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Terranes of Peninsular California and Adjacent Sonora

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The prebatholithic rocks of peninsular California can be grouped into several belts, according to age and lithology. The Continental Borderland is underlain by Triassic to Cretaceous ophiolite, oceanic arc, and forearc facies rocks. The northwestern coast is a Jurassic to medial Cretaceous volcanic arc. The axis of the peninsula consists of cratonally derived flysch-type with minor siliceous and carbonate rock. It is Mississippian to medial Cretaceous in age. The east-central edge of the peninsula (Ballenas Channel) is predominantly deep-water clastic and siliceous strata with cherty carbonate rock and pillow basalt. The only age so far determined for these rocks is Lower Devonian. The northeastern edge of the peninsula consists of miogeoclinal quartzite-carbonate facies of Lower Ordovician and possibly older ages. Prebatholithic rocks range from zeolite metamorphic facies in the Continental Borderland to upper amphibolite facies along the peninsular axis.

The stratigraphic and structural contacts between these lithologic belts are poorly understood, and localities of age determination are few in number. On best evidence we have divided the peninsula into five terranes. The Continental Borderland is a composite terrane and very likely exotic. The Jurassic-Cretaceous arc terrane is probably also exotic, but was sutured to the eastern peninsula during medial Cretaceous time and has been attached to the Borderland terrane since Turonian time. The Peninsular flysch terrane is probably a late Paleozoic to Cretaceous clastic apron deposited off the edge of cratonal North America. The Ballenas terrane may be exotic but has been attached to cratonal North America since mid-Paleozoic time. The San Felipe (northeastern) terrane is probably part of cratonal North America.

INTRODUCTION

Peninsular California, which spans the international boundary, was formed in the Miocene when California west of the San Andreas fault system broke away from mainland Mexico. It includes all of "Pacific Plate North America" south of the Transverse Ranges.

A terrane must be distinct both by virtue of rock assemblage and structural limits. In Peninsular California it is easy to recognize contrasting rock assemblages but difficult to establish the nature of the structural boundaries between them. Most of the rocks discussed here have been metamorphosed by Late Cretaceous thermal events. Until recent fossil discoveries, few of these metamorphic rocks could be assigned geologic ages, and we are still working with only a few points of fossil control. Thus, in order to divide the entire peninsula into terranes it is necessary to extrapolate by lithologic correlation.

In this report we present a list of different rock packages found in different portions of the peninsula (Fig. 1) and then discuss the evidence relative to the structural boundaries between these suspect terranes.

CONTINENTAL BORDERLAND TERRANE

Westernmost Peninsular California is a composite terrane that includes the channel islands of southern California, Isla Cedros, the western capes of Baja California Sur, and small areas exposed near Loreto and Tambobiche on the gulf coast of Baja California Sur (Fig. 2). Distinguishing rocks are ultramafic to calcic (or plagiogranite) Late Triassic to Early Cretaceous plutonic rocks, Upper Triassic and Middle Jurassic arc volcanic and volcaniclastic rocks, Upper Jurassic to Lower Cretaceous forearc deposits, and medial Cretaceous to Paleogene molasse. Blueschist-bearing breccias juxtapose serpentinites and olistostromal deposits that include blocks of shallow water, Upper Paleozoic carbonate-quartzite strata, and Triassic argillite and chert in an Upper Jurassic matrix (Boles and Landis, 1984). These rocks are considered by Moore (this volume).

VOLCANIC ARC TERRANE

From the Santa Ana Mountains of southern California to the Vizcaino Desert of Baja California Sur there is a continuous belt of volcanic and volcaniclastic rocks (II, Figs. 1, 3). South of Valle Santo Tomás (latitude 31° 34′), only rocks of latest Jurassic age have been recognized. South of Valle Santo Tomás, all recognized rocks are Albian-Aptian in age except at Arroyo San Jose (latitude 29° 20′) where Early Jurassic rocks unconformably underlie the Albian-Aptian strata (Minch, 1969). Rocks of this belt are also exposed in the Loreto area (Gastil et al, 1978) and in Sinaloa (Bonneau, 1971). The rocks are largely andesite to rhyolite, with clastic deposits composed entirely

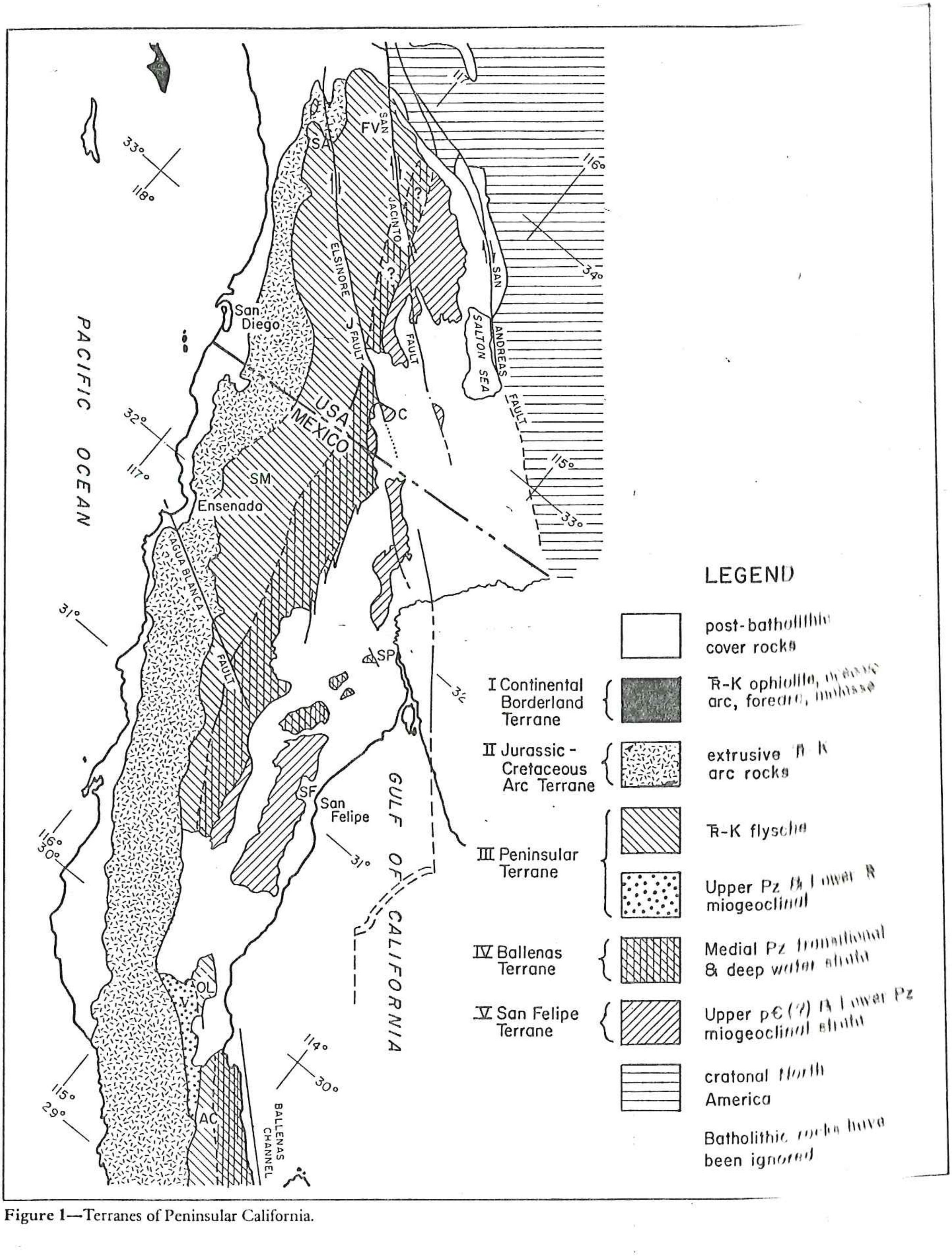

Figure 1—Terranes of Peninsular California.

volcanic detritus. Reef limestones are common in the Cretaceous strata of both Baja California and Sinaloa. The volcanic strata are intruded by calcic to calc-alkaline granitic rocks ranging in age from 120 Ma to Paleogene.

In western Sonora (IIA, Fig. 3), medial Cretaceous and Upper Jurassic volcanic strata are interbedded with marine carbonate and clastic strata (Hardy, 1981; Beauvais and Stump, 1976). In eastern Sonora is a belt of interbedded carbonate and andesitic volcanic rocks, first described by King (1939) and recently confirmed by Rangin (1982) after a very critical field review (IIB, Fig. 3).

Mullen (1978) describes these rocks as they appear in northernmost Sinaloa. The continuation of these rocks southward in Sinaloa (IIC, Fig. 3) is described by Bonneau (1971). He finds that in Sinaloa these strata are Albian–Cenomanian rather than Albian–Aptian.

A belt of Cretaceous volcanic and sedimentary rocks in western Nayarit (IID, Fig. 3) is reported by Gastil (1979) and Gastil et al (1979). At Barra Navidad (latitude 19° 10′), these are interbedded with carbonate rock. Work by Jensky (1975) suggests that these arc volcanic strata are in part younger than Cenomanian.

PENINSULAR FLYSCH TERRANE

A nearly continuous belt of metamorphosed flysch can be followed from the northernmost end of Peninsular California southward to the Agua Blanca Fault (latitude 31° 30′ N) (III, Fig. 1). These northern flysch sequences, the Bedford Canyon Formation of the Santa Ana Mountains, the French Valley Formation of the Hemet area, and the type Julian Schist of San Diego County, have been dated respectively as Triassic and Jurassic (Criscione et al, 1978), Upper Triassic (?) (Gastil et al, 1975), and Triassic (?) (Hudson, 1922). Strata in northwestern Baja California Norte are locally well-preserved but have yielded no fossils.

South of the Agua Blanca Fault, thick flysch sections have been mapped near Rancho El Rosarito (latitude 30° 30′ N), in the Mina Olvidada area (latitude 30° 00′ N), and in the Arroya Calamujue area (latitude 30° 25′ N). In these sections the only fossils are from the 30th parallel (Phillips, 1984) and indicate an Early Cretaceous, probably Albian–Aptian age (Durham, 1984; personal communication).

The strata attributed to this terrane range from proximal turbidites with boulder conglomerate to distal turbidites with intercalated chert beds. Quartzite conglomerates (Phillips, 1984) and Precambrian zircons (Bushee et al, 1963) suggest a cratonal provenance for the flysch sequences, whereas minor amounts of andesite-rhyolite volcanic material in the Cretaceous sections suggest proximity to the contemporaneous arc. Some 6.5+ km (4 mi) of stratigraphic thickness has been measured on the 30th parallel.

It is tempting to relate all of these deposits to a single Triassic to Cretaceous apron of continentally derived debris, but it is entirely possible that the Triassic–Jurassic strata of southern California and the Lower Cretaceous strata of the 30th parallel belong to unrelated terranes. Flysch deposits, reportedly including a Jurassic ammonite, are found in western Nayarit (IIIA, Fig. 3; Gastil et al, 1979).

PALEOZOIC AND LOWER TRIASSIC ROCKS OF THE 30th PARALLEL AND CALAMUJUE CANYON

A several kilometer thick section along the 30th parallel includes highly variable lithologies of quartzite-carbonate, fine-grained clastics, thin-bedded carbonate rocks, bedded chert, and olistostrome blocks. The Paleozoic portion of this section has yielded few identified fossils, the most significant being early Permian *Parafusulina kummeli* (Stevens, in Gastil and Miller, 1983). Strata below the recognized Permian contain unidentified crinoidal debris, corals, and byrozoan fragments (Delattre, 1984).

Above the Permian rocks are fine-grained clastics, interbedded chert-carbonate-sandstone-pebble conglomerate, and thin intervals of organic-rich, micritic limestone. These dark limestones contain Early Triassic (Smithian) conodonts and ammonites (Gastil et al, 1981; Gastil and Miller, 1983; Buch, 1984). The entire section has undergone upper greenschist to lower amphibolite grade regional metamorphism.

Recent conodont discoveries in Calamujue Canyon (latitude 29° 30′) indicate the presence of clastic and carbonate strata of Lower Mississippian age.

THE BALLENAS TERRANE

Rocks grouped in this terrane occur along the Ballenas Channel of the Gulf of California from latitude 29° 30′ to 29° 40′ N, on the southwestern coast of Isla Angel de la Guarda, on the southern tip of Isla Tiburon, and at one point along the adjacent coast of Sonora (Gastil and Krummenacher, 1976, 1977) (for place names refer to Fig. 2; for generalized stratigraphy refer to Fig. 4). The only identified fossils are from horizons of bioclastic (crinoidal) limestone that yield conodont fragments of Lower Devonian age. This section consists largely of thin-bedded graywacke, chert, and carbonate rocks, with some olistostromal breccias. Parts of this section can be termed carbonate-rich flysch. There are also thicker carbonate rock units, grading to quartz arenite. One 100 m (328 ft) thick unit consists primarily of volcanic/volcaniclastic (basaltic?) strata. Other (possibly overlying) sections contain considerable metadolostone and quartzite, bedded chert, and pillow basalt.

Rocks of the Ballenas Channel appear to be greenschist facies, except where in contact with small bodies of tonalite and gabbro. Locally the rocks have been tightly folded but do not display the extreme flattening or strong downdip lineation found in some of the terranes described above. Fold axes are subhorizontal, and recumbent and thrust structures occur locally. It is possible that this terrane correlates with rocks in the Sierra Pintas (latitude 31° 35′ to 31° 50′) and with rocks east of Hermosillo, Sonora (Noll, 1981; Poole et al, 1983).

ROCKS OF THE SIERRA PINTAS

McEldowney (1970) mapped the northern Sierra Pintas and made the first discovery of Paleozoic fossils in Peninsular California. They are crinoid columnals, rugose

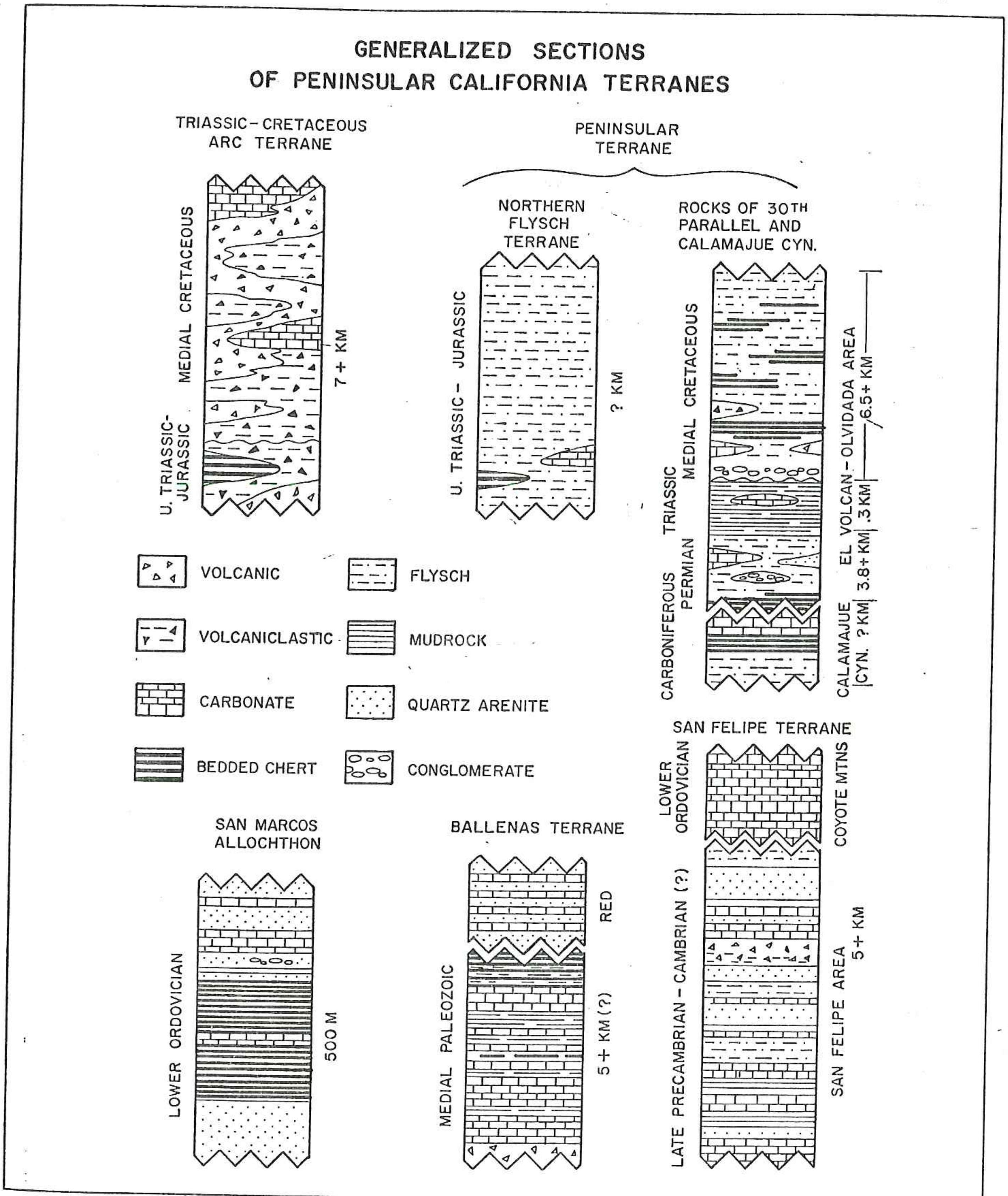

Figure 4—Generalized stratal sections for the terranes of Peninsular California.

corals, and brachiopods. No precise age has been determined, but Stevens (personal communication) has identified a coral as an upper Paleozoic lophophyllid. In the area where these fossils were found, the strata consist of fine clastics, chert, a crinoidal carbonate bed about 3 m (10 ft) thick, and sandstones and conglomerates consisting largely of basaltic debris with admixtures of carbonate rock and chert, both as clasts and as interbeds. In the northwestern part of the range, the section is largely flysch with a thick section of bedded chert. In the southern part of the range, the section includes a variety of carbonate rocks, bedded chert, and pebbly mudstones. No granitic intrusions are exposed, and much of the range appears to be greenschist facies. The northern basement rocks are recumbently folded on near horizontal N 80° west-trending fold axes, in sharp contrast with adjacent parts of the peninsula.

Most of the range is covered by Tertiary volcanic strata, and considering the contrasts of both lithology and structure between the northern and southern Sierra Pintas, it is possible that more than one terrane is represented. There are lithologic similarities both to the rocks of the Ballenas Terrane and to the more highly metamorphosed rocks of the Sierra Juarez, to the northwest.

Rocks of the El Fuerte Formation and San Jose de Garcia, northernmost Sinaloa, are reportedly calcareous flysch and chert deposits, similar to the Ballenas terrane of Baja California and Sonora (Mullen, 1978; Roldan, 1983, personal communication).

SAN FELIPE TERRANE

Near the town of San Felipe, the rocks range from lower greenschist grade along the coast to lower amphibolite grade a few kilometers inland. Anderson (1982) mapped these rocks in detail and constructed a composite stratigraphic section. He concludes that there is a strong resemblance to the Upper Precambrian/Lower Cambrian section of the Caborca area in western Sonora. Prominent units are the thick ultrapure quartz arenite (La Provedora–Zabriskie equivalent?) and a metabasalt unit (Puerto Blanco equivalent?). Unfortunately, no fossils have been discovered.

Although the rocks of the Sierra Cucapach are more metamorphosed than those of either San Felipe or the Coyote Mountains, they include at least two distinct metasedimentary sequences. The section exposed along the Mexicali–San Felipe Highway is thinly interlaminated metamorphosed dolostone/argillite, with some thicker argillite units. The assemblage exposed on the west side of the range includes interbedded metacarbonate and metaclastics rocks, a single unit of coarsely recrystallized ultrapure metaquartzite, and a section of "finely bedded" amphibolite. This association of laminated amphibolite with carbonate and metaquartzite strata is also found in the Coyote Mountains (latitude 32° 50′), west of Punta Diggs (latitude 30° 55′), and west of the Sierra Santa Rosa (latitude 30° 55′). These amphibolites, like those at San Felipe, may correlate with the basalt and basaltic conglomerate at the base of the Cambrian in the Caborca area (Eells, 1972; Stewart et al, in press).

Conodonts of Early Ordovician age were first reported from carbonate-quartzite rocks of the eastern peninsula by Miller and Dockum (1983). This locality is in a section of the Coyote Mountains estimated to be 1,200 m (3,937 ft) thick and consisting of 90% dolomitic marble. This section may overlie (stratigraphic-top indicators have yet to be recognized) a section of mixed clastics and subordinate carbonate rock, including at least one prominent ultrapure quartz arenite and one pebbly arkose member. It is tempting to speculate that the Lower Ordovician conodont-bearing carbonate rock is equivalent to part of the southern Great Basin Pogonip Group and that "underlying" strata include correlatives of the Zabriskie and Wood Canyon Formations. Engle (1982, personal communication) reports that conodonts believed to be of similar age have subsequently been recovered from carbonate-quartzite strata of the Borrego and Santa Rosa Mountain area, northeastern San Diego and Riverside Counties. Similar carbonate quartzite-rich sections are known from the San Jacinto Mountains south to the southeastern end of the Sierra San Pedro Martir.

Throughout the San Felipe Terrane (Figs. 1, 4) units are thick-bedded, fine clastic rocks are subordinate, and carbonate rock predominates over quartzite. Most rocks are amphibolite facies metamorphic grade and in many areas are intimately intruded by Cretaceous age tonalite and granodiorite.

SAN MARCOS ALLOCHTHON

Lothringer (1984) made a detailed study of an allochthonous block (blocks) measuring 5.5 by 1 km (3.4 by .62 mi), 44 km (27 mi) south of Tecate. These blocks are part of a melange, and we consider them to be giant olistoliths. The two major lithologies are ultrapure quartzite (>99% SiO_2) and bedded chert (grading to siliceous shale) with thin argillaceous partings. Calcium carbonate marble is a third but relatively minor section component. Upper Lower Ordovician conodonts have been recovered from a crinoidal limestone (Gastil and Miller, 1981, 1983). Algal (?) and oolitic structures were observed in other carbonate rock layers. Cross-bedding occurs but is rare in both the quartzite and carbonate rocks. Granule-size quartz grains are common in the quartzite, and a well-rounded pebble to cobble conglomerate of chert and quartzite clasts occurs locally. A few meters of carbonaceous slate is found at one locality.

We interpret the giant olistoliths of Rancho San Marcos to have been deposited into a flysch basin during the Mesozoic (?). They were intruded, folded, and metamorphosed to zeolite and greenschist grades during the Upper Cretaceous. The resistant quartzite layers are bent into open folds, with less resistant flysch showing a strong axial plane foliation.

The combination of carbonate rock and massive clean quartzite with thick-bedded chert sections also suggests a correlation to the Valmy, Vinini, and other "transitional" rocks of north-central Nevada and east-central California (Ketner, 1984, personal communication). This allochthonous block occurs within the Triassic–Cretaceous flysch of the Peninsular Terrane.

A block of carbonate rocks, covering only a few acres, crops out a few kilometers northwest of the San Marcos blocks. A considerable area of allochthonous rock exists some 6 km (3.7 mi) to the southwest (Friet, 1984, San Diego State University Senior Report). It is possible that many of the carbonate rock exposures within the Peninsular flysch terrane of western Baja California are also allochthonous blocks.

There are several contrasts between the Lower Ordovician rocks of San Marcos and the Lower Ordovician rocks of Coyote Mountain (San Felipe Terrane). One is the small ratio of carbonate rock to metaquartzite and the relative abundance of bedded chert at San Marcos. A second is the fact that the conodont fauna of Coyote Mountain has "Midcontinent" faunal affinities, common to the miogeoclinal rocks of the Great Basin, whereas the San Marcos fauna is similar to Early Ordovician "North Atlantic" faunas, found in the deeper water facies rocks of the Roberts Mountain allochthon. These contrasts suggest that the Coyote Mountain and Rancho San Marcos localities, respectively, correlate with the miogeoclinal facies (as found in southern Nevada) and the "inner arc basin" facies (as found in the Roberts Mountain allochthon of west-central Nevada).

ROCKS OF WESTERN SONORA

The Caborca area (Eells, 1972; Stewart et al, in press), consists of Precambrian gneiss and granite overlain by Late Precambrian to Devonian miogeoclinal rocks, platform deposits of Carboniferous to Early Jurassic age, and arc volcanic strata of Late Jurassic age. The Paleozoic rock of the Caborca area is bounded on the northeast by the Mojave–Sonora megashear and on the southwest by the Late Cretaceous batholith.

Southeast of Hermosillo, in the Sierra Cobachi and near the Barita de Sonora Mine, Rebeico quadrangle (IV, Fig. 3), are rocks of Ordovician to Devonian age that more resemble the "inner arc basin" facies of the Roberts Mountains allochthon (Ross, 1977; Poole et al, 1977). It is the recognition of these strata that led Dickinson (1981) to bring the tectonic elements of northern California and Nevada all the way around to Sonora and inspired Silver and Anderson (1983) to add Megashear II. These rocks are included in the Ballenas Terrane (IVA, Fig. 3).

Near the Gulf of California, prebatholithic rocks of Sonora have been metamorphosed and intruded much as they are in the Peninsula. Some metamorphosed strata are clearly a continuation of strata in the Caborca area, but others are thinly bedded carbonate/flysch and/or interbedded with andesite/rhyolite volcanic rocks. Between latitudes 29° 30′ N and 29° 50′ Anderson and Silver (1969) reported volcanic rocks of latest Jurassic and medial Cretaceous ages (IIA, Fig. 3). Throughout the Sierra Bacha, Sierra Seri, and eastern Isla Tiburón, andesitic to rhyolitic volcanic rocks are associated with metacarbonate and other metasedimentary strata of uncertain age (Gastil and Krummenacher, 1977).

AS-YET UNIDENTIFIED TERRANES

Although much of what has already been described may appear to the reader as "unidentified," Peninsular California includes additional large areas of metamorphic rock for which correlation is even less certain.

Extensive areas of highly foliated and recrystallized granitic rock occur in the Santa Rosa Mountains of Alta California, north of the town of Julian, throughout the Laguna Mountains of San Diego County, the Coyotes, the Cucupahs, and the northern Sierra San Pedro Martir. In many cases these rocks are so foliated and recrystallized as to be of uncertain protolith (Hirsch, 1984, MS Thesis, San Diego State University). The fact that these rocks include xenoliths of metasedimentary rock tempts the observer to identify them as earlier (probably Mesozoic) intrusives into Paleozoic and/or Mesozoic country rock, and for many this is probably the correct explanation. However, there are reasons to be suspicious. Many of these rocks, unlike most plutons of the Cretaceous batholith, are S type (Todd and Shaw, 1979) and have heavy mineral concentrates that are predominantly monazite or xenotime rather than zircon. Xenoliths in the granitic gneiss near Julian are largely calc-silicate rock, although calc-silicate rocks are rare in the host Julian Schist. We cannot yet dismiss the possibility that some of these gneisses are Precambrian basement.

Until recently, the largely metaclastic rocks found throughout the Sierra Juarez and the northern half of the Sierra San Pedro Martir (Santa Eulalia Formation of Woodford and Harriss, 1938) were carelessly referred to as "Julian Schist"—the amorphous "country rock" of the batholith. The discovery of Ordovician conodonts in the Coyote Mountains now forces us to make new assessments. The Coyote Mountain miogeoclinal section appears to give way progressively to carbonate-poor strata southwestward across the eastern foothills of the main Peninsular Range. However, patches of metacarbonate rock occur throughout the Sierra Juarez, and there are also intervals of recrystallized bedded chert. The type Julian Schist and the Mesozoic(?) flysch of northwestern Baja California do not contain carbonate rock or bedded chert. We are forced to speculate whether we are looking at two very different assemblages of dominantly metaclastic rock, one that is early to middle Paleozoic, possibly even older, and one that is Mesozoic. We have included these possibly older dominantly flysch rocks in the Ballenas Terrane.

Because these unidentified rocks are almost entirely of sillimanite metamorphic grade, it is unlikely that the puzzle will be unraveled by fossil discoveries. A solution will require the systematic description of protoliths in both the weakly and strongly metamorphic terranes and techniques of geochemical fingerprinting.

TERRANE BOUNDARIES

We will consider terrane boundaries in sequence from west to east across the peninsula. As stated earlier, we will not attempt here to delineate boundaries within the composite continental borderland terrane.

At Arroya San Jose, arc volcanics of the medial

Cretaceous Alisitos Formation unconformably overlie Upper Triassic and Lower Jurassic volcanic arc strata (Minch, 1969). In the Vizcaino peninsula, clasts up to a meter in diameter, believed to be derived from the Alisitos arc, form conglomerates of Turonian age (Robinson, 1979; Patterson, 1979). Thus, by Turonian time, it appears that the pre-Cretaceous arc and the arc-derived molasse of the borderland were part of the same terrane as the Jurassic–Cretaceous arc.

Despite considerable search, no depositional contacts have been found between the arc volcanic rocks of the western peninsula and the adjacent flysch belt to the east. In the two places where direct contact is observed, the contact is a fault. In the Santa Ana Mountains, harzburgite and melange are exposed in the fault zone (Davis, 1981, personal communication). Along the southwestern edge of the Sierra San Pedro Martir there is not only a contrast in lithology but in metamorphic grade and deformational style, with the zone of mylonitization being a kilometer wide. The deformation style in the flysch suggests reverse faulting of the interior of the peninsula over the arc, rather than strike-slip faulting.

On the 30th parallel, however, Lower Cretaceous flysch rests unconformably on Triassic and Permian strata. There is a temptation to conclude from this that the entire belt of Upper Triassic–Cretaceous flysch rocks is in depositional contact with Lower Triassic and Paleozoic rocks to the east. For this reason, these two sequences have been grouped together as the Peninsular Terrane.

The proposed correlation of carbonate-quartzite rocks of the San Felipe area with the Caborca rocks (cratonal North America) (Fig. 3) argues against major strike-slip separation between the two areas (beyond the 300 km [186 mi] of post-Miocene translation). Silver and Anderson's (1983) Megashear II contradicts this proposed correlation. Any reconstruction that brings Peninsular California from far to the south ignores the fact that there are no reported strata similar to the Caborca rocks in southern Mexico or Central America.

Although many of the Jurassic–Cretaceous volcanic rocks of western Sonora are in low-angle fault contact with the underlying Caborca rocks, the evidence adequately demonstrates that these volcanic rocks were deposited on the same kinds of rocks that they now rest on. Large metamorphosed quartzite and carbonate bodies in the southern Sierra Bacha and Sierra Seri suggest that the Caborca rocks are exposed nearly all the way to the Gulf coast (Figs. 2, 3).

DISCUSSION

Except for paleomagnetic evidence from gabbroic and granitic rocks of the western peninsula (Beck and Plumbley, 1979; Beck, 1980; Erskine and Marshall, 1980), there would be no reason to consider terranes of Peninsular California exotic to North America. In the Vizcaino Peninsula borderland rocks appear to have been in depositional contact with the peninsular arc since at least Turonian time. The arc is in fault contact with the flysch, but most probably by reverse faults resulting from the postemplacement uplift of the batholith's axis. The flysch rests unconformably on Triassic and upper Paleozoic strata near Mina Olvidada. And the Lower Paleozoic carbonate-quartzite rocks of the eastern edge of the peninsula appear continuous with those on the opposite side of the Gulf (Fig. 3). Thus, one can argue that the best evidence at hand, skimpy as it is, favors in situ origins for Turonian and younger rocks (save for 300 km [186 mi] on the San Andreas Plate Boundary) and for all rocks east of the Jurassic–Cretaceous arc (except for 800 km [497 mi] of mid-Jurassic translation on the Mojave–Sonora megashear).

Faunal and lithologic similarities exist between the "inner arc basin" Ordovician and Devonian rocks of northwestern Nevada and east-central California, and similar age rocks found in Baja California, and between the Permian and Triassic rocks of the 30th parallel and those of the Inyo Mountains, California. Eight hundred kilometers (497 mi) of left-lateral slip along the Mojave–Sonora Megashear I places Baja California adjacent to these proposed correlatives. It is not our purpose to propose these correlations as additional evidence for the megashear but rather to indicate that the distribution is not inconsistent with the megashear. It is of course still possible to make the stratigraphic correlations without strike-slip juxtaposition.

Several questions are left unanswered. From what location did the giant olistoliths of Ordovician quartzite and bedded chert slide into a Mesozoic(?) flysch basin at Rancho San Marcos? If the Ordovician rocks in the eastern part of the peninsula were part of the miogeocline, was there also an exotic cratonal terrane to the west? On Isla Cedros, Boles and Landis (1984) found that upper Paleozoic olistostromal blocks of shallow-water carbonate rock and quartzite were transported from the north and deposited into a Jurassic clastic basin. Then there is the Sierra Pintas with medial (?) Paleozoic basaltic strata and a structural style foreign to the peninsula, located almost astride the belt of miogeoclinal rocks. Are all of these suspect rocks part of an exotic terrane sutured onto western North America at some time near the end of the Paleozoic and moved northeastward during the Jurassic?

If we assume that paleomagnetic indications of transport from far to the south for much of the Peninsula is correct, are there any scenarios left by which this evidence can be reconciled? To answer this we should first define the total extent of Cretaceous and older rocks that have shared this hypothetical translation. If all of the peninsular granitic rocks moved together, then there is no choice but to place the candidate "suture" in or east of the Gulf of California. In which case proposed correlations across the Gulf of California are either erroneous or result from the fortuitous existence of a subparallel, left-lateral Megashear II that effectively cancels out right-lateral movement for pre-Jurassic rocks. If the granitic rocks in the eastern part of the peninsula do not show this translation, we are dealing with a Sumatran-type intra-arc fault that was active during the emplacement of the batholith for which the evidence has been largely destroyed by the continued emplacement and final uplift of the granitic rocks. The paleomagnetically hypothesized provenance of the Mesozoic arc terrane (locality IIE) is along the Middle American Trench.

In summary, the prebatholithic rocks of Peninsula California can be considered as an integral part of western North America, but unexplained relationships still exist, and exotic provenance for some terranes cannot be ruled out.

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