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THE LOWER CRETACEOUS GLANCE CONGLOMERATE AND MORITA FORMATION OF THE SIERRA EL CHANATE, NORTHWESTERN SONORA

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ABSTRACT

The Lower Cretaceous Glance Conglomerate and Morita Formation are well exposed in the sierra El Chanate, about 20 km northeast of Caborca, northwestern Sonora, Mexico.

One partial section of the upper 21 m of the Glance Conglomerate reveals that it consists of green to mottled, massive pebble conglomerate. Three sections of the Morita indicate that its maximum thickness, of more than 480 m, occurs on the northern side of the sierra; thickness decreases to 200–250 m on the southern side because of faulting. The basal contact of the Glance is not exposed, but it could have been deposited on volcanic breccia exposed as isolated patches in the northern side of the sierra El Chanate. The Morita Formation consists of red to purplish-red mudstone and shale, minor gray and reddish to purplish-gray sandstone, and rare coarse fossil-debris limestone beds. The basal contact is transitional with the Glance Conglomerate, and the upper contact is sharp to transitional with the Arroyo Sásabe Formation.

The Glance Conglomerate and the Morita Formation are the lowest two formations of the Bisbee Group and are extensively exposed in northeastern Sonora and southeastern Arizona. The importance of the sierra El Chanate sequence is that it represents an extension of the Early Cretaceous Bisbee basin as far west as Caborca. Previously, the westernmost exposure of Bisbee basin rocks was in the Santa Ana area, 70 km to the east.

The Glance Conglomerate from the sierra El Chanate is interpreted to have been accumulated in a fluvial system, whereas the Morita Formation was deposited in a tidal flat–alluvial plain environment with minor marine influence. These two units represent the transgressive phase of the Bisbee Group, which has its maximum sea advance during Mural-Arroyo Sásabe time.

Key words: stratigraphy, Glance Conglomerate, Morita Formation, Lower Cretaceous, sierra El Chanate, Sonora, Mexico.

RESUMEN

El Conglomerado Glance y la Formación Morita, ambos del Cretácico Temprano, están bien expuestos en la sierra El Chanate, a unos 20 km al noreste de Caborca, en la parte noroccidental de Sonora.

Fueron medidos los 21 m superiores del Conglomerado Glance, el cual está constituido por conglomerado que varía desde verde hasta abigarrado, principalmente de grava de pedernal, y arenisca gruesa a media, también verde. El contacto inferior del Glance no aflora, pero pudo haberse depositado sobre brecha volcánica, expuesta en afloramientos aislados. Tres secciones medidas en la Morita indican que el espesor máximo, de más de 480 m, se encuentra en el flanco septentrional; el espesor disminuye, debido a fallamiento, a unos 200-250 m en el lado meridional. La Formación Morita está formada por lodolita y lutita de color rojo a rojo violáceo, y escasas capas de caliza constituida por fragmentos gruesos de molusco. El contacto inferior es transicional con el Conglomerado Glance, mientras que el superior varía de abrupto a transicional con la Formación Arroyo Sásabe.

El Conglomerado Glance y la Formación Morita son las dos unidades más inferiores del Grupo Bisbee, el cual aflora ampliamente en la parte nororiental de Sonora y sudoriental de Arizona. La localidad de la descripción original del Glance se encuentra en las montañas Mule, cerca de Bisbee, Arizona, y la de la Morita se encuentra en el cerro La Morita, cerca de Agua Prieta.

La importancia de la secuencia aquí descrita radica en que representa una extensión de la cuenca Bisbee, del Cretácico Temprano, hacia el oeste, hasta el área de Caborca. Anteriormente se consideraba el área de Santa Ana, a unos 70 km al este, como la margen occidental de esta cuenca.

El depósito del Conglomerado Glance de la sierra El Chanate se interpreta como un sistema fluvial, en tanto que la Formación Morita se depositó en una planicie, de mareas a aluvial, con alguna influencia marina. Estas unidades constituyen la fase transgresiva del Grupo Bisbee, cuyo máximo avance se registra con la Caliza Mural-Formación Arroyo Sásabe.

Palabras clave: estratigrafía, Conglomerado Glance, Formación Morita, Cretácico Inferior, sierra El Chanate, Sonora, México.

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INTRODUCTION

This is the second paper on the stratigraphic units of the Bisbee Group in the sierra El Chanate (Figure 1); the first one described the Arroyo Sásabe Formation (Jacques-Ayala, 1989). This is devoted to the Glance and Morita units, and the third will be on the Cintura Formation (Jacques-Ayala, in press).

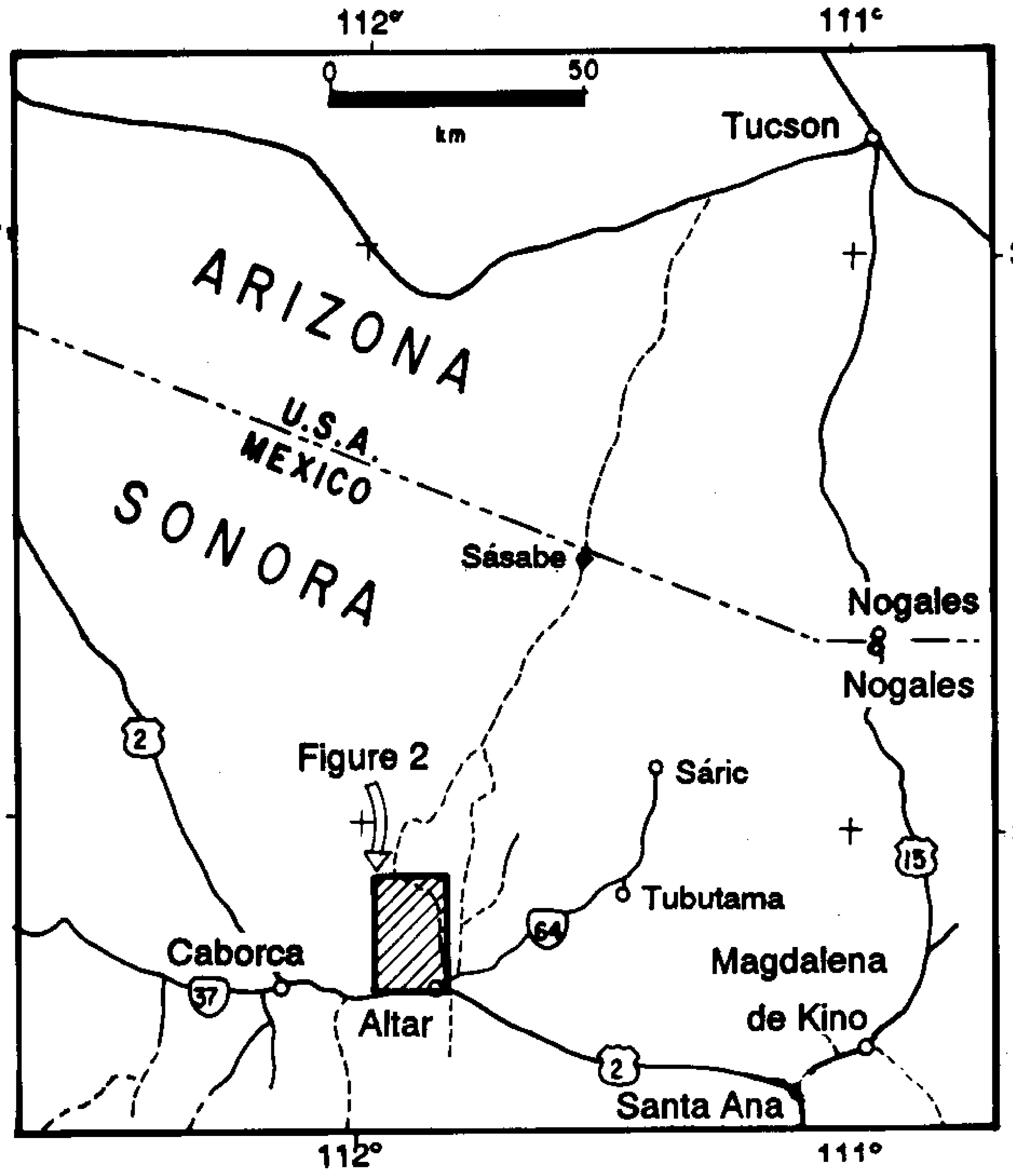

Figure 1.- Map of northwestern Sonora and southern Arizona with the location of study area.

The first report of the Bisbee Group in the sierra El Chanate (Figure 2) was by Jacques-Ayala (1983, p. 32), but the name of Sásabe formation was used instead. It was divided into three members (Figure 3), the lower one being what is now named as Morita Formation. Later, Jacques-Ayala and Potter (1987, p. 204) renamed the Sásabe formation as Arroyo Sásabe, keeping the three-member division, and reporting the presence of the Glance Conglomerate as part of the lower member. Now the Arroyo Sásabe Formation of Jacques-Ayala and Potter (*op. cit.*) has been identified as equivalent in age and partly in lithology, to the Bisbee Group of northeastern Sonora and southeastern Arizona (Jacques-Ayala *et al.*, 1990). The lower and upper members are equivalent to the Morita and Cintura Formations, respectively. The middle member has been named Arroyo Sásabe Formation (Jacques-Ayala, 1989), and is correlative to the Mural Limestone (Figure 3). Changing the name of Arroyo Sásabe Formation to Bisbee Group is justified to avoid the proliferation of different names for similar lithologic units.

The sequence of the Bisbee Group was first described as the Bisbee beds by Dumble (1902) in the Mule Mountains, near Bisbee. Later, Ransome (1904) defined and named that sequence as the Bisbee Group, with the four known units: Glance Conglomerate at the base, Morita Formation, Mural Limestone, and Cintura Formation at the top. The type locality of the Morita Formation is located at the Morita Hills, west-southwest of Agua Prieta, Sonora, whereas for the Glance Conglomerate and the other units of the Bisbee Group, the type locality is located in the Mule Mountains.

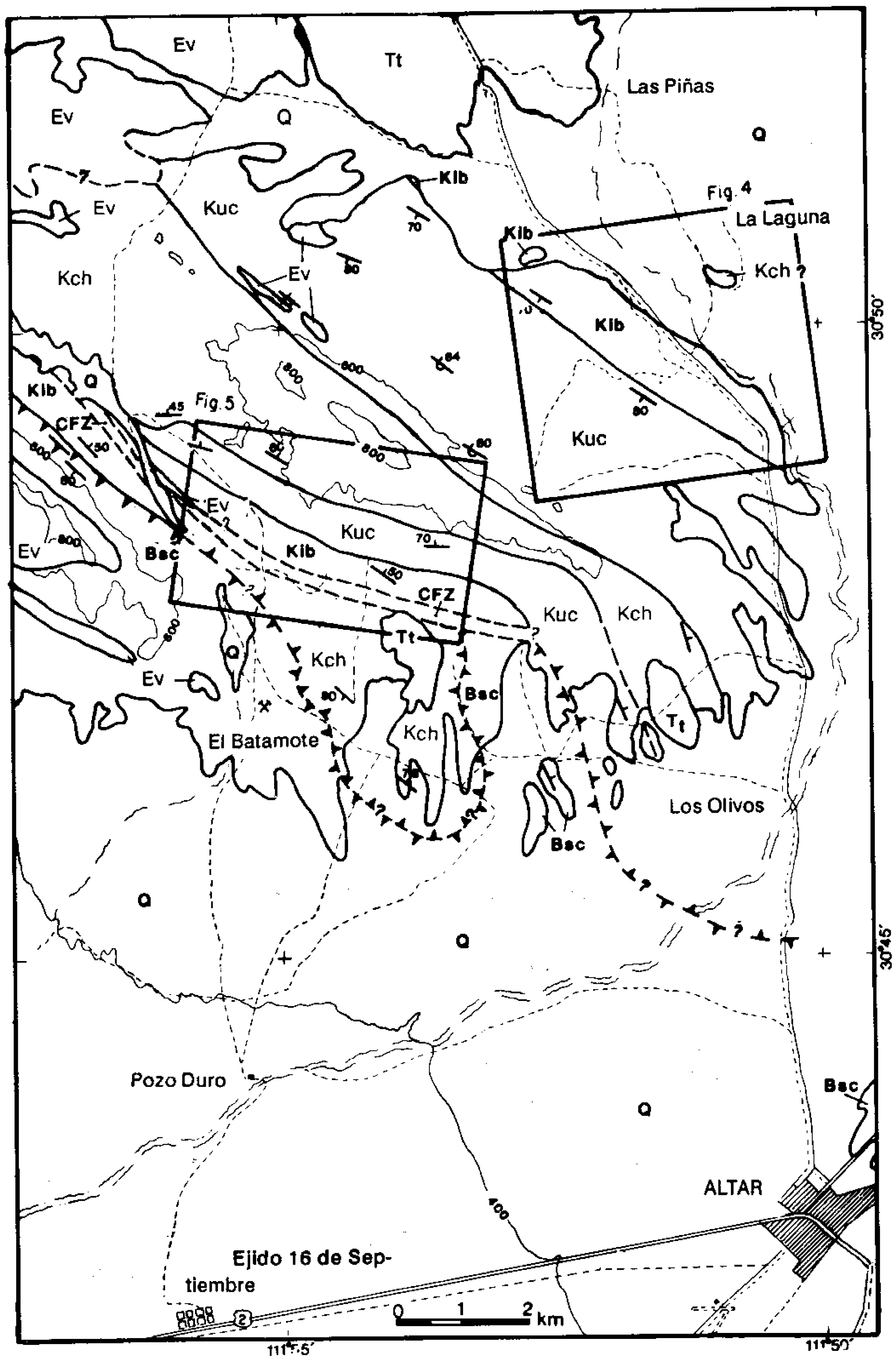

Figure 2.- Simplified geologic map of the Sierra El Chanate. Symbols for stratigraphic units are: Q—Quaternary; Tt—Tertiary terrace deposits; Ev—Eocene andesitic extrusive rocks; Kch—Upper Cretaceous El Charro volcanic complex; Kuc—Albian to Upper Cretaceous El Chanate Group; Kib—Lower Cretaceous Bisbee Group; Bsc—Mesozoic El Batamote structural complex; CFZ—El Chanate fault zone; line with black triangles—low angle fault (dashed where inferred) (modified after Jacques-Ayala, 1989; and Jacques-Ayala *et al.*, 1990).

STRATIGRAPHY

GLANCE CONGLOMERATE (FORMAL NAME)

The name Glance Conglomerate is assigned to the steeply dipping sequence of green to mottled green to buff conglomerate and coarse sandstone exposed north of the sierra El Chanate. It underlies the Morita Formation. The description of this section is included in Section I of the Morita Formation.

Distribution

The described outcrop is in the Arroyo Sásabe, off the road that goes to the La Laguna Ranch (Figure 4), where it is exposed only in its uppermost 21 m. Recently, a more extensive exposure was identified farther northwest, along the road that goes to rancho Los Chirriones (Figure 2). Its thickness was not determined, but it consists of brown, coarse to medium sandstone and brown to mottled conglomerate. On the southern side of the sierra,

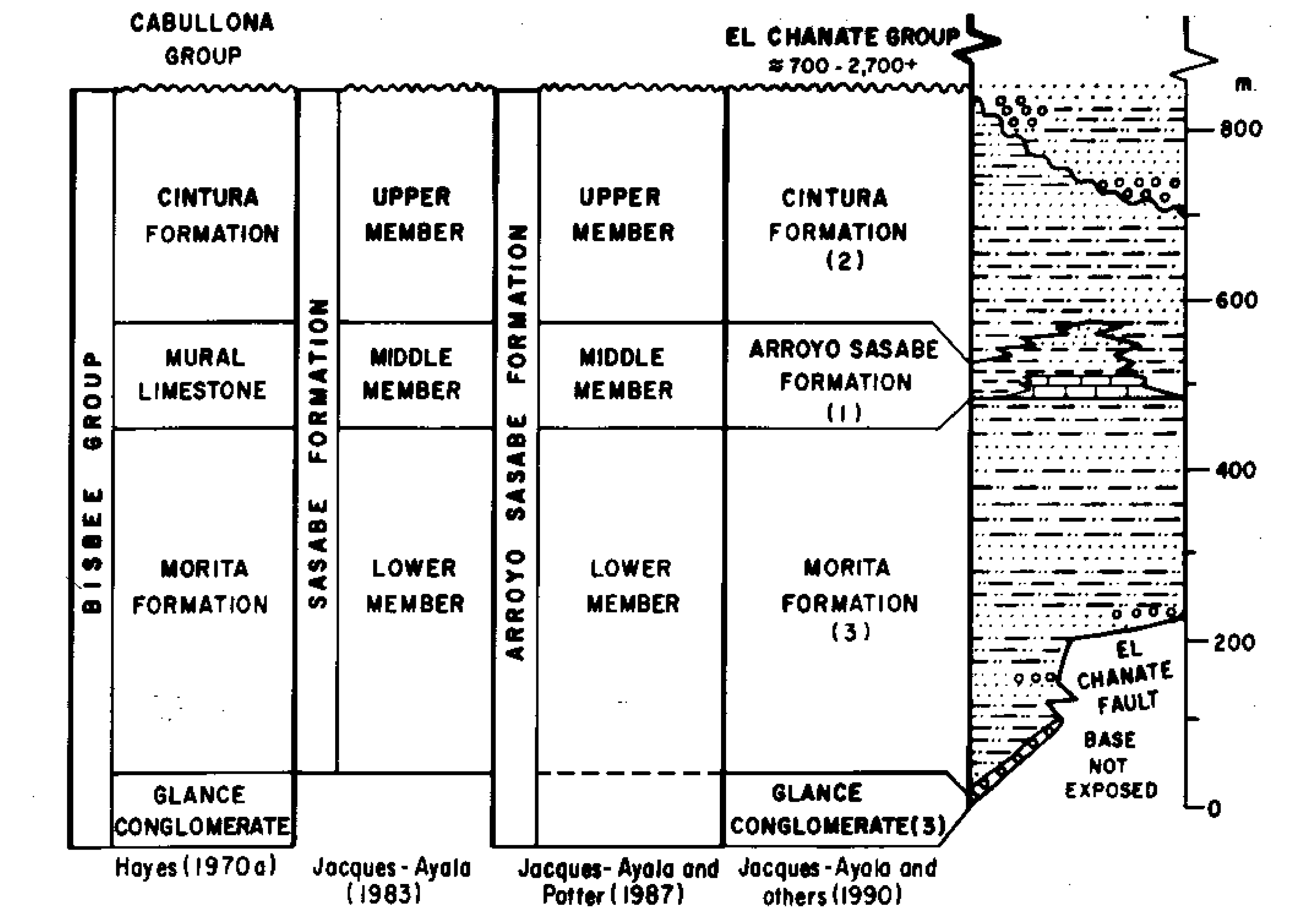

Figure 3.- Stratigraphic column of the Bisbee Group in the sierra El Chanate, northwestern Sonora, with previously used nomenclature and lithologic correlation with the Bisbee Group from southern Arizona. (1) Jacques-Ayala, 1991; (2) Jacques-Ayala, in press; (3) this paper.

brown conglomerates associated with steeply dipping andesitic breccia could belong to the Glance. The stratigraphic relationship between these conglomerates and the Bisbee Group has not been determined.

Also on the southern side, a buff shale with thin gray limestone beds could underlie the Morita Formation. The El Chanate fault zone separates this buff shale from the Morita, causing their relationship to remain unclear.

Stratigraphic relationships

The base of the Glance is not exposed. In the northwestern part of the area, strongly altered andesitic breccias may underlie the Glance. Comparable volcanic breccia crops out on the road to La Laguna Ranch. It is exposed in the lower parts of the hills

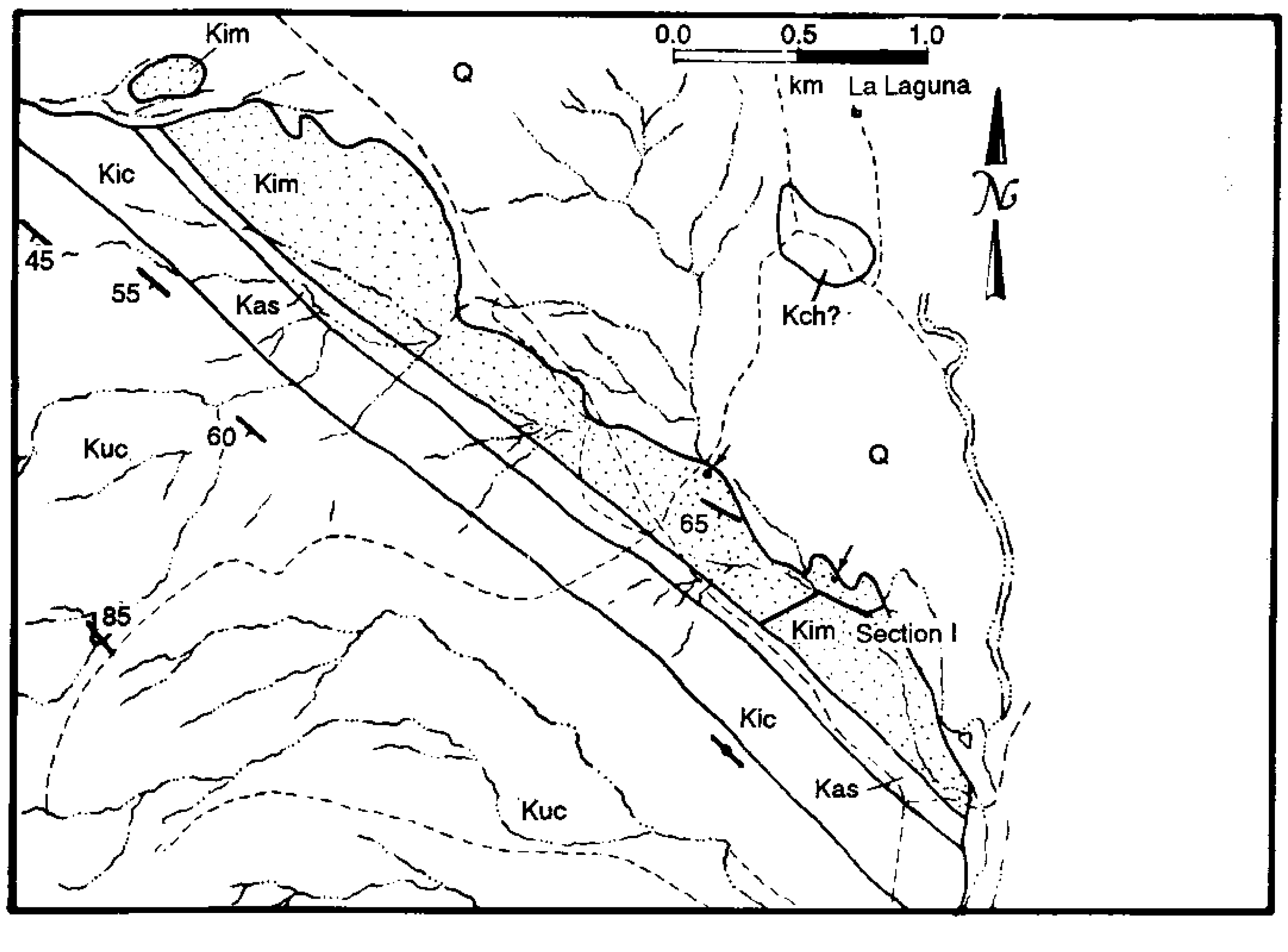

Figure 4.- Detailed geologic map of the northeastern corner of the Sierra El Chanate area showing the location of section I. Map drawn from a 1:20,000 scale aerial photograph. Symbols same as in Figure 2, except for: Kim (stippled)—Morita Formation; Kas—Arroyo Sásabe Formation; Kic—Cintura Formation. Arrow indicates where the Glance Conglomerate crops out (modified after Jacques-Ayala, 1989).

underlain by the Glance and Tertiary terrace deposits, suggesting a stratigraphic relationship with the Glance. Because similar andesitic breccias have been observed as part of the Anita Formation, of the Cretaceous El Chanate Group (Jacques-Ayala *et al.*, 1990), in the Cretaceous El Charro volcanic complex (Jacques-Ayala and Potter, 1987), and in Eocene volcanic rocks exposed a few kilometers to the west (Figure 2), no tentative age assignment can be made at present. The upper Glance Conglomerate is transitional into the Morita Formation.

Age and correlation

The age of the Glance Conglomerate is poorly constrained. In southern Arizona, interbedded volcanic rocks in the lower part of the unit have been dated as Late Jurassic (Marvin *et al.*, 1978; Kluth *et al.*, 1982). The age of the upper part of the section is unconstrained. It is older than the Morita and the Mural Limestone, of late Aptian-Albian age (Scott, 1987; Warzeski, 1987). Therefore, the Glance can be as young as Aptian, and as old as Late Jurassic.

The Glance Conglomerate has been reported in several areas in southeastern Arizona and northeastern Sonora (Drewes, 1971; Hayes, 1970a; Bilodeau, 1978; Bilodeau and Lindberg, 1983; Bilodeau *et al.*, 1987). It also has been reported in northeast and north-central Sonora (Taliaferro, 1933; Rangin, 1982; Nourse, 1989), and as far southeast as Arivechi, where it has been named Zoropuchi Conglomerate (Pubellier, 1987, p. 64). Age equivalent units have been described in Cerro de Oro (González-León and Jacques-Ayala, 1989), Tuape (Rodríguez-Castañeda, 1988) and northeast of Huépac (Bojórquez-Ochoa and Rosas-Haro, 1988). In these three localities the sequences correspond to marine shale and limestone, locally interbedded with volcanic rocks (NE of Huépac). Closer to the study area, Willard (1988) described the Chupurate formation as underlying the Bisbee Group (formerly Arroyo Sásabe Formation), which consists of brown, coarse grain sandstone and conglomerate. Similar rocks are probably present within the Rajón Group or the Chino Group, south of Pitiquito (Longoria and Pérez, 1979).

MORITA FORMATION (FORMAL NAME)

The name Morita Formation is assigned to the steeply dipping, NW-SE striking sequence of red to purplish-red mudstone and shale, minor fine to medium sandstone, lenses of conglomerate made of igneous rock pebbles, and rare limestone beds made mainly of coarse molluscan debris. It is exposed on both the northern and southern flanks of the sierra El Chanate. Five stratigraphic sections were measured and described; of these, three are considered as representative, and are presented here. Two of the three representative sections are faulted in their lower parts by the El Chanate fault.

Distribution

The Morita Formation exposed on the northern side of the sierra El Chanate is 486 m thick and represents the most complete section measured in this study (Figure 4). On aerial photographs and satellite images it is easily distinguished from the Arroyo Sásabe Formation (Jacques-Ayala, 1989) on the basis of their gray tones. The upper half of the formation is poorly exposed because it forms low topography. The lowermost part has excellent exposures along the Arroyo Sásabe. The lower contact of the Morita is not present in the measured section, but can be observed just off the road that goes to rancho La Laguna, where it crosses the Arroyo Sásabe (Figure 4). On the southern flank of the sierra

(Figure 5), the Morita forms rolling hills. On aerial photographs it is not clearly observable because its gray tone is similar to other lithologic units. The two sections measured here are 193 and 225 m thick. In this area, the Morita is very well exposed, especially along the arroyos. The lower part of the unit is cut by the El Chanate fault, where it is strongly fractured (Jacques-Ayala, 1983; Jacques-Ayala *et al.*, 1990). This part of the section was not described, and may be incomplete due to faulting. As the El Chanate fault zone cuts the sequence almost parallel to the strike, the base was not observed.

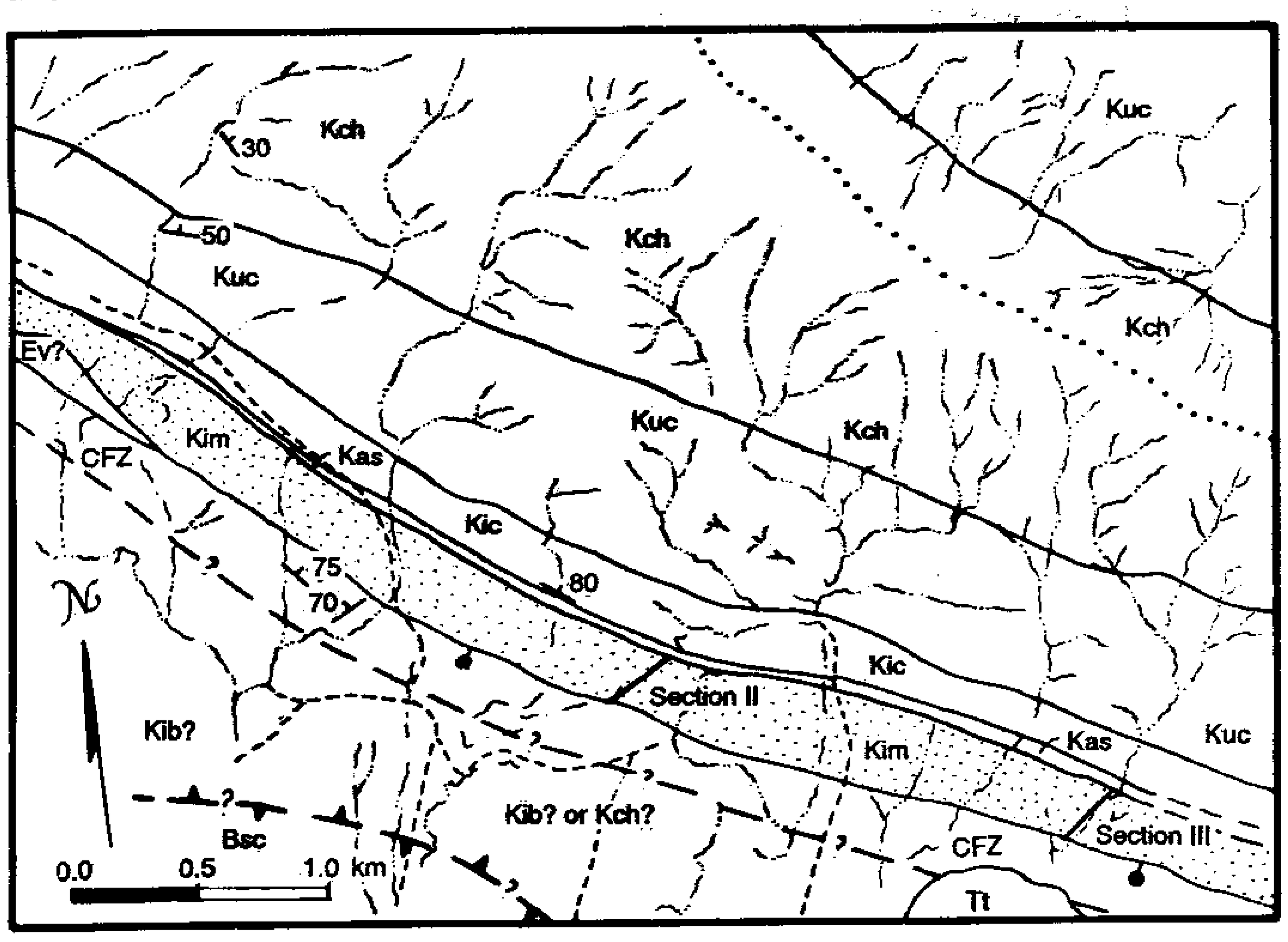

Figure 5.- Detailed geologic map of the south-central part of the Sierra El Chanate area showing the location of sections II and III. Map drawn from a 1:20,000 scale aerial photograph. See Figures 2 and 3 for symbols; dotted line—crest of the sierra (modified after Jacques-Ayala, 1989).

Description of sections

Section I. This section was measured on the northern side of the sierra El Chanate (Figure 4). This part of the area is characterized by a nearly flat topography interrupted by a few hills elongated along strike formed by the basal conglomerate of Pozo Duro Formation of the El Chanate Group (Jacques-Ayala *et al.*, 1990). The Morita locally occupies low areas, cropping out as regolith. The section was measured beginning about 700 m southeast of the road-crossing to the rancho La Laguna and ending in the wide bend of the Arroyo Sásabe. Mercator coordinates for the upper and lower ends are, respectively: X = 418,750; Y = 3'410,375, and X = 419,370; Y = 3'410,500 (DEGETENAL, 1980). As this section is exposed entirely, it is defined as a reference section (Figure 6).

SECTION I

Unit	Lithology	Thickness (m) Unit	Cumul.
1.-	Shale, red to purplish and ocher, fissile to flaggy and homogeneous. Intercalations of purplish-red sandstone layers less than 50 cm thick as well as fossiliferous limestone lenses less than 30 cm thick. Near the top occur several 1 m thick beds of fragmented mollusc and gastropod rudestone, with *Serpulidae* tubes. Covered contact with...		52
2.-	Sandstone, purplish gray, thin to medium bedded with plane parallel stratification, medium to coarse grained. Interbedded with red mudstone, shale and very fine-grained sandstone. Poorly exposed, specially the fine-grain portions. Sharp, irregular contact with...	17	69
3.-	Shale, red to purplish red, fissile to flaggy. Contains few intercalations of gray, medium to coarse grained, as well as red fine-grained sandstone. Also present are few lenses of mollusc-fragment rudestone. Poorly and irregularly exposed as pediment...	220	289
4.-	Sandstone, gray, massive, medium to fine grained; wedges eastward into a red mudstone. From this unit down section, fracturing and faulting are present and locally intense. Faults chiefly parallel bedding. Regular, sharp contact with...	3	292
5.-	Mudstone, red to purplish and ocher red, massive to laminated with local bioturbation structures. Contains interbeds of red, fissile shale; red to gray, fine to medium grained, thin to medium bedded sandstone. Locally, the shale grades upward into mudstone, and sandstone, forming coarsening upward cycles. Sharp contact with...	60	352
6.-	Sandstone, gray, medium to thin bedded with plane-parallel and cross lamination. At the base there is a mudstone and shale rip-up clast conglomerate. Few thin intercalations of red mudstone. The thickness of the sandstone is increased by a small fault striking almost parallel to bedding. Sharp, irregular contact with...	2	354
7.-	Mudstone, red, massive, and structureless. Transitional contact with...	6	360
8.-	Sandstone, gray, medium grained, and massive. In sharp regular contact, locally along a fault surface, with...	2	362
9.-	Shale, purplish red to purple, fissile, homogeneous, with intercalations of red, blocky, slightly sandy mudstone and red, very fine-grained sandstone. Transitional contact with...	18	380
10.-	Sandstone, light green, medium grained, massive. Covered contact with...	1	381
11.-	Mudstone and shale, red to purplish red, and fissile. Strongly fractured. Transitional contact with...	9	390
12.-	Sandstone, grayish green, very fine grained, massive, grades down to a gray to greenish-gray sandstone, fine to medium grained, medium bedded with planar and cross stratification and lamination. At the base it has a thin rip-up clast conglomerate. Forms a fining upward cycle with unit 11. Sharp irregular contact with...	10	4C
13.-	Mudstone, purplish red to purple, massive, locally with plane-parallel lamination and bioturbation. Contains abundant calcareous nodules, mainly 3 to 10 cm in diameter, the larger ones being at the top. Transitional contact with...	10	41
14.-	Sandstone, gray, medium to thin bedded with plane-parallel and cross stratification, medium to coarse grained with some mudchip-conglomerate lenses. Sharp, regular contact with...	3	41:
15.-	Mudstone, red to purplish red, medium bedded, with intercalations of red to purplish red, medium bedded sandstone. Few intercalations of red shale. The top of the unit displays a 0.5 m displacement by a fault. Transitional contact with...	12	425
16.-	Sandstone, gray to purplish gray, in medium to thin beds with plane parallel- and faint cross stratification, coarse to medium grain, with intercalations of mud-chip conglomerate lenses. Sharp, regular contact with...	2	427
17.-	Mudstone, red to purplish red, and massive, with calcareous nodules. Transitional contact with...	4	431
18.-	Sandstone, gray, medium to thick bedded with plane-parallel and cross stratification. Thin intercalations of red mudstone and mud-chip conglomerate. Sharp, irregular contact with...	5	436
19.-	Mudstone, purple to purplish red, medium bedded, which alternates with medium to fine grained sandstone, in medium beds with plane-parallel,		

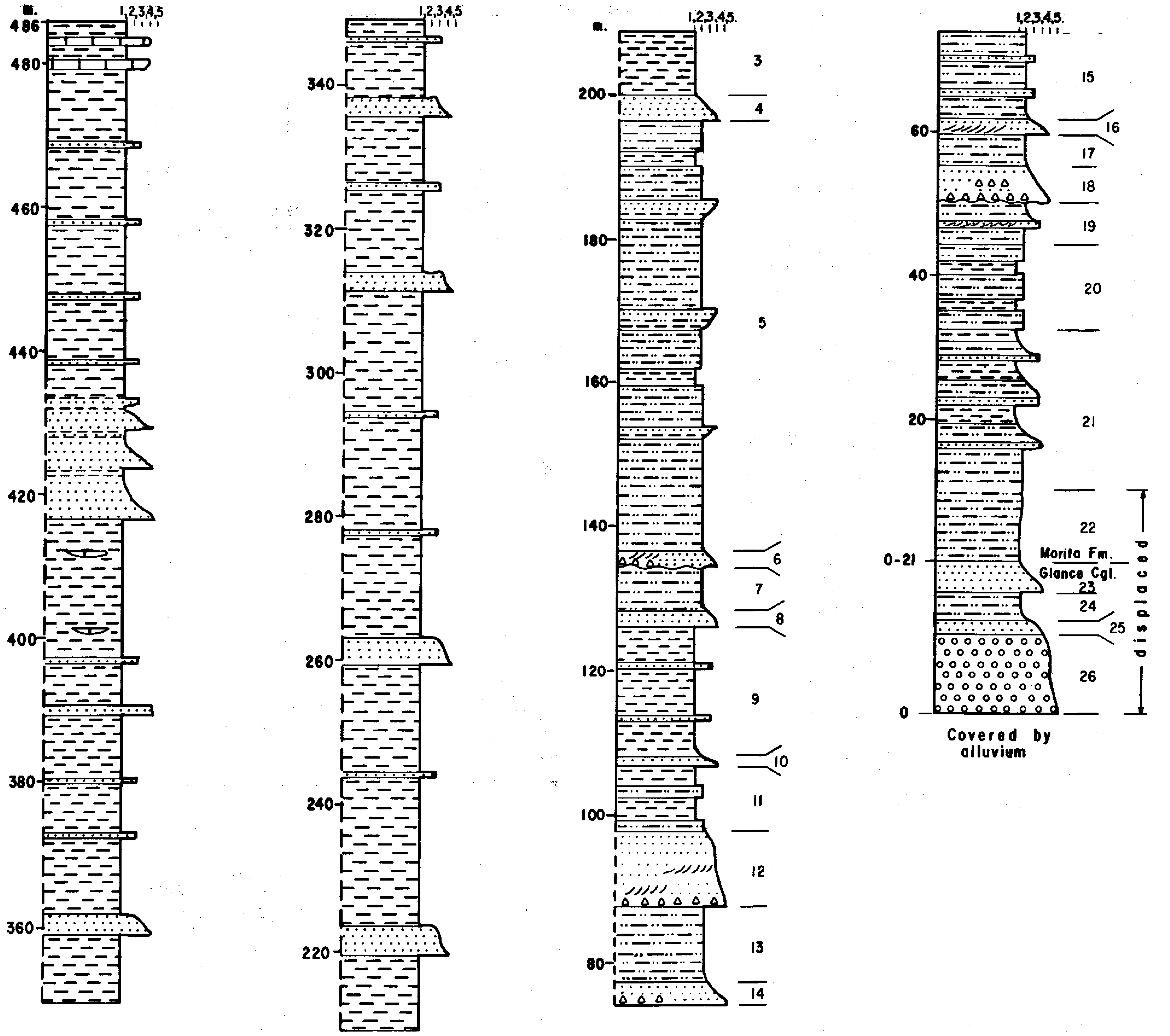

Figure 6.- Stratigraphic column of section I, location shown in Figure 4. Numbers to the right correspond to units described in text. Numbers on the top right indicate grain size: (1) clay; (2) silt; (3) fine sand; (4) medium sand; (5) coarse sand; (6) pebbles; (7) cobbles. Dashed line on left side of column indicates poor exposure.

planar and trough cross stratification and lamination. Sharp, regular contact with... 6 442

20.- Mudstone, purple to purplish red, medium bedded, alternates with shale, red, medium to thick bedded, and foliated. Contains elongated calcareous nodules... 12 454

21.- Mudstone, red, medium bedded, intercalated with gray, medium tothin-bedded sandstone, and red, medium to thick-bedded, foliated shale. The sandstone is medium grained, and has graded bedding... 22 476

(section displaced north-westward along strike to the place where the road to rancho La Laguna crosses the Sásabe gully; λ = 418,550; Y = 3'410,950).

22.- Mudstone, red, massive, foliated, and poorly exposed. Transitional contact with... 10 486

GLANCE CONGLOMERATE

23.- Sandstone, green, medium bedded with cross-bedding, medium to coarse grained. Sharp contact with... 4 4

24.- Mudstone, red, massive, foliated, poorly exposed. Sharp contact with... 4 8

25.- Sandstone, same as unit 23. Transitional contact with... 2 10

26.- Conglomerate, green to mottled green, thick to massively bedded, clast supported, formed mainly by green, red and black chert, with minor quartz sandstone and metamorphic pebbles and few cobbles (Figure 7)... 11 21

End of measured section. Covered by alluvium.

Section II. This section (Figure 8A) was described in the central part of the southern flank of the sierra El Chanate (Figure 5). It was measured along a gully located about 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 El Batamote mine and northwest (Figure 2). Mercator coordinates for the ending point of the section are X = 413,050; Y = 3'407,750.

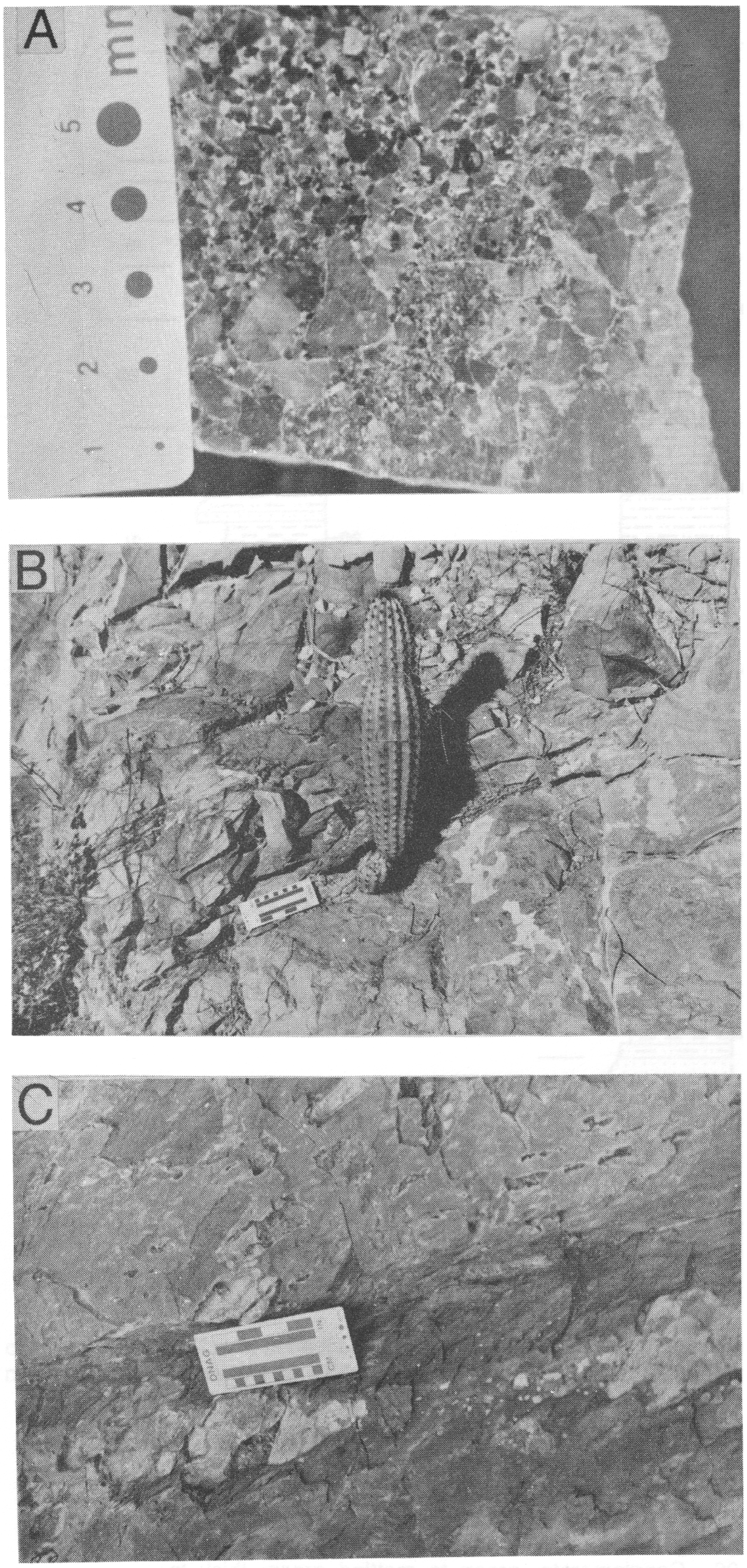

Figure 7.- (A) Polished surface of the Glance Conglomerate, formed mainly by chert pebbles. (B) Exposure of thick, massively bedded mudstone of the Morita Formation. (C) Morita as medium bedded mudstone with thin intercalations of shale. Rock is foliated, and calcareous nodules (in light gray) are slightly stretched in the same direction.

SECTION II

Unit	Lithology	Thickness (m) Unit	Cumul.
1.-	Mudstone, purplish red, homogeneous, in thick beds, has bioturbation and calcareous nodules, some of which have been dissolved (Figure 7B). Transitional contact with...	3	3
2.-	Sandstone, gray, thick bedded with plane-parallel and planar cross lamination. In sharp irregular contact with...	2	5
3.-	Mudstone to shale, purple, thick bedded. Contains calcareous nodules which can be disseminated or concentrated along bedding planes. Transitional contact with...	43	48
4.-	Sandstone, gray, thick bedded, medium grained. Covered contact with...	3	51
5.-	Mudstone, purple, thick bedded, homogeneous, with intercalations of purple, fissile, homogeneous shale. The unit is cut by several small faults, and intruded by a green, 1 m-thick dike of andesitic composition. Transitional contact with...	30	81
6.-	Sandstone, purplish gray, medium bedded, and medium grained. Covered contact with...	2	83
7.-	Mudstone, purple, with bioturbation structures, and calcareous nodules. Transitional contact with...	19	102
8.-	Sandstone, gray, medium bedded with plane-parallel thin stratification to lamination, and medium grained. Transitional contact with...	3	105
9.-	Conglomerate, mottled, medium bedded, contains purple rip-up clasts from the unit below. Sharp, erosional contact with...	2	107
10.-	Shale, purple, fissile to slightly foliated, homogeneous, alternating with purple, thick-bedded mudstone. Toward the top, thin sandstone beds become more conspicuous. Disseminated calcareous nodules occur in the unit (Figure 7C). A fault zone cuts the upper half, but appears to have only minor displacement. Transitional contact with...	45	152
11.-	Mudstone, purple, massive, homogeneous, with few thin beds of very fine sandstone, and toward the top, a few thin beds of slightly foliated shale. Contains small calcareous nodules disseminated or forming lenses which weather into dark ocher...	41	193

End of section. Toward the bottom of the unit, faulting and fracturing become more abundant, and several cream-colored, rhyolitic intrusions are present. Stratigraphically (?) beneath the Morita Formation is a brown, foliated shale with thin beds of limestone containing no visible fauna.

Section III. This section was measured along a gully on the southern rim of the sierra El Chanate (Figure 5). The end point of the section (Mercator coordinates: X = 414,650; Y = 3'407,500) can be reached by the road that goes southwestward from the El Batamote mine, and a hard-to-follow road that goes to the north (Mercator coordinates: X = 414,650; Y = 3'404,650). Section III is depicted in Figure 8B.

SECTION III

Unit	Lithology	Thickness (m) Unit	Cumul.
1.-	Shale, purple, fissile, poorly exposed. Grades into...	10	10
2.-	Sandstone, purple, thin bedded, fine grained, with few intercalations of shale. Toward the top, the sandstone has a mottled appearance, probably because of bioturbation. Transitional contact with...	10	20
3.-	Sandstone, gray, weathers blackish green, and medium grained, thick bedded, but has a few thin beds. Sharp contact with...	6	26
4.-	Mudstone, purple, thin bedded to laminated, with intercalations of purple, fissile shale. A 1.5 m thick, rip-up clast conglomerate occurs 18 m above the base. Clasts are of purple mudstone. Covered contact with...	29	55
5.-	Mudstone to fine-grained sandstone, purple, medium bedded, about 2 m thick. Grades downward to a		

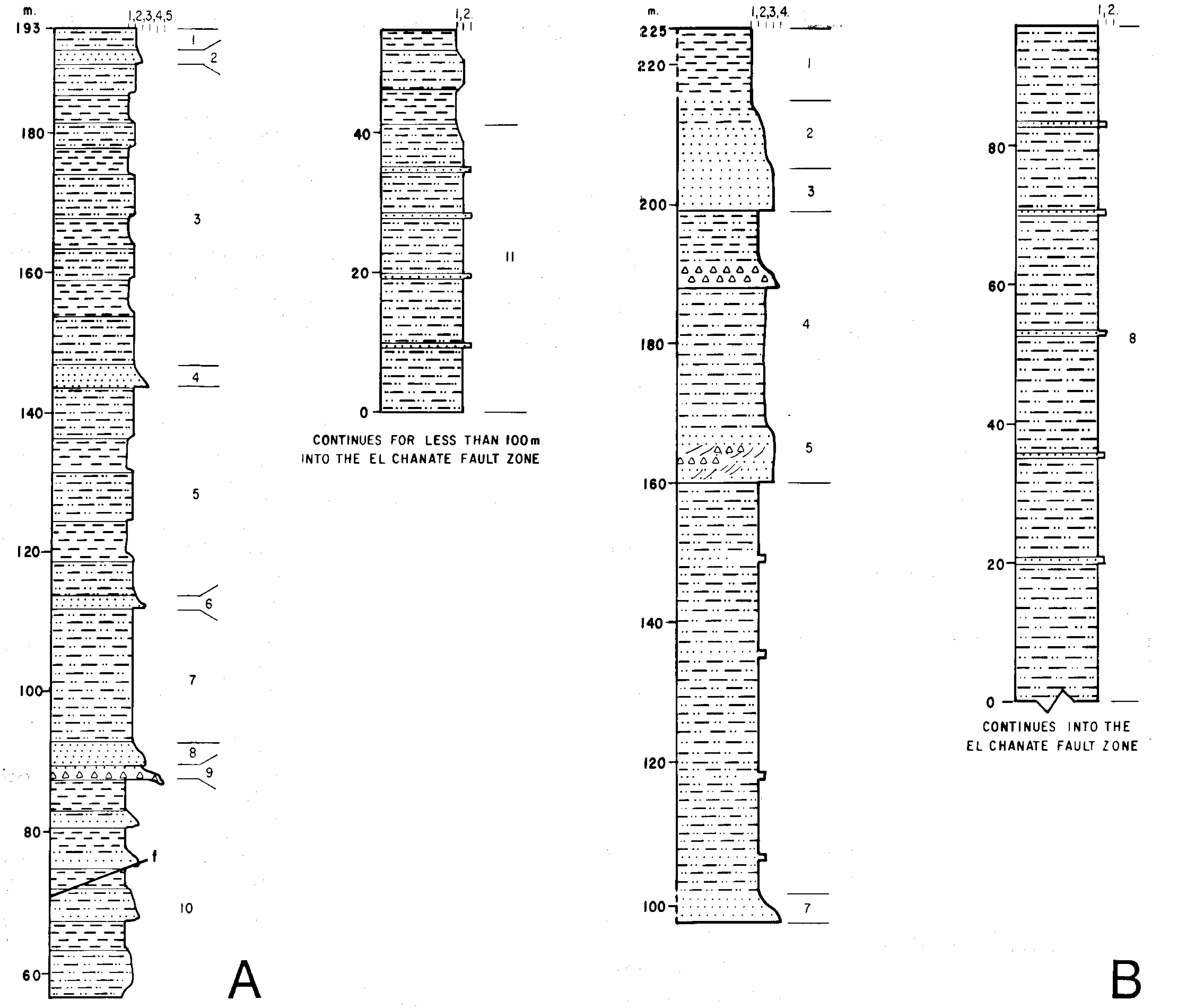

Figure 8.- (A) Measured stratigraphic column of section II; and (B) measured stratigraphic column of section III. For their location see Figure 5. Notes same as in Figure 6.

gray, thick bedded, medium-grained sandstone. Locally there are disseminated mudstone rip-up clasts several centimeters in diameter. Beds display thin plane-parallel and cross stratification. Thin interbeds of mud-chip conglomerate. Sharp contact with...	10	65
6.- Mudstone, purple, locally fissile, medium to thick bedded and massive, containing disseminated calcareous nodules, some several centimeters in diameter. Local zones display irregular, lighter colors, apparently caused by bioturbation. There are thin intercalations of fine-grained sandstone and siltstone. Transitional contact with...	59	124
7.- Sandstone, gray, thick bedded, medium to coarse grain. Poorly exposed. Sharp contact with...	4	128
8.- Mudstone, same as unit 6...	97	225

The unit continues for a distance, but it is strongly fractured and faulted, and poorly exposed. A thick alluvium cover continues southward.

Stratigraphic relationships

In the northern outcrop belt, the base of the Morita Formation is transitional with the Glance Conglomerate. On the southern flank of the sierra, the base of the Morita is cut by the El Chanate fault zone, placing it against the El Batamote structural complex. This complex includes folded to locally foliated and metamorphosed, clastic, volcaniclastic and igneous rocks of Jurassic(?) (Willard, 1988; Harrar, 1989) and Cretaceous age (Jacques-Ayala, 1981). On this same flank, within and south of the fault zone, is a buff shale with thin non-fossiliferous limestone beds. A similar rock unit was described in the same stratigraphic position beneath the Morita as the Cerro de Oro Formation (González-León and Jacques-Ayala, 1988). Along the Arroyo el Charro, in the northwestern part of the area, the base of the Morita appears to rest on gray, strongly fractured and weathered, andesitic rock. This fracturing and weathering could have been caused by the proximity to the El Chanate fault. Another possibility is that weathering was the result of exposure and erosion prior to the deposition of the Morita. The upper contact is transitional to sharp with the Arroyo Sásabe Formation (Jacques-Ayala, 1989). Locally, the base of the Arroyo Sásabe is a limestone, but where it is not present, the contact is placed where the sandstone or shale are green. Where the Arroyo Sásabe is missing, it is difficult to separate the Morita from the Cintura Formation.

Age and correlation

No fossils have been collected from the Morita Formation in the sierra El Chanate area. The Arroyo Sásabe, overlying it, is assigned to the late Aptian-Albian (Jacques-Ayala and Potter, 1987, p. 206; Jacques-Ayala *et al.*, 1991), and the Cerro de Oro Formation in the Cerro de Oro area (González-León and Jacques-Ayala, 1988) is Barremian-Aptian. If the buff shale apparently underlying the Morita, in the southeastern part of the sierra El Chanate, is equivalent to the Cerro de Oro unit, then an Aptian age can be assigned to the Morita.

Rocks similar to the Morita Formation have been reported from nearby areas. Willard (1988) described a sequence of red mudstone and sandstone in the Puerto El Alamo, 10 km west of the El Chanate, overlying the El Chupurate formation, a coarse clastic sequence which could be equivalent to the Glance Conglomerate. Above the Morita is the "green shale member", correlative to the Arroyo Sásabe. This sequence is at present the westernmost exposure of Bisbee-like rocks that have been described. Harrar (1989) reported the continuation of these units eastward into the sierra El Batamote. Jacques-Ayala and coworkers (1990) reported the presence of the Bisbee Group in the northwestern part of the cerros El Amol, 5 km east of Oquitoa. Navarro-Fuentes and Téllez-Duarte (1988) described the Morita Formation in the Santa Ana area, which was reported but not identified as such by Flores (1929) and Salas (1968). The author has also recognized rocks similar to this unit in the cerros El Puerto and cerros Cabeza Colgada.

Regional correlation can be made with the Morita from the Cerro de Oro area (González-León and Jacques-Ayala, 1988); with the Tuape unit from the Tuape-Cucurpe area (formerly unit *c* of Rodríguez-Castañeda, 1988), and with the well known areas in northeast Sonora and southeast Arizona (Ransome, 1904; Taliaferro, 1933; Drewes, 1971; Hayes, 1970a; Rangin, 1982; Archibald, 1987). In central and east-central Sonora, time equivalent units have been described in Lampazos (González-León, 1988; Scott and González-León, 1991), where it consists mainly of marine limestone and shale; and, south of Nácori Chico, where it consists of dark gray to black shale (Araujo-Mendieta and Estavillo-González, 1987).

Toward the northwest, correlativeness can probably be demonstrated with the "Mesozoic red beds" described by Robison (1980), and included within the McCoy Mountains Formation by Harding and Coney (1985). Jacques-Ayala and coworkers (1986) suggested that the McCoy could be correlated with the sequence of the sierra El Chanate, included by them within the El Chanate group.

DISCUSSION

The Glance Conglomerate and the Morita Formation have been described widely in southeastern Arizona and, in some localities, in northeastern Sonora. As very few reports have been published on the stratigraphy of the Bisbee Group from central, northwestern and southern Sonora, the interpretation of the geometry of the Early Cretaceous Bisbee basin has been incomplete. This basin has been considered as a narrow one (Hayes, 1970b; Bilodeau and Lindberg, 1983; Dickinson *et al.*, 1986; Klute, 1987; Kitz and Anderson, 1988), restricted to southeastern Arizona and northeasternmost Sonora (*cf.* Klute, 1987, fig. 2). Therefore, it is of great importance to have new data on stratigraphic sections of Early Cretaceous rocks to better understand the geometry of the Bisbee basin (González-León and Jacques-Ayala, in press). Paleogeographically, the Glance Conglomerate was deposited in a fluvial system, whereas the Morita Formation was deposited in a tidal flat to alluvial plain environment with some fluvial and some marine influence. The Morita represents the margin of the basin, that is, the marine/terrestrial transition. As proposed by González-León and Jacques-Ayala (in press), the margin of the basin can be extended into Sonora from west of Nogales (Riggs, 1987) to the Caborca area, and southeast, probably between Hermosillo and Ures. This new interpreted margin greatly modifies earlier reconstructions.

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