UNITED STATES DEPARTMENT OF THE INTERIOR

GEOLOGICAL SURVEY

PALEODEPOSITIONAL UNITS IN UPPER JURASSIC ROCKS IN THE GALLUP-LAGUNA URANIUM AREA, NEW MEXICO

By Morris W. Green

Open-File Report 75-610

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This report is preliminary and has not been edited or reviewed for conformity with U.S. Geological Survey standards and nomenclature.

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PALEODEPOSITIONAL UNITS IN UPPER JURASSIC ROCKS

IN THE GALLUP-LAGUNA URANIUM AREA, NEW MEXICO[1]

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ABSTRACT[2]

In the southern part of the San Juan Basin in the Gallup-Laguna area of northwest New Mexico, outcropping Upper Jurassic sedimentary rocks of the San Rafael Group, Cow Springs Sandstone, and Morrison Formation can be stratigraphically divided into three major units on the basis of differences in paleodepositional environments and, in part, on the presence of bounding unconformities. These superimposed depositional units are designated informally, in ascending order, as units "A," "B," and "C."

Depositional unit A includes the San Rafael Group, which consists of Entrada Sandstone, Todilto Limestone, and Summerville Formation, and also includes the lower two-thirds of the overlying Cow Springs Sandstone. Paleodepositional environments reflected by sediment type and genetic sedimentary structures include arid eolian shallow lacustrine, inland sabkha, and mixed eolian-sabkha. The absence of fluvially deposited sediments is characteristic of unit A.

[1]Modified from paper presented on June 3, 1975, at AAPG-SEPM Rocky Mountain Section meeting in Albuquerque, New Mexico.

[2]Abstract approved by Director, U.S. Geological Survey, and subsequently published in the American Association of Petroleum Geologists Bulletin, May 1975, v. 59, no. 5, p. 910.

Depositional unit B includes the upper one-third of the Cow Springs Sandstone and, in the eastern part of the area, the lower part of the Recapture Member of the Morrison Formation. Paleo-depositional environments include arid to semi-arid eolian, lacustrine, mixed eolian-sabkha, and low- to medium-energy fluvial. Abrupt lateral change in environments and resultant lithofacies change are marked characteristics of unit B.

Depositional unit C comprises the upper two-thirds of the Morrison Formation, which includes the upper part of the Recapture and the Westwater Canyon and Brushy Basin Members. In contrast to units A and B, which are composed primarily of multicyclic sediment, unit C is composed dominantly of arkosic to subarkosic first-cycle sediments, which were deposited under dominantly high energy subhumid to humid fluvial environments. Unit C is the main uranium-bearing unit in the Jurassic sequence.

INTRODUCTION

The objective of this report is to present the basis for an informal three fold division of Upper Jurassic sedimentary rocks that crop out on the southern margin of the San Juan Basin between the vicinities of Gallup and Laguna, New Mexico. The importance of using basin-analysis techniques as a method of aiding efforts in uranium exploration is also suggested. Jurassic continental red beds of the San Rafael Group, Cow Springs Sandstone, and Morrison Formation are, in this report, divided into three major paleodepositional units on the basis of contrasting sedimentary depositional environments, lithologic variation, and the presence, in part, of physically traceable depositional unconformities at the unit boundaries. These units are designated informally, and in ascending order, as units "A," "B," and "C" (fig. 1).

It is important to point out that this report does not suggest a formal change in stratigraphic nomenclature for Jurassic rocks in the report area. However, an important aspect of the division made here is that boundaries between depositional units do not, in all instances, coincide with formal stratigraphic boundaries as currently accepted and used in geologic reports on the report area.

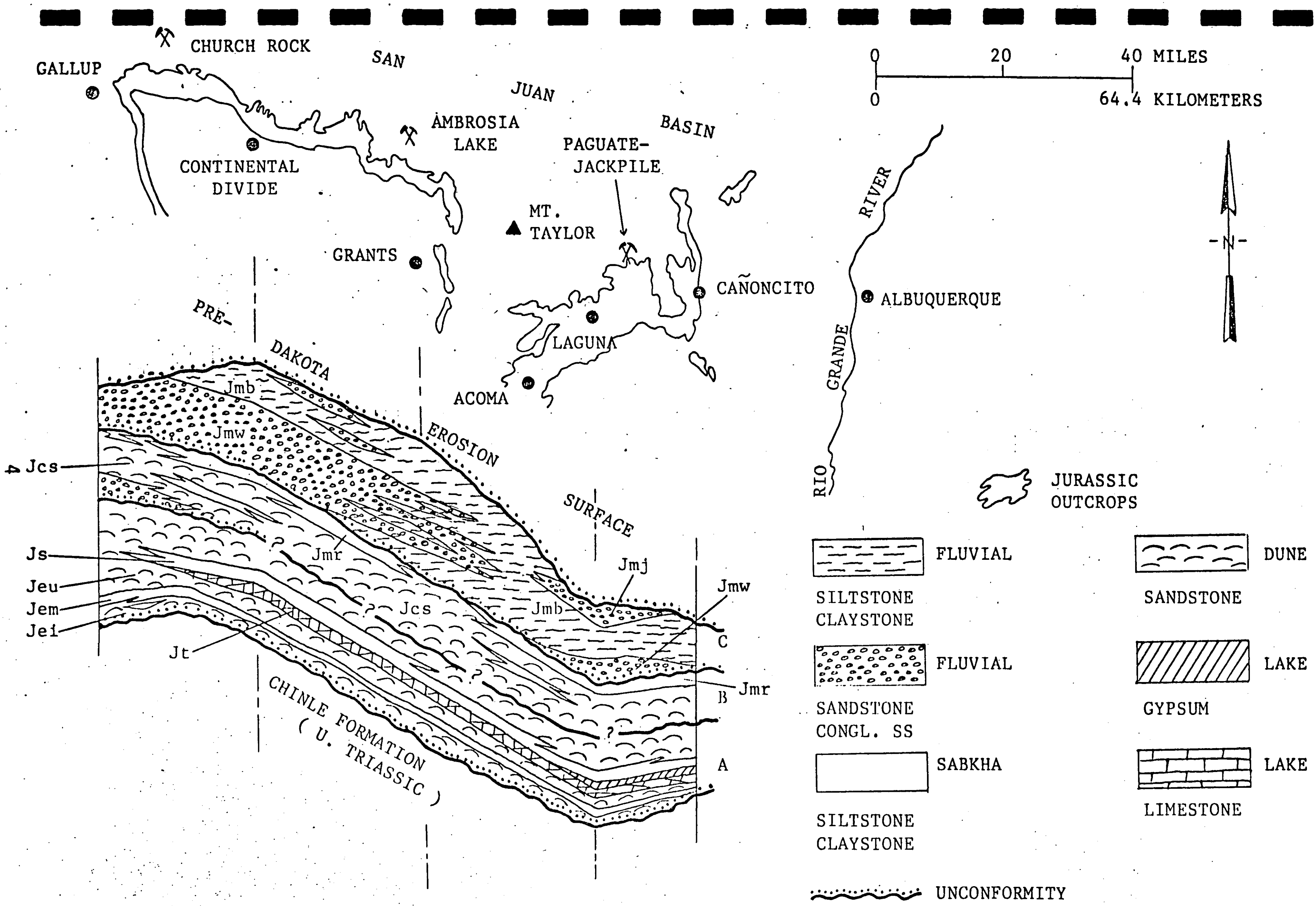

Figure 1.--Map of Gallup-Laguna area, New Mexico, and schematic east-west cross section of outcropping Jurassic rocks keyed to map.

PALEODEPOSITIONAL UNIT A

Unit A includes the three members of Entrada Sandstone, the Todilto Limestone, the Summerville Formation, and the lower two-thirds of the Cow Springs Sandstone. As recognized and mapped in the eastern part of the area, the Bluff Sandstone is also included in unit A as an undifferentiated part of the Cow Springs. The stratigraphic interval now considered to be the lowermost member of the Entrada Sandstone (the Iyanbito Member as shown on figure 2) was previously considered by Harshbarger, Repenning, and Irwin (1957, p. 8-12) to be a southeastern wedge of the Triassic Wingate Sandstone of northeastern Arizona. On the basis of stratal relationships described by Moench and Schlee (1967, p. 6-8) and by Green (1974, p. 1-12), the former Wingate interval is now considered to be a part of the Entrada throughout the Gallup-Laguna area.

Lithologically, depositional unit A is composed mainly of an alternating succession of thick, large-scale, high-angle, cross-bedded, orange-brown, medium- to fine-grained, fair- to well-sorted, quartzose sandstone and relatively thin, flat-lying, dark- to light-reddish-brown beds of massive siltstone, sandy siltstone, and claystone. These clastics are interpreted to be multicyclic on the basis of composition, texture, sorting, and grain shape of sand-sized particles. Overlying the Entrada, the Todilto interval contains light- to dark-gray limestone beds, and, in the eastern part of the area, the limestone beds are overlain by massive gypsum beds. The sandstone and siltstone sequence overlying the Todilto in the Summerville, Cow Springs, and Bluff intervals does not differ significantly from the Entrada interval of unit A.

DEPOSITIONAL UNIT	LITHOLOGY AND ENVIRONMENT	FORMATION AND MEMBER
C	FIRST-CYCLE SEDIMENT HIGH-ENERGY FLUVIAL LOW-ENERGY FLUVIAL	MORRISON BRUSHY BASIN WESTWATER CANYON RECAPTURE (UPPER 1/3)
B	MULTICYCLIC SEDIMENT EOLIAN DUNE INLAND SABKHA LOW-ENERGY FLUVIAL	MORRISON RECAPTURE (LOWER 2/3) COW SPRINGS (UPPER 1/3)
A	MULTICYCLIC SEDIMENT EOLIAN DUNE INLAND SABKHA SALINE LAKE	COW SPRINGS (LOWER 2/3) SUMMERVILLE TODILTO LIMESTONE ENTRADA UPPER SANDSTONE MEDIAL SILTSTONE IYANBITO

Figure 2.--Stratigraphy and environmental correlation of Jurassic rocks in the Gallup-Laguna area, New Mexico.

Taken together, exogenetic sedimentary structures, sediment texture, lack of fossils, and stratal relationships indicate that the sequence was most likely deposited under extremely arid climatic conditions in a subaerial basin where wind constituted the dominant transport and depositional medium for sediments in the sequence. The general absence of stream-deposited sediments in the sequence is one of the main characteristics of depositional unit A. This aspect of the unit sets it apart from overlying units.

Two main desert subenvironments can be recognized in unit A. These are eolian dune and inland interdune sabkha. Limestone and gypsum of the Todilto interval also attest to a third desert subenvironment; namely, saline lake.

Eolian crossbedded sandstone makes up the bulk of sediment in the sequence. The deposits are interpreted to have been deposited in ancient dune fields, which were common throughout the extent of the depositional basin. Transport directions preserved in the dune deposits are as follows: In the lower part of the sequence; that is, the Entrada, a general transport direction from northeast to southwest is indicated. In the upper part of the sequence; that is, the Cow Springs-Bluff interval, the dominant transport direction was from west to east.

Thin siltstone and claystone beds in the sequence are interpreted to be loesslike accumulations of airborne sediment winnowed from adjacent dune fields and deposited as blanketlike deposits in interdune areas. Preservation of these fine-grained deposits is primarily the result of the existence of inland interdune sabkhas in the central and or deeper parts of the depositional basin, where a climatically controlled fluctuating ground-water table periodically coincided with or exceeded ground level in interdune areas. During periods when the water table was high, shallow ponds or ground-water-saturated zones existed in the interdune areas and served as "dust traps" for airborne clastics. Because of the increased cohesiveness of silt- and clay-sized particles when wet, these deposits were more resistant to wind erosion when deposited in the wet interdune areas. Oscillation ripple marks are rarely seen on upper bedding surfaces of fine-grained beds. These structures probably were formed by wind-generated ripples in shallow ponds during high-water-table stage. No evidence of water-generated current ripples has been observed in association with unit-A sediments. During periods of low water table, mudcracks were formed on upper surfaces of silt deposits. These structures are common in siltstone beds, particularly in the lower part of Unit A.

The thickness of siltstone-claystone beds is probably, in part, proportional to the length of time that interdune areas remained stable because of high-water-table conditions. The thickness of individual siltstone-claystone beds ranges from a few millimetres to over 10 m. During periods of high water table, dunes immediately adjacent to the sabkhas were probably stabilized. It was only during low-water-table stage that dunes migrated and buried the sabkha deposits.

Limestone and gypsum beds in the Todilto interval are interpreted as saline lake deposits. This interpretation concurs with that made by Anderson and Kirkland (1960). For details relating to the origin of these lake sediments, see Anderson and Kirkland's work.

PALEODEPOSITIONAL UNIT B

Depositional unit B includes the upper one-third of the Cow Springs Sandstone and as much as two-thirds of the overlying Recapture Member of the Morrison Formation. With minor exception, rock type and sedimentary depositional environments in unit B are the same as those in unit A. For the first time in the Jurassic sequence, however, low- to medium-energy fluvial deposits are locally present. Fluvial intervals are composed of poorly sorted, thin, channel crossbedded sandstones and interbedded thin beds of overbank siltstones. These fluvial deposits lie adjacent to dune sandstones and sabkha siltstones. Although minor in occurrence, the presence of fluvial deposits in association with other desert deposits in unit B probably indicates some change in tectonic and climatic conditions at the end of unit-A time.

Dune and sabkha deposits in unit B show a marked increase in frequency of occurrence, both laterally and vertically in the sequence, indicating that the water table within the basin probably fluctuated more rapidly than it did during depositional unit-A time. A distinguishing characteristic of unit B is the very rapid lateral and vertical changes in lithofacies produced by the dune, sabkha, and fluvial environments.

Sabkha deposits in unit B commonly contain less siltstone and claystone than sabkha deposits in unit A. These deposits in unit B are commonly composed of reworked dune sandstone and sandy siltstone.

PALEODEPOSITIONAL UNIT C

Unit C, the main uranium-bearing sequence in the Jurassic in the report area, includes the upper part of the Recapture Member in the eastern part of the area and the Westwater Canyon and Brushy Basin Members of the Morrison Formation.

In contrast to the underlying depositional units, unit C is composed predominantly of first-cycle arkosic to subarkosic conglomeratic sandstone, coarse-grained, poorly sorted, angular sandstone, silty sandstone, siltstone, and claystone. Textural characteristics and composition indicate that unit-C sediment was, for the most part, derived from a fresh granitic-source terrain. Facies relationships indicate that the source area was located south-southwest of Gallup. Grain size in the sequence becomes finer vertically upward as well as finer laterally from west to east across the outcrop belt. Large localized accumulations of carbonaceous plant debris interbedded with the sediments probably indicates that climatic conditions during unit-C time were humid to subhumid. Deposition was almost exclusively by high- to low-energy meandering and braided streams traversing a large alluvial-fan complex located, in part, in the report area. The sandstone-shale ratio reverses almost completely from Gallup in the west to the vicinity of Laguna in the east. Conglomeratic and coarse-grained sandstones of the Westwater Canyon interval (proximal and mid-fan facies) decrease in thickness and abundance eastward across the outcrop belt and give way to increased thicknesses of distal siltstone deposits of the Recapture and Brushy Basin Members.

Coarse clastic bed-load sediments of the Westwater Canyon were deposited in superimposed, elongate tabular beds in the western part of the area or as lenticular "stacked" channel-shaped beds in the central part of the area. Siltstones in the sequence are predominantly suspended-load deposits, which were deposited in overbank flood-plain environments adjacent to streams or in low-lying areas at the distal edges of fans. Distal-facies siltstones in the eastern part of the area also contain minor amounts of chert and limestone deposited in small shallow ponds in the distal-fan areas.

UNCONFORMITIES

All three paleodepositional units are bounded by erosional unconformities. Unit A is bounded at the base by a widespread regional unconformity that separates Triassic from Jurassic rocks throughout the southern part of the Colorado Plateau. Unit A is separated from unit B by an unconformity in the western and southeastern parts of the report area. In the central and eastern parts of the area, Units A and B are conformable. Apparently, the two units were deposited in the same depositional basin, and deposition was continuous in the central part of the basin during unit-A and unit-B time. Unconformable relationships at the basin margins probably reflect a period of source-area uplift or basin downwarp accompanied by gradual changes in climatic and other environmental factors sufficient to produce the differences in the units.

Depositional unit C is bounded at the base by a previously undescribed unconformity having at least area-wide distribution. The significance of this unconformity is that it marks the base of the main uranium-bearing sequence in the Grants Mineral belt. It also marks the position of a major change in Jurassic depositional regimes and source terrain, which, in turn, are probably major contributing factors controlling the uranium mineralization in unit C. Althouth this unconformity can be identified across the entire breadth of the outcrop belt, it is immediately conspicuous only in the western part of the area, where high-energy fluvial sandstones of the Westwater Canyon interval of unit C are in contact with dune and sabkha deposits of unit B. From the vicinity of the Continental Divide eastward, where distal fluvial siltstones of unit C are in contact across the unconformity with similar-appearing sabkha siltstones of unit B, the unconformity becomes more difficult to recognize. This siltstone-on-siltstone contact is, however, usually marked by the presence of a laterally persistent 0.5- to 2.0-m-thick basal bed of lag conglomerate and conglomeratic sandstone superadjacent to the erosion surface. In the eastern part of the report area, this conglomerate bed also contains numerous well-preserved bone fragments.

In the central part of the report area, stratal relationships set up by definition of the unit B-unit C unconformity show that sabkha siltstones at the top of unit B and fluvial siltstones in the basal and distal portions of unit C are included in the Recapture Member of the Morrison. In the eastern part of the report area, where the Westwater Canyon Member of the Morrison is virtually absent, siltstones in units B and C are included in the Brushy Basin Member of the Morrison.

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