

SEDIMENTOLOGY AND STRATIGRAPHY OF THE MORRISON FORMATION IN DINOSAUR NATIONAL MONUMENT

CHRISTINE E. TURNER ♦ FRED PETERSON
U. S. GEOLOGICAL SURVEY ♦ DENVER

The objective of this study is to establish a stratigraphic, sedimentologic, and geochronologic framework of the Upper Jurassic Morrison Formation within Dinosaur National Monument (DNM) and to tie this framework to the rest of the Colorado Plateau and other important fossil-bearing localities in the Western Interior of the U.S. The study is also designed to complement ongoing paleontological inventories of the Morrison Formation within the Monument. During the 1990 field season emphasis was placed on the larger aspects of stratigraphic and sedimentologic work and collection of samples for various types of analyses. Work during the 1991 field season was concentrated on detailed stratigraphic and sedimentologic studies of the quarry interval and on the regional studies that will relate the Morrison Formation at DNM and its contained bones to important bone-bearing localities elsewhere in the Western Interior of the U.S.

♦ METHODS

Significant progress has been made on all four aspects of the research endeavor, which are 1) Stratigraphy, 2) Sedimentology, 3) Geochronology, and 4) Regional relationships.

STRATIGRAPHY

Two complete sections of the entire Morrison

Formation were measured, one just west of the quarry (DQW) in the western part of DNM and another at Bill White's Cabin (BWC) in Deerlodge Park in the eastern part of the Monument. In addition, a partial section consisting of the lower 3 members was measured at Rainbow Draw (RD) on the north side of the western part of DNM about 16 km northeast of the main quarry.

The Morrison Formation in DNM was found to contain 4 members that are recognized elsewhere on the Colorado Plateau. From oldest to youngest these are the Windy Hill, Tidwell, Salt Wash, and Brushy Basin Members.

Several key beds or units that are being evaluated for their potential to aid in regional correlations were also found at DNM. 1) A zone of authigenic red chert, called the welded chert, is present in the lower part of the Tidwell Member and has been found farther south on the Colorado Plateau and even in central and eastern Colorado and northeastern New Mexico. 2) The Salt Wash Member can be divided into two parts: the lower part contains fluvial sandstone beds with relatively few pebbles whereas the upper part tends to contain abundant pebbles. This distinction may allow correlation with the lower and upper parts of the member farther south in the central and western parts of the Colorado Plateau. 3) The Brushy Basin Member of the Colorado Plateau contains two parts

that are distinguished by the types of clay minerals that they contain. Nonswelling clays are characteristic of the lower part of the member and swelling clays characterize the upper part of the member. A similar vertical change in clay mineralogy has been found in the Morrison off the Plateau in central Colorado near Denver and Garden Park where members are not distinguished, suggesting that the change in clay minerals marks a widespread event throughout the southern part of the Western Interior. Preliminary investigations in Wyoming suggest that a similar change in clay mineralogy also occurs there, offering the potential to extend lithologic correlations from DNM to the quarry localities in that state.

Two other stratigraphic units that lie just below or above the Morrison were also measured and studied at the DQW locality. These are the Redwater Member of the Stump Formation of earliest Late Jurassic age and the Cedar Mountain Formation of Early Cretaceous age. These additions to the DQW section provide a better understanding of changes in rock types at the formation boundaries.

Selected rock samples were collected to be processed for detailed dating of the formation. These included samples from bentonite beds for isotopic dating and samples of organic-rich and (or) reduced mudstone or claystone for palynological analyses (chiefly spores and pollen). Other microfossil-bearing samples for charophytes, ostracodes, and conchostracans were also collected. Their value will be primarily for interpretation of depositional environments although the charophytes may also yield detailed age information.

SEDIMENTOLOGY

While measuring the sections, information such as lithologic descriptions, fresh and weathered colors, textures, bedding structures, alteration types, the type and nature of fossils, and crossbed orientation were also made to help in determining the environments of deposition of the beds. Particular emphasis was given to determining the sedimentology of the quarry interval and quarry bed. We use the term quarry interval to denote the fluvial sandstone and conglomerate unit in the Brushy Basin Member that is about 7-10 m thick and consists of about a dozen fluvial channel sandstone beds. Only one of these fluvial beds contains the abundant dinosaur bones and it is designated as the quarry bed.

The quarry interval was studied by lateral profiling in which approximately 32 closely spaced measured sections (averaging about 30 m apart) were measured along the approximately 1,000 m extent of the outcrop belt. Correlations were then made of important surfaces within the interval that define the individual fluvial beds by tracing the surfaces between the sections. The resulting panel shows the relationships of the various fluvial channels, including the quarry bed, to each other as well as to other significant rock types.

Crossbedding studies were also made in fluvial and eolian sandstone beds in the Morrison and Cedar Mountain Formations to determine the direction of flow of the streams or winds that deposited these beds. Considerable effort was also given to determining the direction of flow of the streams that deposited the quarry interval and the strata that lie above the quarry interval in the uppermost part of the Brushy Basin Member.

GEOCHRONOLOGY

By this term, we include either isotopic or paleontologic methodologies for determining the age of the rocks. For isotopic age determinations we collected stratigraphically controlled samples of bentonite beds (actually altered volcanic ash deposits) from the Tidwell Member at the RD section and from the Brushy Basin Member at the DQW and BWC sections. These were sent to laboratories in Provo (Utah), Berkeley (California), and Reston (Virginia) for preparation and analysis.

For paleontologic age determinations, stratigraphically controlled samples for palynomorphs (spores and pollen) or charophytes were collected from all 4 members of the Morrison as well as from the underlying Redwater Member of the Stump Formation and the overlying Cedar Mountain Formation. Within DNM, palynomorphs offer the best possibility for detailed dating of the Morrison as rock types favorable for containing these microfossils occur throughout most of the formation. These samples have been sent to the appropriate laboratories for processing and analysis by specialists. Most of the sampling was done at the DQW section although especially promising samples were also collected from the BWC and RD sections. We also collected palynomorph samples from other localities either inside or outside the Monument, wherever we felt

that the additional control was needed that would help in understanding the age of the formation within DNM.

◆ PRELIMINARY RESULTS AND INTERPRETATIONS

The four members that have been recognized in DNM can be correlated elsewhere on the Colorado Plateau by means of their characteristic lithologies, stratigraphic position, and (or) their contained marker beds or correlatable horizons. Along with the detailed geochronologic work in progress, this should allow us to achieve a detailed chronology within the formation and allow us to correlate Morrison dinosaur quarries at DNM with other important Morrison bone-bearing localities in the Western Interior.

Paleocurrent studies on crossbedding in fluvial sandstone beds indicate that Morrison streams flowed generally to the southeast across DNM and probably originated in a highland region in northwestern Utah or southern Idaho. Similar studies on eolian sandstone beds in the eastern part of the Monument indicate that the prevailing winds came from the west, consistent with paleowind determinations made farther south on the Colorado Plateau.

Our studies indicate the need for a revision in thought concerning the origin of the quarry bed that

contains the abundant bones in the quarry building. The bones occur at and near the bottom of an ancient stream channel, not on a bar on the side of the channel. This interpretation is the result of detailed examination of the quarry interval and quarry bed in light of modern sedimentologic techniques for studying fluvial strata. We can also identify the quarry bed in outcrops east of the quarry building where it also contains a large quantity of dinosaur bones.

Considerable progress has been achieved in the regional studies that will allow us to relate the dinosaur bones at DNM with other dinosaur quarries in the Western Interior. We have studied other important dinosaur-bearing localities at Kenton (Oklahoma), Garden Park (Colorado), Morrison (Colorado), Dry Mesa (Colorado), East Canyon (Utah), and Strickland Creek (Montana). At each of these localities, sections were measured if not already available, the stratigraphic positions of the quarries were determined, stratigraphically controlled microfossil samples were collected, and samples for isotopic dating were also collected if the appropriate rock types were present. Although detailed correlations between these localities and DNM cannot be made without the micropaleontological analyses, work already accomplished gives us confidence that the goal of relating the various dinosaur quarries in the Western Interior with those at DNM can be achieved.