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ARROYO SÁSABE FORMATION (APTIAN-ALBIAN), NORTHWESTERN SONORA, MEXICO – MARGINAL MARINE SEDIMENTATION IN THE SONORA BACK-ARC BASIN

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ABSTRACT

The Lower Cretaceous Arroyo Sásabe Formation is described and defined as a formal stratigraphic unit for northwestern Sonora, Mexico. The type locality is the Sierra El Chanate, located about 20 km northeast of Caborca. The Arroyo Sásabe Formation has a maximum thickness of 95.5 m, but thins to 0 m, and has two members: the lower member consists of greenish buff shale, green, very fine-grained sandstone and mudstone, limestone, and thin vitric tuffs, whereas the upper member is more homogeneous and includes olive to light green volcaniclastic sandstone and tuff, and gray sandstone. The Arroyo Sásabe Formation overlies conformably the Morita Formation, and is overlain conformably by the Cintura Formation. These three units constitute the Bisbee Group, which has been described in southeast Arizona-northeast Sonora. Therefore, the Arroyo Sásabe Formation is time-correlative to the Mural Limestone.

The Sierra El Chanate section is one of the first well-dated Lower Cretaceous sequences in northwestern Sonora with volcanically derived rocks. The Arroyo Sásabe Formation records marginal marine deposition with volcanic influence along the western margin of the Sonora back arc basin. This sequence thus can represent the link between the Bisbee basin, to the east, and the Alisitos basin, to the west.

Key words: stratigraphy, Arroyo Sásabe Formation, Aptian-Albian, Sonora, Mexico.

RESUMEN

Se describe y define a la Formación Arroyo Sásabe como unidad estratigráfica formal para el noroeste de Sonora. La localidad tipo se encuentra en la sierra El Chanate, a 20 km al noreste de Caborca. La Formación Arroyo Sásabe tiene un espesor de 95.5 m acuñándose hasta desaparecer, y se divide en dos miembros. El miembro inferior está constituido por lutita pardo-verdosa, arenisca de grano muy fino a lodolita verde, caliza y tobas vítreas delgadas. El miembro superior consiste en arenisca volcaniclástica y toba de color verde olivo a claro, y arenisca de color gris. La Formación Arroyo Sásabe descansa en concordancia sobre la Formación Morita; la Formación Cintura sobreyace en concordancia a la Formación Arroyo Sásabe. Estas tres formaciones constituyen el Grupo Bisbee, el cual ha sido descrito en el sureste de Arizona y noreste de Sonora.

La sección de la sierra El Chanate es una de las primeras secuencias del Cretácico Inferior del noroeste de Sonora que se ha descrito conteniendo rocas volcánicas intercaladas. La Formación Arroyo Sásabe representa un depósito en ambientes marinos marginales con influencia volcánica, los cuales se ubicaban en la margen occidental de la cuenca de postarco de Sonora. Por tanto, esta secuencia puede representar la unión entre las cuencas de Bisbee, al este, y Alisitos, al oeste.

Palabras clave: estratigrafía, Formación Arroyo Sásabe, Aptiano-Albiano, Sonora, México.

INTRODUCTION

The name Sásabe formation was first used by Jacques-Ayala (1983) for a sequence exposed in the Sierra El Chanate (Figures 1 and 2), which was divided into three members; the lower and upper consisting of red mudstone and shale with gray sandstone, and a middle member consisting of green shale and sandstone with intercalations of oyster-rich limestone. Later, Jacques-Ayala and Potter (1987) renamed it as Arroyo Sásabe Formation keeping the three-member division. Now this sequence has been identified as equivalent to the Bisbee Group of northeast Sonora, and will be renamed as such. The name Arroyo Sásabe is here formally proposed for what was the middle member of the former Arroyo Sásabe. The other two members would better be named the Morita and Cintura Formations, to which they are lithologically similar. The renaming of the Arroyo Sásabe Formation as Bisbee Group is recommended to avoid the proliferation of names for lithologically similar units.

Jacques-Ayala and others (1986) used the informal name El Chanate group, to include the Chupurate (Willard, 1988), Arroyo Sásabe, El Chanate and El Charro formations (Jacques-Ayala and Potter, 1987). Now the El Chanate group has been redefined to include only the former El Chanate Formation (Jacques-Ayala *et al.*, 1990).

The Bisbee Group of the Sierra El Chanate is formally divided into three units: the Morita, Arroyo Sásabe and Cintura Formations. The Morita and Cintura Formations were defined by Ransome (1904) in southeastern Arizona. The Arroyo Sásabe is a new name here defined formally to include the rock sequence between the Morita and the Cintura Formations, characterized by green, volcaniclastic sandstone and tuffs, purplish red sandstone, vitric tuffs, as well as small oyster bindstone mounds and floatstone beds. This formation is time equivalent to the Mural Limestone (Ransome, 1904) but represents different facies, being sandier and with intercalated volcanic rocks. The newly designated Arroyo Sásabe Forma-

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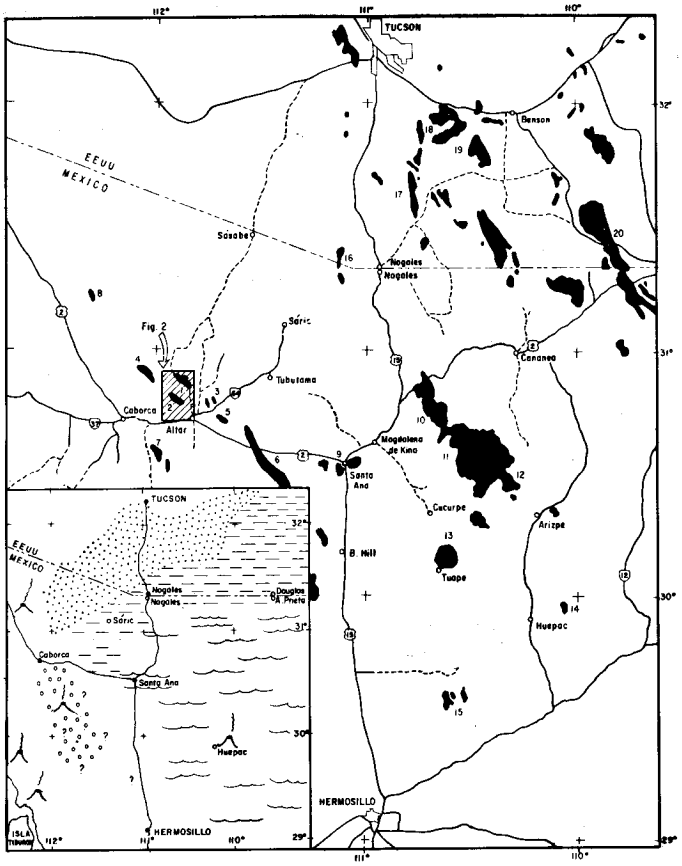

Figure 1.- Map of northwestern Sonora and southern Arizona showing the location of the Sierra El Chanate, reference locality of the Arroyo Sásabe Formation. Also shown some of the localities mentioned in text, or where Early Cretaceous and probable Early Cretaceous rocks have been reported. Localities: (1) Sierra El Chanate, (2) Sierra El Batamote, (3) Cerros El Puerto, (4) Puerto El Alamo, (5) Cerros El Amol, (6) Cerros Cabeza Colgada, (7) Cerro Rajón, (8) Sierra La Comancha, (9) Santa Ana, (10) Sierra La Madera; (11) Sierra Azul, (12) Arizpe, (13) Tuape, (14) NE of Huepac, (15) Cerro de Oro, (16) Pajarito Mountains, (17) Santa Rita Mountains, (18) Empire Mountains, (19) Whetstone Mountains, (20) Mule Mountains. Inset: Paleogeographic settings for Early Cretaceous time, modified after Dickinson and others (1986) and González-León and Jacques-Ayala (in press): wave pattern = marine; dashes = continental and marine; stippled = continental; circles = mainly coarse-grained continental; volcanoes = Alisitos arc related volcanism.

tion is correlative in age to the Mural Limestone, but not lithologically. Both units, however, are in the same stratigraphic position with respect to the Morita and Cintura Formations.

STRATIGRAPHY

ARROYO SÁSABE FORMATION (NEW NAME)

The name Arroyo Sásabe Formation is proposed for a complex sequence of very fine-grained green shale, green tuff to volcaniclastic siltstone to sandstone, purplish red sandstone with ostreid-bearing floatstone to bindstone as well as intercalated gray, vitric tuffs, all of them well exposed on both flanks of the Sierra El Chanate. The new formation is divided into two members: the lower member consists of greenish buff to gray shale, green mudstone to fine-grained sandstone, limestone, and thin vitric tuffs, whereas the upper member is formed mainly by green to purplish red, coarse-grained, volcaniclastic sandstone to mudstone, and tuff.

The Arroyo Sásabe Formation has a maximum thickness of 95.5 m, but pinches out in the southwestern part of the area. Most important facies changes within it occur on the southern part of the sierra. Considering the varying facies in this unit, four sections are described: one on the northern side, and three on the southern side (Figure 2). All these are reference sections for the composite stratotype of the Arroyo Sásabe.

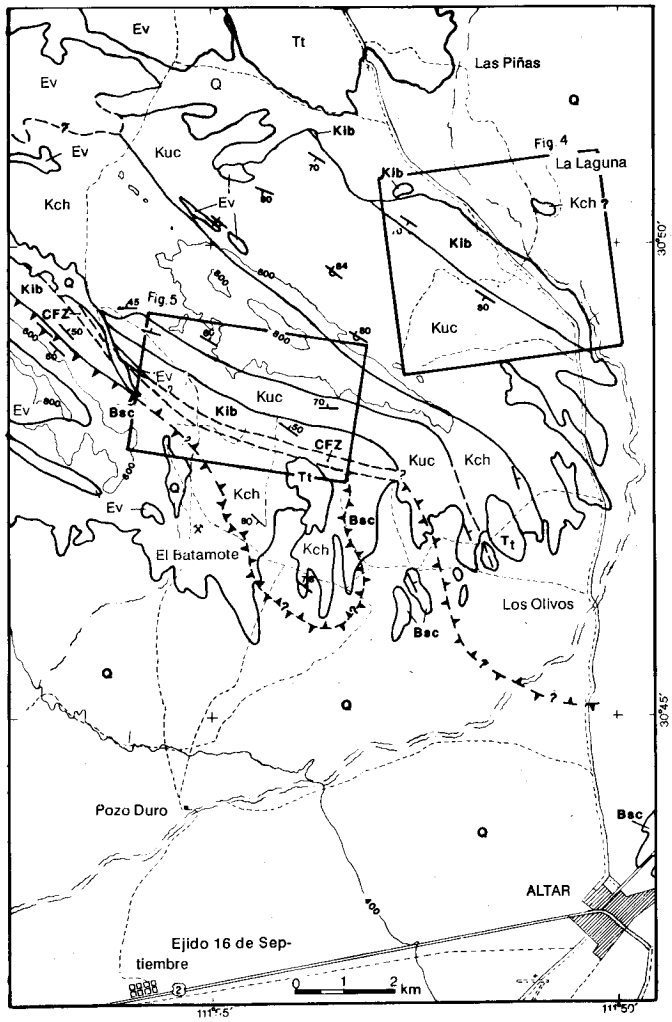

Figure 2.- Simplified geologic map of the Sierra El Chanate. Symbols for stratigraphic units are: Q = Quaternary; Tt = Tertiary terrace deposits; Ev = Eocene andesitic extrusive and intrusive rocks; Kch = Upper Cretaceous El Charro volcanic complex; Kuc = Albian-Upper Cretaceous El Chanate Group; Kib = Lower Cretaceous Bisbee Group; CFZ = El Chanate fault zone; Bsc = Mesozoic El Batamote structural complex; line with black triangles = low-angle fault (dashed where inferred).

Distribution

The Arroyo Sásabe Formation is exposed on the northern rim of the Sierra El Chanate, where it is 38.8 m thick. It has a well-defined pattern in aerial photographs and satellite images, for it shows up as a light gray strip between the two dark gray patterns displayed by the Morita and Cintura Formations. The best exposures are on the southern rim of the sierra, even though its pattern in aerial photographs is not clear. On this side of the sierra it attains 95.5 m in thickness but pinches out toward the west. The lower member is exposed in the northern rim, as well as in the western half of the southern rim of the sierra. The upper member occurs only on the eastern half of the southern rim. Both members are present in section II (Figure 3).

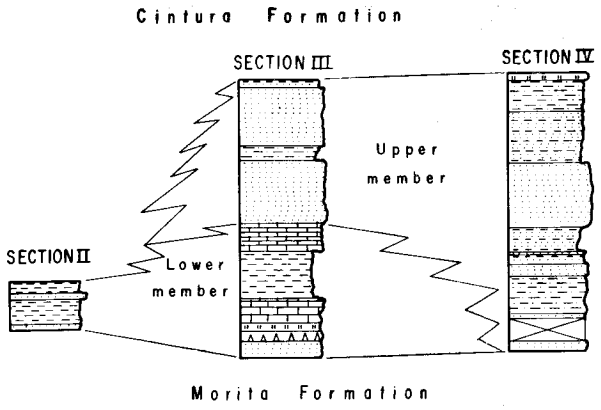

Figure 3.- Facies diagram for sections II, III, and IV, located on the southern rim of the Sierra El Chanate, where the lower and upper members of the Arroyo Sásabe Formation are present.

Rocks similar to the Arroyo Sásabe have been studied in the Cerros El Amol (García y Barragán *et al.*, 1988; Jacques-Ayala *et al.*, 1990), and north of Puerto El Alamo (Willard, 1988). They may also be present in the Cerro El Puerto and Cerros Cabeza Colgada (Figure 1).

Description of sections

Section I. This section was measured on the northern side of the Sierra El Chanate along a gully crossed by the dirt road that goes from Altar to Rancho Los Chirriones (Figure 4). Cartesian coordinates for the section are: X=417,050, and Y=3'411,400 (DEGETENAL, 1980). This part of the area is characterized by a nearly flat topography, with few elongated hills that trend along the strike of the strata.

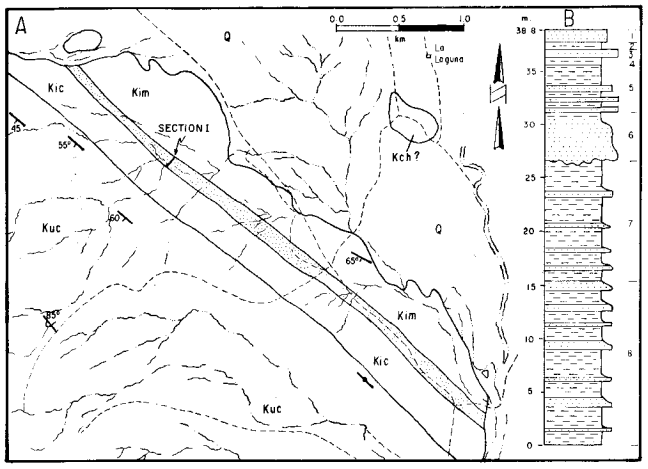

Figure 4.- (A) Detailed geologic map of the northeastern corner of the study area to show the location of section I. Map drawn from a 1:20,000 scale aerial photograph. Symbols same as in Figure 2, except for: Kim = Morita Formation; stippled = Arroyo Sásabe Formation; Kic = Cintura Formation. (B) Stratigraphic column of section I, located on the northern rim of the Sierra El Chanate.

A second section was measured about 600 m east of the road junction to the Rancho La Paloma. This section is 45 m thick, and consists mainly of shale with few fossil-hash rudstone beds less than 1 m thick. It is poorly exposed.

SECTION I

Units	Thickness (m) Unit	Total
LOWER MEMBER		
1.- Siltstone, purple, thin-bedded; it is intercalated with purple, fine-sandstone and some mudstone. Sharp contact with...	1.2	1.2
2.- Shale, mottled, lenticular; it has abundant calcareous nodules and mud chips. Sharp contact with...	0.7	1.9
3.- Sandstone, gray, thin cross-bedded, medium-grained, and with some mud chips. Sharp irregular contact with...	0.6	2.5
4.- Shale, greenish gray to purple and mottled, thin to thick-bedded; it has abundant calcareous nodules; is intercalated with green to purple and buff, thin cross-bedded, fine sandstone. In the lower half the sandstone is thick-bedded and medium- to fine-grained. Sharp contact with...	5.1	7.6
5.- Sandstone, gray but weathers greenish buff, laminated to thinly stratified, medium- to fine-grained; it is intercalated with red, thin-bedded shale in the upper third. In the middle third there is no shale and the sandstone has planar cross-bedding, and in the lower one, bedding is plane parallel. Few small lenses of coarse sandstone occur. Erosional contact with...	4.5	12.1
6.- Shale (80%), buff to green and purple, thick-bedded, homogeneous, foliated; it is intercalated with green to purple, thin- to medium-bedded, fine-sandstone (20%). Transitional contact with...	11.1	23.2
7.- Shale (70%), ocher green, medium- to thick-bedded, homogeneous, with calcareous nodules at the upper contact; it is intercalated with ocher green, thin to medium plane parallel bedding, fine to silty sandstone. Covered contact with the Morita Formation.	15.6	38.8

Section II. This section was described on the southern rim of El Chanate, toward the northwestern part of the area (Figure 5). This section is the thinnest, only 17 m thick (Figure 6), and disappears toward the west. Cartesian coordinates for this section are: X=411,250, and Y=3'409,500.

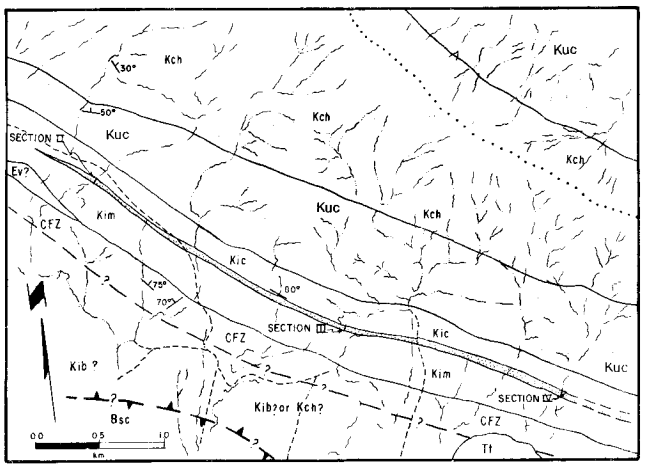

Figure 5.- Detailed geologic map of the south-central part of the Sierra El Chanate showing the location of sections II, III, and IV. Map drawn from a 1:20,000 scale aerial photograph. Symbols same as in Figure 2, except for: Kim = Morita Formation; stippled = Arroyo Sásabe Formation; Kic = Cintura Formation; dotted line = topographical axis of the sierra.

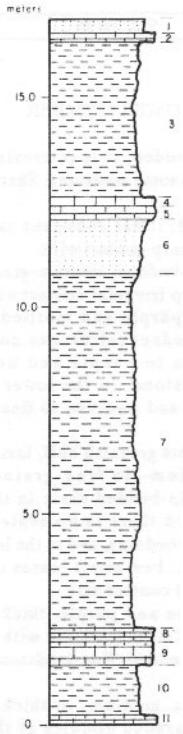

Figure 6.- Stratigraphic column of section II. Numbers to the right correspond to the description of units given in text. For location of section, see figure 5.

SECTION II

Units	Thickness (m) Unit	Total
LOWER MEMBER		
1.- Sandstone, greenish buff, weathers with a reddish buff surface. Laterally grades into a shale of the same color. Sharp, irregular contact with...	0.3	0.3
2.- Rudstone consisting chiefly of broken pelecypods, gray, weathers in dark buff. Sharp regular contact with...	0.2	0.5
3.- Shale, greenish buff, with no apparent structure. Contains intercalated lenses of mollusc framestone up to 15 cm. Strongly foliated. Covered contact with...	3.7	4.2
4.- Rudstone, same as in unit 2. Transitional contact with...	0.2	4.4
5.- Framestone; it contains both complete and fragmented oysters and other pelecypods, gray, weathers buff (Figure 7). Sharp contact with...	0.3	4.7
6.- Sandstone, greenish buff, structureless, fine-grained, and fractured. Sharp contact with...	1.3	6.0
7.- Shale, greenish buff, and strongly foliated. Sharp contact with...	8.5	14.5
8.- Grainstone, gray; it weathers brownish gray. Sharp contact with...	0.4	14.9
9.- Rudstone, gray; it weathers brownish gray; it consists of whole pelecypods, many of which have both valves joined, and some fragmented ones also. Sharp contact with...	0.5	15.4
10.- Shale, same as in unit 7. Sharp contact with...	1.2	16.6
11.- Rudstone, same as unit 9. Whole oysters become more abundant toward the base. Sharp contact with the Morita Formation.	0.2	16.8

Section III.- The central part of the sierra has good exposures, and is considered as the stratotype unit (Figure 8). The section was measured along a gully located on the southern rim of the Sierra El Chanate, 2.2 km north of the El Batamote mine. The end point of the section can be reached by the road that goes from Rancho Pozo Duro to the north, parallel to the Arroyo El Charro, continuing northeast to the Dos Vírgenes mine claim (Figure 5).

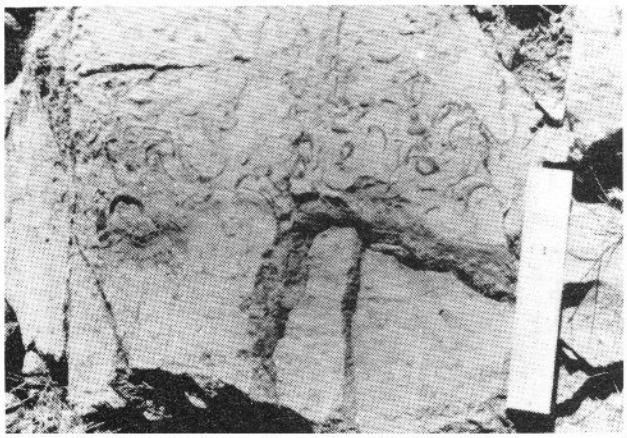

Figure 7.- Close-up of oyster floatstone bed from unit number 5 in section II. Length of scale is 15 cm.

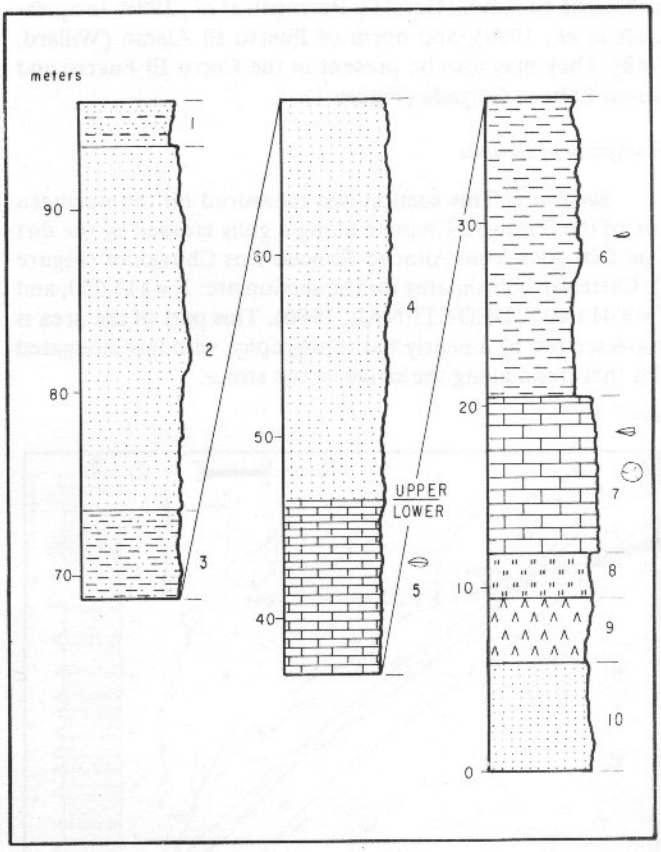

Figure 8.- Stratigraphic column of section III. Numbers to the right correspond to description given in text. For location of section see Figure 5.

Cartesian coordinates for the base of the section are: X=413,000, and Y=3'407,950.

The best, and thicker, limestone exposures are in this part of the area. Here, and at the base of the formation, the limestone is formed mainly by complete and unabraded, to slightly fragmented oysters (Figure 9). Also present are rudists(?), equinoids, and gastropods, as well as miliolids, orbitolinids, and fragments of algae. Specimens of *Yaadia (Quadratotrigonia) mearnsi* Stoyanow and *Macraster* sp., that

assign an Aptian-Albian age to the Arroyo Sásabe (Jacques-Ayala and Potter, 1987) were collected from this part of the unit. Both members of the formation are present in this section.

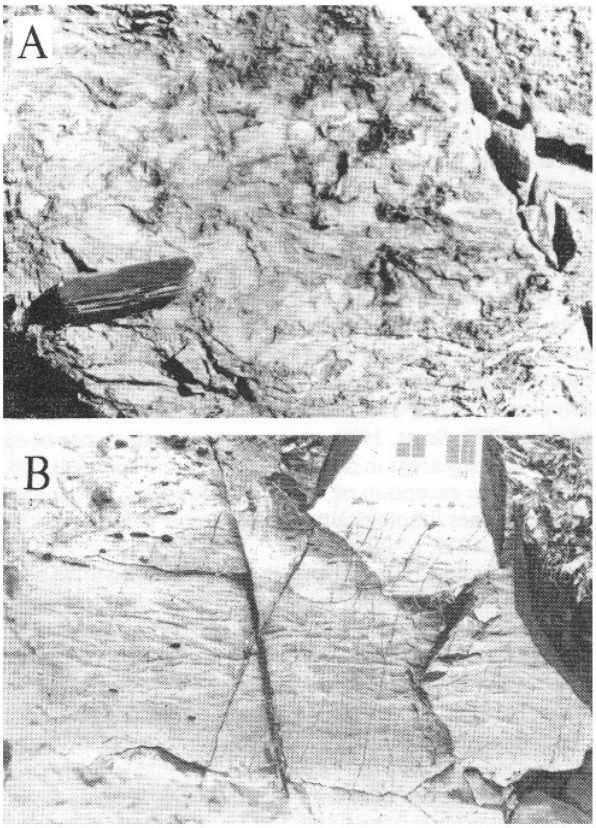

Figure 9.- (A) Close-up of the oyster bindstone in section III, unit number 7. Length of scale is 15 cm. (B) Close-up of green, fine-grained sandstone with small-scale wavy ripples and flaser bedding.

SECTION III

Units	Thickness (m) Unit	Total
UPPER MEMBER		
1.- Mudstone, purple, medium- to thin-bedded, intercalated with green, medium- to thin-bedded, fine- to very fine-grained sandstone. Sandstone becomes more abundant toward bottom. Transitional contact with...	2.5	2.5
2.- Sandstone, green to gray, medium- to thick-bedded, fine- to very fine-grained, displays locally thin planar cross-stratification and lamination, as well as symmetrical ripple marks. Mud-chip conglomerates occur in lenses. Sharp irregular contact with...	20.0	22.5
3.- Mudstone, red, homogeneous, thick-bedded, with disseminated calcareous nodules, some of which have been dissolved. Sharp irregular contact with...	5.0	27.5
4.- Sandstone, grayish green, weathers light green, and very fine-grained, commonly occurs in thick beds but has some thin stratification and stromatolitic(?) structures. Some mud-chip conglomerates in lenses less than 50 cm thick. The pebbles are made of micstone** and mudstone, rounded to "ragged" in shape. Minor bioturbation. Covered contact with...	22.0	49.5
LOWER MEMBER		
5.- Limestone and dolomite, dark gray, in alternating thin beds. The dolomite has both parallel and cross-lamination. Sharp contact with...	9.5	59.0
6.- Shale, dark gray to black, weathers to green and ocher, thin-bedded and homogeneous, slightly calcareous. Contains interbeds of dark gray, medium-bedded packstone with fragmented molluscs? Sharp, regular contact with...	16.5	75.5
7.- Framestone to boundstone, gray, weathers yellowish ocher, and massive, has well preserved pelecypods, and some echinoderms. Many pelecypods have their valves joined (Figure 9, A). Intercalations of gray wackestone occur. Sharp irregular contact with...	8.5	83.0
8.- Tuff, dark gray, aphanitic, with apparent flow structure, vitric. Between the tuff and unit 9 is a very thin, light gray wackestone with fragments of pelecypods. Sharp contact with...	2.5	85.5
9.- Andesitic sill, green, tabular, porphyritic texture, with phenocrystals of amphibole, which are more abundant toward the lower contact, but very scarce near the upper contact. No contact metamorphism is apparent. Sharp irregular contact with...	3.5	89.0
10.- Sandstone, purplish gray, massive, very fine-grained; interbeds of green sandstone with thin, wavy ripples to flaser bedding (Figure 9, B). Sharp irregular contact with the Morita Formation.	6.0	95.0

** Micstone is used in place of mudstone as defined by Dunham (1974); originally mudstone was defined as a mixture of clay and silt.

Section IV.- In section IV (Figures 5 and 10) the Arroyo Sásabe Fm. consists mainly of green, coarse- to medium- and fine-grained sandstone. The section was measured along a gully on the southern rim of the Sierra El Chanate. The end point of the section can be reached by the road that goes southeastward from the El Batamote mine and an inaccessible road that goes to the north, starting from the crossing of the road with an arroyo, next to a locked gate. Cartesian coordinates for the bottom of the section are: X=414,650, and Y=3'407,450.

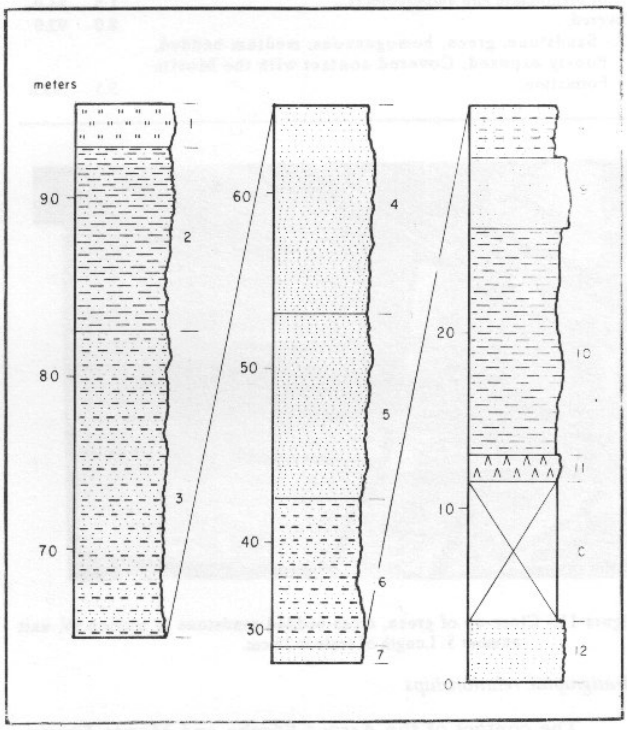

Figure 10.- Stratigraphic column of section IV. Numbers to the right correspond to description given in text. For location of section see Figure 5.

SECTION IV

Units	Thickness (m) Unit	Total
UPPER MEMBER		
1.- Andesitic flow, green, aphanitic, apparently stratified, is probably a crystal-vitric tuff, the base being more crystalline. Sharp irregular contact (by color, it appears to be transitional) with...	2.5	2.5
2.- Mudstone, green at the top, changes to purple, has thin, planar to irregular stratification, but is locally bioturbated. Contains few calcareous nodules. Sharp irregular contact with...	10.5	13.0
3.- Sandstone, green, medium-bedded, fine- to medium-grained, intercalated with green to purple shale in medium to thick beds. Covered locally by caliche. Unit is fractured and cut by small faults. Sharp contact with...	17.5	30.5
4.- Sandstone, green, thin- to medium-bedded, has thin, plane parallel stratification, as well as planar and tangential cross-stratification (Figure 11), and contains intercalated lenses of rip-up clasts. Clasts consist of red and green mudstone and gray micstone. Transitional(?) contact with...	12.0	42.5
5.- Sandstone, green and medium-bedded, fine-grained to siltstone. Sharp, irregular contact with...	10.5	53.0
6.- Sandstone, green, medium-bedded, medium- to fine-grained, interbedded with green, thin bedded shale. Sharp contact with...	8.5	61.5
7.- Sandstone, gray, thin-bedded, coarse to granular (up to 5 mm in diameter), cemented by calcite. Fragments are mostly micstone. Sharp irregular contact with...	1.0	62.5
8.- Sandstone, green, thin-bedded, intercalated with green, thin-bedded shale. Poorly exposed. Covered contact with...	3.0	65.5
9.- Sandstone, green, homogeneous, medium- to thick-bedded, fine-grained. Transitional contact with...	4.0	69.5
10.- Siltstone to mudstone, light green, hard, homogeneous, medium- to thick-bedded, has calcareous nodules which dissolve and leave cavities...	13.0	82.5
11.- Andesite flow, green, porphyritic, has small phenocrysts of plagioclase and amphibole(?)...	1.5	84.0
Covered...	8.0	92.0
12.- Sandstone, green, homogeneous, medium-bedded. Poorly exposed. Covered contact with the Morita Formation.	3.5	95.5

Figure 11.- Close-up of green, cross-bedded sandstone in section IV, unit number 5. Length of scale is 15 cm.

Stratigraphic relationships

The contact of the Arroyo Sásabe and Morita Formations grades from transitional to sharp. Locally, the limestone of the Arroyo Sásabe rests on the red mudstone with a sharp contact. When the limestone is not present, the contact is generally designated where the sandstone and shale acquire a green color. The upper contact is also sharp to transitional with the Cintura, and is placed where the color changes back to red.

Age and correlation

Jacques-Ayala and Potter (1987) found *Trigonia* and equinoids (*Macraster* sp.) in the Arroyo Sásabe Formation. These two fossils define a late Aptian-Albian age. The overlying El Chanate Group was assigned in part to the Albian (Jacques-Ayala and Potter, 1987), therefore, the upper limit of the Bisbee is placed in the middle(?) Albian. Keller (1928) and Cooper and Arellano (1946) collected fossils of Aptian-Albian age somewhere in the study area, but failed to include the taxonomic identification and exact location of collection.

Correlation of the Arroyo Sásabe in Sonora can be made with the terrigenous and calcareous sequences that have been described in the northern half of Sonora and southern Arizona (see localities and references in Figure 1). The best known correlative unit is the Mural Limestone (Ransome, 1904; Taliaferro, 1933; Scott, 1979, among others), which has been described in many areas in northeast Sonora and southeast Arizona. With the exception of volcaniclastic rocks, the Arroyo Sásabe correlates lithologically with the lower member of the Mural (Scott, 1979, p. 1109).

In the vicinity of Santa Ana, the Represo Formation consists of thick limestone with intercalated sandstone and shale (Flores, 1929; Salas, 1968; Morales-Montaño, 1984; Navarro-Fuentes and Téllez-Duarte, 1988). Salas (1968) also reports the occurrence of andesitic volcanics with intercalated limestone, northeast of Santa Ana. Salas assigned them a probable Cretaceous age, even though no age-diagnostic fossils were collected.

In nearby areas a few sequences of probable Early Cretaceous age have been described. In the Sierra de Santa Rosa, Hardy (1973) reported the Cerro San Luis Formation, consisting of clastics and volcaniclastics, covering the Lower Jurassic Santa Rosa formation. In Cerro Chino, Longoria and Pérez-Venzor (1979) described the Chino Group, which consists mainly of coarse-clastics, that overlie the Rajón Group of Early Jurassic age. In the Sierra del Alamo, González-León (1979) reports a sequence of volcanic-volcaniclastic rocks overlying the Upper Triassic-Lower Jurassic El Antimonio Formation. Preliminary K-Ar results yield an age of 107 Ma for a rhyolite sequence in the Sierra La Comancha (Jacques-Ayala *et al.*, 1990), north of Tajitos (Figure 1). Anderson and others (1969) dated several volcanic and metavolcanic rocks exposed in the Sierra Seri and Sierra Bacha, along the coast of Sonora, which yielded 142 and 128 Ma, respectively. Intrusive rocks along the coast, from Bahía Kino to San Luis Río Colorado yield ages between 100 and 83 Ma (Anderson *et al.*, 1969).

In southwestern Arizona, near the town of Quartzite, Robison (1980) described some Mesozoic red beds of probable Cretaceous age which display a very similar lithology to the Bisbee Group of the El Chanate area. Later, Harding and Coney (1985) included the Mesozoic red beds and the Livingston Hills Formation (Harding, 1980; Marshak, 1980) into the McCoy Mountains Formation.

Depositional environment

The Bisbee Group represents a transgressive-regressive cycle, in which the Arroyo Sásabe/Mural Formations were de-

posited during the maximum advance of the sea. During Morita deposition, the area was a tidal flat with some fluvial input from the north-northeast (Jacques-Ayala and Potter, 1987). Later, during Arroyo Sásabe time, the depositional environment in the area was a lagoon, where mud and sand were associated with oyster patch reefs, which laterally graded into zones of carbonate deposition where few oysters thrived. Nearby volcanic activity shed tuffs and thin lava flows into the basin. Locally and overlying the patch reef, dark gray clays and carbonate suggest the presence of small areas of high organic content, probably marshes. During the deposition of the Cintura Formation, the coastline regressed, with sedimentation being again part of a tidal flat with important fluvial influence.

DISCUSSION

The Arroyo Sásabe Formation was deposited along the western margin of a basin located east of the northern extension of the Alisitos Arc, considering a northward translation of the Baja California peninsula (Hagstrum *et al.*, 1985; Gastil *et al.*, 1986). The Alisitos Formation is at present located on the northwestern margin of the Baja California peninsula, and represents fore arc deposition (Rangin, 1982; Busby-Spera and Boles, 1986; Almazán-Vázquez, 1988). An Early Cretaceous back arc basin has been postulated for Sonora, but very little evidence has been provided (Rangin, 1978; Araujo-Mendieta and Estavillo-González, 1987). Most workers have considered the presence of volcanic detritus as derived from the erosion of a Jurassic volcanic arc, and not from contemporaneous Early Cretaceous volcanism. Reports on the presence of tuffs are very scarce (Rangin, 1982, p. 173).

Distribution of Lower Cretaceous and probable Lower Cretaceous sediments with intercalated volcanics is indicated in Figure 1. Hence, a proximal-to-the-arc back arc basin in Sonora can be documented for the Caborca region. The northern margin of the basin is well-defined in central and eastern Arizona. The southern margin is yet to be determined, but it may extend as far south as Sinaloa, where calcareous rocks with intercalated volcanics have been reported (Bonneau, 1972; McAnulty, 1981). The northwestern limit of this basin is still to be established. Several workers have proposed the McCoy Mountains Formation (Harding and Coney, 1985) as correlative to the Bisbee Group in southeastern Arizona (Robison, 1980). Jacques-Ayala and others (1986) have speculated that the the McCoy Mountains Formation and the Sierra El Chanate sequence could belong to the same basin; and by extension, also the Bisbee basin. The only evidence at present is the lithological similarity, which probably represents similar tectonic setting.

Paleogeographic reconstructions of the Bisbee basin have lacked much information from Sonora, mainly because of the scarcity of stratigraphic information. For this reason, the Bisbee basin has been interpreted as narrow, restricted to southeastern and southcentral Arizona and northeastern Sonora (Hayes, 1970; Bilodeau and Lindberg, 1983; Dickinson *et al.*, 1986; Kitz and Anderson, 1988). As more Lower Cretaceous sections are described, the geometry of the basin will be better defined; knowledge of the geometry of a basin is fundamental for the interpretation of its tectonic setting.

The paleotectonic setting for the Bisbee basin has also been the subject of some speculation, mainly because of the uncertain ages of many of the sequences, although recent studies have provided new insights to the problem, as well as important changes to previous data. Bojórquez-Ochoa and Rosas-Haro (1988) reported in a small area northeast of Huepac, in central Sonora, the occurrence of limestone with intercalations of andesite flows and conglomerate. The age of the limestone is well established as Early Cretaceous (Neocomian-early Aptian). The reported Lower Cretaceous limestones and andesites in central Sonora by Dumble (1901), could be of early Late Cretaceous age (Cruz-Frisby, oral communication, 1989). Also, the Potrero Formation described by King (1939) in east-central Sonora as Early Cretaceous has been reassigned to the Late Cretaceous (Pubellier, 1987). Furthermore, Pubellier (1987) reports K-Ar ages between 83±4 and 47.46±2.37 Ma (Late Cretaceous-early Tertiary) from volcanic rocks previously considered as Lower Cretaceous. This indicates that volcanic activity occurred intermittently throughout the Cretaceous. In order to reconstruct the volcanic trends in Sonora, it is imperative to date more volcanic successions.

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