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Geologic Interpretation of Gravity Data from the Date Creek Basin and Adjacent Area, West-central Arizona

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Abstract

A gravity survey of the Date Creek Basin and adjacent areas was conducted in June 1977 to provide information for the interpretation of basin geology. A comparison of facies relations in the locally uraniferous Chapin Wash Formation and the position of the Anderson mine gravity anomaly in the Date Creek Basin suggested that a relationship between gravity lows and the development of thick lacustrine sections in the region might exist. A second-order residual gravity map derived from the complete Bouguer gravity map for the survey area (derived from survey data and pre-existing U.S. Department of Defense data) shows an excellent correspondence between gravity lows and sediment-filled basins and suggests considerable variation in basin-fill thickness. Using the Anderson mine anomaly as a model, gravity data and facies relations suggest that the southeastern flank of the Aguila Valley gravity low and the gravity low at the western end of the Hassayampa Plain are likely areas for finding thick sections of tuffaceous lacustrine rocks.

Introduction

The Bouguer gravity map of Arizona (West and Sumner, 1973) shows a prominent gravity low in the Date Creek Basin about 150 km northwest of Phoenix, Arizona. The Anderson uranium mine is located at the northern edge of this gravity low, hereafter called the Anderson mine anomaly. Since 1972, the Date Creek Basin has been the site of intensive uranium exploration activity that was initially centered around the Anderson mine. During the last two years, the exploration has spread throughout the basin and, more recently, into adjacent basins. More than 20 companies now hold land positions in the area. Much of the exploration drilling has been blind; that is, the basin sediments are being drilled for the favorable lacustrine horizons when there are no surface indications of uranium. Facies distribution in the Anderson mine host unit, which was correlated by Reyner, Ashwill, and Robinson (1956) with the Chapin Wash Formation as described by Lasky and Webber (1949) may have been controlled by structures reflected in present gravity features. This possibility suggested that a detailed study of gravity data in the Date Creek Basin and adjacent areas might prove fruitful for exploration.

During late May and early June 1977, a gravity survey of the Date Creek Basin and adjacent areas was conducted. The data from that survey, plus U.S. Department of Defense gravity data in the same area, have been released as an open-file report (Wynn and others, 1978). This report also discusses data collection and reduction methods.

Gravity maps and three-dimensional gravity-based basin models for the survey area and two sub-areas were derived from the gravity data (Wynn and Otton, 1978). The gravity maps, basin models, and available facies information on the Chapin Wash Formation suggest areas where the favorable lacustrine facies of the Chapin Wash Formation are likely to be found in the subsurface.

Data processing, modeling, and contouring

The gravity data were all reduced to complete Bouguer anomalies using a density of 2.67 g/cc and the 1971 datum of the Defense Mapping Agency (Defense Mapping Agency Aerospace Center, 1974). The resulting data were gridded using a minimum curvature method developed by M. Webring and B. K. Bhattacharyya of the U.S. Geological Survey (USGS) and contoured using the USGS plotting system of G. I. Evenden and R. Wahl.

Two subsets of the resulting grid were blocked out, one around the Anderson mine anomaly, and one incorporating a larger area that also includes the Anderson mine anomaly. The Anderson mine anomaly was modeled using vertical prisms (Cordell and Henderson, 1968), 2 km on a side (the grid spacing), and extending from the ground surface to varying depths. These prisms effectively modeled the basin fill as a homogeneous unit with a density of 0.72 g/cm^3 less than that of the crystalline basement. The depths of the prism bottoms (the basin fill-basement contact) were varied through four iterations after the first approximation. At the end of each iteration, the theoretical gravity field of the

prisms in aggregate was calculated and compared to the gridded field results, and the individual prism lengths were adjusted accordingly to improve the fit. The resulting model field is everywhere within 1.0 milligal of the observed field.

Physiographic and geologic setting

The Date Creek Basin is near the eastern margin of the Basin and Range Province adjacent to the Colorado Plateau-Basin and Range Transition Zone (fig. 1). The basin has a northwest-southeast elongation and is bounded to the southwest by the Harcuvar, Buckskin, and Rawhide Mountains. The Poachie Range and the Black Mountains lie to the northeast. Low ridges and hills of granite, diorite, and andesite separate the Date Creek Basin from Aguila Valley to the south and Congress Basin to the east. The western end of the Date Creek Basin is poorly defined. Exposures of young basin fill sediments terminate just west of the Bill Williams River, however, older basin-fill sediments are exposed in the Artillery Mountains and farther to the west.

The geology of the Date Creek Basin and adjacent areas is complex (fig. 2). The basins are largely covered by alluvium of late Tertiary and Quaternary age. In the Date Creek Basin, older Tertiary rocks are exposed along the northeastern and northern sides, at the western end, and at the southeastern edge of the basin. The Date Creek Basin is presently being dissected by east-to-west through-going drainages: Bullard Wash, Date Creek and the Santa Maria River.

Use of the term "basin" must be qualified in that the older

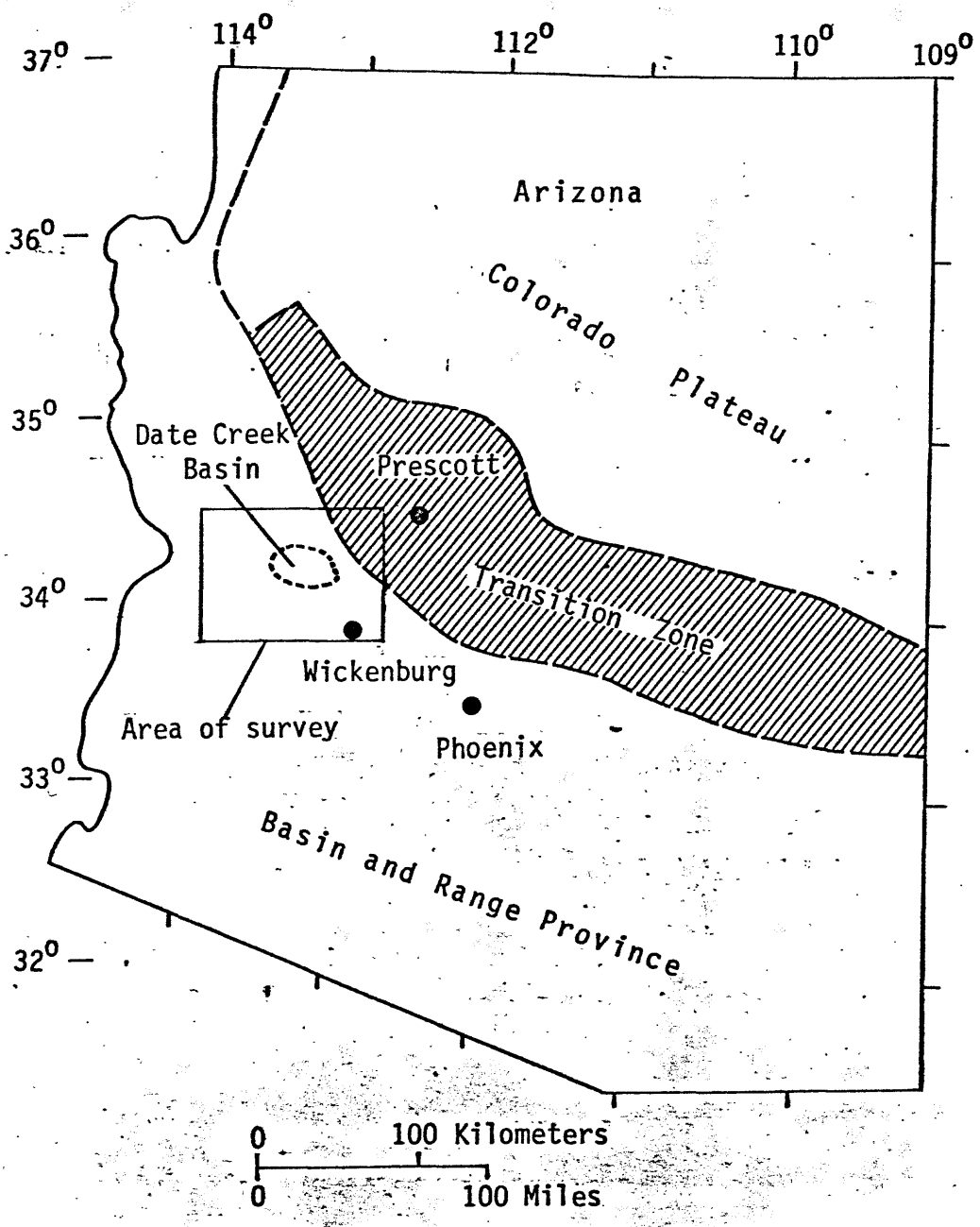

Figure 1.-Area of gravity survey in west-central Arizona.

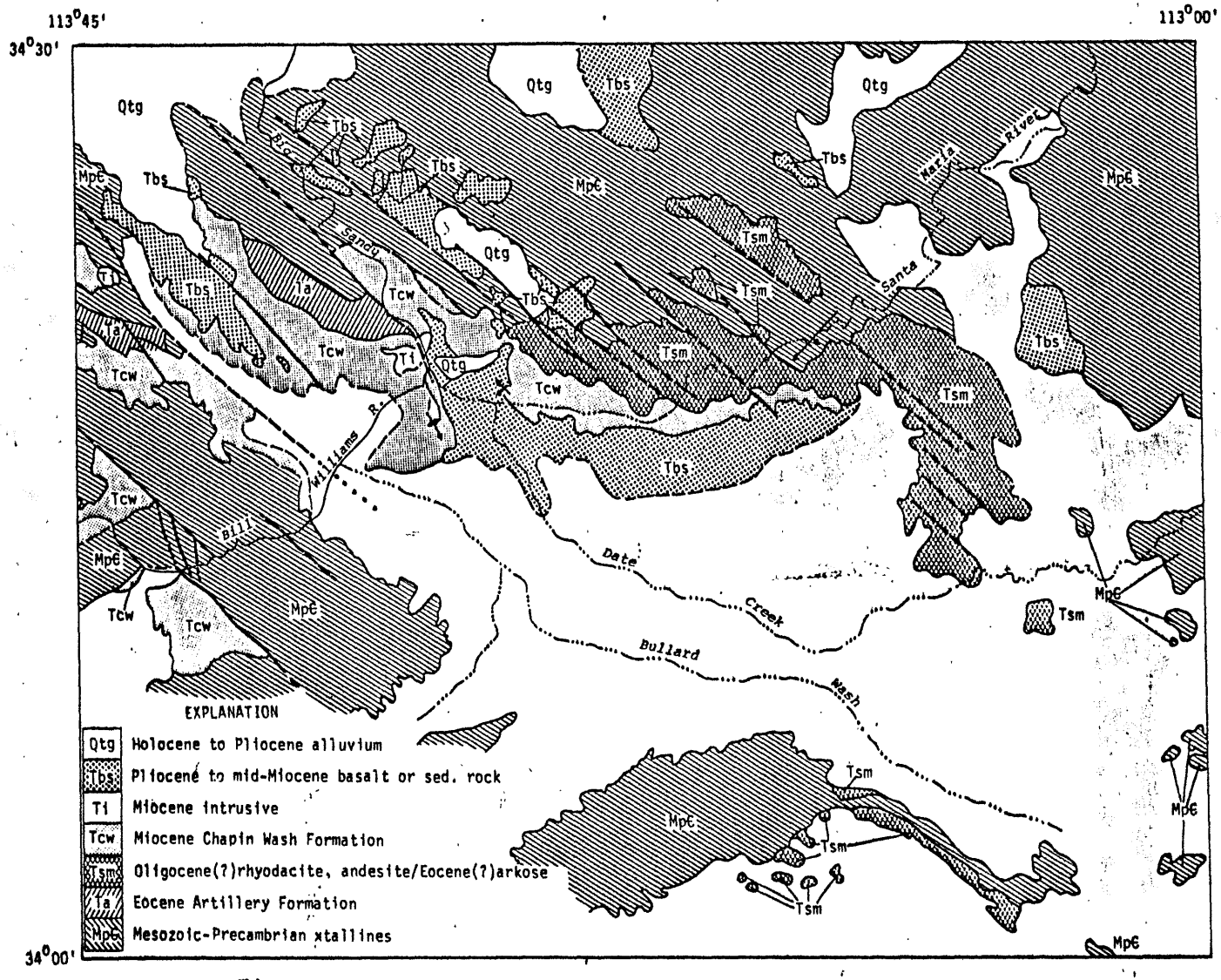

Figure 2.-Generalized geologic map of the Date Creek Basin.

sedimentary and volcanic units now exposed in the basin probably were originally deposited over much larger areas, and facies relations in those units may not have been determined by the present basin configuration. Those units are now preserved by the same structural events that formed the basin. The present basin configuration appears to be controlled by a normal(?) fault that bounds the southwestern margin (Shackelford, 1976) and that has dropped basin-fill gravels of Pliocene(?) age down on the northeast side.

The Tertiary stratigraphy of the Date Creek Basin is summarized in table 1. The table treats the eastern and western parts of the basin separately because of the differences in the section on either side of the Big Sandy River. The uraniferous Chapin Wash Formation and its equivalents are rather widely exposed throughout the area. The principal structural features of the area can be seen in figure 2.

Regional gravity

The complete Bouguer gravity map for the survey area (fig. 3) shows the Anderson mine anomaly discussed above. Other principal features of the map include a regional gradient that strikes northwest, is tilted to the northeast, and ranges from high values of -55 milligals to low values of -150 milligals; a broad high in the central and southwest part of the area; a sharp northwest-trending "step" in the central part of the area; a northeast-trending trough in the south-central section; a northeast-trending ridge in the southeast corner; and a low in the east-central part.

Table 1.--Stratigraphy of the Date Creek Basin.

Age	West (Artillery Mountains)	East (Anderson mine)
Holocene to Pleistocene	Alluvium, river terrace deposits.	Alluvium, river terrace deposits.
Pliocene(?)	Older alluvium, basalt	Basin-fill alluvium.
Late Miocene to mid-Miocene(?).	Sandy conglomerate/ basal basalt.	Sandy conglomerate, sandstone, siltstone/ basal basalt (12.0 m.y.).
Mid-Miocene to late early Miocene.	Chapin Wash Formation, western facies: Mn-rich sandy conglomerate and sandstone, breccia, fluvial lacustrine rocks, acidic volcanic rocks, basalt.	Chapin Wash Formation, eastern facies: Sandy conglomerate, sandstone, uraniferous tuffaceous fluvial-lacustrine rocks, minor andesite.
Oligocene(?)	Unrepresented	Rhyodacitic to andesitic volcanic rocks, minor basalt, sandstone, conglomerate, rhyolitic tuff.
Eocene(?)	Artillery Formation: Arkose, tuffaceous mudstone, siltstone and sandstone, algal, limestone welded tuff.	Basal arkose
Pre-Tertiary	Mesozoic, Paleozoic and Precambrian metamorphic complex.	Precambrian granitic gneisses, diabase.

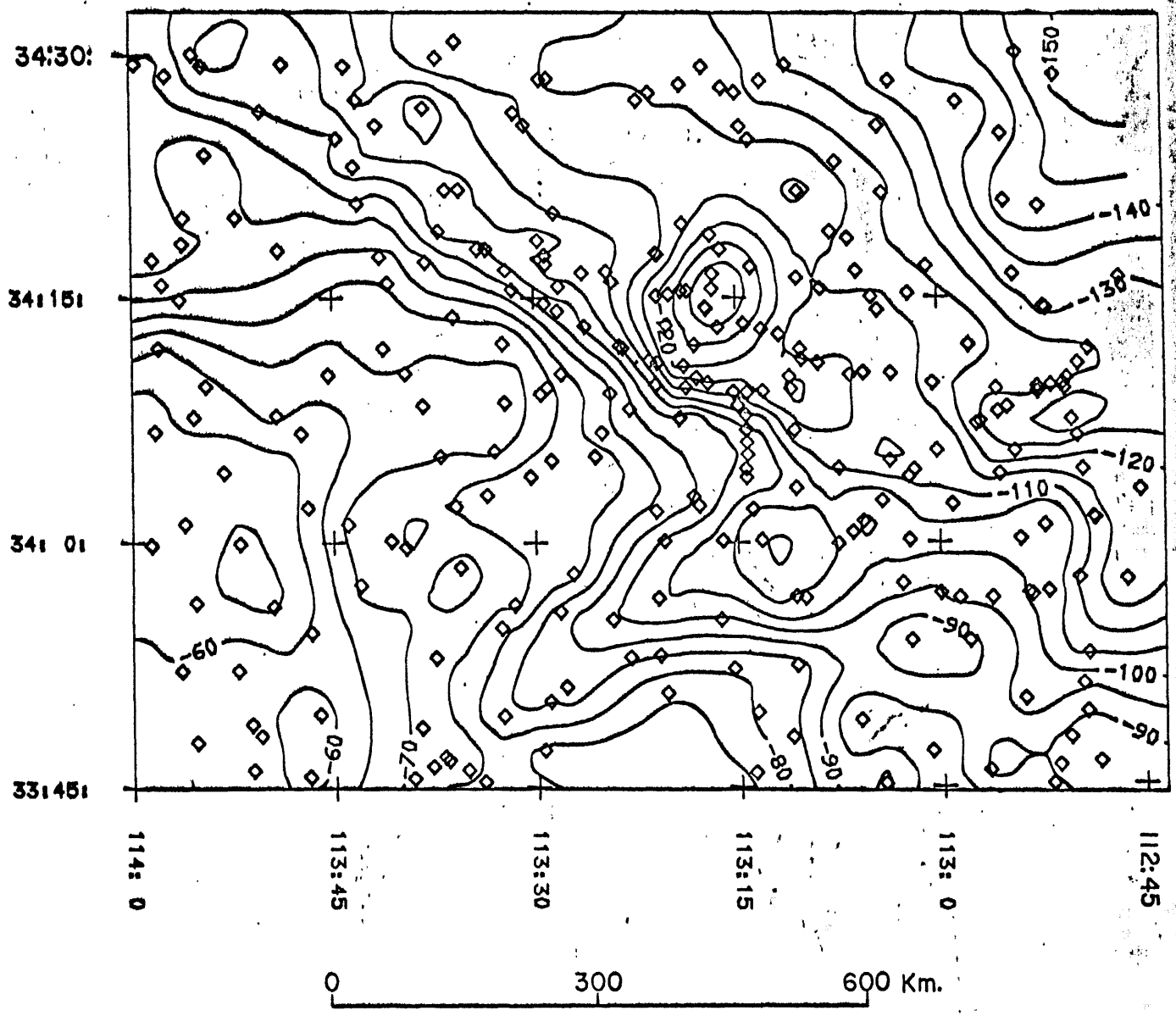

Figure 3.-Complete Bouguer gravity for the Date Creek Basin and Vicinity. Diamonds show station locations.

The regional gravity gradient partially obscures some details of the gravity features of the area. Figure 4 shows the residual gravity data after the second-order trend surface has been removed. The major features noted above have been enhanced and other detailed features can be seen. The gross features can be related directly to existing mountains underlain by crystalline rocks and to adjacent valleys underlain by varying thicknesses of basin-fill sedimentary rocks. The Rawhide, Buckskin, Harcuvar, Granite Wash, Harquahala, and Vulture Mountains have corresponding gravity highs, whereas Aguila Valley, Date Creek Basin, Congress Basin, the southern end of Sacramento Valley, Sunflower Flat, and the western end of the Hassayampa Plain have corresponding lows. Butler Valley does not have a gravity expression comparable to that of similarly sized valleys; the basin-fill sediments are probably rather thin throughout most of Butler Valley.

The Date Creek Basin

The Date Creek Basin is expressed in the gravity data as a northwest-trending trough between two high areas, and the roughly circular Anderson mine anomaly is in the center of the trough (fig. 4). The eastern end of the basin is well defined in the gravity data, whereas the western end is as difficult to determine by the gravity data as geologically. The gravity data suggest that the basin-fill sediments are relatively thin in the western third of the basin.

The northwestern margin of the Anderson mine anomaly corresponds to the northeast-trending monocline observed at the

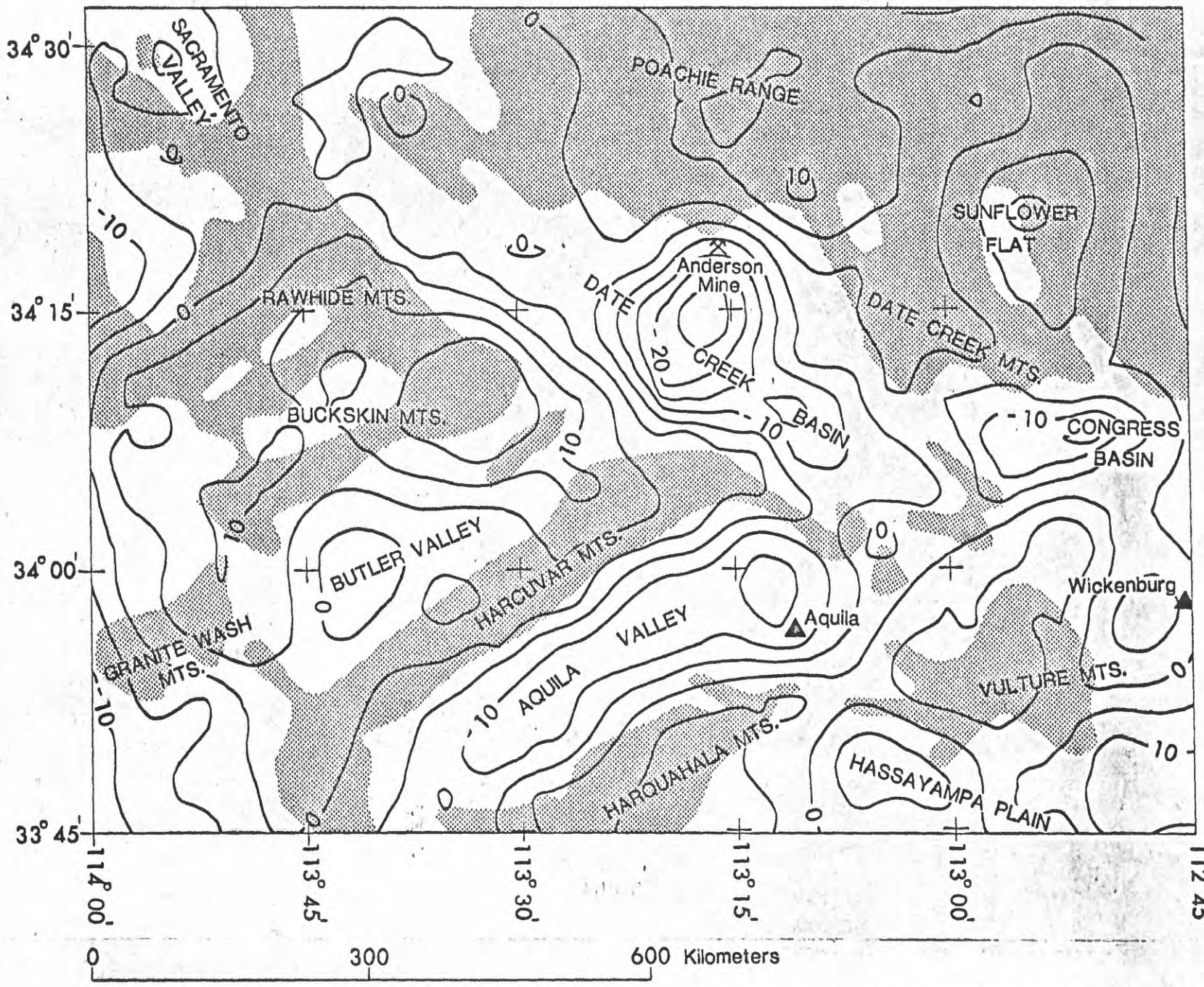

Figure 4.-Second-order residual gravity for Date Creek Basin and vicinity. Stippled areas underlain largely by Precambrian through Mesozoic igneous and metamorphic rock. Blank areas underlain by Tertiary and Quaternary sedimentary and volcanic rock.

surface (fig. 2). The northwest-trending basin-bounding normal fault observed at the surface at the western end of the basin appears to extend in the subsurface to the southeast.

In the early 1970's the Anderson mine anomaly attracted the attention of gas companies seeking salt domes to serve as gas storage vaults. El Paso Natural Gas drilled the feature in 1970 to a depth of 3831 feet (1175 m) (Arizona Oil and Gas Commision, written commun., 1977), but the hole encountered no salt. The hole was deepened by Brown and Thorpe Oil to 5685 feet (1735 m) in 1972. It intersected basement gneisses at 5620 feet (1720 m) below the surface but, again, no salt. Logs show that the drilling encountered conglomerate, sandstone, tuffaceous lacustrine siltstone and mudstone, tuff, thin rhyolite flows, andesite, and basalt. The top of the Chapin Wash Formation (the Anderson mine host) occurs at a depth of about 1130 feet (347 m). Its base is uncertain; however, the Chapin Wash Formation is at least 2700 feet (828 m) thick. The top of the andesite-basalt unit is at 5450 feet (1665 m). below the surface.

The distribution of the lacustrine facies of the Chapin Wash Formation in the Date Creek basin is clearly related to the gravity low. In the Anderson mine area, the entire section is 425 feet (130 m) thick (at maximum) and the basal lacustrine facies is about half of the total. Drilling to the south shows that the lacustrine facies thickens rapidly towards the center of the gravity low. In addition, as the Anderson mine host unit is traced to the west, the lacustrine facies disappears just east of

Palmerita Ranch. This location corresponds approximately to the western edge of the gravity low. Relatively thin fluvial facies predominate in the Chapin Wash Formation in the western third of the basin.

It thus appears that the gravity low present in the Date Creek Basin was a structural depression during deposition of the Chapin Wash Formation. This depression may have been formed by monoclinal folding and southwesterly tilting prior to and contemporaneous with deposition of the Chapin Wash Formation. In addition, drilling to the south of the Anderson mine shows that the lacustrine facies intertongues gradually with fluvial units in the subsurface. Pebble counts in the upper fluvial facies in the mine area show numerous clasts known only in outcrops to the south and southwest. These relations suggest that this section of the basin was filled largely from either a southerly or southwesterly source and that the lacustrine facies occupied the central and northern parts of the basin.

Basin models

A gravity model of the basement-basin fill surface for the Anderson mine anomaly was produced from the gravity data (fig. 5). A density contrast of 0.72 g/cm^3 was required to fit the model to the known basement intercept of 5620 feet (1.71 km) at the center of the anomaly. The reference surface was the drill-hole collar elevation of 2226 feet (0.67 km) above sea level. The model predicts basement intercepts elsewhere in the Anderson mine area. Differences between the model and reality will be due to variation

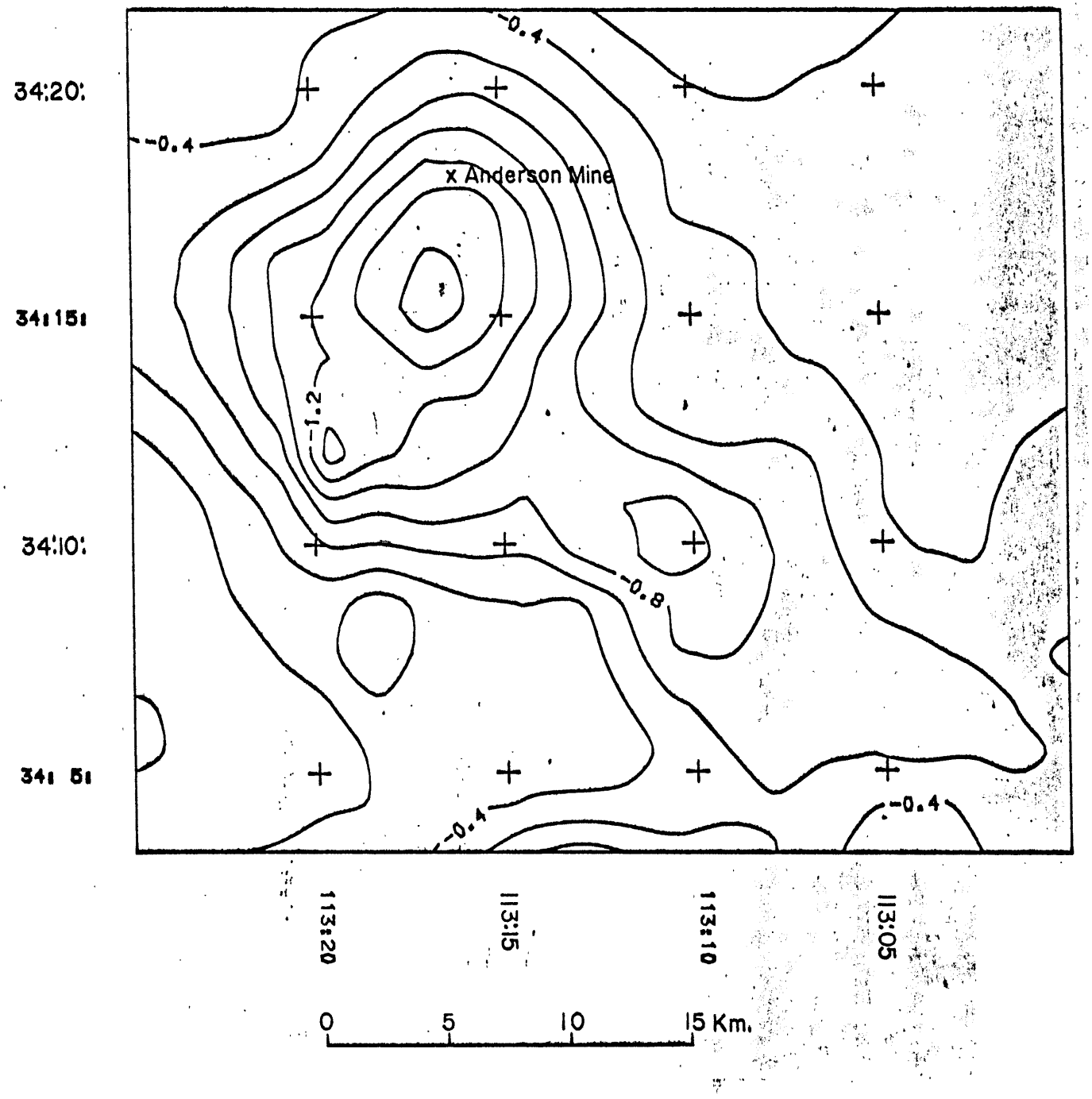

Figure 5.-Anderson mine gravity model in km(drho=0.72 g/cm^3)

in density contrast between the basement and basin-fill rocks away from the known basement intercept.

An additional model was produced for the southwestern three-fourths of the survey area (fig. 6) using the same density contrast of 0.72 g/cm^3 that was derived in the Anderson mine model. A somewhat different reference datum surface was used because of limitations in the computer program, but the model data were then shifted 1380 feet (412 m) to correspond with the reference surface used in the Anderson model. The model predicts basement-intercept elevations beneath (or above) the reference surface. For example, just northwest of Aguila, a 3200-foot (1.0-km) intercept is predicted. The average elevation of that area is about 2150 feet (0.65 km), which is very close to the reference surface; thus, basement rocks should be intercepted at about 3200 feet (1.0 km) below the land surface.

Implications for uranium exploration

If other gravity lows in the area were also structural depressions during deposition of the Chapin Wash Formation (the Anderson mine host), then they are also likely areas for thick lacustrine sections to have been deposited. That assumption can be tested in the Black Butte area, southeast of Aguila. A thin section of tuffaceous lacustrine mudstones with minor uranium is found there. These rocks are correlative with the Chapin Wash Formation. Black Butte lies at the northeastern edge of a gravity low which occupies the western end of the Hassayampa Plain. It seems probable that the tuffaceous lacustrine section thickens

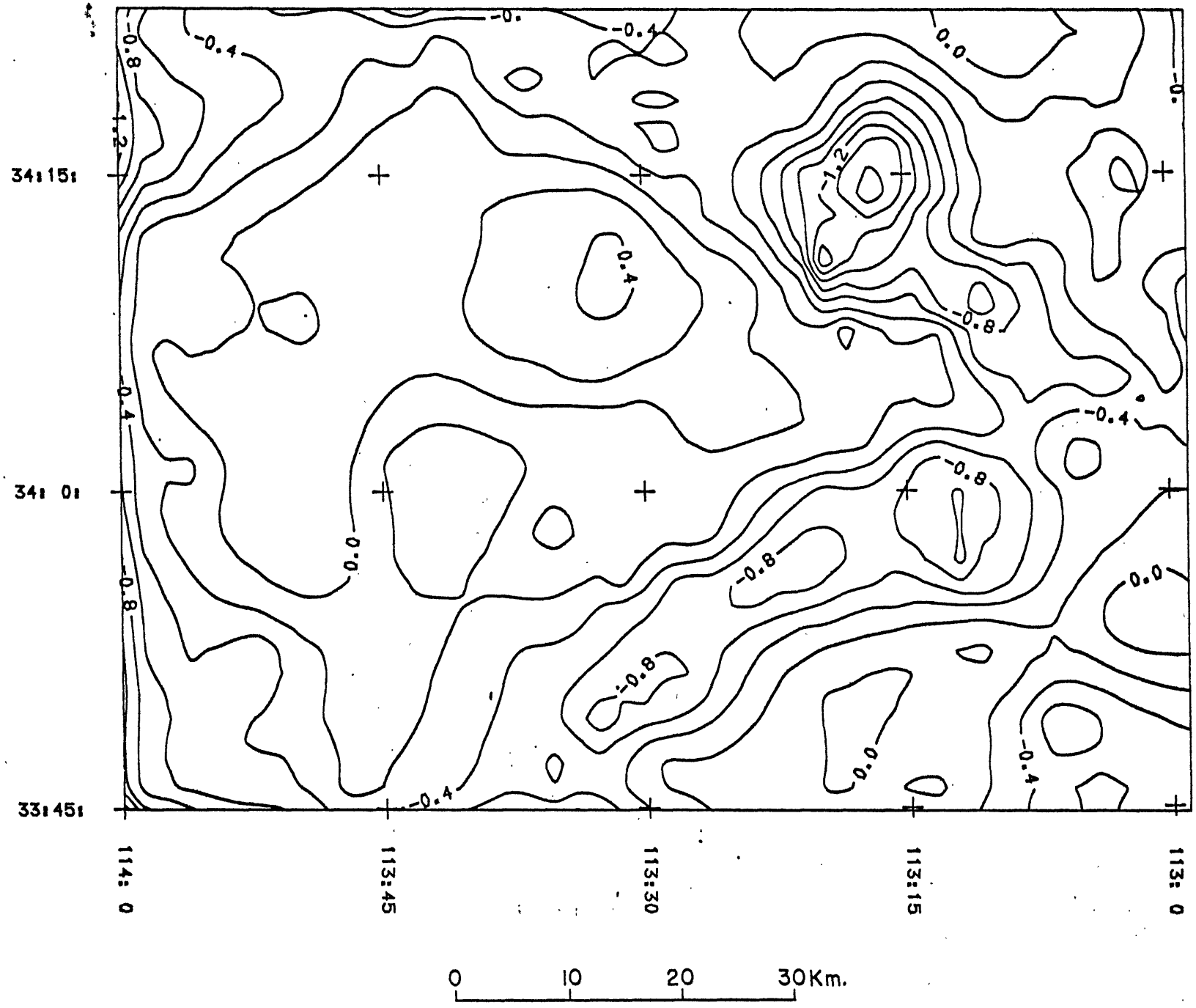

Figure 6.-Two-basin gravity model, datum shifted 1380 feet(412 meters) to correspond to datum of figure 5.

towards the center of that low. The maximum thickness of basin-fill rocks to be expected (from fig. 6) is about 2400 feet (735 m).

It seems likely that adjacent parts of Aguila Valley are also good exploration targets. Outcrops of coarse fluvial manganiferous Chapin Wash sandstones are known on the northwestern flank of the valley. If the Harcuvar Mountains were the source area for those fluvial sediments as they apparently were for the eastern part of the Date Creek Basin, then it seems most likely that lacustrine facies can be found in the subsurface along the southeastern margin of the basin.

Similar reasoning suggests that other gravity lows in the survey area may also be favorable exploration targets.

Conclusions

The relationship between gravity features and the favorable lacustrine facies of the Chapin Wash Formation seems evident in the Date Creek Basin and likely elsewhere. Whether significant uranium is present in those rocks is dependent upon additional factors: the presence of abundant plant debris and the proper hydrologic and chemical conditions for transport and fixation of the uranium.

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