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THE MORRISON FORMATION IN THE GALLUP REGION

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INTRODUCTION

The Gallup region in northwestern New Mexico lies completely within the western half of McKinley County, except for a strip along the Arizona side of the state line from Lupton to Fort Defiance. The area investigated extends from a point six miles east of Gallup, New Mexico, west to Lupton, Arizona, and from Nutria and Zuni Pueblos north to Todilto Park. U.S. Highway 66 (Interstate 40) bisects the region from east to west.

This paper discusses the areal distribution and stratigraphic relations of the Morrison Formation in the Gallup region and is based upon data given in the author's master's thesis which was accepted by the University of New Mexico in the spring of 1967.

GEOLOGIC SETTING

The area studied lies in the southern part of the Colorado Plateau, along the southwest margin of the San Juan Basin. It is bordered on the east and west by the Zuni and Defiance uplifts, respectively. Strata dipping off the uplifts into the Gallup sag (Kelley, 1957) form two long, sinuous, north-trending hogbacks which have been named the Nutria monocline (on the east), and the Defiance monocline (on the west). Exposures of Jurassic rocks are excellent generally, but are limited to outcrops along these two monoclines, and to outcrops on the north flank of the Zuni uplift. Jurassic rocks exposed in the region belong either to the San Rafael Group or to the Morrison Formation, and they consist almost entirely of sandstones of continental origin.

GENERAL STATEMENT

West of the Rocky Mountains, strata believed to be equivalent to the Morrison Formation of Late Jurassic age have been divided, on lithologic grounds, into four members. In ascending order, these are: the Salt Wash Member, the Recapture Member, the Westwater Canyon Member, and the Brushy Basin Member. In the Gallup Region, all the members except the Salt Wash are present. The two lower members in this region, the Recapture and the Westwater Canyon are predominantly sandstone with associated conglomerate and thin mudstone beds. They have been interpreted as being alluvial "fan" deposits (Craig, 1955). The Brushy Basin Member is predominantly shale, with minor sandstone lenses. In the more restricted area of this study, however, only the Recapture and Westwater Canyon Members are present.

The Morrison Formation overlies the San Rafael Group conformably, but it is unconformable with the overlying Dakota Sandstone of Cretaceous age. The unconformity is angular in the Gallup Region, for the Morrison has been progressively truncated to the south (Silver, 1948).

RECAPTURE MEMBER

The Recapture Member of the Morrison Formation was named by Gregory (1938, p. 58) for exposures at the mouth of Recapture Creek, east of Bluff, Utah. Stokes (1944) amended the original description to include in the Recapture only the upper shales of the type locality. The Recapture was first recognized in northern Arizona and New Mexico by Harshbarger, Repenning, and Jackson (1951). The following year, Rapaport, Hadfield, and Olsen (1952), in a report for the Atomic Energy Commission, applied the Utah terminology to rocks in the area east of Gallup.

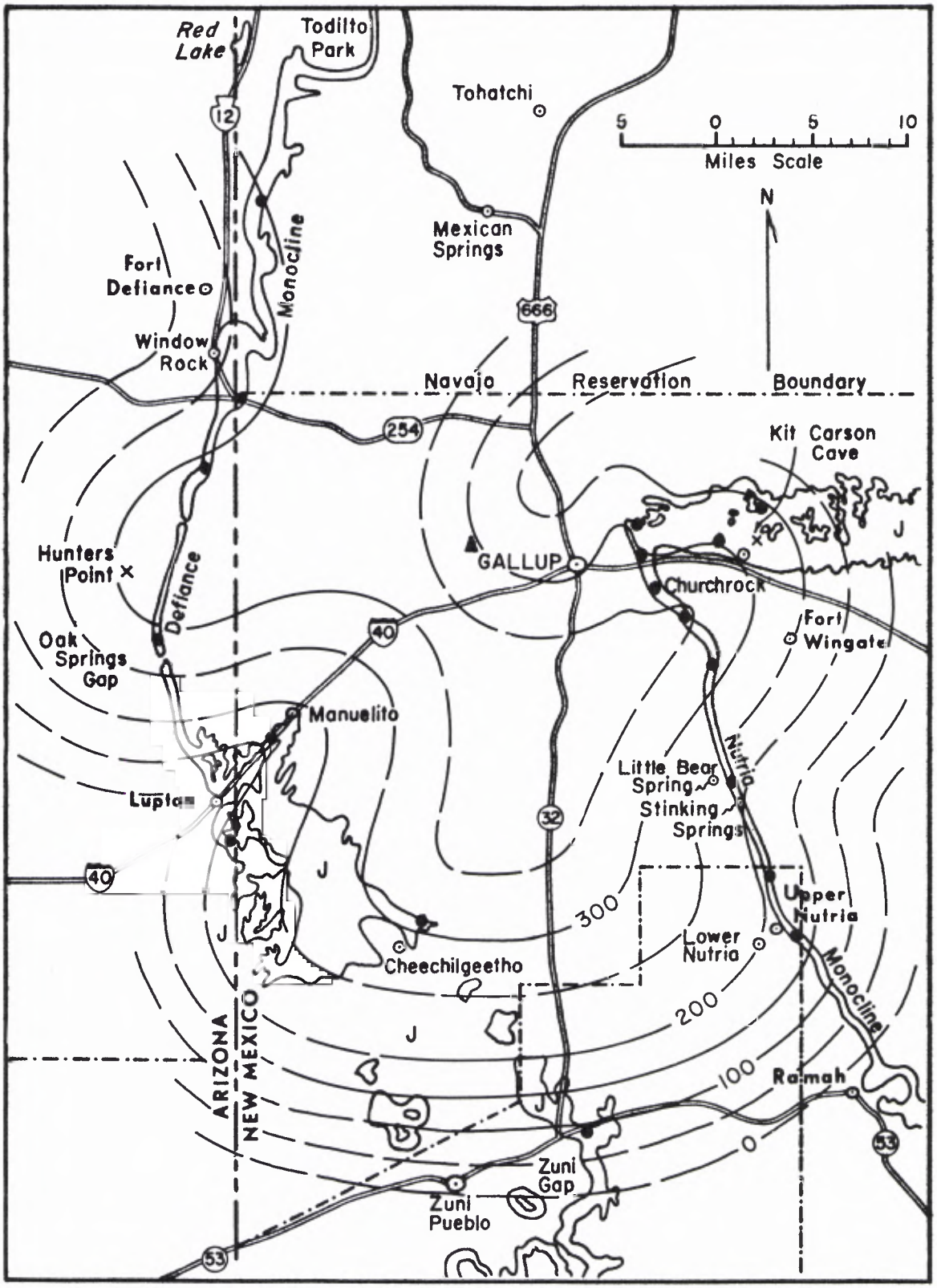
A more comprehensive stratigraphic study of the Morrison by Craig and his associates (1955), extended the Utah terminology over the entire Colorado Plateau. Subsequent workers, especially in the Grants-Laguna area of New Mexico, have employed the Utah names (Freeman and Hilpert, 1956; Foster, 1957; Harshbarger and others, 1957; Mirsky, and Treves, 1963; Hilpert, 1963).

Prior to the introduction of the Utah terms into New Mexico, Kelley and Wood (1946) included this stratigraphic interval in their white sandstone and brown-buff sandstone members of the Morrison and Smith, (1954), introduced a new set of stratigraphic names for members of the Morrison west of Grants, New Mexico. His Chaves Member, and Prewitt Sandstone Member are correlated with the Recapture and Westwater Canyon Members, respectively.

General Description

The Recapture Member of the Morrison Formation in the Gallup Region is the most lithologically inconsistent rock unit present. North of U.S. Highway 66 this inconsistency serves as a distinguishing characteristic of the member. Vertical and lateral changes in facies within short distances are the rule. In gross aspect, three principal facies can be distinguished. Essentially the same three facies were defined by Craig and his associates in 1955.

From Zuni Pueblo, New Mexico, northwest to Oak Springs, Arizona, and from Nutria Pueblo, New Mexico, north to Little Bear Springs, (Fig. 1) the Recapture is predominantly a pale reddish-brown, fine- to medium-grained massive sandstone. The sand grains of this facies are poorly sorted, subrounded to rounded, and are composed of quartz with minor amounts of rock fragments, chert, feldspar, and volcanic material. The sandstone is cross-bedded and some units are fine-grained and well-sorted. Several beds were noted in which very coarse, angular



EXPLANATION

● Measured section

▲ Drill-hole

50 Isopach, dashed where inferred, interval 50 feet.

FIGURE 1

Isopachous map of the Recapture Member of the Morrison Formation. (Outcrop pattern of Jurassic rocks (J) taken from Geol. Map of New Mexico, 1965).

grains of feldspar and quartz were scattered in a fine- to medium-grained matrix. Small pebbles were found at some places in these beds. Northward from Zuni Pueblo, sandstones that have average grain size larger than medium become thin, and eventually disappear. This facies is thought to represent the foot of an alluvial fan that extended northward from west-central New Mexico.

The second facies is a pale-red to grayish-yellow, very fine to fine-grained sandstone. The grains are very well sorted, subrounded to well-rounded, and frosted. This sandstone is cross-bedded on a large scale and it weathers to vertical cliffs. When well developed, as at Navajo Church and at Diamond No. 2 mine, this facies may occupy almost the entire Recapture interval.

The facies is distinguished by large to very large sets of tabular, planar, and trough cross-bedding. The scale of the trough cross-bedding sets range from less than one foot to over 12 feet in thickness, whereas the planar sets may be as much as 75 feet thick.

The best development of the planar type cross-bedding was observed at Pyramid Peak, just east of Gallup, where one set of cross-strata exposed in a vertical face can be distinguished from U.S. Highway 66, a distance of 1.5 miles. Harshbarger, and others (1957) believed that this facies, north of Fort Wingate, was the upper tongue of the Cow Springs Sandstone. A detailed examination of this distinctive facies near Gallup revealed it to be a local accumulation of sand which is most probably eolian in origin. A similar development of large-scale cross-bedding occurs in the Recapture between Fort Defiance and Todilto Park. Tongues of this facies were found in most of the sections measured.

The third facies consists of interstratified very fine-grained sandstone and lenticular siltstone and mudstone. The sandstone is usually a pale greenish-yellow, medium to poorly-sorted, and angular to sub-rounded. The thin siltstone and mudstone lenses are a dark red-brown, and are somewhat fissile. The best development of this facies is at Window Rock and at the northwest apex of the Zuni uplift. Southward, the facies intertongues with the other two facies, and eventually disappears completely in the vicinity of Nutria Pueblo. This facies weathers to colorful cones or "hoodoos" near Kit Carson Cave, but, more frequently, it simply castellates upon weathering.

The third facies, together with the eolian facies, suggests a dry climate. Cross-bedding indicates that the prevailing wind blew almost due east. It is postulated that at the foot of the alluvial fan, from Nutria Pueblo northward, there may have been a broad expanse of playa. Many dunal mounds and ridges separating interdunal basins probably existed on the playa. The small basins were the sites of ephemeral lakes where the red-brown, calcareous silts were deposited.

A possible regional stratigraphic marker occurs in the third facies, near the top of the member. A gray to green mudstone unit, 2 to 10 feet thick, contains calcium carbonate nodules and concretions that were found in no other part of the section. The concretions are gray, and range in size from 3 to 15 inches in diameter. They are composed of radiating crystals of calcite and usually have a limestone core. Most of the concretions are discoid in shape, and some have a septarian development.

Associated with the concretion-bearing mudstone are several thin-bedded, very fine-grained, laminated, sandstones. Primary current lineations, rib-and-furrow structures and mudcracks are well developed in these flaggy beds. The mudstone and laminated sandstones were found associated together in approximately the same stratigraphic position from Hunter's Point, Arizona, northward. They were also seen in a section measured at Cheechilgeetho, New Mexico. A similar association of units was noted in approximately the same stratigraphic position in exposures along the Nutria monocline, but the limestone concretions were absent.

From a consideration of the sedimentary structures, it is believed that the concretion-bearing mudstone unit was deposited in a broad, wind-swept playa lake, and that this bed may serve as a useful stratigraphic marker over a very large area along the Arizona-New Mexico border.

FIELD RELATIONS

The Recapture Member overlies the Cow Springs Sandstone conformably and gradationally throughout the region. North of U.S. Highway 66 the contact is easily distinguished as it is placed at the base of the lowest persistent red-brown siltstone in the Recapture. This siltstone is three to nine feet thick and commonly marks a break in slope that separates the massive cliff-forming Cow Springs Sandstone below from the overlying less resistant sandstones and siltstone beds of the Recapture. Elsewhere the basal siltstone unit makes a prominent dark-brown stripe across the face of outcrops.

South of U.S. Highway 66, the lower contact is not so easily defined. The dark color band and break in slope disappear rapidly to the south as the lower Recapture becomes coarser-grained, and more resistant. The Cow Springs Sandstone, however, remains fine-grained and well-sorted in the southern part of the area; therefore the contact is placed arbitrarily at the base of the lowest sandstone composed of grains that average larger than fine.

The Recapture Member is overlain in the northern half of the region by the Westwater Canyon Member. Where the Westwater Canyon is absent in the southern one third of the region, the Dakota Sandstone rests on the Recapture unconformably. In almost all instances where it is overlain by the Westwater Canyon, the Recapture exceeds 300 feet in thickness, the average being 330 feet. Approaching Zuni Pueblo from the north, the Recapture is progressively truncated by the Dakota Sandstone; and only 80 feet was measured at Zuni River Gap.

The ultimate disappearance of the Recapture a short distance south of Zuni Pueblo is inferred (Fig. 1). Smith (1957, p. 58) and Edmonds (1961, p. 36) concur in their belief that the Morrison is lost between Nutria Springs and Ramah, New Mexico. The termination of the Recapture is due principally to pre-Dakota beveling, although

gradation into the Zuni Sandstone may also contribute to its disappearance.

WESTWATER CANYON MEMBER

The Westwater Canyon Member of the Morrison Formation was named by Gregory (1938, p. 59) for exposures in Westwater Canyon, 15 miles southwest of Blanding, Utah. This member subsequently has been recognized over much of northeastern Arizona and northwestern New Mexico (Harshbarger, Repenning, and Jackson, 1951, p. 98), and may be correlated approximately with part of the white sandstone member of Kelley and Wood (1946), and with the Prewitt Sandstone Member of Smith (1954). Some of the more important references to this area are Smith (1954, 1957, 1959); Allen and Balk (1954); Craig and others (1955); Freeman and Hilpert (1956); Foster (1957); and Harshbarger and others (1957).

General Description

The Westwater Canyon Member, unlike the Recapture Member, is more consistent lithologically. Throughout the Gallup Region it is a yellow-gray to pale-red, fine- to coarse-grained, poorly sorted to unsorted, locally conglomeratic sandstone. Color was found to be the least consistent physical character of the member. The average grain size is 0.38 mm, or medium-grained. The grains are angular to subrounded and are composed predominantly of quartz, chert, and quartzite rock fragments.

Examination of ten disaggregated specimens under a binocular microscope revealed the presence of volcanic material such as sanidine, and small doubly-terminated, bipyramidal quartz crystals called quartzoids. In addition, tuffaceous galls, rhyolitic pebbles and montmorillonite clay found in the member strongly suggest that a considerable portion of the Westwater Canyon was derived from a volcanic source. The presence of volcanic material in the Morrison has been previously noted by Kelley (1955), Waters, and Granger (1953), and Allen and Balk (1954).

In places, enough feldspar is present to label the sandstone feldspathic. The sandstone generally has a distinctly "gritty" texture.

Exposures of the Westwater Canyon generally are massive and cliff forming.

A somewhat distinctive feature of the Westwater Canyon Member is the relatively widespread occurence of fossil woods within the unit. Much of the wood is in local concentrations but specimens can be found generally throughout the member.

In the northern part of the region, the upper half of the Westwater Canyon Member is somewhat coarser-grained and more conglomeratic than the lower half. This characteristic was noted also by Smith (1954, p. 17) in the Thoreau Quadrangle. Pebbles and cobbles in the conglomeratic units were seldom in contact, but rather were scattered in a matrix of medium- to coarse-grained, sandstone.

A close examination of the pebbles and cobbles at 13 localities revealed that almost 90 per cent of the conglomerate consists of sedimentary rocks. The most common pebble lithology is a yellowish-brown, very fine grained sandstone. Next in abundance are greenish-gray to yellowish-brown pitted cherts. The third most common lithology represented is a violet, fine- to very coarse-grained quartzite. Approximately five to ten per cent of the pebbles are a light-weight, off-white to pink welded tuff or rhyolite. The great bulk of the sandstone and pebbles in the member were derived from pre-existing sedimentary rocks. No granite pebbles were observed anywhere in the Westwater Canyon Member.

The Westwater Canyon is everywhere trough or festoon cross-bedded. Concentrations of very coarse sand and pebbles commonly occur along cross-bedding foresets. Clay galls may be locally abundant above the scoured contacts which separate many cross-bedding cosets. The small- to medium-scale of the cross-bedding and the medium- to very coarse-grained, unsorted sand composing the member all strongly suggest a fluvial environment of deposition. This is in complete agreement with the conclusions reached by previous workers. The average of a number of paleo-current indicator readings taken on cross-bedding, primary lineations, and elongate concretionary structures is N. 13° E.

The maximum thickness of the member was measured in Black Creek Valley where it is 287 feet thick. From this point southward, the member thins rapidly, and wedges out completely at Oak Springs, Arizona. This is contrary to the stratigraphic interpretations of Craig and Freeman who measured 94.4 feet of Westwater Canyon at Lupton, Arizona (*in* Cooley, and others, 1964, p. 150). They placed a question mark on this part of the section to emphasize its doubtful status; however, the measurement was accepted without reservation by subsequent workers.

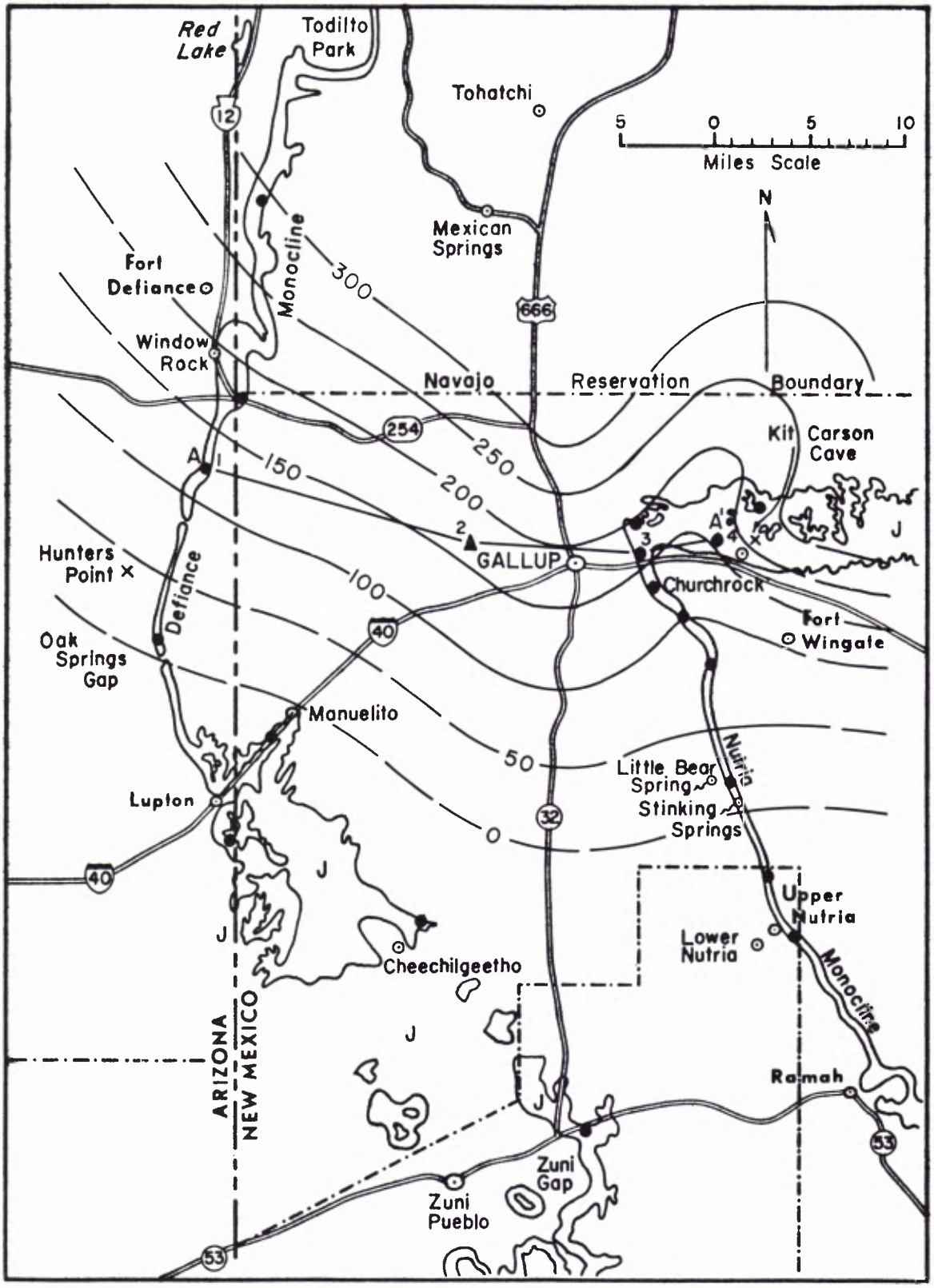
The interpretation presented here is illustrated in Fig. 2. The zero isopach passes from Oak Springs across the Gallup sag, slightly south of east to Stinking Springs, New Mexico. The disappearance of the Westwater Canyon Member to the south is believed to be entirely the result of post-Jurassic, north to northeastward tilting, and subsequent erosion prior to the deposition of the Dakota Sandstone.

Field Relations

In the area of this study, the Westwater Canyon Member is bounded by the Dakota Sandstone above, and the Recapture Member below. The contact between the Dakota and the Westwater Canyon is uncomformable. This unconformity could be identified throughout the region, and it served as a valuable stratigraphic marker.

At Church Rock, New Mexico, one or more thin, lenticular, maroon and green mudstone beds appear in the member. These minor interstratified mudstones become more persistent and thicken in an easterly direction. In some cases, mudstone beds in the upper half of the member can be traced directly into the Brushy Basin Member of the Morrison which is exposed east of Kit Carson Cave.

The Westwater Canyon displays a sharp, erosional,



EXPLANATION

● Measured section

▲ Drill-hole

50 Isopach, dashed where inferred, interval 50 feet.

See Fig. 3 for Section on Line A–A'

FIGURE 2

Isopachous map of the Westwater Canyon Member of the Morrison Formation. (Outcrop pattern of Jurassic rocks(J)—taken from Geol. Map of New Mexico, 1965).

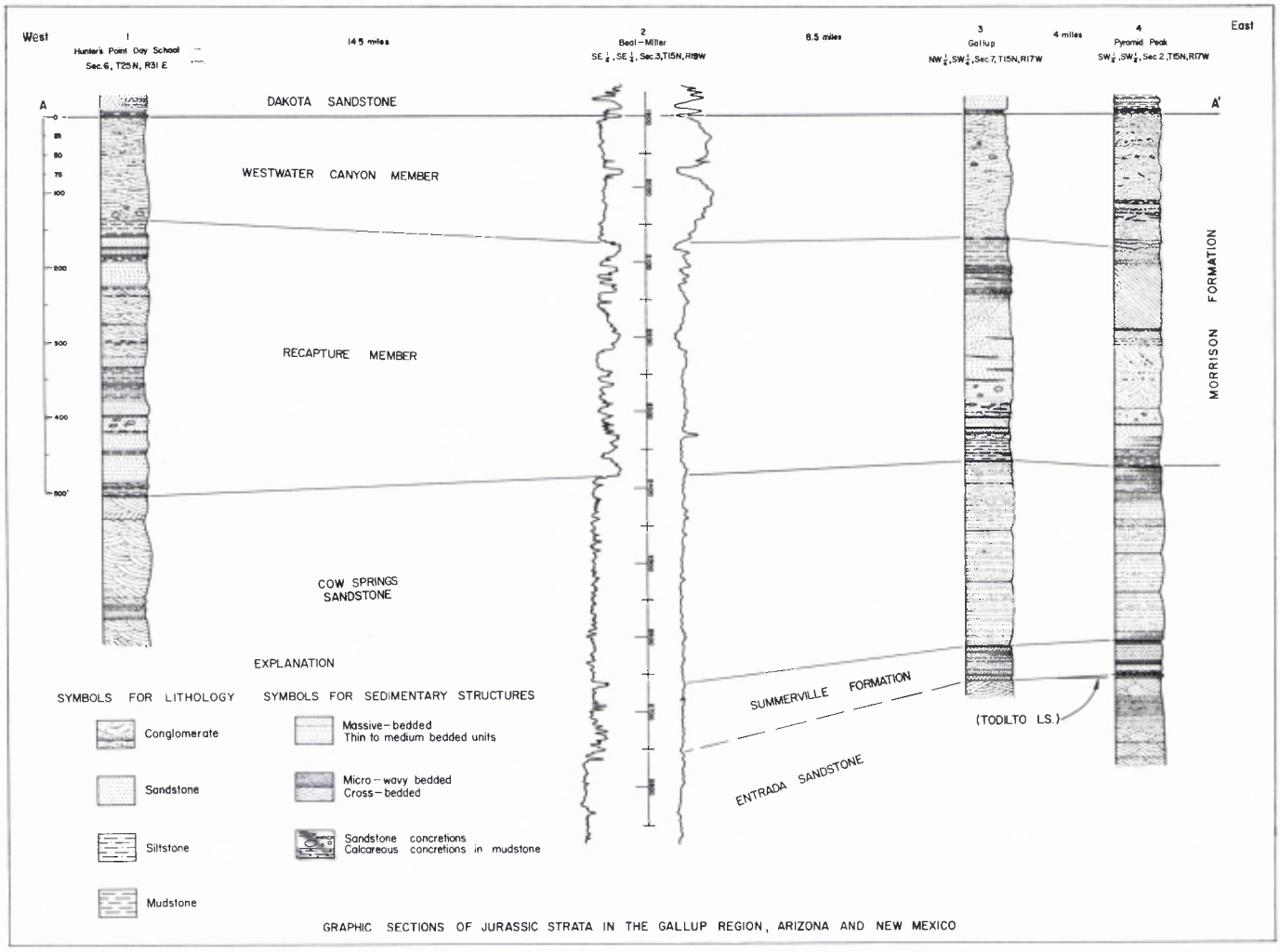


FIGURE 3

Columnar sections of Jurassic strata correlated with the Beal-Miller #1 across the Gallup sag. The line of section is shown in figure 2.

basal contact with the Recapture in almost all places where it is well exposed. Relief along the contact is generally three feet or less, but it increases to as much as eight feet northeast of Gallup. Smith (1954, p. 17) observed a relief of four to five feet in places along the contact between Gallup and Grants, New Mexico.

The Westwater Canyon Member can be followed south along the Nutria monocline from Gallup to Stinking Springs with very little change in lithologic character. As it thins, it also changes from a deep pink to a yellowish-white, and this change in color is accompanied by an increase in interstitial clay. The basal contact, however, remains fairly sharp and scoured all the way.

In addition to the scouring, the contact usually is marked by an abrupt change in grain size and sorting. For instance, the top of the Recapture at several localities is a very well-sorted, massive, fine-grained sandstone which is in marked contrast to the overlying coarser, unsorted sandstone of the Westwater Canyon. Only in the vicinity of Hunter's Point, Arizona, is the contact so poorly exposed that the relationships remain obscure. The lower contact of the Westwater Canyon is therefore drawn at the base of the massive-bedded, medium- to coarse-grained sandstones. No well-sorted sandstone units are included in this member as here defined.

It thus appears that the Westwater Canyon is disconformable with the Recapture in the Gallup region (Fig. 3). This minor disconformity probably disappears to the north and northeast where deposition in the basin proper was uninterrupted. As Allen and Balk observed (1954, p. 84), the Westwater Canyon, ". . . . is a new lithologic element in the Morrison sedimentation." Only a relatively rapid uplift to the south or southwest can account for the flood of coarse sand and gravel represented by the Westwater Canyon. Volcanic material found incorporated in the sediment may indicate that the uplift was accompanied by explosive volcanic activity.

The fact that the member is entirely a fluvial deposit

and contains a relative abundance of fossil wood is taken as evidence that the climate had become less rigorous than what it had been during Recapture time.

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