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Augustus K. Armstrong

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THE STRATIGRAPHY AND FACIES OF THE MISSISSIPPIAN STRATA OF SOUTHWESTERN NEW MEXICO

A. K. Armstrong
Shell Oil Co., Farmington, New Mexico

INTRODUCTION

This paper is a brief résumé of the Escabrosa Group and Paradise Formation of extreme southwestern New Mexico. For detailed information on the Mississippian strata of the region see Laudon and Bowsher (1949) and Armstrong (1958 a, 1958 b, 1962, 1963). Formal systematic faunal studies and documentation of stratigraphic zonation used in this paper are in Armstrong (1958, 1962) and Hernon (1935).

The classification of carbonate rocks used in this paper is that of Dunham (1962). A brief outline of Dunham's classification is given in table 1.

ESCABROSA GROUP

The Escabrosa Limestone of Mississippian age was named by Girty (1904) for the Lower Carboniferous section in the Escabrosa cliffs west of Bisbee, Arizona. The name "Escabrosa limestone" was extended through Cochise County, Arizona, by the U.S. Geological Survey in reports dealing with various mining areas. The Escabrosa Limestone was elevated by Armstrong (1962) to the Escabrosa Group and divided into two formations: the Keating Formation with two members, A and B; and the Hachita Formation (fig. 1.). This nomenclature was extended into Luna, Hidalgo, and Grant Counties, New Mexico. Within this region the Escabrosa Group is a thick sequence of shelf to miogeosynclinal bioclastic carbonates. The Escabrosa Group is separated from the underlying Upper Devonian rocks by a disconformity. This hiatus represents a small portion of late Devonian and a significant part of Kinderhook time. The top of the Escabrosa Group is Meramec in age and is defined as the first appearance of thin-bedded, argillaceous limestones and shale beds.

Paleontologic and field studies indicate no significant hiatus within the Escabrosa Group. The contact between the overlying Paradise Formation and the Escabrosa Group (Hachita Formation) is gradational. The shales, silts, and shallow water thin-bedded limestones of the Paradise Formation reflect development of the Chesterian highlands of central New Mexico and the resulting influx of terrigenous sediments into the Paradise sea. Extensive erosion in southwestern and central New Mexico in late Chesterian and early Pennsylvanian time removed a considerable thickness of Mississippian strata (fig. 5) and produced everywhere a pronounced unconformity between Mississippian and Pennsylvanian strata.

KEATING FORMATION

The type section of the Keating Formation (Armstrong 1962) is on the southeast side of Blue Mountain, Chiricahua Mountains, Arizona. The thickest section in New Mexico is on the north side of the Big Hatchet Mountains, where it is 590 feet thick. The Keating Formation thins to the north in the Peloncillo Mountains and to the northeast in the Klondike Hills. The Keating Formation is readily divisible into two lithic members, which are called in ascending order, members A and B.

Member A contains a brachiopod and coral fauna (figs. 2 and 3) which is transitional between high upper Kinderhook and lower Osage. It rests with a disconformity on marine shales and carbonates of late

TABLE 1. CLASSIFICATION OF CARBONATE ROCKS ACCORDING TO DEPOSITIONAL TEXTURE

<table>
<tr><th colspan="5">DEPOSITIONAL TEXTURE RECOGNIZABLE</th><th rowspan="2">DEPOSITIONAL TEXTURE NOT RECOGNIZABLE</th></tr>
<tr><td colspan="4">Original Components Not Bound Together During Deposition</td><td rowspan="4">Original components were bound together during deposition . . . as shown by intergrown skeletal matter, lamination contrary to gravity, or sediment-floored cavities that are roofed over by organic or questionably organic matter and are too large to be interstices.</td></tr>
<tr><td colspan="3">Contains mud (particles of clay and fine silt size)</td><td rowspan="3">Lacks mud and is grain-supported</td><td rowspan="3">Crystalline Carbonate

(Subdivide according to classifications designed to bear on physical texture or diagenesis.)</td></tr>
<tr><td colspan="2">Mud-supported</td><td rowspan="2">Grain-supported</td></tr>
<tr><td>Less than 10 percent grains</td><td>More than 10 percent grains</td></tr>
<tr><td>Mudstone</td><td>Wackestone</td><td>Packstone</td><td>Grainstone</td><td>Roundstone</td><td></td></tr>
</table>

Devonian age. The hiatus between the Devonian and Mississippian Systems represents very late Late Devonian and part, if not all, Kinderhook (Tournaisian) time.

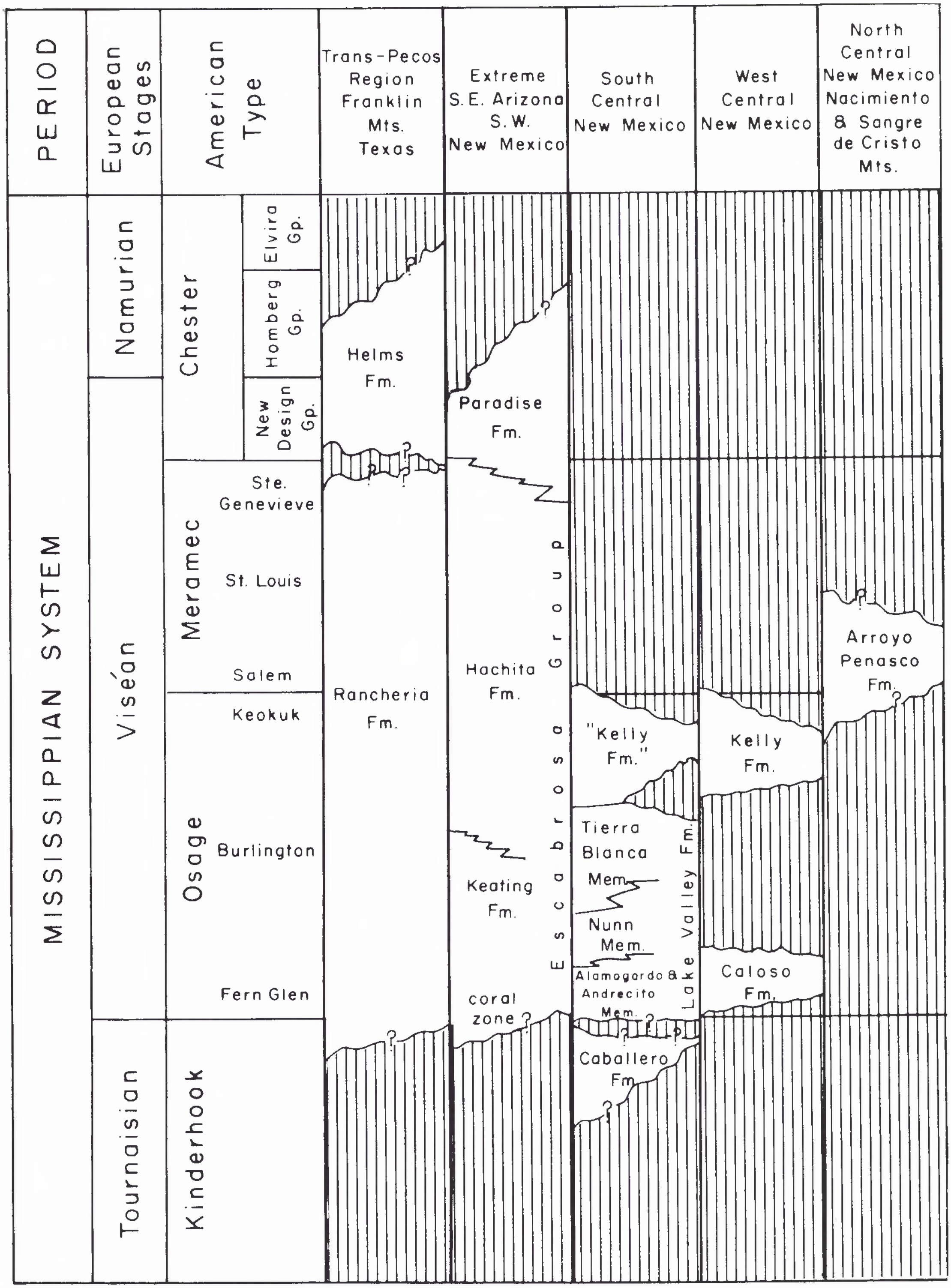


FIGURE 1

Correlation diagram of the Mississippian rocks of Southwestern New Mexico

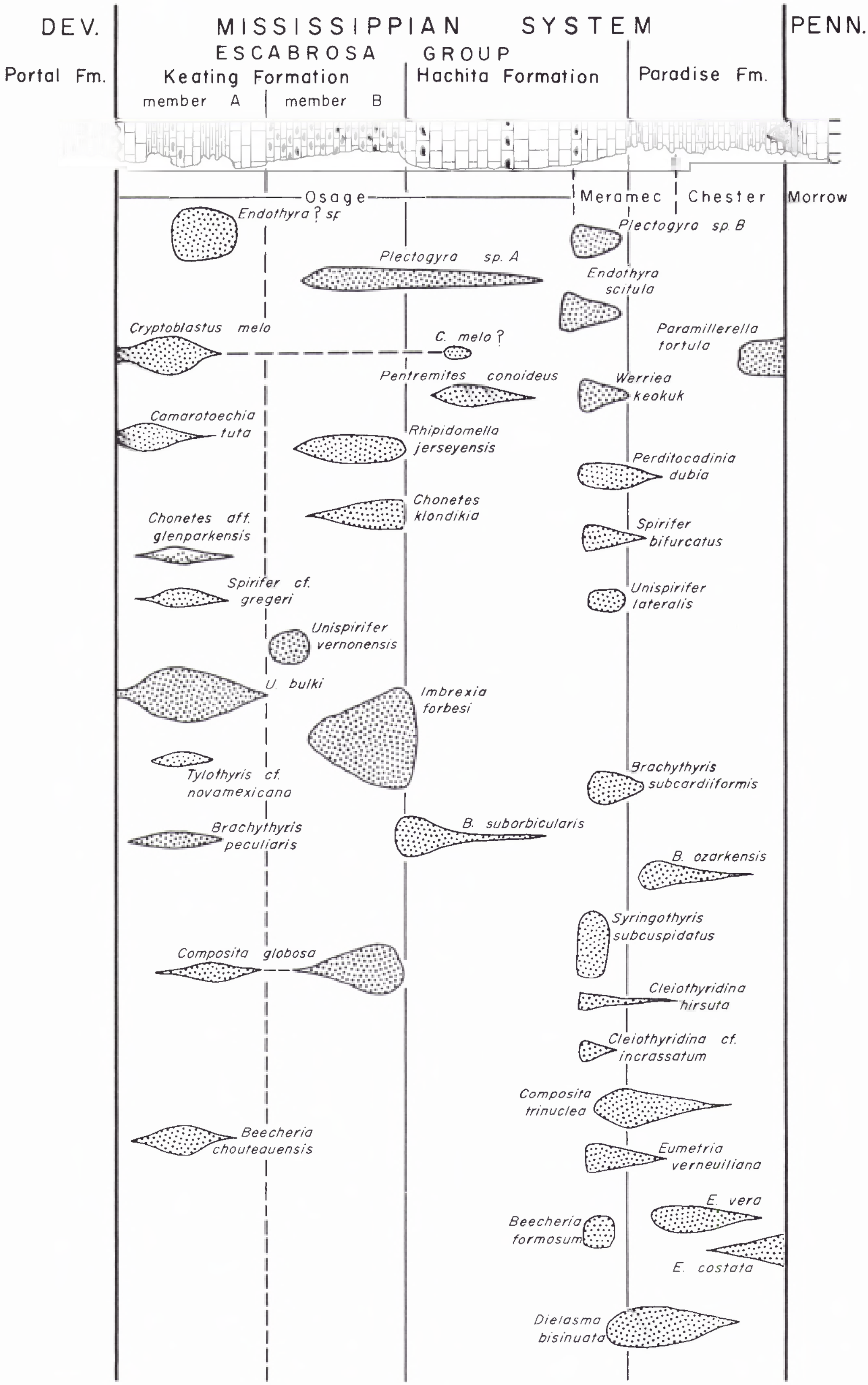


FIGURE 2

Mississippian Brachiopods and other forms of Southwestern New Mexico and Southeastern Arizona

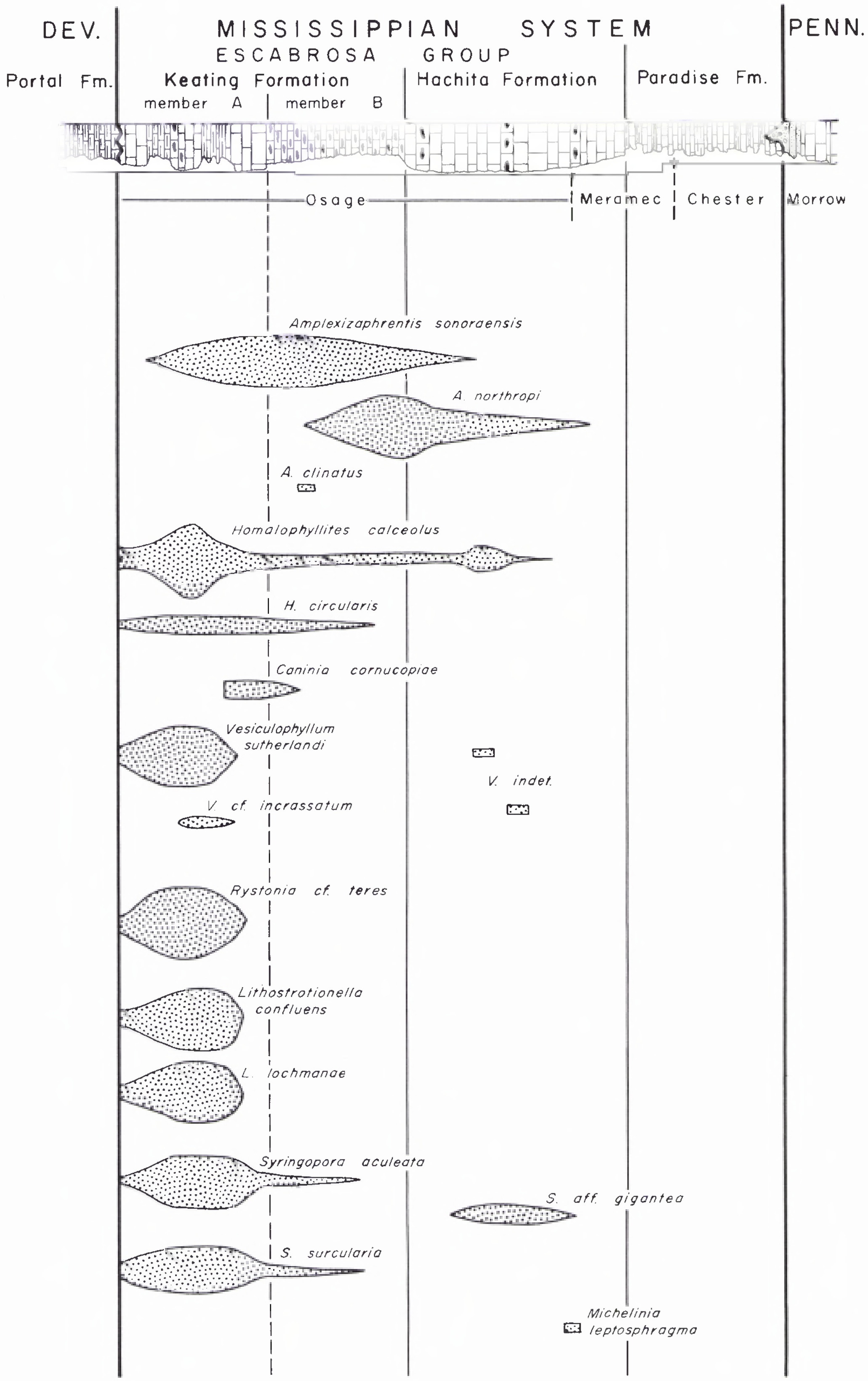


FIGURE 3

Mississippian Corals of Southwestern New Mexico and Southeastern Arizona

Member A carbonates are the initial phase of a carbonate transgression over a weathered and peneplaned Devonian surface. The lowest beds contain appreciable amounts of calcareous shale, silt, and fine-grained sand-size quartz disseminated in the limestone. The higher beds of member A are almost pure carbonates of bryozoan, echinoderm, brachiopod, and coral lime wackestones and packstones with occasional lenticular bodies of oolite packstones.

Member A was deposited in shallow marine waters of open circulation. The zones of oolites and bioclastic grainstones are believed to reflect recurrent disjunct shoaling environments. In the field the most diagnostic feature of member A is its massive bedding and chert-free carbonates.

In contrast, member B is characterized by thin-bedded mudstone and wackestone to packstones with dark-gray to black lenticular chert. The chert bodies are generally parallel to the bedding but are commonly grown together in coalescing masses. The chert, both from field observations and from thin-section study, is clearly the result of diagenetic or post-diagenetic replacement of the original carbonate.

The contact between members A and B is gradational. It is a zone 10 to 30 feet thick in which the bedding becomes thinner and the percentage of chert increases upward.

The lower horizons of member B are soft pellet lime mudstones and pellet packstones, but higher horizons contain progressively larger percentages of echinoderm bioclasts. The upper horizons of member B generally are echinoderm packstones and grainstones. The higher beds of member B at Blue Mountain contain an angular intraformational conglomerate which is composed of material similar to that in the enclosing strata.

HACHITA FORMATION

The type section of the Hachita Formation is at the south end of Blue Mountain, Chiricahua Mountains, Arizona. The Hachita Formation is lithologically and topographically the most characteristic part of the Escabrosa Group. It forms a persistent cliff throughout its area of exposure. This cliff is due primarily to the massive nature of the encrinites, in part to the weak Devonian argillaceous limestone and shale below and in part to the thinner-bedded, less resistant Paradise Formation (Chesterian age) above. The lower two-thirds of the Hachita Formation is almost devoid of bedding and is composed of crinoid fragments to the virtual exclusion of other organic remains. The upper third of the formation is darker gray, has persistent massive bedding, and is composed to a large extent of crinoid packstone, although it also contains appreciable amounts of brachiopod and bryozoan remains.

The thickest known section of the Hachita Formation is at the northern end of the Big Hatchet Mountains, where the maximum thickness is 380 feet. Because of original deposition, the Hachita Formation thins to the north and west (fig. 4). West of the Chiricahua Mountains in Arizona, where the Chesterian Paradise Formation is absent, the Hachita Formation thins, partly because of erosion during the pre-Pennsylvanian and early Pennsylvanian time. To the east, because of the sparseness of exposures, the complexity of Cenozoic faulting and, in the Klondike Hills, the presence on some of the Hachita exposures of extensive late-Cenozoic pediment surfaces, the exact thickness of the formation is not known. In the Klondike Hills northeast of the Big Hatchet Mountains, the Hachita Formation is at least 350 feet thick and may be considerably thicker.

PARADISE FORMATION

The Paradise Formation is a sequence of alternating thin-bedded limestones, shales, and occasional fine-grained sandstones. It is 250 to 300 feet thick in the Big Hatchet Mountains. It thins rapidly to the north and east due to late Chesterian and early Pennsylvanian erosion. It is 150 feet thick at Blue Mountain, Chiricahua Mountains, Arizona, and less than 50 feet in the Peloncillo Mountains north of Granite Gap.

The fauna of the Paradise Formation in the Chiricahua Mountains was studied and described by Hernon (1935). A cursory review of the Paradise fauna and lithology within the region was given by Armstrong (1962).

The thin-bedded carbonates and terrigenous clastics of the Paradise Formation clearly indicate that it was deposited in very shallow to shoaling waters and that the younger beds were deposited under lagoonal to fluctuating shoreline conditions. Within the Paradise Formation the overall trend was one of marine regression and increasing influence of terrestrial clastics.

REGIONAL FACIES RELATIONSHIPS

The time-stratigraphic relationships of the Escabrosa Group and Paradise Formation to adjacent time equivalent strata are graphically shown in figures 1 and 5.

Member A of the Keating Formation is a carbonate transgressive facies. To the northeast it is represented by the Andrecito and Alamogordo Members of the Lake Valley Formation and farther north by the Caloso Formation of central New Mexico. The abundant chert and dark color of member B probably represent the deepest water carbonates of the Escabrosa Group and a short interval of time in which subsidence out-

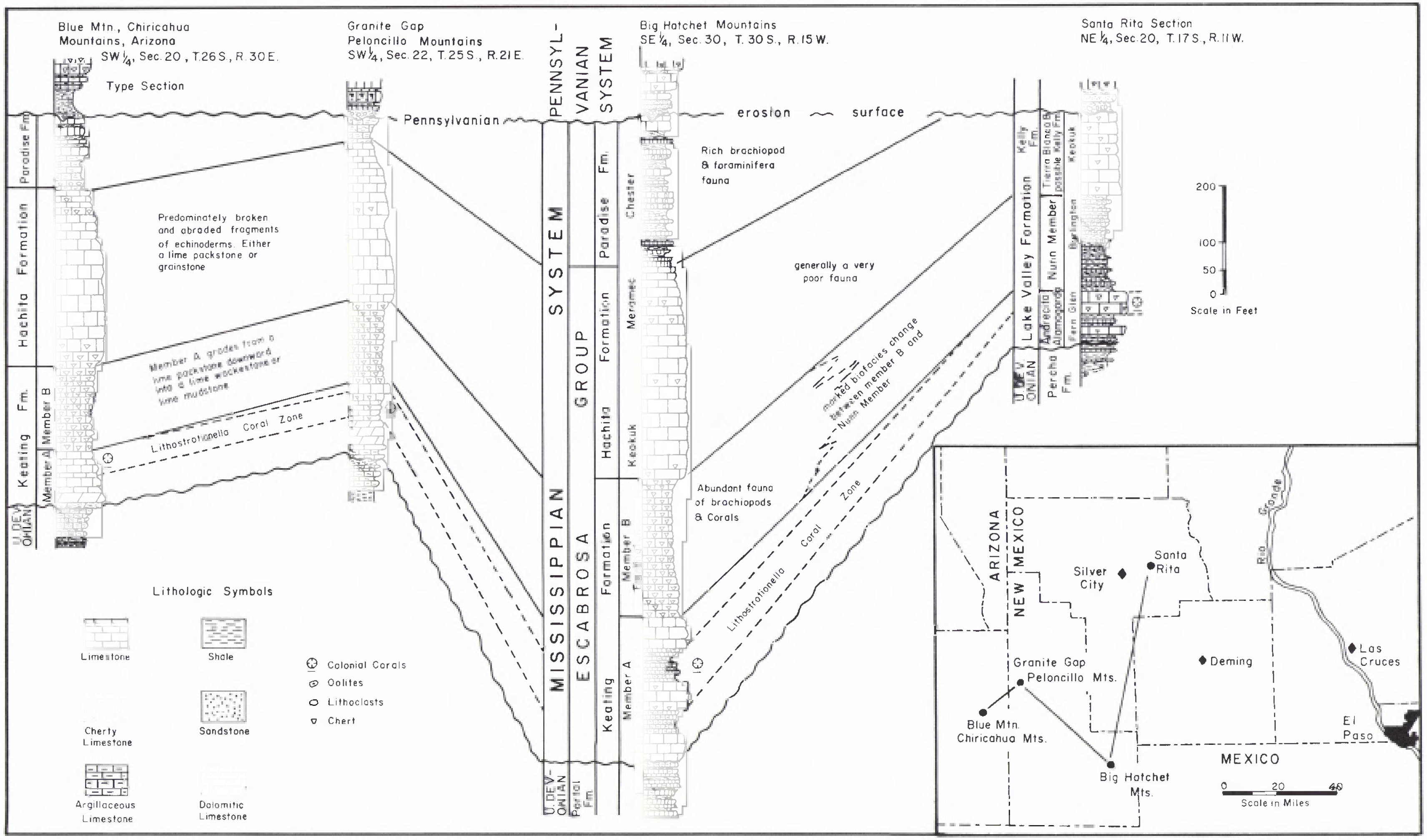
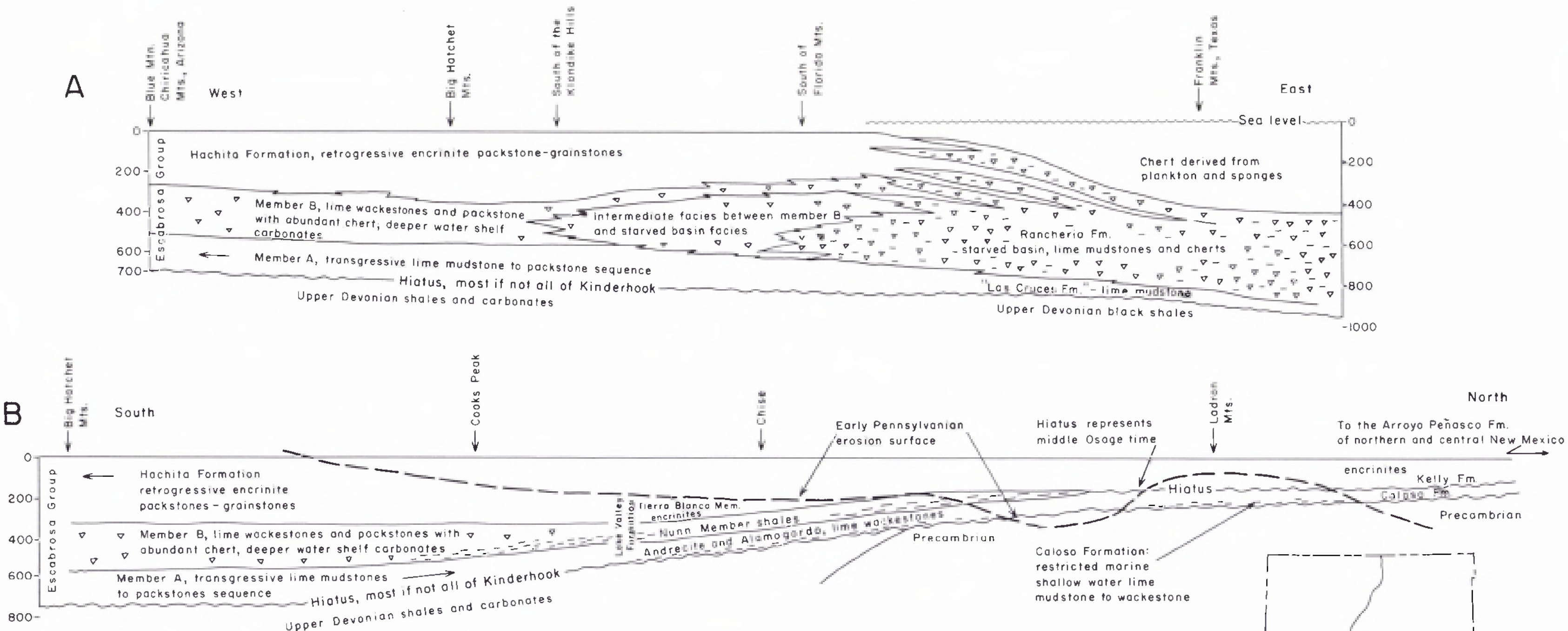
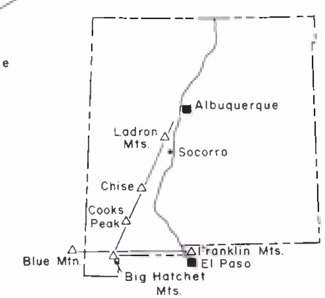


FIGURE 4

Columnar Sections of Mississippian Rocks (modified after Armstrong, 1962)





Schematic restoration of the Escabrosa Group at the end of Meramec time illustrating its relationship to the:
(A) Starved-basin Rancheria Formation to the east,
(B) Shelf carbonates of the Lake Valley, Kelly, and Caloso Formations to the north.

Modified after Armstrong, (1958, 1962, 1963); for details of facies relationship between Rancheria Formation and shelf carbonates of the Lake Valley Formation in the Sacramento Mts., see Armstrong (1963, fig. 8)

FIGURE 5

paced carbonate production. (Water depth probably never exceeded 100 feet with member B.)

The origin of widespread bodies of encrinite packstones and grainstone in Osage and Meramec times is difficult to explain in terms of modern marine analogs. All of the Paleozoic crinoid orders became extinct in the Permian, and the modern order Articulata first appeared in the stratigraphic record in the Middle Triassic. Hyman (1955, p. 112) stated that crinoid faunas are rich in the littoral zones of the Indo-Pacific region as compared to their paucity in the Atlantic and eastern Pacific regions. In the areas of research on modern carbonates, the Bahama platform, southern Florida, and the Persian Gulf, living crinoids are rare to absent. Thus there is little or no factual knowledge as to the ecology of shallow water crinoids and their role in formation of encrinite packstones.

The development of massive encrinite beds such as the Hachita Formation of the Escabrosa Group or the Tierra Blanca Member of the Lake Valley Formation of central New Mexico is believed by the writer to have been the result of an encrinite or crinoid bank or banks which prograded across the shallow shelf areas. The face of the bank supported active growth of crinoids which upon their death contributed bioclasts to the sediments. The rate at which wedges of encrinite packstone could prograde forward and upward would have been a function of substance and echinoderm bioclast production. The upper limits of growth would have been probably controlled by the depths of normal wave base.

Paleontologic and field studies indicate that the contact between the Hachita and Paradise Formations is gradational and represents a shift in ecology and type of sedimentation. The Paradise Formation of late Meramecian and Chesterian age with its thin-bedded lime mudstone to packstone and its increasing amounts of terrigenous clastics in higher horizons represents a marked environmental change from the deposition that occurred during Osagian and early Meramecian time in the Escabrosa Group.

The Rancheria Formation of the Franklin Mountains, Texas, is a starved basin facies of the platform carbonates of the Escabrosa Group and the Lake Valley Formation. Paleontologic evidence to support this view is now meager, but a detailed study on the foraminifera of the Rancheria Formation is in process by Dr. James Conkin of the University of Louisville. Field and lithologic studies clearly indicate this facies relationship. In the southern Florida Mountains, south of Deming, New Mexico, outcrops of Mississippian rock equivalent to member B, Keating Formation, have a chert and limestone lithology transitional to that of the Rancheria Formation.

The facies relationship of the shallow water limestones of the Lake Valley Formation to the starved basin Rancheria Formation is demonstrable in outcrops in the Sacramento Mountains of south-central New Mexico. This relationship is graphically illustrated by Armstrong (1962, fig. 8).

The concept of Laudon (1948) and Laudon and Bowsher (1949) that the Rancheria Formation of the southern San Andres Mountains and Sacramento Mountains forms a lower Meramecian overlap northward onto an eroded Lake Valley Formation (Osagian) surface is rejected by this writer.

In southeastern Arizona, Nations (1963) has proved, by means of a rich coral fauna, that the Black Prince Limestone overlies the Escabrosa Group with an unconformity and is not a localized member of the Meramecian Hachita Formation as proposed by Armstrong (1962).

Strata of the Paradise Formation are not known north of Highway 60 or west of the Chiricahua Mountains. This is believed due to original depositional patterns, but also to extensive early Pennsylvanian erosion. The Helms Formation of the Franklin Mountains, Texas, appears to be of Chesterian age. The distinctive coral fauna described by Armstrong (1962) and characterized by *Dibunophyllum bipartitum konincki* (Milne-Edwards and Haime) is typical of the upper Viséan and lower Namurian of Europe and is strongly suggestive of a Chesterian age. No detailed study of the large brachiopod and foraminifera fauna of Helms Formations has been made. Preliminary studies on these collections do indicate that the Paradise and Helms Formation have no species of megafossils in common. Lithologic investigations further support the view that the Helms and Paradise Formations are two distinct lithologic facies of probable similar age.

The chronological and facies relationship is obscure between the Helms and Paradise Formations. These problems may be resolved when the lithology, megafossils, and microfossils of the Helms Formation are studied in detail to discover its depositional environment and its age.

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