MARINE SEDIMENTATION IN SOUTHERN ARIZONA

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INTRODUCTION

The present paper summarizes the history of marine sedimentation in southern Arizona. The lithology, formation descriptions, distribution, correlations, thickness, and other details are discussed in individual papers dealing with the particular periods of geological time.

The tectonic framework which controlled sedimentation in Arizona can be summarized as (1) the Cordilleran geosyncline along the western edge and across the northwestern corner of Arizona; (2) the Sonoran geosyncline in southeastern Arizona and adjacent New Mexico and Mexico; (3) a broad northeast-trending shelf zone extending across the central part of the state which was covered occasionally by seas spreading from one or both geosynclines; (4) the Defiance and related positive areas in northeastern Arizona and northwestern New Mexico and the postulated Mazatzal highlands of central Arizona.

During Paleozoic and Cretaceous time southeastern Arizona was essentially a marine embayment or geosyncline opening to the south and east. It was bounded on the west by an area of little-known post-Precambrian sedimentation, on the northwest by a central highland area of reduced sedimentation, and on the north by the Defiance positive area.

Southwestern Arizona has few reported Paleozoic outcrops, and in the adjacent State of Sonora, Mexico, Paleozoic sediments are present, but their extent and thickness are unknown. These deposits may be related more closely to the Cordilleran geosyncline than to the Sonoran geosyncline.

The Paleozoic section in central Arizona is thin owing to either non-deposition or post-depositional erosion. This area has been called Mazatzal land and covered much of central Arizona. It was believed to have extended at times into southwestern Arizona (Ensenada land) and to have connected with the Defiance positive area. As more information has become available the extent of the highland has been reduced and modified. Whether it existed as a complete barrier or as a series of islands along a general shoal area has not been determined.

The Defiance positive area was either above sea level throughout much of Paleozoic time or erosion stripped off the earlier formations prior to deposition of Pennsylvanian sediments across it.

In a nutshell, the sedimentational history of southeastern Arizona consists of marine sedimentation during Precambrian and Paleozoic time; absence of sedimentation and erosion during Triassic and Jurassic time; primarily continental deposition, volcanism, and erosion during Cretaceous and Cenozoic time. Ordovician and Silurian sediments essentially are restricted to southwestern New Mexico; Lower Cretaceous marine sediments are restricted to extreme southeastern Arizona and adjacent New Mexico.

PRECAMBRIAN

Older Precambrian

The older Precambrian sedimentary history is obscure because the strata have been extensively metamorphosed, deformed, and intruded, and exposures are limited.

Since the metasedimentary Pinal schist and its equivalents are locally exposed in the southeastern part of the state, it is presumed that older Precambrian seas covered most of the area, but details of the distribution of the seas and their geography have not been determined. Sediments deposited in the seas were primarily clastic, from as yet unknown sources. The clastics consisted of shale, siltstone, arkose, relatively pure sandstone, and locally conglomerate beds. Some volcanic tuffs and flows apparently were interbedded with the sediments.

The thickness of accumulation was probably on the order of thousands of feet, and in the Dragoon Mountain area the accumulation in a eugeosyncline (Cooper and Silver, 1954) may have been as much as 20,000 feet. The extent and limits of this trough have not been determined, but Wilson (1951) and Cooper (23) have related it to the area of the Mazatzal Revolution.

Younger Precambrian

Following the deposition of the older Precambrian sediments, mountain building, intrusion, metamorphism, uplift, and beveling occurred. The younger Precambrian seas advanced across a remarkably featureless peneplain. Deposits included conglomerate, arkosic sandstone, shale, limestone, siltstone, and quartzitic sandstone.

The seas were apparently shallow and conditions of deposition such that no great accumulations of sediments occurred. Some of the sandstone and siltstone strata show crossbedding and ripple marks and frequently are thin bedded. The limestone may be pure or argillaceous and in places it carries algal structures.

Oxidizing environments were present either at the source of the sediments or in the areas of deposition because at many places the sediments show red, purple, and brown colors. At times vulcanism occurred as shown by tuffaceous beds and basalt flows.

About 1,200 feet of younger Precambrian sediments accumulated in southeastern Arizona. The original area of the basin of deposition has not been determined since erosion has removed parts of the younger Precambrian deposits. The southern shoreline extended southeastward from the general vicinity of Tucson; the northern shoreline was an unknown distance north of the present Mogollon Rim. The northwestern extent of the seaway is uncertain since patches of younger Precambrian are found considerably northwest of Tucson (McClymonds, 16) and may correlate with some of the Precambrian Grand Canyon series. Connection of the seaway may have been with the Cordilleran geosyncline to the west. The sources of the sediments were from positive areas south of Tucson and perhaps from north of the Mogollon Rim.

Local absence of younger Precambrian formations indicates some ep-Algonkian diastrophism, but the near conformity of younger Precambrian and Cambrian deposits indicates that the uplift was generally epeirogenic.

CAMBRIAN PERIOD

Cambrian time opened with Arizona largely a positive area undergoing erosion. In southeastern Arizona no appreciable deformation had occurred between the end of younger Precambrian and Middle Cambrian time, nor had the area been strongly uplifted or subjected to pronounced erosion. In general the land had little relief and was apparently relatively low lying. Across this peneplain the Middle Cambrian seas advanced northward from the Sonoran geosyncline to about the location of the present Mogollon Rim.

The seas reworked the weathered debris and deposited a basal sandstone, which locally may be conglomeratic, across the Precambrian rocks. This was followed by more sandstone, some red beds, shale, and arkose. Sedimentation was in a broad, shallow, open seaway. By Upper Cambrian time clastic sediments were less common and mainly carbonates were being deposited. As the Cambrian period came to a close, a thin layer of sandstone was deposited locally across the limestone.

ORDOVICIAN PERIOD

Over most of southeastern Arizona and adjacent New Mexico, sedimentation was continuous from Cambrian into Ordovician time. Local warpings and changes in sedimentary patterns resulted in local sandstone bodies at or near the contact between the rocks of the two systems. In general, however, the open, clear seas necessary for carbonate deposition prevailed throughout Lower Ordovician time.

The Lower Ordovician seas were confined to a limited area in eastern-southeastern Arizona and to New Mexico and northern Sonora. Between Lower Ordovician and Middle Devonian time, southeastern Arizona was low lying and subject to no significant deposition or to erosion of the underlying sediments, although there is some evidence of beveling and channeling in central Arizona. Upper Ordovician seas existed in southwestern New Mexico, but there is no evidence that they extended into southeastern Arizona.

SILURIAN SYSTEM

Lower and Middle Silurian dolomites are found in southwestern New Mexico, but have pinched out east of Arizona. The Silurian seas in which they were deposited appear to have been essentially continuous with the Late Ordovician seas in the same area. They were apparently open and clear and favorable for a shelf type of carbonate deposition. Following Middle Silurian time a withdrawal of the seas occurred, and the area was emergent and apparently low lying.

DEVONIAN PERIOD

There is no record of Lower Devonian sedimentation in southeastern Arizona and southwestern New Mexico. By Middle Devonian time seas had encroached upon the area from the south, and sediments filled channels cut in the pre-Devonian rocks. As the Devonian seas of southeastern Arizona merged with those spreading eastward across northwestern Arizona, sediments were deposited around the Devonian islands in central Arizona.

Deposition was mainly of a shelf-type of carbonate and clastics in the south-central parts of Arizona. In southeastern Arizona and southward into Mexico, clear, clean limestone deposits accumulated in a more open sea. In the vicinity of the Swiss-

helm Mountains in southeastern Arizona, calcareous silt and impure limestone were deposited. These deposits were thicker than, and grade westward into thinner open-sea facies and eastward into a thinner shale and siltstone facies. This Swisshelm accumulation may have formed a barrier throughout Late Devonian time, separating the western open-sea carbonate environment from the shallow eastern euxinic, fine clastic environment. The clastic barrier restricted circulation, and stagnant and reducing conditions existed in the basin to the east.

Apparently there was little or no withdrawal of the seas at the close of Devonian time.

MISSISSIPPIAN PERIOD

Sedimentation in Lower Mississippian time began with little change in the conditions from those in uppermost Devonian time. There apparently was no withdrawal of the seas in southeastern Arizona and southwestern New Mexico between the two periods. Mississippian seas occupied approximately the same position as in the preceeding period. As the Sonoran geosyncline continued to subside during Mississippian time, the restrictions which had governed sedimentation in the Upper Devonian in southwestern New Mexico were eliminated. The seas became clearer and predominately clean, massive carbonate with some chert was deposited. The seas were apparently moderately deep, the shores far enough removed and the land low lying enough so that clastics are not abundant in these carbonates.

With the close of Lower Mississippian time epeirogenic uplift of Arizona caused gradual withdrawal of the seas southeastward from the region. The area was subjected to a moderate amount of erosion and weathering which developed local karst topography. In many areas the Lower Mississippian limestone was covered by concentrations of chert and red debris representing reworked residues.

PENNSYLVANIAN PERIOD

Perhaps by late Morrowan time, the seas from the Sonoran geosyncline again began to transgress southwestern New Mexico and southeastern Arizona. By Des-Moinesian time, all of southeastern Arizona was inundated. The surface over which the seas advanced had slight topographic relief except for local karst topography. The covering soils were reworked and redistributed by the advancing seas, forming red mud, silt, chert residue, and pebble beds at the base of the Pennsylvanian carbonates.

The seas were clear and moderately deep during the early part of DesMoinesian time and suitable for extensive carbonate and chert accumulation. However, there were short periods when red, green, and gray mud and some coarser clastics were washed into the area.

By Virgilian time the basins had become somewhat filled, and more and more clastic material was being deposited. Shoreline and shelf sedimentary types displaced geosynclinal carbonate sediments, except for brief intervals when waters deepened or currents shifted and limestone was again deposited.

By late DesMoinesian time the seas of southeastern Arizona were continuous with those spreading eastward from the Cordilleran geosyncline. By Virgilian time essentially all of Arizona was covered by shallow Pennsylvanian seas.

PERMIAN PERIOD

No withdrawal of seas occurred at the end of the Pennsylvanian period. During Wolfcampian time, clastic deposition increased, and limestone deposition decreased. The western end of the basin of deposition was shallower and evaporites and clastics accumulated in local restricted areas. Farther east the basin filled more slowly or subsided more rapidly, and lime deposition persisted for a longer period.

Toward the end of Wolfcampian time a slight deepening of the basins caused fresh limestone accumulation in the southeast part of the area. Farther west, where shallow sea conditions continued, the basin continued to receive mainly clastic sediments.

Deposition during Leonardian time, except in the western end of the basin, was limestone and dolomite with varying amounts of clastics. Toward the end of Leonardian time two periods of clean siliceous sand deposition occurred with an intermediate period of dolomitic carbonate deposition. The influx of sand occurred over the entire area and marked a sharp change in conditions of deposition and perhaps sources of sediment. During Guadalupian time, carbonates and clastics were again deposited in a shelf environment.

The time of final withdrawal of the Permian seas is obscure since later erosion has removed all post-Guadalupian sediments.

MESOZOIC AND CENOZOIC ERAS

Except in southeastern Arizona no marine sedimentation occurred during Mesozoic time. Triassic and Jurassic times were periods of erosion and there is a nearly complete lack of sedimentary deposits. Marine deposits again accumulated in southeastern Arizona during Lower Cretaceous time and consist of a basal conglomerate ranging widely in thickness, followed by a succession of clastic and limestone beds.

Adjacent to this marine area a series of shelf deposits of clastic sediments with increasing amounts of arkose and red beds accumulated around the margins of the Cretaceous sea. Farther west, the near-shore marine deposits grade into or interfinger with continental deposits containing considerable quantities of volcanic material.

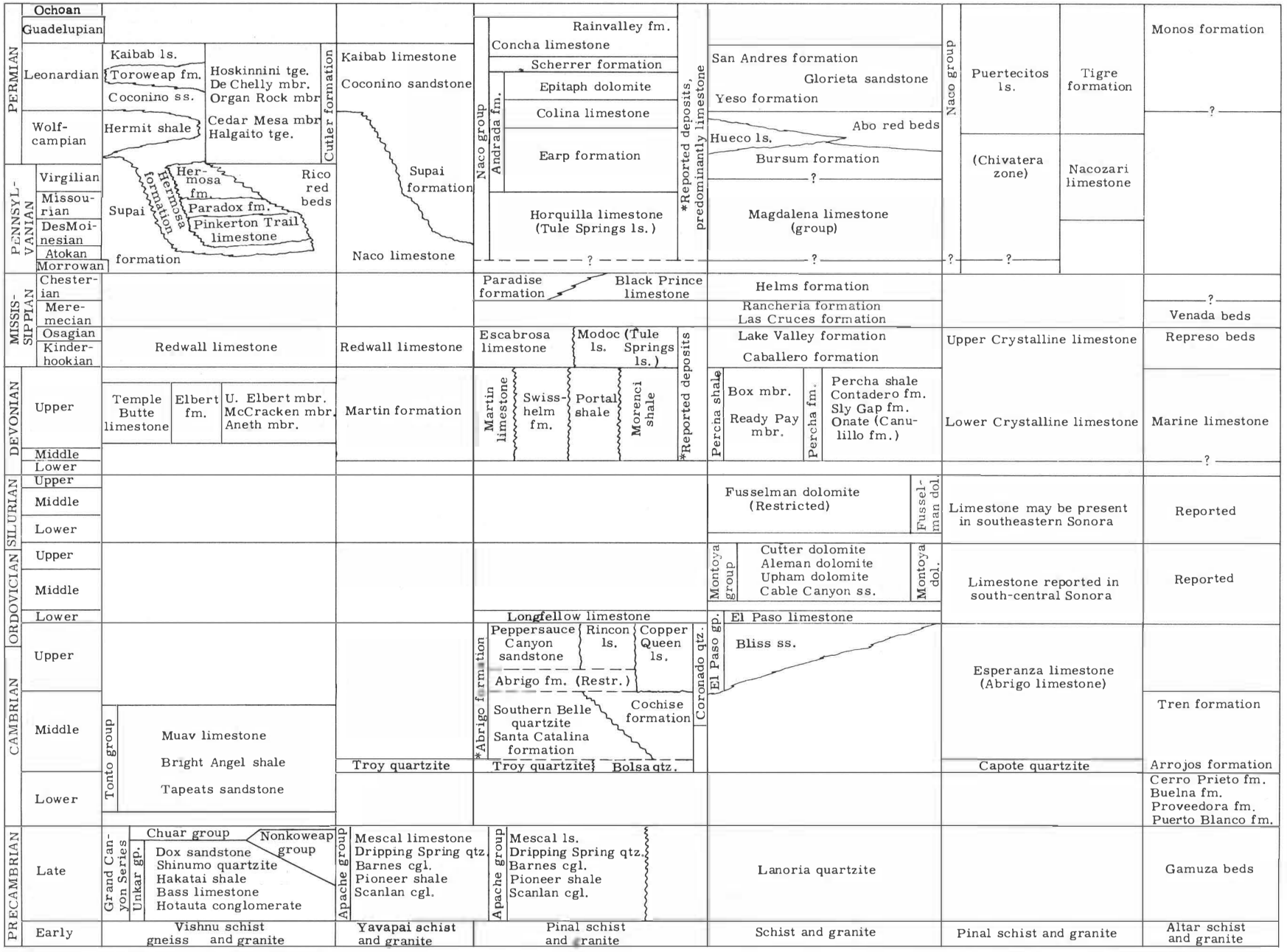
Upper Cretaceous marine and near-shore marine deposits occur in the northern part of southeastern Arizona and may represent a southern extension of the Upper Cretaceous seas that covered northwestern New Mexico. Elsewhere in southern Arizona, the Upper Cretaceous consists of non-marine clastic and volcanic deposits.

South of western Arizona, there are extensive marine deposits of Triassic, Jurassic, and Cretaceous age.

North of Yuma, about 1,000 feet of Tertiary marine deposits represent a probable incursion of the seas from the southwest. This is the only known occurrence of Tertiary marine deposits in southern Arizona.

Table 1. Nomenclature chart showing names and assigned ages of sedimentary rocks in southern Arizona and adjacent areas.

		NORTHERN ARIZONA	CENTRAL ARIZONA	SOUTHERN ARIZONA*	SOUTHWESTERN NEW MEXICO	EASTERN SONORA	WESTERN SONORA
QUATERNARY	Recent, Pleistocene	Alluvium	Alluvium	Alluvium	Alluvium	Alluvium	Alluvium
TERTIARY	Pliocene	Gravels and basalt flows; Bidahochi formation; Chuska sandstone	Verde fm.; Hickley fm.; Milk Creek beds	Valley fill (in part Gila conglomerate); Whitetail cgl., in part equivalent to Gila cgl.; (*Continental deposits); *Marine beds in Yuma Co	Gila conglomerate; Mimbres formation; Santa Fe group	Báucarit formation; Nogales formation; Trincheras formation	Báucarit fm.; Marine beds at head of Gulf of Calif.
	Miocene				Datil fm.; Baca fm.	LaMesa formation; Elenita formation; Henrietta formation; Nabosáigame formation	Nogales formation
	Oligocene			Mineta formation; Pantano formation			
	Eocene			"Silver Bell conglomerate"; Tucson Mountain chaos			
	Paleocene						
CRETACEOUS	Upper	Mesaverde group: Yale Point sandstone; Wepo formation; Toreva formation; Mancos shale; Dakota sandstone		Amole arkose and Recreation red beds; Sonoita group; Fort Crittenden formation; Fort Buchanan formation; Pinkard formation; *Reported deposits, predominantly clastic	Colorado shale; Benton quartzite	Lista Blanca fm.; Tarahumara fm.; Cabullona gp.; Rhyolite tuff; Upper Red beds; Packard shale; Camas sandstone; Snake River fm.	Marine clastic strata with limestone lenses and continental clastic and volcanic rocks
	Lower			? Clastic units in Tucson Mts.; ? Patagonia gp.; ? Molly Gibson fm.; Bisbee fm.; Bisbee gp.; Cintura fm., Mural ls., Lowell fm., Morita fm., Glance cgl.	Bisbee group; Hidalgo volcanics	Potrero fm.; Palmar fm.; Bisbee gp.; Cintura fm., Mural ls., Lowell fm., Morita fm., Glance cgl.	
JURASSIC	Upper	Morrison formation: Brushy Basin mbr., Westwater Canyon mbr., Recapture mbr., Salt Wash mbr.					
	Middle	Cow Springs sandstone; San Rafael group: Summerville fm., Todilto limestone, Entrada sandstone, Carmel formation				?	?
	Lower	Glen Canyon group: Navajo sandstone, Kayenta formation					Marine clastic beds with limestone lenses
TRIASSIC	Upper	Glen Canyon group: Moenave fm., Dinosaur Can. mbr., Springdale mbr.; Wingate sandstone, Lukachukai mbr., Rock Point mbr.; Chinle formation, Shinarump member				Barranca formation	?
	Middle						
	Lower	Moenkopi formation					



* Rock sequences reported in western Arizona.

Compiled by Willard D. Pye and Carl Fries, Jr.