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Synthesis of late Paleozoic and Mesozoic eolian deposits of the Western Interior of the United States

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Abstract

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Late Paleozoic and Mesozoic eolian deposits include rock units that were deposited in ergs (eolian sand seas), erg margins and dune fields. They form an important part of Middle Pennsylvanian through Upper Jurassic sedimentary rocks across the Western Interior of the United States. These sedimentary rock units comprise approximately three dozen major eolian-bearing sequences and several smaller ones. Isopach and facies maps and accompanying cross sections indicate that most eolian units display varied geometry and complex facies relations to adjacent non-eolian rocks.

Paleozoic erg deposits are widespread from Montana to Arizona and include Pennsylvanian formations (Weber, Tensleep, Casper and Quadrant Sandstones) chiefly in the Northern and Central Rocky Mountains with some deposits (Hermosa and Supai Groups) on the Colorado Plateau. Lower Permian (Wolfcampian) erg deposits (Weber, Tensleep, Casper, Minnelusa, Ingleside, Cedar Mesa, Elephant Canyon, Queantoweap and Esplanade Formations) are more widespread and thicken into the central Colorado Plateau. Middle Permian (Leonardian I) erg deposits (De Chelly and Schnebly Hill Formations) are distributed across the southern Colorado Plateau on the north edge of the Holbrook basin. Leonardian II erg deposits (Coconino and Glorieta Sandstones) are slightly more widespread on the southern Colorado Plateau. Leonardian III erg deposits formed adjacent to the Toroweap-Kaibab sea in Utah and Arizona (Coconino and White Rim Sandstones) and in north-central Colorado (Lyons Sandstone).

Recognized Triassic eolian deposits include major erg deposits in the Jelm Formation of central Colorado–Wyoming and smaller eolian deposits in the Rock Point Member of the Wingate Sandstone and upper Dolores Formation, both of the Four Corners region. None of these have as yet received a modern or thorough study.

Jurassic deposits of eolian origin extend from the Black Hills to the southern Cordilleran arc terrain. Lower Jurassic intervals include the Jurassic part of the Wingate Sandstone and the Navajo–Aztec–Nugget complex and coeval deposits in the arc terrain to the south and west of the Colorado Plateau. Major Middle Jurassic deposits include the Page Sandstone on the Colorado Plateau and the widespread Entrada Sandstone, Sundance Formation, and coeval deposits. Less extensive eolian deposits occur in the Carmel Formation, Temple Cap Sandstone, Romana Sandstone and Moab Tongue of the Entrada Sandstone, mostly on the central and western Colorado Plateau. Upper Jurassic eolian deposits include the Bluff Sandstone Member and Recapture Member of the Morrison Formation and Junction Creek Sandstone, all of the Four Corners region, and smaller eolian deposits in the Morrison Formation of central Wyoming and apparently coeval Unkpapa Sandstone of the Black Hills.

Late Paleozoic and Mesozoic eolian deposits responded to changing climatic, tectonic and eustatic controls that are documented elsewhere in this volume. All of the eolian deposits are intricately interbedded with non-eolian deposits, including units of fluvial, lacustrine and shallow-marine origin, clearly dispelling the myth that eolian sandstones are simple sheet-like bodies. Rather, these units form some of the most complex bodies in the stratigraphic record.

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Introduction

The most voluminous expanse of eolian depositional systems in the geological record occurs across the Western Interior of the United States. The area stretches from southern Nevada and adjacent California across the Mogollon Rim of Arizona across the northern half of New Mexico into the Texas and Oklahoma panhandles, northward through eastern Utah and western Colorado, eastward into north-central Colorado, northward into Wyoming and the Black Hills of South Dakota, west into southwestern Montana, and full circle south along the Cordilleran Hinge Line through southwest Utah to southern Nevada (Fig. 1 *). Within this vast area, the greatest concentration of eolian-bearing formations occurs on the Colorado Plateau in south-central Utah and adjacent Arizona (Blakey, this volume). Eolian deposition began in the Early and Middle Pennsylvanian (Atokan, Desmoinesian), reached an initial climax during the early Permian (Wolfcampian, Leonardian), waned during the Triassic, and reached a second climax during the Middle Jurassic; eolian deposition declined during the Late Jurassic and is absent in the Cretaceous (Fig. 2). Thus eolian deposits are distributed throughout 160 m.y. of time and dominated deposition in some areas.

Purpose and scope

The chief purpose of this paper is to describe the geometry of the late Paleozoic and Mesozoic eolian deposits of the Western Interior. We are presenting an atlas that documents geometry, stratigraphy, and facies relations of the eolian-bearing intervals. The information is presented in a series of maps and cross sections, each of which is carefully documented by maps and tables to the source of the original data.

Methods

Field-based observations and studies of the authors, both published and unpublished, form the foundation of this paper; however, most of the basic data has been collected from the literature. The isopachs were constructed from data points that were carefully plotted by township and range, numbered, listed with author, their section designation, interval of study, and thickness of eolian interval. Because much of the information in the literature does not specify the environment of deposition of the rocks of interest or misinterpreted the origin of the rocks, or contains outdated stratigraphic terminology, we used our collective experience to define the eolian intervals within the original authors' section. Thus it is possible for subsequent workers to take our data back to the original source and see how our interpretations fit within the framework of the original authors' work. Space limitations and tremendous breadth of subject demanded that our conclusions be arrived at directly without much discussion or debate of numerous hypotheses.

It should be noted that the isopachs show the thickness of the eolian-bearing interval and not necessarily the thickness of a formal rock-stratigraphic interval or rocks of a particular age (Table 1). In general the isopachs show the thickness of erg or dune deposits from the base of the oldest eolian sandstone to the top of the youngest one. In some instances the thickness of simple, thick, non-eolian tongues is subtracted from the isopached interval. Because many geologic units contain mixtures of eolian and non-eolian rocks, the isopachs may vary considerably from previously published maps of a given formation; or where specified, they may include parts of more than one formation or stratigraphic unit. Most of the maps have patterns that show approximate percentages of eolian rocks within the overall eolian-bearing sequence. If a given eolian interval shows an isopach of 100 m and a percentage of 50, this means that the thickness of the eolian-bearing rocks of a given interval is 100 m and that approximately half of that interval contains eolian-deposited rocks.

We caution the reader that because the maps vary slightly in method of construction, Table 1 must be consulted when examining our presentation of a given eolian sequence; be aware of what the data mean! We found it necessary to vary the

* Due to their large size Figs, 1, 4, 5, 6, 8, 9, 10, 11, 12, 13, 15, 17, 18, 20, 21, 22, 24, 25, 27, 28, 30, 31, 33 and 34 are placed together on the foldouts in this article.

method of presentation because of the nature of the data. Some of the eolian units are very poorly studied and required some estimation on our part. Some of the differences reflect the great variety in the eolian-bearing deposits themselves. Some of the intervals have not had much previous discussion in the literature but have been the subject of recent study and therefore are covered in more depth here than some of the better-known eolian deposits. In general, our interpretation of amounts and distribution of eolian-formed rocks is probably conservative; that is, we expect that future detailed studies will likely show an increase in the volume of eolian deposits in the interval of study.

Cross-sections of the eolian sequences were constructed to show the lateral relations of the rocks of interest. These sections indicate the distribution of the eolian rocks within the isopached intervals and show which portion of the interval contains the most eolian deposits.

The terminology of this paper (Fig. 2) generally follows accepted previous terminology of earlier workers. No new nomenclature is proposed nor do we attempt to settle old nomenclature disputes except where major revision or updating of stratigraphic terminology was necessary. Both the Permian and Jurassic rock units are fraught with correlation problems; we readily admit to using our own experience and prejudice where necessary. Because we have concentrated on the eolian rocks, we have been able to trace patterns that have been overlooked by previous geologists. In addition, some major regional correlations of late Paleozoic and Mesozoic rocks have recently appeared in the literature (Condon and Peterson, 1986; Blakey, 1987; Blakey and Knepp, in press). The correlations and definitions of eolian intervals, as used in this report, rely heavily on local and regional stratigraphic data. The recognition and correlation of major regional Jurassic unconformities by Pipiringos and O'Sullivan (1978) strongly aided our correlation and differentiation of the Middle Jurassic eolian deposits. The relations of erg-bearing units to fossiliferous sequences has facilitated the division of Permian rocks (Blakey, 1980). The persistence of certain units such as the redbed Hermit–Organ Rock–Abo Formations of the Permian on the Colorado Plateau, the red marker presumed to mark the Pennsylvanian–Permian boundary across much of eastern Wyoming, and Jurassic redbed units like the Carmel and Wanakah Formations across the Colorado Plateau greatly aid regional correlation and differentiation of eolian deposits. In some cases the only resolution is by carefully measured and closely spaced measured sections such as those published by O'Sullivan (1980a,b). Well logs proved useful for subsurface correlation where sufficient stratigraphic data was available.

An apparent discrepancy exists in the number of maps shown per interval of geologic time. Although the Pennsylvanian Period spans approximately 30 m.y. and the Middle Jurassic only 16 m.y., we show only one facies-isopach map for the former and six for the latter. Pennsylvanian ergs are widespread and are locally datable to smaller subdivisions of the period. However, these subdivisions cannot be recognized on a regional basis. The Middle Jurassic, however, has been subdivided and rocks correlated regionally by use of unconformities as shown by Pipiringos and O'Sullivan (1978). Four of the Jurassic intervals we show are relatively small, easily distinguishable, and therefore separable as shown on the maps. To attempt the same with Pennsylvanian eolian deposits would not be practical at present.

The general regional stratigraphy of the late Paleozoic and Mesozoic of the Western Interior and the location of the eolian deposits is shown on Fig. 2. The cross-sections presented later in this paper detail the relations between the erg and non-erg deposits. By carefully comparing our maps and cross-sections and referring back to the original references cited in the tables, the reader should be able to clearly see how our conclusions were reached; therefore, our presentations of geometries of eolian-formed units should still prove useful even if subsequent work shows adjustment to be necessary in regional correlation. The authors are responsible for the construction of the isopachs as follows: Blakey—Paleozoic, Jelm, Wingate units; Kocurek—Page and Entrada Sandstones; Peterson—Temple Cap, Romana and Morrison-age units; Peterson (with assistance from Larry Middleton)—Navajo Sandstone and related units.

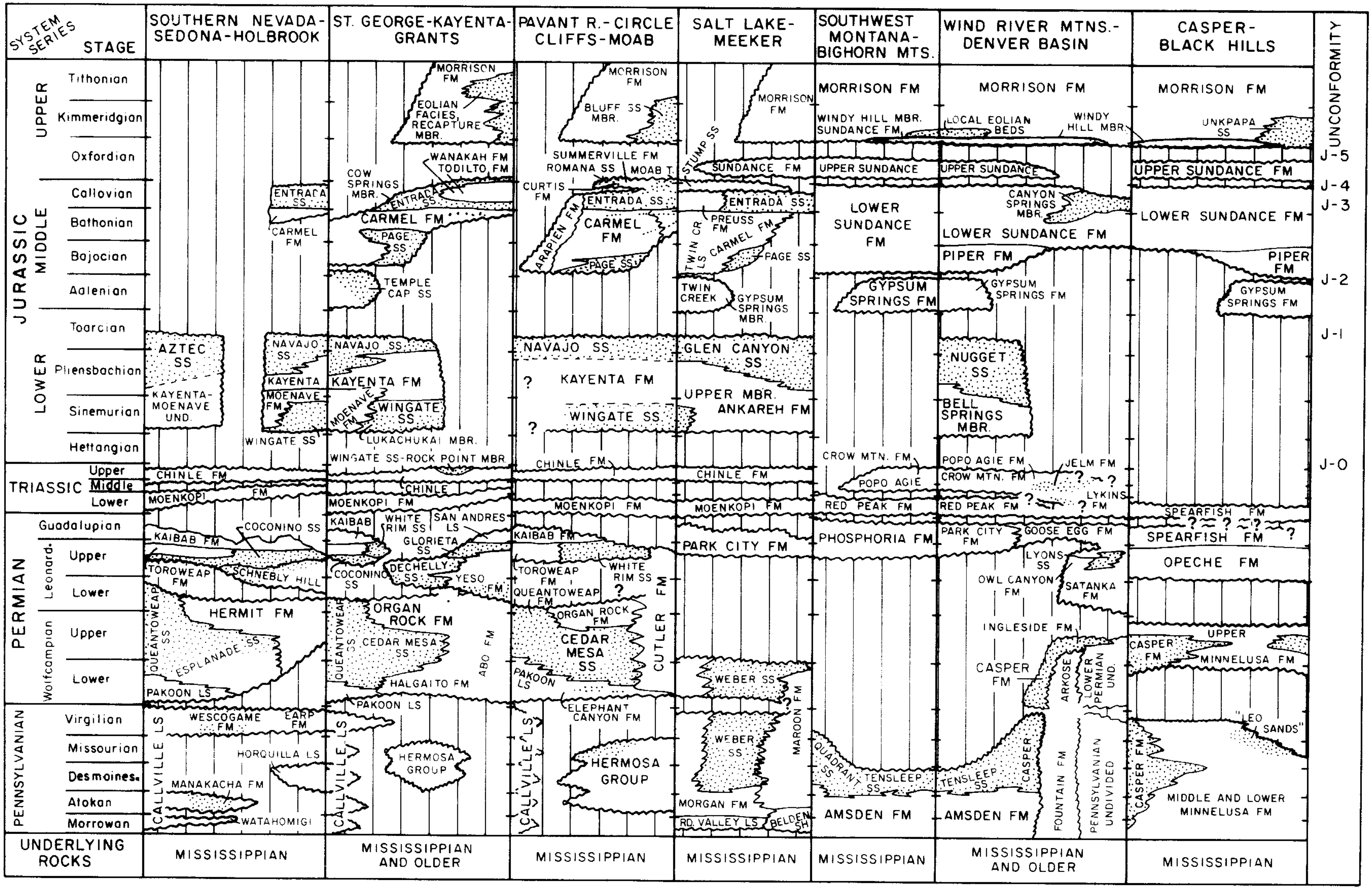


Fig. 2. Time–rock chart of Pennsylvanian through Jurassic Systems of Western Interior showing all known eolian-bearing intervals (shaded). Also shown are principal unconformities (ruled). Not to scale.

The presentation of each eolian-bearing sequence will follow the same format. Description in the text will be brief, especially in cases where the rocks are well described in previous literature. Emphasis will be placed on facies and geometric relations of the eolian units, especially lateral configurations. We will show that few eolian deposits are simple layer-cake sand bodies, and rather that most are complex units that change vertically and laterally and show strong diachronous characteristics. Preliminary and general interpretations of erg geometry will be offered, although this topic is more completely discussed in other papers in this volume.

Isopachs alone are insufficient for interpretation of complex sandstone-body geometry. Most of the isopach maps have additional symbols for interpretation of eolian sandstone-body geometry. The lines that show percentage of eolian deposits document trends of increasing or decreasing eolian sediment within an interval. The bounding lines of the eolian interval also aid interpretation of the maps. Zero lines indicate wedge-out of an eolian body, either by pinch-out of the entire interval as in the case of the De Chelly-Schnebly Hill Formation and eastern edge of the Page Sandstone, or pinch-out of eolian sandstone into other facies of the interval as in the case of the western edge of the Page Sandstone. The latter may be accompanied by facies change as well as pinch-out. The narrow saw-toothed lines indicate major facies change throughout the entire erg-bearing interval. Cross-sections aid in the interpretation of eolian geometry. One or more are presented for each interval discussed in the text.

Another situation that is not clearly shown on the maps is the pinch-out of a major eolian tongue with the continuation in the direction of pinch-out of the main eolian body. This can be shown clearly only in cross-section. An example is the Navajo–Kayenta intertonguing across southwestern Utah and north-central Arizona; the main body of the Navajo continues well southwest of the area of major intertonguing. Figure 3 diagrammatically shows various types of eolian sandstone margins and refers to a real example of each.

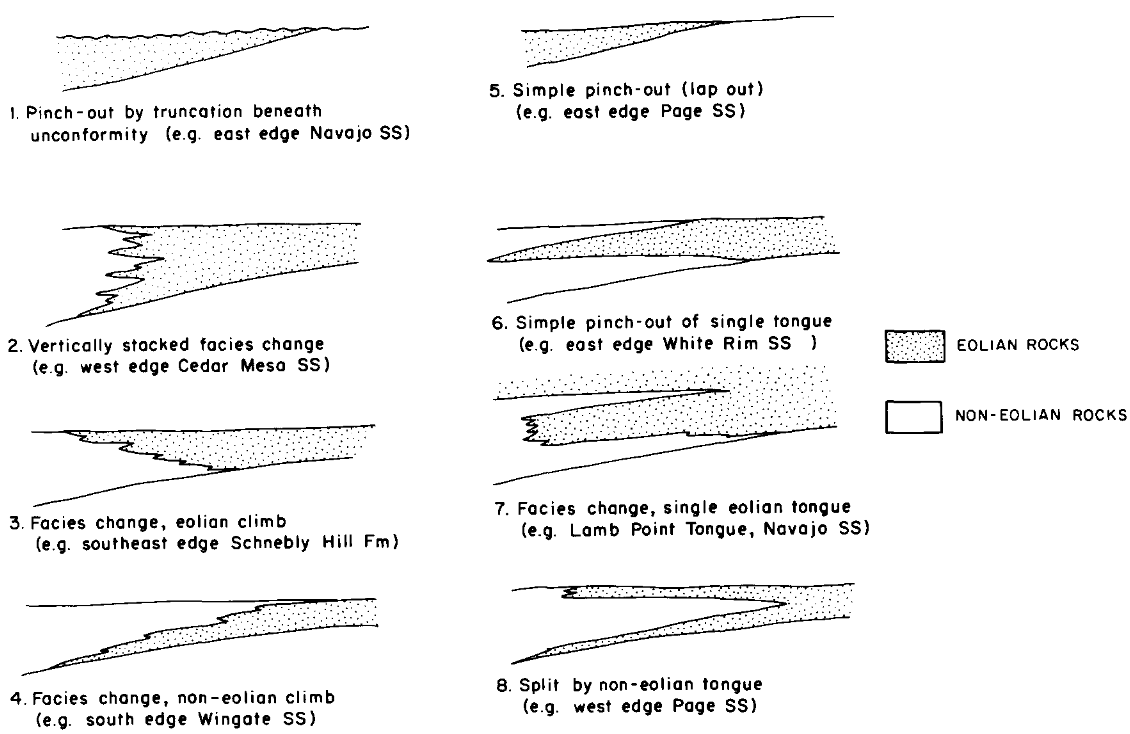


Fig. 3. Simple cross-sections depicting geometry of various margins of ergs. An example from eolian sandstones of the Western Interior is given for each. Compare with actual isopach maps and cross sections for true scale and geometry.

Many eolian sandstones have one or more margins that were removed by later erosion or are covered by younger strata and no subsurface data is available. This is most common along the western and southern margins of the region of study.

Late Paleozoic eolian deposits

Introduction

The late Paleozoic eolian sandstones range in age from Atokan to late Leonardian and possibly Guadalupian (Fig. 2). They are divided here into five erg-bearing sequences: Pennsylvanian, Wolfcampian, Leonardian I, Leonardian II and Leonardian III. Each sequence is intercalated with or bracketed by fossil-bearing rocks. Pennsylvanian eolian deposits are primarily distributed north of the Ancestral Rockies, whereas Permian ergs are extensively distributed to the southwest of these major barriers. Figure 4 shows the distribution of late Paleozoic tectonic elements that affected Pennsylvanian and Permian deposition.

Pennsylvanian eolian deposits

Pennsylvanian eolian deposition is widespread and has been documented from the lower Casper Formation (Steidtmann, 1974), lower Tensleep Sandstone (Mankiewicz and Steidtmann, 1979; Kerr, this volume) and Quadrant Sandstone (Saperstone and Ethridge, 1984) in Wyoming and adjacent Montana and Colorado, in the lower Weber Sandstone of Utah, Wyoming and Colorado (Bissell and Childs, 1958; Driese and Dott, 1984), and from the Honaker Trail Formation of the Hermosa Group of southeastern Utah (Loope, 1984). In addition, eolian sandstone is present in the Manakacha and Wescogame Formations of the Supai Group in northern Arizona but has yet to be documented in the literature. The Pennsylvanian age of each of the above is well documented by intercalated fossil-bearing marine rocks. Figure 5 and Table 2 present the data base for Pennsylvanian and Permian eolian deposits.

The Pennsylvanian deposits, although almost certainly a series of separate ergs ranging from Atokan to Virgilian in age, are herein isopached on a single map. Eolian-bearing units consist of several stratigraphic units across Wyoming, southern Montana, northern Utah and northern Colorado (Fig. 6). The lack of detailed stratigraphic and sedimentologic data prevent further subdivision. The eolian deposits in southeastern Utah and the Grand Canyon region do not have sufficient data available to construct isopachs; only their known and inferred lateral distribution are shown. For simplicity, the northern sand body will be referred to as the Tensleep complex and it also includes part of the Weber, Quadrant and Casper stratigraphic units. The Tensleep forms a broad sheet across the Central and Northern Rocky Mountain region that generally ranges to 100 m thick but the erg-bearing interval locally exceeds 300 m in northern Utah and 500 m in southwestern Montana (Bissell and Childs, 1958; Mallory, 1967; Saperstone and Ethridge, 1984). Figure 7A, B and C shows the Tensleep and related units in cross-section. Although the unit is renowned for exposures of large-scale, high-angle sand-flow strata that dip to the south and southeast (Steidtmann, 1974; Mankiewicz and Steidtmann, 1979), detailed sedimentologic studies have documented a broad variety of eolian stratification styles including small-scale trough and planar-tabular wind-ripple cross strata, horizontal to gently inclined wind-ripple strata, and wet and dry interdune deposits (Mankiewicz and Steidtmann, 1979; Driese and Dott, 1984; Saperstone and Ethridge, 1984; Kerr, this volume; J. Haslett, pers. commun., 1986). In addition, each of the above authors have noted interbedding of eolian and marine-sabkha strata within the Tensleep Sandstone, especially near erg-deposit margins.

The Tensleep complex is a north-northwest-trending sandstone body (Fig. 6) bordered by marine clastic and carbonate rocks to the west (Oquirrh and Wood River Groups and related rocks), marine carbonate to the east (lower Minnelusa Formation and related rocks), and fluvial clastic rocks to the south (Maroon Formation and Fountain Arkose; Maughan and Wilson, 1960). Little is known about the erg margins to the north, although Stewart and Walker (1980) reported Pennsylvanian eolian deposits in the Rockies of southern Canada.

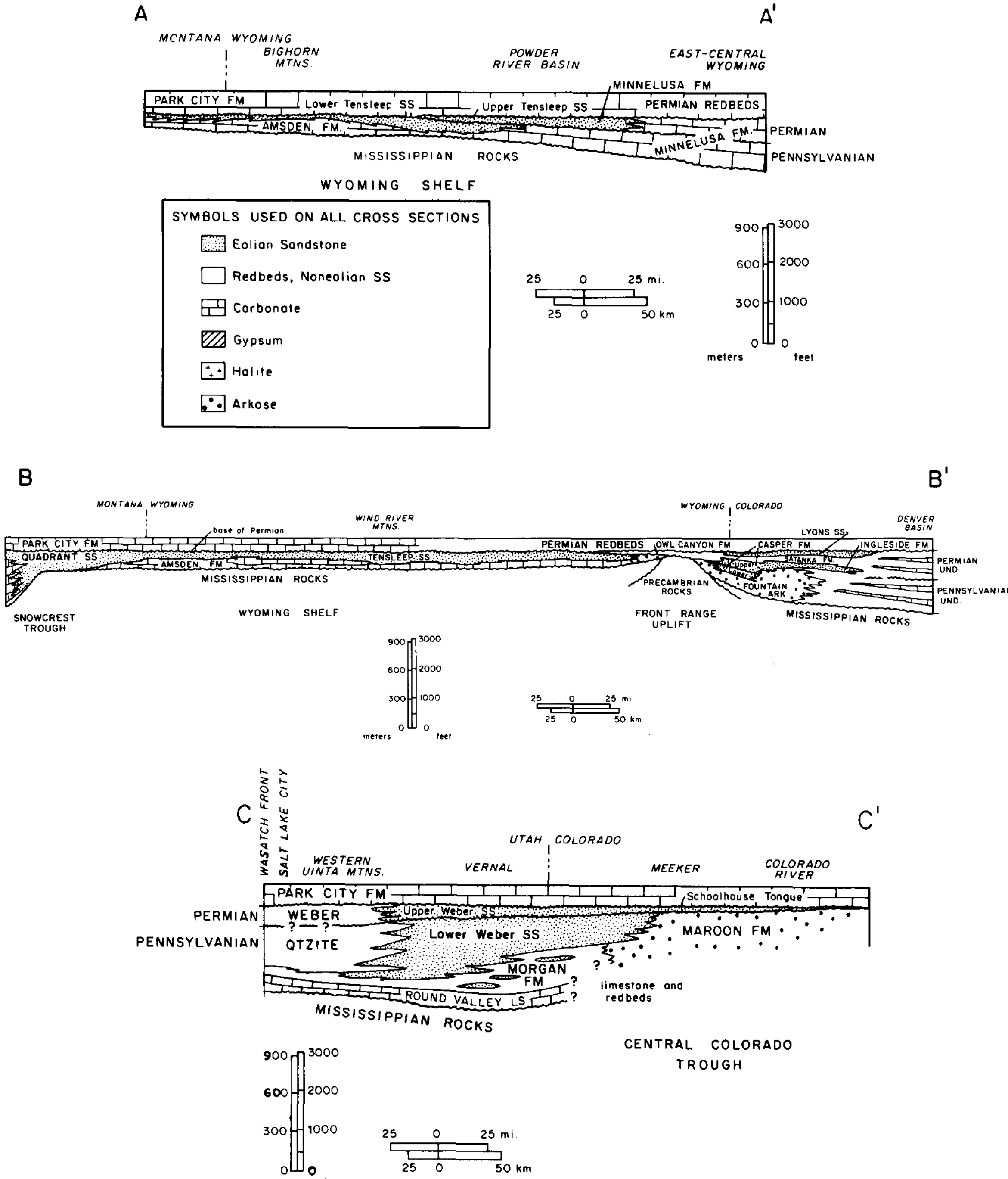
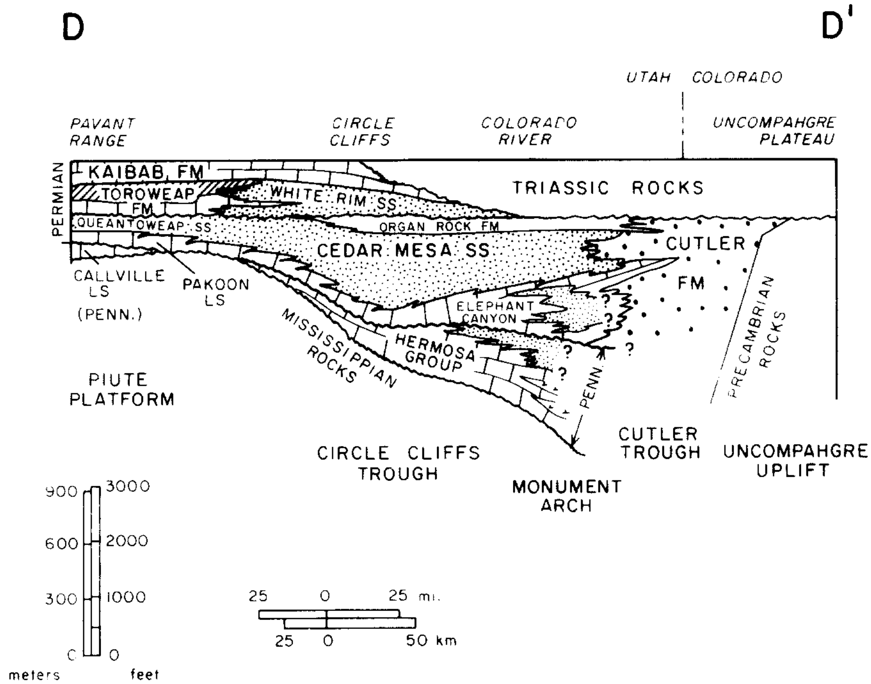
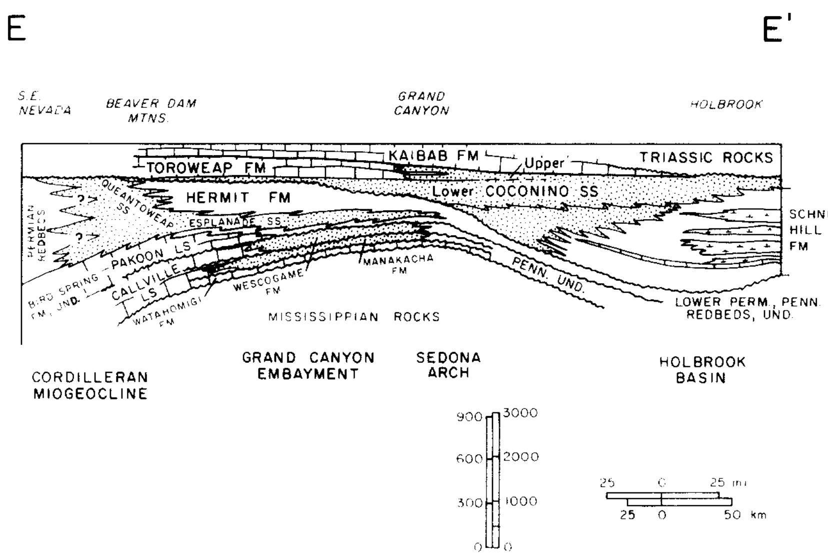


Fig. 7. Restored cross-sections of Pennsylvanian and Permian eolian deposits. Locations shown on Fig. 5.

The Pennsylvanian eolian deposits of the central and southern Colorado Plateau (Fig. 7D and E) are less well known. Loope (1984) described the sedimentology of a 150 m-thick eolian sequence in the Honaker Trail Formation from a relatively small area so regional isopachs cannot be constructed. The eolian deposits are complexly intercalated with marine carbonate. Whether these represent isolated dune deposits or tongues of a larger yet undescribed erg is unknown.





The eolian deposits in the Manakacha and Wescogame Formations of the Supai Group in the Grand Canyon and Mogollon Rim are not described in the literature. Blakey (unpublished data) has studied eolian deposits in the Mogollon Rim and observed eolian strata in the Grand Canyon as has Peterson (unpublished data). One coset of probable eolian strata in the Manakacha Formation was estimated to be 20 m thick. R. Hunter (pers. commun., 1985) reported to Blakey the presence of eolian strata in the Supai Group of Grand Canyon. The two formations each range from 30 to 70 m thick where eolian strata are suspected and may be about half eolian in origin. Interestingly, McKee (1982) made no mention of eolian deposits in the Supai Group, yet some of

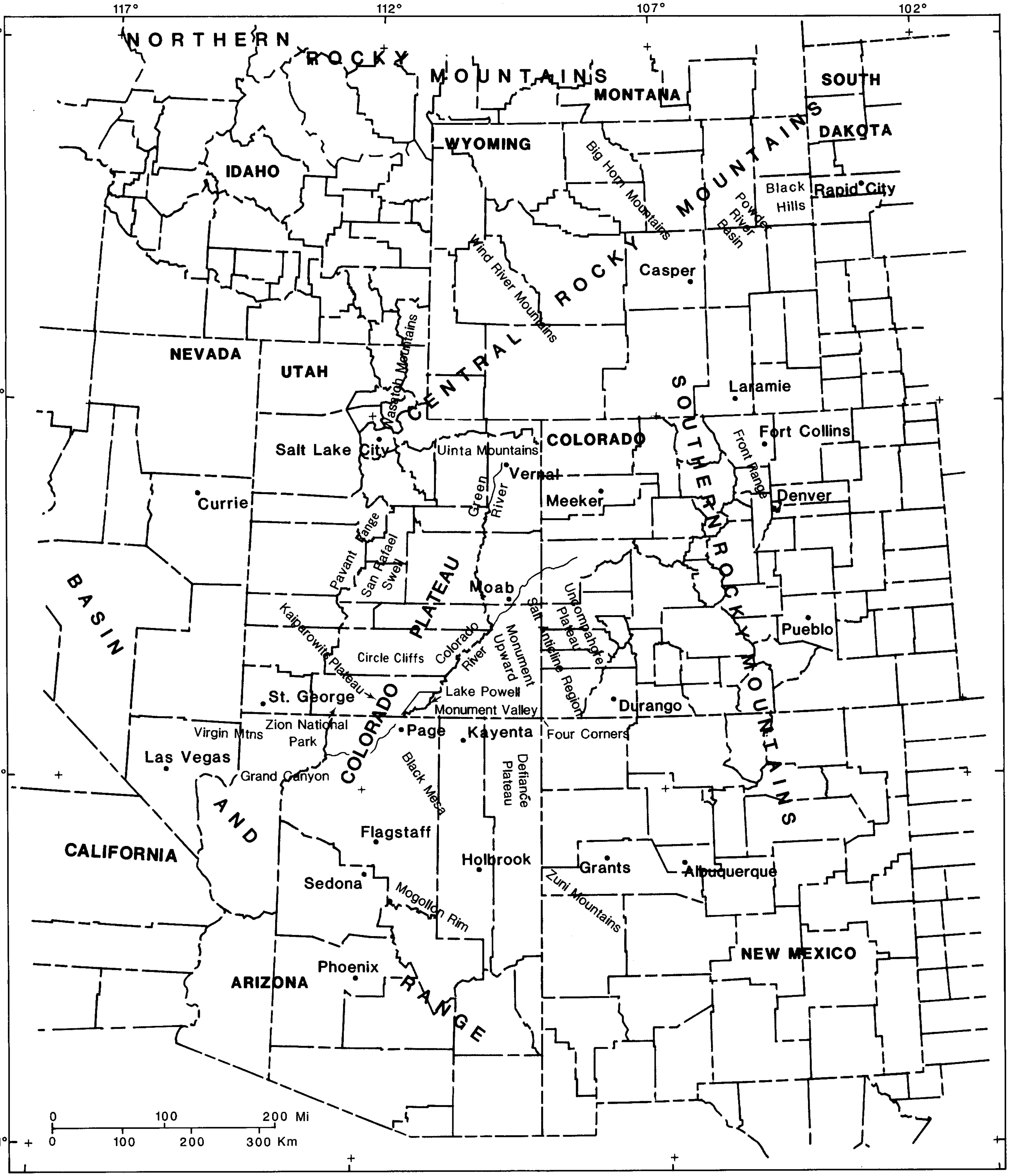


Fig. 1. Index map of Western Interior of United States showing geographic locations mentioned in text.

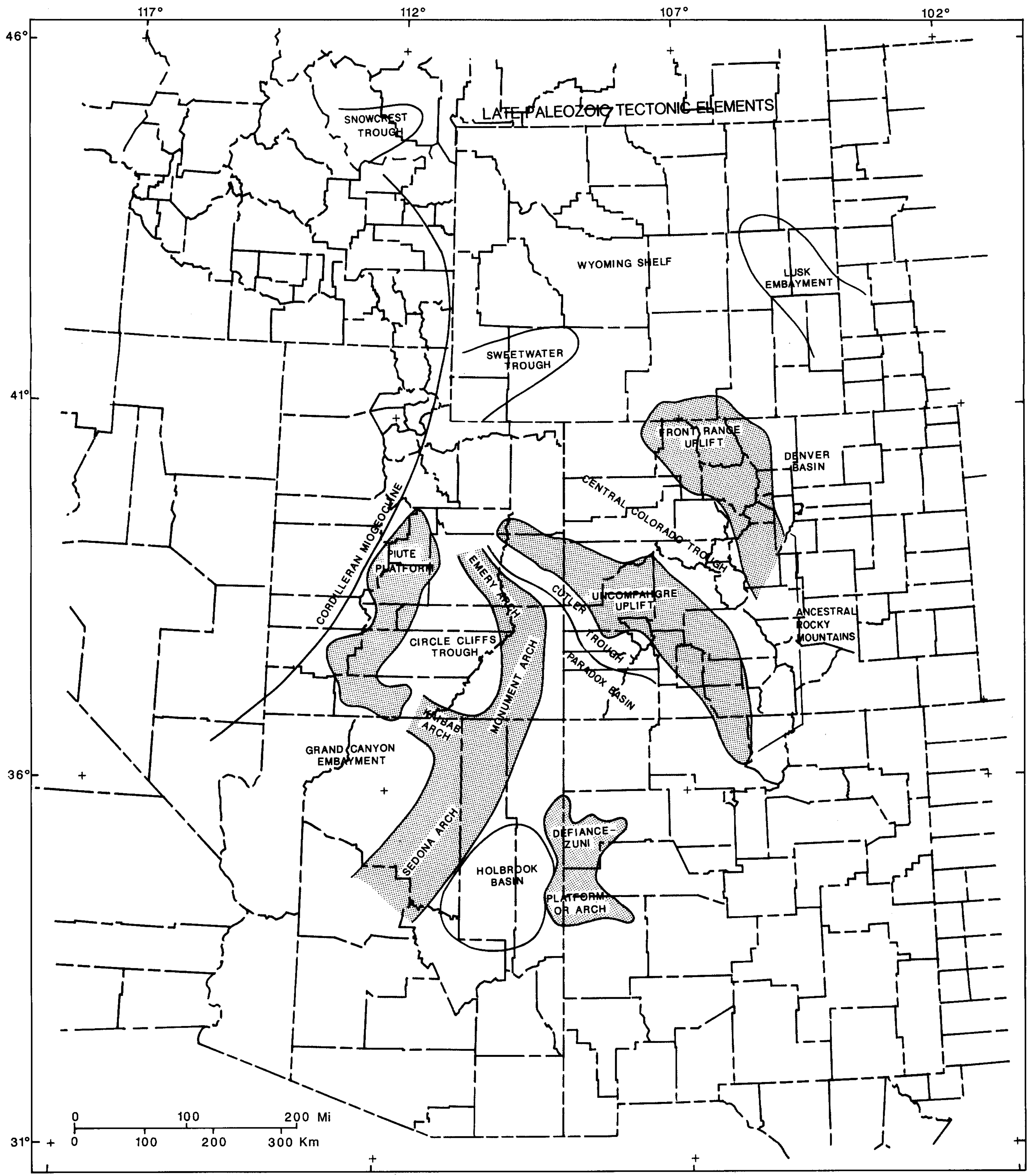


Fig. 4. Generalized late Paleozoic tectonic elements that influenced sedimentation in Pennsylvanian and Permian eolian-bearing rocks of the Western Interior. Boundaries are approximate and varied through time.

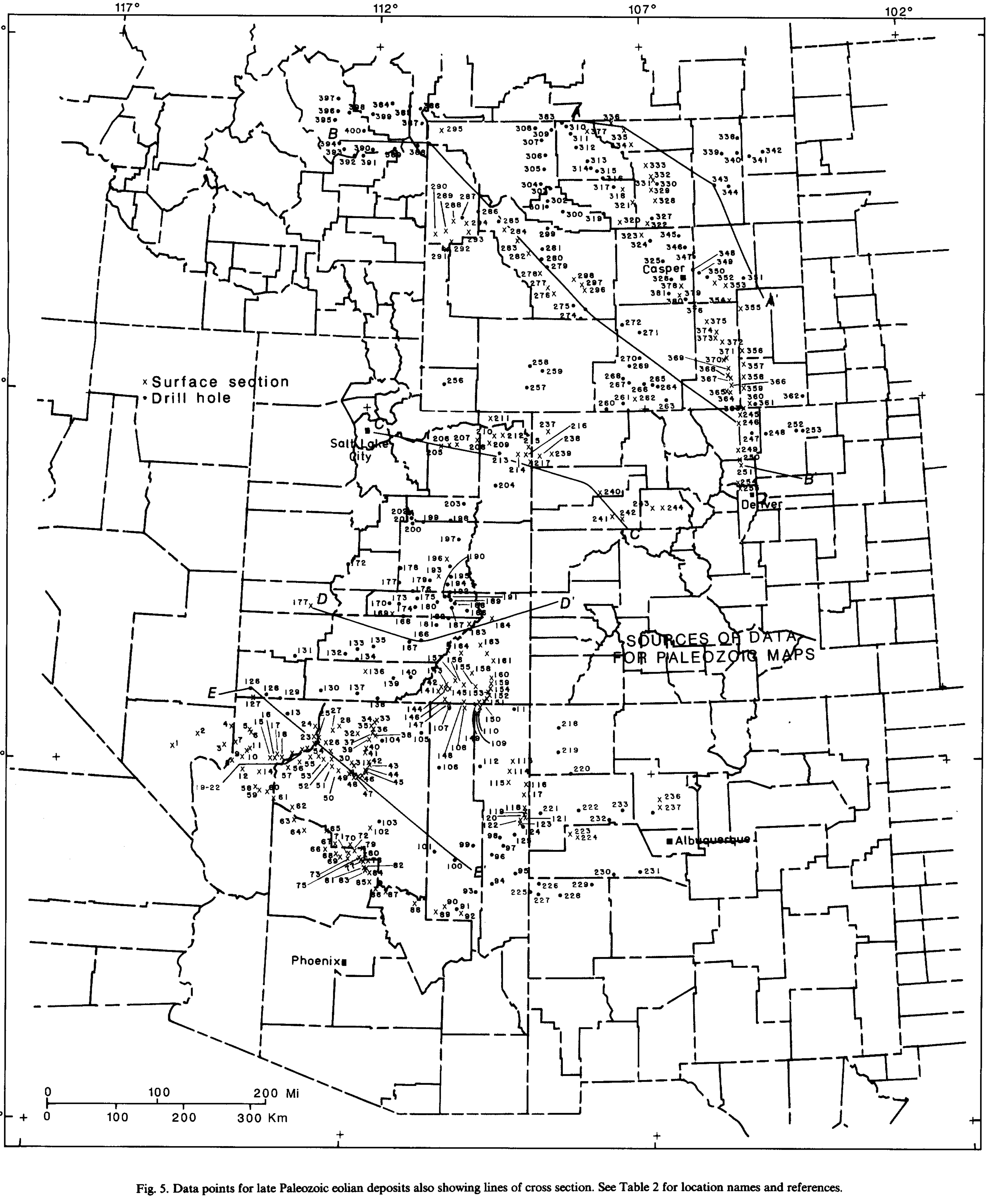
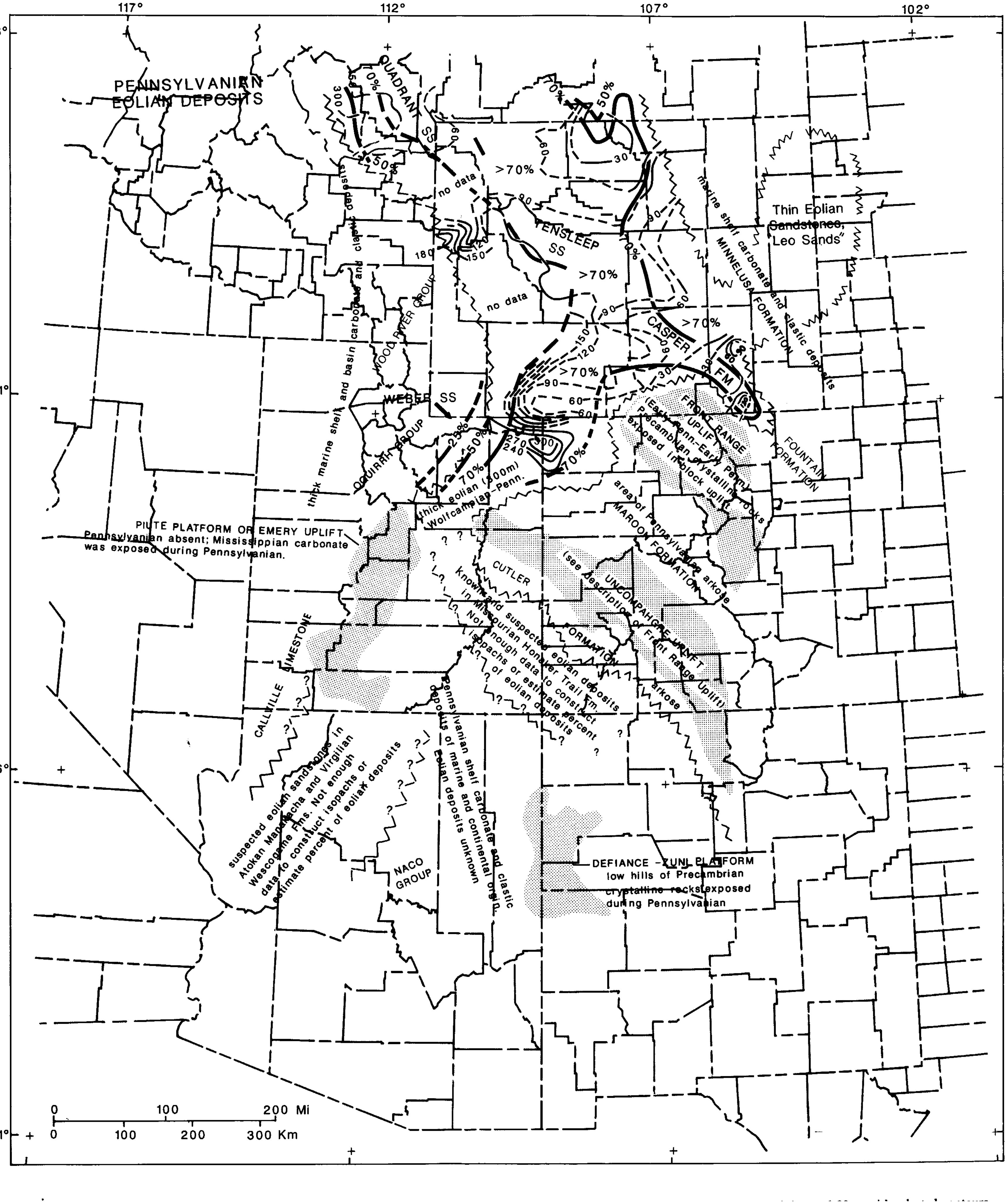
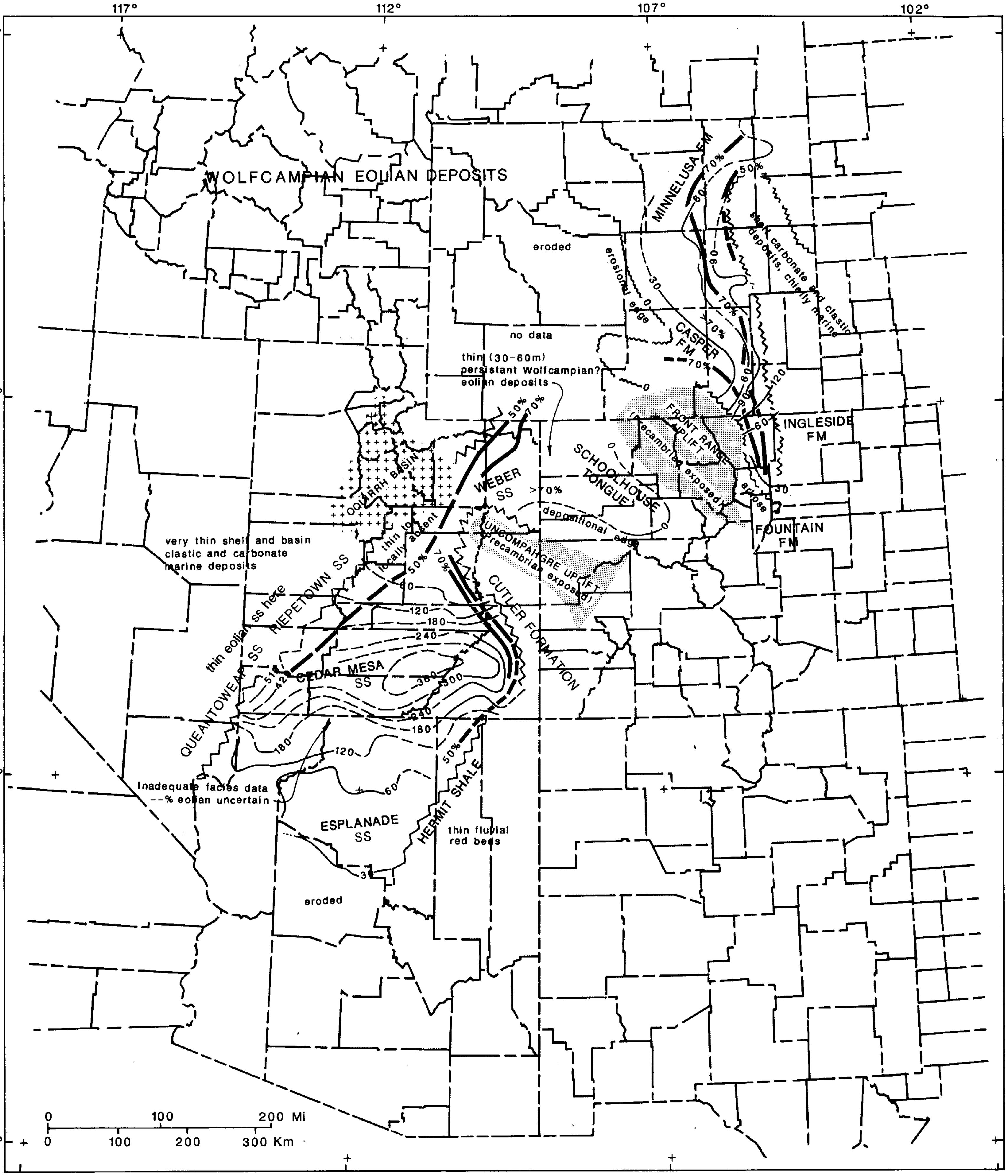


Fig. 5. Data points for late Paleozoic eolian deposits also showing lines of cross section. See Table 2 for location names and references.



PENNSYLVANIAN EOLIAN DEPOSITS
117°
112°
107°
102°
46°
41°
36°
31°
QUADRANT SS
TENSLEEP SS
CASPER FM
WEBER SS
WOOD RIVER GROUP
OQUIRRH GROUP
>70%
no data
thick marine shelf and basin carbonate and clastic deposits
marine shelf carbonate and clastic deposits
MINNELUSA FORMATION
Thin Eolian Sandstones, "Leo Sands"
FRONT RANGE UPLIFT
(Early Penn.-Early Perm.) Precambrian crystalline rocks exposed in block uplift
FOUNTAIN FORMATION
area of Pennsylvanian arkose
MAROON FORMATION
thick eolian (300m) Wolfcampian-Penn.
PIUTE PLATFORM OR EMERY UPLIFT
Pennsylvanian absent; Mississippian carbonate was exposed during Pennsylvanian.
CUTLER FORMATION
Known and suspected eolian deposits in Missourian Honaker Trail Fm. Not enough data to construct isopachs or estimate percent of eolian deposits
UNCOMPAHGRE UPLIFT (see description of Front Range Uplift)
arkose
CALLVILLE LIMESTONE
suspected eolian sandstones in Atokan Manakacha and Virgilian Wescogame Fms. Not enough data to construct isopachs or estimate percent of eolian deposits
NACO GROUP
Pennsylvanian shelf carbonate and clastic deposits of marine and continental origin. Eolian deposits unknown
DEFIANCE - ZUNI PLATFORM
low hills of Precambrian crystalline rocks exposed during Pennsylvanian
0 100 200 Mi
0 100 200 300 Km



117°
112°
107°
102°
46°
41°
36°
31°
WOLFCAMPIAN EOLIAN DEPOSITS
eroded
no data
thin (30-60m) persistant Wolfcampian? eolian deposits
MINNELUSA FM
erosional edge
CASPER FM
shelf carbonate and clastic deposits, chiefly marine
INGLESIDE FM
FRONT RANGE UPLIFT (Precambrian exposed)
arkose
FOUNTAIN FM
SCHOOLHOUSE TONGUE
depositional edge
OQUIRRH BASIN
WEBER SS
>70%
UNCOMPAHGRE UPLIFT (Precambrian exposed)
thin to locally absent
very thin shelf and basin clastic and carbonate marine deposits
PIEPETOWN SS
thin eolian ss here
QUEANTOWEAP SS
CEDAR MESA SS
CUTLER FORMATION
HERMIT SHALE
Inadequate facies data --% eolian uncertain
ESPLANADE SS
thin fluvial red beds
eroded
0 100 200 Mi
0 100 200 300 Km

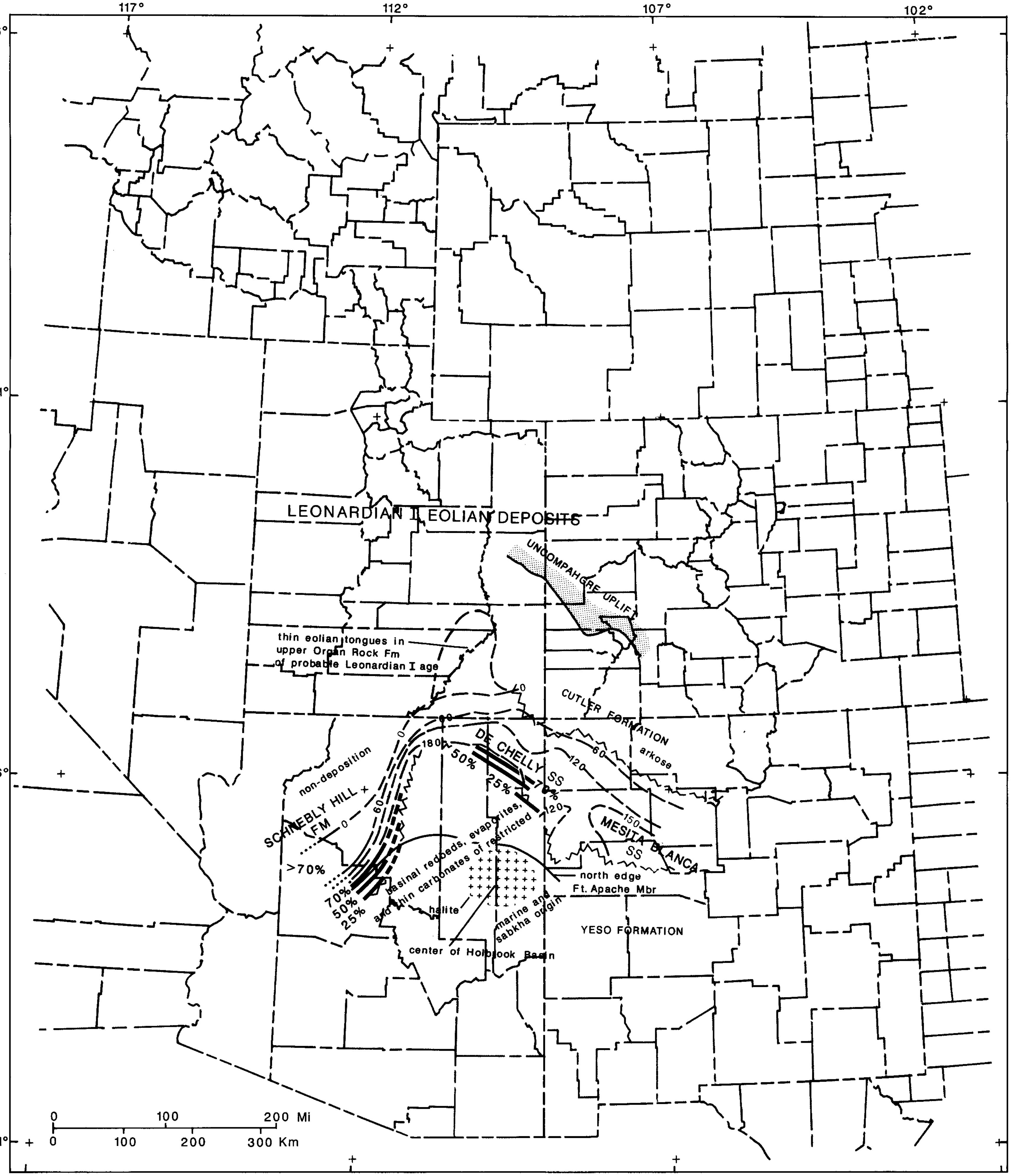


Fig. 9. Geometry and facies relations of Leonardian I eolian deposits. Heavy lines show approximate percentage of eolian sandstone. Isopach interval 30 and 60 m. Solid lines where outcrops occur; dashed lines where interval in subsurface or removed by erosion.

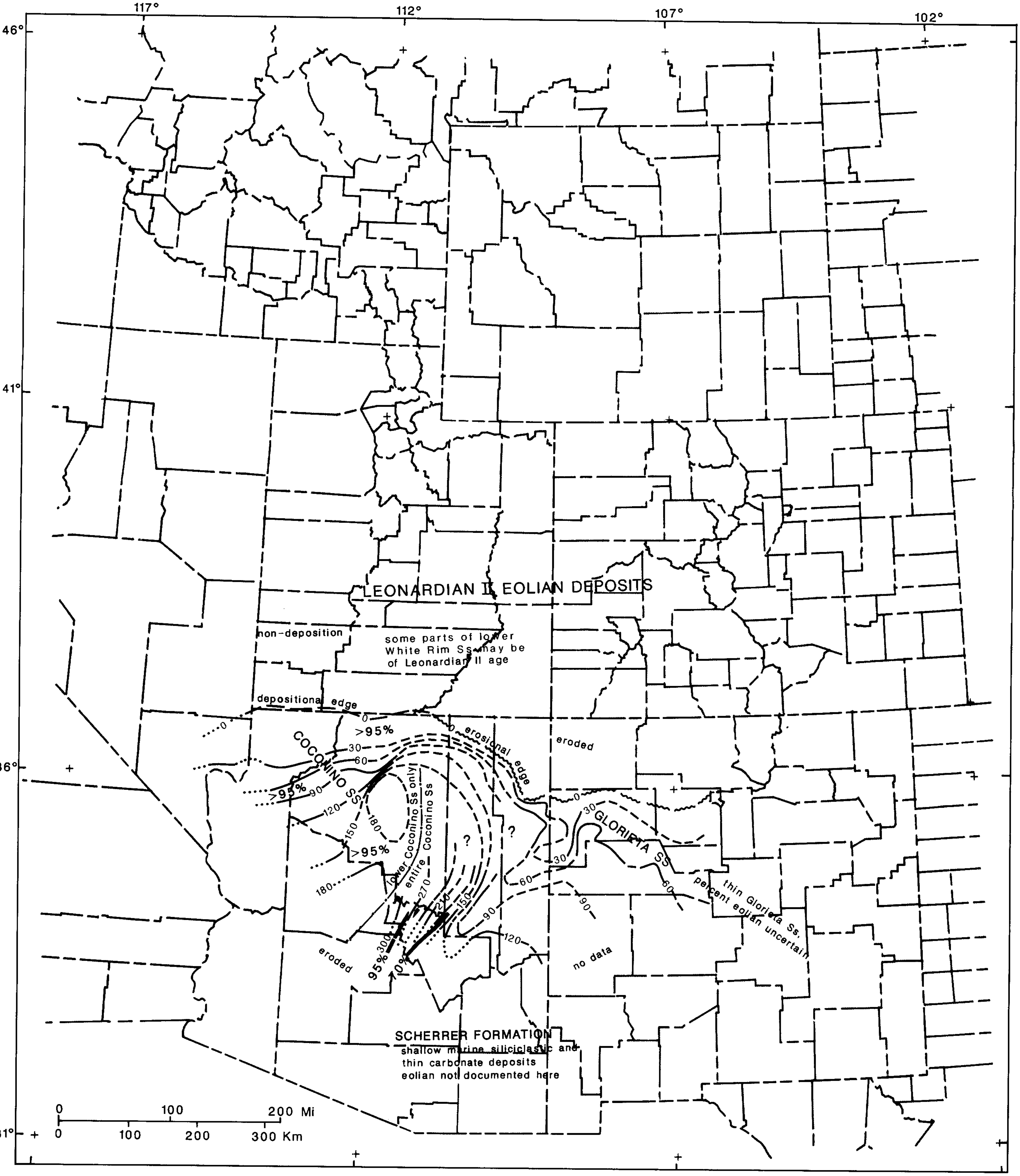


Fig. 10. Geometry and facies relations of Leonardian II eolian deposits. Heavy lines show approximate percentage of eolian sandstone. Isopach interval 30 m. Solid lines where outcrops occur; dashed lines where interval in subsurface or removed by erosion.

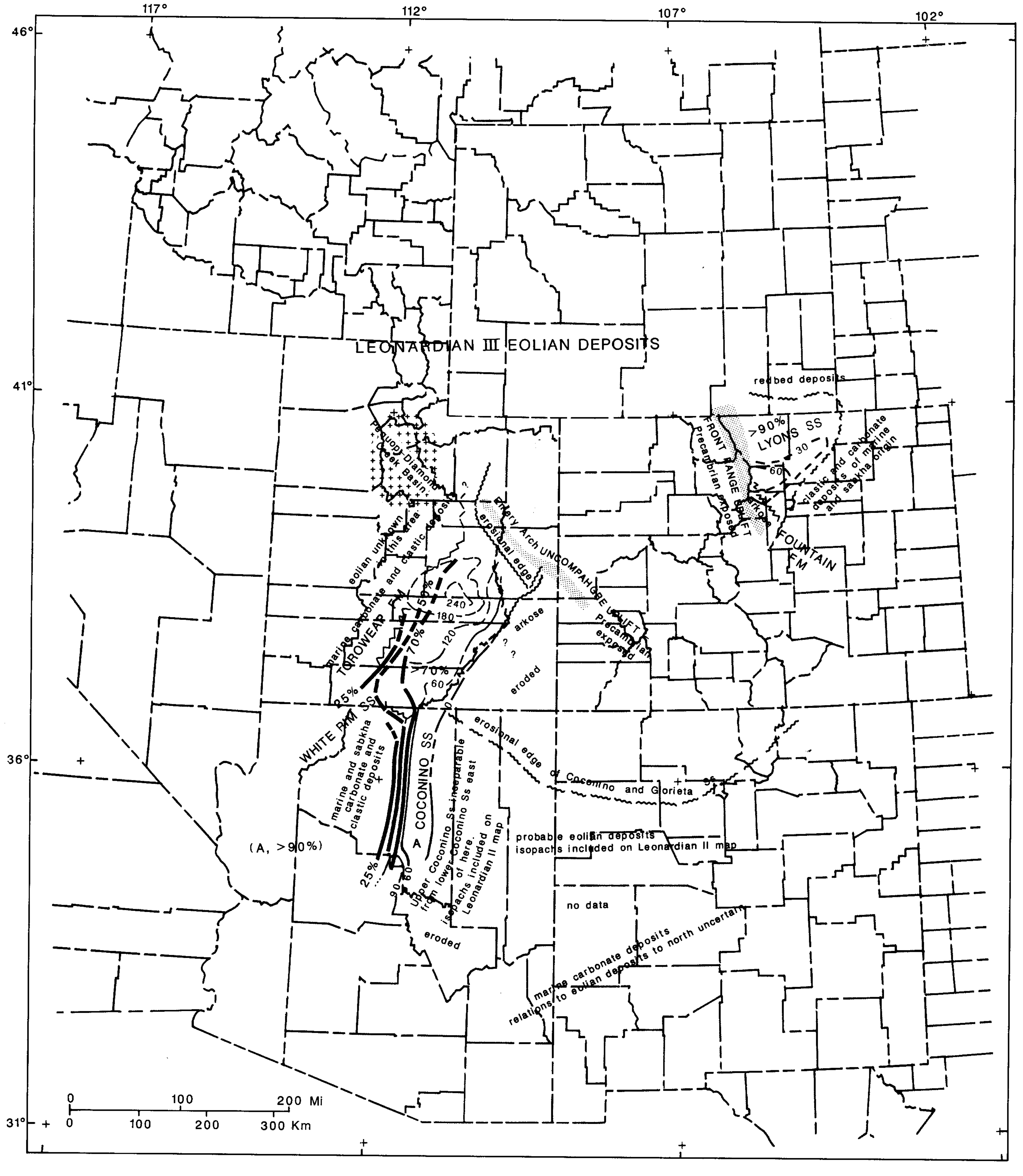


Fig. 11. Geometry and facies relations of Leonardian III eolian deposits. Heavy lines show approximate percentage of eolian sandstone. Correlations from Colorado Plateau to north-central Colorado based on regional relations that are subject to verification. Isopach interval 30 and 60 m. Solid lines where outcrops occur; dashed lines where interval in subsurface or removed by erosion.

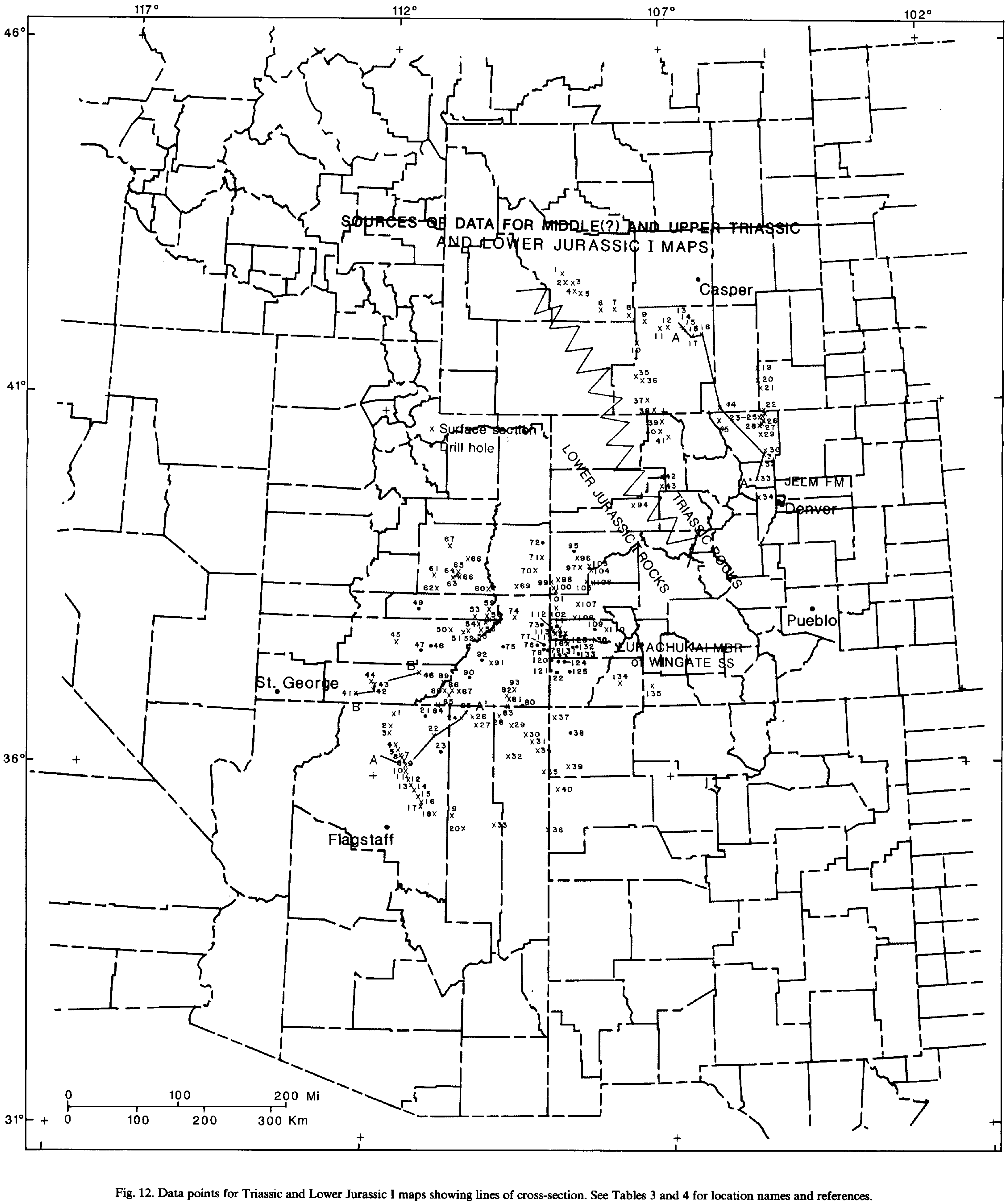


Fig. 12. Data points for Triassic and Lower Jurassic I maps showing lines of cross-section. See Tables 3 and 4 for location names and references.

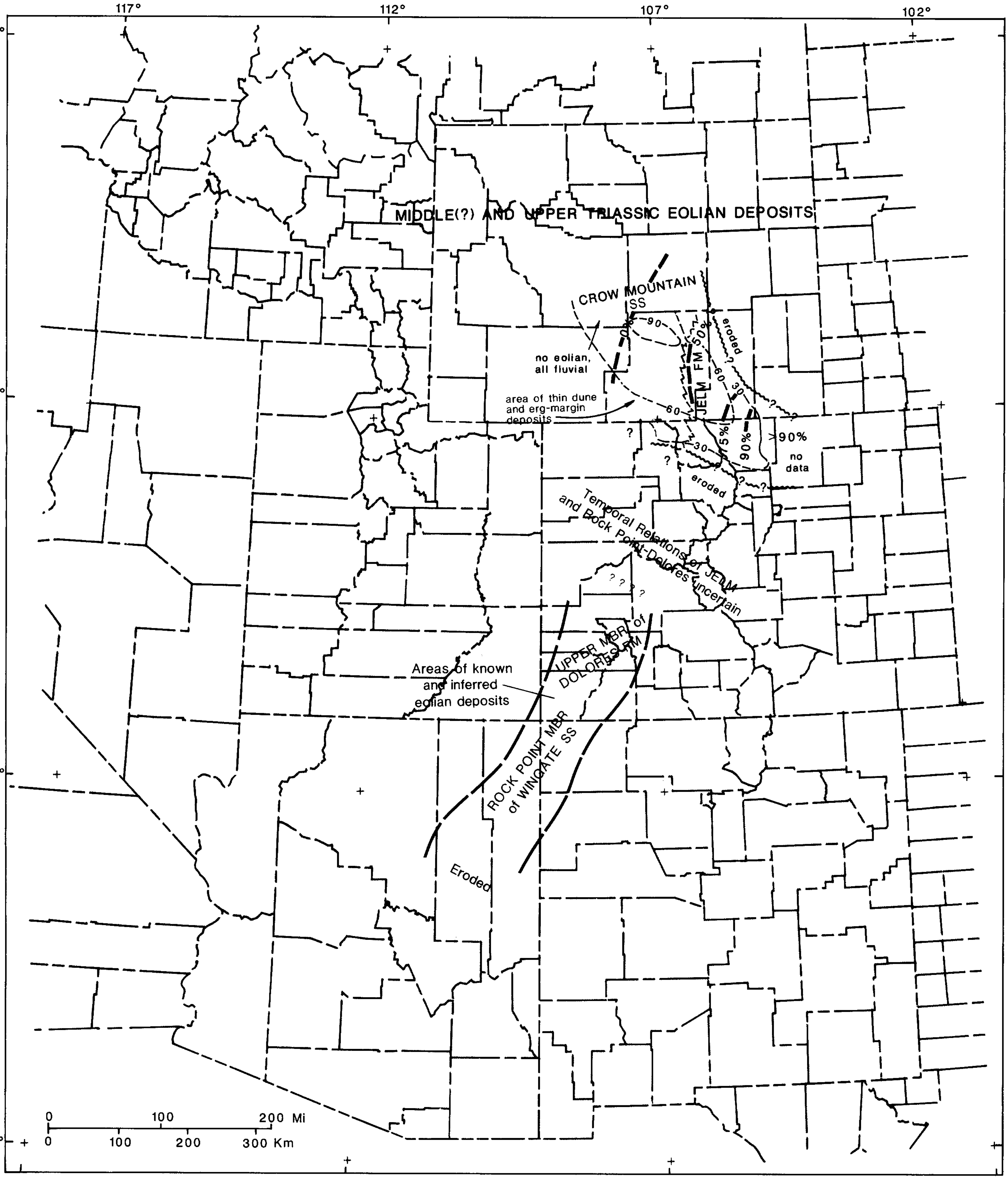


Fig. 13. Geometry and facies relations of Upper Triassic eolian deposits. Heavy lines show approximate percentage of eolian sandstone. Data is inadequate for isopaching eolian interval on Colorado Plateau. Isopach interval 30 m. Solid lines where outcrops occur; dashed lines where interval in subsurface or removed by erosion.

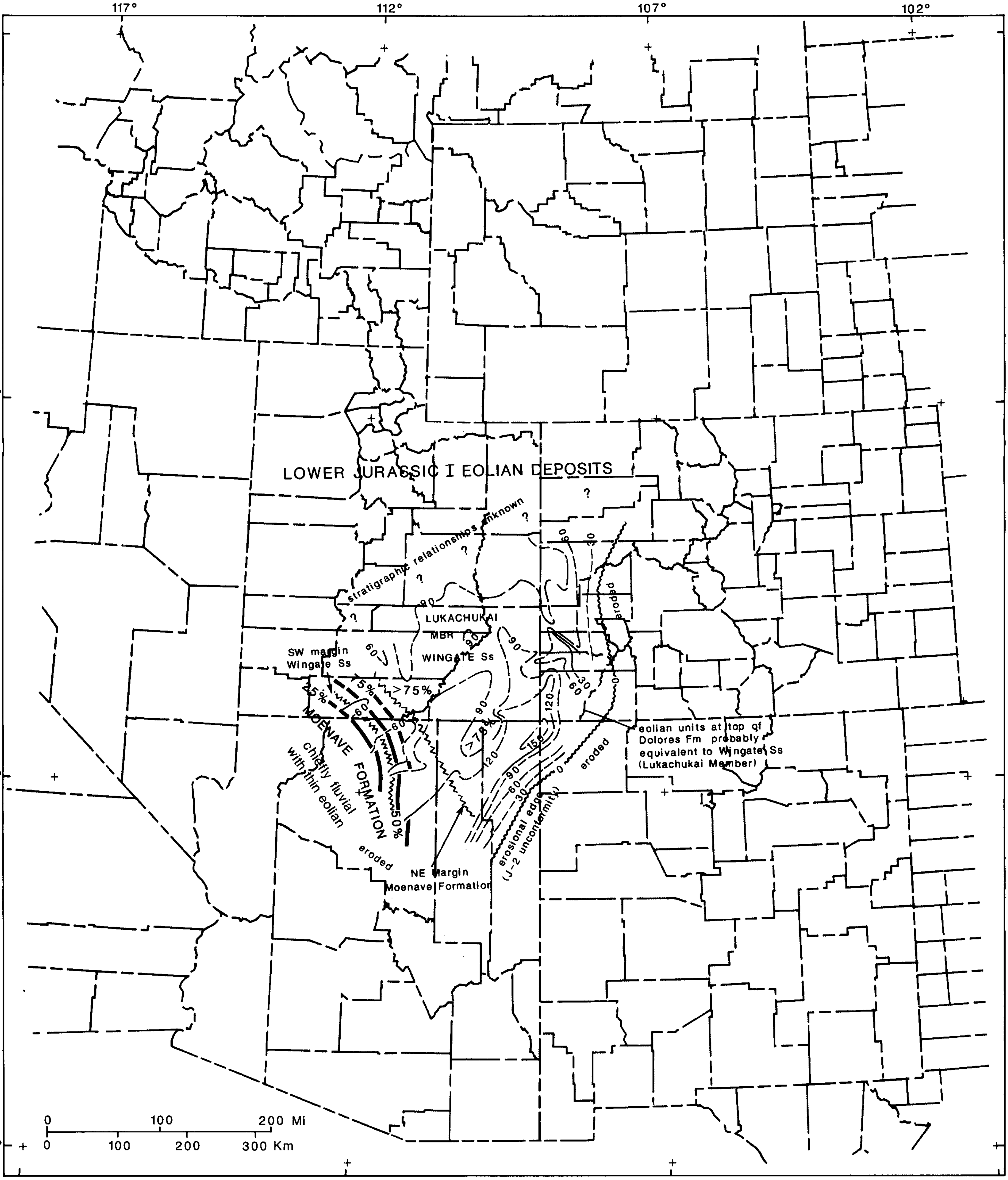


Fig. 15. Geometry and facies relations of Lower Jurassic I eolian deposits. Heavy lines show approximate percentage of eolian sandstone. Isopach interval 30 m. Solid lines where outcrops occur; dashed lines where interval in subsurface or removed by erosion.

his figures show suspiciously eolian-looking features. Present data does not allow accurate isopaching of these eolian deposits but known stratigraphic information suggests extremely complex relations between eolian sandstone bodies and intercalated marine carbonates and redbeds of uncertain origin.

The Tensleep Sandstone and related units covered the Wyoming shelf, which was bordered to the east by a broad carbonate epicontinental sea and to the west by marine basins of the Cordilleran miogeocline (Fig. 4). The sand moved southward from an uncertain source (see Johansen, this volume) and abutted the edge of the Ancestral Rockies, which shed coarse arkosic debris into the southern edge of the ergs. Repeated transgressions and repressions of the Pennsylvanian sea and episodic uplift of the Ancestral Rockies caused the complex interfingering of eolian and non-eolian deposits at the erg margins. Some of the sand spilled southwestward along the west edge of the Uncompahgre uplift and formed dune fields or small ergs along the edge of the Pardox basin. Some sand drifted southward across the Piute platform of southern Utah into the Grand Canyon embayment and accumulated as a series of eolian deposits between marine strata (Fig. 7). Eolian deposits in the Atokan Manakacha Formation would be as old as or older than the eolian deposits in the Tensleep Sandstone to the north, the presumed direction of source.

Wolfcampian eolian deposits

Wolfcampian strata of the Western Interior contain vast erg deposits that stretch from the Mogollon Rim on the south to the Black Hills to the north-east. Eolian deposits have been documented in the Esplanade Sandstone (Blakey, unpublished data), Queantoweap Sandstone (Johansen, 1981), Cedar Mesa Sandstone and Elephant Canyon Formation (Loope, 1984), upper Weber Sandstone (Bissell and Childs, 1958), upper Casper Formation (Steidtmann, 1974), and upper Minnelusa Formation (Fryberger, 1984). These units likely once formed a single continuous sandstone body, which probably formed by the amalgamation of numerous ergs and dune fields. Each of the stratigraphic units is known to intertongue with fossiliferous Wolfcampian marine rocks (Fig. 7), though the youngest age of some of the eolian deposits is in doubt. For convenience, eolian deposits will be lumped into the Casper complex in Wyoming and north-central Colorado, the upper Weber Sandstone in the Uinta Mountains area, and the Cedar Mesa complex on the Colorado Plateau. Figure 8 is an isopach and facies map of the eolian-bearing interval of Wolfcampian age.

The Casper complex is a horseshoe-shaped sandstone body that wraps around the Lusk embayment and abuts the Ancestral Front Range to the south. Comprising parts of the upper Minnelusa Formation, upper Casper Formation, and Ingleside Formation (Fig. 7A and B), the erg thins from 100 m in thickness along the north-northwest-trending Lusk embayment to an irregular-trending erosional edge across central Wyoming. Steidtmann (1974) has described the eolian characteristics and the relations with thin marine carbonates in the southern portion of the erg deposits; Fryberger (1984) has documented transgressive–regressive events and eolian, sabkha and marine relations for the northern portion of the area. Agatston (1954) provided the stratigraphic framework that documents the facies change to Wolfcampian marine carbonates and clastics (upper Minnelusa Formation and related rocks) along the western margin of the Lusk embayment. To the south, the Casper and Ingleside grade into coarse clastics of the upper Fountain Formation (Hoyt, 1963). The relations of the Casper with coeval Wolfcampian eolian deposits to the southwest is uncertain due to lack of data in southwest Wyoming. Most likely before post-Wolfcampian erosion removed the erg deposits across western Wyoming, a continuous eolian sheet spread across the Uinta Mountains area into central Utah.

The upper Weber Sandstone (Fig. 7C) is preserved along the flanks of the Uinta Mountains and eastward into northern Colorado (Fig. 8). Bissell and Childs (1958) have documented the eolian origin and stratigraphic framework of the unit. They have delineated a northeast-trending facies change through the central Uinta Mountains to marine siliciclastics to the west and traced a thin eolian tongue (Schoolhouse Tongue) southeast into the Central Colorado trough. The eolian tongue grades into and is enclosed by arkose of the upper Maroon Formation. Sparse subsurface data (Irwin, 1976) suggests that to the south of the Uinta Mountains the upper Weber Sandstone grades into the arkose along the flank of the Ancestral Uncompahgre Range and eolian sand spilled southwest around the uplift into the Cedar Mesa erg.

The Cedar Mesa complex, which includes parts of the Queantoweap Sandstone to the west and Esplanade Sandstone to the south, is a broad sheet that thickens to over 400 m thick in south-central and southwestern Utah (Fig. 7D and E). Stratigraphic and sedimentologic framework for this complex body has been provided by Blakey (1980), Johansen (1981), McKee (1982) and Loope (1984), although it should be pointed out that McKee did not recognize eolian deposits in the Esplanade Sandstone. The present configuration of the eolian-bearing sandstone describes a parabolic trough whose axis trends N60°E across southern Utah and thins rapidly on the northeast and southeast flanks. The erg deposits also undergo major facies changes along all of their margins. To the northeast and east the Cedar Mesa grades abruptly into the Cutler Formation (Baars, 1962: Campbell, 1979; Mack, 1979); southward along the Sedona arch the Esplanade Sandstone grades eastward into continental redbeds of the Hermit and Organ Rock Formations (Blakey, 1979, 1980); westward along the Cordilleran hingeline eolian deposits grade rapidly into Wolfcampian marine carbonate of the Pakoon and Elephant Canyon Formations (Baars, 1962; Irwin, 1976; McKee, 1982). Near the junction of the Green and Colorado rivers, the Elephant Canyon also contains eolian strata. The Cedar Mesa Sandstone thins across the Emery arch in central Utah to less than 30 m (Irwin, 1976) and should not be confused (Fig. 7D) with thick younger eolian sandstone of the overlying White Rim Sandstone (D. Baars, pers. commun., 1985). The Cedar Mesa Sandstone probably connects directly with the upper Weber Sandstone across and to the north of the Emery arch.

The Wolfcampian ergs were probably once continuous and are now separated geographically and structurally into three bodies (Fig. 8). Wolfcampian eolian deposits are confined to a trend defined by parallel northeast-trending lines, the western one running from southwest Utah to north-central Wyoming and the eastern one running from central Arizona to northeast Wyoming. The Casper Sandstone formed as a coastal and inland sand sea adjacent to marine deposits of the Lusk embayment and north of the Ancestral Rockies. Episodic changes in sea level caused the interdigitation of marine and eolian deposits across much of east-central Wyoming (Steidtmann, 1974; Fryberger, 1984). In the Laramie–Fort Collins area, narrow facies belts and abrupt facies changes reflect the complex interactions between uplift to the southwest, coastal dunes, and marine transgressive–regressive events to the east (Steidtmann, 1974).

The eolian deposits of the upper Weber Sandstone were sandwiched between the Ancestral Uncompahgre and Front Ranges and the Oquirrh Basin and Cordilleran miogeocline. As such, it was a triangular deposit that responded to uplift to the east and sea level changes to the west.

The Cedar Mesa Sandstone accumulated during a time of rapid subsidence accompanied by numerous sea-level changes and uplift in the Ancestral Uncompahgre Range. The southern Cordilleran miogeocline and Circle Cliffs trough were strongly negative but the influx of eolian sand was strong enough to keep the sea to the west much of the time. The rather straight margins of this complex unit suggest long-ranging tectonic controls on the erg margins (see Blakey, this volume).

Leonardian I eolian deposits

Ergs deposited during the lower Leonardian are restricted to the southern Colorado Plateau and are represented by major unconformity to the north (Figs. 2 and 7). The eolian sedimentology is provided by Blakey and Middleton (1983) and Vonderharr (1986) and the stratigraphic framework by Blakey (1979, 1980), and Blakey and Knepp (in press). The eolian deposit comprises parts of the Schnebly Hill and Yeso Formations and De Chelly Sandstone. It forms a broad horseshoe-shaped eolian body that wraps around the northern edge of the Holbrook Basin in eastern Arizona and related negative areas of western New Mexico (Fig. 9). Sandstones thicken towards the basin from a probable depositional edge along the Sedona Arch (Fig. 4) and a zone of facies change to Cutler Formation in the Four corners region and rapidly changes facies to marine and sabkha carbonate and redbed deposits in basinal areas. The erg deposits are thickset, about 180 m thick, near the sharp facies change toward the basin. The rocks are firmly dated by the interbedded Fort Apache Member of the Schnebly Hill Formation (Blakey and Knepp, in press) although exact temporal correlations within this complex body, especially with the Mesita Blanca Sandstone Member of the Yeso Formation in New Mexico are yet to be solved. It is suggested here that the oldest eolian deposits in this sequence are contained in the Mesita Blanca Sandstone of New Mexico and lower Schnebly Hill Formation of the western Mogollon Rim, and that the youngest eolian deposits are in the upper part of the De Chelly Sandstone in northeast Arizona and upper Schnebly Hill formation in the Mogollon Rim. We also suggest, based on physical stratigraphy and cursory sedimentologic observations, that a thin eolian tongue near the top of the Organ Rock Formation in the upper Lake Powell region of southeastern Utah may be a northward extension of the De Chelly Sandstone.

The De Chelly and related formations were deposited during a period of erosion to the north and abrupt subsidence along the southern Colorado Plateau. It appears that the period of erosion to the north saw the mobilization of large amounts of sand from older Pennsylvanian and Permian ergs and that the sand was fed southward until it crossed the Sedona Arch and encountered rapid subsidence along the Holbrook basin. Here the sand was trapped between a broad slightly positive region to the north and marine and sabkha conditions in the negative area to the south (Blakey and Middleton, 1983). During periods of low sea level and/or extensive influx of sand from the north, the erg prograded southward across the coastal plain. Rises in sea level caused transgression and destruction of the ergs, which resulted in an unconformity overlain by sabkha and marine redbeds and carbonate.

Leonardian II eolian deposits

The middle Leonardian eolian complex is likewise restricted to the southern Colorado Plateau and includes the bulk of the Coconino Sandstone and coeval Glorieta Sandstone (Fig. 10). The Coconino has long been considered eolian (McKee, 1933) but details concerning eolian sedimentology remain largely unpublished. The Coconino perhaps most closely approaches the stereotype of the layer-cake, monotonous quartzarenite eolian deposit. The unit displays less intertonguing and facies changes than most other late Paleozoic erg deposits and, in many places, is chiefly large-scale, cross-stratified sandstone; however, as will be discussed, there are exceptions to the above. The age of the Coconino and Glorieta is based on stratigraphic position; it overlies and intertongues with the De Chelly Sandstone of Yeso age and underlies the upper Coconino and White Rim Sandstones which intertongue with the marine Toroweap Formation. The above stratigraphic relations are best exposed along the west side of the Sedona Arch and are thoroughly documented by Rawson and Turner-Peterson (1980).

The Coconino thickens from a feather edge along the Utah–Arizona border to nearly 300 m in the central Mogollon Rim (Figs. 7E and 10). East of the Sedona Arch, the lower and upper Coconino are inseparable and isopachs are combined. The north feather edge is probably depositional; it was modified by post-Coconino erosion especially in northeastern Arizona across the Defiance Plateau. The erg-bearing sequence is exposed across much of central and northern New Mexico in the Glorieta Sandstone but south and east of the Colorado Plateau little sedimentological data is available and it is uncertain how much of the formation is eolian.

In the central and eastern Mogollon Rim, the typical Coconino grades into alternating small- to medium-scale cross-stratified sandstone and intercalated wavy bedded to horizontally stratified sandstone. Though this eastern facies has been considered to be of marine origin by some workers, Blakey (1986) documented the presence of small eolian dunes and sabkha and/or wet interdune deposits for this facies.

The Coconino Sandstone formed downwind from eroding eolian and marine rocks to the north. Reworked eolian sand moved southward across the featureless terrain of central and northern Utah until it encountered an area of subsidence associated with the last stages of the Holbrook Basin. Some areas in the Mogollon Rim were close enough to marine areas to the south to form interbedded sabkha and coastal dune deposits. However, most of the Coconino and at least some of the Glorieta were deposited in an inland erg far removed from direct marine influence as shown by a dominance of deposits formed by large dunes with few wet interdune deposits.

Leonardian III eolian deposits

The latest Leonardian ergs, possibly partially Guadalupian in age occur in widely separated areas of the Colorado Plateau and north-central Colorado. Correlation of these two eolian complexes is considered somewhat tentative but is based on relations with adjacent marine rocks and regional correlation as shown by Rascoe and Baars (1972). The White Rim Sandstone and upper Coconino Sandstone form the western erg deposits and the Lyons Sandstone forms the eastern one (Fig. 11). Eolian deposits have also recently been identified to the east in the Leonardian and Guadalupian of west Texas and adjacent New Mexico (Nance, this volume). At present it is uncertain as to how these deposits related to the major erg systems to the west. The Lyons Sandstone was carefully documented to be of eolian origin by Walker and Harms (1972). Stratigraphic relations were provided by Thompson (1959) and Hoyt (1963). The Lyons forms a parabolic-shaped deposit in which the trough of the parabola trends east-northeast (Fig. 11). The center of the unit is about 60 m thick. To the north the Lyons intertongues with marine carbonate and sabkha redbeds of the Owl Canyon and Satanka Formations (Figs. 2 and 7B). Eastward and southeastward it grades into marine carbonates and redbeds and southwestward it intertongues with the upper Fountain Formation. The west edge of the parabola is truncated by the present-day Front Range, though it seems probable that the Lyons once extended several tends of kilometers west across the edge of the Ancestral Front Range.

The White Rim and upper Coconino Sandstone complex is confined to the west of the Sedona and Monument Arches and extends from central Utah to the Mogollon Rim in Arizona. Sedimentologic data are provided by Baars and Seager (1970), Rawson and Turner-Peterson (1980), and Kamola and Chan (this volume). Stratigraphic data are provided by Irwin (1976) as well as the above authors. The eastern feather edge of the White Rim follows the present course of the Colorado River southward into Arizona; however, in Arizona the upper Coconino extends eastward to an area across the Sedona Arch where it can no longer be separated from the lower Coconino and is therefore included with it on Fig. 10. The White Rim Sandstone averages about 60 m in thickness across much of its extent but thickens to over 250 m in the Circle Cliffs trough (Figs. 7D and 10). Baars and Seager (1970) pointed out that the eastern margin is not a true feather edge but rather the unit thins to less than 10 m and grades eastward into redbeds of the Organ Rock Formation. In some areas this edge has been modified by pre-Triassic erosion. The White Rim and upper Coconino everywhere grade westward through a zone of complex facies change into marine carbonate and sabkha evaporite and sandstone of the Toroweap Formation (Fig. 7D and E). This change is well documented by Irwin (1976) and Rawson and Turner-Peterson (1980). The facies change follows the west edge of the Sedona Arch from the Mogollon Rim northward to near Page, Arizona and then swings northwestward along the Kaibab Arch; then it swings back to the northeast near and parallel to the west edge of the Colorado Plateau (Fig. 11). The White Rim Sandstone is truncated by erosion along the northwest-trending Emery Arch in central Utah (Rascoe and Baars, 1972; Irwin, 1976).

We have field-checked some of the reports of intertonguing of the White Rim and upper Coconino with the overlying Kaibab Formation. In areas that we have field checked, we have not been able to document such intertonguing; however, in many areas of north-central Arizona and south-central Utah, the Kaibab is very sandy and the White Rim, Toroweap, and Kaibab are very difficult to separate on outcrop, much less the subsurface. Although regional stratigraphic data may suggest that a White Rim-type sand body lay to the east of the Kaibab sea, such an occurrence has not yet been clearly documented.

The White Rim and upper Coconino Sandstones were deposited by a coastal sand sea that bordered the Toroweap sea. Intertonguing with the Toroweap was caused by changes in sea level coupled with changes in sand supply. The Sedona and Monument arches formed an eastern barrier to eolian deposition and preservation (see Blakey, this volume). The erg systems were apparently fed by eolian sand reworked from the north.

The Lyons was deposited between mountains, alluvial fans, and a coastal plain. The erg expanded and contracted in response to tectonism, sea-level change and sand supply. The sand may have been reworked from older ergs to the north or derived from coeval alluvial fan deposits.

Upper Triassic and Lower Jurassic eolian deposits

Introduction

The latest Permian and most of the Triassic lack recognized eolian deposits. Eolian deposition was renewed in the Late Triassic and culminated with major eolian sedimentation in the Early Jurassic (Fig. 2). We recognize three erg-bearing intervals: Jelm Formation, Wingate Sandstone and Navajo Sandstone and related units, which include the Nugget and Aztec Sandstones.

Upper Triassic eolian deposits

The Jelm Formation is exposed in south-central Wyoming and north-central Colorado. The eolian deposits occur in both members of the Jelm as recognized by Pipiringos (1972) and Pipiringos and O'Sullivan (1976). However, neither of the above papers considered the origin of the Jelm Formation. An eolian origin for part of the formation is based on unpublished information gathered by Peterson. Peterson's field work has confirmed an eolian origin for the large-scale, cross-stratified sandstone shown in columns published by Pipiringos (1972) and Pipiringos and O'Sullivan (1976). Our maps show the thickness of the Jelm Formation based on the above sections and the distribution and percentage of eolian sandstone as inferred from the sections (Table 3) and Peterson's preliminary field work. Given the relatively sparse data, the maps and the following discussion must be considered preliminary.

Based primarily on regional stratigraphy, the Jelm Formation is assigned a Late Triassic age (Pipiringos and O'Sullivan, 1978). No comprehensive discussion of its origin or tectonic setting presently exists; however, the regional isopach and facies map (Figs. 12 and 13) provides some background for preliminary discussion. The erg deposits are apparently confined to the southeast portion of the Jelm Formation (Fig. 14) in south-central Wyoming. The area roughly coincides with that of Permian erg deposition (Fig. 8). A large fluvial plain lay to the west of Jelm erg sedimentation and possibly served as a partial source of the sand in the erg. As the south and east margins of the unit are truncated by the J-2 unconformity, no information is available concerning its original extent. Clearly this unit is in need of major regional study.

The Rock Point Member of the Wingate Sandstone contains eolian deposits throughout most of its extent. Although equivalent to the upper part of the Chinle Formation, Harshbarger et al. (1957) included the Rock Point in the Wingate Sandstone because of supposed intertonguing between the Rock Point and Lukachukai Members. Later work has failed to confirm intertonguing and instead has suggested the presence of an unconformity, the J-0, between the two units (Pipiringos and O'Sullivan, 1978; Peterson and Pipiringos, 1979). Nevertheless, the Rock Point and Lukachukai are still officially considered members of the Wingate Sandstone, the former Upper Triassic and the latter, Lower Jurassic. Given that the Rock Point Member is thickest in the southern Four Corners region and that the Chinle Formation is beveled to successively older units to the west by the J-0 unconformity, it seems likely that the Rock Point

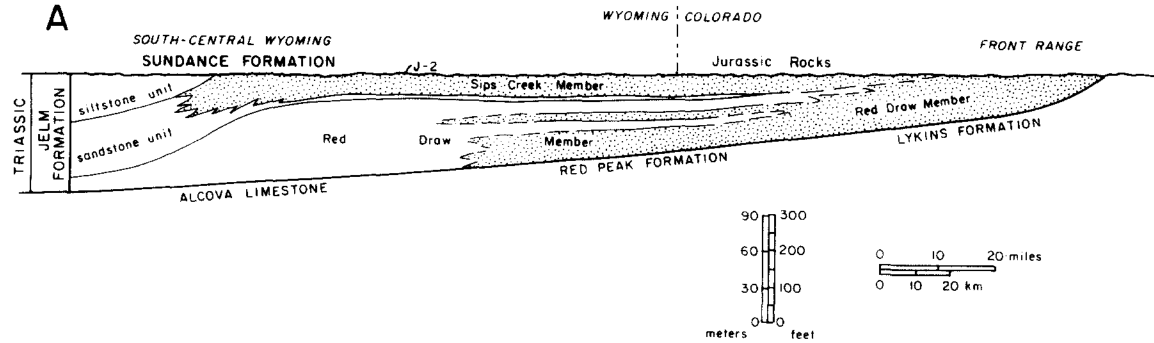


Fig. 14. Restored cross-section showing Upper Triassic eolian deposits in Jelm Formation. Location shown on Fig. 12.

Member represents the youngest Triassic deposits on the Colorado Plateau. It can perhaps be inferred that youngest Rock Point strata are nearly conformable with overlying Lukachukai units and that it is no coincidence that this is where some of the thickest Triassic eolian deposits occur.

The thickest Upper Triassic rocks of the Western Interior occur across the northern edge and along the east flank of the Defiance upwarp. Thus this long-ranging positive area was a basin during the Late Triassic. This area lies along the Zuni trend as defined by Blakey (this volume). It was in this low area that the only known Triassic eolian deposits on the Colorado Plateau were deposited. In southwestern Colorado, these rocks are assigned to the upper member of the Dolores Formation (Blodgett, 1984). Eolian deposits consist of cross-stratified sandstone of dune origin and laminated to hummocky sandstone of sand-sheet origin, both intercalated with fluvial and lacustrine deposits (Harshbarger et al., 1957; Stewart et al., 1972; Blodgett, 1984). We are unable to construct either isopach maps or percentage-of-eolian-strata maps from existing literature or unpublished information known to us. Figure 13 shows a rough outline of known and inferred eolian strata in Upper Triassic rocks of the Four Corners region. Temporal correlation with eolian strata of the Jelm Formation to the north is possible but unproven.

Lower Jurassic I erg deposits

The Lower Jurassic Wingate Sandstone forms a persistent vertical cliff throughout the canyonlands of southeastern Utah and adjacent Arizona and Colorado. Plagued by a series of miscorrelations, especially in northwestern New Mexico, the presently accepted eastern margin is shown on Fig. 15. Only the southwestern and eastern margins of eolian rocks, where the Wingate intertongues with the Dinosaur Canyon Member of the Moenave Formation (Fig. 16 and Table 4), are exposed and reasonably well understood. The nature of the formation to the west, northwest, and northeast is uncertain although we discuss our inferences later in this paper. As discussed above, the present terminology of the Wingate Sandstone is somewhat confusing. North, northwest and west of Kayenta, Arizona, the Wingate Sandstone unconformably overlies the Upper Triassic Chinle Formation and in this region the formation is undivided. East, southeast and south of Kayenta, the formation includes the lower Rock Point Member which is equivalent to the upper Chinle Formation (Harshbarger et al., 1957). In this region the upper part of the formation (the Wingate Sandstone, undivided to the north) is assigned to the Lukachukai Member. Our isopach and facies map (Fig. 15) concerns only the Wingate Sandstone (undivided) and Lukachukai Member of the Wingate Sandstone; the Rock Point Member of the Wingate Sandstone (Chinle equivalent) is not included. An eolian origin for most of the Wingate Sandstone has long been accepted; however, the details of eolian sedimentation have yet to appear in the literature. Tabular cosets 2–5 m thick comprised of trough sets filled with climbing wind-ripple lamination have been observed at several local-

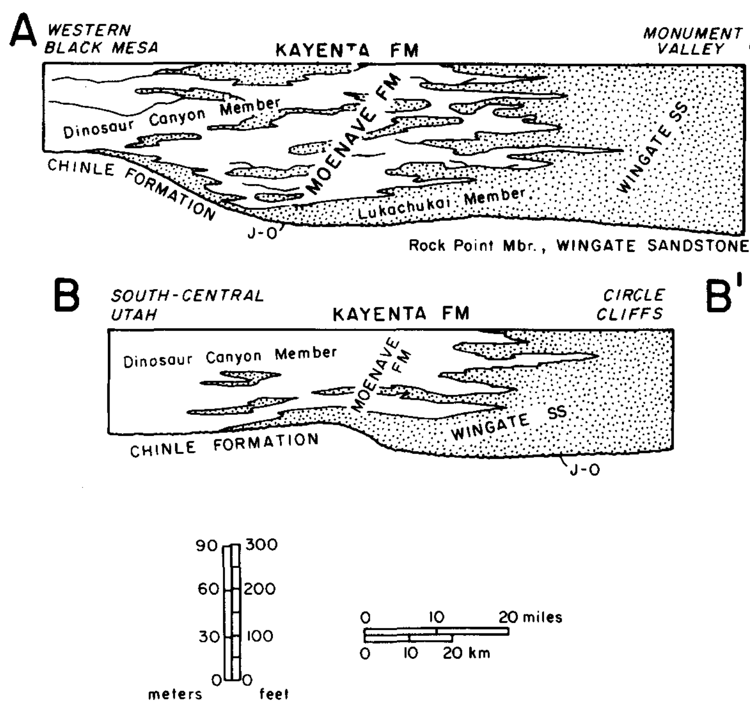


Fig. 16. Restored cross-sections showing Lower Jurassic I eolian deposits in Lukachukai Member of Wingate Sandstone and Dinosaur Canyon Member of Moenave Formation. Locations shown on Fig. 12.

ities across the Colorado Plateau. We have been able to confirm an eolian origin at a number of locations across the Colorado Plateau but are unable to present a detailed regional summary of eolian history. In northeastern Arizona the Wingate Sandstone (Lukachukai Member) contains persistent internal erosional surfaces probably correlative to fluvial events to the south. This would suggest several episodes of erg formation and destruction. To the north in Utah and Colorado no such surfaces have yet been identified. No studies document vertical changes in the Wingate nor present consistent information on the nature of the upper contact with the overlying fluvial Kayenta Formation.

The age of the Wingate Sandstone has long been in doubt but the most recent age assignment based on scarce paleontological data and regional stratigraphy suggests it is Early Jurassic (Sinemurian to Pliensbachian) (Pipiringos and O'Sullivan, 1978; Peterson and Pipiringos, 1979). The Wingate Sandstone unconformably overlies Upper Triassic rocks except where the formation is divided into two members. There the Triassic–Jurassic boundary lies between the Lukachukai and Rock Point Members; the erg deposits as included on Fig. 15 everywhere unconformably overlie Triassic rocks (see also Fig. 2).

The Wingate Sandstone forms a broad sandstone sheet that thickens and thins slightly across the southern, central and eastern Colorado Plateau. The unit is broadest in a southwest–northeast direction and in general, isopach trends parallel this. The erg deposits are thickest along a northeast-trending broad trough that lies adjacent to the southeastern erosional margin. The rapid thinning along this margin reflects the truncation of the erg beneath the J-2 unconformity (Pipiringos and O'Sullivan, 1978). We have no idea how far eastward the erg once extended. The erg deposits show local thinning and thickening in the Salt Anticline region of eastern Utah and western Colorado. Whether this is because of syn-depositional tectonic movement on the salt structures or post-depositional uplift and erosion is unknown. The Wingate displays local thick areas slightly east of and parallel to the present Colorado River and in the northwestern Circle Cliffs area. It thins across the southern Monument Uplift and across the northern Kaibab Uplift. Nothing is known about the erg to the west and north of its area of outcrop in southeastern Utah. We offer three untested hypotheses concerning its margins in these directions: (1) the eolian deposits thin to an erosional or depositional edge; (2) they merge with the Navajo Sandstone because of northwestward pinch-out of the intervening Kayenta Formation; and (3) the eolian sandstones undergo facies change with fluvial and sabkha redbeds as can be documented along its present southwestern margin; our discussion of the Navajo–Nugget Sandstone in the next section favors the third hypothesis.

The southwestern margin of the Wingate is exposed along a line of cliffs that trend from near Holbrook, Arizona to Zion National Park, Utah. Figure 16 shows restored cross-sections across the erg margin. Edwards (1985) documented fluvial–eolian interactions in north-central Arizona and work in progress by Lars Clemmensen and Henrik Olsen of the University of Copenhagen in conjunction with Blakey is studying the erg margin along the Vermilion Cliffs. These studies document an initial erg progradation southwest to a line from north-central Arizona to south-central Utah (Fig. 16). Fluvial deposits, chiefly of ephemeral sheet-flood and stream-flood origin, encroached upon and reworked the erg margin. The fluvial deposits, the Dinosaur Canyon Member of the Moenave Formation, extended as far northeastward as a line from the Defiance Plateau in Arizona to west of the Circle Cliffs in Utah (Figs. 15 and 16). Most stratigraphic work has placed the lower southwest extension of the erg in the Wingate Sandstone and the interval of alternating fluvial and eolian deposition in the Dinosaur Canyon Member of the Moenave Formation.

The Wingate Sandstone is in need of additional sedimentologic and stratigraphic study. Little is known about regional sedimentologic trends and history of erg development. The isopachs (Fig. 15) and cross sections (Fig. 16) show some relations to regional syn-depositional tectonic patterns (Blakey, this volume), especially the southern margin, which closely parallels the Zuni lineament of Kelley (1955). Apparently the northeast margin of northwesterly flowing streams in the Moenave Formation was somehow influenced by this line.

Lower Jurassic II eolian deposits

Eolian strata of late Early Jurassic age depicted on the data base and isopach maps (Figs. 17 and 18) probably formed the largest eolian deposits in North America. These rocks include such well-known units as the Aztec Sandstone (Nevada and southeastern California), the Glen Canyon Sandstone (northwestern Colorado and northeastern Utah), the Navajo Sandstone (northern Arizona, western Colorado, southern and central of Utah), and the upper member of the Nugget Sandstone (southeastern Idaho, northern Utah and Wyoming). Eolian strata in southern Arizona that are thought to correlate at least approximately with these units are included in several formations, each of which is restricted to one or a few of the mountain ranges in the Basin and Range Province. These includes the Ali Molina, Mount Wrightson, and Sil Nakya Formations, the Cobre Ridge Tuff, and the Ox Frame Volcanics (Bilodeau and Keith, 1986). Data used in preparation of the isopach map are included in Table 5 and the distribution of data points is shown on Fig. 17. These beds are here considered late Early Jurassic in age (Pliensbachian and Toarcian Ages; Peterson and Pipiringos, 1979).

Not included in this study are quartzites of Early Jurassic age in the southern part of western Nevada that may also be eolian and that may correlate with late Early Jurassic eolian units farther east in the Western Interior. Although highly metamorphosed, cross-bedding in the quartzites can still be recognized even though finer details such as grading, ripple cross-laminations, details of the laminations, and grain shape have been largely or entirely obliterated, making it difficult to find conclusive evidence of the mode of deposition. Proffett and Dilles (1984) considered Jurassic quartzites (their quartzitic sandstone) of the Singatsee Range (sect. 27, T13N, R24E, Lyons County, Nevada) eolian in origin but a field check revealed only poorly suggestive evidence such as the moderately large thickness (as much as 1.5 m) of a small number of sets and the relatively pure

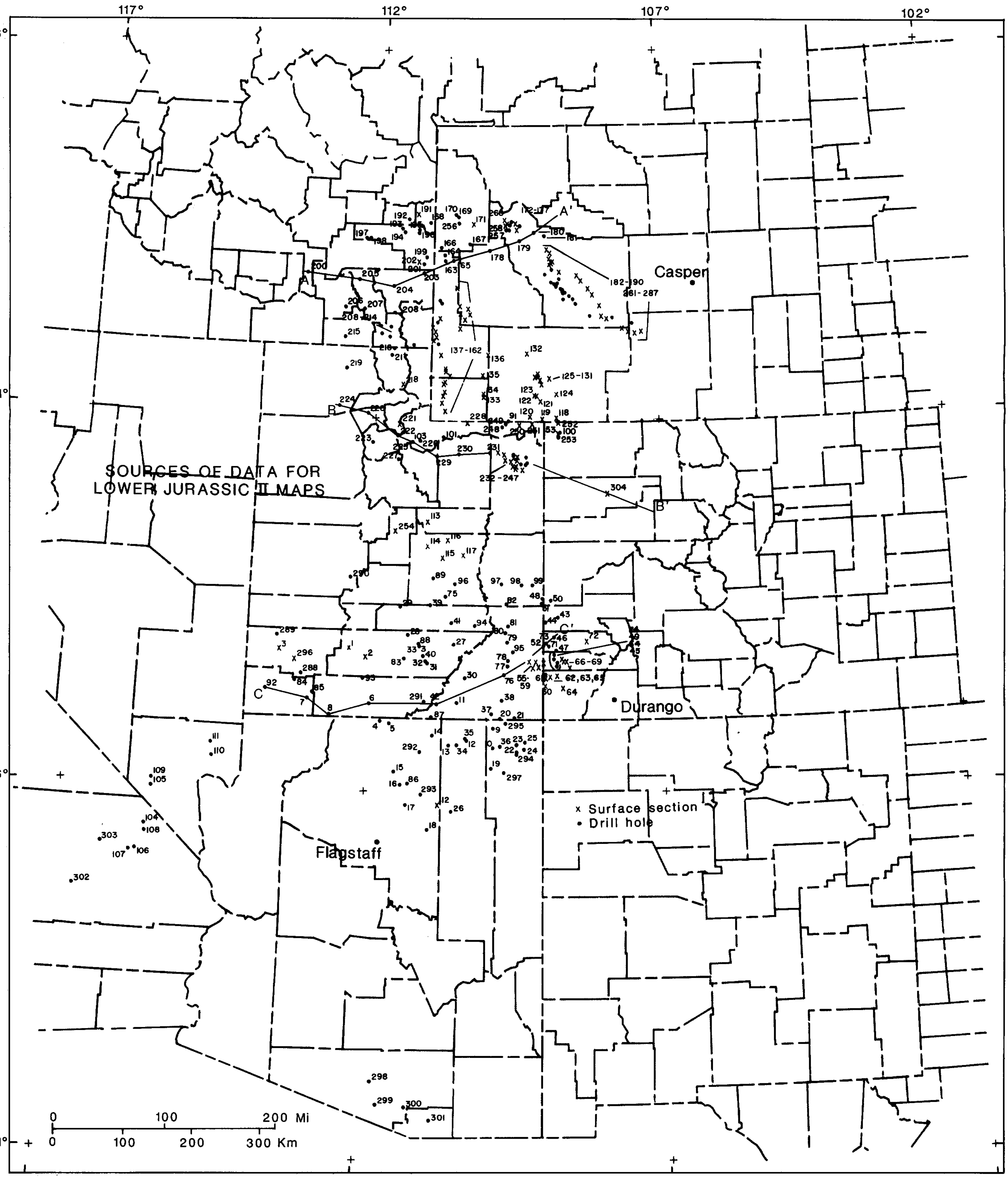


Fig. 17. Data points for Lower Jurassic II maps also showing lines of cross-section. See Table 5 for location names and references.

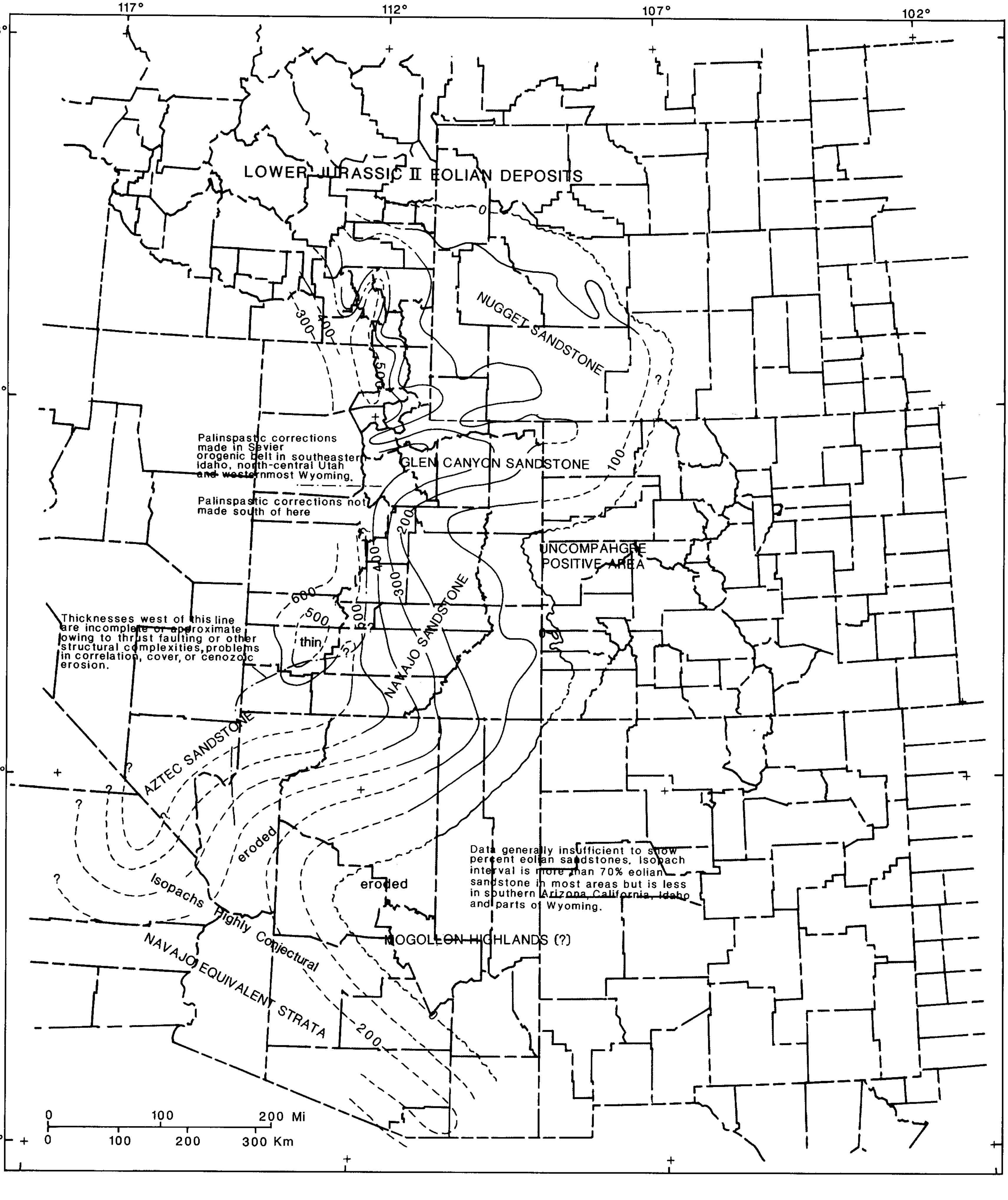


Fig. 18. Geometry and facies relations of Lower Jurassic II eolian deposits. Eolian sandstone generally exceeds 75% and in many places 90% except along southwest margin of map where facies relations are complex and variable. Isopach interval 100 m. Solid lines where outcrops occur; dashed lines where interval in subsurface or removed by erosion.

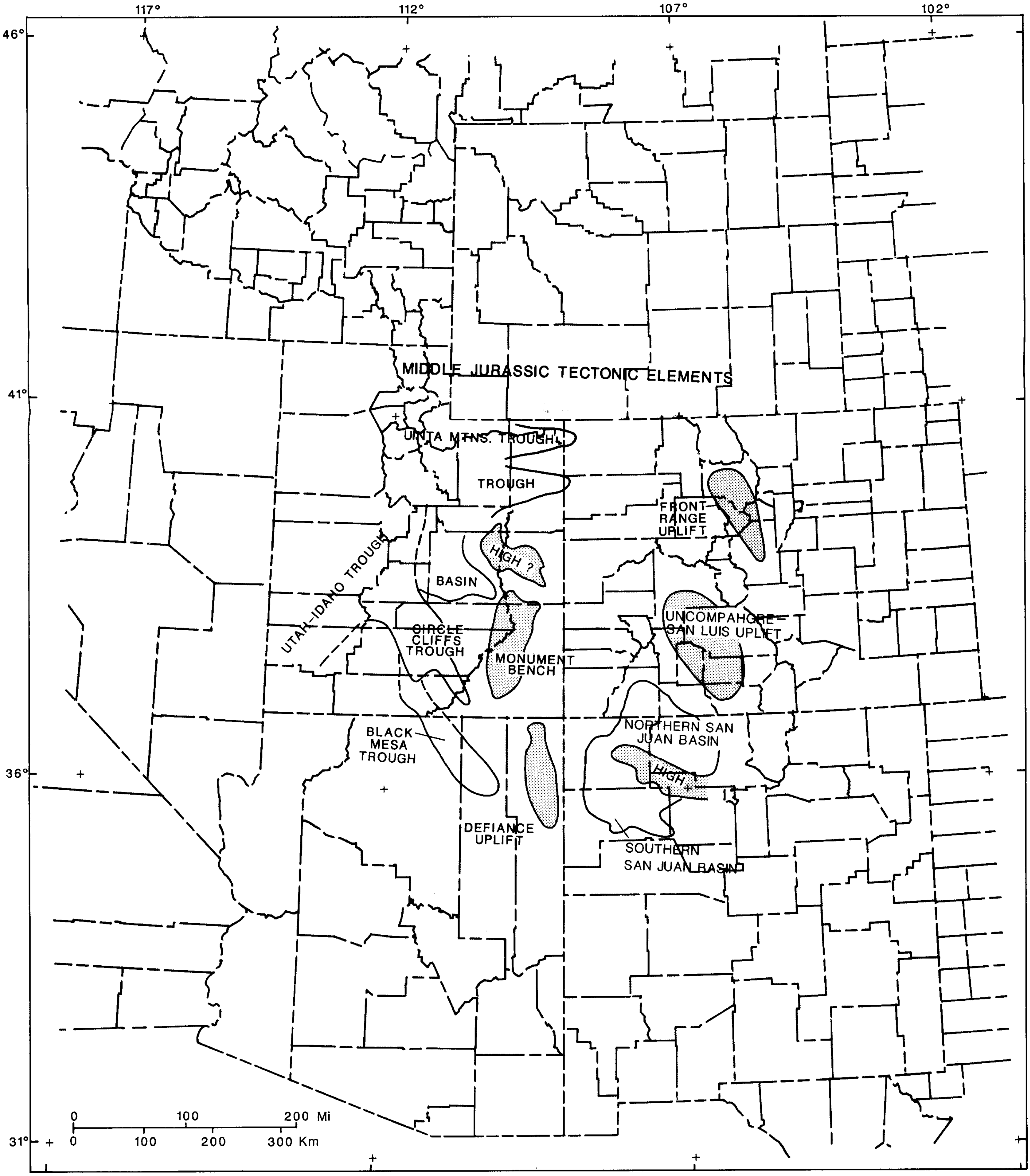


Fig. 20. Generalized Middle Jurassic tectonic elements that influenced eolian sedimentation in the Western Interior. Boundaries are approximated and varied through time.

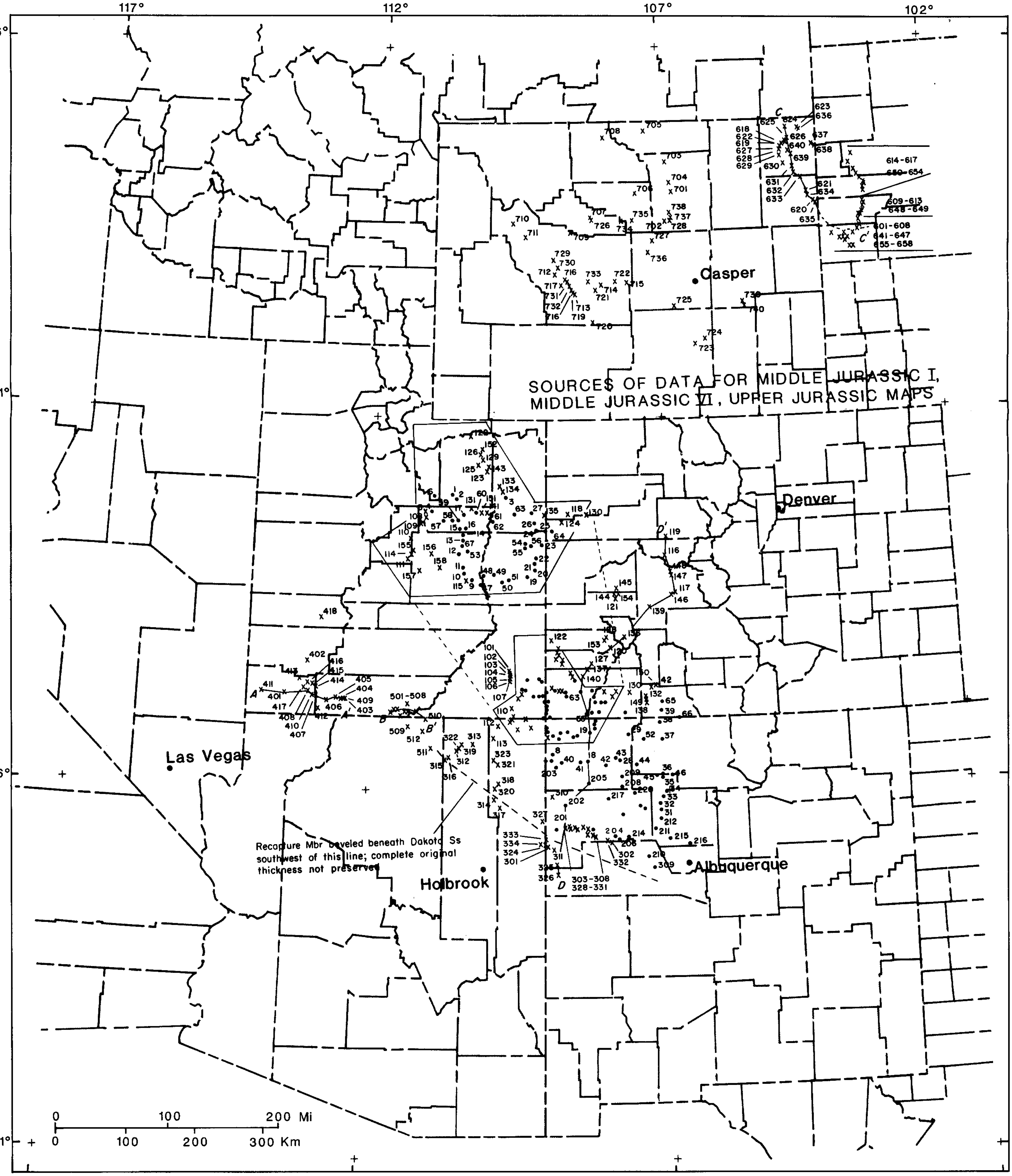


Fig. 21. Data points for Middle Jurassic I, VI, and Upper Jurassic maps also showing lines of cross section. See Table 6 for location names and references.

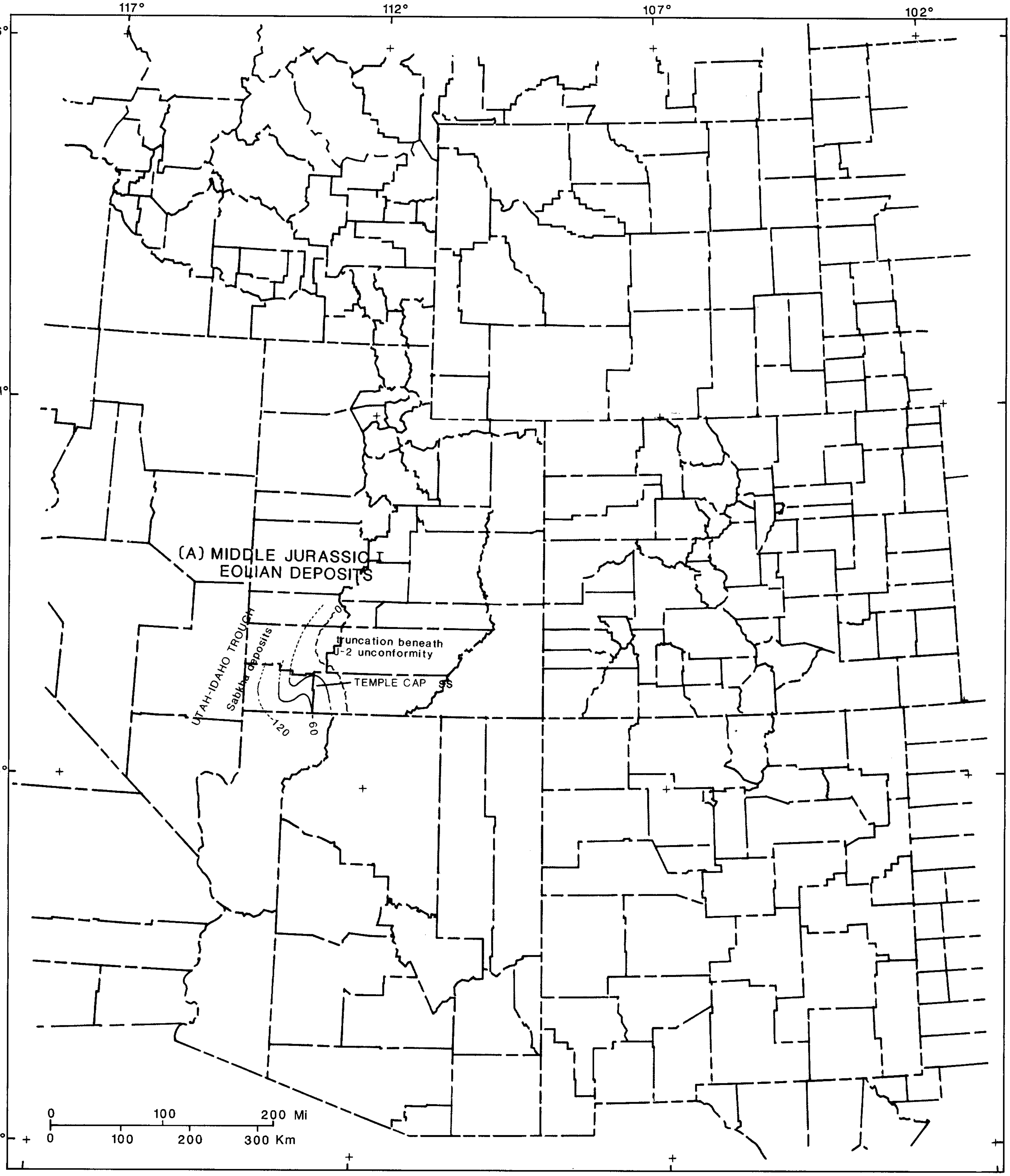


Fig. 22A. Geometry of Middle Jurassic I eolian deposits in the Temple Cap Sandstone. Isopach interval 30 m. Solid lines where outcrops occur; dashed lines where interval in subsurface or removed by erosion.

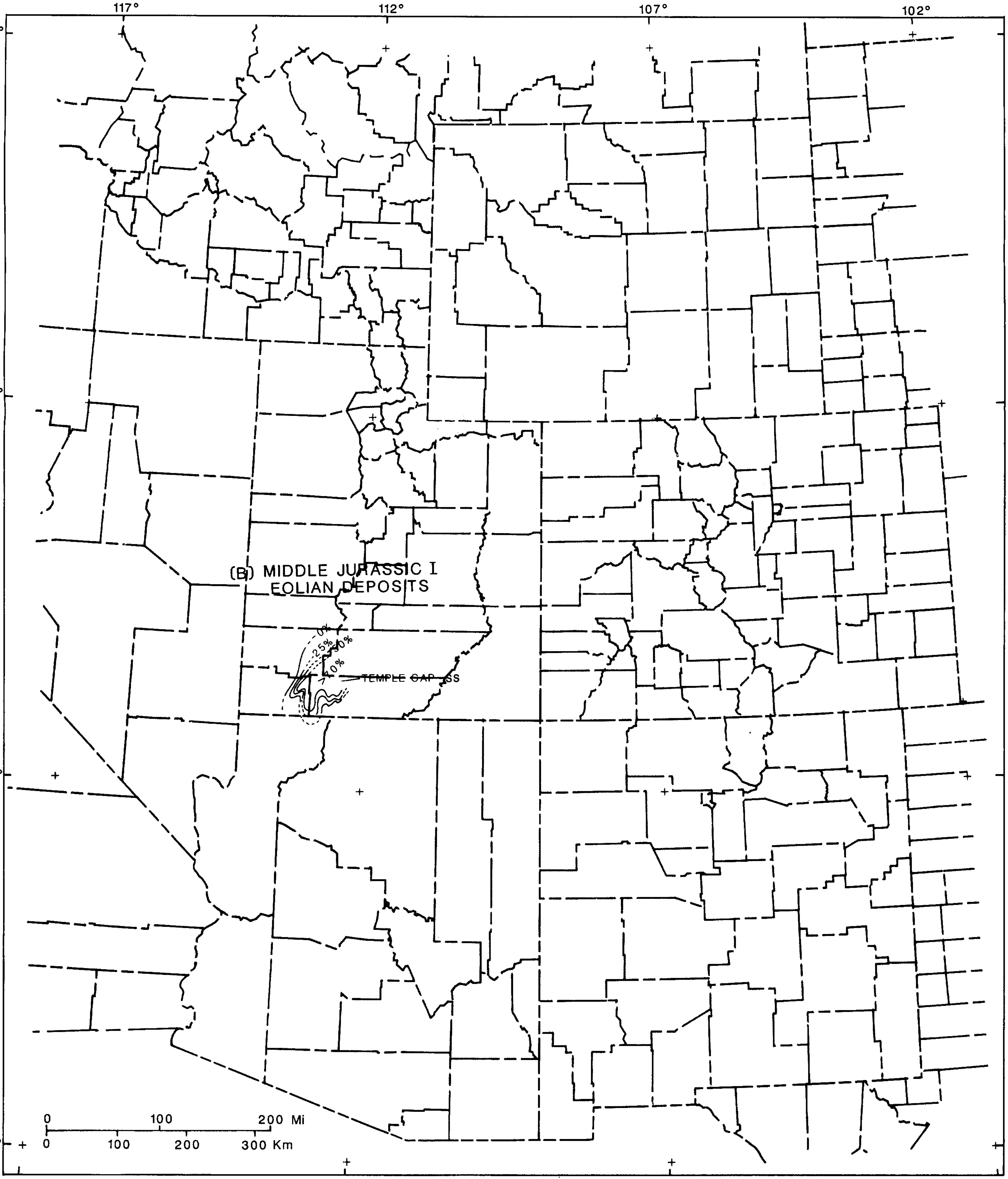


Fig. 22B. Facies relations of Middle Jurassic I eolian deposits in the Temple Cap Sandstone. Isopach interval 30 m. Solid lines where outcrops occur; dashed lines where interval in subsurfaces or removed by erosion.

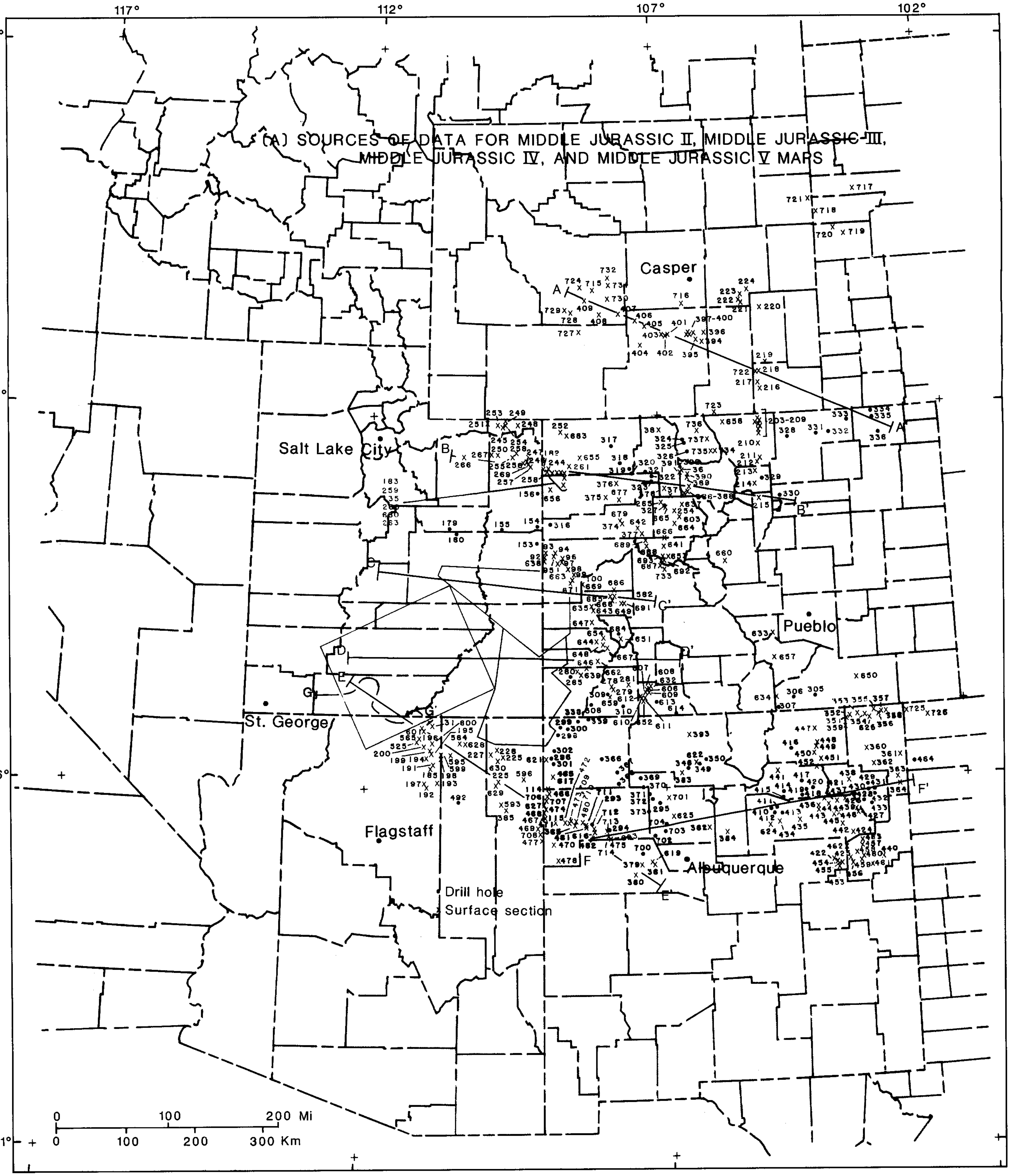


Fig. 24A. Data points for Middle Jurassic II, III, IV and V maps also showing lines of cross section. See Table 7 for location names and references.

(B) SOURCES OF DATA FOR MIDDLE JURASSIC II, MIDDLE JURASSIC III, MIDDLE JURASSIC IV, AND MIDDLE JURASSIC V MAPS

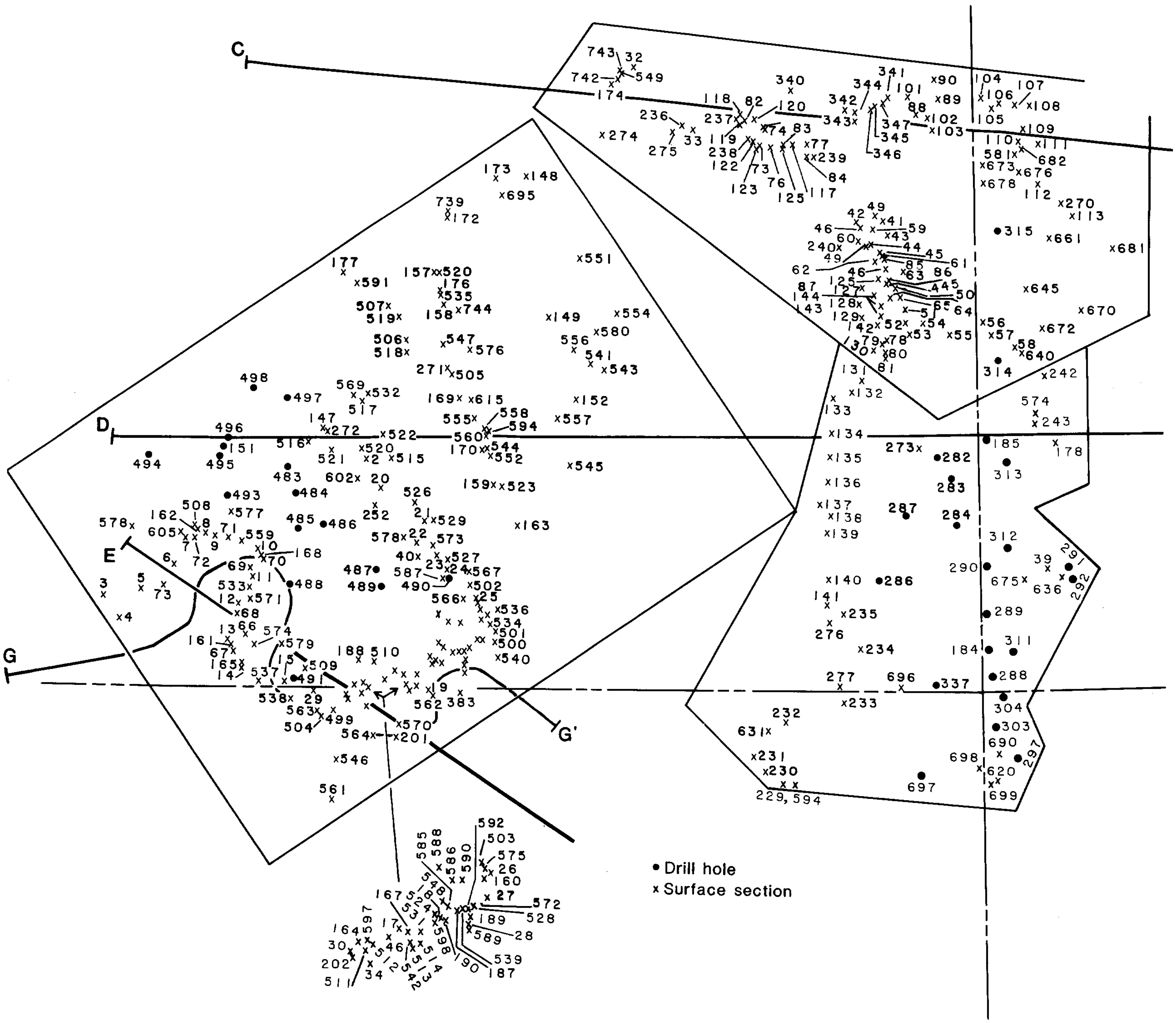


Fig. 24B. As Fig. 24A but enlarged to show detail in areas of tight control. See Table 7 for location names and references.

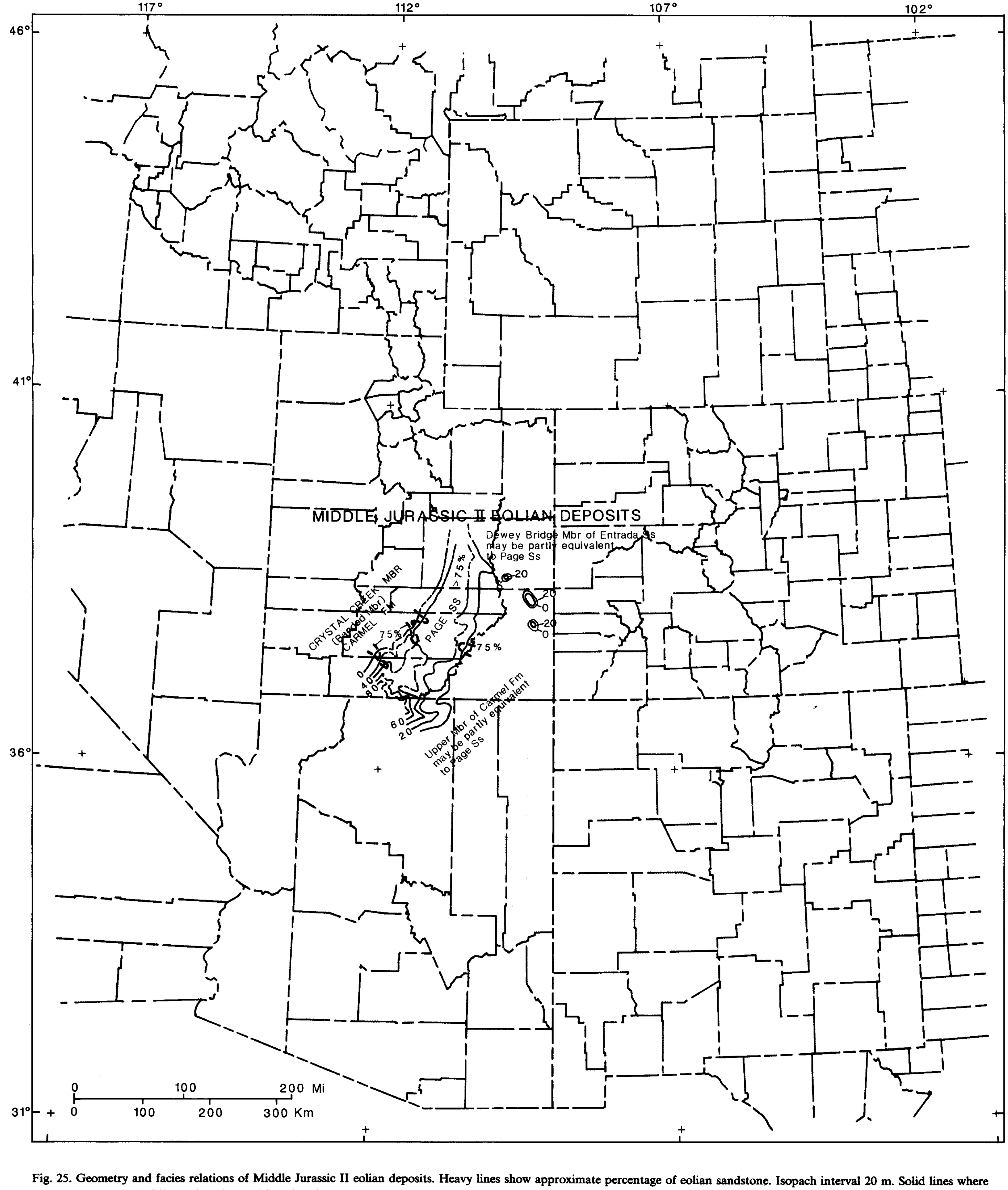


Fig. 25. Geometry and facies relations of Middle Jurassic II eolian deposits. Heavy lines show approximate percentage of eolian sandstone. Isopach interval 20 m. Solid lines where outcrops occur; dashed lines where interval in subsurface or removed by erosion.

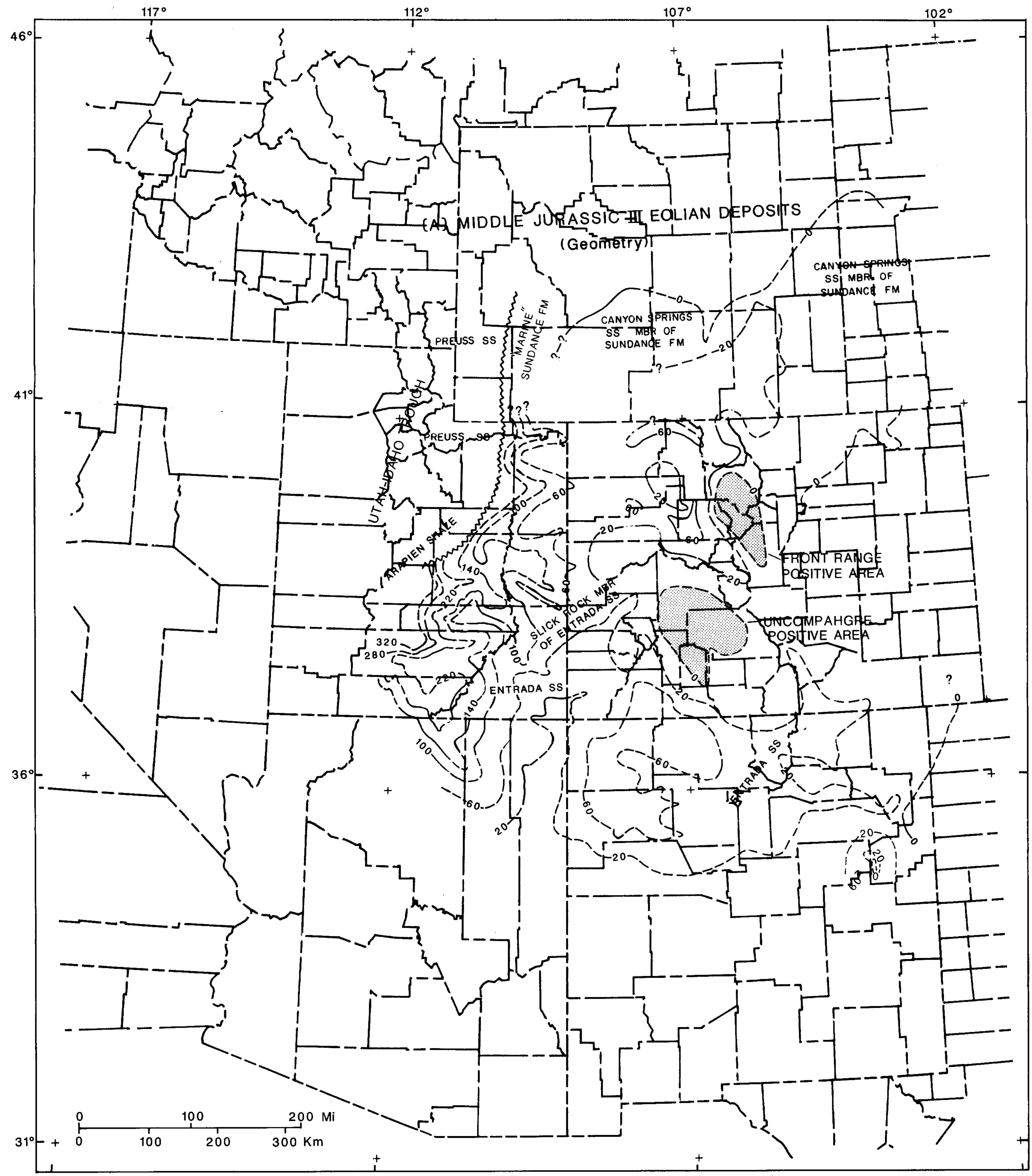


Fig. 27A. Geometry of Middle Jurassic III eolian deposits. Isopach interval 20 and 40 m. Solid lines where outcrops occur; dashed lines where interval in subsurface or removed by erosion.

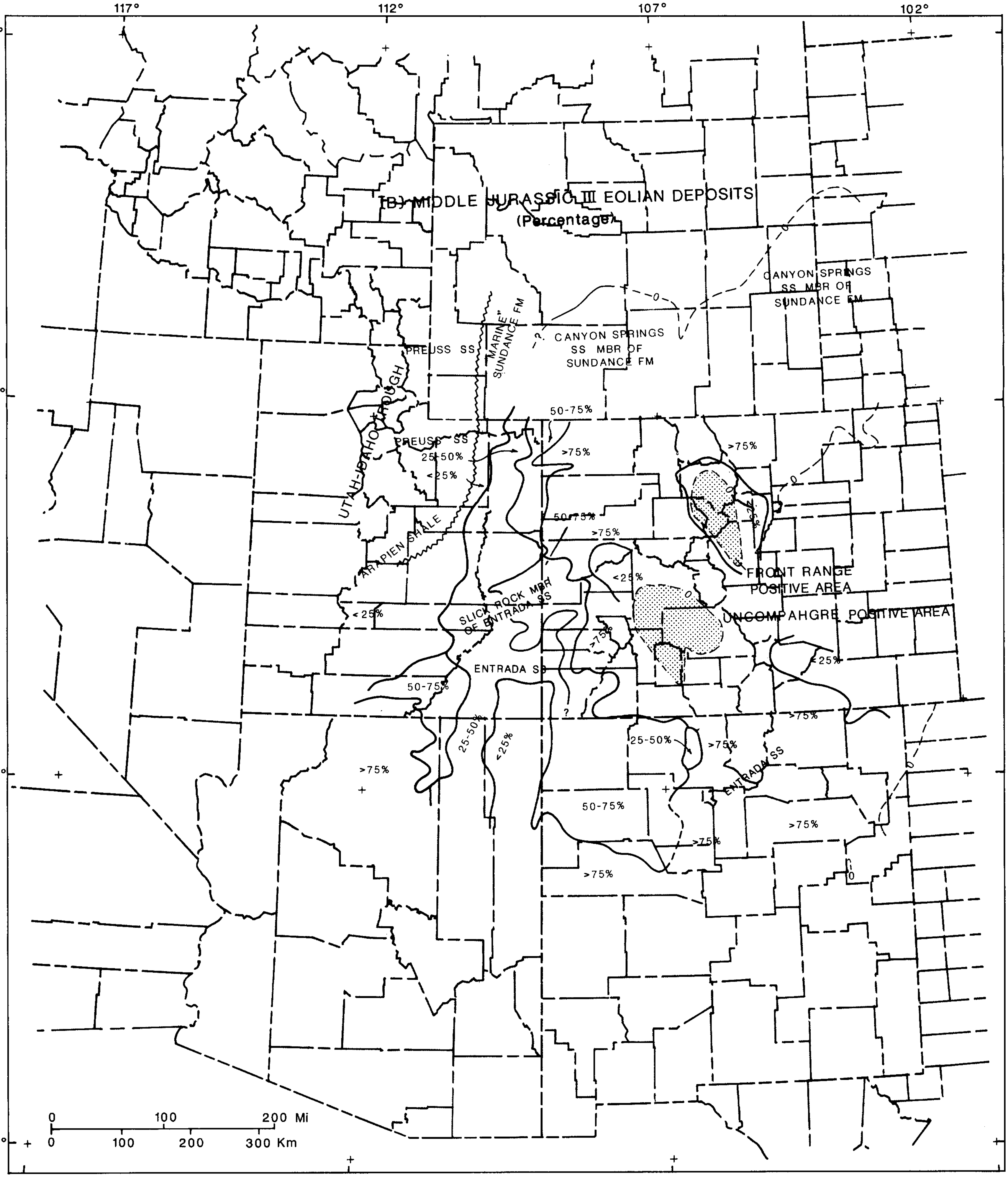


Fig. 27B. Facies relations of Middle Jurassic III eolian deposits. Isopach interval 20 and 40 m. Solid lines where outcrops occur; dashed lines where interval in subsurface or removed by erosion.

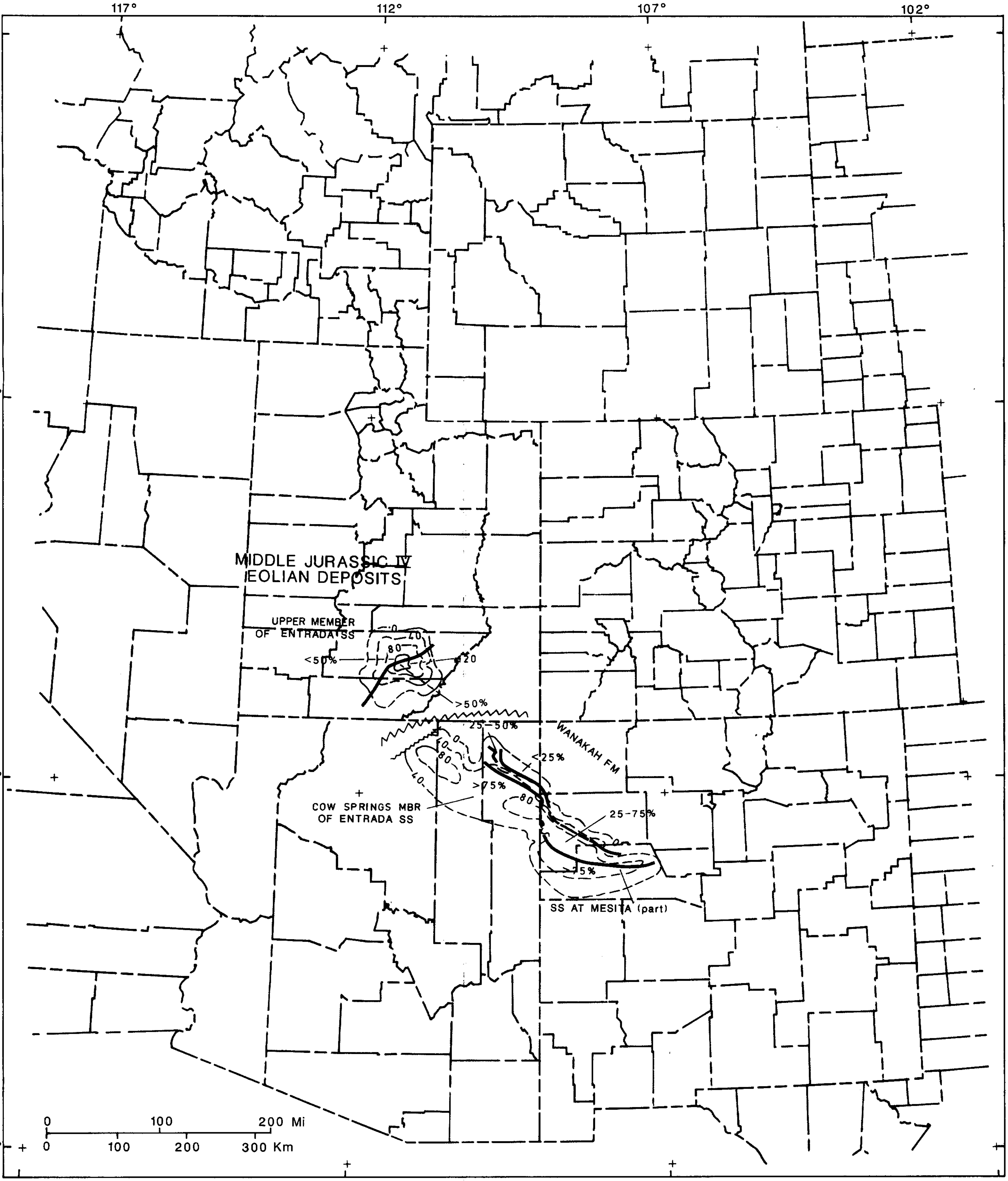


Fig. 28. Geometry and facies relations of Middle Jurassic IV eolian deposits. Cow Springs Member and upper member may be only partly coeval as regional correlations are uncertain. Isopach interval 40 m. Solid lines where outcrops occur; dashed lines where interval in subsurface or removed by erosion.

quartzose composition of the rock. The quartzite of McGery Canyon in the Paradise Range (sect. 33, T12N, R37E, Nye County, Nevada), currently being mapped by N.J. Silberling of the U.S. Geological Survey, consists of similar lithologies and has similarly poor but suggestive evidence of an eolian origin. The thickness of these units is unknown but each is at least 100 m thick and the quartzite of McGery Canyon may be considerably thicker.

Isolated outcrops of clean quartz sandstone and quartzite near Currie in northeastern Nevada that are interpreted by some workers as a marine facies of the Aztec Sandstone have added more confusion than resolution to interpretations of late Early Jurassic eolianites. The beds are flat laminated or contain scarce thin tabular-planar crossbed sets (most of which are less than 15 cm thick) that do not appear to be eolian in origin. Orange quartz sandstone beds less than 2 km south of Currie may well correlate with the Aztec but they are largely flat laminated and do not represent dune deposits. They could have been deposited on eolian flats adjacent to the main body of an erg or they may have been deposited in subaqueous environments. Red quartz sandstones or quartzites about 10 km north and northwest of Currie are almost entirely flat laminated and may have been deposited in environments similar to the beds just south of Currie. These beds are better cemented (with silica) and a different color (red rather than orange) than the beds south of Currie. The stratal relationships of these beds are questionable and it is conceivable that they might be Paleozoic in age. In summary, none of the beds around Currie appear to have been deposited in eolian dune fields and for that reason they were not included in this study.

Stratigraphic relationships at the base of the isopach interval are poorly understood in northwestern Colorado and northeastern Utah. Poole and Stewart (1964) suggested that much of the Glen Canyon Sandstone in this area may be equivalent to the Lukachukai Member of the Wingate Sandstone and Kayenta Formation farther southwest in southeastern Utah and southwestern Colorado. On the other hand, we feel that the regional stratigraphic relationships (for example, see Pipiringos and O'Sullivan, 1978, pl. 1, section B–B′ between U12 and W59–W60) point toward a correlation in which only the lower 15–30 m of flat-bedded strata in the Glen Canyon Sandstone correlate with the Lukachukai Member and Kayenta Formation. If correct, this yields a correlation of the upper or predominantly eolian part of the Glen Canyon Sandstone with the Navajo and Aztec Sandstones and with the eolian upper part of the Nugget Sandstone. We recognize interfingering at the base of eolian strata that comprise the upper Nugget, upper Glen Canyon, Navajo and Aztec Sandstones. However, we do not feel that the interfingering is of sufficient magnitude to make the upper Glen Canyon equivalent to the Lukachukai Member of the Wingate Sandstone or to any significant part of the Kayenta Formation, nor do we think that the upper Glen Canyon correlates with any appreciable part of the lower or Bell Springs Member of the Nugget Sandstone. The isopach interval on Fig. 18 reflects these correlations.

The late Early Jurassic erg deposits attain a maximum thickness of 677 m in the central Utah part of the Utah–Idaho trough; they thin and pinch out eastward owing to eastward beveling beneath the J-2 unconformity (Fig. 19). The original eastward extent of the erg is unknown, but to our knowledge there are no sedimentologic hints that the sandstone grades eastward into a non-eolian facies a short distance east of the outcrop limits of these beds. Thus, the erg could well have extended some considerable distance farther east than its present extent suggests. The erg deposits tend to thicken westward into the Utah–Idaho trough and, in southeastern Idaho and southeastern California, they appear to thin west of the trough. However, the data are unreliable in these areas and one cannot be assured that the westward thinning is real and not a reflection of scarcity of measurements and poor quality of the data (owing to cover, estimated thicknesses rather than measurements, and to structural or stratigraphic complexities). Most time-stratigraphic units of late Paleozoic and Mesozoic age in the Western Interior thin eastward onto the craton by depositional processes. Judging from this, it would seem as though the late Early Jurassic erg units

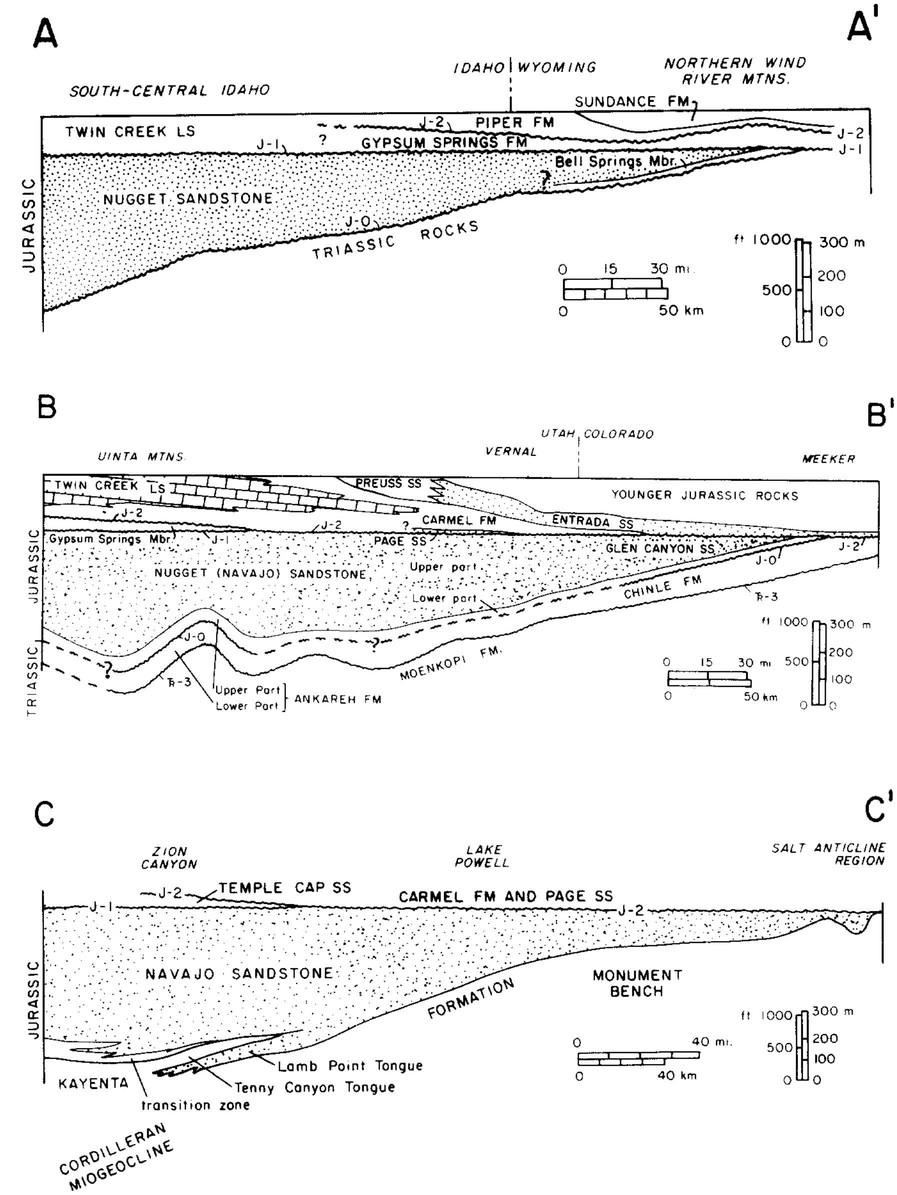


Fig. 19. Restored cross-sections showing eolian deposits in Lower Jurassic II rocks. Locations shown on Fig. 17.

also thinned eastward depositionally, but lack of stratigraphic markers within these deposits makes this difficult to confirm.

The role of intertonguing of the crossbedded eolian beds with other strata must be understood when evaluating thickness variations in the late Early Jurassic. Hypothesized intertonguing of the Navajo Sandstone with the Middle Jurassic Carmel Formation reported by earlier workers (Wright and Dickey, 1963) is now known to involve another formation (the Page Sandstone) rather than the Navajo. Accordingly, the Aztec, Navajo, Glen Canyon and Nugget Sandstones are now thought to be unconformably overlain everywhere by Middle Jurassic or younger strata (Peterson and Pipiringos, 1979). On the other hand, intertonguing at the base of the Aztec and Navajo Sandstones has been documented by several workers (Harshbarger et al., 1957; Averitt, 1962; Wilson, 1965; Middleton and Blakey, 1983). How much lateral replacement of the uppermost or eolian part of the Nugget Sandstone by underlying strata of the Bell Springs Member of the Nugget (Pipiringos, 1968; Doelger and Steidtmann, 1985) has not, to our knowledge, been determined but it is not considered to be appreciable.

The direction of lateral replacement of Navajo or Aztec tongues by units in the underlying Kayenta Formation is only documented in a few areas, but where it has been determined it is consistent with paleowind patterns determined from crossbedding dip vector studies. Harshbarger et al. (1957, p. 22, pl. 2) report southeastward gradation of Navajo tongues into the Kayenta Formation in northeastern Arizona, which is parallel to the southeastward direction of eolian transport in this area during Early Jurassic time (Peterson, this volume). It is highly likely that the Lamb Point and Shurtz Sandstone Tongues of the Navajo in southwestern Utah (Averitt, 1962; Wilson, 1965) are different names in different areas for the same tongue of the Navajo. If this correlation is correct, the tongue thins southwestward in the same direction (Fig. 19) that the winds moved in this area (Peterson, this volume).

During Early Jurassic time an Andean-type magmatic arc extended northwestward from southern Arizona into California (Bilodeau and Keith, 1986). Eolian strata included in the isopach interval (Fig. 18) lap southward onto older rocks in this area, apparently because the erg migrated into highlands produced by uplift in the arc. Interfingering or interbedding of the eolian sand with arc volcanics was documented by Marzolf (1983a) and Bilodeau and Keith (1986). In this area, the upper boundary of the Lower Jurassic Series (and thus of the isopach interval) is difficult to determine owing to the difficulty of distinguishing Middle Jurassic volcanics that postdate strata of the isopach interval from Early Jurassic volcanics that were coeval with the eolian beds. Clearly, a study of the isotopic dates of the volcanics in this area is sorely needed.

In summary, the isopach interval thins eastward owing primarily to truncation beneath the J-2 unconformity, and probably to some as yet undetermined amount of depositional thinning. The lower contact of the isopach interval is diachronous, becoming younger generally toward the south owing to interfingering with and lateral replacement by non-eolian units in the Kayenta Formation and probably with non-eolian strata in the lower part of the Nugget and Glen Canyon Sandstones. In southern Arizona and California, the eolian unit appears to thin southward by onlap where it rests on the landward side of the Early Jurassic Andean-type magmatic arc. Intertonguing and southward regional replacement of the lower part of the Aztec and Navajo Sandstones by non-eolian units should be reflected in southward thinning of the isopach interval, but this is not apparent from the isopach map (Fig. 18). Although there may be several explanations for this, the simplest and most appealing is that the intertonguing does not involve an appreciable thickness of beds (100 m or less in most locations). Also, the zone of intertonguing is at or near the southern margin of Jurassic outcrops on the Colorado Plateau so trends to the south are uncertain.

Several positive and negative structural elements (Fig. 20) are reflected by the configuration of the isopach lines. In northeastern Utah and adjacent areas, a trough is reflected as a west-southwest-trending area of thick Nugget and Glen Canyon Sandstones that coincides roughly with the present-day Uinta Mountains structural element. The Uinta Mountains element is known to have been active, either as a positive or negative structural feature, since Precambrian time (Bryant, 1985; Hansen, 1986) and movement in the Jurassic is therefore not unexpected. A parallel trend of thick Nugget Sandstone just northwest of the Uinta trough may reflect a separate trough or, by reconfiguring the isopach lines around the thin area between the two thick areas, both thick areas combined may reflect a somewhat complicated but considerably larger Uinta trough. Another thick trough-like area is suggested by the configuration of the isopach lines in southern Arizona but stratigraphic complexities and uncertainties as well as incomplete sections make such an interpretation speculative.

A broad structural bench or terrace identified as the Monument bench (Fig. 20) is identifiable in southeastern Utah in the vicinity of the present-day Monument upwarp. Isopach and facies studies in this area indicate that this feature was tectonically active, either as a structural bench or uplift, all during the Jurassic Period (Peterson, 1986). A reentrant in west-central Colorado and adjacent parts of Utah reflects the ancestral Uncompahgre uplift, an important structure that was repeatedly activated in late Paleozoic, Mesozoic and Cenozoic time. A similar reentrant in central Arizona may reflect positive movement of the Mogollon uplift, but lack of data over a broad area makes the configuration of this feature somewhat speculative.

Differential movement on salt-cored anticlines in west-central Colorado is reflected in the irregular configuration of the isopach interval east of the Monument bench. The salt was deposited during Pennsylvanian time but it moved from the Late Pennsylvanian to at least the end of the Jurassic to produce several salt-cored anticlines (Cater, 1970). The anomalously thin area within the Utah–Idaho trough in west-central Utah is in an area of considerable structural complexity and may not be real.

Available data are too sparse to determine the percent of cross-bedded sandstone in the isopach interval. Visual observations aided by a few measurements indicate that the isopach interval consists of more than 70% cross-bedded sandstone in most places in the Western Interior. However, the eolian sandstone is interbedded with volcanics and (or) non-eolian, flat-bedded siltstone and sandstone in southern Arizona and California where the percentages are considerably lower. Additional complications in this area are that the isopach interval is incomplete due to erosion or faulting, or reliable criteria to distinguish Middle Jurassic from Lower Jurassic beds have not been found.

The precise timing of movement on the above-mentioned structures remains somewhat conjectural because of a lack of detailed facies studies that might yield an indication of movement during deposition. Judging from the isopach map alone, one can only speculate that the movement was during and (or) immediately after deposition of the isopach interval. However, judging from the record of movement on many of these structures throughout much of the Phanerozoic, it would seem more likely that the structures moved continuously during deposition as well as during the succeeding erosion interval.

Middle Jurassic eolian deposits

Introduction

The base of the Middle Jurassic is either the J-1 or J-2 unconformity (Pipiringos and O'Sullivan, 1978). The unconformity is overlain by a variety of deposits of continental and marine origin. Within rocks of Middle Jurassic age we recognize the following eolian-bearing units: Temple Cap Sandstone, Page Sandstone, Entrada Sandstone and Romana Sandstone (Fig. 2).

Middle Jurassic 1 eolian deposits

The Temple Cap Sandstone of early Middle Jurassic age (early part of the Bajocian Age according to Imlay, 1980) is the oldest formation in the Middle Jurassic San Rafael Group and is only present in the southwestern part of the Colorado Plateau in southwestern Utah (Fig. 2). Based on its stratigraphic position between the J-1 and J-2 unconformities, the formation correlates with the Gypsum Springs Member of the Twin Creek Limestone in northern Utah, which occupies a similar stratigraphic position. Information used to construct the isopach map is given in Table 6 and the geographic distribution of data points is shown on Fig. 21. Eolian beds in the formation are of limited extent but may have once been more extensive (Chan and Kocurek, this volume).

The Temple Cap consists of two members on the Colorado Plateau but only the upper member is eolian. The upper or White Throne Member consists of crossbedded sandstone deposited in eolian environments. The underlying Sinawava Member consists of flat-bedded silty sandstone and scarce mudstone deposited in sabkha and possibly hypersaline marine environments. At the west edge of the Colorado Plateau, the White Throne grades into red beds that are included in the Sinawava Member but, in addition to the lithologies noted above, the westernmost Sinawava includes thin beds of limestone and gypsum (Peterson and Pipiringos, 1979).

Temple Cap strata contain the record of crustal movements coincident with deposition. The formation is wedge-shaped and thickens irregularly

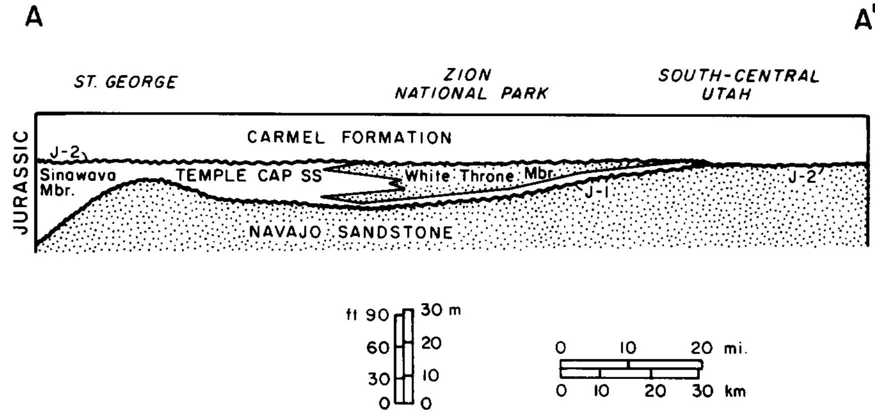


Fig. 23. Restored cross-section of Temple Cap Sandstone. Location shown on Fig. 21.

southwestward and westward toward the Utah–Idaho trough (Fig. 22), supporting the contention that the trough continued as an active downwarp from Early Jurassic time (Fig. 20). The westward facies change from eolian sandstone of the White Throne Member to red beds of the Sinawava occurs rather abruptly at the Hurricane fault, suggesting that the eastern boundary of the trough, at least in southwestern Utah, was the ancestral Hurricane fault. Movement would have been with the west side down, which is the same as that which is presently displayed there. The formation thins eastward toward the west side of the Kaibab uplift, suggesting that this structural element also was active during and (or) immediately following deposition. Although the formation has an erosion surface at the top (the J-2 unconformity), the Sinawava Member is overlain depositionally by the overlying White Throne Member and thins eastward by onlap toward the Kaibab uplift (Fig. 23). This, then, is an indication that the Kaibab uplift was elevated immediately before and (or) during deposition as well as immediately after deposition. It is difficult to interpret the structural history in the northeastern part of the area underlain by the Temple Cap owing to the lack of drill hole information.

Interpretations gleaned from the percentages of eolian sandstone can be misleading in some cases and should be done with consideration of the stratigraphy of the formation. The percent eolian sandstone drops abruptly at the Hurricane fault, as might be expected because it coincides with the abrupt facies change of the White Throne Member into the Sinawava. A southward lowering in the percent of eolian sandstone is an indication that the dune facies probably did not extend very far south into Arizona. Lower values in eolian sandstone percentages at the east end of the Temple Cap outcrop belt, however, reflect abrupt truncation of eolian beds in the White Throne Member beneath the J-2 unconformity and are not necessarily an indication that the eolian facies did not extend farther east.

Eolian deposits in the Carmel Formation

Scattered eolian deposits are present in the Carmel Formation across southern Utah and north-central Arizona. Many of these deposits are undocumented or casually mentioned in the literature. We are unable to isopach or accurately map most of these deposits, but merely offer the following brief discussion:

(1) Eolian deposits, both of dune and sand-sheet origin, occur in the upper member in south-central Utah. Similar deposits at approximately the same horizon occur at scattered locations along the Utah–Arizona state line eastward to near Page, Arizona.

(2) Eolian dune deposits occur in isolated, preserved dune forms in the upper part of the undivided Carmel Formation along the Green River northwest of Moab, Utah.

(3) In north-central Arizona, the Carmel Formation is a poorly exposed sandy unit informally

called the "Reservation facies". At several localities where fair exposures are present, thin eolian deposits are present including both small dune and sand-sheet deposits.

(4) In the southern Four Corners region east of Monument Valley, a light-colored sandstone in the Carmel Formation (undivided) may be of eolian origin.

Middle Jurassic II eolian deposits

The Middle Jurassic (Bajocian–Bathonian) Page Sandstone (Fig. 2) consists of a north-northeastward-trending sandstone body in south-central Utah and north-central Arizona (Figs. 24 and 25). Previous to Peterson and Pipiringos (1979), the Page had been included in the underlying Navajo Sandstone, but recognition of the regional J-2 unconformity of Pipiringos and O'Sullivan (1978) formed the basis for distinguishing it as a separate formation.

In southern Utah, the Page consists of a lower unit, the Harris Wash Tongue, and an upper unit, the Thousand Pockets Tongue, separated by the Judd Hollow Tongue of the Carmel Formation (Fig. 26). Northward the Page Sandstone is undifferentiated, but this probably is the more extensive Harris Wash Tongue, as the Thousand Pockets Tongue apparently pinches out northward in the northwestern part of the Henry basin. As seen in Fig. 26, the Harris Wash Tongue decreases in thickness southward and the Thousand Pockets Tongue increases. The Judd Hollow Tongue thins eastward and pinches out in the undivided Page a few kilometers east of Page, Arizona. For the purpose of the isopach map (Fig. 25), thicknesses of the Judd Hollow Tongue of the Carmel Formation were omitted so that the entire Harris Wash–Judd Hollow–Thousand Pockets interval is thicker than shown. Table 7 lists the data base for the Page Sandstone.

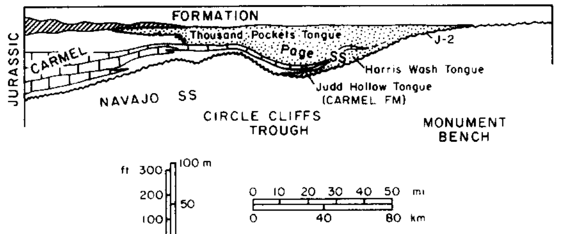


Fig. 26. Restored cross-sections of Middle Jurassic II eolian deposits in the Page Sandstone. Locations shown on Fig. 24.

To the west and northwest the entire Page Sandstone interfingers with and is laterally replaced by the Carmel Formation consisting of red mudstones, limestones, and gypsiferous deposits. Thus, the Harris Wash Tongue grades into the Judd Hollow Tongue (Limestone Member of the Carmel Formation in southwestern Utah). The Thousand Pockets Tongue is replaced westward by the Crystal Creek (Banded) Member of the Carmel Formation. Eastward, the Page Sandstone thins by onlap against the ancestral Monument bench and it may also thin eastward by intertonguing with red beds of the Carmel Formation (Peterson, 1986). To the east the Page is a time-equivalent of the lowermost part of the upper member of the Carmel Formation and possibly to the lowermost red beds of the Dewey Bridge Member of the Entrada Sandstone. The Page Sandstone is overlain by the upper member of the Carmel Formation (Fig. 26), or by the Dewey Bridge Member of the Entrada.

The thickest deposits of the Page are in a southern extension of the Circle Cliffs trough of north-central Arizona (Figs. 20 and 25), adjacent to where it has largely been removed by erosion. The sandstone thins northwestward and southeastward from the axis of the sandstone body. The northern extent of the Page Sandstone is not yet known; Pipiringos and O'Sullivan (1976) show it extending northward into southwestern Wyoming. Outliers of sandstones deposited in depressions on the J-2 surface east of the main body of Page Sandstone have been assigned to the Page by O'Sullivan and Pierce (1983). These may be coincident with structure associated with salt tectonics. Earlier, these same deposits had been included in the Entrada Sandstone (O'Sullivan, 1980a).

The Page Sandstone consists predominantly of cross-stratified eolian sandstone except along its western margins where the percentages of cross-stratified sandstone decrease in tongue-like projections. However, outliers of Page Sandstone and

Page Sandstone-filled depressions up to 10 m thick on the J-2 surface are composed of coarser-grained, flat to low-inclined cross-strata of wind-ripple origin (Knight, 1986). Western outcrops of Page Sandstone commonly are deformed, probably the result of evaporite dissolution in the underlying Carmel Formation.

The Page Sandstone is interpreted as a coastal erg system that paralleled the Carmel sabkha and shallow marine embayment to the west; the eastern inland limits were largely defined by the Monument bench (Fig. 20) (Peterson and Pipiringos, 1979; Caputo, 1980; Blakey et al., 1983; Knight, 1986; Peterson, 1986; Kocurek and Hunter, 1986). Eastward of the Page Sandstone, potentially equivalent units (lower Dewey Bridge Member of the Entrada Sandstone, lower part of the Upper Member of the Carmel Formation) are largely sabkha in origin. The Page Sandstone was deposited over the irregular, eroded J-2 surface that is commonly marked by thin-granule lag deposits and polygonal fractures (Peterson and Pipiringos, 1979), the latter interpreted by Kocurek and Hunter (1986) as forming in an evaporite-encrusted surface. Knight (1986) has interpreted the coarser-grained basal deposits of the Page Sandstone that fill depressions on the J-2 surface as probably predating the Page erg system per se, and representing sand deposit over the J-2 surface in an overall sand-undersaturated environment in which deposition occurred only in depressions.

Middle Jurassic III, IV, V eolian deposits

Introduction

The Middle Jurassic (Bathonian–Callovian) Entrada Sandstone system and directly equivalent units (Fig. 2) form perhaps the most complex eolian system in the western United States, and are present in nine states extending from Utah to the Texas and Oklahoma panhandles, and from Arizona and New Mexico to the Black Hills of South Dakota. This erg system, composed of numerous units, is illustrated here as three units on three maps. Our three units do not necessarily coincide with previous subdivisions of the Entrada as explained below. Because of stratigraphic complexities and uncertainties and despite our attempts to not do so, part of the three intervals possibly overlap in time and all are likely strongly diachronous.

Figure 27 shows the most extensive and oldest parts of the Entrada system consisting of: lower and middle members of the Entrada Sandstone in west-central Utah; Entrada Sandstone of southern Utah, northern Arizona, southwestern and southeastern Colorado, and northern Utah; Slick Rock Member of the Entrada Sandstone in east-central Utah and west-central Colorado; Canyon Springs Member of the Sundance Formation in Wyoming, South Dakota, and northwestern Colorado; Iyanbito, medial silty and upper sandy members of the Entrada Sandstone in northwestern New Mexico; and Entrada Sandstone and Exeter Member of the Entrada Sandstone in east-central and eastern New Mexico, Texas, and Oklahoma. The Dewey Bridge Member of the Entrada Sandstone in east-central Utah is not included on Fig. 27 because this unit generally lacks eolian deposits and because it correlates with the older Carmel Formation (see Page Sandstone discussion).

Figure 28 shows the Upper Member of the Entrada Sandstone of west-central Utah, the possibly somewhat older Cow Springs Member of the Entrada Sandstone in northeastern Arizona and the Cow Springs Member and overlying lower part of the sandstone at Mesita in New Mexico. It should be noted that the Exeter Member of the Entrada Sandstone (included in Fig. 27) in northeastern New Mexico may be time-equivalent to the Cow Springs member (Lucas et al., 1985). Restored cross-sections are shown on Fig. 29 and Table 7 lists Entrada Sandstone data points. Figure 30 shows what may be the youngest part of the Entrada erg systems, the Moab Tongue of the Entrada Sandstone in east-central Utah.

Middle Jurassic III

Overall, the Entrada Sandstone conformably overlies the Carmel Formation. Progressing eastward to the pinch-out of that unit, the Entrada Sandstone rests directly on the J-2 unconformity that is underlain by progressively older rocks to the east.

Across Wyoming the Canyon Springs Member of the Sundance Formation rests on the J-2 surface

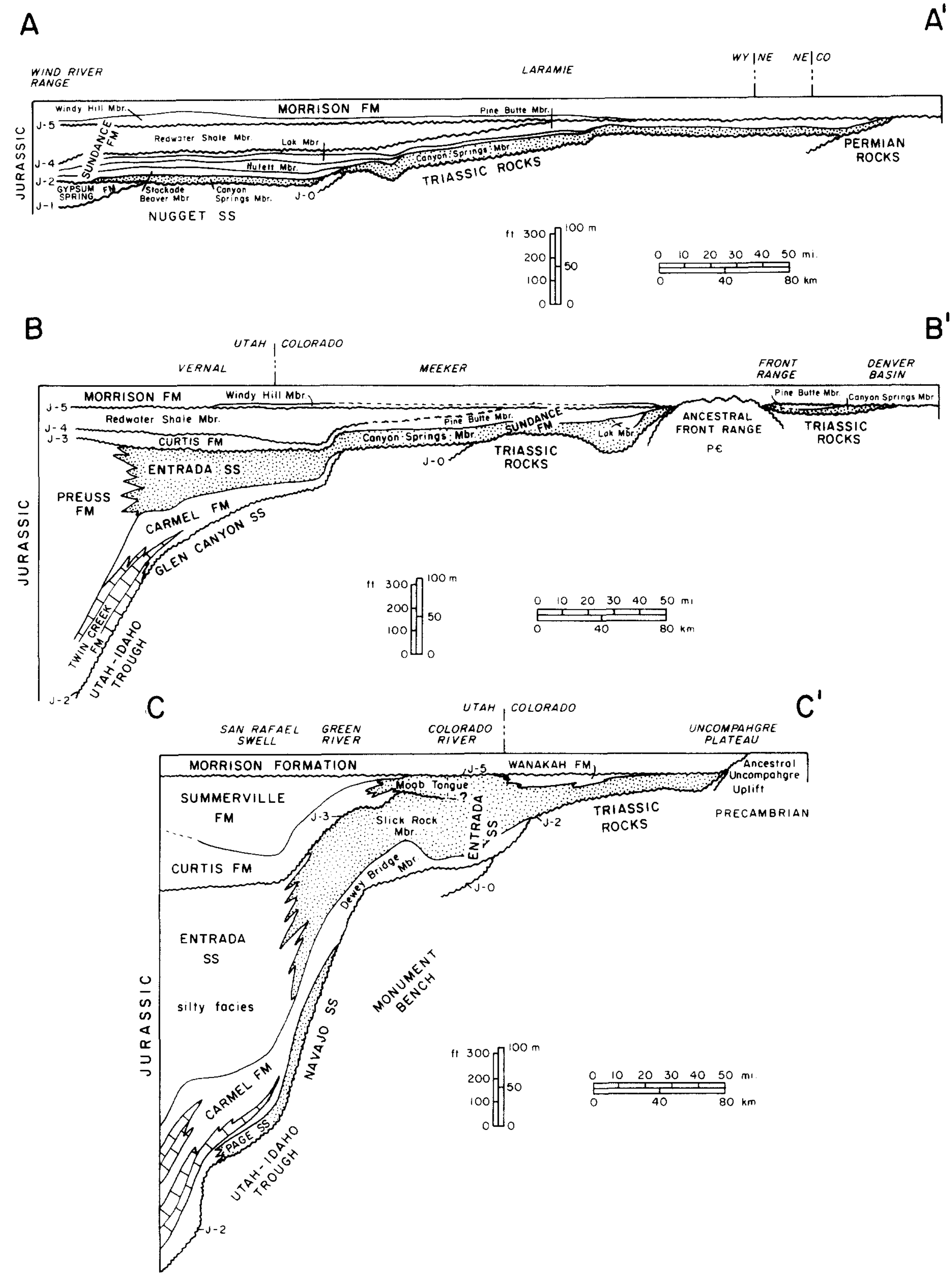


Fig. 29. Restored cross sections of Middle Jurassic II, III, IV and V eolian deposits in Page and Entrada Sandstones and Sundance Formation. Locations shown on Fig. 24.

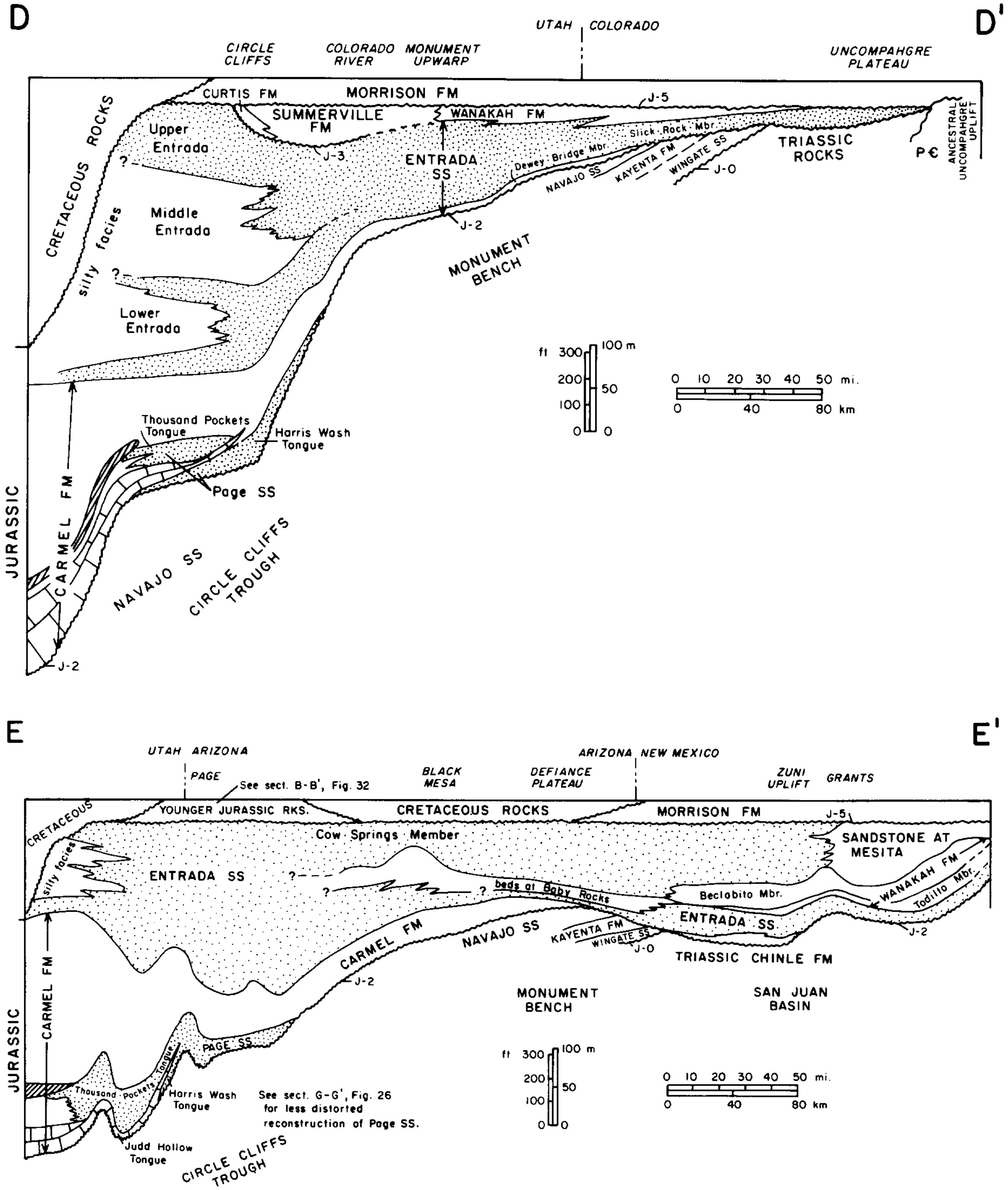


Fig. 29 (continued). See p. 58 for legend.

and pinches out northwestward and northward into marine strata of the Sundance Formation (Fig. 29). In northeastern Utah the Entrada Sandstone overlies the Carmel Formation and grades west into red beds of the Preuss Sandstone. Eastward across northwestern Colorado the Carmel Formation thins to zero and the Canyon Springs Member of the Sundance Formation directly over-

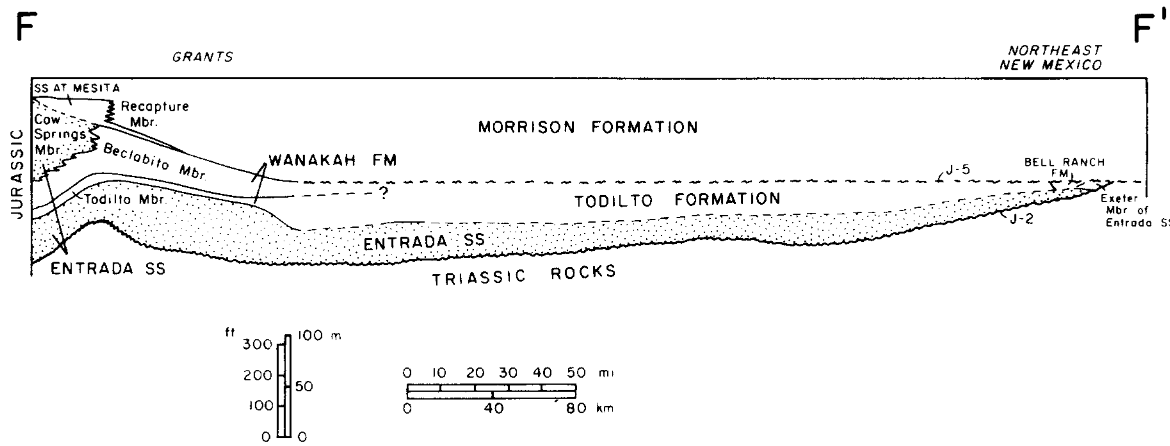


Fig. 29 (continued). See p. 58 for legend.

lies the J-2 surface; the Canyon Springs thins to pinch out by onlap against the ancestral Front Range, but is present again on the east side of the Front Range. A short distance farther east it pinches out again, presumably by onlap.

Correlations by Pipiringos and O'Sullivan (1978) and Imlay (1980) suggested that most of the Canyon Springs Sandstone Member of the Sundance Formation is slightly older than eolian deposits in the Entrada Sandstone to the southwest. The above workers suggested that the Entrada correlates with the Lak Member of the Sundance and that the underlying Canyon Springs Sandstone Member of the Sundance Formation correlates with the upper part of the Carmel Formation on the Colorado Plateau. The Canyon Springs becomes younger progressing southward across southern Wyoming and northern Colorado so that the southern part of the Canyon Springs replaces the Lak and therefore is a direct equivalent of the Entrada (Pipiringos and O'Sullivan, 1976). If correct, this documents the diachronous southward progradation of a major erg complex from the Central Rocky Mountains to the southern Colorado Plateau.

The Entrada Sandstone in central and southern Utah (Figs. 27 and 29C, D, E) grades westward into marine-sabkha deposits (Twist Gulch Member of the Arapien Shale), overlies the Carmel Formation or equivalent Dewey Bridge Member of the Entrada Sandstone, and lies on the J-2 surface in Colorado east of the eastward pinch-out of the Carmel–Dewey Bridge units. Similarly, but farther east, the Entrada Sandstone pinches out against the topographically and probably structurally highest part of the ancestral Uncompahgre uplift.

More complex relationships exist in Arizona and New Mexico where the Cow Springs Member is recognized within the upper part of the Entrada Sandstone (Fig. 29E, F) (see following section). Farther east in New Mexico, the Carmel Formation is absent and eolian deposits of the Entrada Sandstone overlie the J-2 surface and Triassic rocks.

The main body of the Entrada system shown in Fig. 27 is generally overlain by marine or sabkha deposits across the western and northern Western Interior, but in southeastern Utah where the Moab Tongue occurs, in Arizona and New Mexico where the Cow Springs Member rests directly on the main body, and in west-central Utah where the upper member of the Entrada occurs, the unit is overlain by eolian deposits. In Wyoming and northwestern Colorado, the marine units are various members of the Sundance Formation (Figs. 2 and 29A, B). In northern Utah, equivalent marine rocks are the Curtis Member of the Stump Formation. Southward, marine, sabkha, or lacustrine units overlying the Entrada include the Curtis, Summerville and Wanakah Formations, the latter including the Todilto Limestone Member.

The isopach patterns (Fig. 27) illustrate the pronounced westward thickening of the Entrada erg system toward the Utah–Idaho trough, and an eastward thinning of the system across the craton to the irregular pinch-out along a north–south line in eastern Colorado. Superimposed on this overall trend, the isopach patterns reflect tectonic elements that were active at the time of deposition (Fig. 20).

Extending eastward at high angles to the trend of the Utah–Idaho trough are elongate troughs and basins. These include the Uinta Mountain trough, ancestral Uinta basin, an unnamed basin, the Circle Cliffs trough and the Black Mesa trough. Additional basins are evident eastward on the craton. These include the San Juan basin and a basin in east-central New Mexico.

Areas of relative uplift marked by thinning strata are also evident. Most evident are the elements of the Ancestral Rockies (Front Range and Uncompahgre positive areas) where isopach patterns show a thinning toward these elements. An unnamed high bisects the San Juan basin. The Defiance uplift, Monument bench, and an unnamed high in central Utah are evident from thinning of strata over them.

Facies patterns within the main body of the Entrada system are complex (Fig. 27). In general, there is a westward decrease in the percent of cross-stratified sandstone. Strata consisting of over 75% eolian cross-strata occur east of the Utah–Colorado border and east of the San Juan basin in southwestern Colorado and New Mexico. Similarly high percentages of cross-stratified sandstones occur near the outcrop limits in west-central New Mexico, southernmost central Utah and north-central Arizona. The general trend toward less eolian cross-strata westward is also disrupted by the presence of silty sandstone (beds at Baby Rocks) west of the Defiance uplift. Low percentages of eolian cross-strata occur in the southeastern part of the map area within the margins of the unit but near its pinch-out, and adjacent to elements of the Ancestral Rockies. Adjacent to the western portion of the eolian system are large quantities of mudstone. Here the Entrada Sandstone grades laterally into the Preuss Formation.

Aspects of depositional environments of the Entrada Sandstone have been studied in part (Kocurek, 1981; Vincellet and Chittum, 1981; Kocurek and Dott, 1983; Rubin and Hunter, 1983; Lucas et al., 1985; Peterson, 1986; Condon and Peterson, 1986), but, as with most of the eolian units of the western United States, a detailed, regional synthesis has not yet been attempted. Complex facies changes and vertical and lateral differences in the style of cross-strata occur across the region. In a broad view, however, regional patterns are evident. The main body of the Entrada consists of erg–sabkha–shallow marine deposits. Parts of the system represented primarily by eolian dune deposits occur in Colorado and eastern New Mexico; sandy, silty-sandy, sabkha-shallow marine deposits characterize the westernmost portions of the system. Between these facies are units characterized by alternating cross-stratified and flat-bedded deposits. Flat-bedded deposits almost certainly represent thick interdune deposits and inland sabkhas. Areas also marked by the accumulation of primarily dune cross-strata occur near the southern limits of the outcrop in north-central Arizona and western New Mexico. These outcrops mark a southern, inland erg that extended an unknown distance southward toward the volcanic arc. A possible inland sabkha deposit extends around the north and east flanks of the Defiance uplift and is represented by the beds at Baby Rocks. Flat-bedded units present in areas adjacent to the Ancestral Rockies and on the High Plains probably represent sand-sheet and alluvial systems. Judging by the thinning of strata toward the Ancestral Rockies and the facies change from dune to sand-sheet deposits, parts of the Front range and Uncompahgre Plateau formed positive features during Entrada time.

Middle Jurassic IV

Figure 28 and accompanying cross-sections (Fig. 29C, D, E, F) illustrate the thickness and distribution of the upper member of the Entrada Sandstone in west-central Utah, the Cow Springs Member of the Entrada Sandstone in Arizona and New Mexico, and the sandstone at Mesita in New Mexico.

The upper member of the Entrada Sandstone represents an eolian sandstone depocenter that overlies largely sabkha deposits of the middle member of the Entrada Sandstone. The upper member is unconformably overlain by marine deposits of the Curtis or Summerville Formations or the Romana Sandstone, and may be at least equivalent to the upper part of the middle member of the Entrada Sandstone elsewhere. The upper member of the Entrada Sandstone largely occupies the Circle Cliffs basin or trough, with an isopach pattern similar to that of the underlying lower and middle members. Lateral relationships of the upper member are poorly understood, largely because much of the unit was removed prior to deposition of overlying rocks but also because many critical areas are concealed or were removed by erosion (Fig. 28).

The Cow Springs Member of the Entrada has been recognized as a distinct unit within the Entrada (Peterson, in press). The unit retains formation status in the southern San Juan basin pending additional studies. As seen in Fig. 29E, the Cow Springs forms a northwest–southeast elongate body. Progressing northwestward the member apparently grades into the upper part of the middle member of the Entrada Sandstone in north-central Arizona. The northeastern boundary of the Cow Springs is a facies change primarily into silty mudstones of the Wanakah Formation. The Cow Springs is broadly interpreted as a later-phase erg of the Entrada Sandstone that existed inland from sabkha or restricted marine deposits represented by the Wanakah Formation or middle member of the Entrada. Its distribution may partly reflect the nature of preservation beneath the J-5 unconformity. Facies patterns within the Cow Springs show a clear northeastward decrease in the percentage of cross-stratified sandstone toward facies change into the Wanakah Formation.

The sandstone at Mesita (Condon, 1985a, b; Condon and Peterson, 1986) is a predominantly eolian unit in the southeastern San Juan basin of northwestern New Mexico that was formerly assigned to the Bluff Sandstone (Rapaport et al., 1952) or to the Bluff and Zuni Sandstones (Maxwell, 1976, 1982). The Mesita is divided into lower and upper parts (Condon, 1985a, b) that we here tentatively correlate with the Cow Springs Sandstone and the Recapture Member of the Morrison Formation, respectively; this relation is reflected in the isopach map (Fig. 28).

Middle Jurassic V

Following O'Sullivan (1980a, b, 1981a, b) and O'Sullivan and Pierce (1983), the Moab Tongue of the Entrada Sandstone is distinguished by bedding style from the underlying and laterally adjacent Slick Rock Member. The Moab Tongue consists of one to a few large sets of cross-strata, and the Slick Rock Member consists of interbedded thin sets of cross-strata and silty, red, flat-bedded units. Using this criterion, the Moab Tongue is restricted to a fairly small part of southeastern Utah. Earlier, Wright et al. (1962) used different, but now considered unreliable, criteria to trace the Moab Tongue into southwestern Colorado.

The Moab Tongue reaches a maximum thickness of about 34 m along the northeast side of the Monument uplift (Fig. 30). To the northwest, the tongue is replaced laterally by red beds in the lower part of the lower Summerville Formation of McKnight (1940), now the Curtis Formation (Fig. 29C). Here the Moab Tongue is overlain by the restricted marine Summerville Formation, and separated from the Slick Rock Member by the lowermost lower Summerville Formation of McKnight (1940). This lower tongue of Summerville pinches out eastward so that the Moab Tongue directly overlies the Slick Rock Member. Southeastward, most of the Summerville that lies above the Moab is truncated by the J-5 unconformity. O'Sullivan (1980b) showed that Summerville redbeds overlying the Moab are truncated eastward by the sub-Morrison unconformity. However, more recent but as yet unpublished work by R.B. O'Sullivan (pers. commun., 1986) indicates that a thin part of the Summerville does continue eastward to merge with similar redbeds at the top of the Wanakah Formation in southeastern Utah. Hence, the Moab is succeeded by restricted marine, sabkha, or tidal-flat(?) deposits.

In the northeastern portion of the outcrops, the Moab Tongue grades into the Slick Rock Member (Fig. 29C). Similarly, to the south the tongue breaks into numerous cross-stratified and flat-bedded units included in the Slick Rock Member. At the southern localities, a thin wedge of the Wanakah Formation lies on the Moab Tongue and separates it from the overlying J-5 unconformity.

The Moab Tongue represents a small coastal erg that lay adjacent to the Curtis Seaway to the north and west. The erg prograded or retreated in response to transgression or regression of the Curtis Seaway. The relation between the Slick Rock erg and the Moab erg is not clear. Although eastern and southern beds equivalent to the Moab are included in the upper part of the Slick Rock Member, the distinction is based on mapable criteria and is not necessarily genetic. Where the two units are distinguished, the distinctly different bedding styles described above indicate different erg environments. To the west of the Green River in Utah, the J-3 unconformity occurs at this stratigraphic position, but it has not been recognized where the Moab Tongue overlies the Slick Rock Member. The question, therefore, can be posed as two alternatives: (1) the Slick Rock erg persisted to the east and south through deposition of the Moab erg and the bedding change from the Slick Rock to the Moab reflects a lateral change in eolian processes; or (2) the Moab erg was later and distinct from the Slick Rock erg, and the bedding change from the Slick Rock to the Moab reflects a vertical change in eolian processes. The position of the Summerville and Wanakah Formations conformably overlying the Moab Tongue suggests that the Moab erg was terminated by a marine transgression.

Middle Jurassic VI eolian deposits

Eolian strata of late Middle Jurassic age, other than the slightly older Moab Tongue of the Entrada Sandstone, are present in the Romana Sandstone, which is the youngest formation of the San Rafael Group in south-central Utah and north-central Arizona (Fig. 31; Peterson, in press). The Romana is a southern sandstone facies of the Summerville Formation and both are unfossiliferous but considered late Middle Jurassic (late Callovian) in age based on regional relationships with fossiliferous strata farther north (Imlay, 1980). Tabulated data used for this study are given in Table 6 and the data points are shown on Fig. 21.

The Romana was deposited in marginal marine and continental environments at the southern end of the Summerville sea, a large marine embayment that extended southward across Utah and into northernmost Arizona. Eolian strata are only present in the upper part of the Romana in the southwestern part of the Kaiparowits Plateau in south-central Utah (Fig. 32).

The Romana Sandstone occupies a structural trough or basin that coincides fairly well with the present-day Kaiparowits structural basin (Peterson, 1986). At the base, the formation contains a red mudstone or siltstone marker bed that is a tongue of the Summerville Formation. The tongue marks the greatest extent of the Summerville seaway into southern Utah and northernmost Arizona (Peterson, in press). The red marker bed pinches out by onlap on the flanks of the trough, indicating flexing of the trough, probably just before as well as during deposition of the formation. Regional studies indicate that the red mudstone marker connected with Summerville red beds to the northwest and that the Kaiparowits region was a structural trough open to the northwest at this time (Peterson, 1986). However, the same studies also indicate that a closed basin developed by uplift along the northwest flank of the basin during the erosion interval that resulted in the J-5 unconformity. Deformation continued after deposition throughout the basin, though, as the peripherally wedging form of the entire formation suggests (Fig. 31). Romana eolian deposits are only present on the southwest flank of the Kaiparowits trough.

Eolian beds in the Romana constitute a progradational wedge on the southwest side of the marine embayment and were deposited during withdrawal of the seaway. The formation as well as the eolian beds within it are truncated southwestward beneath the J-5 and sub-Dakota unconformities, making it difficult to hypothesize the original extent of the dune field although the following line of reasoning suggests that the field was fairly small. The eastward extent of the eolian beds was against the seaway; the westward extent may have been the Echo Cliffs–Kaibab uplift, which is known to have been a positive structural element at this time (Peterson, 1986). The non-eolian part of the Romana contains coarse sand, granules and small pebbles (chert and scarce quartzite) as much as a centimeter in diameter and

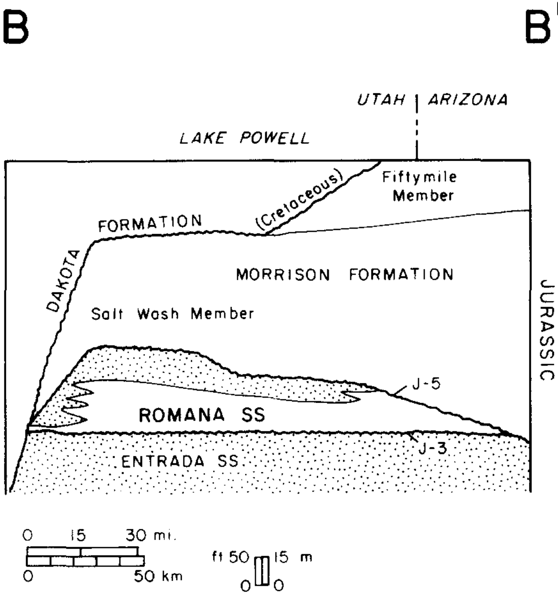


Fig. 32. Restored cross-section of Middle Jurassic VI eolian deposits of the Romana Sandstone. Location shown on Fig. 21.

the size of this material increases westward or landward (Peterson, in press). The coarse material is thought to have been carried into the region by streams although fluvial channel deposits have not yet been identified in the formation. The coarse material must have come from west of the Echo Cliffs–Kaibab uplift as the Entrada Sandstone, the formation exposed on the uplift at this time, does not contain such coarse material. Additionally, the sand in the eolian deposits of the Romana is slightly coarser than the sand in the Entrada, indicating that the Entrada was not the only source of sand in the Romana dune field.

All of these features suggest that streams flowing from a highland source region far to the west, perhaps off the Colorado Plateau, carried sand, granule, and small pebble-sized debris into south-central Utah. There, westerly winds (documented in Peterson, this volume) picked up some of the finer constituents and transported them farther eastward to form the Romana dune field along the shoreline of the Summerville seaway and on the west side of the structural and topographic low that lies east of the Echo Cliffs–Kaibab uplift. The western limit of the dune field may have been governed not only by the uplift but also by the streams, which may have had sufficient energy to remove much if not all of the eolian sand that might have accumulated in their pathways. The southern extent of the dune field is unknown as the beds have been removed by erosion in that direction. The northward extent of the dune field is unknown because the formation is truncated northward in the western part of the Kaiparowits basin (Peterson, 1986). However, no eolian strata are present farther north where approximately age-equivalent continental beds are present in the Summerville Formation (Peterson, in press). Thus, the available evidence suggests that Romana eolian deposits formed a narrow belt, perhaps of limited extent, along the shoreline of the Summerville embayment. This argument also suggests that the Romana coastal dune field was smaller than most of the other units discussed in this paper.

A southwestward increase in percent eolian sandstone in the Romana is shown on Fig. 31. Although this is probably a fair indication of the original trends of eolian sandstone content in the formation, the map is somewhat misleading. The Romana was abruptly beveled southwestward by the J-5 and sub-Dakota unconformities and this resulted in southwestward removal of eolian beds, which lie in the upper part of the Romana, before the underlying non-eolian beds were truncated. With this in mind, the percent of eolian sandstone in the original formation probably would have increased southwestward at a greater rate than indicated on the map. The round northeastward bulge of the contour lines may also be a partial reflection of truncation of eolian beds at the top of the Romana beneath the J-5 and sub-Dakota unconformities and the somewhat arcuate shape of the southwest flank of the Kaiparowits basin or trough.

Upper Jurassic eolian deposits

Introduction

Upper Jurassic eolian strata are present in the Morrison Formation or related strata that lie between the J-5 unconformity and overlying Cretaceous rocks. The most extensive eolian beds or areas known to contain them are present in four broad areas in the Western Interior that are described and discussed in succeeding paragraphs. Considerably smaller eolian beds or lenses are present elsewhere in southern Utah and southwestern Colorado (Peterson, 1980) but they are not included in this study owing to their small areal extent. According to Imlay's (1980) regional studies, these beds are Late Jurassic (late Oxfordian, Kimmeridgian and early Tithonian) in age. The data for constructing the isopach maps are given in Table 6; the isopach and facies map is Fig. 34, and the location of data points is on Fig. 21. Late Jurassic tectonic elements varied somewhat from the Middle Jurassic and are shown on Fig. 33. Restored cross-sections of this interval are shown on Fig. 35.

Unkpapa Sandstone

The Unkpapa Sandstone is on the east flank of the Black Hills in western South Dakota (Fig. 34) and is a likely correlative to basal Morrison sandstone beds on the west side of the Black Hills (Robinson et al., 1964, p. 20). The bedding in this package of beds has been largely or entirely obliterated in most places by unknown causes. Despite these problems, field and petrographic studies by Szigeti and Fox (1981) left the conclusion that it is predominantly eolian in origin. The Unkpapa interfingers with the Morrison Formation and is so closely related to it that Szigeti and Fox (1981) felt it should be considered a member of the Morrison.

The Unkpapa Sandstone and presumably correlative sandstone beds at the base of the Morrison Formation are on the flanks of the Black Hills uplift in western South Dakota and eastern Wyoming (Figs. 34 and 35A). Correlation with basal Morrison sandstone beds on the northwest flank of the uplift is not certain but seems reasonable (Robinson et al., 1964). As contoured from the available surface information, the Unkpapa and related units are restricted to the structural high marked by the Black Hills uplift, a structural feature known to have been active in Jurassic and Cretaceous time (Robinson et al., 1964). Studies by McKee et al. (1956) and Szigeti and Fox (1981) suggest that the sandstone continues southeast from the Black Hills, but whether or not it is eolian in that area has not, to our knowledge, been determined.

The Unkpapa dune field apparently was surrounded by lacustrine environments represented by mudstone layers in the Morrison Formation (Szigeti and Fox, 1981). As the region subsided, the dune field was inundated and eventually covered by lacustrine deposits. Destruction of bedding in the formation may have been caused by chemical reactions between the lacustrine waters and labile grains or possibly by burrowing organisms.

Judging from descriptions in the literature, the percent of eolian sandstone is highest (as much as 35%) in the southern part of the Black Hills (Fig. 34). The thickest part of the Unkpapa (69 m) is in this general area and the rocks probably lay above the level of Morrison lake waters for a longer time than surrounding areas. Thus, if destruction of some of the sedimentary structures is related to chemical reactions with lake waters, the relatively high percentages of cross-bedded sandstone in this area might reflect nothing more than less time in contact with the lake waters.

Central Wyoming eolian deposits

Scattered eolian sandstone lenses are present in the lower part of the Morrison Formation throughout a large part of central Wyoming. These units were not recognized until recently and studies on them are still in progress (D.M. Uhlir, pers. commun., 1986); hence, an adequate isopach map could not be constructed. However, a map showing the approximate area in which these eolian sandstone bodies have been found is given in Fig. 34. The area outlined on this map was found by preparing an isopach map of the lowest sandstone unit in the Morrison Formation from the available literature (none of which indicated the depositional environment) and, where necessary, adjusting this to fit the distribution of cross-bedding dip-vector resultants obtained from the eolian units and kindly furnished by D.M. Uhlir (pers. commun., 1986) or obtained by one of us (FP; see Peterson, this volume, for the distribution of the resultants). The isopach map is not included in this report because the data are inadequate and misleading. The eolian beds are at or near the base of the Morrison Formation and generally lie in depositional contact on the Windy Hill Member, the youngest unit in the Sundance Formation (Fig. 35A). The J-5 unconformity is at the base of the Windy Hill and the Windy Hill interfingers with Morrison strata (Pipiringos, 1968), making that member more closely related to the Morrison than to the rest of the Sundance. The relationship of the eolianites to the Unkpapa Sandstone and related beds around the Black Hills is not clear although stratigraphic position low in the Morrison Formation and near the J-5 unconformity demonstrates that they are equivalent or nearly equivalent in time. The configuration of the central Wyoming eolianites and the Unkpapa as well as its Black Hills correlatives might be interpreted as an indication that a structural downwarp lay between these two areas. Instead, we suggest that this reflects a lack of data in the Powder River basin and may or may not relate to structural downwarping there.

Bluff Sandstone Member of Morrison Formation and Junction Creek Sandstone

The Bluff Sandstone Member of the Morrison Formation along with its correlative—the Junction Creek Sandstone—is part of a large eolian sandstone complex on the east side of the Colorado Plateau (Figs. 34 and 35B). The name Bluff Sandstone Member is used for the part of this complex in southeastern Utah and northeasternmost Arizona, whereas the name Junction Creek Sandstone is used for essentially the same stratigraphic unit in southwestern Colorado and northwesternmost New Mexico. Equivalency of the two units and their continuity as a single entity has been recognized ever since Goldman and Spencer (1941) established the Junction Creek as a separate formation. The Bluff is Late Jurassic (late Oxfordian–Kimmeridgian Ages) because it intertongues with the Tidwell and Salt Wash Members of the Morrison Formation (also of late Oxfordian and Kimmeridgian Ages according to Imlay, 1980). Because of their time-equivalency, the Junction Creek must be of the same age. Thus, an indication that the Junction Creek is late Middle Jurassic in age (late Callovian Age) by Imlay (1980, p. 75) is in error. Bluff has priority of nomenclature (Baker et al., 1936) over Junction Creek (Goldman and Spencer, 1941) but thus far no one has suggested dropping Junction Creek and applying the name Bluff to the entire complex.

The Bluff–Junction Creek eolian complex is highly irregular in plan view and reaches its greatest thickness of 131 m in southwestern Colorado, but three other thick areas are on lobes that extend south, west and northeast from there (Fig. 34).

For the most part, the relationship of the eolian complex to active structures is indirect as it tends to lie in intermediate areas between structural lows and highs. An exception is the northeast lobe, which tends to be thickest on top of the Late Jurassic Uncompahgre uplift. The westernmost part of the eolian complex lies just east of the southern part of the Monument uplift where stratal relationships with the Salt Wash Member of the Morrison suggest that vertical movement on the uplift played a role in determining the location of at least the western part of the dune field.

The Salt Wash Member of the Morrison Formation was deposited by streams that flowed northeastward and eastward, entering the Colorado Plateau province from the west and southwest and forming a broad alluvial complex across the middle of the Colorado Plateau. Lack of Salt Wash fluvial strata above the thickest part of the Bluff (O'Sullivan, 1965) indicates that the streams divided and flowed around the Bluff dune field, but it seems unlikely that unconsolidated dune sands could have withstood the erosive power of Salt Wash streams without some agent other than the sheer bulk of the dune field to divert the streams. The Monument uplift was an active structural element during all of the Jurassic Period and played a significant role in influencing the distribution of Morrison sediment (Peterson, 1984, 1986). Positive movement in the Monument region resulted in a topographic high in the southern part of the uplift. The high divided the Salt Wash alluvial complex into two lobes that extended eastward on either side of the Bluff dune field, which lay just east of the Monument topographic high (Peterson and Tyler, 1985). The dune field

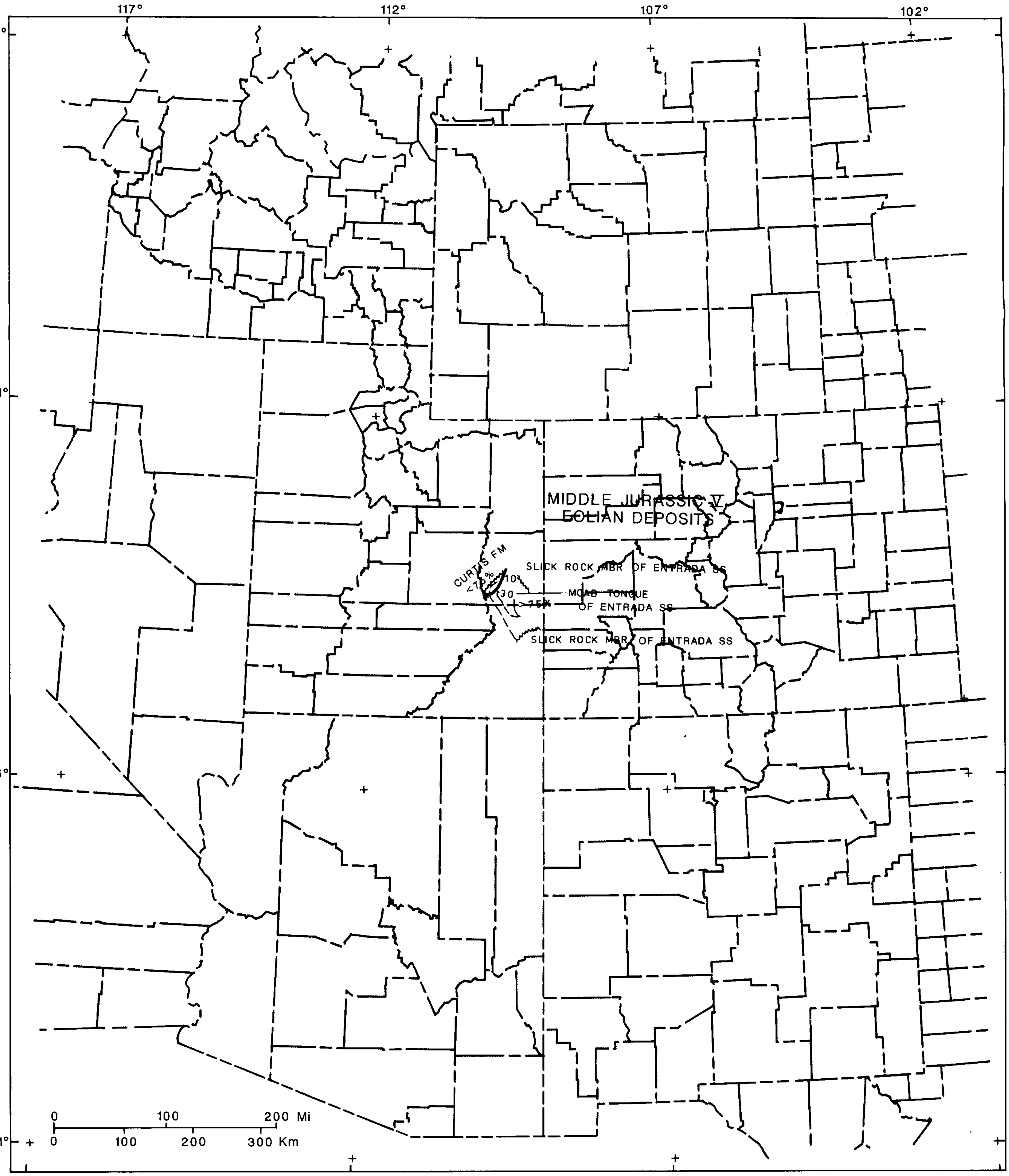


Fig. 30. Geometry and facies relations of Middle Jurassic V eolian deposits. Heavy lines show approximate percentage of eolian sandstone. Isopach interval 10 and 20 m. Solid lines where outcrops occur; dashed lines where interval in subsurface or removed by erosion.

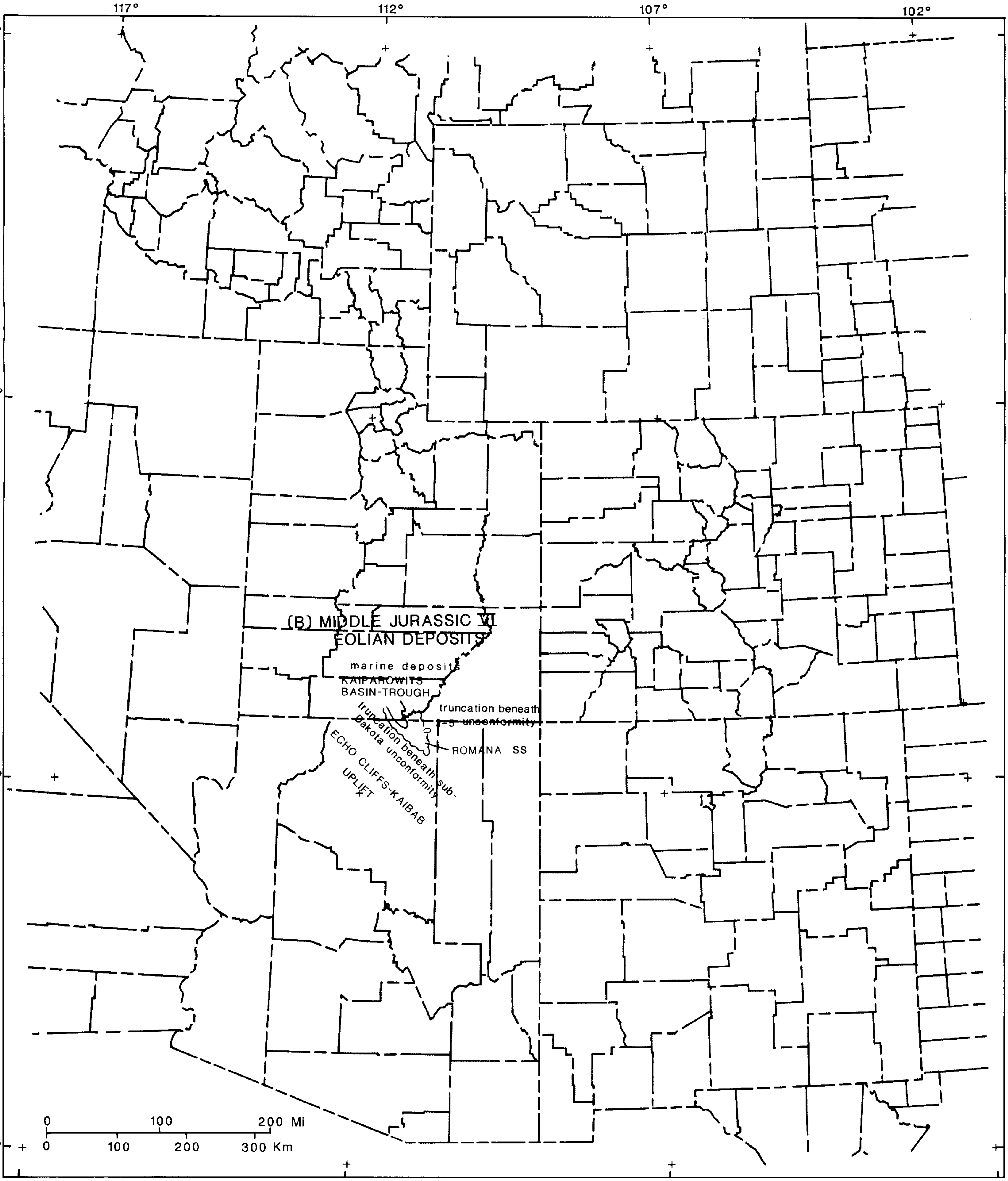


Fig. 31A. Geometry of Middle Jurassic VI eolian deposits. Isopach interval 30 m. Solid lines where outcrops occur; dashed lines where interval in subsurface or removed by erosion.

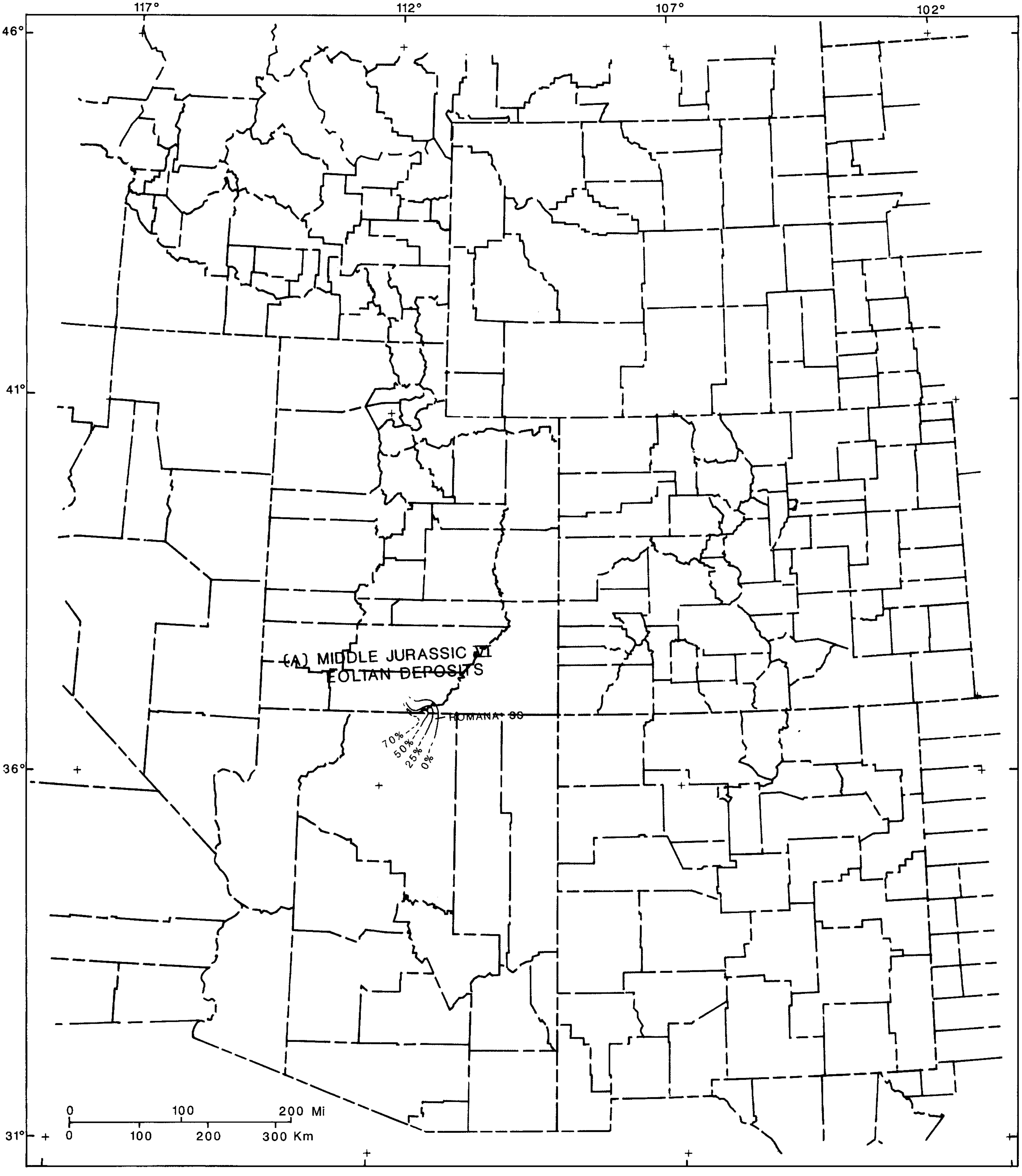


Fig. 31B. Facies relations of Middle Jurassic IV eolian deposits. Isopach interval 30 m. Solid lines where outcrops occur; dashed lines where interval in subsurface or removed by erosion.

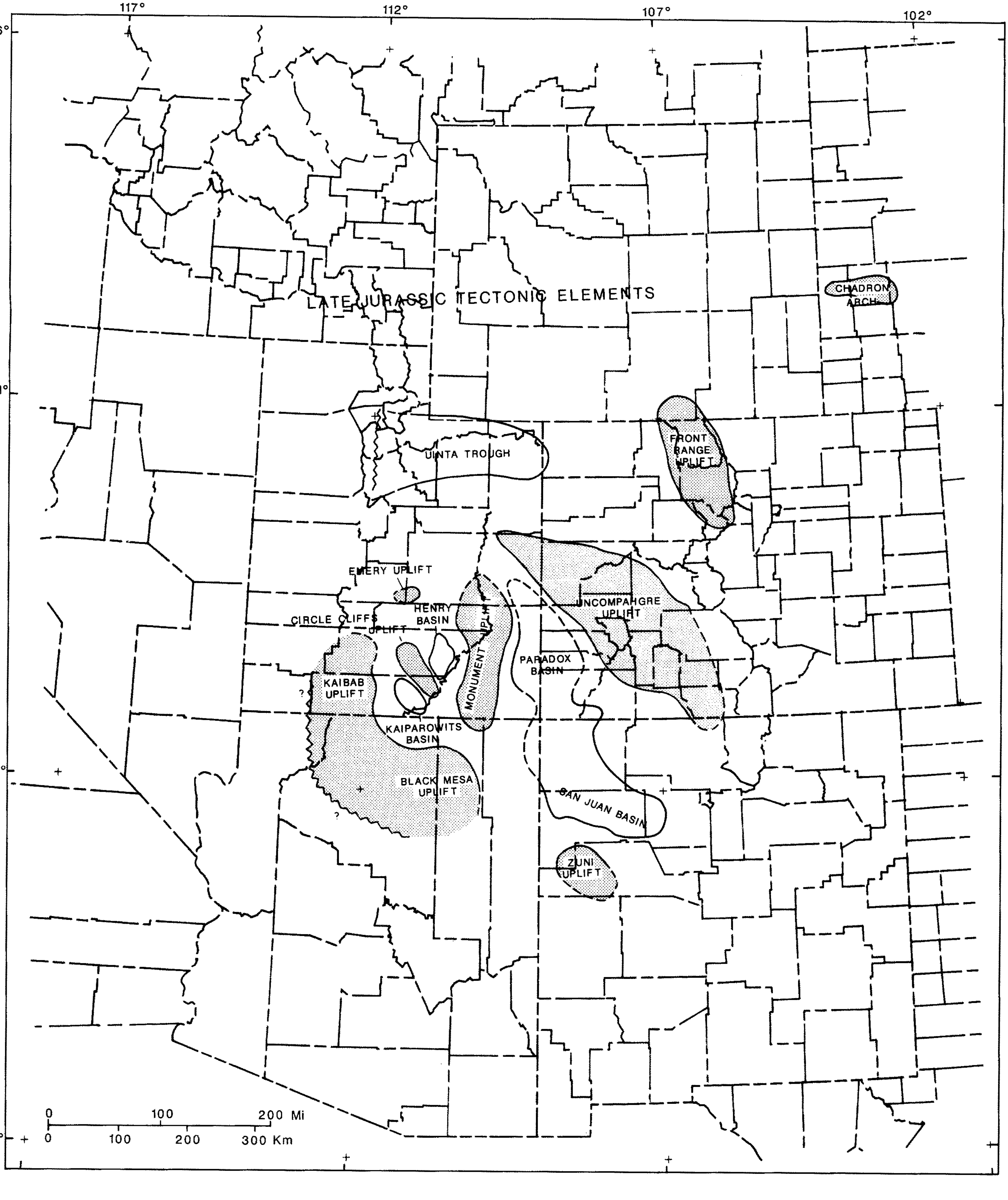


Fig. 33. Generalized Late Jurassic tectonic elements that influenced sedimentation of Morrison-age eolian deposits. Boundaries are approximate and varied through time.

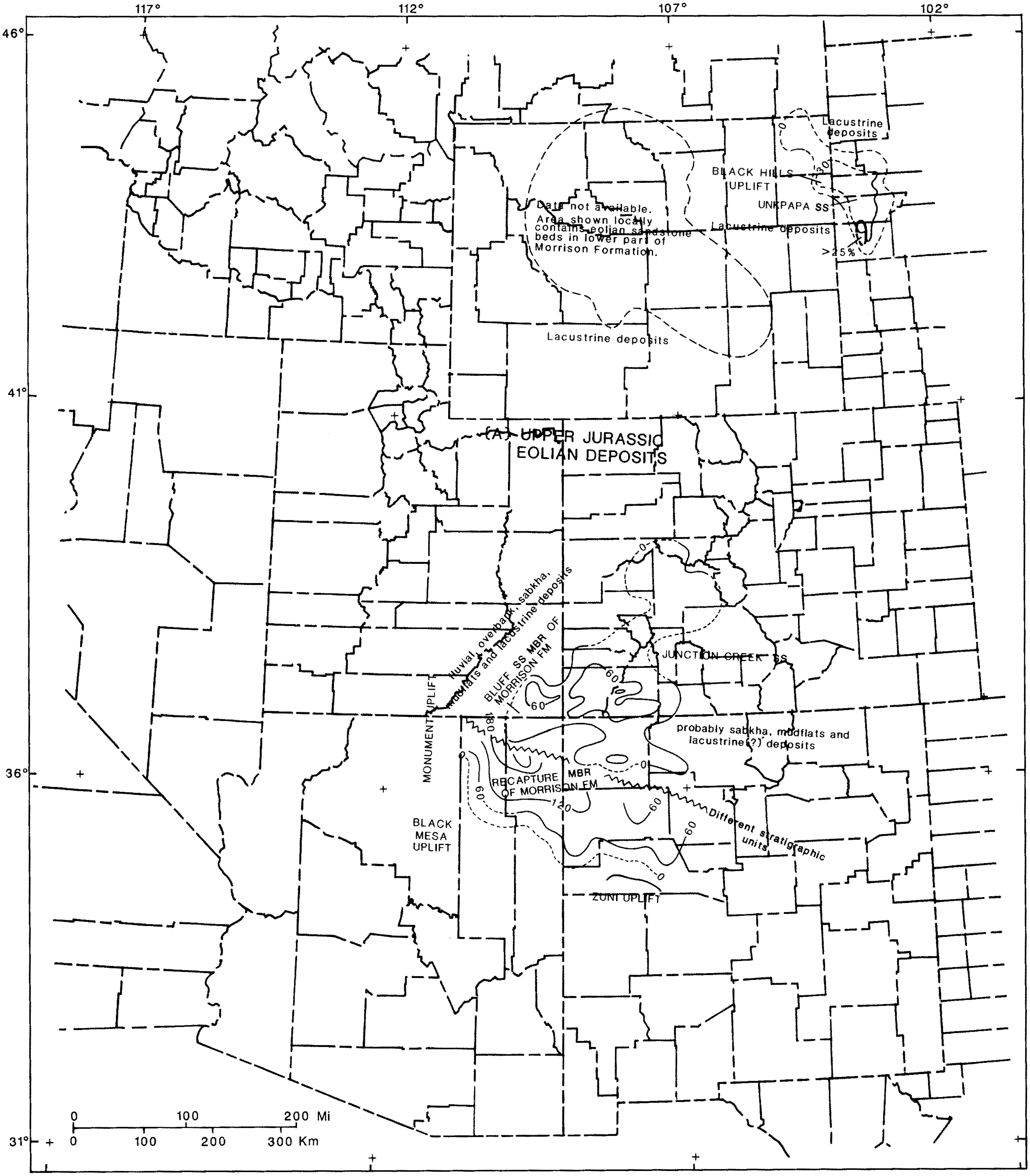


Fig. 34A. Geometry of Upper Jurassic eolian deposits. Detailed regional correlation uncertain. Isopach interval 30 and 60 m. Insufficient data to contour deposits in central Wyoming. Solid lines where outcrops occur; dashed lines where interval in subsurface or removed by erosion.

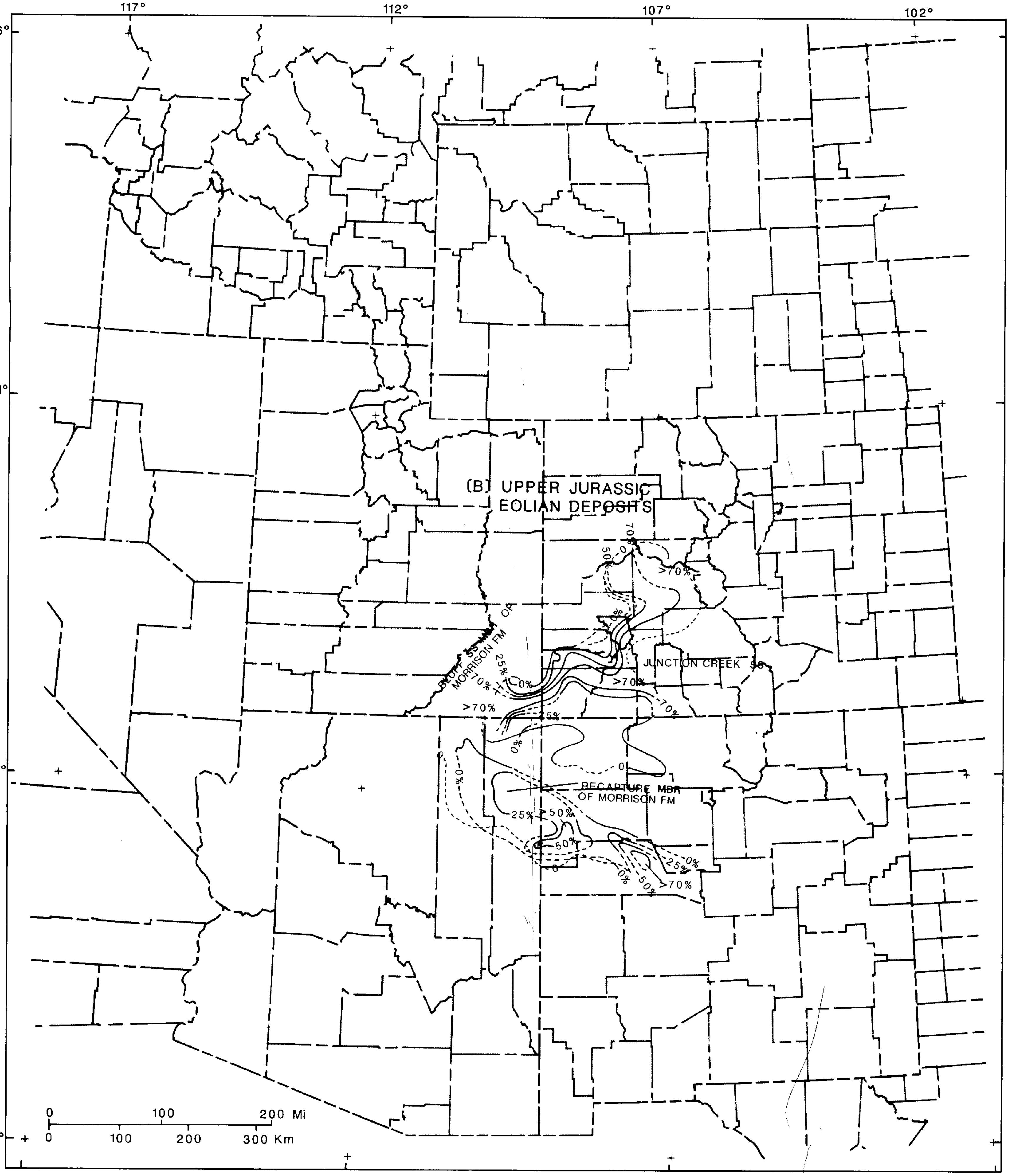


Fig. 34B. Facies relations in Upper Jurassic eolian deposits. Detailed regional correlation uncertain. Isopach interval 30 and 60 m. Insufficient data to contour deposits in central Wyoming. Solid lines where outcrops occur; dashed lines where interval in subsurface or removed by erosion.

lay in a sheltered lowland area protected from Salt Wash fluvial processes by the Monument high. Westerly to southwesterly winds transported the eolian sand (Peterson, this volume), indicating that it was derived largely from the Salt Wash alluvial complex farther west. The topographic high also produced a turbulent area on its leeward side that favored the accumulation of wind-borne sand. The structurally deepest part of the Late Jurassic San Juan basin lay a few tens of kilometers south of the Bluff–Junction Creek eolian complex (Santos and Turner-Peterson, 1986), so the sand accumulated on a structural slope or bench on the northern flank of that basin. This compares well with the structural-topographic setting of the Permian Schnebly Hill–De Chelly eolian-bearing sequence on the sloping flank of the Holbrook basin.

The area of highest percentages of crossbedded sandstone in the Bluff–Junction Creek forms a sinuous belt extending northeastward from the Monument high in southeastern Utah (Fig. 34). The belt lies roughly parallel to wind flow (Peterson, this volume) and tends to lie either along the thickest part of the complex or on the downwind side of the northeast-trending lobe of the complex. Although the Bluff and Junction Creek are readily identified on drill hole logs, no attempt was made to interpret the percent of eolian sandstone from

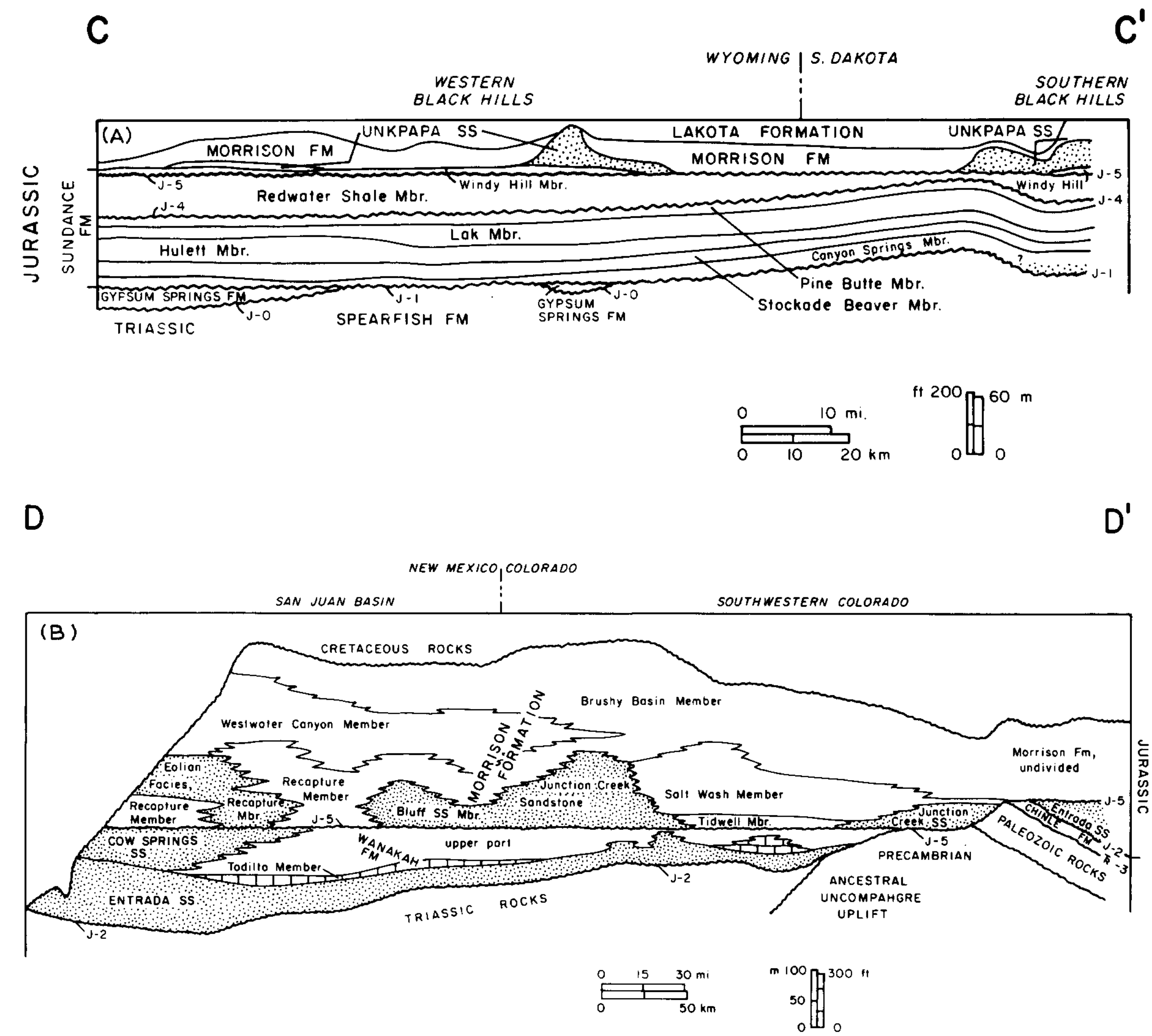


Fig. 35. Restored cross-sections of Upper Jurassic eolian deposits of the Morrison Formation. Locations shown on Fig. 21.

the logs so the contour lines are not extended into the subsurface.

Recapture Member of Morrison Formation

Eolian strata are most abundant in the lower part of the Recapture Member of the Morrison Formation in the southern part of the Colorado Plateau (Figs. 34 and 35B), although scarce lenses occur higher and, at one locality in the southern part of the San Juan basin, a small lens is at the top of the member. Because many Recapture eolian beds are lenticular and irregularly distributed, they could not be readily distinguished as a separate entity that could be isopached by itself. For this reason, the thickness of the entire member is depicted on Fig. 34. Because some of the eolian beds are at a stratigraphically higher position than the Salt Wash Member, eolianites in the Recapture are late Oxfordian, Kimmeridgian and early Tithonian in age (Imlay, 1980), ranging slightly younger than those in the Bluff–Junction Creek complex.

The method of depicting the percent cross-bedded eolian sandstone is different on this map than for the other units in this study where the percentages are based solely on surface measurements. Recapture measurements made at the surface show the percent cross-bedded eolian sandstone reported in the literature but, because it was felt that the underground extent of the eolian beds should be shown, subsurface drill hole logs had to be used even though they are not entirely satisfactory and the results obtained from them are not directly comparable to surface measurements. The percentages obtained from the logs were based on electric-log characteristics of the eolian beds, which have a blocky pattern (low SP and high resistivity) reflecting higher porosity of the eolian sandstone compared to that in fluvial and overbank sandstone. A distinction between cross-bedded and flat-bedded sandstone cannot be made by this method so the values obtained are considered maximum possible values of eolian sandstone in the Recapture. Although this method has its obvious drawbacks, it yields a reasonably accurate indication of the extent of the eolian strata.

Where studied, the Recapture reaches a maximum thickness of at least 207 m in northeastern Arizona (Fig. 34). Abrupt southwestward thinning reflects beveling beneath the early Late Cretaceous Dakota Formation. The entire extent of the member was not studied as only the part shown on the map contains eolian strata.

The percent cross-bedded eolian sandstone decreases northeastward, southwestward and northwestward, reflecting both facies changes and post-depositional beveling (the member is beveled by Cenozoic unconformities to the southeast). The northeast and northwest drop in percentages reflects loss of eolian sandstone in those directions where the eolian strata grade into beds interpreted as fluvial, overbank floodplain, mudflat and lacustrine in origin. Northeastward gradation into non-eolian deposits most likely reflects subsidence along the axis of the ancestral San Juan basin, whose structurally deepest part lay between the eolian deposits of the Recapture and Bluff–Junction Creek ergs in Jurassic time (Santos and Turner-Peterson, 1986). Presumably, wetter environments inimical to eolian sedimentation existed there as a consequence of the structural and related topographic setting.

Interpretation of the southwestward reduction in values is obscured by southwestward regional beveling beneath the Dakota Sandstone. The greater part of the Recapture dune field lay in the area between the Zuni uplift to the southwest and the deepest part of the San Juan basin to the northeast and its location was determined, partly or largely, by these structural elements. Additionally, the Zuni and Black Mesa uplifts appear to have sheltered the dune field from any northward-flowing streams that might have flowed toward the San Juan basin from the Mogollon highland in south-central Arizona.

Recapture eolian beds lie east and downwind from the Late Jurassic Black Mesa and Zuni uplifts in northeastern Arizona (Peterson, 1986; and this volume) and northwestern New Mexico. The upwind position of these structures appear to have played an important role in the genesis of the dune field, both by diverting streams from the site of the dune field and by providing sufficient topographic relief to disrupt atmospheric circulation patterns and foster the accumulation of dune sand farther east.

Conclusions

Late Paleozoic and Mesozoic erg deposits of the Western Interior dominate much of the "great sand pile", especially on the south-central Colorado Plateau. Apparently sand was fed into the region from the north by northerly winds, westerly flowing rivers, and southerly flowing coastal currents. The ergs initiated, expanded, and waned in response to tectonic, climatic and eustatic events. In terms of present distribution, maximum extent was during the Wolfcampian, Early Jurassic and Middle Jurassic time. With the exception of the latest Permian, Early, Middle and early Upper Triassic, eolian deposits occur somewhere across the region at any given defined interval of time. Such widespread and continuous deposition of eolian sediments is unique, in our experience, in the stratigraphic record.

We hope that this paper provides a service to both those wanting an introduction to eolian depositional systems of the Western Interior and those familiar with the overall stratigraphic and depositional framework. We have attempted to summarize the currently available data for these units, both published and unpublished. Our conclusions and brief discussions are based on great volumes of data, much of which could not be presented or illustrated because of space limitations. If one message or thought is left with the reader, we hope it will be that eolian depositional systems are very complex and that most are in need of additional detailed study. The stereotype of clean, widespread, uniform eolian formations is unrealistic. Margins range from complex, vertically stacked facies changes to thinning tongues or wedges of eolian sandstone. Although a few margins represent simple onlap–offlap pinch-outs, most are associated with facies changes to non-eolian deposits.

Correct reconstruction of facies relations and geometric configuration of erg intervals is critical to interpretation of ancient eolian sequences. The major goal of this paper is to present this information so that the depositional history, paleogeography and paleotectonics of the sedimentary rocks of late Paleozoic and Mesozoic age across the Western Interior can be more fully understood.

Acknowledgments

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TABLE 1

Methodology used in construction of each isopach

Erg interval or name	Isopached interval and comments
Pennsylvanian erg deposits	For Tensleep, Weber and Quadrant Sandstones, isopachs show thickness of those units as currently defined by previous workers. Base of interval is gradational contact and generally lower several meters varies among workers. Top is major unconformity across most of central and western Wyoming and adjacent Montana. Pennsylvanian top of Weber after Bissell and Childs (1958). Casper Formation interval from lowest sandstone considered eolian to red marker horizon of previous workers.
Wolfcampian erg deposits	For Cedar Mesa and Queantoweap Sandstones, isopachs show thickness of these units as currently defined by previous workers. Both contacts are locally gradational through several meters. In subsurface of central Utah, all quartz sandstone was considered eolian for isopaching purposes, although this is subject to verification. Esplanade Sandstone of Grand Canyon is isopached from base to top of calcareous cross-stratified sandstone of McKee (1982, his fig. P12) and eolian origin for entire interval is subject to verification. Eolian interval shown in Mogollon Rim occurs at top of Esplanade Sandstone and based on McAllen (1984) and unpublished data by Blakey. Includes Permian parts of Weber, Casper, and Minnelusa Formations from lowest eolian rocks above the red marker bed to highest eolian rocks. Includes Ingleside Sandstone of previous usage.
Leonardian I erg deposits	For De Chelly Sandstone, entire unit on Monument Upwarp; White House member of Peirce (1964) on Defiance Plateau. For Schnebly Hill Formation from base of lowest eolian sandstone to base of Coconino Sandstone. Supplementary contour shows thickness of entire formation in Holbrook Basin.
Leonardian II erg deposits	Includes Type Coconino Sandstone of Grand Canyon and lower Coconino Sandstone in Sedona area as defined in this report. East of line on Fig. 10 includes entire Coconino and Glorieta Sandstones.
Leonardian III erg deposits	Includes Lyons Sandstone as recognized by previous workers. Includes eastern phase of Toroweap Formation (Rawson and Turner-Peterson, 1980) and coeval rocks; White Rim Sandstone of Utah as currently defined; upper Coconino Sandstone of Sedona area as herein defined.
Wingate Sandstone	Includes entire Wingate Sandstone north and west of Kayenta, Arizona; Lukachukai Member south and east of Kayenta (does not include Rock Point Member). Where Dinosaur Canyon Member of Moenave Formation overlies the Lukachukai Member of the Wingate Sandstone, the isopached interval includes *both* units.
Jelm Formation and Rock Point Member	Includes entire thickness of Jelm Formation. Distribution of known and suspected eolian deposits of Rock Point Member of Wingate Sandstone and coeval deposits of Dolores Formation also shown.
Navajo Sandstone, Nugget Sandstone	Includes entire Navajo and Aztec Sandstones and upper eolian portion of Nugget Sandstone (does not include Bell Springs Member). Where Navajo intertongues with Kayenta Formation along southern and southwestern margin of outcrop, thickness of Navajo tongue(s) included but thickness of intervening Kayenta is not included.
Temple Cap Sandstone	Includes thickness of White Throne Member.
Page Sandstone	Includes thickness of Harris Wash and Thousand Pockets Tongues but *does not* include thickness of any intervening Carmel Formation.
Entrada Sandstone and related units	Includes thickness of eolian-bearing intervals within each defined interval, related, units or member. See text for further discussion.
Morrison erg deposits and related strata	Includes thickness of eolian-bearing interval. See text for further discussion.

Key to symbols used in tables: A = incomplete section; B = as modified or defined by Blakey for this report; K = as modified or defined by Kocurek for this report; P = as modified or defined by Peterson for this report; PI = Petroleum Information data cards.

TABLE 2

Data base for Paleozoic eolian deposits

Section No.	Author	Interval	Their designation, section name
1	Bissell, 1969	Wolf, Leon II	Frenchman Mtn, Nev
2	Bissell, 1969	Wolf, Leon II	South Muddy Mtn, Nev
3	Bissell, 1969	Wolf, Leon II	Tramp Ridge, Nev
4	McNair, 1951	Wolf, Leon II	Virgin Mtns, Nev
5	McNair, 1951	Wolf, Leon II	N. Grand Wash Cliffs
6	McKee, 1982 (B)	Wolf	Hidden Canyon
7	Bissell, 1969	Wolf, Leon II	Pakoon Ridge
8	McKee, 1982 (B)	Wolf	Iceberg Canyon
9	McKee, 1982 (B)	Penn, Wolf	Snap Canyon
10	Bissell, 1969	Wolf, Leon II	Grand Wash Cliffs
11	McKee, 1982 (B)	Penn, Wolf	Pigeon Wash
12	McKee, 1982 (B)	Penn, Wolf	Guano Cave
13	Irwin, 1976	Wolf, Leon II	Falcon Seaboard Antelope
14	McKee, 1982 (B)	Penn, Wolf	Twin Springs Canyon
15	McKee, 1982 (B)	Penn, Wolf	Andrus Canyon
16	McKee, 1982 (B)	Penn, Wolf	Parashant Canyon
17	McNair, 1951	Wolf, Leon II	South Hurricane Cliffs
18	McKee, 1982 (B)	Penn, Wolf	Whitmore Wash
19	McKee, 1982 (B)	Penn, Wolf	Toroweap Valley
20	McKee, 1982 (B)	Penn, Wolf	Tuckup Canyon
21	McKee, 1982 (B)	Penn, Wolf	SB Canyon
22	McKee, 1982 (B)	Penn, Wolf	Kanab Canyon
23	McKee, 1933	Leon II	Kanab Canyon
24	Noble 1922	Leon II	Kanab Canyon
25	McKee, 1933	Leon II	Jumpup Canyon
26	McKee, 1982 (B)	Penn, Wolf	Thunder River Trail
27	McKee, 1933	Leon II	Big Springs
28	Rawson and Turner –Peterson, 1980	Leon III	14—Warm Springs Canyon
29	McKee, 1982 (B)	Penn, Wolf	Shinumo Trail
30	McKee, 1933	Leon II Bright Angel	
31	McKee, 1982 (B)	Penn, Wolf	Kaibab Trail North
32	Rawson and Turner –Peterson, 1980	Leon III	5—Kane Ranch
33	Rawson and Turner –Peterson, 1980	Leon III	6—Soap Creek
34	Phoenix 1963	Leon II	Marble Canyon
35	McKee, 1933	Leon II	Marble Canyon
36	Rawson and Turner –Peterson, 1980	Leon III	7—Marble Canyon
37	McKee, 1982 (B)	Penn, Wolf	House Rock Canyon
38	Rawson and Turner –Peterson, 1980	Leon III	8—Marble Canyon
39	Rawson and Turner –Peterson, 1980	Leon III	9—Marble Canyon
40	Rawson and Turner –Peterson, 1980	Leon III	10—Marble Canyon
41	McKee, 1982 (B)	Penn, Wolf	Eminence Fault
42	Irwin et al., 1971	Leon III	11—Marble Canyon
43	McKee, 1982 (B)	Penn, Wolf	Blue Spring
44	McKee, 1982 (B)	Penn, Wolf	Horsetrail Canyon

TABLE 2 (continued)

Section No.	Author	Interval	Their designation, section name
45	Rawson and Turner –Peterson, 1980	Leon III	12—Desert View
46	McKee, 1982 (B)	Penn, Wolf	Bunker Trail
47	McKee 1982 (B)	Penn, Wolf	Grandview Trail
48	McKee, 1933 (B)	Leon II	Kaibab Trail South
49	McKee, 1982 (B)	Penn, Wolf	Kaibab Trail South
50	McKee, 1982 (B)	Penn, Wolf	Hermit Trail
51	Rawson and Turner –Peterson, 1980	Leon III	15—Bass Trail
52	McKee, 1982 (B)	Penn, Wolf	Bass Trail
53	McKee, 1933	Leon II	Powell Plateau
54	McKee, 1982 (B)	Penn, Wolf	Topocoba Trail
55	McKee, 1982 (B)	Penn, Wolf	Havasu Canyon
56	McKee, 1982 (B)	Penn, Wolf	National Canyon
57	McKee, 1982 (B)	Penn, Wolf	Prospect Valley
58	McKee, 1982 (B)	Penn	Separation Canyon
59	McKee, 1982 (B)	Penn	Hindu Canyon
60	McNair, 1951	Leon II	Peach Springs Canyon
61	McKee, 1982 (B)	Penn, Wolf	Blue Mountain
62	McNair, 1951	Leon II	Aubrey Cliffs
63	McAllen 1984	Wolf	Chino Point
64	Blakey, 1979	Penn, Wolf	Picacho Butte
65	Rawson and Turner –Peterson 1980	Leon III	16—Ash Fork
66	Blakey, 1979	Penn, Wolf	Hell Canyon
67	Blakey and Knepp, 1987	Leon I	Chino Valley (the Matterhorn)
68	Blakey and Knepp, 1987	Penn, Wolf	Chino Valley (Bear Canyon)
69	Blakey and Knepp, 1987	Penn, Wolf	Chino Valley (Perkinsville)
70	Rawson and Turner –Peterson, 1980	Leon III	17—Tule Canyon
71	Blakey and Knepp, 1987	Leon I	Sycamore Canyon
72	Blakey and Knepp, 1987	Leon I	Sedona (Loy Butte)
73	Blakey and Knepp, 1987	Penn, Wolf	Sycamore Canyon
74	Blakey and Knepp, 1987	Leon I	Sedona (Hart Well)
75	Blakey and Knepp, 1987	Leon I	Sedona (Capitol Butte)
76	Blakey and Knepp, 1987	Leon I	Sedona (West Scheurman Mtn)
77	Blakey and Knepp, 1987	Leon I	Sedona (South Scheurman Mtn)
78	Cloud, 1983	Leon II, III	Lee Mountain
79	Broomhall, 1978	Leon II, III	West Fork
80	Blakey and Knepp, 1987	Penn, Wolf	Sedona (Oak Creek)
81	McAllen, 1984	Wolf	Carroll Canyon
82	Blakey and Knepp, 1987	Leon I	Sedona (Bell Rock)
83	Blakey and Knepp, 1987	Leon I	Sedona (Dry Beaver)
84	Blakey and Knepp, 1987	Leon I	Sedona (Beaver Creek)
85	Blakey and Knepp, 1987	Leon I	Sedona (West Clear Creek)
86	Blakey and Knepp, 1987	Leon I	Fossil Creek
87	McKee, 1933	Leon II	Pine
88	Blakey and Knepp, 1987	Leon I	Colcord Canyon
89	Finnell, 1966	Leon I, II, III	Chediski Peak
90	Peirce et al., 1970	Leon I, II, III	Tenneco #1 Fed
91	Peirce et al., 1970	Leon I, II, III	Tenneco #1-x Ft. Apache
92	McKay, 1972	Leon I, II, III	Corduroy Creek
93	Peirce et al., 1970	Leon I, II, III	Pan Am N.M. and Az. B-1

TABLE 2 (continued)

Section No.	Author	Interval	Their designation, section name
94	Wengerd, 1962	Leon I, II, III	Pan Am N.M. and Az. No. 1–A
95	Wengerd, 1962	Leon I, II, III	Argo 1 State
96	Wengerd, 1962	Leon I, II, III	K—M Horstenstein
97	Wengerd, 1962	Leon I, II, III	Eastern 3, Santa Fe
98	Wengerd, 1962	Leon I, II, III	Eastern 1, Santa Fe
99	Wengerd, 1962	Leon I, II, III	Gen. Pet. Creager State
100	McKee, 1933	Leon II, III	Holbrook
101	McKee, 1933	Leon II, III	Winslow
102	Blakey (unpubl. data)	Leon I, II, III	Mt. Elden
103	Irwin et al., 1971	Leon I, II, III	Water Well near Sunset Crater
104	Baars, 1962	Leon I, II, III	Burrell–Collins
105	Baars, 1962	Leon I, II, III	Sinclair Navajo #1
106	Irwin et al., 1971	Leon I, II, III	Hopi
107	Irwin et al., 1971	Leon I, II, III	Hoskinnini Test
108	Witkind and Thaden, 1963	Leon I, II, III	Monument Valley
109	Read and Wanek, 1961	Leon I, II, III	South Comb Ridge
110	O'Sullivan, 1965	Leon I, II, III	Boundary Butte
111	Irwin et al., 1971	Leon I, II, III	East Boundary Butte Shell
112	Lessentine 1969	Leon I, II, III	Amarada Black Mountain
113	Read and Wanek, 1961	Leon I, II, III	Canyon del Muerto
114	Read and Wanek, 1961	Leon I, II, III	Monument Canyon
115	Peirce, 1964	Leon I, II, III	Nazlini Canyon
116	Read and Wanek, 1961	Leon I, II, III	Buell Park
117	Read and Wanek, 1961	Leon I, II, III	Bonito Canyon
118	Peirce, 1964	Leon I, II, III	Hunters Point
119	Read and Wanek, 1961	Leon I, II, III	Oak Springs
120	Peirce, 1964	Leon I, II, III	Black Creek Canyon
121	Read and Wanek, 1961	Leon I, II, III	Black Creek North
122	Irwin et al., 1971	Leon I, II, III	Hogback oil test
123	Read and Wanek, 1961	Leon I, II, III	Black Creek South
124	Peirce, 1966	Leon I, II, III	Water well
125	Perice, 1966	Leon I, II, III	Brown Petroleum
126	Welch, 1976	Wolf	Shivwits Beaver Dam Mtns
127	Steed, 1980	Wolf, Leon II	Virgin River Gorge
128	Irwin, 1976	Wolf	Cal St. George
129	Irwin, 1976	Wolf	Intex–Knowles
130	Irwin, 1976	Wolf, Leon II, III	Superior Kanab Creek #1
131	Welch, 1976 (A)	Wolf	Mtn Fuel Shurtz
132	Welch, 1976	Leon II, III	Monsanto Bryce
133	Irwin, 1976	Leon II, III	Tidewater Johns Valley
134	Irwin, 1976	Leon II, III	Tenneco Tropic #1
135	Lessentine, 1969	Leon II, III	Calco Upper Valley
136	Heylmun, 1958	Wolf, Leon II, III	Midwest Butler Valley
137	Irwin, 1976	Wolf, Leon II, III	Tidewater Utah Fed
138	Irwin, 1976	Wolf, Leon II, III	Union Judd Hollow
139	Lessentine, 1969	Wolf, Leon II, III	Byrd Rees Canyon
140	Irwin, 1976	Wolf, Leon II, III	Shell Soda
141	Read and Wanek, 1961	Leon I	Nokai Canyon
142	Mullens, 1960	Leon I	Clay Hills
143	Mullens, 1960	Leon I	Clay Hills
144	Irwin et al., 1971	Leon I	Monitor Mesa
145	Read and Wanek, 1961	Leon I	Monitor Butte

TABLE 2 (continued)

Section No.	Author	Interval	Their designation, section name
146	Read and Wanek, 1961	Leon I	Copper Canyon
147	Read and Wanek, 1961	Wolf, Leon I	Hoskinnini Mesa
148	Read and Wanek, 1961	Wolf, Leon I	Wide Butte
149	Read and Wanek, 1961	Leon I	Upper Gypsum Creek
150	O'Sullivan, 1965	Leon I	Boundary Butte area
151	O'Sullivan, 1965	Leon I	Moses Rock
152	Scott, 1960	Wolf	
153	Gregory, 1938	Wolf	Raplee Anticline
154	O'Sullivan, 1965	Leon I	San Juan River
155	O'Sullivan, 1965	Wolf	Cedar Mesa
156	Read and Wanek, 1961	Wolf	Douglas Mesa
157	Mullens, 1960	Wolf	Organ Rock Anticline
158	Sears, 1956	Wolf	Grand Gulch Plateau
159	Sears, 1956	Leon I	Comb Wash (south)
160	Sears, 1956	Leon I	Comb Wash (north)
161	Scott, 1960	Wolf	
162	Lewis and Campbell, 1965	Wolf	South of Elk Ridge
163	Scott, 19C0	Wolf	
164	Thaden et al., 1964	Wolf	White Canyon
165	Thaden et al., 1964	Leon II	Settlement of White Canyon
166	Irwin, 1976	Wolf, Leon II, III	Superior Swap Mesa
167	Davidson, 1967	Leon II, III	N.B. Hunt Govt. #1
168	Smith et al., 1963	Wolf, Leon II, III	Pacific Western Teasdale
169	Smith et al., 1963 (A)	Leon II, III	Fremont River
170	Irwin, 1976	Wolf, Leon II, III	Texaco Thous. Lakes Mtn.
171	Welch, 1976	Wolf	Mineral Mountains
172	Welch, 1976	Wolf	Shell Sunset Canyon
173	Irwin, 1976	Wolf, Leon II, III	Phillips Spring Canyon
174	Heylmun, 1958	Wolf	Stanolind Cainville
175	Irwin, 1976	Wolf	Amax Moroni slopes
176	Heylmun, 1958	Leon II, III	Mtn. Fuel Last Chance
177	Welch, 1976 (A)	Wolf, Leon II, III	Mtn. Fuel Desert Wash
178	Irwin, 1976	Wolf, Leon II, III	Skelly Emergy
179	Hawley et al., 1968	Leon II, III	Blackwood–Nichols
180	Irwin, 1976	Wolf, Leon II, III	Tenneco Pinto Hills
181	Irwin, 1976	Wolf, Leon II, III	Belco Henry Mtns
182	Irwin, 1976	Wolf, Leon II, III	Richfield Paradox Brown
183	Baker, 1946	Wolf	Cataract Canyon
184	Baker, 1946	Wolf	Indian Creek
185	Scott, 1960	Leon II, III	Shafer Trail
186	Irwin, 1976	Wolf, Leon II, III	Sinclair Orange Cliffs
187	Irwin, 1976	Wolf, Leon II, III	Murphy Nequoia Arch
188	Irwin, 1976	Wolf, Leon II, III	Phillips Dirty Devil
189	Irwin, 1976	Wolf, Leon II, III	Continental State
190	Irwin, 1976	Wolf, Leon II, III	Superior Hanksville
191	Irwin, 1976	Wolf, Leon II, III	Pan Am Nequoia Arch
192	Irwin, 1976	Wolf, Leon II, III	Texaco Temple Springs
193	Scott, 1960	Leon II, III	Straight Wash
194	Irwin, 1976	Wolf, Leon II, III	Superior Iron Wash
195	Irwin, 1976	Wolf, Leon II, III	Amax Green River Desert
196	Hawley et al., 1968	Leon II, III	Black Box
197	Irwin, 1976	Perm, undiff.	Lemm Woodside
198	Irwin, 1976	Perm, undiff.	Pan Am Cullen

TABLE 2 (continued)

Section No.	Author	Interval	Their designation, section name
199	Irwin, 1976	Wolf, Leon II, III	Shell North Springs
200	Irwin, 1976	Perm, undiff.	Atlantic–Richfield Hiawatha
201	Irwin, 1976	Perm, undiff.	Skelly Richard Bryner
202	Irwin, 1976	Perm, undiff.	Tenneco Clear Creek
203	Irwin, 1976	Perm, undiff.	Chevron Stone Cabin
204	Irwin, 1976	Perm, undiff.	Continental Federal
205	Bissell and Childs, 1958	Penn, Wolf	5—Rock Creek
206	Bissell and Childs, 1958	Penn, Wolf	6—Moon Lake
207	Bissell and Childs, 1958	Penn, Wolf	7—Yellowstone River
208	Bissell and Childs, 1958	Penn, Wolf	8—Whiterocks River
209	Bissell and Childs, 1958	Penn, Wolf	9—Dry Fork
210	Bissell and Childs, 1958	Penn, Wolf	10—Ashley–Brush Creeks
211	Bissell and Childs, 1958	Penn, Wolf	12—Sheep Canyon
212	Bissell and Childs, 1958	Penn, Wolf	11—Barker Spring
213	Irwin, 1976	Penn, Wolf	Atlantic—Rich. Maeser Fed.
214	Bissell and Childs, 1958	Penn, Wolf	13—Split Mountain
215	Bissell and Childs, 1958	Penn, Wolf	14—Diamond Gulch
216	Bissell and Childs, 1958	Penn, Wolf	15—Morris Ranch
217	Bissell and Childs, 1958	Penn, Wolf	16—S.W. Yampa Plateau
218	Baars, 1962	Leon I	Stanolind USG 13
219	Baars, 1962	Leon I	Gulf Navajo Fed. 1
220	Baars, 1962	Leon I	Southern Union Stony Butte 1
221	Baars, 1962	Leon I, II, III	Marshall Beal–Miller 1
222	Baars, 1962	Leon I, II, III	Tidewater Mariano Dome
223	Baars, 1962	Leon I, II, III	Kettner, Zuni Mountains
224	Baars, 1962	Leon I, II, III	Sawyer, Zuni Mountains
225	Wengerd, 1962	Leon I, II, III	Skelly Goesling 1
226	Wengerd, 1962	Leon I, II, III	Skelly 1–C Teel
227	Wengerd, 1962	Leon I, II, III	Skelly 1–M Teel
228	Wengerd, 1962	Leon I, II, III	Huckleberry 1 Fed
229	Wengerd, 1962	Leon I, II, III	Spanel–Heinze 1H–SF
230	Wengerd, 1962	Leon I, II, III	Spanel–Heinze 1M–SF
231	Baars, 1962	Leon I, II, III	Lucero Uplift
232	Baars, 1962	Leon I, II, III	Superior San Mateo
233	Baars, 1962	Leon I, II, III	Richfield Drouthe—Booth 1
234	Baars, 1962	Leon I, II, III	Avila Odium Fed
235	Baars, 1962	Leon I, II, III	Penasco Arroyo
236	Baars, 1962	Leon I, II, III	Guadalupe Box Canyon
237	Bissell and Childs, 1958	Penn, Wolf	19—Vermillion
238	Bissell and Childs, 1958	Penn, Wolf	17—Hells Canyon
239	Bissell and Childs, 1958	Penn, Wolf	18—Yampa River Gorge
240	Bissell and Childs, 1958	Penn, Wolf	20—Miller Creek
241	Bissell and Childs, 1958	Penn, Wolf	21—Elk Creek
242	Bissell and Childs, 1958	Penn, Wolf	22—Glenwood Springs
243	Bissell and Childs, 1958	Penn, Wolf	23—Elby Creek
244	Bissell and Childs, 1958	Penn, Wolf	24—Kent
245	Hoyt, 1963	Penn, Leon III	Antelope Creek
246	Hoyt, 1963	Penn, Leon III	Owl Canyon
247	Hoyt, 1963	Penn, Leon III	Cal Meyer 1
248	Hoyt, 1963	Penn, Leon III	Cal UPRR Ferch 1
249	Hoyt, 1963	Penn, Leon III	Dry Creek
250	Hoyt, 1963	Penn, Leon III	Dowe Pass
251	Hoyt, 1963	Penn, Leon III	Lyons

TABLE 2 (continued)

Section No.	Author	Interval	Their designation, section name
252	Hoyt, 1963	Penn, Leon III	British—Am. Wise 1
253	Hoyt, 1963	Penn, Leon III	Shell Colo Nat Bank 1
254	Thompson, 1949	Penn, Leon III	Eldorado Springs
255	Thompson, 1949	Penn, Leon III	Ralston Creek
256	Mallory, 1967	Penn	186
257	Mallory, 1967	Penn	176
258	Mallory, 1967	Penn	178
259	Mallory, 1967	Penn	177
260	Mallory, 1967	Penn	60
261	Mallory, 1967	Penn	39
262	Mallory, 1967	Penn	35
263	Mallory, 1967	Penn	40
264	Mallory, 1967	Penn	42
265	Mallory, 1967	Penn	41
266	Mallory, 1967	Penn	43
267	Mallory, 1967	Penn	44
268	Mallory, 1967	Penn	45
269	Mallory, 1967	Penn	46
270	Mallory, 1967	Penn	49
271	Mallory, 1967	Penn	54
272	Mallory, 1967	Penn	57
273	Mallory, 1967	Penn	89–A′
274	Mallory, 1967	Penn	88
275	Mallory, 1967	Penn	90
276	Mallory, 1967	Penn	75
277	Mallory, 1967	Penn	77
278	Mallory, 1967	Penn	70
279	Mallory, 1967	Penn	84
280	Mallory, 1967	Penn	85
281	Mallory, 1967	Penn	86
282	Mallory, 1967	Penn	72
283	Mallory, 1967	Penn	73
284	Mallory, 1967	Penn	79
285	Mallory, 1967	Penn	97
286	Mallory, 1967	Penn	185
287	Mallory, 1967	Penn	184
288	Mallory, 1967	Penn	183
289	Mallory, 1967	Penn	181
290	Mallory, 1967	Penn	122
291	Mallory, 1967	Penn	121
292	Mallory, 1967	Penn	179
293	Mallory, 1967	Penn	180
294	Mallory, 1967	Penn	182
295	Mallory, 1967	Penn	197
296	Mallory, 1967	Penn	92
297	Mallory, 1967	Penn	94
298	Mallory, 1967	Penn	96
299	Mallory, 1967	Penn	83
300	Mallory, 1967	Penn	100
301	Mallory, 1967	Penn	107
302	Mallory, 1967	Penn	109
303	Mallory, 1967	Penn	148

TABLE 2 (continued)

Section No.	Author	Interval	Their designation, section name
304	Mallory, 1967	Penn	149
305	Mallory, 1967	Penn	155
306	Mallory, 1967	Penn	157
307	Mallory, 1967	Penn	158
308	Mallory, 1967	Penn	160
309	Mallory, 1967	Penn	159
310	Mallory, 1967	Penn	34
311	Mallory, 1967	Penn	31
312	Mallory, 1967	Penn	35
313	Mallory, 1967	Penn	27
314	Mallory, 1967	Penn	25
315	Mallory, 1967	Penn	23
316	Mallory, 1967	Penn	22
317	Mallory, 1967	Penn	195
318	Mallory, 1967	Penn	190
319	Agatston, 1954	Penn	Farmers Union Shad–1
320	Agatston, 1954	Penn	Trout Creek
321	Agatston, 1954	Penn	Hampton Ranch
322	Agatston, 1954	Penn	Middle Fork
323	Agatston, 1954	Penn	Buffalo Creek
324	Mallory, 1967	Penn	143
325	Mallory, 1967	Penn	139
326	Mallory, 1967	Penn	135
327	Mallory, 1967	Penn	115
328	Agatston, 1954	Penn	Pass Creek
329	Agatston, 1954	Penn	Middle Fork Crazy Woman
330	Agatston, 1954	Penn	Carter Rider #3
331	Agatston, 1954	Penn	North Fork Crazy Woman
332	Agatston, 1954	Penn	Dry Kelly Creek
333	Agatston, 1954	Penn	So. Fk. Rock Creek
334	Agatston, 1954	Penn	Big Goose Creek
335	Agatston, 1954	Penn	Amsden Creek
336	Agatston, 1954	Penn	Little Big Horn River
337	Agatston, 1954	Penn	Cottonwood Creek
338	Nomenclature Comm. 1956	Penn, Wolf	Pure #1 Unit
339	Fryberger, 1984	Penn, Wolf	True–White B
340	Fryberger, 1984	Penn, Wolf	Davis–Larr. Fed.–A
341	Fryberger, 1984	Penn, Wolf	NCRA 1–Biggers
342	Fryberger, 1984	Penn, Wolf	Tenneco 10–1
343	Fryberger, 1984	Penn, Wolf	Arco 1–USA–Appel
344	Fryberger, 1984	Penn, Wolf	Cal Oil–1–Chambers
345	Nomenclature Comm., 1956	Penn, Wolf	Stanolino IT–PWW
346	Nomenclature Comm., 1956	Penn, Wolf	US Navy NPR 31–6–10
347	Nomenclature Comm., 1945	Penn, Wolf	Amerada Unit 1
348	Nomenclature Comm., 1956	Penn, Wolf	Gen. Pet. 32–X–21–G
349	Nomenclature Comm., 1956	Penn, Wolf	Phillips 2 Cole
350	Nomenclature Comm., 1956	Penn, Wolf	Phillips 1 McNeil
351	Nomenclature Comm., 1956	Penn, Wolf	Carter 1 Neiman
352	Agatston, 1954	Penn, Wolf	La Prol
353	Agatston, 1954	Penn, Wolf	Bed Tick Creek
354	Agatston, 1954	Penn, Wolf	La Bonte Ranch
355	Agatston, 1954	Penn, Wolf	Meeferiene Ranch

TABLE 2 (continued)

Section No.	Author	Interval	Their designation, section name
356	Agatston, 1954	Penn, Wolf	Deadhead Basin
357	Agatston, 1954	Penn, Wolf	Underwood
358	Agatston, 1954	Penn, Wolf	Horse Creek
359	Agatston, 1954	Penn, Wolf	Lorenz Ranch
360	Agatston, 1954	Penn, Wolf	Granite Canyon
361	Agatston, 1954	Penn, Wolf	Cal King #1
362	Nomenclature Comm., 1956	Leon III	Ginther Warren and Ginther 1 Fritz
363	Agatston, 1954	Penn, Wolf	Ripple Ranch
364	Mallory, 1967	Penn, Wolf	2
365	Agatston, 1954	Penn, Wolf	Telephone Canyon
366	Mallory, 1967	Penn, Wolf	5
367	Agatston, 1954	Penn, Wolf	King Canyon
368	Mallory, 1967	Penn, Wolf	6
369	Mallory, 1967	Penn, Wolf	7
370	Agatston, 1954	Penn, Wolf	Wheatland Cutoff
371	Mallory, 1967	Penn, Wolf	9
372	Mallory, 1967	Penn, Wolf	10
373	Agatston, 1954	Penn, Wolf	Gillespie Anticline
374	Mallory, 1967	Penn, Wolf	11
375	Agatston, 1954	Penn, Wolf	Marshall
376	Mallory, 1967	Penn	62
377	Agatston, 1954	Penn, Wolf	Deer Creek
378	Mallory, 1967	Penn	127
379	Mallory, 1967	Penn	124
380	Mallory, 1967	Penn	131
381	Agatston, 1954	Penn, Wolf	Pac. West Osborne #1
382	Agatston, 1954	Penn	Shell–Crow #1
383	Agatston, 1954	Penn	Warren Montana
384–400	Saperstone and Ethridge, 1984	Penn	Sections located but data not given; isopachs in this area directly from their fig. 4

TABLE 3

Data base for Jelm Formation

Section No.	Author	Interval	Their designation, section name
1	Pipiringos, 1968	Crow Mountain SS	5—Lauder
2	Pipiringos, 1968	Crow Mountain SS	6—Dallas Anticline
3	Pipiringos, 1968	Crow Mountain SS	7—Derby Dome
4	Pipiringos, 1968	Crow Mountain SS	9—Sheep Mountain
5	Pipiringos, 1968	Crow Mountain SS	10—Beaver Creek
6	Pipiringos, 1968	Crow Mountain SS	28—Happy Spring
7	Pipiringos, 1968	Crow Mountain SS	30—Green Mountain
8	Pipiringos, 1968	Jelm Fm	31—Ferris Mtn, West
9	Pipiringos, 1968	Jelm Fm	32—Ferris Mtn, East
10	Pipiringos, 1968	Jelm Fm	56—Bell Springs
11	Pipiringos, 1968	Jelm Fm	33—Hurt Creek
12	Pipiringos, 1968	Jelm Fm	35—Sips Creek
13	Pipiringos, 1968	Jelm Fm	37—Troublesome creek
14	Pipiringos, 1968	Jelm Fm	38—Roaring Creek
15	Pipiringos, 1968	Jelm Fm	39—Mud Spring
16	Pipiringos, 1968	Jelm Fm	40—Watkins Draw
17	Pipiringos, 1968	Jelm Fm	42—Freezeout Mtns, SW
18	Pipiringos, 1968	Jelm Fm	44—Freezeout Mtns, East
19	Pipiringos and O'Sullivan, 1976	Triassic–Jurassic	7—Farthing
20	Pipiringos and O'Sullivan, 1976	Triassic–Jurassic	8—Horse Creek
21	Pipiringos and O'Sullivan, 1976	Jelm Fm	9—Mesa
22	Pipiringos and O'Sullivan, 1976	Jelm Fm	10—Boundary Line
23	Pipiringos and O'Sullivan, 1976	Jelm Fm	11—Sand Creek
24	Pipiringos and O'Sullivan, 1976	Jelm Fm	12—Table Mountain
25	Pipiringos and O'Sullivan, 1976	Jelm Fm	13—Box Elder Creek, north
26	Pipiringos and O'Sullivan, 1976	Jelm Fm	14—Box Elder Creek, south
27	Pipiringos and O'Sullivan, 1976	Jelm Fm	15—Park Creek
28	Pipiringos and O'Sullivan, 1976	Jelm Fm	16—Owl Canyon
29	Pipiringos and O'Sullivan, 1976	Jelm Fm	17—Bellvue
30	Pipiringos and O'Sullivan, 1976	Jelm Fm	19—Loveland
31	Pipiringos and O'Sullivan, 1976	Jelm Fm	20—Dry Creek
32	Pipiringos and O'Sullivan, 1976	Jelm Fm	21—Little Thompson
33	Pipiringos and O'Sullivan, 1976	Triassic–Jurassic	22—Four Mile Canyon
34	Pipiringos and O'Sullivan, 1976	Triassic–Jurassic	23—Ralston Reservoir
35	Pipiringos, 1972	Jelm Fm	61—Littlefield Creek
36	Pipiringos, 1972	Jelm Fm	62—Space Creek Basin
37	Pipiringos, 1972	Jelm Fm	63—Big Sandstone Creek
38	Pipiringos, 1972	Jelm Fm	65—Roaring Fork
39	Pipiringos, 1972	Jelm Fm	96—Hahns Peak
40	Pipiringos, 1972	Jelm Fm	95—Clark
41	Pipiringos, 1972	Jelm Fm	94—Coral Creek
42	Pipiringos, 1972	Triassic–Jurassic	92—King Mountain
43	Pipiringos, 1972	Triassic–Jurassic	A–Elk Creek
44	Pipiringos, 1968	Jelm	Red Mountain
45	Craig et al., 1959	Jelm	104—Laramie River

TABLE 4
Data base for Wingate Sandstone

Section No.	Author	Interval	Their designation, section name
1	Phoenix, 1963	Dinosaur Canyon	Lees Ferry
2	Wanek and Stevens, 1953	Dinosaur Canyon	Tanner Wash
3	Wanek and Stevens, 1953	Dinosaur Canyon	Tanner Wash
4	Wanek and Stevens, 1953	Dinosaur Canyon	Cedar Ridge
5	Wanek and Stevens, 1953	Dinosaur Canyon	Cedar Ridge
6	Wanek and Stevens, 1953	Dinosaur Canyon	The Gap
7	Wanek and Stevens, 1953	Dinosaur Canyon	The Gap
8	Edwards, 1985	Dinosaur Canyon	1
9	Edwards, 1985	Dinosaur Canyon	2
10	Edwards, 1985	Dinosaur Canyon	3
11	Edwards, 1985	Dino. Can., Lukachukai	4
12	Edwards, 1985	Dino. Can., Lukachukai	5
13	Edwards, 1985	Dino. Can., Lukachukai	6
14	Edwards, 1985	Dino. Can., Lukachukai	7
15	Edwards, 1985	Dino. Can., Lukachukai	8
16	Edwards, 1985	Dino. Can., Lukachukai	9
17	Harshbarger et al., 1957	Lukachukai	SE Ward Terrace
18	Edwards, 1985	Dino. Can., Lukachukai	13
19	Harshbarger et al., 1957	Lukachukai	Tovar Mesa
20	Harshbarger et al., 1957	Dino. Can., Lukachukai	Montezumas Chair
21	Harshbarger et al., 1957	Dino. Can., Lukachukai	Navajo Creek
22	Peterson and Pipiringos, 1979	Dino. Can., Lukachukai	Square Butte
23	Imlay, 1980	Dino. Can., Lukachukai	Cow Springs
24	Witkind and Thaden, 1963	Wingate Sandstone	Skeleton Mesa, south
25	Witkind and Thaden, 1963	Wingate Sandstone	Skeleton Mesa, north
26	Witkind and Thaden, 1963	Wingate Sandstone	Boot Mesa
27	Witkind and Thaden, 1963	Wingate Sandstone	Kayenta
28	Witkind and Thaden, 1963	Wingate Sandstone	Dinnehotso
29	Harshbarger et al., 1957	Wing. SS, Lukachukai Mbr	Rock Point
30	Harshbarger et al., 1957	Wing. SS, Lukachukai Mbr	NE of Round Rock
31	Strobell, 1956	Wing. SS, Lukachukai Mbr	Lukachukai Mtns.
32	Stewart et al., 1972	Wing. SS, Lukachukai Mbr	Many Farms
33	Harshbarger et al., 1957	Dino. Can., Lukachukai	Greasewood
34	Stewart et al., 1972	Lukachukai Mbr	Lukachukai Trading Post
35	Stewart et al., 1972	See comments	Chee Dodge
36	Stewart et al., 1972	See comments	Lupton
37	Strobell, 1956	Lukachukai Mbr.	Beclabito Dome
38	Strobell, 1956	Lukachukai Mbr.	Cont. Oil, Rattlesnake 100
39	Stewart et al., 1972	See comments	Toadalena
40	Stewart et al., 1972	See comments	Todilto Park
41	Stewart et al., 1972	Dino. Can. Mbr.	Utah Petrified Forest
42	Blakey, 1970	Wing. SS, Dino. Can. Mbr	Cockscomb
43	Blakey, 1970	Wing. SS, Dino. Can. Mbr	Paria
44	Stewart, 1972	Wing. SS, Dino. Can. Mbr	Paria
45	Imlay, 1980	Wingate Sandstone	Pine Creek
46	Imlay, 1980	Wingate Sandstone	Big Hollow Wash
47	Davidson, 1967	Wingate Sandstone	Western Circle Cliffs
48	Davidson, 1967	Wingate Sandstone	Eastern Circle Cliffs
49	Smith et al., 1963	Wingate Sandstone	Capitol Reef
50	Peterson (unpubl. data)	Wingate Sandstone	The Block
51	Peterson (unpubl. data)	Wingate Sandstone	North Wash
52	Baker, 1946	Wingate Sandstone	Dirty Devil River

TABLE 4 (continued)

Section No.	Author	Interval	Their designation, section name
53	Baker, 1946	Wingate Sandstone	Happy Canyon
54	Baker, 1946	Wingate Sandstone	South Trail
55	Baker, 1946	Wingate Sandstone	Red Point
56	Baker, 1946	Wingate Sandstone	South Block
57	Baker, 1946	Wingate Sandstone	Lands End
58	Baker, 1946	Wingate Sandstone	North Trail
59	Baker, 1946	Wingate Sandstone	Bigwater Canyon
60	Baker, 1946	Wingate Sandstone	Horseshoe Canyon
61	Hawley et al., 1968	Wingate Sandstone	Tomisich Butte
62	Hawley et al., 1968	Wingate Sandstone	Delta Mine
63	Hawley et al., 1968	Wingate Sandstone	Temple Mtn.
64	Baker, 1946	Wingate Sandstone	Iron Wash
65	Hawley et al., 1968	Wingate Sandstone	Straight Wash
66	Hawley et al., 1968	Wingate Sandstone	San Rafael Reef
67	Imlay, 1980	Wingate Sandstone	Buckhorn Wash
68	Imlay, 1980	Wingate Sandstone	Black Dragon Canyon
69	Dane, 1935	Wingate Sandstone	Dry Gulch
70	Imlay, 1980	Wingate Sandstone	Dewey Bridge
71	Dane, 1935	Wingate Sandstone	Big Hole, Westwater Canyon
72	Dane, 1935	Wingate Sandstone	Home Oil #2
73	Shawe et al., 1968	Wingate Sandstone	#1
74	Lewis and Campbell, 1965	Wingate Sandstone	North of India Creek
75	Lewis and Campbell, 1965	Wingate Sandstone	Elk Ridge
76	Shawe et al., 1968	Wingate Sandstone	#3
77	Shawe et al., 1968	Wingate Sandstone	#4
78	Shawe et al., 1968	Wingate Sandstone	#11
79	Shawe et al., 1968	Wingate Sandstone	#12
80	Strobell, 1956	Wingate Sandstone	Western Gas #1 English
81	Stewart et al., 1972	Wingate Sandstone	Poncho House
82	O'Sullivan, 1965	Wingate Sandstone	Moses Rock
83	O'Sullivan, 1965	Wingate Sandstone	Arizona–Utah line
84	Baker, 1946	Wingate Sandstone	Horse Canyon
85	Baker, 1946	Wingate Sandstone	West Side Piute Canyon
86	Baker, 1946	Wingate Sandstone	Piute Canyon
87	Baker, 1946	Wingate Sandstone	North Side No Mans Mesa
88	Baker, 1946	Wingate Sandstone	San Juan River at Wilson Creek
89	Peterson, unpub.	Wingate Sandstone	The Rincon
90	Mullens, 1960	Wingate Sandstone	Clay Hills
91	Thaden et al., 1964	Wingate Sandstone	North Moss Back
92	Thaden et al., 1964	Wingate Sandstone	White Canyon
93	O'Sullivan, 1965	Wingate Sandstone	San Juan River
94	Craig et al., 1959	Wingate Sandstone	Rifle
95	Lohman, 1981	Wingate Sandstone	Colorado National Monument
96	Craig et al., 1959	Wingate Sandstone	Ladder Canyon
97	Craig et al., 1959	Wingate Sandstone	East Unaweap Canyon
98	Craig et al., 1959	Wingate Sandstone	Tenderfoot Mesa
99	Imlay, 1980	Wingate Sandstone	John Brown Canyon
100	Craig et al., 1959	Wingate Sandstone	John Brown
101	Craig et al., 1959	Wingate Sandstone	North Sinbad Valley
102	Craig et al., 1959	Wingate Sandstone	Cashin Mine
103	Craig et al., 1959	Wingate Sandstone	Bridgeport
104	Stewart et al., 1972	Wingate Sandstone	Bridgeport
105	Craig et al., 1959	Wingate Sandstone	N. Fork, Escalante Creek

TABLE 4 (continued)

Section No.	Author	Interval	Their designation, section name
106	Peterson (unpubl. data)	Wingate Sandstone	Escalante Canyon
107	Craig et al., 1959	Wingate Sandstone	Tabequache Canyon
108	Craig et al., 1959	Wingate Sandstone	Dry Creek
109	Shawe et al., 1968	Wingate Sandstone	#8
110	Bush et al., 1959	Wingate Sandstone	4 miles west of Placerville
111	Shawe et al., 1968	Wingate Sandstone	D265
112	Shawe et al., 1968	Wingate Sandstone	D270
113	Shawe et al., 1968	Wingate Sandstone	M230
114	Imlay, 1980	Wingate Sandstone	Slick Rock
115	Craig et al., 1959	Wingate Sandstone	Summit
116	Shawe et al., 1968	Wingate Sandstone	#6
117	Shawe et al., 1968	Wingate Sandstone	D225
118	Shawe et al., 1968	Wingate Sandstone	OW250
119	Shawe et al., 1968	Wingate Sandstone	#13
120	Shawe et al., 1968	Wingate Sandstone	#16
121	Shawe et al., 1968	Wingate Sandstone	#18
122	Shawe et al., 1968	Wingate Sandstone	#25
123	Shawe et al., 1968	Wingate Sandstone	#21
124	Shawe et al., 1968	Wingate Sandstone	#22
125	Shawe et al., 1968	Wingate Sandstone	#26
126	Shawe et al., 1968	Wingate Sandstone	M190
127	Shawe et al., 1968	Wingate Sandstone	M200
128	Shawe et al., 1968	Wingate Sandstone	M200
129	Shawe et al., 1968	Wingate Sandstone	M194
130	Craig et al., 1959	Wingate Sandstone	Lookout Point
131	Shawe et al., 1968	Wingate Sandstone	#14
132	Shawe et al., 1968	Wingate Sandstone	#15
133	Shawe et al., 1968	Wingate Sandstone	#23
134	Stewart et al., 1972	Upper Dolores Formation	Durango
135	Stewart et al., 1972	Wingate absent	South Canyon

TABLE 5

Data base for Navajo Sandstone and related units

Section No.	Author	Interval	Their designation, section name
1	PI	Navajo Sandstone	Arco #2Dixie
2	PI	Navajo Sandstone	Chevron #13—29 Clay Creek
3	PI	Navajo Sandstone	Hunt #1 Table Butte
4	Phoenix, 1963	Navajo Sandstone	Cedar Mountain
5	Phoenix, 1963	Navajo Sandstone	Rawhide Cave
6	Blakey, 1970	Navajo Sandstone	Paria River
7	Wilson, 1965	Navajo Sandstone	2—Zion Canyon
8	Wilson, 1965	Navajo Sandstone	3—Kanab
9	Harshbarger et al., 1957	Navajo Sandstone	6—Dinnehotso
10	Harshbarger et al., 1957	Navajo Sandstone	1—Rech Point Trading Post
11	Harshbarger et al., 1957 (A)	Navajo Sandstone	Monitor Mesa
12	Harshbarger et al., 1957 (A)	Navajo Sandstone	Kayenta
13	Harshbarger et al., 1957 (A)	Navajo Sandstone	Betatakin Ruin
14	Harshbarger et al., 1957 (A)	Navajo Sandstone	Navajo Creek
15	Harshbarger et al., 1957 (A)	Navajo Sandstone	Gap
16	Harshbarger et al., 1957 (A)	Navajo Sandstone	Moenave
17	Harshbarger et al., 1957 (A)	Navajo Sandstone	Dinosaur Canyon
18	Harshbarger et al., 1957 (A)	Navajo Sandstone	Kachina Point
19	Harshbarger et al., 1957 (A)	Navajo Sandstone	Yale Point
20	O'Sullivan, 1965	Navajo Sandstone	Chinle Wash
21	Strobell, 1956	Navajo Sandstone	A—Boundary Butte
22	Strobell, 1956	Navajo Sandstone	9—Toh Acon Mesa
23	Strobell, 1956	Navajo Sandstone	10—Kinusta Mesa
24	Strobell, 1956	Navajo Sandstone	6—Cove Mesa
25	Strobell, 1956	Navajo Sandstone	Regional estimate
26	Peterson (unpubl. data)	Navajo Sandstone	123—Second Mesa
27	Peterson (unpubl. data)	Navajo Sandstone	1100—North Wash
28	Smith et al., 1963	Navajo Sandstone	Boulder Mtn. UT
29	Smith et al., 1963	Navajo Sandstone	Waterpocket fold, UT
30	Thaden et al., 1964	Navajo Sandstone	Red Canyon, UT
31	Davidson, 1967	Navajo Sandstone	12—E. Cent. Circle Cliffs
32	Davidson, 1967	Navajo Sandstone	Grand Gulch
33	Davidson, 1967	Navajo Sandstone	Regional estimate
34	Beaumont and Dixon, 1964	Navajo Sandstone	8—Marsh Pass AZ
35	Beaumont and Dixon, 1964	Navajo Sandstone	13—Kayenta AZ
36	O'Sullivan and Green, 1973	Navajo Sandstone	Round Point, AZ
37	O'Sullivan and Green, 1973 (A)	Navajo Sandstone	2—Bluff, UT
38	O'Sullivan and Green, 1973 (A)	Navajo Sandstone	1—Comb Ridge, UT
39	Hunt et al., 1953	Navajo Sandstone	Muddy River
40	Hunt et al., 1953	Navajo Sandstone	Burr Trail
41	Hunt et al., 1953	Navajo Sandstone	Angel Cove
42	Gregory, 1938	Navajo Sandstone	South side Wilson Mesa
43	F. Peterson (unpubl. data)	Navajo Sandstone	1196—Uravan, CO
44	Craig et al., 1959	Navajo Sandstone	35—Cashin Mine, CO
45	Craig et al., 1955	Navajo Sandstone	58—Dove Spring, CO
46	Craig et al., 1959	Navajo Sandstone	87—Hamm Spring, CO
47	Craig et al., 1959	Navajo Sandstone	99—Horseshoe Groupo, CO
48	Craig et al., 1959	Navajo Sandstone	101—John Brown Canyon, CO
49	Craig et al., 1959	Navajo Sandstone	120—Lookout Point, CO
50	Craig et al., 1959	Navajo Sandstone	136—Maverick Canyon, CO
51	Craig et al., 1959	Navajo Sandstone	150—N. Sinbad Valley, CO
52	Craig et al., 1959	Navajo Sandstone	200—Summit Point, CO
53	Craig et al., 1959	Navajo Sandstone	220—Vermillion Creek, CO

TABLE 5 (continued)

Section No.	Author	Interval	Their designation, section name
54	Craig et al., 1959	Navajo Sandstone	226—Wild Bill Canyon, CO
55	Shawe et al., 1968	Navajo Sandstone	3—White Cany. Mining Co, UT Frost #1
56	Shawe et al., 1968	Navajo Sandstone	4—Western Natural Gas, UT Redd 1
57	Shawe et al., 1968	Navajo Sandstone	11—Gulf Oil Corp, UT Coalbed Cany. 1
58	Shawe et al., 1968	Navajo Sandstone	12—Gulf Oil Corp, UT Coalbed Cany. 2
59	Craig et al., 1959	Navajo Sandstone	13—Continental Oil Co, CO Baumgartner–Sane 1
60	Shawe et al., 1968	Navajo Sandstone	18—Hathaway Co, CO Lyon–Federal 1
61	Shawe et al., 1968	Navajo Sandstone	17—Three States Natural Gas White #1, CO
62	Shawe et al., 1968	Navajo Sandstone	19—Byrd--Frost J.W. White #1
63	Shawe et al., 1968	Navajo Sandstone	20—Byrd–Frost Driscoll 1, CO
64	Shawe et al., 1968	Navajo Sandstone	26—Gulf Oil Corp, Fulks 1, CO
65	Shawe et al., 1968	Navajo Sandstone	22—HER Drill. Co., CO Lane–Coffee 1A
66	Shawe et al., 1968	Navajo Sandstone	23—Continental Oil Co, Lone Dome 1, CO
67	Shawe et al., 1968	Navajo Sandstone	15—Moody Oil Corp, CO Stathepulous 1
68	Shawe et al., 1968	Navajo Sandstone	14—Byrd–Frost J.A. Uhl–Govt. 1, CO
69	Shawe et al., 1968	Navajo Sandstone	10—Carter Oil Co., Glade 1, CO
70	Shawe et al., 1968	Navajo Sandstone	5—Prestidge–Allison Long 1, CO
71	Shawe et al., 1968	Navajo Sandstone	6—Reynolds Mining Co, Egnar 1, CO
72	Shawe et al., 1968	Navajo Sandstone	8—Fred Turner Bues 1, CO
73	Shawe et al., 1968	Navajo Sandstone	M40, 43N, 19W, CO
74	Shawe et al., 1968	Navajo Sandstone	M12, 42N, 18W, CO
75	Shawe et al., 1968	Navajo Sandstone	1—Temple Mtn, UT
76	Shawe et al., 1968	Navajo Sandstone	3—Bear Ears, UT
77	Shawe et al., 1968	Navajo Sandstone	4—Horse Flats, UT
78	Shawe et al., 1968	Navajo Sandstone	5—Abajo Mtns, UT
79	Shawe et al., 1968	Navajo Sandstone	6—Bridger Jack Mesa, UT
80	Shawe et al., 1968	Navajo Sandstone	7—North Sixshooter Peak, UT
81	Shawe et al., 1968	Navajo Sandstone	8—Lockhart Basin, UT
82	Shawe et al., 1968	Navajo Sandstone	9—Moab, UT
83	Shawe et al., 1968	Navajo Sandstone	10—Sevenmile Canyon, UT
84	Hamilton, 1978	Navajo Sandstone	Horse Ranch Mtn, UT
85	Hamilton, 1978	Navajo Sandstone	Wynopits Mtn, UT
86	Baker et al., 1936	Navajo Sandstone	77—Tuba City, AZ
87	Baker et al., 1936	Navajo Sandstone	50—Navajo Mtn, UT
88	Baker et al., 1936	Navajo Sandstone	14—Circle Cliffs, UT
89	Baker et al., 1936	Navajo Sandstone	68—Saddle Horse Canyon, UT
90	Baker et al., 1936	Glen Canyon SS.	22—Dinosaur Quarry, UT
91	Baker et al., 1936	Glen Canyon SS.	29—Flaming Gorge, UT
92	Baker et al., 1936	Navajo Sandstone	23—Diamond Valley, UT
93	Baker et al., 1936	Navajo Sandstone	54—Paria River, UT
94	Baker et al., 1936	Navajo Sandstone	33—Green River Desert, UT
95	Baker et al., 1936	Navajo Sandstone	37—Indian Creek, UT
96	Baker et al., 1936	Navajo Sandstone	4—Black Dragon Canyon, UT
97	Baker et al., 1936	Navajo Sandstone	75—Salt Valley Canyon, UT
98	Baker et al., 1936	Navajo Sandstone	20—Dewey, UT
99	Baker et al., 1936	Navajo Sandstone	67—Schart Ranch, UT
100	Knapp, 1976	Nugget Sandstone	Vermillion Creek, CO
101	Knapp, 1976	Nugget Sandstone	Farm Creek, UT
102	Knapp, 1976	Nugget Sandstone	Split Mtn, UT
103	Pacht, 1976	Nugget Sandstone	Mahagony Hills, UT
104	Hewett, 1956	Aztec Sandstone	2 mi W of Kokoweef Peak CA
105	Hewett, 1931 (A)	Aztec Sandstone	N. boundary Goodsprings Quad, N.M.

TABLE 5 (continued)

Section No.	Author	Interval	Their designation, section name
106	Porter, 1985	Aztec Sandstone	N. Old Dad Mtn, CA
107	Porter, 1985	Aztec Sandstone	S. Old Dad Mtn, CA
108	Porter, 1985	Aztec Sandstone	Notch Draw, Mescal Range, CA
109	Porter, 1985	Aztec Sandstone	Spring Ranch, NV
110	Porter, 1985	Aztec Sandstone	Visitor Center, Valley of Fire, NV
111	Longwell, 1928	Aztec Sandstone	3 mi W. Logandale NV
112	PI	Navajo Sandstone	1 Hopi—9, AZ
113	Uggur, 1980	Navajo Sandstone	465
114	Uggur, 1980	Navajo Sandstone	423
115	Uggur, 1980	Navajo Sandstone	430
116	Uggur, 1980	Navajo Sandstone	350
117	Uggur, 1980	Navajo Sandstone	370
118	PI	Nugget Sandstone	Mtn. Fuel Supply Co. Canyon Cr #17
119	PI	Nugget Sandstone	Pan American Jim Springs #7
120	PI	Nugget Sandstone	Exxon Red Creek #1
121	PI	Nugget Sandstone	Devon Joyce Ck #11–8
122	PI	Nugget Sandstone	Mtn. Fuel S. Baxter #1
123	PI	Nugget Sandstone	Mtn. Fuel S. Baxter #15
124	PI	Nugget Sandstone	Champlin Petroleum Brady #1
125	PI	Nugget Sandstone	Red Desert Edith Aspden #1
126	PI	Nugget Sandstone	Mtn. Fuel Agnes Fay #1
127	PI	Nugget Sandstone	Mtn. Fuel Hetzler #2
128	PI	Nugget Sandstone	Pongratz Gas Clark #1
129	PI	Nugget Sandstone	Mtn. Fuel UPRR #3
130	PI	Nugget Sandstone	Mtn. Fuel UPRR #2
131	PI	Nugget Sandstone	Cities Service UPRR #1
132	PI	Nugget Sandstone	Barnes Federal #5–11
133	PI	Nugget Sandstone	Mtn. Fuel Church Buttes #2
134	PI	Nugget Sandstone	Mtn. Fuel Church Buttes #19
135	PI	Nugget Sandstone	Mtn. Fuel Bruff #1
136	PI	Nugget Sandstone	Mtn. Fuel
137	PI	Nugget Sandstone	Helis Estate E. Sulphur Creek
138	PI	Nugget Sandstone	Brinkerhoff Piedmont 1–31
139	PI	Nugget Sandstone	Shell Leroy Unit 1–4295
140	PI	Nugget Sandstone	Helis Estate Bridger State 3–1
141	PI	Nugget Sandstone	Arrowhead Scully Gap Gut. 1
142	PI	Nugget Sandstone	Cal. Oil VP–1, Muddy Creek
143	PI	Nugget Sandstone	Marathon Albert Creek–1
144	PI	Nugget Sandstone	Belco Hams Fork 30–2
145	PI	Nugget Sandstone	Quad States Cumberland
146	PI	Nugget Sandstone	Conoco Hams Fork 23–1
147	PI	Nugget Sandstone	Union Carter
148	Asquith (pers. commun.)	Nugget Sandstone	Jackson Creek
149	PI	Nugget Sandstone	Brack Drilling Co. Fontonelle #2
150	Asquith (pers. commun.)	Nugget Sandstone	Fontonelle Creek
151	PI	Nugget Sandstone	Phillips Co. Fort A#1
152	PI	Nugget Sandstone	Carter Oil Meridian Ridge
153	Asquith (pers. commun.)	Nugget Sandstone	La Barge Creek
154	Furer (pers. commun.)	Nugget Sandstone	Rock Creek
155	PI	Nugget Sandstone	Mtn. Fuel Dry Piney #24
156	PI	Nugget Sandstone	Mobil Oil Tip Top #83–11
157	PI	Nugget Sandstone	Exxon Hobada II Unit #2

TABLE 5 (continued)

Section No.	Author	Interval	Their designation, section name
158	PI	Nugget Sandstone	General Petroleum Lake Ridge #43–19
159	PI	Nugget Sandstone	California Oil Tierney #1
160	Bragdon, 1965	Nugget Sandstone	E. Fork Greys River
161	Asquith (pers. commun.)	Nugget Sandstone	North Darby
162	PI	Nugget Sandstone	Phillips Oil Hoback A#1
163	Wanless et al., 1955	Nugget Sandstone	Fall Creek
164	Froidenaux, 1968	Nugget Sandstone	Claus Peak
165	Thompson (pers. commun.)	Nugget Sandstone	Hoback Peak
166	Wanless et al., 1955	Nugget Sandstone	Hoback Mtn.
167	Wanless et al., 1955	Nugget Sandstone	Dell Creek
168	Wanless et al., 1955	Nugget Sandstone	Moose Creek
169	Wanless et al., 1955	Nugget Sandstone	Gros Ventre Canyon
170	Foster 1947	Nugget Sandstone	Ditch Creek
171	PI	Nugget Sandstone	Tennessee Gas Transmission Sohare #2
172	PI	Nugget Sandstone	True Oil Kirkwood—Federal #11–23
173	Love et al., 1945	Nugget Sandstone	1—Horse Creek
174	PI	Nugget Sandstone	Shell Oil Goose Lake #1
175	Love et al., 1945	Nugget Sandstone	2—Duncan P.O.
176	Love et al., 1945	Nugget Sandstone	2N Ranch
177	PI	Nugget Sandstone	Carter Oil #1 State
178	Richmond 1985	Nugget Sandstone	Green River Lakes
179	Love et al., 1945	Nugget Sandstone	3—Red Grade
180	Love et al., 1945	Nugget Sandstone	4—Red Creek
181	Love et al., 1945	Nugget Sandstone	5—Maverick Springs
182	PI	Nugget Sandstone	British American Tribal #C–3
183	PI	Nugget Sandstone	British American Tribal #A–1
184	PI	Nugget Sandstone	Stanolind Oil and Gas Tribal #1
185	Love et al., 1945	Nugget Sandstone	29—Sage Ck Anticline
186	Love et al., 1945	Nugget Sandstone	13—Crooked Creek
187	Love et al., 1945	Nugget Sandstone	15—Lander Anticline
188	Love et al., 1945	Nugget Sandstone	16—Squaw Creek
189	Love et al., 1945	Nugget Sandstone	17—Dallas Anticline
190	Love et al., 1945	Nugget Sandstone	Derby Anticline
191	PI	Nugget Sandstone	Phillips Horseshoe Creek #1
192	Espach and Royse 1960	Nugget Sandstone	E. Big Hole Mtns.
193	Wanless et al., 1955	Nugget Sandstone	Snake River
194	Williams and Kraetsch (pers. commun.)	Nugget Sandstone	Teton Basin
195	Wyman and Newcomb (pers. commun.)	Nugget Sandstone	North Snake
196	Chevron (unpubl. data)	Nugget Sandstone	Bonneville
197	Chevron (unpubl. data)	Nugget Sandstone	Garden Creek
198	Chevron (unpubl. data)	Nugget Sandstone	Pritchard Creek
199	Asquith (pers. commun.)	Nugget Sandstone	Bailey Lake
200	Mansfield 1927	Nugget Sandstone	Fort Hall
201	Asquith (pers. commun.)	Nugget Sandstone	Barley Lake
202	Asquith (pers. commun.)	Nugget Sandstone	True Oil Greys River #44–25
203	Asquith (pers. commun.)	Nugget Sandstone	Blind Bull Creek
204	Wolf (pers. commun.)	Nugget Sandstone	Swift Creek
205	Mansfield, 1927	Nugget Sandstone	Freedom quad.
206	Cressman, 1964	Nugget Sandstone	Preuss Creek
207	Cressman, 1964	Nugget Sandstone	Dunns Canyon

TABLE 5 (continued)

Section No.	Author	Interval	Their designation, section name
208	Asquith (pers. commun.)	Nugget Sandstone	S. LaBarge Creek
209	Asquith (pers. commun.)	Nugget Sandstone	Allen Creek
210	Asquith (pers. commun.)	Nugget Sandstone	Hams Fork
211	Asquith (pers. commun.)	Nugget Sandstone	Fontonelle Creek
212	Asquith (pers. commun.)	Nugget Sandstone	Pine Creek
213	Asquith (pers. commun.)	Nugget Sandstone	Cokeville Butte
214	Asquith (pers. commun.)	Nugget Sandstone	Trail Creek
215	Chevron (unpub. data)	Nugget Sandstone	Sheep Creek
216	Asquith (pers. commun.)	Nugget Sandstone	Rock Creek Ridge
217	Asquith (pers. commun.)	Nugget Sandstone	Miller Canyon
218	PI	Nugget Sandstone	Amoco Ryckman Ck #224
219	Richardson, 1941	Nugget Sandstone	Randolph quad.
220	Eardley, 1944	Nugget Sandstone	Weber Canyon
221	PI	Nugget Sandstone	American Quasar Pineview
222	Morris, 1953	Nugget Sandstone	Weber River
223	Granger, 1953	Nugget Sandstone	Parleys Canyon
224	Stokes, 1959	Nugget Sandstone	Toone Canyon
225	Thomas and Krueger, 1946	Nugget Sandstone	Mahogany Hills
226	Asquith (pers. commun.)	Nugget Sandstone	Pullem Creek
227	Baker et al., 1936	Nugget Sandstone	Scott's Draw
228	PI	Nugget Sandstone	Phillips Fork A#10
229	Thomas and Krueger, 1945	Nugget Sandstone	Duchesne River
230	Thomas and Krueger, 1945	Nugget Sandstone	Lake Fork
231	Thomas and Krueger, 1945	Nugget Sandstone	Whiterocks
232	PI	Nugget Sandstone	Cotten Petroleum Bruchez #1
233	PI	Nugget Sandstone	Basin Petroleum Riley–Federal #1–29
234	PI	Nugget Sandstone	Arco #1 Maeser–Federal
235	PI	Nugget Sandstone	Conoco McKonkie #1
236	Thomas et al., 1945	Nugget Sandstone	Vernal
237	PI	Nugget Sandstone	Promontory Oil Buckskin Hill
238	PI	Nugget Sandstone	Flying Diamond #1 N. Ashley–State
239	PI	Nugget Sandstone	Dunlap D.P. Federal #1
240	PI	Nugget Sandstone	Dimension Oil and Gas #1
241	PI	Nugget Sandstone	Sunray Ox Oil Ceceil R. Rupple #1
242	PI	Nugget Sandstone	Equity Oil Ashley Valley
243	PI	Nugget Sandstone	Moore Govt. #1
244	Chevron (unpubl. data)	Nugget Sandstone	Dinosaur quarry
245	Thomas et al., 1945	Nugget Sandstone	Split Mountain
246	Chevron (unpubl. data)	Nugget Sandstone	Island Park
247	PI	Nugget Sandstone	Hiko Bell Federal #1
248	Hansen, 1965	Nugget Sandstone	Manila
249	Hansen, 1965	Nugget Sandstone	Horseshoe Canyon
250	PI	Nugget Sandstone	Ohio Oil Co. Brush Creek #1
251	PI	Nugget Sandstone	Mtn. Fuel Supply Co. Clay Basin
252	PI	Nugget Sandstone	Texaco #3 Van–Schailk
253	PI	Nugget Sandstone	Mtn. Fuel Supply Co. Irish Cany. #1
254	PI	Nugget Sandstone	Hanson Oil Co. #1–AX Moroni
255	Pacht, 1976	Nugget Sandstone	La Barge Creek
256	Pacht, 1976	Nugget Sandstone	Gros Ventre River
257	Pacht, 1976	Nugget Sandstone	Du Bois
258	Keefer, 1957	Nugget Sandstone	Sinclair Wyo. DuBois Well #1
259	Love et al., 1942	Nugget Sandstone	Horse Creek
260	Keefer, 1957	Nugget Sandstone	Sinclair Wyo. DuBois Well #2

TABLE 5 (continued)

Section No.	Author	Interval	Their designation, section name
261	Love, 1957	Nugget Sandstone	Tribal Well #1
262	Love, 1957	Nugget Sandstone	Tribal Well B2
263	Love, 1957	Nugget Sandstone	Shoshone-Arapahoe 1
264	Love, 1957	Nugget Sandstone	Tribal #1
265	Love, 1957	Nugget Sandstone	Baldwin Creek
266	Love, 1957	Nugget Sandstone	Squaw Creek
267	Pacht, 1976	Nugget Sandstone	Lander
268	Pipiringos, 1968	Nugget Sandstone	Dallas Anticline
269	Pipiringos, 1968	Nugget Sandstone	Derby Dome
270	Pipiringos, 1968	Nugget Sandstone	Johnson Ranch
271	Pipiringos, 1968	Nugget Sandstone	Sheep Mountain
273	Knapp, 1976	Nugget Sandstone	Lander
274	Pipiringos, 1968	Nugget Sandstone	Happy Spring
275	Pipiringos, 1968	Nugget Sandstone	Green Mountain
276	Pipiringos, 1968	Nugget Sandstone	Ferris Mountains
277	Love, 1957	Nugget Sandstone	Beaver Creek
278	Love, 1957	Nugget Sandstone	Embar #14
279	Love, 1957	Nugget Sandstone	Heaney #1
280	Love, 1957	Nugget Sandstone	Emigrant Trail #1
281	Love, 1957	Nugget Sandstone	Happy Springs Unit #23
282	Love, 1957	Nugget Sandstone	Crooks Gap #10
283	Love, 1957	Nugget Sandstone	Werty E-31
284	Love, 1957	Nugget sandstone	Bailey #3
285	Love, 1957	Nugget Sandstone	Hintze #1
286	Love, 1957	Nugget Sandstone	C-F-7
287	Love, 1957	Nugget Sandstone	2 S-7
288	Averitt, 1962	Navajo Sandstone	Sugarloaf Mountain
289	Weaver, 1980	Navajo Sandstone	Blue Mountain
290	George, 1985	Navajo Sandstone	Pavant Range
291	Harshbarger et al., 1957	Navajo Sandstone	Navajo Point
292	Harshbarger et al., 1957	Nugget Sandstone	Square Butte
293	Harshbarger et al., 1957	Navajo Sandstone	Coal Canyon
294	Harshbarger et al., 1957	Navajo Sandstone	Bound Rock
295	Harshbarger et al., 1957	Navajo Sandstone	Mexican Water
296	PI	Navajo Sandstone	Three Peaks No. 1
297	Harshbarger et al., 1957	Navajo Sandstone	Many Farms
298	Bilodeau and Keith, 1986	Sil Nakya Formation	Sil Nakya Hills
299	Bilodeau and Keith, 1986	Ali Molina Formation	Baboquivari Mountains
300	Bilodeau and Keith, 1986	Ox Frame Volcanics	Sierrita Mountains
301	Bilodeau and Keith, 1986	Mt. Wrightson Form.	Santa Rita Mountains
302	Miller and Carr, 1978	Metaquartzite	Rodman Mountains
303	Marzolf, 1983	Aztec Sandstone	Soda Mountains
304	Thomas et al., 1945		Meeker Dome

TABLE 6

Data base for Temple Cap Sandstone, Romana Sandstone, and Morrison-age eolian deposits

Section No.	Author	Interval	Their designation, section name
1	Lupe, 1983 (P)	Bluff Sandstone	308
2	Lupe, 1983 (P)	Bluff Sandstone	310
3	Lupe, 1983 (P)	Bluff Sandstone	133
4	Lupe, 1983 (P)	Bluff Sandstone	321
5	Lupe, 1983 (P)	Bluff Sandstone	320
6	Lupe, 1983 (P)	Bluff Sandstone	315
7	Lupe, 1983 (P)	Bluff Sandstone	56
8	Lupe, 1983 (P)	Bluff Sandstone	212
9	Lupe, 1983 (P)	Bluff Sandstone	91
10	Lupe, 1983 (P)	Bluff Sandstone	89
11	Lupe, 1983 (P)	Bluff Sandstone	97
12	Lupe, 1983 (P)	Junction Creek Sandstone	268
13	Lupe, 1983 (P)	Junction Creek Sandstone	278
14	Lupe, 1983 (P)	Junction Creek Sandstone	283
15	Lupe, 1983 (P)	Junction Creek Sandstone	288
16	Lupe, 1983 (P)	Junction Creek Sandstone	287
17	Lupe, 1983 (P)	Junction Creek Sandstone	132
18	Lupe, 1983 (P)	Junction Creek Sandstone	49
19	Lupe, 1983 (P)	Junction Creek Sandstone	85
20	Lupe, 1983 (P)	Junction Creek Sandstone	94
21	Lupe, 1983 (P)	Junction Creek Sandstone	252
22	Lupe, 1983 (P)	Junction Creek Sandstone	247
23	Lupe, 1983 (P)	Junction Creek Sandstone	112
24	Lupe, 1983 (P)	Junction Creek Sandstone	286
25	Lupe, 1983 (P)	Junction Creek Sandstone	285
26	Lupe, 1983 (P)	Junction Creek Sandstone	122
27	Lupe, 1983 (P)	Junction Creek Sandstone	292
28	Lupe, 1983 (P)	Junction Creek Sandstone	46
29	Lupe, 1983 (P)	Junction Creek Sandstone	83
30	Lupe, 1983 (P)	Junction Creek Sandstone	272
31	Lupe, 1983 (P)	Junction Creek Sandstone	156
32	Lupe, 1983 (P)	Junction Creek Sandstone	162
33	Lupe, 1983 (P)	Junction Creek Sandstone	177
34	Lupe, 1983 (P)	Junction Creek Sandstone	22
35	Lupe, 1983 (P)	Junction Creek Sandstone	190
36	Lupe, 1983 (P)	Junction Creek Sandstone	34
37	Lupe, 1983 (P)	Junction Creek Sandstone	65
38	Lupe, 1983 (P)	Junction Creek Sandstone	99
39	Lupe, 1983 (P)	Junction Creek Sandstone	107
40	Lupe, 1983 (P)	Junction Creek Sandstone	208
41	Lupe, 1983 (P)	Junction Creek Sandstone	50
42	Lupe, 1983 (P)	Junction Creek Sandstone	198
43	Lupe, 1983 (P)	Junction Creek Sandstone	47
44	Lupe, 1983 (P)	Junction Creek Sandstone	40
45	Lupe, 1983 (P)	Junction Creek Sandstone	191
46	Lupe, 1983 (P)	Junction Creek Sandstone	195
47	Lupe, 1983 (P)	Junction Creek Sandstone	81
48	Lupe, 1983 (P)	Junction Creek Sandstone	87
49	Lupe, 1983 (P)	Junction Creek Sandstone	226
50	Lupe, 1983 (P)	Junction Creek Sandstone	225
51	Lupe, 1983 (P)	Junction Creek Sandstone	223
52	Lupe, 1983 (P)	Junction Creek Sandstone	73
53	Lupe, 1983 (P)	Junction Creek Sandstone	262

TABLE 6 (continued)

Section No.	Author	Interval	Their designation, section name
54	Lupe, 1983 (P)	Junction Creek Sandstone	274
55	Lupe, 1983 (P)	Junction Creek Sandstone	273
56	Lupe, 1983 (P)	Junction Creek Sandstone	113
57	Lupe, 1983 (P)	Bluff Sandstone	301
58	Lupe, 1983 (P)	Bluff Sandstone	302
59	Lupe, 1983 (P)	Bluff Sandstone	304
60	Lupe, 1983 (P)	Junction Creek Sandstone	131
61	Lupe, 1983 (P)	Junction Creek Sandstone	130
62	Lupe, 1983 (P)	Junction Creek Sandstone	123
63	Lupe, 1983 (P)	Junction Creek Sandstone	128
64	Lupe, 1983 (P)	Junction Creek Sandstone	284
65	Wood et al., 1948	Junction Creek Sandstone	#1 Sullenberger
66	Wood et al., 1948	Junction Creek Sandstone	Crowley #1
67	Wright and Dickey, 1978	Junction Creek Sandstone	Ute Mountain
101	O'Sullivan, 1980	Bluff Sandstone	34—Cottonwood Wash
102	O'Sullivan, 1980	Bluff Sandstone	35—Whiskers Draw N
103	O'Sullivan, 1980	Bluff Sandstone	36—Whiskers Draw S
104	O'Sullivan, 1980	Bluff Sandstone	37—Butler 1
105	O'Sullivan, 1980	Bluff Sandstone	38—Butler 2
106	O'Sullivan, 1980	Bluff Sandstone	40—Butler 4
107	O'Sullivan, 1980	Bluff Sandstone	41—Butler 5
108	Craig et al., 1959	Bluff Sandstone	163—Recapture Creek
109	O'Sullivan, 1978	Bluff Sandstone	13—White Rocks Point
110	O'Sullivan, 1978	Bluff Sandstone	12—Tohonadle
111	O'Sullivan, 1978	Bluff Sandstone	11—Mexican Water
112	O'Sullivan, 1978	Bluff Sandstone	10—Garnet Ridge
113	O'Sullivan, 1978	Bluff Sandstone	8—Red Point Mesa
114	F. Peterson (unpubl. data)	Bluff Sandstone	1139—Nokaito Bench
115	Condon and Huffman, 1984	Bluff Sandstone	7—Beclabito Dome
116	Bryant, 1979	Junction Creek Sandstone	East Snowmass Creek
117	Craig et al., 1959	Junction Creek Sandstone	2—Almont
118	Craig et al., 1959	Junction Creek Sandstone	3—Animas River
119	Craig et al., 1959	Junction Creek Sandstone	5—Basalt
120	Craig et al., 1959	Junction Creek Sandstone	8—Bi Creek
121	Craig et al., 1959	Junction Creek Sandstone	10—Black Canyon
122	Wright and Wright, 1962	Junction Creek Sandstone	18—Slick Rock
123	Craig et al., 1959	Junction Creek Sandstone	58—Dove Spring
124	Craig et al., 1959	Junction Creek Sandstone	66—Durango
125	Wright and Wright, 1962	Junction Creek Sandstone	20—Big Canyon
126	Craig et al., 1959	Junction Creek Sandstone	68—Egnar-Dolores River
127	Craig et al., 1959	Junction Creek Sandstone	74—Fish Creek
128	Craig et al., 1959	Junction Creek Sandstone	110—Leopard Creek Canyon
129	Craig et al., 1959	Junction Creek Sandstone	120-Lookout Point
130	Craig et al., 1959	Junction Creek Sandstone	121—Los Pinos River
131	Craig et al., 1959	Junction Creek Sandstone	124—Lower McElmo Canyon
132	Craig et al., 1959	Junction Creek Sandstone	125—Lower Piedra River
133	Craig et al., 1959	Bluff Sandstone	131—McPhee
134	Craig et al., 1959	Junction Creek Sandstone	132—McPhee—Dolores River
135	Craig et al., 1959	Junction Creek Sandstone	137—May Day
136	Craig et al., 1959	Junction Creek Sandstone	153—Ouray
137	Craig et al., 1959	Junction Creek Sandstone	157—Pease Spring
138	Craig et al., 1959	Junction Creek Sandstone	158—Piedra River
139	Craig et al., 1959	Junction Creek Sandstone	179—Sapinero

TABLE 6 (continued)

Section No.	Author	Interval	Their designation, section name
140	Craig et al., 1959	Junction Creek Sandstone	197—Stoner
141	Craig et al., 1959	Junction Creek Sandstone	214—Upper McElmo Canyon
142	Craig et al., 1959	Junction Creek Sandstone	216—Upper Piedra River
143	Craig et al., 1959	Junction Creek Sandstone	226—Wild Bill Canyon
144	Hansen, 1968	Junction Creek Sandstone	Pitts Meadow W
145	Hansen, 1968	Junction Creek Sandstone	Smith Ford
146	Langenheim, 1957	Junction Creek Sandstone	Almont
147	Langenheim, 1957	Junction Creek Sandstone	Brush Creek
148	Langenheim, 1957	Junction Creek Sandstone	Red Mountain
149	Read et al., 1949	Junction Creek Sandstone	Tres Piedras Ranch
150	Read et al., 1949	Junction Creek Sandstone	Trail Creek
151	Cadigan, 1952	Bluff Sandstone	8—Lower McElmo Canyon
152	Craig et al., 1959	Junction Creek Sandstone	99—Horseshoe Gap
153	Bush et al., 1960	Junction Creek Sandstone	Fall Creek
154	Bush et al., 1960	Bluff Sandstone	South Slope Black Ridge
155	Condon, 1985a	Bluff Sandstone	Boundary Butte
156	Condon, 1985a	Bluff Sandstone	Red Mesa
157	Condon, 1985a	Bluff Sandstone	Toh Atin Mesa
158	Condon, 1985a	Bluff Sandstone	Tsitab Wash
201	Lupe, 1983	Recapture Member	150
202	Lupe, 1983	Recapture Member	17
203	Lupe, 1983	Recapture Member	44
204	Lupe, 1983	Recapture Member	10
205	Lupe, 1983	Recapture Member	189
206	Lupe, 1983	Recapture Member	8
207	Lupe, 1983	Recapture Member	154
208	Lupe, 1983	Recapture Member	29
209	Lupe, 1983	Recapture Member	193
210	Lupe, 1983	Recapture Member	144
211	Lupe, 1983	Recapture Member	148
212	Lupe, 1983	Recapture Member	136
213	Lupe, 1983	Recapture Member	146
214	Lupe, 1983	Recapture Member	7
215	Lupe, 1983	Recapture Member	138
216	Lupe, 1983	Recapture Member	6
217	Lupe, 1983	Recapture Member	20
218	Lupe, 1983	Recapture Member	15
219	Lupe, 1983	Recapture Member	139
220	Lupe, 1983	Recapture Member	186
301	Craig et al., 1959	Recapture Member	128—Lupton
302	Craig et al., 1959	Recapture Member	92—Haystack Butte
303	Saucier, 1967	Recapture Member	24—Gallup
304	Saucier, 1967	Recapture Member	25—Pyramid Peak
305	Harshbarger et al., 1957	Recapture Member	27—Fort Wingate
306	Kirk et al. (unpubl. data)	Recapture Member	Pinedale
307	Huffman and Kirk (unpubl. data)	Recapture Member	30—Coolidge Quarry
308	Craig et al., 1959	Recapture Member	207—Thoreau
309	Craig et al., 1959	Recapture Member	140—Mesa Gigante
310	Craig et al., 1959	Recapture Member	210-Todilto Park
311	Saucier, 1967	Recapture Member	21—Cheechilgeetho
312	Peterson (unpubl. data)	Recapture Member	1060—Black Mesa Road
313	Peterson (unpubl. data)	Recapture Member	1085—Kayenta Point
314	Peterson (unpubl. data)	Recapture Member	1111—Salabkai Mesa

TABLE 6 (continued)

Section No.	Author	Interval	Their designation, section name
315	Peterson (unpubl. data)	Recapture Member	1059—Klethla Valley—361
316	Peterson (unpubl. data)	Recapture Member	1058—Klethla Valley—364
317	Peterson (unpubl. data)	Recapture Member	1113—Steamboat East
318	Peterson (unpubl. data)	Recapture Member	1055—Lohali Point
319	Peterson (unpubl. data)	Recapture Member	1054—Tsegi
320	Craig et al., 1959	Recapture Member	172—Saline Trading Post
321	Craig et al., 1959	Recapture Member	230—Yale Point
322	Peterson (unpubl. data)	Recapture Member	1062—Longhouse Valley
323	Peterson (unpubl. data)	Recapture Member	1091—Tin Yeh Toh
324	Condon, 1985a	Recapture Member	18—Lupton East
325	Anderson, 1983	Recapture Member	Taaiyalone Mesa
326	Anderson, 1983	Recapture Member	Plumosa
327	Condon, 1985a	Recapture Member	14—Pipeline Road
328	Condon, 1985b	Recapture Member	1—Navajo Church
329	Condon, 1985b	Recapture Member	2—Midget Mesa
330	Condon, 1985b	Recapture Member	4—East Thoreau
332	Condon, 1985b	Recapture Member	6—Haystack Mountain
333	Condon, 1985b	Recapture Member	16—Mannelito
334	Condon, 1985a	Recapture Member	17—Lupton West
401	Peterson (unpubl. data)	Temple Cap Sandstone	525—Leeds West
402	Peterson (unpubl. data)	Temple Cap Sandstone	535—3—Cedar City
403	Peterson (unpubl. data)	Temple Cap Sandstone	556—Johnson Canyon
404	Peterson (unpubl. data)	Temple Cap Sandstone	557—Brown Canyon
405	Peterson (unpubl. data)	Temple Cap Sandstone	558—Kanab Canyon
406	Peterson (unpubl. data)	Temple Cap Sandstone	569—Mt. Carmel Junction
407	Peterson (unpubl. data)	Temple Cap Sandstone	570—Zican Lodge
408	Peterson (unpubl. data)	Temple Cap Sandstone	471–Potato Hollow
409	Peterson (unpubl. data)	Temple Cap sandstone	608—Johnson Canyon W
410	Peterson (unpubl. data)	Temple Cap Sandstone	611—Observation Point
411	Peterson (unpubl. data)	Temple Cap Sandstone	618—Gunlock
412	Peterson (unpubl. data)	Temple Cap Sandstone	647—Elephant Butte
413	Peterson (unpubl. data)	Temple Cap Sandstone	832—Taylor Creek
414	Peterson (unpubl. data)	Temple Cap Sandstone	834—N Virgin River
415	Peterson (unpubl. data)	Temple Cap Sandstone	835—N Virgin River W
416	Peterson (unpubl. data)	Temple Cap Sandstone	839—Moapa Stake
417	Peterson (unpubl. data)	Temple Cap Sandstone	840—Pocket Hollow N
418	Peterson (unpubl. data)	Temple Cap Sandstone	843—Mineral Mountains
501	Peterson (unpubl. data)	Romana Sandstone	278—Kane Creek
502	Peterson (unpubl. data)	Romana Sandstone	770—Crosby Canyon
503	Peterson (unpubl. data)	Romana Sandstone	277—Last Chance Bay E
504	Peterson (unpubl. data)	Romana Sandstone	304—Cummings Mesa W
505	Peterson (unpubl. data)	Romana Sandstone	420—Twin Red Buttes
506	Peterson (unpubl. data)	Romana Sandstone	Jb—B–Cotton Point
507	Peterson (unpubl. data)	Romana Sandstone	384—Torera Point
508	Peterson (unpubl. data)	Romana Sandstone	679—Castle Rock
509	Peterson (unpubl. data)	Romana Sandstone	418—Leche–e Rock
510	Peterson (unpubl. data)	Romana Sandstone	381—Cummings Mesa Trail
511	Peterson (unpubl. data)	Romana Sandstone	408—Square Butte
512	Peterson (unpubl. data)	Romana Sandstone	407—Tsai Skizzie
601	Sacrison, 1958	Unkpapa Sandstone	1—Parker Creek
602	Sacrison, 1958	Unkpapa Sandstone	2—Hell Canyon
603	Sacrison, 1958	Unkpapa Sandstone	3—Falls Canyon
604	Sacrison, 1958	Unkpapa Sandstone	4—Alabaugh Canyon
605	Sacrison, 1958	Unkpapa Sandstone	5—Sheps Canyon
606	Sacrison, 1958	Unkpapa Sandstone	6—Hot Springs

TABLE 6 (continued)

Section No.	Author	Interval	Their designation, section name
607	Sacrison, 1958	Unkpapa Sandstone	7—Elm Creek
608	Sacrison, 1958	Unkpapa Sandstone	8—Calico Canyon
609	Sacrison, 1958	Unkpapa Sandstone	9—French Creek
610	Sacrison, 1958	Unkpapa Sandstone	10—Dry Creek
611	Sacrison, 1958	Unkpapa Sandstone	11—Grace Coolidge Creek
612	Sacrison, 1958	Unkpapa Sandstone	12—Battle Creek S
613	Sacrison, 1958	Unkpapa Sandstone	13—Battle Creek N
614	Sacrison, 1958	Unkpapa Sandstone	14—Spring Creek
615	Sacrison, 1958	Unkpapa Sandstone	15—Rapid City
616	Sacrison, 1958	Unkpapa Sandstone	16—Blackhawk
617	Sacrison, 1958	Unkpapa Sandstone	17—Tilford
618	Sacrison, 1958	Unkpapa Sandstone	18—Barlow Canyon N
619	Sacrison, 1958	Unkpapa Sandstone	19—Barlow Canyon S
620	Robinson et al., 1964	Unkpapa Sandstone	Salt Creek W
621	Robinson et al., 1964	Unkpapa Sandstone	Oil Creek W
622	Robinson et al., 1964	Unkpapa Sandstone	Barlow Canyon Dome
623	Robinson et al., 1964	Unkpapa Sandstone	Mona Butte
624	Robinson et al., 1964	Unkpapa Sandstone	2—Bronco John Creek
625	Robinson et al., 1964	Unkpapa Sandstone	4—Moore Canyon
626	Robinson et al., 1964	Unkpapa Sandstone	5—Barnard Canyon
627	Robinson et al., 1964	Unkpapa Sandstone	7—Devils Tower 1
628	Robinson et al., 1964	Unkpapa Sandstone	8—Devils Tower 2
629	Robinson et al., 1964	Unkpapa Sandstone	10—Cabin Creek
630	Robinson et al., 1964	Unkpapa Sandstone	13—Corral Creek
631	Robinson et al., 1964	Unkpapa Sandstone	14—Little Houston Creek
632	Robinson et al., 1964	Unkpapa Sandstone	15—Dark Canyon
633	Robinson et al., 1964	Unkpapa Sandstone	17—Mason Creek
634	Robinson et al., 1964	Unkpapa Sandstone	19—Oil Creek 1
635	Robinson et al., 1964	Unkpapa Sandstone	24—Salt Creek 2
636	Robinson et al., 1964	Unkpapa Sandstone	29—Mona Butte 2
637	Robinson et al., 1964	Unkpapa Sandstone	35—Nicholsons Ranch
638	Robinson et al., 1964	Unkpapa Sandstone	36—Beulah
639	Robinson et al., 1964	Unkpapa Sandstone	39—Rimrock Ranch
640	Robinson et al., 1964	Unkpapa Sandstone	41—Lytle Creek 2
641	Ruede, 1951	Unkpapa Sandstone	1—Craven
642	Ruede, 1951	Unkpapa Sandstone	2—East Minnehahta
643	Ruede, 1951	Unkpapa Sandstone	3—Alabaugh Canyon
644	Ruede, 1951	Unkpapa Sandstone	4—Cheyenne River
645	Ruede, 1951	Unkpapa Sandstone	5—Sheps Canyon
646	Ruede, 1951	Unkpapa Sandstone	7—Buffalo Gap
647	Ruede, 1951	Unkpapa Sandstone	8—Fuson Canyon
648	Ruede, 1951	Unkpapa Sandstone	9—French Creek Tributary
649	Ruede, 1951	Unkpapa Sandstone	10—Brewer
650	Ruede, 1951	Unkpapa Sandstone	13—South Rapid City
651	Ruede, 1951	Unkpapa Sandstone	15—Piedmont
652	Ruede, 1951	Unkpapa Sandstone	17—Sturgis
653	Ruede, 1951	Unkpapa Sandstone	18—Bear Butte
654	Szigeti and Fox, 1981	Unkpapa Sandstone	1—Rapid City
655	Bell and Post, 1971	Unkpapa Sandstone	Falls Canyon
656	Conner, 1963	Unkpapa Sandstone	Red Canyon
657	Post, 1967	Unkpapa Sandstone	Whaley Canyon
658	Post, 1967	Unkpapa Sandstone	Flagpole Mountain
701	Darton, 1906	Unkpapa Sandstone	Crazy Woman Creek

TABLE 6 (continued)

Section No.	Author	Interval	Their designation, section name
702	Darton, 1906	Unkpapa Sandstone	Beaver Creek
703	Darton, 1906	Unkpapa Sandstone	S Fork of Rock Creek
704	Darton, 1906	Unkpapa Sandstone	Muddy Creek S.
705	Darton, 1906	Unkpapa Sandstone	Tongue River
706	Darton, 1906	Unkpapa Sandstone	Tensleep
707	Love et al., 1945	Unkpapa Sandstone	Thermopolis
708	Darton, 1906	Unkpapa Sandstone	Alkali Creek
709	Keefer and Treger, 1964	Unkpapa Sandstone	E Sheep Creek
710	Love et al., 1947	Unkpapa Sandstone	Horse Creek
711	Love et al., 1947	Unkpapa Sandstone	Red Grade
712	Love et al., 1947	Unkpapa Sandstone	Mill Creek
713	Love et al., 1947	Unkpapa Sandstone	Derby Dome
714	Love et al., 1947	Unkpapa Sandstone	Conant Creek
715	Love et al., 1947	Unkpapa Sandstone	Duton Basin
716	Love et al., 1945b	Unkpapa Sandstone	13—Lander Anticline
717	Love et al., 1945a	Unkpapa Sandstone	16—Squaw Creek
718	Love et al., 1945a	Unkpapa Sandstone	17—Dallas Anticline
719	Love et al., 1945a	Unkpapa Sandstone	18—Derby Anticline
720	Love et al., 1945a	Unkpapa Sandstone	21—Bison Basin Anticline
721	Love et al., 1945a	Unkpapa Sandstone	23—Big Sand Draw
722	Love et al., 1945a	Unkpapa Sandstone	25—Muskrat Anticline
723	Pipiringos, 1968	Unkpapa Sandstone	42—Freezout Mountains SW
724	Peterson (unpub. data)	Unkpapa Sandstone	44—Freezout Mountains E
725	D.H. Uhler (unpubl. data)	Unkpapa Sandstone	Alcove
726	D.H. Uhler (unpubl. data)	Unkpapa Sandstone	Thermopolis–Van Norman
727	D.H. Uhler (unpubl. data)	Unkpapa Sandstone	Baker Cabin Road
728	D.H. Uhler (unpubl. data)	Unkpapa Sandstone	Barnum
729	Love et al., 1945b	Unkpapa Sandstone	8—Winkleman Anticline
730	Love et al., 1945b	Unkpapa Sandstone	10—Sage Creek Anticline
731	Love et al., 1945b	Unkpapa Sandstone	14—Wyopo
732	Love et al., 1945b	Unkpapa Sandstone	15—Sulfur Springs
733	Love et al., 1945b	Unkpapa Sandstone	17—Beaver Creek Anticline
734	Love et al., 1945b	Unkpapa Sandstone	24—Kirby Creek Anticline
735	Love et al., 1945b	Unkpapa Sandstone	25—Black Mountain Anticline
736	Love et al., 1945b	Unkpapa Sandstone	26—Aominto
737	Love et al., 1945b	Unkpapa Sandstone	27—South Mayoworth
738	Love et al., 1945b	Unkpapa Sandstone	28—North Mayoworth
739	Pipiringos and O'Sullivan, 1976	Unkpapa Sandstone	3—Manning Ridge NW
740	Pipiringos and O'Sullivan, 1976	Unkpapa Sandstone	4—Manning Ridge SE

TABLE 7

Data base for Page Sandstone and Entrada Sandstone

Section No.	Author	Interval	Their designation, section name
1	Peterson and Pipiringos, 1979	Page Sandstone	1—Pine Creek
2	Peterson and Pipiringos, 1979	Page Sandstone	3—Harris Wash
3	Peterson and Pipiringos, 1979	Page Sandstone	13—Brown Canyon
4	Peterson and Pipiringos, 1979	Page Sandstone	14—Johnson Canyon
5	Peterson and Pipiringos, 1979	Page Sandstone	15—Carly Knoll
6	Peterson and Pipiringos, 1979	Page Sandstone	16—Lick Wash
7	Peterson and Pipiringos, 1979	Page Sandstone	17—Little Bull Valley
8	Peterson and Pipiringos, 1979	Page Sandstone	19—Sheep Creek
9	Peterson and Pipiringos, 1979	Page Sandstone	20—Kodachrome Flat
10	Peterson and Pipiringos, 1979	Page Sandstone	21—The Gut
11	Peterson and Pipiringos, 1979	Page Sandstone	22—Goodwater Seep
12	Peterson and Pipiringos, 1979	Page Sandstone	23—Hackberry Canyon
13	Peterson and Pipiringos, 1979	Page SS, Entrada SS	24—West Cove
14	Peterson and Pipiringos, 1979	Page Sandstone	25—East Cove
15	Peterson and Pipiringos, 1979	Page Sandstone	26—Judd Hollow
16	Peterson and Pipiringos, 1979	Page Sandstone	28—Gunsight Butte
17	Peterson and Pipiringos, 1979	Page Sandstone	29—Kane Wash
18	Peterson and Pipiringos, 1979	Page Sandstone	30—Cummings Mesa NW
19	Peterson and Pipiringos, 1979	Page Sandstone	31—West Canyon
20	Peterson and Pipiringos, 1979	Page Sandstone	34—Seep Flat
21	Peterson and Pipiringos, 1979	Page Sandstone	36—Early Weed Bench
22	Peterson and Pipiringos, 1979	Page Sandstone	37—Cat Pasture
23	Peterson and Pipiringos, 1979	Page Sandstone	38—Big Hollow Wash
24	Peterson and Pipiringos, 1979	Page Sandstone	39—Hurricane Wash
25	Peterson and Pipiringos, 1979	Page Sandstone	40—Cave Point
26	Peterson and Pipiringos, 1979	Page Sandstone	41—Fiftymile Point
27	Peterson and Pipiringos, 1979	Page Sandstone	42—Navajo Point
28	Peterson and Pipiringos, 1979	Page Sandstone	43—Little Arch Canyon
29	Peterson and Pipiringos, 1979	Page Sandstone	27—Sand Valley
30	Peterson and Pipiringos, 1979	Page Sandstone	2—Page
31	Peterson and Pipiringos, 1979	Page Sandstone	32—Cummings Mesa Trail
32	Imlay, 1980	Page SS, Entrada SS	36—Black Dragon Canyon
33	Imlay, 1980	Page Sandstone	37—San Rafael River
34	Imlay, 1980	Page SS, Entrada SS	50—Page
35	Imlay, 1980	Page Sandstone	28—Miller Creek
36	Imlay, 1980	Canyon Springs Member	30—Frantz Creek
37	Imlay, 1980	Canyon Springs Member	29—Elk Creek
38	Imlay, 1980	Canyon Springs Member	31—Hahns Peak
39	Imlay, 1980	Entrada Sandstone	41—McElmo Canyon
40	Imlay, 1980	Entrada Sandstone	51—Big Hollow Wash
41	O'Sullivan, 1981	Page SS, Entrada SS	1—Spanish Valley S
42	O'Sullivan, 1981	Page Sandstone	2—Behind the Rocks 1
43	O'Sullivan, 1981	Page SS, Entrada SS	5—Pole Canyon
44	O'Sullivan, 1981	Page Sandstone	9—Kane Springs 3
45	O'Sullivan, 1981	Page Sandstone	11—Muleshoe Canyon 1
46	O'Sullivan, 1981	Page SS, Entrada SS	14—La Sal Junction
47	O'Sullivan, 1981	Page Sandstone	3—Behind the Rocks 2
48	O'Sullivan, 1981	Page Sandstone	7—Behind the Rocks 4
49	O'Sullivan, 1981	Entrada Sandstone	10—Kane Springs 4
50	O'Sullivan, 1981	Entrada Sandstone	18—Hook and Ladder
51	O'Sullivan, 1981	Entrada Sandstone	22—Casa Colorado Rock
52	O'Sullivan, 1981	Entrada Sandstone	23—White Rock

TABLE 7 (continued)

Section No.	Author	Interval	Their designation, section name
53	O'Sullivan, 1981	Entrada Sandstone	24—East Canyon
54	O'Sullivan, 1981	Entrada Sandstone	25—Day Wash A
55	O'Sullivan, 1981	Entrada Sandstone	29—Three Step Hill E.
56	O'Sullivan, 1981	Entrada Sandstone	30—McIntyre 1
57	O'Sullivan, 1981	Entrada Sandstone	31—McIntyre 2
58	O'Sullivan, 1981	Entrada Sandstone	33—Slick Rock
59	O'Sullivan, 1981	Entrada Sandstone	4—Behind the Rocks 3
60	O'Sullivan, 1981	Entrada Sandstone	9—Kane Springs 2
61	O'Sullivan, 1981	Entrada Sandstone	12—Muleshoe Canyon 2
62	O'Sullivan, 1981	Entrada Sandstone	13—La Sal Junction, NW
63	O'Sullivan, 1981	Entrada Sandstone	15—West Coyote
64	O'Sullivan, 1981	Entrada Sandstone	19—Wilson Arch, S
65	O'Sullivan, 1981	Entrada Sandstone	20—Lopez Gulch 1
66	Caputo, 1980	Page Sandstone	Paria Canyon Primitive Area
67	Caputo, 1980	Page Sandstone	Catstairs Canyon
68	Caputo, 1980	Page Sandstone	Cottonwood Creek A
69	Caputo, 1980	Page Sandstone	Cottonwood Creek B
70	Caputo, 1980	Page Sandstone	Cottonwood Creek C
71	Caputo, 1980	Page Sandstone	Rock Springs Creek
72	Caputo, 1980	Page Sandstone	Bull Valley Gorge D
73	Caputo, 1980	Page Sandstone	Deer Springs Ranch
74	O'Sullivan and Peirce, 1983	Page Sandstone	12—Tenmile Butte N
75	O'Sullivan and Peirce, 1983	Page Sandstone	13—The Needles
76	O'Sullivan and Peirce, 1983	Page Sandstone	14—Dubinky W
77	O'Sullivan and Peirce, 1983	Page Sandstone	18—Courthhouse Rock
78	O'Sullivan and Peirce, 1983	Page Sandstone	41—Lightning Draw S
79	O'Sullivan and Peirce, 1983	Page Sandstone	42—Photo Gap N
80	O'Sullivan and Peirce, 1983	Page Sandstone	43—Photo Gap
81	O'Sullivan and Peirce, 1983	Page Sandstone	44—Photo Gap S
82	O'Sullivan and Peirce, 1983	Page Sandstone	9—Duma Point
83	O'Sullivan and Peirce, 1983	Page Sandstone	17—Bartlett Wash E
84	O'Sullivan and Peirce, 1983	Page Sandstone	19—Sevenmile Canyon
85	O'Sullivan and Peirce, 1983	Page Sandstone	24—Muleshoe Canyon 2
86	O'Sullivan and Peirce, 1983	Page Sandstone	30—Looking Glass Rock
87	O'Sullivan and Peirce, 1983	Page Sandstone	31—Hatch Rock
88	O'Sullivan and Pipiringos, 1983	Entrada Sandstone	3—Cottonwood Canyon
89	O'Sullivan and Pipiringos, 1983	Entrada Sandstone	6—Granite Creek
90	O'Sullivan and Pipiringos, 1983	Entrada Sandstone	8—Buchkhorn Mesa
91	O'Sullivan and Pipiringos, 1983	Entrada Sandstone	12—Westwater
92	O'Sullivan and Pipiringos, 1983	Entrada Sandstone	13—Ruby Canyon
93	O'Sullivan and Pipiringos, 1983	Entrada Sandstone	14—Rabbit Valley
94	O'Sullivan and Pipiringos, 1983	Entrada Sandstone	16—Loma
95	O'Sullivan and Pipiringos, 1983	Entrada Sandstone	17—Rattlesnake Canyon
96	O'Sullivan and Pipiringos, 1983	Entrada Sandstone	18—Fruita
97	O'Sullivan and Pipiringos, 1983	Entrada Sandstone	19—Coke Ovens
98	O'Sullivan and Pipiringos, 1983	Entrada Sandstone	20—Rough Canyon
99	O'Sullivan and Pipiringos, 1983	Entrada Sandstone	21—Cactus Park
100	O'Sullivan and Pipiringos, 1983	Entrada Sandstone	22—Bridgeport
101	O'Sullivan, 1984	Entrada Sandstone	1—Dewey Bridge
102	O'Sullivan, 1984	Entrada Sandstone	2—Blue Chief Mesa
103	O'Sullivan, 1984	Entrada Sandstone	3—Bridge Canyon
104	O'Sullivan, 1984	Entrada Sandstone	9—Lumsden Canyon
105	O'Sullivan, 1984	Entrada Sandstone	10—John Brown Canyon

TABLE 7 (continued)

Section No.	Author	Interval	Their designation, section name
106	O'Sullivan, 1984	Entrada Sandstone	11—Cave Canyon
107	O'Sullivan, 1984	Entrada Sandstone	13—Tenderfoot Mesa A
108	O'Sullivan, 1984	Entrada Sandstone	14—Maverick Canyon B
109	O'Sullivan, 1984	Entrada Sandstone	16—Flat Top Mesa
110	O'Sullivan, 1984	Entrada Sandstone	17—Calamity Mesa SW
111	O'Sullivan, 1984	Entrada Sandstone	18—Blue Creek
112	O'Sullivan, 1984	Entrada Sandstone	20—Beehive Canyon
113	O'Sullivan, 1984	Entrada Sandstone	24—Uravan
114	Wright and Dickey, 1979	Entrada Sandstone	69—Crystal
115	Wright and Dickey, 1979	Entrada Sandstone	75—Twin Buttes Wash
116	O'Sullivan, 1984	Entrada Sandstone	15—Bartlett Wash W
117	O'Sullivan, 1984	Entrada Sandstone	17—Mill Canyon
118	O'Sullivan, 1984	Entrada Sandstone	8—Duma Point
119	O'Sullivan, 1984	Entrada Sandstone	9—Tenmile Canyon W
120	O'Sullivan, 1984	Entrada Sandstone	10—Tenmile Canyon E
121	O'Sullivan, 1984	Entrada Sandstone	11—Tenmile Butte N
122	O'Sullivan, 1984	Entrada Sandstone	12—Tenmile Butte
123	O'Sullivan, 1984	Entrada Sandstone	13—Dubinky W
124	O'Sullivan, 1984	Entrada Sandstone	14—Dubinky E
125	O'Sullivan, 1984	Entrada Sandstone	16—Bartlett Wash E
126	O'Sullivan, 1980	Entrada Sandstone	1—Wilson Arch
127	O'Sullivan, 1980	Entrada Sandstone	3—Hatch Rock
128	O'Sullivan, 1980	Entrada Sandstone	5—Wind Whistle Draw
129	O'Sullivan, 1980	Entrada Sandstone	8—Rone Bailey 3
130	O'Sullivan, 1980	Entrada Sandstone	15—Photo Gap
131	O'Sullivan, 1980	Entrada Sandstone	21—Harts 1
132	O'Sullivan, 1980	Entrada Sandstone	22—Indian Creek E
133	O'Sullivan, 1980	Entrada Sandstone	24—Shay Mountain
134	O'Sullivan, 1980	Entrada Sandstone	26—Mt. Linnaeus
135	O'Sullivan, 1980	Entrada Sandstone	29—Mancos Jim Butte
136	O'Sullivan, 1980	Entrada Sandstone	33—Black Steer Knoll
137	O'Sullivan, 1980	Entrada Sandstone	37—Butler 1
138	O'Sullivan, 1980	Entrada Sandstone	40—Butler 4
139	O'Sullivan, 1980	Entrada Sandstone	42—Butler 6
140	O'Sullivan, 1980	Entrada Sandstone	49—Butler 13
141	O'Sullivan, 1980	Entrada Sandstone	51—Bluff W
142	O'Sullivan, 1980	Entrada Sandstone	9—Rone Bailey SE 1
143	O'Sullivan, 1980	Entrada Sandstone	7—Rone Bailey 2
144	O'Sullivan, 1980	Entrada Sandstone	4—Rone Bailey 1
145	O'Sullivan, 1980	Entrada Sandstone	2—Looking Glass Rock
146	Wright and Dickey, 1978	Entrada Sandstone	4—Cedar Mountain
147	Wright and Dickey, 1978	Entrada Sandstone	18—Pine Creek
148	Wright and Dickey, 1978	Entrada Sandstone	26—Little Wild Horse Mesa
149	Wright and Dickey, 1978	Entrada Sandstone	28—Granite Ranch
150	Wright and Dickey, 1978	Entrada Sandstone	221—249 Flat Top Buttes
151	Wright and Dickey, 1978	Entrada Sandstone	225—Johns Valley Calf Co #1
152	Wright and Dickey, 1978	Entrada Sandstone	299—Pulpit Arch
153	Wright and Dickey, 1978	Entrada Sandstone	372—Barx-Frontier-Stanolind
154	Wright and Dickey, 1978	Entrada Sandstone	378—Phillips Petro. Two Waters #1
155	Wright and Dickey, 1978	Entrada Sandstone	380—Hill Creek Carter Oil Co
156	Wright and Dickey, 1978	Entrada Sandstone	476—Phillips Petrol. Watson "B" #1
157	Wright and Dickey, 1978	Entrada Sandstone	14—Fremont River

TABLE 7 (continued)

Section No.	Author	Interval	Their designation, section name
158	Wright and Dickey, 1978	Entrada Sandstone	16—Burro Wash Notom Bench
159	Wright and Dickey, 1978	Entrada Sandstone	17—Red Slide
160	Wright and Dickey, 1978	Entrada Sandstone	20—Navajo Point
161	Wright and Dickey, 1978	Entrada Sandstone	21—Catstairs
162	Wright and Dickey, 1978	Entrada Sandstone	22—Paria Amphitheater
163	Wright and Dickey, 1978	Entrada Sandstone	24—Baker Ranch, Halls Creek
164	Wright and Dickey, 1978	Entrada Sandstone	42—Wahweap
165	Wright and Dickey, 1978	Entrada Sandstone	44—Adairville
166	Wright and Dickey, 1978	Entrada Sandstone	47—American Liberty Gov #1
167	Wright and Dickey, 1978	Entrada Sandstone	70—Crossing of the Fathers
168	Wright and Dickey, 1978	Entrada Sandstone	84—The Gut
169	Wright and Dickey, 1978	Entrada Sandstone	205—Bitter Spring Seep
170	Wright and Dickey, 1978	Entrada Sandstone	206—Muley Twist
171	Wright and Dickey, 1978	Entrada Sandstone	214—Muddy River W
172	Wright and Dickey, 1978	Entrada Sandstone	215—Starvation Point
173	Wright and Dickey, 1978	Entrada Sandstone	281—Muddy River E
174	Wright and Dickey, 1978	Entrada Sandstone	6—San Rafael Reef
175	Wright and Dickey, 1978	Entrada Sandstone	12—Horn Silver Gulch
176	Wright and Dickey, 1978	Entrada Sandstone	16—98 Notom
177	Wright and Dickey, 1978	Entrada Sandstone	23—Teasdale
178	Wright and Dickey, 1978	Entrada Sandstone	149—Dove Spring
179	Wright and Dickey, 1978	Entrada Sandstone	222—Farnham Dome Mtn Full #1
180	Wright and Dickey, 1978	Entrada Sandstone	223—Grassy Trail Cities Service Fed #1
181	Wright and Dickey, 1978	Entrada Sandstone	347—Salina Canyon
182	Wright and Dickey, 1978	Entrada Sandstone	350—K—Ranch CO—UT Border
183	Wright and Dickey, 1978	Entrada Sandstone	351—Willow Creek
184	Wright and Dickey, 1978	Entrada Sandstone	516—Ute Mtn Cont. Oil Co. #3
185	Wright and Dickey, 1978	Entrada Sandstone	522—Cont. Oil Co #1
186	Johnston, 1975	Entrada Sandstone	Tonalea
187	Johnston, 1975 (K)	Entrada Sandstone	Dangling Rope
188	Johnston, 1975 (K)	Entrada Sandstone	Warm Creek
189	Johnston, 1975 (K)	Entrada Sandstone	NE Cummings Mesa
190	Johnston, 1975 (K)	Entrada Sandstone	W Cummings Mesa
191	Johnston, 1975	Entrada Sandstone	Elephant's Feet
192	Johnston, 1975	Entrada Sandstone	Coal Mine
193	Johnston, 1975	Entrada Sandstone	Blue Canyon
194	Johnston, 1975	Entrada Sandstone	SW White Mesa
195	Johnston, 1975	Entrada Sandstone	NE White Mesa
196	Johnston, 1975 (K)	Entrada Sandstone	Tse Skizzi
197	Johnston, 1975	Entrada Sandstone	NW Coal Mine
198	Johnston, 1975	Entrada Sandstone	Cow Springs
199	Johnston, 1975 (K)	Entrada Sandstone	Window Rock
200	Johnston, 1975	Entrada Sandstone	Kaibito
201	Johnston, 1975 (K)	Entrada Sandstone	Lechee—e Rock
202	Johnston, 1975	Entrada Sandstone	Wahweap
203	Pipiringos and O'Sullivan, 1976	Entrada Sandstone	10—Boundary Line
204	Pipiringos and O'Sullivan, 1976	Entrada Sandstone	11—Sand Creek
205	Pipiringos and O'Sullivan, 1976	Entrada Sandstone	12—Table Mountain
206	Pipiringos and O'Sullivan, 1976	Entrada Sandstone	13—Box Elder Creek N
207	Pipiringos and O'Sullivan, 1976	Entrada Sandstone	14—Box Elder Creek S
208	Pipiringos and O'Sullivan, 1976	Entrada Sandstone	15—Park Creek
209	Pipiringos and O'Sullivan, 1976	Entrada Sandstone	16—Owl Canyon
210	Pipiringos and O'Sullivan, 1976	Entrada Sandstone	17—Bellvue

TABLE 7 (continued)

Section No.	Author	Interval	Their designation, section name
211	Pipiringos and O'Sullivan, 1976	Entrada Sandstone	19—Loveland
212	Pipiringos and O'Sullivan, 1976	Entrada Sandstone	20—Dry Creek
213	Pipiringos and O'Sullivan, 1976	Entrada Sandstone	21—Litle Thompson
214	Pipiringos and O'Sullivan, 1976	Entrada Sandstone	22—Four Mile Canyon
215	Pipiringos and O'Sullivan, 1976	Entrada Sandstone	23—Ralston Reservoir
216	Pipiringos and O'Sullivan, 1976	Entrada Sandstone	9—Mesa Mountain
217	Pipiringos and O'Sullivan, 1976	Entrada Sandstone	8—Horse Creek
218	Pipiringos and O'Sullivan, 1976	Entrada Sandstone	7—Farthing
219	Pipiringos and O'Sullivan, 1976	Entrada Sandstone	6—Chugwater Creek
220	Pipiringos and O'Sullivan, 1976	Entrada Sandstone	5—Horseshoe Creek
221	Pipiringos and O'Sullivan, 1976	Entrada Sandstone	4—Manning Ridge SE
222	Pipiringos and O'Sullivan, 1976	Entrada Sandstone	3—Manning Ridge NW
223	Pipiringos and O'Sullivan, 1976	Entrada Sandstone	2—Sage Hen Anticline
224	Pipiringos and O'Sullivan, 1976	Entrada Sandstone	1—Douglas
225	O'Sullivan, 1978	Entrada Sandstone	1—Lohali Point
226	O'Sullivan, 1978	Entrada Sandstone	2—White Hills
227	O'Sullivan, 1978	Entrada Sandstone	3—White Top Mesa
228	O'Sullivan, 1978	Entrada Sandstone	4—White Top Mesa S
229	O'Sullivan, 1978	Entrada Sandstone	5—White Top Mesa
230	O'Sullivan, 1978	Entrada Sandstone	8—Red Point Mesa
231	O'Sullivan, 1978	Entrada Sandstone	9—Red Point
232	O'Sullivan, 1978	Entrada Sandstone	10—Garnet Ridge
233	O'Sullivan, 1978	Entrada Sandstone	11—Mexican Water
234	O'Sullivan, 1978	Entrada Sandstone	12—Tohonadla
235	O'Sullivan, 1978	Entrada Sandstone	13—White Rock Point
236	Wright et al., 1962	Entrada Sandstone	1—San Rafael River
237	Wright et al., 1962	Entrada Sandstone	3—Ten Mile Wash
238	Wright et al., 1962	Entrada Sandstone	4—Ten Mile Butte
239	Wright et al., 1962	Entrada Sandstone	6—Arches
240	Wright et al., 1962	Entrada Sandstone	12—Mill Creek
241	Wright et al., 1962	Entrada Sandstone	13—Cane Springs
242	Wright et al., 1962 (K)	Entrada Sandstone	19—Horseshoe Group
243	Wright et al., 1962 (K)	Entrada Sandstone	20—Big Canyon
244	Otto and Picard, 1975	Entrada Sandstone	#1
245	Otto and Picard, 1975	Entrada Sandstone	#3
246	Otto and Picard, 1975	Entrada Sandstone	#4
247	Otto and Picard, 1975	Entrada Sandstone	#6
248	Otto and Picard, 1975	Entrada Sandstone	#7
249	Otto and Picard, 1975	Entrada Sandstone	#11
250	Otto and Picard, 1975	Entrada Sandstone	#12
251	Otto and Picard, 1975	Entrada Sandstone	#13
252	Wright et al., 1980	Entrada Sandstone	19—Collet Creek
253	Kocurek, 1980	Entrada Sandstone	W Manila
254	Kocurek, 1980	Entrada Sandstone	Dagget City Dump
255	Kocurek, 1980	Entrada Sandstone	Steinaker
256	Kocurek, 1980	Entrada Sandstone	Dinosaur
257	Kocurek, 1980	Entrada Sandstone	Chew Ranch
258	Kocurek, 1980	Entrada Sandstone	Plug Hat Butte
259	Kocurek, 1980	Entrada Sandstone	Blue Mountain
260	Kocurek, 1980	Entrada Sandstone	Skull Creek
261	Kocurek, 1980	Entrada Sandstone	Elk Springs
262	Kocurek, 1980	Entrada Sandstone	Vermillion Creek

TABLE 7 (continued)

Section No.	Author	Interval	Their designation, section name
263	Kocurek, 1980	Entrada Sandstone	Meeker
264	Kocurek, 1980	Entrada Sandstone	Wolcott
265	Kocurek, 1980	Entrada Sandstone	Derby Creek
266	Thomas and Kreuger, 1946	Entrada Sandstone	Lake Fork
267	Thomas and Kreuger, 1946	Entrada Sandstone	Whiterocks Canyon
268	Thomas and Kreuger, 1946	Entrada Sandstone	Vernal
269	Thomas and Kreuger, 1946	Entrada Sandstone	Split Mountain
270	Cater, 1970	Entrada Sandstone	Dolores
271	Davidson, 1967	Entrada Sandstone	#16
272	Peterson (unpubl. data)	Entrada Sandstone	Pine Creek
273	Huff and Leswe, 1965	Entrada Sandstone	#1
274	Baker, 1946	Entrada Sandstone	p. 77
275	Baker, 1946	Entrada Sandstone	p. 77
276	O'Sullivan, 1965	Entrada Sandstone	p. 75
277	O'Sullivan, 1965	Entrada Sandstone	p. 76
278	Ver Hoeve, 1982	Entrada Sandstone	#12
279	Ver Hoeve, 1982	Entrada Sandstone	#26
280	Ver Hoeve, 1982	Entrada Sandstone	#37
281	Ver Hoeve, 1982	Entrada Sandstone	#34
282	Lupe, 1983	Entrada Sandstone	#306
283	Lupe, 1983	Entrada Sandstone	#307
284	Lupe, 1983	Entrada Sandstone	#310
285	Lupe, 1983	Entrada Sandstone	#123
286	Lupe, 1983	Entrada Sandstone	#320
287	Lupe, 1983	Entrada Sandstone	#315
288	Lupe, 1983	Entrada Sandstone	#268
289	Lupe, 1983	Entrada Sandstone	#283
290	Lupe, 1983	Entrada Sandstone	#132
291	Lupe, 1983	Entrada Sandstone	#130
292	Lupe, 1983	Entrada Sandstone	#123
293	Lupe, 1983	Entrada Sandstone	#10
294	Lupe, 1983	Entrada Sandstone	#146
295	Lupe, 1983	Entrada Sandstone	#137
296	Lupe, 1983	Entrada Sandstone	#56
297	Lupe, 1983	Entrada Sandstone	#91
298	Lupe, 1983	Entrada Sandstone	#81
299	Lupe, 1983	Entrada Sandstone	#87
300	Lupe, 1983	Entrada Sandstone	#226
301	Lupe, 1983	Entrada Sandstone	#44
302	Lupe, 1983	Entrada Sandstone	#212
303	Lupe, 1983	Entrada Sandstone	#97
304	Lupe, 1983	Entrada Sandstone	#268
305	Rocky Mtn Assoc of Geologists	Entrada Sandstone	#56
306	Rocky Mtn Assoc of Geologists	Entrada Sandstone	#53 Continental
307	Rocky Mtn Assoc of Geologists	Entrada Sandstone	#53 Skelly
308	Rocky Mtn Assoc of Geologists	Entrada Sandstone	#98
309	Rocky Mtn Assoc of Geologists	Entrada Sandstone	#11
310	Rocky Mtn Assoc of Geologists	Entrada Sandstone	#12
311	Rocky Mtn Assoc of Geologists	Entrada Sandstone	#14
312	Rocky Mtn Assoc of Geologists	Entrada Sandstone	#16B
313	Rocky Mtn Assoc of Geologists	Entrada Sandstone	#17B
314	Rocky Mtn Assoc of Geologists	Entrada Sandstone	#19B
315	Rocky Mtn Assoc of Geologists	Entrada Sandstone	#22

TABLE 7 (continued)

Section No.	Author	Interval	Their designation, section name
316	Rocky Mtn Assoc of Geologists	Entrada Sandstone	#24
317	Rocky Mtn Assoc of Geologists	Entrada Sandstone	#31
318	Rocky Mtn Assoc of Geologists	Entrada Sandstone	#30
319	Rocky Mtn Assoc of Geologists	Entrada Sandstone	#29
320	Rocky Mtn Assoc of Geologists	Entrada Sandstone	#27
321	Rocky Mtn Assoc of Geologists	Entrada Sandstone	#28
322	Rocky Mtn Assoc of Geologists	Entrada Sandstone	#41
323	Rocky Mtn Assoc of Geologists	Entrada Sandstone	#42
324	Rocky Mtn Assoc of Geologists	Entrada Sandstone	#59
325	Rocky Mtn Assoc of Geologists	Entrada Sandstone	#60
326	Rocky Mtn Assoc of Geologists	Entrada Sandstone	#62
327	Rocky Mtn Assoc of Geologists	Entrada Sandstone	#44
328	Rocky Mtn Assoc of Geologists	Entrada Sandstone	#96
329	Rocky Mtn Assoc of Geologists	Entrada Sandstone	#80
330	Rocky Mtn Assoc of Geologists	Entrada Sandstone	#81
331	Rocky Mtn Assoc of Geologists	Entrada Sandstone	#97
332	Rocky Mtn Assoc of Geologists	Entrada Sandstone	#98
333	Rocky Mtn Assoc of Geologists	Entrada Sandstone	#99
334	Rocky Mtn Assoc of Geologists	Entrada Sandstone	#87
335	Rocky Mtn Assoc of Geologists	Entrada Sandstone	#88
336	Rocky Mtn Assoc of Geologists	Entrada Sandstone	#89
337	Rocky Mtn Assoc of Geologists	Entrada Sandstone	#3
338	Rocky Mtn Assoc of Geologists	Entrada Sandstone	#7
339	Rocky Mtn Assoc of Geologists	Entrada Sandstone	#8B
340	O'Sullivan, 1981	Entrada Sandstone	1—Salt Valley
341	O'Sullivan, 1981	Entrada Sandstone	12—Square Park A
342	O'Sullivan, 1981	Entrada Sandstone	5—Mine Draw
343	O'Sullivan, 1981	Entrada Sandstone	6—Lost Spring A
344	O'Sullivan, 1981	Entrada Sandstone	7—Lost Spring B
345	O'Sullivan, 1981	Entrada Sandstone	8—Fish Seep Draw A
346	O'Sullivan, 1981	Entrada Sandstone	9—Fish Seep Draw B
347	O'Sullivan, 1981	Entrada Sandstone	10—Auger Spring A
348	Smith et al., 1961	Entrada Sandstone	Chama Basinlocal average
349	Smith et al., 1961	Entrada Sandstone	Chama Basinlocal average
350	Smith et al., 1961	Entrada Sandstone	Chama Basinlocal average
351	Baldwin and Muehlberger, 1959	Entrada Sandstone	#5B
352	Baldwin and Muehlberger, 1959	Entrada Sandstone	#7
353	Baldwin and Muehlberger, 1959	Entrada Sandstone	#8B
354	Baldwin and Muehlberger, 1959	Entrada Sandstone	#10A
355	Baldwin and Muehlberger, 1959	Entrada Sandstone	#12
356	Baldwin and Muehlberger, 1959	Entrada Sandstone	#13
357	Baldwin and Muehlberger, 1959	Entrada Sandstone	#14
358	Baldwin and Muehlberger, 1959	Entrada Sandstone	#15
359	Baldwin and Muehlberger, 1959	Entrada Sandstone	#17
360	Baldwin and Muehlberger, 1959	Entrada Sandstone	#22
361	Baldwin and Muehlberger, 1959	Entrada Sandstone	#24
362	Baldwin and Muehlberger, 1959	Entrada Sandstone	#25
363	Baldwin and Muehlberger, 1959	Entrada Sandstone	#27
364	Baldwin and Muehlberger, 1959	Entrada Sandstone	#28
365	Green 1974	Entrada Sandstone	p. D5
366	Vincelette and Chittum, 1981	Entrada Sandstone	Tenneco PAH-1
367	Vincelette and Chittum, 1981	Entrada Sandstone	Sun Navajo 1

TABLE 7 (continued)

Section No.	Author	Interval	Their designation, section name
368	Vincelette and Chittum, 1981	Entrada Sandstone	Sun Navajo Lands 1
369	Vincelette and Chittum, 1981	Entrada Sandstone	Sun Federal 1
370	Vincelette and Chittum, 1981	Entrada Sandstone	Union Caldwell Ranch 1
371	Vincelette and Chittum, 1981	Entrada Sandstone	Pan Am C-USA-1
372	Vincelette and Chittum, 1981	Entrada Sandstone	Magnolia Hutchinson 1
373	Vincelette and Chittum, 1981	Entrada Sandstone	Brinkerhoff Cabezon-1
374	Wright and Dickey, 1979	Entrada Sandstone	53—Main Elk Creek
375	Wright and Dickey, 1979	Entrada Sandstone	72—Flag Creek
376	Wright and Dickey, 1979	Entrada Sandstone	85—Riland-Midnight Mine
377	Wright and Dickey, 1979	Entrada Sandstone	86—Marion Creek
378	Wright and Dickey, 1979	Entrada Sandstone	79—King Creek
379	Wright et al., 1979	Entrada Sandstone	52—Sandy Mine
380	Wright et al., 1979	Entrada Sandstone	68—Puertecito
381	Wright et al., 1979	Entrada Sandstone	57—Correo
382	Wright and Dickey, 1979	Entrada Sandstone	55—Galisteo Creek
383	Wright and Dickey, 1979	Entrada Sandstone	66—Mesa Alta
384	Wright and Dickey, 1979	Entrada Sandstone	67—Blakey's San Cristobal Ranch
385	Wright and Dickey, 1979	Entrada Sandstone	58—Ganado
386	Pipiringos, Hail and Izett	Entrada Sandstone	B—Radium SW
387	Pipiringos, Hail and Izett	Entrada Sandstone	C—Radium SE
388	Wright and Dickey, 1979	Entrada Sandstone	D—Kremmling
389	Wright and Dickey, 1979	Entrada Sandstone	F—Snowshoe Ranch
390	Wright and Dickey, 1979	Entrada Sandstone	G—Tyler Mountain
391	Wright and Dickey, 1979	Entrada Sandstone	H—McMahon Reservoir
392	Wright and Dickey, 1979	Entrada Sandstone	J—Frantz Creek
393	Muehlberger, 1967	Entrada Sandstone	CC—Chaves Canyon
394	Pipiringos, 1968	Entrada Sandstone	#51
395	Pipiringos, 1968	Entrada Sandstone	#42
396	Pipiringos, 1968	Entrada Sandstone	#44
397	Pipiringos, 1968	Entrada Sandstone	#40
398	Pipiringos, 1968	Entrada Sandstone	#39
399	Pipiringos, 1968	Entrada Sandstone	#37
400	Pipiringos, 1968	Entrada Sandstone	#38
401	Pipiringos, 1968	Entrada Sandstone	#35
402	Pipiringos, 1968	Entrada Sandstone	#34
403	Pipiringos, 1968	Entrada Sandstone	#33
404	Pipiringos, 1968	Entrada Sandstone	#56
405	Pipiringos, 1968	Entrada Sandstone	#32
406	Pipiringos, 1968	Entrada Sandstone	#31
407	Pipiringos, 1968	Entrada Sandstone	#30
409	Pipiringos, 1968	Entrada Sandstone	#28
409	Pipiringos, 1968	Entrada Sandstone	#10
410	Lucas et al., 1985	Entrada Sandstone	#1
411	Lucas et al., 1985	Entrada Sandstone	#1
412	Lucas et al., 1985	Entrada Sandstone	#4
413	Lucas et al., 1985	Entrada Sandstone	#8
414	Lucas et al., 1985	Entrada Sandstone	#9
415	Lucas et al., 1985	Entrada Sandstone	#10
416	Lucas et al., 1985	Entrada Sandstone	#11
417	Lucas et al., 1985	Entrada Sandstone	#12
418	Lucas et al., 1985	Entrada Sandstone	#13
419	Lucas et al., 1985	Entrada Sandstone	#15
420	Lucas et al., 1985	Entrada Sandstone	#18

TABLE 7 (continued)

Section No.	Author	Interval	Their designation, section name
421	Lucas et al., 1985	Entrada Sandstone	#28
422	Lucas et al., 1985	Entrada Sandstone	#36
423	Lucas et al., 1985	Entrada Sandstone	#43
424	Lucas et al., 1985	Entrads Sandstone	#44
425	Lucas et al., 1985	Entrada Sandstone	#45
426	Lucas et al., 1985	Entrada Sandstone	#47
427	Lucas et al., 1985	Entrada Sandstone	#49
428	Lucas et al., 1985	Entrada Sandstone	#51
429	Lucas et al., 1985	Entrada Sandstone	#60
430	Lucas et al., 1985	Entrada Sandstone	#61
431	Lucas et al., 1985	Entrada Sandstone	#62
432	Lucas et al., 1985	Entrada Sandstone	#63
433	Lucas et al., 1985	Entrada Sandstone	#64
434	Mankin, 1958	Entrada Sandstone	57—3 San Agustin
435	Mankin, 1958	Entrada Sandstone	57—4 Trujillo Hill
436	Mankin, 1958	Entrada Sandstone	57—5 Sabinoso Canyon
437	Mankin, 1958	Entrada Sandstone	57—8 Burro Canyon
438	Mankin, 1958	Entrada Sandstone	56—2 Mitchell Ranch
439	Mankin, 1958	Entrada Sandstone	57—9 Gallegos Ranch
440	Mankin, 1958	Entrada Sandstone	57—10 San Jon
441	Bachman, 1953	Entrada Sandstone	#5
442	Wanek, 1962	Entrada Sandstone	1—Lacinta Creek
443	Wanek, 1962	Entrada Sandstone	#5
444	Wanek, 1962	Entrada Sandstone	4—Montoya
445	Wanek, 1962	Entrada Sandstone	3—Bell Peak
446	Wanek, 1962	Entrada Sandstone	2—SE Huerfano Mesa
447	Wood et al., 1953	Entrada Sandstone	12—Cora B. Moore #1
448	Wood et al., 1953	Entrada Sandstone	11—Sauble #1-A
449	Wood et al., 1953	Entrada Sandstone	9—Herrera #1
450	Wood et al., 1953	Entrada Sandstone	8—Rito Del Plano #1
451	Wood et al., 1953	Entrada Sandstone	7—Chico #1
452	Wood et al., 1953	Entrada Sandstone	2—Floersheim #1
453	Smith, 1951	Entrada Sandstone	
454	Dobrovolny and Summerson, 1946	Entrada Sandstone	#6
455	Dobrovolny and Summerson, 1946	Entrada Sandstone	#7
456	Dobrovolny and Summerson, 1946	Entrada Sandstone	#5
457	Dobrovolny and Summerson, 1946	Entrada Sandstone	#3
458	Dobrovolny and Summerson, 1946	Entrada Sandstone	#4
459	Dobrovolny and Summerson, 1946	Entrada Sandstone	#8
460	Dobrovolny and Summerson, 1946	Entrada Sandstone	#9
461	Dobrovolny and Summerson, 1946	Entrada Sandstone	#10
462	Savela, 1977	Entrada Sandstone	#2
463	Trauger and Bushman, 1964	Entrada Sandstone	p. 22
464	Knowles et al., 1982	Entrada Sandstone	Regional pinchout of Entrada
465	Turner—Peterson (unpubl. data 1983)	Entrada Sandstone	Toadlena
466	Huffman and Kirk (unpubl. data 1980)	Entrada Sandstone	Todilto Park/Lake Asaryl
467	Saucier, 1967	Entrada Sandstone	Black Creek Valley
468	Saucier, 1967	Entrada Sandstone	Window Rock
469	Saucier, 1967	Entrada Sandstone	Oak Springs Gap
470	Saucier, 1967	Entrada Sandstone	Cheechilgeetho
471	Saucier, 1967	Entrada Sandstone	Beal—Miller
472	Saucier, 1967	Entrada Sandstone	Gallup

TABLE 7 (continued)

Section No.	Author	Interval	Their designation, section name
473	Saucier, 1967	Entrada Sandstone	Pyramid Peak
474	Condon and Peterson, 1986 (K)	Entrada Sandstone	Fort Defiance
475	Condon and Peterson, 1986 (K)	Entrada Sandstone	Haystack Butte
476	Condon unpubl. data, 1980	Entrada Sandstone	Pipeline Road
477	Condon unpubl. data, 1982	Entrada Sandstone	Lupton
478	Anderson, 1983	Entrada Sandstone	Taaiyalone Mesa
479	Harshbarger et al., 1957	Entrada Sandstone	Fort Wingate
480	Kirk et al. (unpubl. data, 1980)	Entrada Sandstone	Pinedale W and W
481	Huffman and Kirk (unpubl. data, 1980)	Entrada Sandstone	Coolidge Quarry
482	Robertson (unpubl. data, 1983)	Entrada Sandstone	Thorean E
483	PI	Page SS, Entrada SS	#1 Unit the California Co.
484	PI	Page SS, Entrada SS	#2 Unit the California Co.
485	PI	Page SS, Entrada SS	#1 S. Upper Valley Tennecy Oil
486	PI	Page SS, Entrada SS	#1 Lyons-Federal Sun Oil Co.
487	PI	Page SS, Entrada SS	#2 Unit Great Western Drilling
488	PI	Page SS, Entrada SS	#1 Tibbet Cany. Tenneco Oil Co
489	PI	Page SS, Entrada SS	#1—16 State Romex Corp.
490	PI	Page SS, Entrada SS	#1 Unit Shell Oil Co.
491	PI	Page Sandstone	# 1 Judd Hollow Unit Union Oil
492	PI	Entrada Sandstone	#123 Second Mesa
493	PI	Entrada Sandstone	#1 USA-Tropic Tenneco Oil Co.
494	PI	Entrada Sandstone	#1 Forest et al., Forest Oil
495	PI	Entrada Sandstone	#41—27 Johns Valley Unit, Tidewater Oil Co.
496	PI	Entrada Sandstone	#1 Unit the California Co.
497	PI	Entrada Sandstone	#1—X North Creek Tenneco Oil
498	PI	Entrada Sandstone	#1—Griffin Point Unit Tenneco Oil
499	Peterson (unpubl. data)	Page Sandstone	Rawhide Cave
500	Peterson (unpubl. data)	Page Sandstone	Sixtymile Point-1
501	Peterson (unpubl. data)	Page Sandstone	Sixtymile Point-2
502	Peterson (unpubl. data)	Page Sandstone	Sooner Wash
503	Peterson (unpubl. data)	Page Sandstone	Soda Spring
504	Peterson (unpubl. data)	Page Sandstone	Thousand Pockets-1
505	Peterson (unpubl. data)	Page Sandstone	Red Canyon
506	Peterson (unpubl. data)	Page Sandstone	Park Ridge
507	Peterson (unpubl. data)	Page Sandstone	Lion Mountain
508	Peterson (unpubl. data)	Page Sandstone	Averett Hollow
509	Peterson (unpubl. data)	Page Sandstone	Jacobs Tanks
510	Peterson (unpubl. data)	Page Sandstone	Warm Creek Mouth E-3
511	Peterson (unpubl. data)	Page Sandstone	Warm Creek Mouth S
512	Peterson (unpubl. data)	Page Sandstone	Warm Creek Mouth W
513	Peterson (unpubl. data)	Page Sandstone	Labyrinth Canyon E
514	Peterson (unpubl. data)	Page Sandstone	Gregory Butte S
515	Peterson (unpubl. data)	Page Sandstone	Big Spencer Flats
516	Peterson (unpubl. data)	Page Sandstone	The Box
517	Peterson (unpubl. data)	Page Sandstone	Boulder S
518	Peterson (unpubl. data)	Page Sandstone	Cons Knoll
519	Peterson (unpubl. data)	Page Sandstone	Chokecherry Creek
520	Peterson (unpubl. data)	Page Sandstone	Capitol Reef Waterfall
521	Peterson (unpubl. data)	Page Sandstone	Escalante E
522	Peterson (unpubl. data)	Page Sandstone	Haymaker Bench
523	Peterson (unpubl. data)	Page Sandstone	Halls Creek Canyon
524	Peterson (unpubl. data)	Page Sandstone	West Ranch Creek

TABLE 7 (continued)

Section No.	Author	Interval	Their designation, section name
525	Peterson (unpubl. data)	Page Sandstone	Kaibito NW—2
526	Peterson (unpubl. data)	Page Sandstone	Egypt
527	Peterson (unpubl. data)	Page Sandstone	Cleopatra's Needle
528	Peterson (unpubl. data)	Page Sandstone	Driftwood Canyon
529	Peterson (unpubl. data)	Page Sandstone	Early Weed Bench E
530	Peterson (unpubl. data)	Page Sandstone	Escalante Viewpoint
531	Peterson (unpubl. data)	Page Sandstone	Gregory Butte S
532	Peterson (unpubl. data)	Page Sandstone	Boulder N
533	Peterson (unpubl. data)	Page Sandstone	Cottonwood Canyon
534	Peterson (unpubl. data)	Page Sandstone	Cottonwood Gulch
535	Peterson (unpubl. data)	Page Sandstone	Capitol Wash
536	Peterson (unpubl. data)	Page Sandstone	Hole-in-the-Rock NW
537	Peterson (unpubl. data)	Page Sandstone	Bridger Point
538	Peterson (unpubl. data)	Page Sandstone	Cedar Mountain S
539	Peterson (unpubl. data)	Page SS, Entrada SS	Dangling Rope Canyon
540	Peterson (unpubl. data)	Page Sandstone	Owl Bridge
541	Peterson (unpubl. data)	Page Sandstone	North Wash
542	Peterson (unpubl. data)	Page Sandstone	Labyrinth Canyon W
543	Peterson (unpubl. data)	Page Sandstone	North Wash
544	Peterson (unpubl. data)	Page SS, Entrada SS	Muley Twist Canyon Mouth
545	Peterson (unpubl. data)	Page Sandstone	Poules Tanks
546	Peterson (unpubl. data)	Page Sandstone	Page S
547	Peterson (unpubl. data)	Page Sandstone	Oak Creek
548	Peterson (unpubl. data)	Page Sandstone	Middle Rock Creek
549	Peterson (unpubl. data)	Page Sandstone	1—70 and San Rafael Swell E
550	Peterson (unpubl. data)	Page Sandstone	1—70 and San Rafael Swell W
551	Peterson (unpubl. data)	Page Sandstone	Gruss Knoll
552	Peterson (unpubl. data)	Page Sandstone	Deer Point
553	Peterson (unpubl. data)	Page Sandstone	Buckhorn Wash
554	Peterson (unpubl. data)	Page Sandstone	Burr Point
555	Peterson (unpubl. data)	Page Sandstone	Burr Trail
556	Peterson (unpubl. data)	Page Sandstone	Little Egypt
557	Peterson (unpubl. data)	Page Sandstone	Mt. Hillers S
558	Peterson (unpubl. data)	Page SS, Entrada SS	The Post
559	Peterson (unpubl. data)	Page Sandstone	Rushbeds Road
560	Peterson (unpubl. data)	Page SS, Entrada SS	The Post S
561	Peterson (unpubl. data)	Page Sandstone	Coppermine
562	Peterson (unpubl. data)	Page Sandstone	Face Canyon E
563	Peterson (unpubl. data)	Page Sandstone	Cedar Mountain
564	Peterson (unpubl. data)	Page Sandstone	Leche-e Rock NE
565	Peterson (unpubl. data)	Page Sandstone	Kaibito NW-1
566	Peterson (unpubl. data)	Page Sandstone	Sooner Slide N
567	Peterson (unpubl. data)	Page Sandstone	Fortymile Gulch
568	Peterson (unpubl. data)	Page Sandstone	Fortymile Ridge
569	Peterson (unpubl. data)	Page Sandstone	Mount Ogden
570	Peterson (unpubl. data)	Entrada Sandstone	Leche-e Rock
571	Peterson (unpubl. data)	Entrada Sandstone	Hackberry Canyon
572	Peterson (unpubl. data)	Entrada Sandstone	Navajo Valley W
573	Peterson (unpubl. data)	Entrada Sandstone	Big Hollow Wash
574	Peterson (unpubl. data)	Entrada Sandstone	East Cove
575	Peterson (unpubl. data)	Entrada Sandstone	Fortynine Mile Point
576	Peterson (unpubl. data)	Entrada Sandstone	Spring Canyon

TABLE 7 (continued)

Section No.	Author	Interval	Their designation, section name
577	Peterson (unpubl. data)	Entrada Sandstone	Kodachrome Flats
578	Peterson (unpubl. data)	Entrada Sandstone	Thursday Canyon
579	Peterson (unpubl. data)	Entrada Sandstone	Coyote Creek
580	Peterson (unpubl. data)	Entrada Sandstone	Little Egypt
581	Peterson (unpubl. data)	Entrada Sandstone	Tenderfoot Mesa
582	Peterson (unpubl. data)	Entrada Sandstone	Red Canyon
583	Peterson (unpubl. data)	Entrada Sandstone	West Canyon
584	Peterson (unpubl. data)	Entrada Sandstone	Tsezi
585	Peterson (unpubl. data)	Entrada Sandstone	Dry Rock Creek SE
586	Peterson (unpubl. data)	Entrada Sandstone	Middle Rock Creek Canyon
587	Peterson (unpubl. data)	Entrada Sandstone	Fortymile Point
588	Peterson (unpubl. data)	Entrada Sandstone	Rock Creek W
589	Peterson (unpubl. data)	Entrada Sandstone	Mountain Sheep Canyon
590	Peterson (unpubl. data)	Entrada Sandstone	Harvey's Fear
591	Peterson (unpubl. data)	Entrada Sandstone	Teasdale S
592	Peterson (unpubl. data)	Entrada Sandstone	Cumming's Mesa E Fingers
593	Peterson (unpubl. data)	Entrada Sandstone	Steamboat E
594	Peterson (unpubl. data)	Entrada Sandstone	Star Mountain
595	Peterson (unpubl. data)	Entrada Sandstone	Klethla Valley
596	Peterson (unpubl. data)	Entrada Sandstone	Lohali Point
597	Peterson (unpubl. data)	Entrada Sandstone	Castle Rock
598	Peterson (unpubl. data)	Entrada Sandstone	Cummings Mesa W Fingers
599	Peterson (unpubl. data)	Entrada Sandstone	Cow Springs
600	Peterson (unpubl. data)	Entrada Sandstone	Square Butte
601	Peterson (unpubl. data)	Entrada Sandstone	Tsai Skizzie
602	Peterson (unpubl. data)	Entrada Sandstone	Tenmile Wash
603	Peterson (unpubl. data)	Entrada Sandstone	Wolcott
604	Peterson (unpubl. data)	Entrada Sandstone	Cedar Mountain
605	Peterson (unpubl. data)	Entrada Sandstone	Little Bull Valley
606	Read et al., 1949	Entrada Sandstone	Trail Creek
607	Read et al., 1949	Entrada Sandstone	Davis Creek
608	Read et al., 1949	Entrada Sandstone	Sand Creek
609	Read et al., 1949	Entrada Sandstone	Weminuche Creek SW
610	Read et al., 1949	Entrada Sandstone	Tres Piedras Ranch
611	Read et al., 1949	Entrada Sandstone	Elk Creek
612	Read et al., 1949	Entrada Sandstone	Indian Creek-Dudley Creek
613	Wood et al., 1948	Entrada Sandstone	#1 Sullenberger Wirt Franklin et al.
614	Wood et al., 1948	Entrada Sandstone	Crowley #1 Phillips Petrol. Co.
615	Craig et al., 1959	Entrada Sandstone	Bitter Springs Seep
616	Craig et al., 1959	Entrada Sandstone	Thoreau
617	Craig et al., 1959 (P)	Entrada Sandstone	Toadlona
618	Craig et al., 1959 (P)	Entrada Sandstone	Todilto
619	Craig et al., 1959 (P)	Entrada Sandstone	Mesa Gigante
620	Craig et al., 1959 (P)	Entrada Sandstone	Oak Spring Wash
621	Craig et al., 1959 (P)	Entrada Sandstone	Sanostee Wash
622	Craig et al., 1959	Entrada Sandstone	Ghost Ranch
623	Craig et al., 1959 (P)	Entrada Sandstone	Haystack Butte
624	Craig et al., 1959	Entrada Sandstone	Las Vegas
625	Craig et al., 1959 (P)	Entrada Sandstone	Cuchillo Arroyo
626	Craig et al., 1959	Entrada Sandstone	Dry Cimmaron
627	Craig et al., 1959	Entrada Sandstone	Fort Defiance
628	Craig et al., 1959 (P)	Entrada Sandstone	Marsh Pass

TABLE 7 (continued)

Section No.	Author	Interval	Their designation, section name
629	Craig et al., 1959 (P)	Entrada Sandstone	Salina Trading post
630	Craig et al., 1959	Entrada Sandstone	Yale Point
631	Craig et al., 1959	Entrada Sandstone	Dinnehotso
632	Craig et al., 1959	Entrada Sandstone	Upper Piedra River
633	Craig et al., 1959	Entrada Sandstone	Wetmore–Beulah
634	Craig et al., 1959	Entrada Sandstone	Stoner
635	Craig et al., 1959	Entrada Sandstone	Traves Creek
636	Craig et al., 1959	Entrada Sandstone	Upper McElmo Canyon
637	Craig et al., 1959	Entrada Sandstone	State Bridge
638	Craig et al., 1959	Entrada Sandstone	State Line
639	Craig et al., 1959	Entrada Sandstone	Stoner
640	Craig et al., 1959	Entrada Sandstone	Slick Rock
641	Craig et al., 1959	Entrada Sandstone	Snowmass Canyon
642	Craig et al., 1959	Entrada Sandstone	South Canyon
643	Craig et al., 1959	Entrada Sandstone	Roubideau
644	Craig et al., 1959	Entrada Sandstone	San Miguel Canyon
645	Craig et al., 1959	Entrada Sandstone	Slein Mesa
646	Craig et al., 1959 (P)	Entrada Sandstone	Pease spring
647	Craig et al., 1959	Entrada Sandstone	Red Canyon
648	Craig et al., 1959	Entrada Sandstone	Sawpit
649	Craig et al., 1959	Entrada Sandstone	Monument
650	Craig et al., 1959	Entrada Sandstone	Officer
651	Craig et al., 1959	Entrada Sandstone	Ouray
652	Craig et al., 1959	Entrada Sandstone	Lower Piedra River
653	Craig et al., 1959 (P)	Entrada Sandstone	Maroon Canyon
654	Craig et al., 1959	Entrada Sandstone	Leopard Creek Canyon
655	Craig et al., 1959	Entrada Sandstone	Little Snake River
656	Craig et al., 1959	Entrada Sandstone	Loma
657	Craig et al., 1959	Entrada Sandstone	Greenhorn Mountain
658	Craig et al., 1959	Entrada Sandstone	Laramie River
659	Craig et al., 1959	Entrada Sandstone	Durango
660	Craig et al., 1959	Entrada Sandstone	Garo
661	Craig et al., 1959	Entrada Sandstone	Dolores Group
662	Craig et al., 1959	Entrada Sandstone	Dunton
663	Craig et al., 1959	Entrada Sandstone	Black Ridge
664	Craig et al., 1959	Entrada Sandstone	Brush Creek
665	Craig et al., 1959	Entrada Sandstone	Burns
666	Craig et al., 1959	Entrada Sandstone	Basalt
667	Craig et al., 1959	Entrada Sandstone	Bilk Creek
668	Craig et al., 1959 (P)	Entrada Sandstone	Black Canyon
669	Craig et al., 1959	Entrada Sandstone	Bridgeport
670	Craig et al., 1959	Entrada Sandstone	Dry Creek Anticline
671	Craig et al., 1959	Entrada Sandstone	E Unaweap Canyon
672	Craig et al., 1959	Entrada Sandstone	Hamm Spring
673	Craig et al., 1959	Entrada Sandstone	John Brown Canyon
674	Craig et al., 1959	Entrada Sandstone	Lookout Point
675	Craig et al., 1959	Entrada Sandstone	Lower McElmo Canyon
676	Craig et al., 1959	Entrada Sandstone	Maverick Canyon
677	Craig et al., 1959	Entrada Sandstone	Meeker
678	Craig et al., 1959	Entrada Sandstone	N Sinbad Valley
679	Craig et al., 1959	Entrada Sandstone	Rifle
680	Craig et al., 1959	Entrada Sandstone	Skull Creek
681	Craig et al., 1959	Entrada Sandstone	Tabeguache Canyon

TABLE 7 (continued)

Section No.	Author	Interval	Their designation, section name
682	Craig et al., 1959	Entrada Sandstone	Tenderfoot Mesa
683	Craig et al., 1959	Entrada Sandstone	Vermillion Creek
684	Weimer, 1981	Entrada Sandstone	Whitlock Swanson 1-A
685	Hansen, 1968	Entrada Sandstone	Pitts Meadow W
686	Hansen, 1968	Entrada Sandstone	Smith Fork
687	Langenheim, 1957 (P)	Entrada Sandstone	Schofield Park
688	Langenheim, 1957 (P)	Entrada Sandstone	Thompson Creek
689	Langenheim, 1957	Entrada Sandstone	Marion Creek
690	Condon and Huffman, 1984	Entrada Sandstone	Beclabito Dome
691	Hansen, 1971	Entrada Sandstone	Grizzly Ridge
692	Bryant, 1979	Entrada Sandstone	Baldy Mountain
693	Bryant, 1979	Entrada Sandstone	E Snowmass Creek
694	McFall, 1955	Entrada Sandstone	Burr Trail
695	McFall, 1955	Entrada Sandstone	Muddy River
696	Strobell, 1956	Entrada Sandstone	Red Mesa
697	Strobell, 1956	Entrada Sandstone	Sunnyside Mine
698	Strobell, 1956	Entrada Sandstone	Syracuse Mine
699	Huffman and Turner-Peterson (unpubl. data)	Entrada Sandstone	Beclabito Dome
700	Santos and Moench, 1971	Entrada Sandstone	Unnamed
701	Santos and Moench, 1971	Entrada Sandstone	Unnamed
702	Santos, 1975	Entrada Sandstone	Drill Hole C
703	Santos, 1975	Entrada Sandstone	Drill Hole D
704	Santos, 1975	Entrada Sandstone	Drill Hole E
705	Condon, 1985A	Entrada Sandstone	11—Todilto Park
706	Condon, 1985A	Entrada Sandstone	12—Navajo
707	Condon, 1985A	Entrada Sandstone	13—Twin Buttes Wash
708	Condon, 1985A	Entrada Sandstone	15—Bowman Park
709	Condon, 1985B	Entrada Sandstone	1—Navajo Church
710	Condon, 1985B	Entrada Sandstone	2—Midget Mesa
711	Condon, 1985B	Entrada Sandstone	3—Pinedale Monocline
712	Condon, 1985B	Entrada Sandstone	4—E Thoreau
713	Condon, 1985B	Entrada Sandstone	5—Andrews Ranch
714	Condon, 1985B	Entrada Sandstone	6—Haystack Mountain
715	Wright, 1973	Entrada Sandstone	12—Vinceant Ranch
716	Wright, 1973	Entrada Sandstone	13—Alcova
717	Wright, 1973	Entrada Sandstone	4—Rapid City
718	Wright, 1973	Entrada Sandstone	6—Newcastle
719	Rautman, 1975	Entrada Sandstone	3—Whaley Canyon
720	Rautman, 1975	Entrada Sandstone	4—Minnekahta
721	Rautman, 1975	Entrada Sandstone	7—Stockade Beaver Creek
722	Rautman, 1975	Entrada Sandstone	15—Farthing
723	Rautman, 1975	Entrada Sandstone	16—Red Mountain
724	Rautman, 1975	Entrada Sandstone	25—Dallas Anticline
725	Finch and Wright, 1983	Entrada Sandstone	29—Labrier Butte
726	Finch and Wright, 1983	Entrada Sandstone	28—W Fork, S Picket House Draw
727	Love et al., 1945	Entrada Sandstone	21—Kirk #1
728	Love et al., 1945	Entrada Sandstone	20—Hailey
729	Love et al., 1945	Entrada Sandstone	19—Noble Ranch
730	Love et al., 1945	Entrada Sandstone	20—Dutton Ranch
731	Love et al., 1945	Entrada Sandstone	25—No. C-2 Well
732	Love et al., 1945	Entrada Sandstone	24—Conant Creek
733	Vanderwilt, 1937	Entrada Sandstone	Copper Creek

TABLE 7 (continued)

Section No.	Author	Interval	Their designation, section name
734	Ward, 1957	Entrada Sandstone	Michigan River
735	Ward, 1957	Entrada Sandstone	Michigan River
736	Grote, 1957	Entrada Sandstone	Battleship Field
737	York, 1957	Entrada Sandstone	Muddy Creek
738	Gilluly and Reeside, 1928	Entrada Sandstone	Entrada Point
739	Gilluly and Reeside, 1928	Entrada Sandstone	Starvation Point
740	Gilluly and Reeside, 1928	Entrada Sandstone	Muddy River
741	Gilluly and Reeside, 1928	Entrada Sandstone	Cottonwood Springs Draw
742	Trimble and Doelling, 1978	Entrada Sandstone	The Squeeze S.
743	Trimble and Doelling, 1978	Entrada Sandstone	The Squeeze
744	Peterson (unpubl. data)	Entrada Sandstone	Tergeson Flats

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