STRUCTURAL RELATIONS AT THE HIDEOUT NO. 1 URANIUM MINE, DEER FLAT AREA, SAN JUAN COUNTY, UTAH-- WITH AN EVALUATION OF GEOLOGIC MAPPING BY MEANS OF GRAPHIC LOCATOR

By T. L. Finnell and W. B. Gazdik

Trace Elements Memorandum Report 1028

UNITED STATES DEPARTMENT OF THE INTERIOR

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ABSTRACT

The Hideout No. 1 uranium-copper mine is in sec. 14, T. 36 S., R. 17 E., Salt Lake meridian, about 30 miles N. 86° W. of Blanding, Utah. An area about 9,000 feet wide and 11,000 feet long that includes the Hideout No. 1 mine was surveyed using a topographic base map, telescopic alidade, and a graphic locator. The elevations of one geologic contact determined with the graphic locator were checked later with stadia and transit, and found to be sufficiently accurate to indicate a subtle monoclinal fold near the mine.

Consolidated sedimentary rocks exposed in the vicinity of the mine range in age from Permian to Triassic. The formations from oldest to youngest are the Cedar Mesa sandstone member, the Organ Rock tongue, and the Hoskinnini tongue of the Cutler formation of Permian age; the Moenkopi formation of Early and Middle(?) Triassic age; and the Shinarump member, the mudstone-sandstone unit, and the Moss Back member of the Chinle formation of Late Triassic age.

The area is on the west flank of the Monument upwarp, and the beds dip 1° to 3° west-southwest. Local monoclines interrupt the regional dip. The prominent joint sets dip steeply and trend N. 45° to 55° E., N. 35° to 70° W., and N. 10° E. to N. 25° W.

The Hideout No. 1 uranium-copper deposit is in the Shinarump member of the Chinle formation where it fills a stream channel cut in the top of the Moenkopi formation. The apparent relation between the uranium-copper deposit and the subtle flexures may be explained in the following ways:

1. The beds may have been folded before the Shinarump member was deposited, as suggested by the apparent erosional thinning of the Moenkopi formation along the anticlinal bends; and the flexures may have altered the course and gradient of the Late Triassic streams and perhaps caused thick sediments to accumulate locally.
2. Regardless of whether the beds were folded before or after deposition of the Shinarump member, the local flattening of dip at the Hideout No. 1 channel may have slowed and guided laterally migrating ore solutions into the channel sediments where ore deposits could form.
3. Tension joints associated with the flexure in the Moenkopi formation may have been pathways that allowed ascending ore solutions to reach the channel sediments.

Thus, the intersection of channels and flexures may be guides to favorable ground for uranium deposits in the Shinarump member of the Chinle formation.

Comparison of the results of two mapping methods indicates that the graphic locator method is much faster than the more precise transit and stadia method, and that it is sufficiently accurate to indicate subtle flexures in regions of moderate to rugged relief. Therefore, the graphic locator is recommended for use in geologic mapping where topographic base maps are available, so that subtle structures may be indicated for further study by more precise surveying methods and so that the possibility of structural control of mineral deposits can be evaluated.

INTRODUCTION

The uranium-copper deposit at the Hideout No. 1 mine, sec. 14, T. 36 S., R. 17 E., Salt Lake meridian, Deer Flat area, White Canyon mining district, San Juan County, Utah, is accessible by two graded dirt roads, 13 and 16 miles long, that connect with Utah Highway 95 about 32 and 35 miles west of Blanding, Utah (fig. 1).

Areal geologic mapping and exploratory diamond drilling at the deposit in 1953 and 1954 revealed variable dips in the vicinity of the mine, and prompted an attempt at closer control on elevations of the most uniform stratigraphic horizon to determine the precise nature of the structure. Existing topographic maps of the area were used in conjunction with a planetable, telescopic alidade, and a graphic locator in a method of geologic mapping that was devised by Varnes (1946, p. 1) to facilitate the horizontal and vertical location of geologic contacts in rugged and inaccessible terrains without the use of a rodman.

Elmer S. Santos recorded vertical angles and William J. Krummel and Clyde Duren, Jr., surveyed the top of the Hoskinnini tongue with transit and stadia. Their interest in this work is gratefully acknowledged.

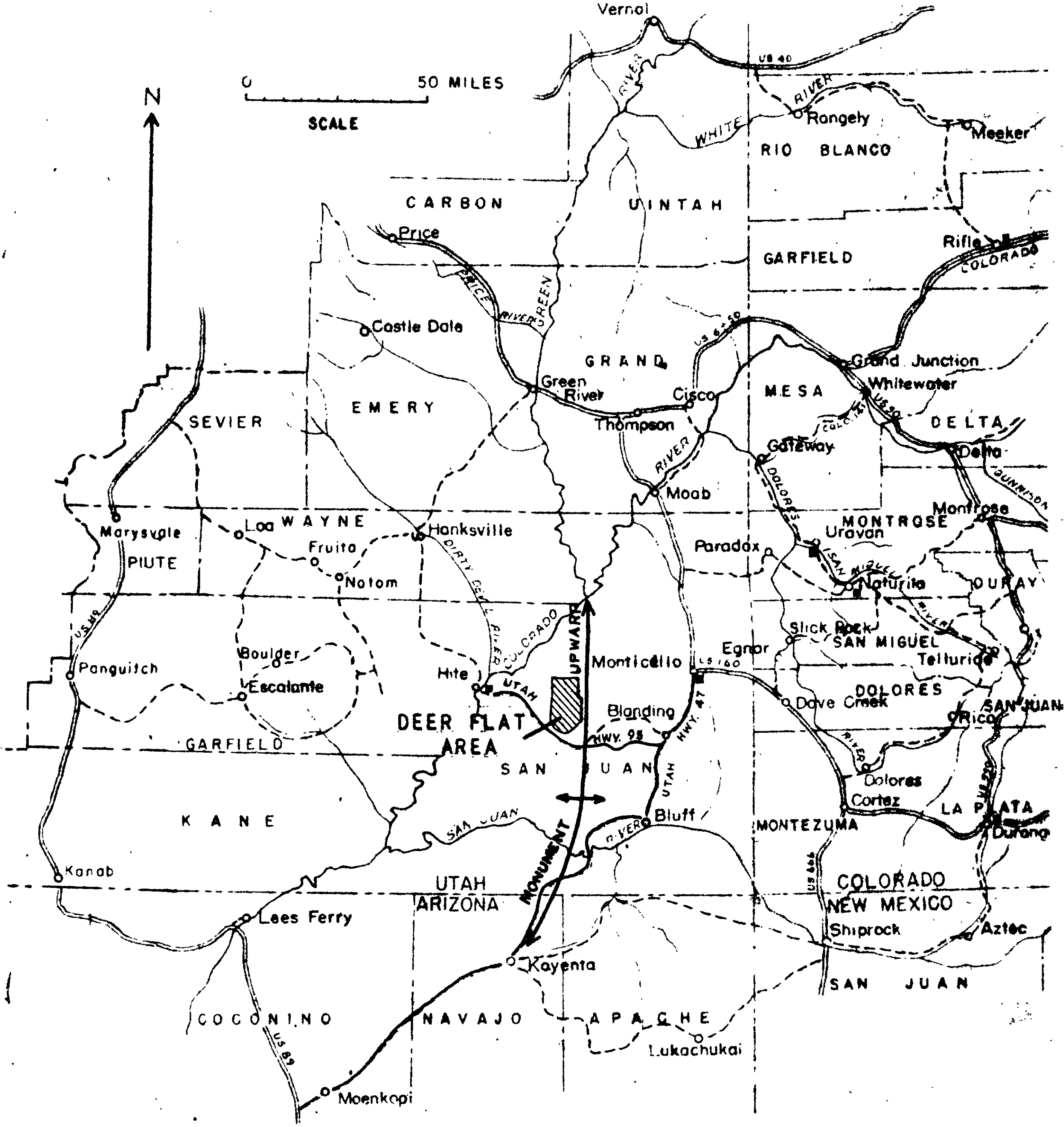


FIGURE 1.--INDEX MAP OF PART OF COLORADO PLATEAU SHOWING THE LOCATION OF THE DEER FLAT AREA, SAN JUAN COUNTY, UTAH.

This work was done by the U. S. Geological Survey on behalf of the Division of Raw Materials of the U. S. Atomic Energy Commission.

GEOLOGY

General statement

The Deer Flat area is in the Canyon Lands section of the Colorado Plateau (Fenneman, 1931, p. 313). The topography of the area is characterized by flat-topped steep-sided mesas separated by deep canyons of intermittent streams that are tributary to the Colorado River.

Sedimentary rocks exposed in the Deer Flat area range in age from Permian to Triassic. The rock units, from oldest to youngest, are: the Cedar Mesa sandstone member, the Organ Rock tongue, and the Hoskinnini tongue of the Cutler formation of Permian age; the Moenkopi formation of Early and Middle(?) Triassic age; and the Shinarump member, the mudstone-sandstone unit, and the Moss Back member of the Chinle formation of Late Triassic age.

Rocks of the Cutler formation are red and grayish-orange sandstones and siltstones that were deposited in continental environments. The rocks of the Moenkopi formation consist of red micaceous shales and red, brown, and yellowish-brown micaceous sandstones in which are preserved abundant ripple marks typical of shallow water deposits. Chinle rocks are fluvial, varicolored, interbedded sandstones, conglomerates, mudstones, and siltstones, with local beds of bentonite which probably represent stream-deposited volcanic ash.

The rocks are part of the west flank of the Monument uplift, and the beds dip 1° to 3° west-southwest and strike north-northwest. Locally, small monoclines modify the regional dip. One set of prominent joints trends N. 45° to 55° E., and dips from 65° SE. to vertical; another prominent joint set trends N. 35° to 70° W., and dips from 85° SW. through vertical to 72° NE.; a less prominent joint set trends N. 10° E. to N. 25° W., and dips from 80° E. to vertical.

The uranium-copper deposit at the Hideout No. 1 mine is in sandstone of the Shinarump member of the Chinle formation where it fills a channel in the top of the Moenkopi formation. The principal ore minerals are uraninite, chalcopyrite, bornite, and chalcocite. They replace fossil plant material, feldspar, and clays, and fill fractures and interstices in the sandstone.

Stratigraphy

The Cedar Mesa sandstone member of the Cutler formation of Permian age consists of crossbedded pale grayish-orange fine-grained sandstone with interbedded red siltstone lenses near the top. The upper 470 feet of the Cedar Mesa sandstone is exposed in the canyons around Deer Flat. The Cedar Mesa sandstone member grades upward into the Organ Rock tongue of the Cutler formation.

The Organ Rock tongue of the Cutler formation comprises about 280 to 300 feet of reddish-brown siltstone and fine-grained sandstone. The Organ Rock tongue apparently grades upward into the Hoskinnini tongue.

The Hoskinnini tongue of the Cutler formation is 75 to 80 feet thick at Deer Flat. It is composed of poorly sorted pale reddish-brown siltstone and very fine to coarse-grained sandstone. The Hoskinnini is disconformably overlain by the Moenkopi formation.

The Moenkopi formation of Early and Middle(?) Triassic age comprises 215 to 300 feet of ripple-laminated reddish-brown siltstones interbedded with pale-red and yellowish-gray sandstones. An extensive erosion surface separates the Moenkopi from the overlying Shinarump member of the Chinle formation.

The Shinarump member of the Chinle formation of Late Triassic age ranges in thickness from less than 1 foot to 50 feet. It consists of crossbedded gray and yellowish-gray fine- to coarse-grained and conglomeratic sandstone with interbedded mudstone lenses. The Shinarump becomes finer grained toward the top and it grades into the overlying mudstone-sandstone unit.

The mudstone-sandstone unit of the Chinle formation comprises 120 to 160 feet of gray and red mudstone interbedded with gray and brown sandstone. The upper contact of this unit is irregular, and channels in the top of the unit are filled by the Moss Back member.

The Moss Back member of the Chinle formation comprises 45 to 110 feet of crossbedded yellowish-gray fine- to coarse-grained and conglomeratic sandstone with interbedded mudstone lenses. The Moss Back member caps Deer Flat.

Structure

Strata in the Deer Flat area strike N. 23° to 25° W., and dip 1° to 3° west-southwest. Geologic mapping and exploratory diamond drilling in 1953 and 1954 indicated that the ore deposit at the Hideout No. 1 mine is near a change in the regional dip. The change of dip is so subtle that it is obscured on the outcrop by irregularities in the topography.

The top of the Hoskinnini tongue of the Cutler formation and the top of the Moenkopi formation were chosen as the stratigraphic horizons to be contoured. The Hoskinnini tongue is considered to have been essentially flat lying in this area while the Moenkopi formation was being deposited because (1) the Hoskinnini tongue varies only 5 feet in thickness within the area, and (2) the widespread thinly ripple-laminated siltstones of the Moenkopi formation suggest slow deposition in shallow water on extensive tidal flats (McKee, 1954, p. 78-79). Therefore, any structure indicated by contours on the top of the Hoskinnini tongue (base of the Moenkopi formation) presumably has been imposed by deformation subsequent to deposition of the Moenkopi formation. The top of the Moenkopi formation was extensively eroded prior to and during the deposition of the Shinarump member, and contours on the top of the Moenkopi formation indicate this erosion.

Structure contours based on altitudes obtained with the graphic locator method indicated that a north-trending monoclinal flexure is present near the Hideout No. 1 mine, and it was decided to resurvey the outcrop with a transit and stadia to check the accuracy of the method. In addition, 12 holes were diamond drilled to the top of the Hoskinnini tongue to determine the position of the flexure beneath Deer Flat. Detailed contours using these elevations show that the monoclinal flexure trends about N. 10° W., and that the ore deposit in the Hideout No. 1 mine is on a narrow structural terrace downdip from the monoclinal flexure (fig. 2).

The structure is so subtle that precise surveying is required to delineate it. Comparison of elevations obtained by two methods, the graphic locator method and the transit and stadia method, suggests that the more rapid graphic locator method is sufficiently accurate to indicate the presence of these subtle structures.

Origin and age of deformation

The mode of origin of the monocline is problematical. It may have developed under lateral compressive forces or it may have developed by draping of the beds over a high-angle fault at depth, similar to the fault-fold relations that have been found elsewhere in the White Canyon district.

The Moenkopi formation seems to thin across the anticlinal bend northeast of the Hideout No. 1 mine, suggesting that the flexure may have been present when the Shinarump member of the Chinle formation was deposited (fig. 3). Crossbedding in sandstone of the Shinarump member that fills the Hideout No. 1 channel dips generally westward, suggesting that the currents that deposited the sands flowed westward. If the flexure east of the channel was present before the Shinarump was deposited, it would have provided a steep westward

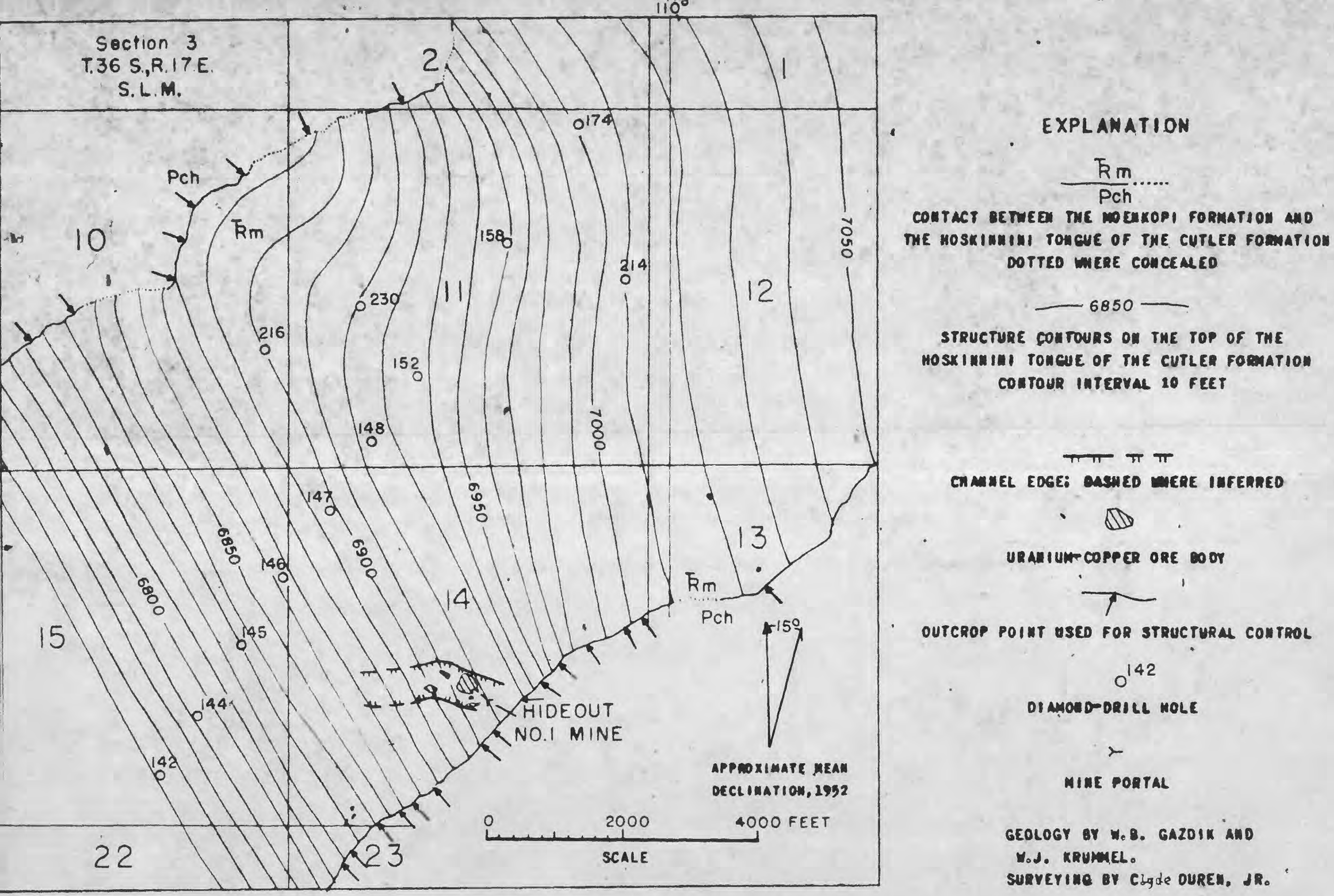


FIGURE 2.--STRUCTURE CONTOURS ON THE TOP OF THE HOSKINNINI TONGUE OF THE CUTLER FORMATION USING ELEVATIONS FROM A TRANSIT AND STADIA TRAVERSE AND FROM DIAMOND-DRILL HOLES, DEER FLAT AREA, SAN JUAN COUNTY, UTAH.

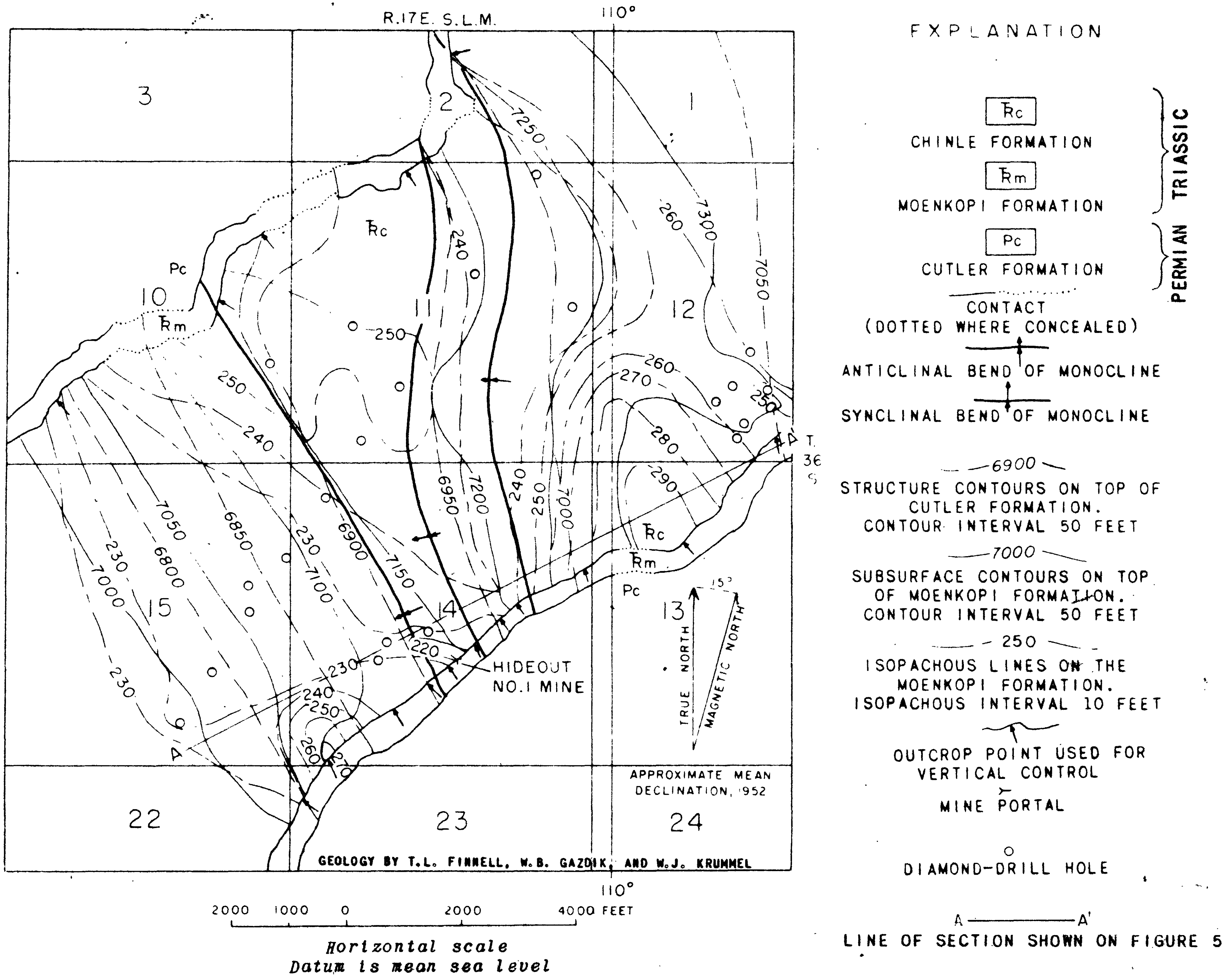


FIGURE 3.--MAP OF PART OF THE DEER FLAT AREA SHOWING STRUCTURE CONTOURS ON THE TOP OF THE CUTLER FORMATION, SUBSURFACE CONTOURS ON THE TOP OF THE MOENKOPI FORMATION, AND THICKNESS OF THE MOENKOPI FORMATION.

gradient relative to the area farther east (fig. 3). This increase in grade would have caused the streams flowing across the area to scour their channels down toward local base level. Such scouring would not be restricted to the steep limb of the flexure, but more probably would extend some distance into the terraces on both sides of the monocline because of momentum in the direction of stream flow and headward erosion in the opposite direction. The deepest part of the Hideout No. 1 channel is between the outcrop and the point where the channel turns to the west (fig. 2). The point where the channel starts to become more shallow (near the turn) is only about 900 feet from the synclinal bend that defines the western edge of the monocline (fig. 2). Thus, the channel may have been cut as a result of a steep gradient in the vicinity of the monocline.

If the monocline affected the streams that cut the Hideout channel, the structure must be older than the Shinarump sediments that fill the channel; and if such folds were present in the Colorado Plateau during deposition of the Shinarump, they may have affected sedimentation in other areas. Pre-Chinle folds in the Moenkopi formation have been described in the vicinity of St. Johns, Ariz., by Camp and others (1957, p. 4-5); in the Moab district by Baker (1933, p. 36, 37, 77); in the area between the Green and Colorado Rivers by McKnight (1940, p. 61-62, 129); and along the flanks of the salt anticlines in western Colorado by Stokes and Phoenix (1948), and Cater (1954).

The flexure may be post-Shinarump in age, but the absence of reliable key beds above the Moenkopi precludes the possibility of proving this. For example, the top of the Shinarump member at the Hideout No. 1 channel has a vertical relief of at least 20 feet that cannot be the result of either tilting or folding, but, rather, seems to represent the irregularity of deposition (fig. 4).

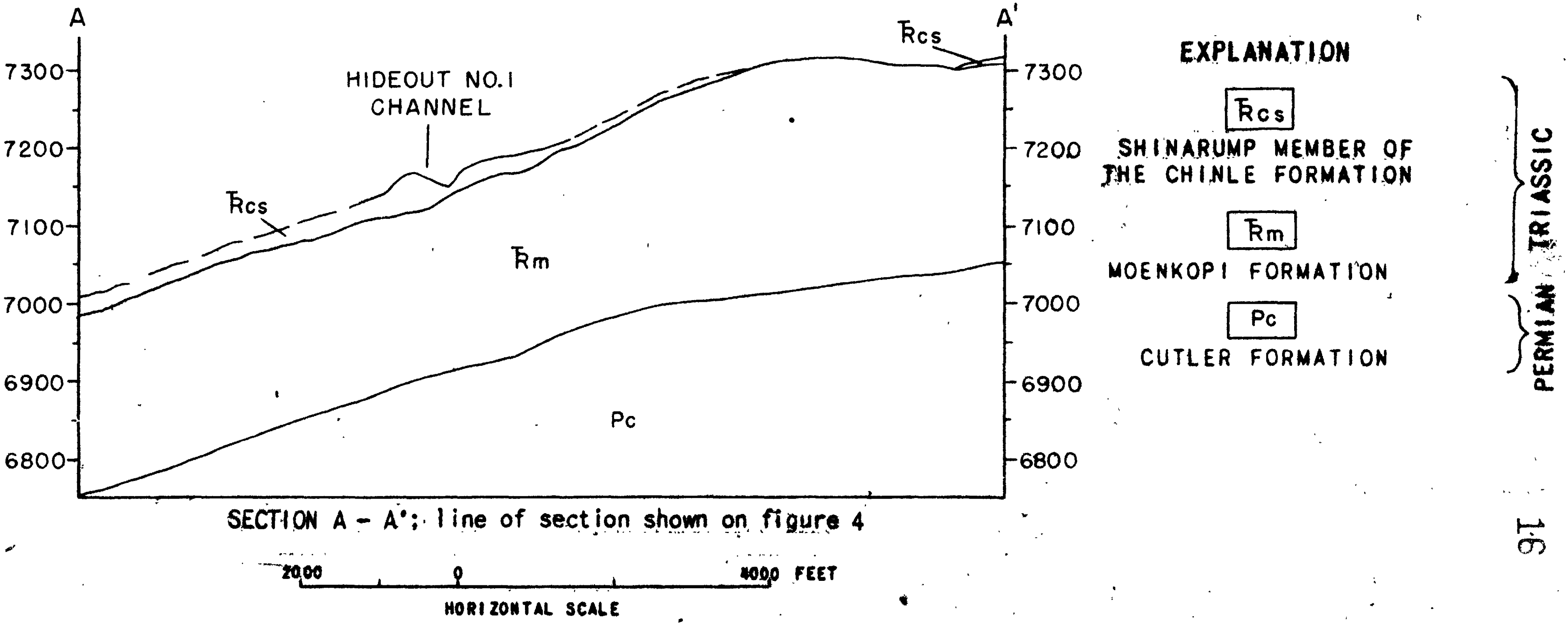


FIGURE 4.—STRUCTURE SECTION SHOWING THE RELATION OF THICKNESS VARIATIONS IN THE MOENKOPI FORMATION AND THE SHINARUMP MEMBER OF THE CHINLE FORMATION TO THE FLEXURES IN THE DEER FLAT AREA, SAN JUAN COUNTY, UTAH.

Possible control of ore deposition

The monoclinal flexure near the Hideout No. 1 mine may have determined the location of the uranium deposit in the channel in a number of different ways. The flexure may have affected the stream that cut the channel and caused it to cut deeper near the steep monoclinal limb. If the channels that were established during erosion of the Moenkopi formation guided the streams that deposited the sediments of the Shinarump member at least until they were filled to the level of the channel banks, any sediment subsequently added to the area would also add to the thickness of the sediments associated with the channels, thus making them thicker than the sediments deposited in the areas between channels. The top of the Shinarump member at the Hideout No. 1 channel has a vertical relief of at least 20 feet (fig. 5), and it is lower near the northeast edge of the channel than it is at the southwest edge. This suggests that deposition of sediments shifted downdip across the channel after the scour was filled.

Uranium ore at the Hideout No. 1 mine occurs with carbonized fossil plant fragments in sandstone beneath mudstone in the lower few feet of the channel sediments. The ore deposit seems to have preferred the sandstone in the deep part of channel, and the association of the ore deposit with thicker sections of the Shinarump member may not be any more significant than the fact that the Shinarump member tends to be thicker where it fills channels for the reasons stated earlier.

Regardless of whether the beds were folded before or after deposition of the Shinarump member, the terrace at the Hideout No. 1 mine may have slowed the ore solutions and perhaps guided them to the channel where conditions were favorable for ore deposition.

If the ore solutions came from a source at depth, the easiest pathway to the channel sediments would have been along joints. According to numerous structural geologists, tension joints in folded beds commonly radiate outward from the convex side of the folds (Balk, 1937, p. 98 and 102; and Turner, 1948, p. 182-183). This suggests that tension in folded beds may increase upward in anticlines and downward in synclines. If the same inference can be drawn about anticlinal bends and synclinal bends, then it is possible that the northerly trending joints in the Hideout No. 1 mine area are tension joints related to the synclinal bend, and they may extend to considerable depth. If the ore solutions ascended along such joints, they may have moved laterally into the lower part of the Shinarump member because the joints would be poorly developed in the incompetent Chinle mudstones above the Shinarump member. No matter how the ore solutions entered the Shinarump, uranium and copper minerals were deposited wherever the solutions reached rocks that were amenable to replacement.

In any case, the intersection of channels with monoclinal flexures might be most favorable locations for ore deposits. Somewhat similar structural control of uranium deposits is reported in the southern Black Hills region (Bell and others, 1956, p. 348-349), where deposits occur on structural terraces just updip from monoclines and near anticlinal noses superimposed on the terraces, but the authors do not discuss the reasons for the apparent structural control of the deposits.

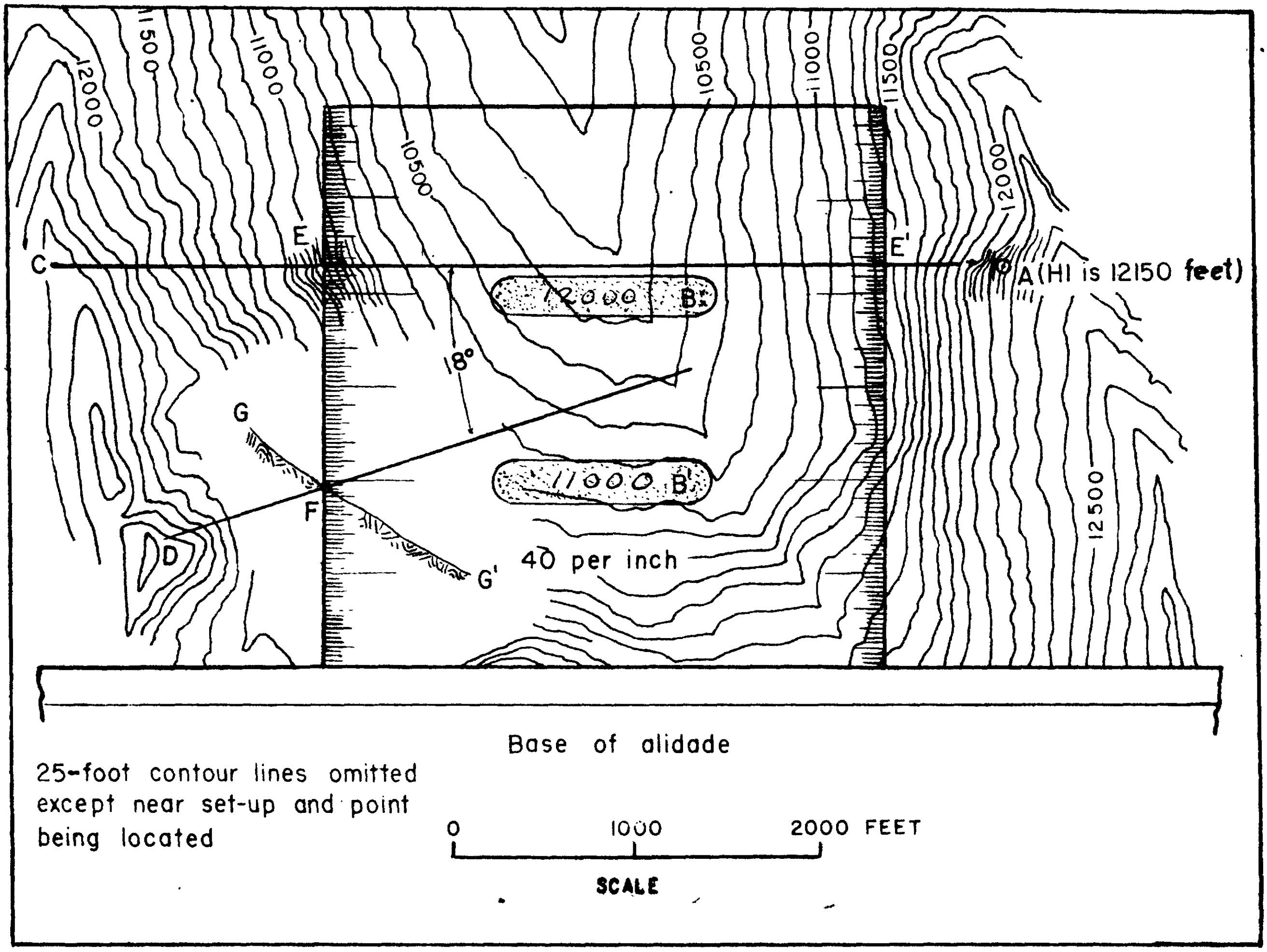
GRAPHIC LOCATOR

The graphic locator method of locating geologic contacts (Varnes, 1946) on topographic maps was used to delineate the structure near the Hideout No. 1 mine. In about 3 hours, the horizontal and vertical positions of the top of the Hoskinnini tongue of the Cutler formation and the top of the Moenkopi formation for 12,000 feet of the outcrop along the southeast side of Deer Flat were determined with a graphic locator, topographic base map, and telescopic alidade; about 12,000 feet of the northwest side of Deer Flat was similarly surveyed in about 2 hours. A single planetable station was used on each side of Deer Flat.

Varnes (1946) gives a description of the graphic locator and the procedure for using it that is difficult to improve upon. Varnes' description of the graphic locator and its use, including his figure 1, is reproduced here (fig. 5). Varnes states (1946, p. 2-3):

"The graphic locator consists of a single rectangle of xylonite or other transparent plastic material, about 3 inches square and 1/16 inch thick.

"Two scales, graduated in divisions corresponding to the contour interval of the topographic map with which it is to be used, are marked or engraved on the under side of the rectangle, one at the right and one at the left edge. Because of the simplicity of its construction, sets of



After Varnes, 1946

Figure 5.--Graphic locator technique.

these graphic locators can readily be made for use with maps having any specified contour intervals or horizontal scales. The accompanying drawing (fig. 1, [fig. 5 of this report]) illustrates the graphic locator used in mapping an area in the San Juan region, Colorado, on a topographic map having a contour interval of 25 feet and a horizontal scale of 1 inch to 1,000 feet. The scale division on the model, computed from the equation $25 \times 12 \times \frac{1}{1{,}000 \times 12} = 1/40$ inch, are 1/40 inch apart. The etched areas B and B', on figure 1, between the major scale divisions, are used for recording with pencil the range of elevations for any particular setup.

"The procedure for using the graphic locator (see fig. 1 for example, [fig. 5 of this report]) is as follows:

1. Location of the planetable setup point A is plotted on the topographic map by resection or other suitable means.

2. Elevation of the alidade ("HI") is determined to be 12,150 feet.

3. Reference elevations are written in the opaque areas B and B' on the graphic locator, assuming that the range in elevations for the shot used in this example will be between 10,000 and 13,000 feet.

4. Telescopic alidade is sighted at point to be plotted; ray A-C is drawn on map, and the vertical angle read. If an open sight alidade is used, the line-of-sight is drawn and the angle is read with a Brunton compass.

5. From the ray A-C the vertical angle CAD is plotted with an 8-inch protractor and a segment of the line A-D drawn. In the example the angle is 18°.

6. The graphic locator is placed over the ray A-C so that the scale readings at both edges (E and E') correspond to the HI of the instrument (12,150 feet). While held firmly in this position the straightedge of the alidade base is placed against either the top or bottom edge to serve as a guide for shifting the graphic locator laterally.

7. The locator is then shifted along the straightedge until the edge of the scale at E intersects line A-C at the estimated position on the map of the point being shot.

8. Next, it is noted whether the scale reading at F (the point where line A-D crosses the edge of the scale) is greater or less than the contour reading at E. If, for example, the contour elevation of the estimated position at E is 10,900 feet the scale reading at F would be approximately 10,975 feet. This means that the line of sight has not yet intersected the ground surface at point E. A profile of the ground surface, G-G', has been added to figure 1 to indicate the relation of the ground surface to the line of sight.

9. If the graphic locator is moved farther to the left so that the scale reading at E is 11,000 feet, then the scale reading at F will read approximately 10.930 feet, meaning that the line of sight has penetrated the surface and the point as located by this second estimate lies beneath the ground surface. The point sought must, therefore, lie between the 10,900- and 11,000-foot contour lines on line A-C. The range between the trial points is then quickly reduced by moving the graphic locator back and forth between the 10,900- and 11,000-foot contour lines.

10. When the position of the graphic locator is such that the contour elevation at E is the same as the scale-reading at F (10,950 feet in the example) the point of intersection at E is the point on the map that is sought."

According to Varnes (1946, p. 2-3), the mean horizontal error is less than 1 percent when the angle between the line of sight and the surface of the ground in the vicinity of the point sought is greater than 15°. The error becomes greater when this angle is less than 15°, and large errors may occur in grazing shots because the position of the point sought on the ground is commonly difficult to determine. The degree of accuracy of points determined with the graphic locator is also dependent upon the accuracy of the topographic map and the accuracy of manipulation of the instrument.

In the mapping with the graphic locator at Deer Flat, the angle between the line of sight and the surface of the ground in the vicinity of the points sought ranged from about 14° to 31°; only two of the angles were less than 15°. To avoid the errors inherent in the estimation of elevation of the points sought by extrapolating between the topographic contours, the difference of elevation between the planetable and the points sought was determined trigonometrically using the horizontal distance determined with the graphic locator and the vertical angle read from the vertical angle arc of the telescopic alidade.

ACCURACY OF GRAPHIC LOCATOR METHOD IN DEER FLAT MAPPING

Mapping with the graphic locator at Deer Flat indicated a low amplitude monoclinal flexure near the Hideout No. 1 mine. Because of the possibility that the uranium deposit may be related to the structure, it was decided to resurvey the base of the Moenkopi formation with transit and stadia. Cross sections comparing the results of the graphic locator survey with the results of the transit survey (fig. 6) show that, on the southeast side of Deer Flat, the graphic locator elevations varied from 11 to 33 feet higher than the true elevations, and on the northwest side the graphic locator elevations varied from 16 feet lower to 25 feet higher than the true elevations. The contour interval of the topographic map used is 40 feet and the variations are within the limits of topographic map accuracy (not more than 10 percent of the contours are more than one-half contour interval from their true position). The configurations of the two contacts are very similar and it is inferred from figure 6 that the graphic locator method is sufficiently accurate to indicate the presence of subtle flexures, although more precise surveying methods are necessary to determine the true position and shape of the flexures.

About $1\frac{1}{4}$-man days were spent in mapping two geologic contacts with the graphic locator, and about $11\frac{1}{2}$-man days were spent in remapping one of the geologic contacts with transit and stadia.

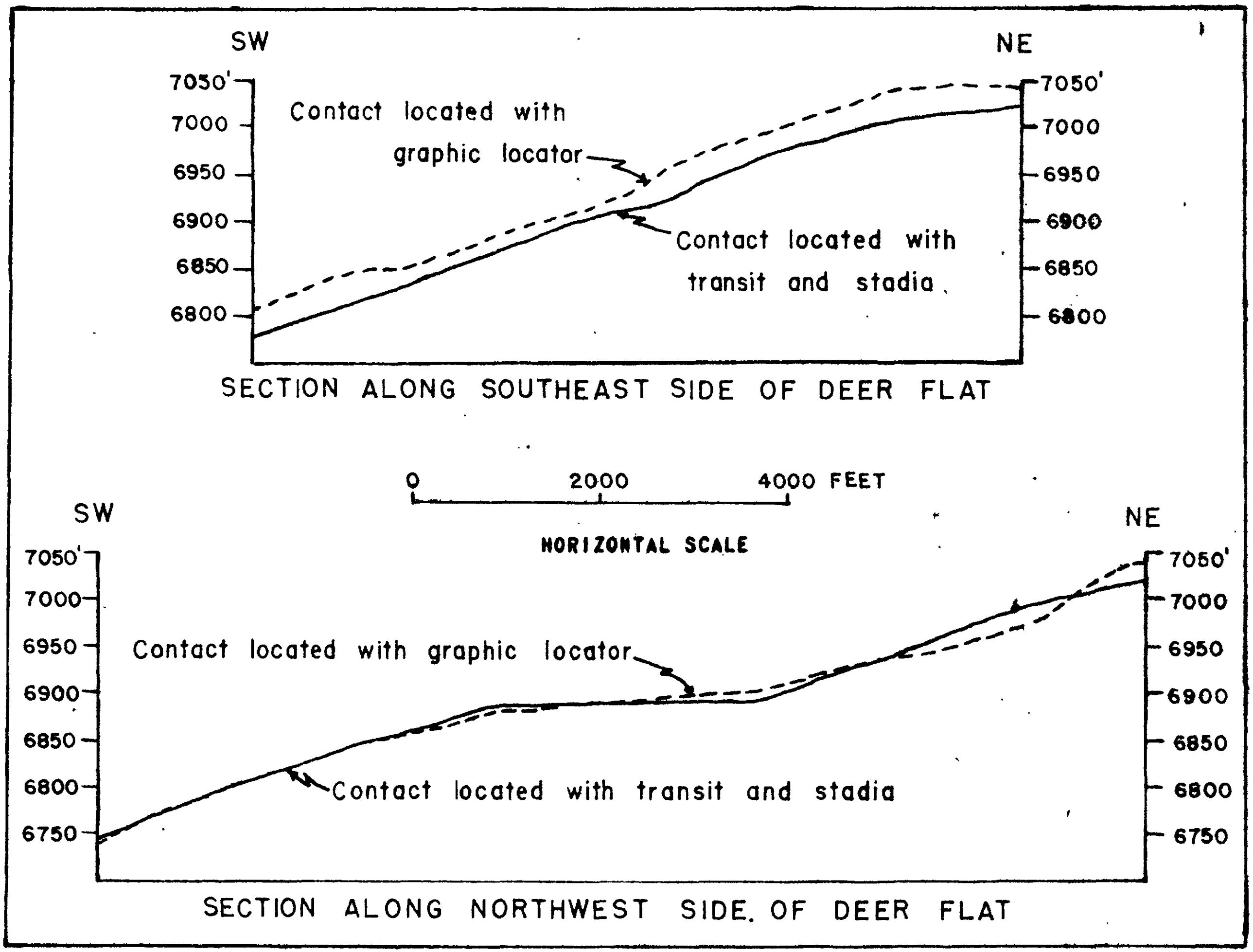


FIGURE 6.--DIAGRAMMATIC CROSS SECTIONS SHOWING THE DIFFERENT POSITIONS OF A GEOLOGIC CONTACT DETERMINED BY TWO DIFFERENT METHODS OF SURVEYING, DEER FLAT AREA, SAN JUAN COUNTY, UTAH.

CONCLUSIONS

The close association of uranium ore in the Hideout No. 1 channel with a local change in the dip of the underlying rocks indicates that further work is needed to determine if similar relations exist at other deposits on the Colorado Plateau.

Geologic mapping with a graphic locator is a rapid, practical method of mapping on topographic maps in regions of moderate to rugged relief. The presence of obscure low-amplitude flexures can be determined much more rapidly with this method than it can be by a transit and stadia traverse of the same outcrop, but the indicated flexures must be delineated by more precise methods before the relation of ore deposits to structure can be evaluated.

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