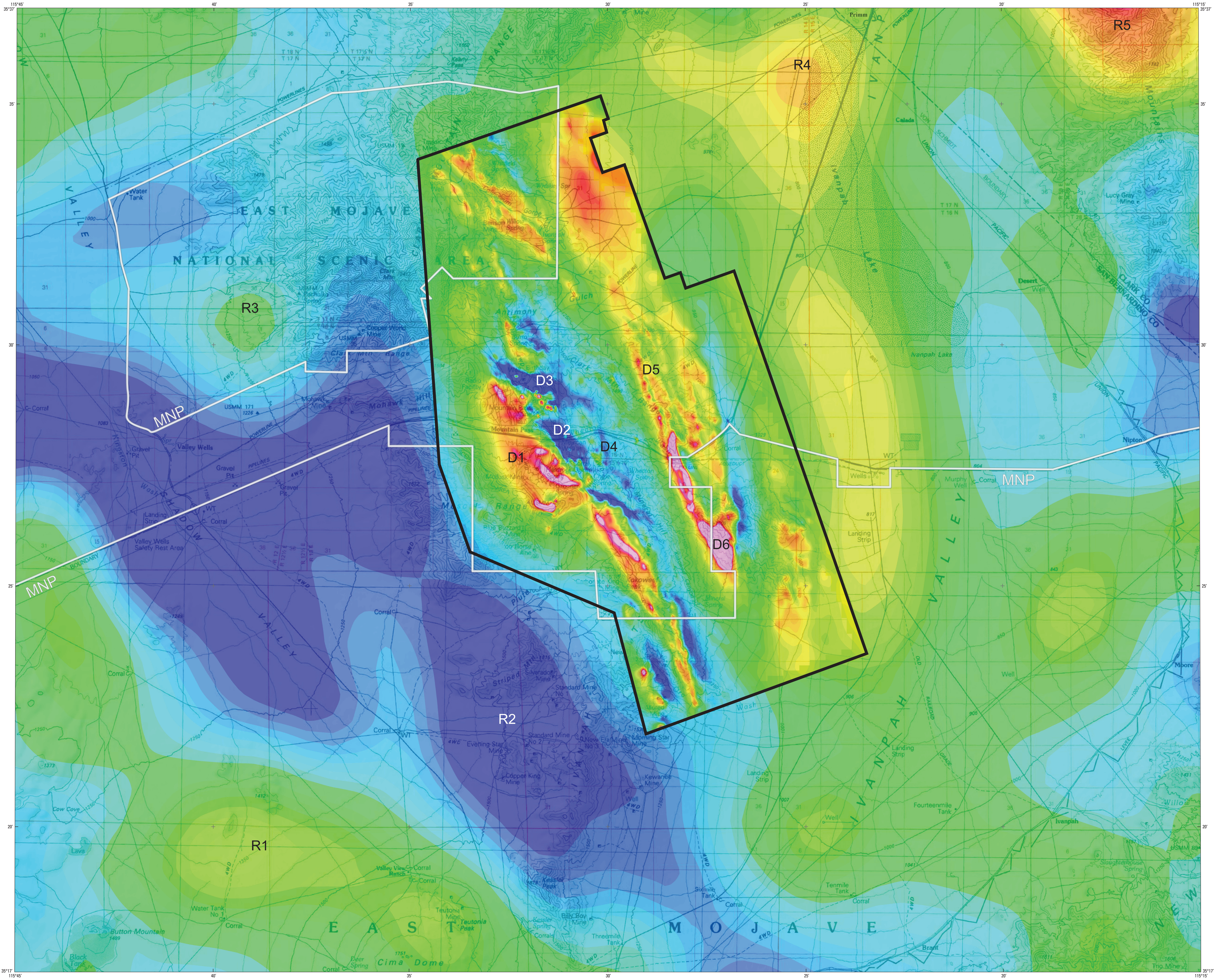

Base map from U.S. Geological Survey 1:100,000-scale quadrangles: Ivanpah, 1985; Mesquite Lake, 1985

Universal Transverse Mercator projection, Zone 11N, North American Datum of 1983 (NAD 83)

APPROXIMATE MEAN DECLINATION, 2018

SCALE 1:62 500

CONTOUR INTERVAL 50 METERS

Data compiled in 2017–2018

GIS database and digital cartography by D.A. Ponce and K.M. Denton

Edited by Taryn A. Lindquist; digital cartographic production by Katie Sullivan

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Aeromagnetic Map of Mountain Pass and Vicinity, California and Nevada

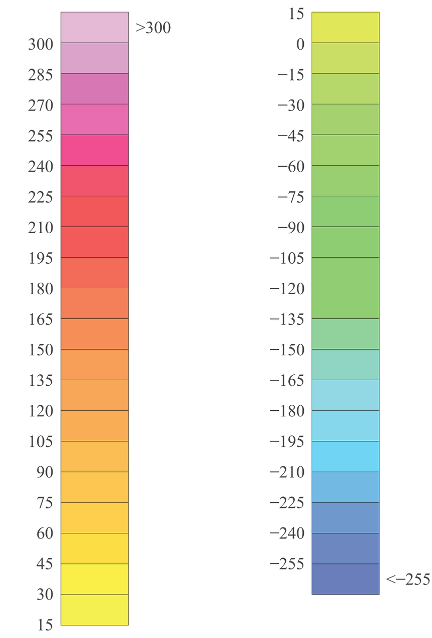
By

D.A. Ponce and K.M. Denton

2018

EXPLANATION

Residual magnetic intensity, in nanoteslas (nT)



Boundary of Mojave National Preserve (MNP)

Area of detailed aeromagnetic survey

D1 Location of magnetic anomaly discussed in text

INTRODUCTION

Magnetic investigations of Mountain Pass and vicinity were conducted as part of an effort to study regional crustal structures as an aid to understanding the geologic framework and mineral resources of the eastern Mojave Desert. The study area, which straddles the state boundary between southeastern California and southern Nevada (fig. 1), encompasses Mountain Pass, which is host to one of the world's largest rare earth element carbonatite deposits. The deposit is found along a north-northwest-trending, fault-bounded block that extends along the eastern parts of the Clark Mountain Range, Mescal Range, and Ivanpah Mountains (fig. 1). This Paleoproterozoic block is composed of a 1.7-Ga metamorphic complex of gneiss and schist that underwent widespread metamorphism and associated plutonism during the Ivanpah orogeny (Wooden and Miller, 1990). The Paleoproterozoic rocks were intruded by a Mesoproterozoic (1.4 Ga) ultrapotassic alkaline intrusive suite and carbonatite body (Olson and others, 1954; DeWitt and others, 1987; Premo and others, 2016). The intrusive rocks include, from oldest to youngest, shonkinite, mesosyenite, syenite, quartz syenite, potassic granite, carbonatite, carbonatite dikes, and late shonkinite dikes (Olson and others, 1954).

MAGNETIC METHODS

REGIONAL MAGNETIC MAP

The regional aeromagnetic map was derived from statewide aeromagnetic maps of California and Nevada that were compiled from numerous surveys flown at various flightline altitudes and spacings (Roberts and Jachens, 1999; Kucks and others, 2006). Aeromagnetic data were corrected for diurnal variations of the Earth's magnetic field, upward- or downward-continued to a constant elevation of 305 m above the ground surface, adjusted to a common datum, and merged to produce a uniform map (Roberts and Jachens, 1999; Kucks and others, 2006). This compilation, although composed of surveys acquired using different specifications, allows seamless interpretation of magnetic anomalies across survey boundaries.

Regional aeromagnetic surveys in the study area range in flightline spacing from 800 to 1,600 m, and they have a flightline altitude of 305 m (fig. 2). Because of the moderate spacing of the surveys, shallow magnetic sources may not be well resolved in some parts of the regional aeromagnetic map.

DETAILED MAGNETIC MAP

A detailed aeromagnetic survey of the inset area (black outline on map and on fig. 1) was flown by CGG Canada Services Ltd. This high-resolution helicopter survey, which was flown at flightline spacings of 100 and 200 m, a flightline azimuthal direction of 70°, and a nominal flightline elevation above ground of 70 m (fig. 2), consists of about 1,814 line-kilometers of data. Tie lines, which were spaced at 1-km intervals, were flown in a flightline azimuthal direction of 160° (fig. 2). Scintrex CS-3 cesium magnetometers were used throughout the airborne survey and also for the ground base-station survey. Data were corrected by the contractor for diurnal variations of the Earth's magnetic field, were tie-line leveled, and were microleveled, and then an International Geomagnetic Reference Field of the Earth was removed (Ponce and Denton, 2018a).

DISCUSSION

Generally speaking, magnetic anomalies reflect lateral changes in subsurface magnetization that can be used to infer subsurface geologic structure, provided that a magnetization contrast is present across geologic boundaries. Magnetic anomalies can, for example, reveal variations in lithology and delineate geologic features such as faults, plutons, volcanic rocks, calderas, and sedimentary basins, all of which play an important role in defining the geologic framework of the eastern Mojave Desert.

REGIONAL MAGNETIC MAP

A broad, regional magnetic high near the southwest corner of the map area (R1) reflects the weakly magnetic "Teutonia batholith" of Beckerman and others (1982); the high can be used to infer the horizontal extent of the batholith. A magnetic low in Shadow Valley (R2) reflects nonmagnetic basin-fill material in a relatively shallow basin, which is about 1- to 2-km deep as defined by gravity data (see Ponce and Denton, 2018b). This magnetic low extends eastward across the Mescal Range, where it reflects nonmagnetic Paleozoic sedimentary rocks, then continues southeastward across the Ivanpah Mountains, where it reflects the (informally named) Ivanpah granite of Beckerman and others (1982), which is essentially nonmagnetic. A small, circular magnetic high in the northeastern part of Shadow Valley and also along the western margin of the Clark Mountain Range (R3) probably reflects a buried magnetic pluton, part of which may be exposed in small outcrops there (Miller and others, 2007). Owing to its circular nature, a magnetic high along the north edge of the map area near Ivanpah Lake (R4) is inferred to reflect a buried pluton. Another broad magnetic high in the northeast corner of the map area (R5) reflects a large pluton, part of which is exposed (Jennings and others, 1977) in the northern part of the Lucy Gray Mountains (fig. 1).

DETAILED MAGNETIC MAP

The detailed magnetic survey (black outline on map and on figs. 1, 2) shows a prominent magnetic high along the western part of the Clark Mountain Range near exposures of nonmagnetic undivided Mesoproterozoic gneiss and Paleozoic rocks (D1). This anomaly probably represents a moderately magnetic granitic body, the top of which is at a depth of about 2 to 4 km on the basis of matched filtering (Phillips, 2001); the granitic body also is expressed as a terrace or area of flattening in the gravity-anomaly map (Ponce and Denton, 2018b) owing to its relatively low density. The "Mountain Pass carbonatite and alkaline intrusive suite" is present along the eastern margin of this anomaly, and the intrusive suite may have preferentially followed the source of the magnetic feature (or vice versa). Although carbonatites usually have distinctive magnetic signatures because they (or their associated alteration zones) commonly contain magnetic minerals, physical-property data indicate that the Mountain Pass carbonatite (D2) is essentially nonmagnetic, having an average magnetic susceptibility of 0.18×10^{-3} SI units (Denton and Ponce, 2016). Many rocks exposed at the surface, which also are only weakly magnetic to essentially nonmagnetic, include shonkinite, syenite, granite, granitic gneiss, and dolomite (Denton and Ponce, 2016). For example, a large shonkinite body, the "Birthday stock," which is essentially nonmagnetic, is expressed as a large magnetic low (D3). Another shonkinite body, the "Wheaton stock" (or "Pop's pluton") and its associated dikes (Haxel, 2005), in the central part of the area of detailed magnetic mapping, is weakly magnetic. The "Wheaton stock" is associated with a low-amplitude magnetic high (D4), which indicates that this stock is more extensive in the subsurface than its outcrop pattern suggests. In the eastern part of the area of detailed magnetic mapping, a long, narrow amphibolite dike (Miller and others, written commun., 2018) coincides with a prominent linear magnetic high (D5). On the basis of detailed magnetic and geologic data, this anomaly likely represents one of a number of radiating dikes that extend to the north-northwest from a large, inferred (buried) amphibolite intrusion, which is expressed by a pronounced magnetic high (D6).

The diverse physical properties (Denton and Ponce, 2016) of rocks that underlie the study area are well suited to geophysical investigations. The contrasts in magnetic properties between Proterozoic crystalline basement, Mesozoic granitoids, Cenozoic volcanic rocks, and Cenozoic unconsolidated alluvium, for example, produce a distinctive pattern of magnetic anomalies that can be used to infer subsurface geologic structure, which in turn aids in the understanding of the geologic framework and mineral resource potential of the eastern Mojave Desert.

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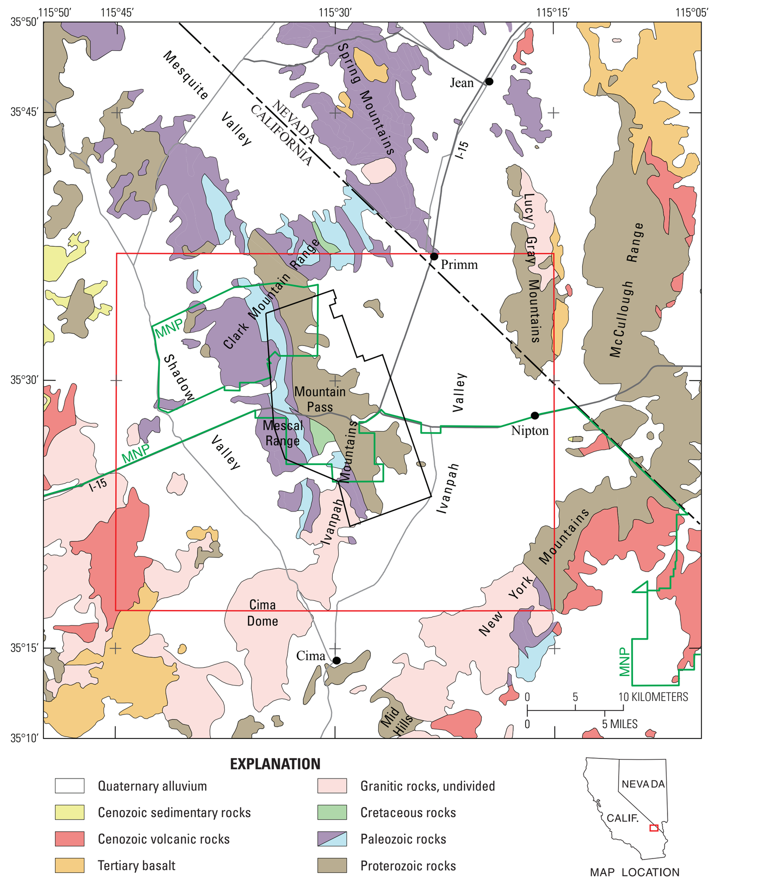

Figure 1. Index map showing simplified geology of eastern Mojave Desert (modified from Jennings and others, 1977; Stewart and Carlson, 1978). Red outline, study area; black outline, area of detailed aeromagnetic survey; green line, boundary of Mojave National Preserve (MNP); gray lines, roads.

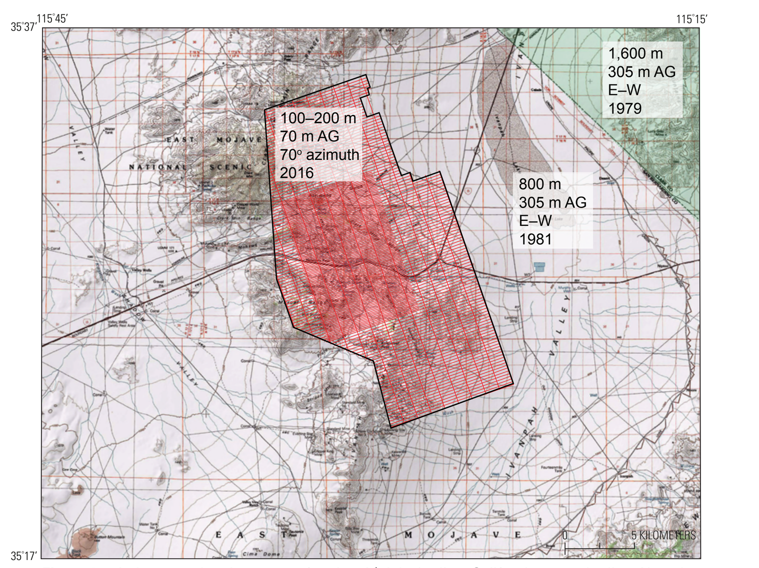

Figure 2. Index map showing areas of regional (pink shading, California; gray shading, Nevada; Roberts and Jachens, 1999; Kucks and others, 2006) and detailed (black outline; red lines show flightlines) aeromagnetic surveys. White transparent boxes highlight flight specifications of surveys, listed from top to bottom: spacing (for example, 1,600 m); elevation (for example, 305 m above ground [AG]); direction (for example, east-west [E–W]; and year flown (for example, 1979). Base map from U.S. Geological Survey 1:100,000-scale quadrangles: Ivanpah, 1985; Mesquite Lake, 1985.

Digital files available at https://doi.org/10.3133/sim3412B

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