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A MODEL OF THE EVOLUTION OF MIDDLE AMERICA AND THE GULF OF MEXICO-CARIBBEAN SEA REGION DURING MESOZOIC TIME

(Note: For G.S.A. Data Bank)

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Within this region, a third generation of plutons, recognized as distinct by Silver (1968), intrudes the older orogenic assemblages. These intrusives, which fall within the interval 1400 to 1500 m.y., lack a consanguineous stratified sequence as well as geographic restrictions comparable to the older terranes. They intrude the older basement from New Mexico to California (Silver, 1968; 1971). In the central United States rocks of this generation are associated with volcanics and may form a distinctive province (Bickford and Mose, 1975; Silver and others 1977).

3) The Van Horn mobile belt and other crystalline basement rocks whose ages fall within the interval 950 to 1200 m.y. (King and Flawn, 1953; Wasserburg and others, 1962; Denison and others, 1969; Grenvillian belt of King, 1975). In west Texas, near Van Horn, and in the Carrizo Mountains, granitic rocks, gneiss, schist and metavolcanics comprise this terrane (King and Flawn, 1953). These crystalline rocks are locally overlain by a distinctive assemblage of sedimentary rocks and rare volcanic units, which are markedly less metamorphosed than underlying rocks and whose ages may range from late Precambrian through early Paleozoic (Fig. 8).

4) The Ouachita orogenic belt (Flawn and others, 1961). This belt provides a key linear element along which correlations can be made. Interruptions in the continuity of the belt suggest offsets which we believe are caused by major faults. For this reason the character of the Ouachita belt is described in somewhat greater detail.

Flawn and others (1961) applied the name Ouachita system to the belt of deformed Paleozoic rocks which fringes the southern margin of the

Central Stable Region of North America in the same way that the Appalachian System fringes the eastern margin.

A two-fold tectonic subdivision of rocks of the belt was suggested: 1) essentially unmetamorphosed sedimentary rocks which are folded and faulted but not penetratively deformed and 2) metamorphosed and penetratively deformed sedimentary and much less abundant igenous rocks. The former group lies adjacent to the foreland and defines a belt called the frontal zone. South and east of the frontal zone, rocks of the second group define the interior zone.

King (in Flawn and others, 1961) subdivided the geologic history of the Ouachita system into the following phases (based primarily on the history recorded by rocks within the frontal zone):

1) Early geosynclinal phase (Cambrian to Devonian). Rocks characteristic of this phase form a distinctive suite comprised of chert and novaculite interbedded with shale and slate, quartzose sandstone, graywacke, and argillaceous limestone.
2) Late geosynclinal phase (Mississippian and Early Pennsylvanian). This phase is distinguished by great abundance of clastic rocks disconformably overlying the youngest siliceous beds. The clastic deposits include boulder conglomerate to shale with rare limestone.
3) Orogenic phase (mainly Pennsylvanian, but migrating with time to the south and west). Clastic rocks which may have accumulated in shallow or deep-water environments and which may include some nonmarine deposits comprise the rocks of this phase.
4) Post-orogenic phase (Permian and later) marine or non-marine clastic rocks, includes carbonate units and reefs where marine conditions persisted.

Outcrops of rocks and structures which characterize the frontal zone occur in the Ouachita Mountains, Marathon region (Fig. 8) and Solitario uplift. Southwest of Solitario uplift in the state of Chihuahua, in northern Mexico, Flawn (Flawn and others, 1961) suggested that rocks which crop out in the Placer de Guadalupe area and in the Sierra del Cuervo area southwest of Solitario uplift in the state of Chihuahua, in northern Mexico lie just within the frontal zone near its border with the foreland (Figs. 1, 8). Bridges (1964a, 1964b), who mapped this area demurred with respect to the Placer de Guadalupe area for the following reasons (1964b, p. 93):

> " . . . it might be more accurate to place the Mina Plomosas-Placer de Guadalupe area in Foreland. The main reasons for doing this are: (1) There is no thick geosynclinal or flysch facies. The total thickness of the entire Paleozoic section does not greatly exceed 2,000 meters and much of this is platform limestone. (2) Paleozoic tectonism was mild."
>
> "Previously, the writer has informally suggested that the Mina Plomosas-Placer de Guadalupe area lay between the platform and geosyncline. At present he still believes that the frontal zone of the Ouachita structural belt lies not far to the south of Mina Plomosas. Thus the suggested change is not a major consequence."

The "flysch-like sediments" of Late Pennsylvanian (?) and Wolfcampian age, which crop out in Sierra del Cuervo, are more than 1,000 m thick and appear to belong inside the frontal zone (Flawn and others, 1961).

Rocks of the Ouachita system cannot be traced west from this area. In Sierra Magistral, which lies 60 kilometers southwest of Chihuahua City, Bridges (1964 b, p. 93), noted the occurrence of "more than 500 meters of Cretaceous or Permian (?) pre-Glen Rose sandstone." He concluded that (1964 b, p. 93-94) "Precambrian metasedimentary rocks were probably exposed to the west of Sierra Magistral in parts of Paleozoic and perhaps Mesozoic time. Therefore, a Ouachita geosynclinal facies is precluded west of Sierra Magistral and the Ouachita structural belt must turn abruptly south."

The interior zone of the Ouachita belt is less well known than the frontal zone because rocks which characterize this zone rarely crop out. Well cores provide the vast majority of data pertaining to these rocks. The interior zone has been identified in the subsurface south of the Llano uplift (Flawn and others, 1961, Plate 2). In this area, two lithologies may be discerned: 1) abundant fine-grained schist-phyllite-slate-metaquartzite-marble and 2) less common black graphitic slate. The zone continues west as far as the Rio Grande where it swings northwest and trends roughly parallel to the present river course. Just south of the Rio Grande in Coahuila, Mexico, rocks which crop out in Sierra del Carmen have been interpreted as being part of the interior zone (Fig. 1), (Flawn and Diaz G., 1959). These outcrops consist of interlayered very fine-grained sericite-muscovite-chlorite schist and phyllite, very fine-grained metaquartzite, and calcite marble.

Subsurface data for northern Mexico are sparce. In the states of Coahuila and Nuevo Leon published data for several wells are available (Fig. 1) (Flawn and Diaz G., 1959). Highly sheared slate and metagraywacke were encountered in No. 2-A Peyotes. No. 1 Barril Viejo bottomed in granodiorite.

Outcrops of pre-Cretaceous intrusive rocks are also rare, but available stratigraphic and radiometric data suggest that at three localities, plutons which probably represent the terminal events of orogenesis within the interior zone are preserved. Granodiorite at Potrero de la Mula, which is overlain by Cretaceous beds according to Kellum and others (1936), yielded a K/Ar hornblende date of 206 $\pm$ 4 (Denison and others, 1969). Similarly on the flanks of the range between Acatita and Las Delicias, two distinct granitic masses were described as post-Permian by Kelly (1936) and King and others (1944) on the basis of intrusive relationships with the Permian section and unconformable relations with overlying Cretaceous beds. One of these rocks, a granodiorite, similar to the one at Potrero de la Mula, yielded a K/Ar biotite date of 203 $\pm$ 4 (Denison and others, 1969).

Indirect evidence of crystalline rocks within the interior zone is provided by thick sections of arkose of Neocomian age derived from the Coahuila Peninsula, which lacks sedimentary rocks of Triassic and Jurassic age (Kellum and others, 1936). Older elements of the interior zone whose radiometric ages vary from about 450 to 350 m.y. have been identified by Denison and others (1969). These include granitic gneiss and metarhyolite boulders from the Haymond Formation of the Marathon Basin and granite gneiss from a well in northeastern Mexico.

The most southerly outcrops of rocks of Paleozoic age on the Coahuila Peninsula occur in the Valle de Las Delicias (King and others, 1944) (Fig. 1). Beds range in age from at least Wolfcampian to possibly Ochoan. The section which crops out is more than 3000 meters thick and is comprised of mafic and intermediate flows and intrusives interlayered with graywacke, conglomerate, sandstone, fossiliferous limestone, minor quartzite and shale. King and others (1944) make the following conclusions:

> "The faunas indicate direct connection with the Permian Basin of West Texas and New Mexico, and this thick section, lying some 200 miles south of the Rio Grande, indicates the course of the Permian geosyncline across Mexico. The detrital sediments appear to be derived largely from the east but the volcanics came chiefly from the west side of the geosyncline."

Rowett and Hawkins (1975, p. 231) suggested that these rocks "accumulated on the seaward and eastern side of a volcanic island archipelago."

Yaqui Block

Precambrian and Paleozoic rocks are poorly exposed in this block which is bounded on the north by the Mojave-Sonora megashear and on the south by the Mexican volcanic belt megashear. From northwest to southeast the following major pre-Mesozoic elements are recognized (Fig. 1). 1) The Sonobari Complex, which crops out just south of the border between Sonora and Sinaloa, consists of biotite schist, amphibolite, gneiss and quartzite. De Cserna (1971 a), who initially mapped this region (Cserna and Kent, 1961) considered its age to be Precambrian, although he emphasized the lack of satisfactory stratigraphic or geochemical dating. A homogeneous suite of zircons derived from biotite gneiss collected from Sierra de Sonobari yields concordant ages at about 220 m.y. (Anderson and Silver, unpublished data). Recently, Carillo (1971) and Malpica-Cruz

(1972) identified a fauna of Late Mississippian to Early Pennsylvanian age in black slate 70 km southeast of this area.

2) Late Precambrian and Paleozoic clastic and carbonate rocks. Beds which are correlative to units in southeastern California crop out in western Sonora (Cooper and Arellano, 1946). Lithologic characteristics and ages of these units as well as their unconformable relationship to underlying crystalline basement have been described in a series of papers by Cooper and others (1952), Cooper and others (1953), Arellano (1956), and Easton and others (1958).

3) Crystalline basement - Precambrian rocks were initially identified by Damon and others (1962) near Caborca, Sonora. These units are composed of biotite gneiss, mica schist and quartzose gneiss which have been intruded by concordant sheets of amphibolite and rhyo-dacite. Plutons which range in composition from quartz diorite to quartz monzonite cut the layered sequence. Geochronologic studies in the Caborca area and in other parts of Sonora indicate the existence of rocks which range in age from 1770 $\pm$ 15 m.y. to 1725 $\pm$ 15 m.y. as well as plutons about 1.4 b.y. old (Anderson and Silver, 1970; 1971 b; and 1975). These ages suggest correlation to rocks in California and Arizona. Precambrian rocks whose ages fall in the interval 1720 to 1660 have not yet been recognized to the east. In the states of Chihuahua and Durango no Precambrian rocks are known and much work remains to be done in these areas where basement is thickly covered by young volcanic units. Plutons whose ages fall in the interval 1.45 $\pm$ .025 b.y. intrude the old sequence as they do to the north.

4) Late Precambrian (?) basement: In northern Zacatecas, about 180 km west of Ciudad Victoria, a strongly deformed metasedimentary sequence,

which includes some novaculite, overlies sheared metarhyolite (Cordoba, 1964) (Fig. 8-B). Although these units are unfossiliferous, lithologic similarities invite comparison with Precambrian and Paleozoic units in Texas. Cordoba (1964, p. 61) states:

> "The possibility of Precambrian age (for Caopas Schist) is suggested by the degree of metamorphism, the complexity of the structure, and the fact that 1,690 m of pre-"Nazas" rocks rest unconformably over the Caopas Schist. It is also suggestive that the upper part of the pre-"Nazas" sequence resembles the Tesnus Formation and Caballos Novaculite of late Paleozoic age in the Marathon region in Texas. There is a lithologic similarity between the Caopas Schist and the Carrizo Mountain Schist of the Van Horn area."

Geochronologic study of the Caopas Schist (Denison and others, 1971) has resulted in apparent Rb-Sr ages from 140 to 220 m.y. and a K-Ar date of 55 m.y. These ages are probably not the time of intrusion but record later history. De Cserna (1976 b) suggested that the Caopas Schist had been emplaced tectonically and therefore was not stratigraphically the oldest unit in northern Zacatecas, but was correlative with mafic volcanic units of Triassic age to the south, near Fresnillo, Zacatecas.

5) "Grenville" age crystalline rocks: These rocks are exposed in the cores of two great anticlinoria: Huizachal-Peregrina near Ciudad Victoria and Huayacocotla, north of Pachuca (Fig. 1). Granite gneiss, schist, and paragneiss from the Peregrina-Huizachal area have been studied by means of K-Ar, Rb-Sr, and Pb-a techniques and yield apparent Precambrian ages

between 1350 and 740 m.y. (Fries and others, 1962 a, 1962 b; Fries and Rincon-Orta, 1965; Fries and others, 1974; Denison and others, 1971). The metamorphic grade recorded by these rocks as well as their distinctive lithologies are similar to more widespread exposures in Oaxaca (Ortega-Gutierrez, 1978 a).

Granulite-grade gneiss from the Huayacocotla area yields Pb-a ages from 1210 to 800 m.y. (Fries and others, 1974; Fries and Rincon - Orta, 1965). Fries and others (1974) suggest that these data indicate a northward extension of the Oaxacan tectonic belt as far as Ciudad Victoria. According to these authors the development of the belt was as follows: (1) sedimentation between 1350 and 900 m.y.; (2) plutonic activity between 990 and 800 m.y.; and (3) metamorphism between 920 and 740 m.y.

In the Ciudad Victoria area and to the west near Aramberri, K-Ar and Rb-Sr isotopic data from schist, graphitic schist and pegmatite, yield apparent ages from 446 to 260 m.y. (Denison and others, 1971; Cserna and others, 1978). Denison and others (1971), de Cserna and others (1978), Ramirez-Ramirez (1978) Garrison (1978) and de Cserna and Ortega-Gutierrez (1978) have discussed these data in some detail and the following may be concluded: (1) the schist is a product of low-rank metamorphic processes and is distinct from associated gneisses of upper amphibolite to granulite grade, (2) the schist was metamorphosed in Pennsylvanian time; the age of its accumulation is uncertain, (3) the schist records a history different from the older gneiss and fossiliferous Paleozoic sequence and was emplaced tectonically.

6) Ouachita system (?) - frontal zone - Strata of early and middle Paleozoic age crop out above the crystalline basement and in places bear striking resemblance to rocks of the Ouachita system to the north. In

the Huizachal-Peregrina area, Carrillo-Bravo (1961) described more than 1600 meters of marine beds of Paleozoic age (Fig. 8). The age and lithology of these units suggest correlation with the sections in northern Chihuahua and Marathon. As mentioned above, distinctive lithologies also occur in the sequence described by Cordoba (1964) in northern Zacatecas. Lower and middle Paleozoic rocks do not crop out in the core of Huayacocotla anticlinorium and are not known from other localities within the Yaqui block.

Pennsylvanian and Permian rocks which are comparable lithologically have been described from several localities (Lopez-Ramos, 1969) including important outcrops at Ciudad Victoria and Huayacocotla (Fig. 8). These beds consist predominantly of clastic rocks which range from conglomerate to lutite with local minor intercalations of limestone. Thickness of the known sections range from 100's to 1000's of meters.

Upper Paleozoic beds extend eastward under the coastal plain as indicated by well data. Carrillo-Bravo (1961) noted that southeast of Ciudad-Victoria in Gonzalez No. 101 well, 1430 m. of Lower Pennsylvanian black shale, sandstone and conglomerate were encountered. Farther east near the coastline two wells (Tepehuaje #1 and Zamorina #1) cut beds of Permian age (Lopez-Ramos, 1969).

7) Ouachita system (?) - interior zone - Additional subsurface data from more than 150 wells is summarized by Lopez-Ramos (1972). These data clearly show that strongly metamorphosed rocks, fossiliferous beds of Paleozoic age and intrusive masses comprise a major part of the terrane which underlies the coastal plain. Some of these units are probably comparable to the "interior zone" of the Ouachita system.

Schist which crops out at Ciudad Victoria and Aramberri may also be a part of the sequence comprising the interior zone. As noted above, many characteristics of the schistose rocks are in contrast to those of associated gneisses. Ramirez-Ramirez (1978) interpreted these rocks as part of an island arc which formed along a convergent margin. De Cserna (1971 b) argued that the schist was tectonically emplaced in slices that define a belt of thrusts throughout eastern Mexico.

Maya Block

The Maya block was defined by Dengo (1969) as an area which extended from the Motagua fault zone north to the state of Chiapas, Mexico. It is underlain by basement which consists of rocks of early Paleozoic and perhaps older ages which have been metamorphosed to predominantly amphibolite and garnet amphibolite facies. This crystalline basement is overlain by sedimentary rocks of late Paleozoic (Pennsylvanian - Permian and possibly older), Mesozoic and Cenozoic ages. For the purposes of this paper it seems logical to suggest that the northern boundary of the Maya block be designated as the Mexican volcanic belt. This alteration does not violate the original definition by Dengo and does result in boundaries that may coincide with fundamental crustal fractures.

Although crystalline rocks are more widely exposed in the Maya block than adjacent blocks, high, mountainous terrain, and a paucity of available data make geologic overviews hazardous at best. Geology of this block appears to be complicated by the fact that Ouachita and Cordilleran orogenic belts are probably very close together and normally evident tectonic symmetries may be obscured because they are intermingled or have been superposed.

From west to east, initial studies suggest the presence of the following major pre-Mesozoic geologic elements:

1) Xolapa gneiss - On the west coast of Mexico, near Acapulco, de Cserna (1965) described a sequence of metamorphic rocks which includes quartzite, biotite schist, and locally cordierite schist, amphibolite, and gneiss. De Cserna (1971 a) recognized that the area had experienced a very complex history and pointed out that (p. 1502) "both paleontologic and radiometric evidence bracketed the metamorphic rocks as pre-medial Cretaceous". More recent isotopic studies (Cserna and others, 1978) yield Rb-Sr isochron age of 311 $\pm$ 30 m.y. Zircons derived from Xolapa gneiss, a different unit within this complex, yield U/Pb isotopic ages of about 170 m.y. (Guerrero and others, 1978) which indicate that parts of this terrane formed during Jurassic time. Extensive study will be required to unravel the complexities of this large area adjacent to the Pacific Ocean.

2) Taxco Schist - North of Acapulco, in the region between Taxco and Toluca, greenish-gray crenulated sericite schist derived from rhyolite tuff in places underlies greenstones of Late Triassic (?) age. No conclusive radiometric date is available for these rocks. De Cserna (1971 a) suggests the probability of their Precambrian age, although they could be Paleozoic age or younger (?).

3) Late Precambrian basement - In the vicinity of the city of Oaxaca strongly metamorphosed rocks of upper amphibolite and granulite grade comprise the crystalline terrane. Quartzo-feldspathic gneiss is predominant and may contain any one or a combination of biotite, amphibole, garnet and pyroxene. This gneiss is distinctly banded in outcrops where abundant mafic minerals define the foliation. As the percentage of mafic constituents increases, the quartzo-feldspathic gneiss is transitional to

amphibolite or pyroxene gneiss. Marble and quartzite crop out throughout the area although they are confined to layers whose thickness commonly does not exceed a few 10's of meters. Graphite is a common constituent in some gneiss layers and in place graphite schist crops out. Granite, granodiorite, and diorite masses intrude the layered sequence and commonly show strong deformation. Pegmatites cut the gneissic and granitic rocks. Studies of isotopic relationships of K-Ar, Rb-Sr, and Pb-a in minerals from pegmatites and gneiss in the region around Ciudad Oaxaca yielded ages which range from 1190 to 670 m.y. (Fries and others, 1962 a; 1966; 1974; Fries and Rincon-Orta, 1965). U-Pb isotopic relationships from zircons derived from paragneisses and a metamorphic pegmatite yield ages of about 1050 m.y. and suggest that a major metamorphic culmination occurred at that time. A concordant age from a post-deformational pegmatite of 960 $\pm$ m.y. provided a younger limit to deformation which effected the gneisses (Anderson and Silver, 1971 a).

Within the Maya block the full extent of the province underlain by strongly metamorphosed, 1.0 b.y. rocks is not known. Lithologically similar rocks have been reported from many localities and it seems probable that these rocks underlie much of the state of Oaxaca and southern Puebla. East of Oaxaca, almost no additional radiometric data pertaining to Precambrian rocks is available. Gneisses of the Chuacus series from central Guatemala have been studied. Zircons derived from these paragneisses "yield an age of 1075 $\pm$ 25 m.y. which may be either the age of source terrain for the original sediments, or the age of principal metamorphism" (Gomberg and others, 1968, p. 121). In the widespread intervening area which includes western Guatemala and the state of Chiapas, Mexico, no Precambrian ages have been published. De Cserna (1971 a) alludes to unpublished data of Pantoja and others which suggests the existence of granite of Pre-cambrian age in westernmost Chiapas.

4) Early to Middle Paleozoic rocks: Fossiliferous early Paleozoic beds crop out at only one locality within the Maya Block. Near Nochixtlan, 45 km northwest of Oaxaca, Pantoja-Alor and Robison (1967) reported the existence of at least 200 m of limestone, shale and sandstone which occupy an age interval from Late Cambrian to Early Ordovician. These beds are unconformably overlain by Mississippian strata (Fig. 8).

Studies in the southern Mexican states of Puebla (Rodríguez-Torres, 1970; Ruiz-Castellanos, 1970; Ortega-Gutierrez, 1978 b) and Chiapas (Pantoja-Alor and others, 1974) and in western Guatemala (Kesler, 1971; Kesler and others, 1970; Anderson and others, 1973) and earlier research (e.g. Webber and Ojeda-Rivera, 1957; McBirney, 1963) have established the existence of substantial terranes of pre-Pennsylvanian metasediments. Metamorphic facies characteristic of these rocks are commonly greenschist or lower to middle amphibolite grade in contrast to the upper amphibolite or granulite facies rocks which yield 1.0 b.y. age. These metamorphic rocks, derived from sedimentary beds with intercalated volcanic units, are cut by syntectonic and post-tectonic intrusives. Dated plutonic rocks include two from southern Puebla (Acatlan augen schist and Totoltepec granodiorite) which yield Rb-Sr ages of about 450 m.y. (Fries and others, 1966; and Fries and others, 1974), the Rabinal granite, whose interpreted zircon age is about 350 m.y. (Gomberg and others, 1968), and the Mountain Pine granite from Maya Mountains which yields an apparent Rb-Sr age near 400 m.y. (Bateson, 1972). Large masses of granitic rocks which intrude Pre-cambrian (?) rocks in Oaxaca have been mapped by de Cserna (1971 a) as Paleozoic as have numerous plutons which intrude the metamorphic sequence in western Guatemala (Kesler and others, 1971; Anderson and others, 1973). Rb-Sr isotopic data from scattered localities in Chiapas yield a variety of apparent Paleozoic ages (Salas, 1975). Subsurface data indicates the presence of Carboniferous basement as far north as central Yucatan (Dengo, 1969). Dengo (1969, p. 313) noted that a basement core in the Yucatan Peninsula yielded probable age of 420 m.y. and recorded a possible metamorphic event at 330 m.y. (written communication by M. N. Bass based upon isotopic study by R. Zartman);

5) Fossiliferous Carboniferous and Permian rocks - Strata of late Paleozoic age crop out sporadically from Puebla to Belize. In southern Puebla crinoid-bearing, Carboniferous (?) clastic rocks with interbedded carbonate and rare volcanic units have been correlated with Pennsylvanian beds to the east at Tehuacán and Nochistlán (Ruiz-Castellanos, 1970). Abundant plant fossils (Silva-Pineda, 1970) firmly establish the Pennsylvanian age of the sequence of sandstone and lutite at Tehuacan and these rocks probably correlate with the shaly beds which crops out near Nochistlan (Pantoja-Alor and Robison, 1967) and contain Early to Middle Pennsylvanian marine fauna. Exposures of fossiliferous Paleozoic strata have not been recognized in the Isthmus of Tehuantepec, although Lopez-Ramos (1969) suggested that metamorphic rocks including abundant phyllite, schist, quartzite and marble might be equivalents of late Paleozoic strata.

From eastern Chiapas across Guatemala to Belize (Fig. 8) clastic rocks of Pennsylvanian (?) age are transitional into a carbonate section whose Permian age is firmly established (see Clemons and others, 1974 for a recent summary). Most recently in western Guatemala, Litke (1975) reported that plant fossils occur with a marine fauna in clastic rocks of Pennsylvanian-Permian age and suggested that these beds accumulated nearshore in shallow water. This belt of Pennsylvanian (?) Permian sediments has been interpreted as forming part of an east-west geosyncline, whose foreland was to the north in Yucatan and whose deeper parts were to the south (Dengo and Bohnenberger, 1969; Hall and Bateson, 1972). An alternative interpretation is that Yucatan was an uplifted orogenic belt from which detritus was shed southward toward a narrow strip of slightly older basement. Facts which contribute to either of these interpretations include:

1) The presence of an early to middle Permian carbonate section in Guatemala which thins to the north and is transitional into clastic rocks;
2) The distribution of Late Pennsylvanian volcanic rocks in Belize (Hall and Bateson, 1972) and their possible equivalence to volcanic rocks to the west in Guatemala (Fargher, 1968-1969; Forth, 1971);
3) The absence of subsurface late Paleozoic rocks in most of Yucatan (Dengo, 1969).

Plutons of late Paleozoic to Triassic age which intrude layered sequences have been dated from Belize, central and western Guatemala. Permo-Triassic granite is mentioned from western Guatemala by Marcus and others (1975). In central Guatemala a stock which intrudes presumably early to mid-Paleozoic metamorphic rocks yields an Rb-Sr age of 275 m.y. (Pushkar, 1968). Bateson (1972) reports Rb-Sr and K-Ar dates from three intrusives in Belize which range from 390 to 200 m.y.

Cuba

Cuba is considered part of the Maya block but, because of its role in the model and location is described separately. Between the Yucatan Peninsula and Cuba, topographic ridges in the sea floor (Baie, 1970) and dredge samples composed of muscovite schist and phyllite and marble (Moore and others, 1971; Vedder and others, 1971; Vedder and others, 1973) support the suggestion (eg. Dengo, 1969; Uchupi, 1973) that parts of Cuba are an extension of pre-Mesozoic crystalline terrane which underlies the Yucatan Peninsula.

Three major outcrops of metamorphic rocks occur along the southern flank of Cuba. From west to east these are 1) Isle of Pines metamorphics, 2) Sierra de Trinidad metamorphics, and 3) metamorphic rocks near the southeasternmost part of the island in Oriente province. On the Isle of Pines, marble, quartzitic phyllite, quartzite, graphite-sericite schist, biotite schist, biotite-staurolite schist, garnet-muscovite schist and sillimanite schist have been intruded by serpentinite and gabbro, locally metamorphosed to amphibolite. Metamorphic outcrops in Sierra de Trinidad include a thick unit of marble in addition to epidote-quartz-micaschist, graphitic schist, gneissic quartzite, garnet-bearing graphitic quartzite coarsely crystalline gneiss, chlorite schist, actinolite schist, serpentinite, amphibolite and metagabbro. In eastern Oriente province, the metamorphic rocks lithologically resemble San Cayetano Formation and may be metamorphosed equivalents of these units. The above descriptions are taken from Khudoley and Meyerhoff's (1971) summary which also includes a thorough discussion of the vigorous debate which exists about the ages of these beds. Although Khudoley considered the metamorphic rocks most likely to be equivalents of Jurassic beds, Meyerhoff in Khudoley and Meyerhoff (1971) and Tijomirov (1967) argued that the more strongly metamorphosed units and those rocks that are derived from lithologies which are not known in the Jurassic sequence, are probably Paleozoic or Precambrian.

Chortis Block

In contrast to the metamorphic rocks of amphibolite and garnet amphibolite facies which characterize the Maya block:

> "the basement of the Chortis block consists mainly of phyllites and schists of the greenschist facies, which are here designated as the Palacaguina metamorphics, after the formation of the same name in Nicaragua (Zoppis Bracci, 1957). The Chortis block is the area of southern Guatemala, El Salvador, Honduras, northern Nicaragua and the Nicaraguan Rise (or bank) in the Caribbean"

(Dengo, 1969, p. 312).

Horne, Clark and Pushkar (1976) provide a summary of the basement rocks which comprise the Chortis block (Figs. 1 and 5). They point out that initial geological reports from areas south of the Motagua fault resulted in oversimplification of basement stratigraphy, which has been complicated by displacements along major faults. Between the Motagua and Jocotán-Chamelecón faults three sequences of metamorphic strata have been recognized. In Guatemala, according to Horne, Clark and Pushkar (1976, p. 571-572):

> "The most widespread sequence consists dominantly of low-grade phyllite and mica schist with subordinate quartzite, and marble prevalent at the top; it has been correlated with the unmetamorphosed Santa Rosa group found farther north (Clemons, 1969). These phyllites are underlain, perhaps unconformably, by the El Tambor Forma-

tion, a sequence of mafic pelitic strata, metachert, and locally common greenstone; the El Tambor was interpreted as a eugeosynclinal assemblage (McBirney and Bass, 1969). The third sequence is a high-grade metasedimentary and metaigneous complex of garnet-staurolite to sillmanite schist and gneiss, amphibolite, migmatite, and marble; it was called the Las Ovejas Group (Schwartz, 1972)."

Only sparse isotopic data exist for these units (McBirney and Bass, 1969; Pushkar and others, 1972) and the ages of protoliths and subsequent metamorphic modification have not been established. El Tambor Formation is probably equivalent to beds which bear Cretaceous fossils according to Wilson (1974). Lawrence (1976) concludes on the basis of the geochemistry and petrology of the El Tambor rocks, that this unit likely represented oceanic crust and overlying sediments. Concurrent mapping along the eastern part of the Motagua fault trace led Schwartz and Newcomb (1973) and Donnelly (1977) to suggest that during late Cretaceous time, continent-continent collision had occurred as a small ocean basin was closed by plate convergence. The suture zone is probably nearly coincident with the active Motagua fault trace. In view of the complex history of the Motagua zone and the likelihood that major fault displacements as well as convergence have occurred along this zone, we consider correlations between units from northern Guatemala to Honduras tenuous.

Farther east in Honduras, Horne, Clark and Pushkar (1976) conducted field studies in Sierra de Omoa and this work revealed a great variety of low to medium grade metasedimentary and metavolcanic units. This complex has been intruded by plutons, some of which record metamorphic and/ or deformational overprints. Rb-Sr isotopic results indicate that some of these rocks are at least Ordovician in age and may be as old as late Precambrian. Younger magmatic episodes have been dated as middle Carboniferous age and Jurassic age.

South of this province large areas of Honduras are underlain predominantly by schist, phyllite with less abundant marble and rare quartzite metamorphosed to greenschist facies. Locally augen gneiss and schist of almandine-amphibolite facies underlie (?) the greenschist grade rocks.

Motilon Block

The Motilon block refers to those parts of northwestern South America, mainly in Colombia, underlain by pre-Jurassic rocks. This terrane was situated southeast of Chortis block during Permian time.

Recent summaries of the geology of this region (Irving, 1975; Shagam, 1975; Tschanz and others, 1974) provide invaluable guides to stratigraphy and structure as well as to many additional references. Stratigraphic sections are provided for Sierra Nevada de Santa Marta (Fig. 8) (Tschanz and others, 1974) and Sierra de Perija (Fig 7) (Miller, 1962) because of their proximity to the northern margin of South America. Sierra de Perijá trends northeasterly and is separated from the Santa Marta block by the Cesar lineament. The Santa Marta block is bounded by major fault systems on the north (Oca) and west (Santa Marta-Bucaramanga) and probably has been transported northwest by displacements along these fault systems. Geologic subprovinces are delineated within the block by the Sevilla lineament. Few geochronologic studies have been made on crystalline rocks from ranges between the Guayana shield and the Caribbean sea according to Tschanz and others (1974, p. 275):

> "The available Precambrian radiometric ages from the Sierra Nevada massif and from the broad region between it and the Guayana Shield suggest that the ages in the Sierra Nevada massif (presumably ~ 3.0 b.y.) were reset by two or three subsequent Precambrian metamorphic events about 1,200 to 1,400, 940, and possibly about 752 m.y. ago. The geologic and radiometric belts developed during these orogenies around the margin of the granulite nucleus of the ancestral Guayana Shield."

Two overlapping, north-northeasterly-trending orogenic belts of Paleozoic age developed along the previously modified northwestern margin of the Guayana shield. The older of these belts formed during Cambrian and Ordovician and its later development is marked by an episode of plutonism which is indicated by rare concordant masses of biotite-quartz-feldspar orthogneiss which yield ages from 450 $\pm$ 80 to 413 $\pm$ 30 m.y. Along the western flank of Serrania de Perija miogeosynclinal facies of the Cambro-Ordovician belt are comprised of clastic sedimentary rocks (Fig. 8). These strata are probable equivalents of thin-bedded shale, with minor limestone interbeds which crop out along strike far to the south and yield faunas ranging in age from Middle Cambrian to Early Ordovician (Harrington and Kay, 1951). In places, overlying rocks consist of thousands of feet of quartzite beds.

The absence of Silurian rocks throughout Colombia is compatible with the interpretation that much of the area had been uplifted and was undergoing erosion.

Clastic sedimentary rocks of Devonian age rest unconformably upon older units and in places may have been affected by sharp, local disturbances (Irving, 1975).

Latest-Mississippian age beds crop out in Colombia and they consist of sandstone, shale, mudstone and limestone. These units are probably transitional into sequences, commonly a few hundreds of meters thick, of Pennsylvanian-Permian age. In Sierra de Perija several late Paleozoic localities are known (Miller, 1962; Trumpy, 1953), although details of stratigraphy are sketchy. Pertinent units bearing Carboniferous brachiopods crop out in the northern part of the range and consist of olive-brown colored sandy shale and sandstone, with scattered shale, sandstone and limestone interbeds which become more abundant higher in the sections. In the east-central part of Sierra de Perija, plant remains are found in beds of presumed Carboniferous age. Gray, slightly dolomitic, cherty limestone in a fault-bounded block contains a distinctive Permian fauna (Trumpy, 1953).

Northwest of Perijá, within the Santa Marta block, 300 meters of probable late Paleozoic rocks consist from bottom to top of graphitic schist, quartz-pebble conglomerate, quartz sandstone and limestone (Gansser, 1955). A layer of hornblende-diorite porphyry crops out near the middle of the sequence.

Beds of basaltic and spilitic rocks and volcanogenic graywacke and paraschist, orthoschist, metadiorite and amphibolite, also within the Santa Marta block, possibly represent a eugeosynclinal suite of Permian age which probably accumulated along the western edge of South America (Tschanz and others, 1974). Equivalent units may crop out on the Guajira Peninsula. Culmination of this orogenic cycle appear to be marked by metamorphism and plutonism whose ages range from about 250 to 200 m.y.

CITED REFERENCES

APPENDIX

Anderson, C. A., Blacet, P. M., Silver, L. T., and Stern, T. W., 1971, Revision of Precambrian stratigraphy in the Prescott-Jerome area, Yavapai County, Arizona: U.S. Geological Survey Bulletin 1324-C, p. C1-C16.

Anderson, C. A., and Silver, Leon T., 1976, Yavapai Series - A greenstone belt: Arizona Geological Society Digest, v. X, p. 13-26.

Anderson, Thomas H., Burkart, Burke, Clemons, Russell E., Bohnenberger, Otto H., and Blount, Don N., 1973, Geology of the Western Altos Cuchumatanes, northwestern Guatemala: Geological Society of America Bulletin, v. 84, p. 805-826.

Anderson, T. H. and Silver, L. T., 1971a, Age of granulite metamorphism during the Oaxacan orogeny, Mexico (abs.): Geological Society of America Abstracts with Programs for 1971, v. 3, p. 492.

____________________ 1971b, Preliminary history for Precambrian rocks, Bamori region, Sonora, Mexico (abs.): Geological Society of America Abstracts with Programs, v. 3, p. 72-73.

____________________ 1975, Extent and development of the craton under part of the Sierra Madre Occidental, northwestern Mexico (abs.): Geological Society of America Abstracts with Programs, v. 7, p. 141.

Arellano, A. R. V., 1956, Relaciones del Cambrico de Caborca, especialment con la base del Paleozoico: Congr. Geol. Intern., XX Ses., Mexico, 1956, Symposio sobre el Sistema Cambrico, su Paleogeográfica y el Problema de su Base, Parte 11, p. 509-527.

Cited References P. 2

Baie, Lyle F., 1970, Possible structural link between Yucatan and Cuba: American Association of Petroleum Geologists Bulletin, v. 54, p. 2204-2207.

Bateson, J. H., 1972, New interpretation of Geology of Maya Mountains, British Honduras: American Association of Petroleum Geologists Bulletin, v. 56, p. 956-963.

Bickford, M. E., and Mose, D. G., 1975, Geochronology of Precambrian rocks in the St. Francois Mountains, southeastern Missouri: Geology, v. 3, p. 537-540.

Bridges, Luther W., 1964a, Stratigraphy of Mina Plomosas-Placer de Guadalupe area, in Geology of Mina Plomosas-Placer de Guadalupe area, Chihuahua, Mexico: West Texas Geological Society publication 64-50, Fieldtrip guidebook, p. 50-59.

________ 1964b, Regional speculations in northern Mexico, in Geology of Mina Plomosas-Placer de Guadalupe area, Chihuahua, Mexico: West Texas Geological Society, publication 64-50, Fieldtrip guidebook, p. 93-98.

Carillo-M., Miguel, 1971, Notas referentes al Paleozoico de San Jose de Gracia, Sinaloa, in El coloquio sobre las geología de los Estados de Sinaloa y Durango: Instituto de Geología, Ciudad Universitaria Mexico (20) D. F.

Carillo-Bravo, J., 1961, Geología del anticlinorio Huizachal-Peregrina al NW de Ciudad Victoria, Tamaulipas: Boletín Asociación Mexicana de Geólogos Petroleros, v. 12, p. 1-98.

Cited References P. 3

Clemons, R. E., 1969, Geologic history of the Chiquimula region, Guatemala, <u>in</u> Trabajos tecnicos presentados en la segunda reunión de geólogos de America Central: Instituto Centroamericano de Investigacion y Tecnología Industrial Publicaciones Geológicas 2, p. 72-75.

Clemons, R. E., Anderson, Thomas H., Bohnenburger, Otto H., and Burkart, Burke, 1974, Stratigraphic nomenclature of recognized Paleozoic and Mesozoic rocks of western Guatemala: American Association of Petroleum Geologists Bulletin, v. 58, 313-320.

Cooper, G. A., Arellano, A. R. V., 1946, Stratigraphy near Caborca, Northwest Sonora, Mexico: American Association of Petroleum Geologists Bulletin, v. 30, p. 606-611.

Cooper, G. A., Arellano, A. R. B., Johnson, J. H., Okulitch, V., Stoyanow, A. and Lockman, C., 1952, Cambrian stratigraphy and paleontology near Caborca, northwest Sonora, Mexico: Smithsonian Miscellaneous Collections, v. 119, 184 p.

Cooper, G. A., Dunbar, C. O., Duncan, H., Miller, A. K., and Knight J. B., 1953, Permian fauna at El Antimonio, western Sonora, Mexico: Smithsonian Miscellaneous Collection, v. 119, p. 106.

Cooper, John R., and Silver, Leon T., 1964, Geology and ore deposits of the Dragoon quadrangle Cochise County Arizona: U.S. Geological Survey Professional Paper 416, 196 p.

Cserna, Zoltan de, 1965, Reconocimiento geologico en la Sierra Madre del Sur de Mexico, entre Chilpancingo y Acapulco, Estado de Guerrero: Universidad Nacional Autónoma de México, Instituto de Geología, Boletín 62, 76 p.

Cited References P. 4

Cserna, Zoltan de, 1971a, Precambrian sedimentation tectonics, and magmatism in Mexico: Geologische Rundschau, v. 60, p. 1488-1513.

__________________ 1971b, Taconian (early Caledonian) deformation in the Hausteca structural belt of eastern Mexico: American Journal of Science, v. 271, p. 544-550.

__________________ 1976, Mexico-Geotectonics and Mineral deposits: in Woodward, L. A., and Northrop, S. A., eds., Tectonics and mineral resources of southwestern North America: New Mexico Geological Society Special Publication Number 6, p. 18-25.

Cserna, Zoltan de, Armstrong, Richard L., Yáñez-Garcia, Camilo and Solorio, Jose, 1978, Rocas meta-volcanicas e intrusivos relacionados Paleozoicos de la región de Petatlán, Estado de Guerrero: Universidad Nacional Autónoma de México, Instituto de Geología, Revista, v. 2, p. 1-7.

Cserna, Zoltan de, Graf, J. L., Jr., and Ortega-Gutierrez, Fernando, 1977, Alóctono del Paleozoico inferior en la region de Ciudad Victoria Estado de Tamaulipas: Universidad Nacional Autónoma de México, Instituto de Geología, Revista, v. 1, p. 33-34.

Cserna, Zoltan de and Kent, B. H., 1961, Mapa geologico de Reconocimiento y secciones estructurales de la region de San Blas y El Fuerte, Estados de Sinaloa y Sonora: Universidad Nacional Autónoma de México Instituto Geología, Cartas Geológicas Mineras, 4, map with text, scale 1:100,000, Mexico, D. F., 1961.

Cited References P. 5

Cserna Zoltan de and Ortega-Gutierrez, Fernando, 1978, Reinterpretation of isotopic age data from the Granjeno Schist, Ciudad Victoria, Tamaulipas y reinterpretación tectónica del Esquisto Granjeno de Ciudad Victoria, Tamaulipas; contestación: Universidad Nacional Autónoma de México, Instituto Geología, Revista, v. 2, p. 212-215.

Damon, Paul E., Livingston, Donald, E., Mauger, Richard L., Giletti, Bruno, J., and Pantoja-Alor, Jerjez, 1962, Edad del Precambrico "Anterior" y de otras rocas del zocalo de la región de Caborca-Altar de la Parte Noroccidental del Estado de Donora: Universidad Nacional Autónoma de México, Instituto de Geología, Boletín 64, p. 11-44.

Dengo, Gabriel, 1969, Problems of tectonic relations between Central America and the Caribbean, in Geology of the American Mediterranean: Gulf Coast Association of Geological Societies Transactions, v. 19, p. 311-320.

Dengo, Gabriel and Bohnenberger, O., 1969, Structural development of Northern Central America, in McBirney, A. R., ed., Tectonic relations of Northern Central America and the Western Caribbean: The Bonacca Expedition: American Association of Petroleum Geologists Memoir 11, p. 203-221.

Denison, Rodger E., Kenny, George S., Burke, William H. Jr., and Hetherington, Ernest A. Jr., 1969, Isotopic ages of igneous and metamorphic boulders from the Haymond Formation (Pennsylvanian), Marathon Basin, Texas, and their significance: Geological Society of America Bulletin, v. 80, p. 245-256.

Cited References P. 6

Denison, Rodger E., Burke, W. H., Hetherington, E. A., and Otto, J. B., 1971, Basement rock framework of parts of Texas, southern New Mexico and northern Mexico _in_ Seewald, Ken and Sundeen, Dan, eds., The Geologic framework of the Chihuahua tectonic belt: West Texas Geological Society, Midland, P. 3-14.

Donnelly, T. W., 1977, Metamorphic rocks and structural history of the Motagua suture zone, eastern Guatemala (abs.): Abstracts 8th Caribbean Geological Conference, Curacao, p. 41-42.

Easton, W. H., Sanders, J. E., Knight, J. B., and Miller, A. K., 1958, Mississippian Fauna in Northwestern Sonora, Mexico: Smithsonian Miscellaneous Collections, v. 119, p. 87.

Fargher, M., 1968-1969, United Nations Mineral Survey, Guatemala: United Nations, unpub. repts.

Flawn, P. T., and Diaz-G., T., 1959, Problems of Paleozoic tectonics in north-central and northeastern Mexico: American Association of Petroleum Geologists Bulletin, v. 42, p. 224-230.

Flawn, P. T., Goldstein, A. Jr., King P. B., and Weaver, C. E., 1961 The Ouachita System: Bureau of Economic Geology, Publication No. 6120, The University of Texas, Austin, 401 p.

Forth, D. R., 1971, Structure and stratigraphy of the Sacapulas quadrangle, Guatemala with particular emphasis on Paleozoic rocks (M.S. Thesis): Louisiana State University, Baton Rouge, LA 113 p.

Fries, C. Jr., Schmitter-Villada, E., Damon, P. E., and Livingston, E.E., 1962a, Rocas precambricas de edad grenvilliana de la parte central de Oaxaca, en el sur de México: Universidad Nacional Autónoma de México, Instituto Geología, Boletín 64, p. 45-53.

Cited References P. 7

Fries, C. Jr., Schmitter, Eduardo, Damon, P. E., Livingston, E. E., y Erickson, Rolfe, 1962b, Edad de las rocas metamórficas en los canones de La Peregrina y de Caballeros, parte centro-occidental de Tamaulipas: Universidad Nacional Autónoma de México, Instituto de Geología, Boletin 64, pt. 4, p. 55-69.

Fries, C. Jr., and Rincon-Orta, Cesar, 1965, Nuevas aportaciones geocronológicas y tecnicas empleadas en el laboratorio de geocronometría; Universidad Nacional Autónoma de México, Instituto de Geología, Boletín 73, p. 57-133.

Fries, C. Jr., and Schlaepfer, C. J., and Rincon-Orta, C., 1966, Nuevos datos geocronologicos del complejo Oaxaqueno: Boletín Sociedad Geológica Mexicana, v. 29, p. 59-66.

Fries, C. Jr., Rincon-Orta, Cesar, Silver, Leon T., McDowell, Fred W., Solario-Munguia, Jose, Schmitter-Villada, Eduardo, y Cserna, Zoltan de, 1974, Nuevas aportaciones a la geocronología de la faja tectónica Oaxaqueña: Associación Mexicana Geólogos Petroleros Boletín, v. XXVI, p. 157-182.

Garrison, James R. Jr., 1978, Reinterpretation of isotopic age data from the Granjeno Schist, Ciudad Victoria Tamaulipas: Universidad Nacional Autónoma de México, Instituto de Geología, Revista, v. 2, p. 87-89.

Gomberg, D. N., Banks, P. O., and McBirney, A. R., 1968, Guatemala: Preliminary zircon ages from Central Cordillera: Science, v. 162 p. 121-122.

Cited References P. 8

Guerrero, J. and Helsley, C. E., 1974, Paleomagnetic evidence for post-Jurassic tectonic stability of southeastern Mexico (abs.): EOS, Transactions of the American Geophysical Union, v. 56, p. 1110.

Hall, I. H. S., and Bateson, J. H., 1972, Late Paleozoic lavas in Maya Mountains, British Honduras, and their possible regional significance: American Association of Petroleum Geologists Bulletin, v. 56, 950-956.

Harrington, H. J., and Kay, Marshall, 1951, Cambrian and Ordovician faunas of Eastern Colombia: Journal of Paleontology, v. 25, p. 655-668.

Horne, Gregory S., Clark, George S., and Pushkar, Paul, 1976, Pre-Cretaceous rocks of northwestern Honduras, Basement terrane in Sierra de Omoa: American Association of Petroleum Geologists Bulletin, v. 60, p. 566-583.

Irving, Carl M., 1975, Structural evolution of the northernmost Andes, Colombia: U.S. Geological Survey Professional Paper 846, 47 p.

Kelly, W. A., 1936, Evolution of the Coahuila Peninsula, Mexico, Part II, Geology of the mountains bordering the valleys of Acatita and Las Delicias: Geological Society of America Bulletin, v. 47, p. 1008-1038.

Kellum, L. B., Imlay, R. W., and Kane, W. G., 1936, Evolution of the Coahuila Peninsula, Mexico Part I. Relation of structure, stratigraphy, and igneous activity to an early continental margin: Geological Society of America Bulletin v. 47, 969-1007.

Kesler, Stephen E., 1971, Nature of Ancestral orogenic zone in Nuclear Central America: American Association of Petroleum Geologists Bulletin, v. 55, p. 2116-2129.

Cited References P. 9

Kesler, S. E., Josey, W. L., and Collins, E. M., 1970, Basement rocks of western nuclear Central America, The Western Chuacus Group, Guatemala: Geological Society of Bulletin, v. 81, p. 3307-3322.

Khudoley, K. M. and Meyerhoff, A. A., 1971, Paleogeography and geological history of Greater Antilles: Geological Society of America Memoir 129, 199 p.

King, Philip B., 1975, Ancient southern margin of North America: Geology, v. 3, p. 732-734

King, Philip B., and Flawn, Peter T., 1953, Geology and mineral deposits of Pre-Cambrian rocks of the Van Horn area, Texas: The University of Texas Publication No. 5301, 218 p.

King, Robert E., Dunbar, Carl O., Cloud, Preston E., and Miller, A. K., 1944, Geology and paleontology of the Permian area northwest of Las Delicias, southwestern Coahuila, Mexico: Geological Society of America Special Paper No. 52, 130 p.

Lawrence, D. P., 1976, Tectonic implications of the geochemistry and petrology of El Tambor formation probable oceanic crust in Central America (abs.): Geological Society America Abstracts with Programs, v. 8, p. 973-974.

Litke, Gene R., 1975, The stratigraphy and sedimentation of Barillas Quadrangle, Department of Huehuetenango, Guatemala, C.A. (M.S. thesis): Baton Rouge, Louisiana State University, 196 p.

Lopez-Ramos, Ernesto, 1969, Marine Paleozoic rocks of Mexico: American Association of Petroleum Geologists Bulletin, v. 53, p. 2399-2417

Cited References P. 10

________ 1972, Estudio del basamento igneo y metamorfico de las zonas norte y Poza Rica entre Nautla, Ver. y Jiménez, Tamps: Boletín de la Asociación Mexicana de Geólogos Petroleros, v. XXVI, p. 265-323.

Malpica-Cruz, Rodolfo, 1972, Rocas marinas del Paleozoico tardío en el area de San Jose de Grácia, Sinaloa (Resumen): II a Convención Nacional Memoria, Mazatlán, Sociedad Geológica Mexicana, p. 189.

Marcus, Donald L., Burkart, Burke and Fischer, J. F., 1975, Reconnaissance igneous and metamorphic petrology of Barillas quadrangle, northwestern Guatemala (abs.): Geological Society of America abstracts with programs; v. 7, p. 213.

McBirney, A. R., 1963, Geology of a part of the central Guatemalan Cordillera: California University Publications in Geological Science, v. 38, No. 4, p. 177-242.

McBirney, A. R. and Bass, M. N., 1969, Structural relations of Pre-Mesozoic rocks of Northern Central America, in McBirney, A. R., ed., Tectonic relations of Northern Central America and the Western Caribbean: The Bonacca Expedition: American Association of Petroleum Geologists Memoir 11, p. 269-281.

Miller, John B., 1962, Tectonic trends in Sierra de Perija and adjacent parts of Venezuela and Colombia: American Association of Petroleum Geologists Bulletin, v. 46, p. 1565-1595.

Moore, G. W., and others, 1971, USGS - IDOE Leg 1, Bahia de Campeche: Geotimes, v. 16, no. 11, p. 16-17.

Cited References P. 11

Ortega-Gutierrez, Fernando, 1978a, El Gneiss Novillo y rocas metamorficas asociadas en los cañones del Novillo y de La Peregrina, area de Ciudad Victoria, Tamaulipas: Universidad Nacional Autónoma de México, Instituto de Geología, Revista v. 2, p. 19-30

______________________________ 1978b, Estratigrafia del complejo Acatlan en la Mixteca Baja, Estados de Puebla y Oaxaca: Universidad Nacional Autónoma de México, Instituto de Geología, Revista, v. 2, p. 112-131.

Pantoja-Alor, Jerjes, Fries Jr., Carl, Rincon-Orta, Cesar, Silver, Leon T., and Solorio-Munguia, Jose, 1974, Contribucion a la geocronología del Estado de Chiapas: Boletín Asociación Mexicana de Geólogos Petroleros, v. XXVI, p. 205-223.

Pantoja-Alor, Jerjes and Robison, Richard A., 1967, Paleozoic Sedimentary rocks in Oaxaca, Mexico: Science, v. 157, No. 3792, p. 1033-1035.

Pushkar, P., 1968, Strontium isotope ratios in volcanic rocks of three island arc areas: Journal of Geophysical Research, v. 73, p. 2701-2714.

_________ A. R. McBirney, and Rudo, A. M., 1972, The isotopic composition of strontium in Central American ignimbrites: Bulletin Volcanologique, v. 35, p. 265-294.

Ramirez-Ramirez, Calixto, 1978, Reinterpretación tectónica del Esquisto Granjeno de Ciudad Victoria, Tamaulipas: Universidad Nacional Autónoma de México, Instituto de Geología, Revista v. 2, p. 31-36.

Cited References P. 12

Rodríguez-Torres, Rafael, 1970, Geología metamorfica del area de Acatlan, Estado de Puebla: Libroguia de la excursion Mexico-Oaxaca, Sociedad Geologica Mexicana, 51-54.

Rowett, Charles L., and Hawkins, C. M., 1975, Late Paleozoic volcanic island arctrench system in northern Mexico (abs.): Geological Society of America Abstracts with programs, v. 7, p. 230-231.

Ruiz-Castellanos, Mario, 1970, Reconocimiento geológico en el area de Mariscala-Amatitlán, Estado de Oaxaca: Libro-guía de la excursión México - Oaxaca, Sociedad Geológica Mexicana, 55-66.

Salas, G. P., 1968, Carta geológica de la Republica Mexicana: Comite de la Carta Geológica de México, Mexico, D.F.

Salas, Guillermo P., 1975, Carta y provincias metalogenéticas de La Republica Mexicana: Publicación 21 E, Consejo de Recursos Minerales, 242 p.

Schwartz, D. P., 1972, Petrology and structural geology of the Motagua fault zone, Guatemala (abs.): Margarita, 6th Caribbean Geological Conference Transactions, p. 299.

Schwartz, D. P. and Newcomb, W. E., 1973, Motagua fault zone: a crustal suture (abs.): EOS, v. 54, p. 477.

Shagam, R., 1975, The northern termination of the Andes, in Nairn, Alan, E. M. and Stehli, Francis, G., The ocean basins and margins-Vol. 3 - The Gulf of Mexico and the Caribbean: Plenum Press, New York, p. 325-420.

Cited References P. 13

Silva-Pineda, Alicia, 1970, Plantas del Pensilvanico de la region de Tehuacan, Puebla: Universidad Nacional Autónoma de México Instituto Geología, Paleontología Mexicana 29, 108 p.

Silver, L. T., 1968, Precambrian batholiths of Arizona (abs.): Geological Society America Special Paper 121, p. 558-559.

________, 1971, Problems of crystalline Rocks of the Transverse Ranges (abs.): Geological Society America Abstracts with Programs, v. 3, p. 193-194.

Silver, L. T., Bickford, M. E., Van Schmus, W. R., Anderson, J. L., Anderson, T. H., Medaris, L. G., Jr., 1977, The 1.4 - 1.5 b.y. transcontinental anorogenic plutonic perforation of North America (abs.): Geological Society America Abstracts with Programs, v. 9, p. 1176-1177.

Stewart, J. H., 1976, Late Precambrian evolution of North America: Plate tectonics implication: Geology, v. 4, p. 11-15.

Stewart, J. H., and Poole, F. G., 1974 Lower Paleozoic and uppermost Precambrian Cordilleran miogeocline, Great Basin, western United States, in Dickinson, W. R., ed., Tectonics and sedimentation: Society of Economic Paleontologists and Mineralogists Special Publication 22, p. 28-57.

Tijomirov, I. N., 1967, (1968), Formaciones magmáticas de Cuba y algunas particularidades de su metalogenia: La Habana, Ministerio de Industrias, Revista Tecnológica, v. 5, No. 4, p. 13-22.

Cited References P. 14

Trumpy, P. 1953, Pre-Cretaceous of Colombia: Geological Society of America Bulletin, v. 54, p. 1261-1304.

Tschanz, Charles M., Marvin, Richard F., Cruz, Jaime B., Mehnert, Harold H., and Cebula, Gerald T., 1974, Geologic evolution of the Sierra Nevada de Santa Marta, northeastern Colombia: Geological Society America Bulletin, v. 85, p. 273-284.

Uchupi, Elazar, 1973, Eastern Yucatan continental margin and western Caribbean tectonics: American Association of Petroleum Geologists Bulletin, v. 57, p. 1075-1085.

Vedder, J. G., and others, 1971, U.S.G.S. -- IDOE Leg 2: Geotimes, v. 16, p. 10-12.

Vedder, J. G., MacLeod, N. S., Lanphere, M. A., and Dillon, W. P., 1973, Age and tectonic implications of some low-grade metamorphic rocks from the Yucatan Channel: Journal of Research U.S. Geol. Survey, v. 1, p. 157-164.

Wasserburg, G. J., Wetherill, G. W., Silver, L. T., and Flawn, P. T., 1962, A study of the ages of the Precambrian of Texas: Journal of Geophysical Research, v. 67, p. 4021-4047.

Webber, R. J., and Ojeda-Rivera, J., 1957, Investigación sobre lateritas fosiles en las regiones sureste de Oaxaca y sur de Chiapas: Instituto de Nacional Recursos Minerales, Boletín 37, p. 1-67.

Wilson, H. H., 1974, Cretaceous sedimentation and orogeny in Nuclear Central America: American Association of Petroleum Geologists Bulletin, v. 58, p. 1348-1396.

Cited References P. 15

Zoppis Bracci, L., 1957, Estudio geológico de la región de Palacaguina y de su deposito de antimonio: Nicaragua Servicio Geológico Nacional Boletín 1, p. 29-34.