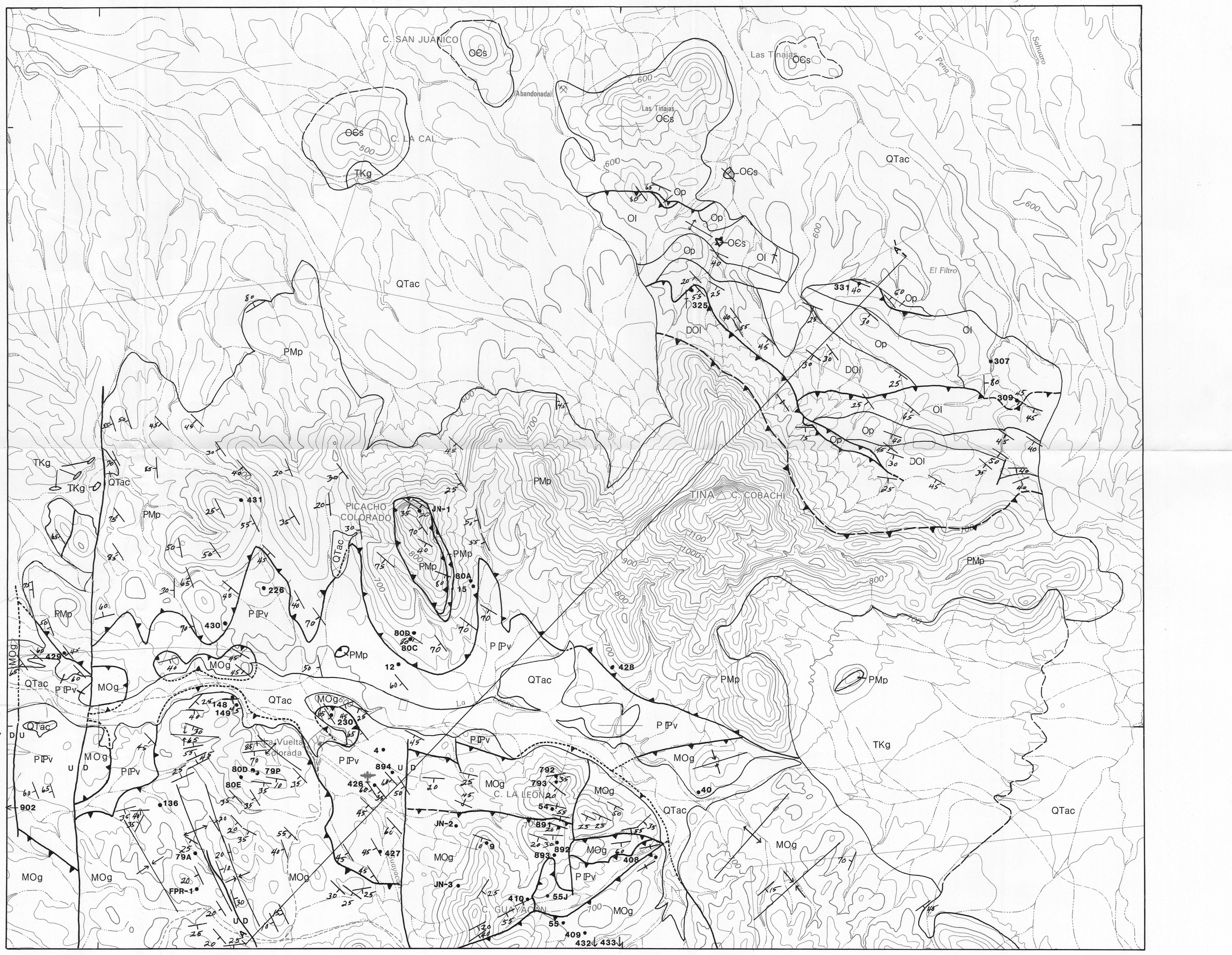
DEPARTMENT OF THE INTERIOR
U.S. GEOLOGICAL SURVEY

MISCELLANEOUS FIELD STUDIES
MAP MF-1980

Paleontological Control
[Portions of sample numbers in bold-face type are shown on map]

Number	Age	Paleontologist	Collector
	Carbonate-quartzite, shallow-water assemblage		
	Picacho Colorado Formation		
1-12-**80C**	Wordian	Douglass	Noll
1-12-**80D**	Leonardian	Douglass	Noll
JN-1	Leonardian	Douglass	Noll
29428-PC	late Wolfcampian	Wardlaw, Stamm	Ketner
29429-PC	late Wolfcampian	Wardlaw, Stamm	Ketner
29430-PC	Morrowan-Atokan	Wardlaw, Stamm	Ketner
29431-PC	late Morrowan	Wardlaw, Stamm	Ketner
82-FP-**15**	Chesterian	Wardlaw	F.G. Poole
1-12-**80A**	Probably Mississippian	Sando	Noll
	Tinajas Group		
12325	Middle or Late Devonian	Repetski, Harris	Ketner
12309	late Canadian or early Whiterockian	Repetski	Ketner
12331	late Canadian or early Whiterockian	Repetski	Ketner
12307	early Canadian	Repetski	Ketner
	Siliceous, deep-water assemblage		
	Vuelta Colorada Formation		
82-FP-**12**	early middle Leonardian	Wardlaw	F.G. Poole
82-FP-**226**	early middle Leonardian	Wardlaw	F.G. Poole, Noll
82-FP-**4**	early middle Leonardian	Wardlaw	F.G. Poole, Noll
55J	Atokan-Desmoinesian	Murchey	Murchey, Ketner
28894-PC	late Morrowan or Atokan	Harris	Harris, Wardlaw, Ketner
29426-PC	late Morrowan	Wardlaw, Stamm	Ketner
29427-PC	late Morrowan	Wardlaw, Stamm	Ketner
	Guayacan Group		
29409-PC	late Osagean	Denkler, Harris	Ketner
29432-PC	middle Osagean	Wardlaw, Stamm	Ketner
29433-PC	middle Osagean	Wardlaw, Stamm	Ketner
82-FP-**148**	Osagean	Wardlaw	F.G. Poole, Noll
28892-PC	early Osagean	Harris	Harris, Wardlaw, Ketner
28893-PC	early Osagean	Harris	Harris, Wardlaw, Ketner
28891-PC	late Kinderhookian	Harris	Harris, Wardlaw, Ketner
82-FP-**149**	late Kinderhookian	Wardlaw	F.G. Poole, Noll
82-FP-**230**	late Kinderhookian	Wardlaw	F.G. Poole, Noll
29408-PC	middle Kinderhookian	Denkler, Harris	Ketner
29410-PC	Early Mississippian	Denkler, Harris	Ketner
11054-SD	latest Famennian	Denkler, Harris	Ketner
11055-SD	latest Famennian	Denkler, Harris	Ketner
6-12-**79P**	Famennian	Dutro	Noll
8-9-**80D**	Famennian	Dutro	Noll
8-9-**80E**	Famennian	Dutro	Noll
10792-SD	latest Frasnian to earliest Famennian	Harris	Harris, Wardlaw, Ketner
10793-SD	latest Frasnian to earliest Famennian	Harris	Harris, Wardlaw, Ketner
82-FP-**9**	late Frasnian	Wardlaw	F. G. Poole, Noll
82-**JN-40**	Frasnian	Wardlaw	Noll
11902	latest Ordovician	Riva	Ketner
12136	Middle Ordovician	Carter	Ketner
FPR-1	Middle Ordovician	Riva	F. Peiffer-Rangin (1980)
6-18-**79A**	Middle Ordovician	Riva	Noll
JN-2	Ordovician	Noll	Noll
JN-3	Ordovician	Noll	Noll

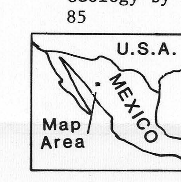


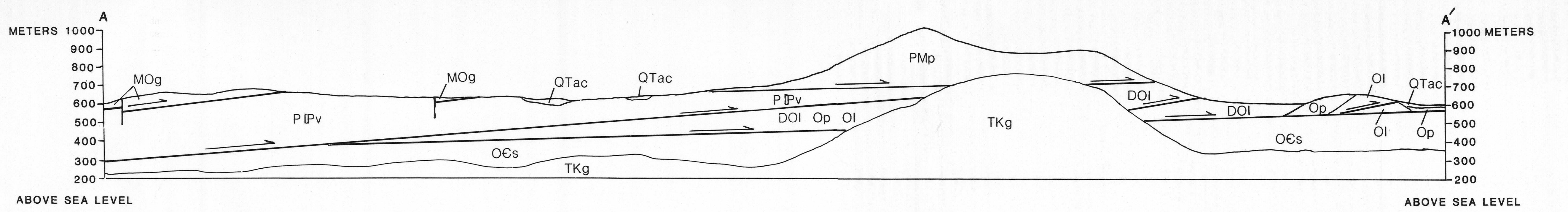
Base from Estados Unidos Mexicanos Comision de Estudios del Territorio Nacional, Cobachi quadrangle (H12D53) 1975, 1:50,000

SCALE 1:20,000

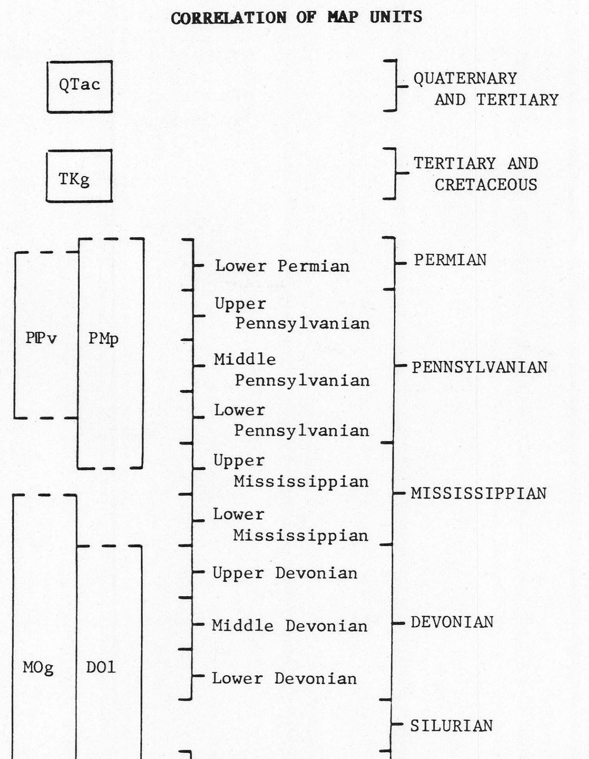
CONTOUR INTERVAL 20 METERS
DATUM IS MEAN SEA LEVEL

Geology by John H. Noll, Jr., 1979–80, and Keith B. Ketner, 1983–85





CORRELATION OF MAP UNITS



DESCRIPTION OF MAP UNITS

QTac **Alluvium and colluvium (Quaternary and Tertiary)**--Unconsolidated sand and gravel; thick soil and talus

TKg **Granitic intrusives (lowest Tertiary or Cretaceous)**--Coarse-grained granodiorite and granite. Granodiorite near the western boundary of the map area was dated by the potassium-argon method. Hornblende yielded an age of 65.9± 1.4 my and biotite yielded an age of 66.7± 1.4 my (Noll, 1981). Granite at Cerro La Cal in the northwestern part of the map area was dated in U.S. Geological Survey laboratories by the fission track method. Zircons yielded a date of 137.3± 15.3 my (R.A. Zimmerman, 1987, written commun.)

CARBONATE-QUARTZITE, SHALLOW-WATER ASSEMBLAGE

PMp **Picacho Colorado Formation (Permian to Mississippian)**--Thick-bedded limestone containing abundant shelly fauna; cliffy exposures tend to weather pink; some beds quartz-sandy and silty or dolomitic; sporadic chert nodules; altered to marble and calc-silicates near contact with granite. Named and first described by Noll (1981). Thickness probably very great but unknown owing to faults, subparallel to bedding, whose presence is revealed only by reversals in faunal sequence.

Tinajas Group (Devonian to Ordovician)--Subdivided into three mappable units:

DOl **Upper limestone (Devonian, Silurian?, and Upper Ordovician?)**--Thick sequence of thinly laminated black limestone that contains lenses of coarse, gray limestone in upper part and grades upward to thick-bedded, coarse-grained, gray limestone; dark dolomite locally at base. No fossils have been obtained from the dolomite or the thinly laminated limestone, but a single Middle or Late Devonian conodont was extracted from thick-bedded, coarse-grained part of sequence (J.E. Repetski, oral commun., 1985). Thickness of upper limestone is at least 250 m, but the top, and possibly base, are faults.

Op **Quartzite of Peña Blanca (Middle Ordovician)**--Mature fine- to medium-grained quartzite; upper, major part of unit is massive, pure-white, dense quartzite; basal beds are limy, bioturbated, discolored, and porous; constituent grains well sorted and well rounded; upper contact may be a fault or unconformity. Informally named quartzite of Peña Blanca and correlated with Middle Ordovician Eureka Quartzite by Ketner (1986). Thickness about 132 m.

Ol **Lower limestone (Lower and Middle? Ordovician)**--Thick-bedded, gray, quartz-silty, coarse-grained limestone; sporadic chert nodules and lenses; sparse, poorly preserved shelly fauna in upper part; probably gradational with overlying quartzite but contact obscure; unit well dated by conodonts; exposed thickness about 200 m, but base not exposed

O€s **Skarn (Ordovician? and Cambrian?)**--Limestone strongly metamorphosed to marble and calc-silicates; base not exposed, top faulted

SILICEOUS, DEEP-WATER ASSEMBLAGE

PIPv **Vuelta Colorada Formation (Permian and Pennsylvanian)**--Mainly limy, pyritic siltstone; lesser argillite, bedded chert, nodular and bedded barite; weathers to distinctive red soil, but all units dark gray or black in fresh exposures; graded bedding, sporadic lenses of coarse carbonate debris; dated by conodonts and radiolarians. Named and first described by Noll (1981). Base and top faulted; exposed thickness unknown owing to faults, subparallel to bedding, whose presence is indicated by reversals in faunal sequence

MOg **Guayacan Group (Mississippian to Ordovician)**--Subdivided into five units that locally can be mapped separately; unit named and first described by Noll (1981)

Limestone, argillite, siltstone, chert (Lower Mississippian)--Limestone is turbiditic, quartz-sandy, and chert-pebbly; argillite and siltstone are black; chert forms lenses in limestone and occurs as bedded chert sequences. Thickness probably great; top not exposed in map area; base unconformable on Devonian to Ordovician strata

Limestone, bedded chert, sandstone, conglomerate, bedded barite (Upper Devonian)--Extremely heterogeneous unit that includes some beds of probable deep-water origin (bedded chert, graded sandstone) and some beds that may be of shallow-water origin (grain-supported conglomerate, cross-bedded calcarenite, crinoidal limestone). Thickness at one point 180 m, but top and base are unconformities

Chert (Silurian?)--Massive white chert and thinly bedded, mainly light-colored chert; locally altered to strongly pigmented, porous gossan; thickness a few meters, but top is an unconformity

Chert (Upper Ordovician)--Black, bedded chert; beds generally more than 30 cm thick; sporadic ovoid nodules as much as 30 cm in diameter; dated by graptolites in shaly partings; contact with overlying light-colored Silurian(?) chert is gradational; thickness about 25 m

Shale (Middle Ordovician)--Pyritic, black shale; sandstone bed a few meters thick near top; abundant graptolites; upper contact conformable; locally metamorphosed to phyllitic schist. Base not exposed; exposed thickness about 100 m

Contact--Dashed where position uncertain

Anticline

Syncline

High-angle fault--Dotted where concealed, U on upthrown side; D on downthrown side

Thrust fault--Dashed where position uncertain, dotted where concealed; sawteeth on upper plate

Strike and dip of beds

Inclined

Vertical

Overturned

Location and number of fossil collection

STRUCTURE

Eight principal thrust plates were mapped in the Cerro Cobachi area. Plates 1, 2, and 8 comprise a relatively autochthonous carbonate and quartzite assemblage and plates 3-7 comprise a relatively allochthonous siliceous assemblage. Each plate is internally complex and consists of folded and faulted sequences, some of which include significant unconformities. Each plate, however, is bounded by major thrust faults and consists of an originally coherent stratigraphic sequence.

One of the most important structures, a thrust fault that juxtaposed the two assemblages of lower Paleozoic rocks, is not exposed. However, it is inferred to be present, concealed beneath plate 8, because units of the siliceous assemblage exposed on the south side of plate 8 are less than 2 km from contemporaneous but contrasting units of the carbonate and quartzite assemblage exposed on the north side of it.

Plate 1, the structurally lowest plate of the limestone and quartzite assemblage, is composed of marble and calc-silicates. Its internal structure is probably complex but remains unknown in the absence of paleontologic dating of beds.

Plate 2, which consists of carbonate and quartzite, is sliced by thrust faults and locally folded. The axis of one well-defined fold trends northwest, and nearly all beds and faults strike northwest and dip southwest.

Plate 3, the structurally lowest plate of the siliceous assemblage, is composed entirely of the Permian and Pennsylvanian Vuelta Colorada Formation. Although the bedding consistently strikes northwest and dips southwest as if it were an uncomplicated homoclinal sequence, paleontologically dated beds are out of normal sequence, indicating the probable presence of concealed faults. No evidence of large-scale, tight folding was observed, but in several outcrops small-scale folds, breccia, and mylonite are visible.

Plate 4 consists of units assigned mainly to the siliceous Guayacan Group. Reconnaissance indicates that the Vuelta Colorada Formation may be present also near the southern border of the map area. The rocks of plate 4 are strongly folded about northeast-trending axes. These folds have yet to be defined by detailed mapping and measurements of bedding attitudes, but they are plainly visible on the ground and on aerial photographs.

The structure of plate 5, composed of all units of the Guayacan Group, is basically simple, consisting of a series of broad, gentle folds whose axes strike northwest. Locally, however, this pervasive pattern is interrupted by small, sharp folds, breccia zones, minor thrusts, and high-angle faults. Bedded chert seems especially prone to be locally tightly folded. The major folds in the western part of this plate have wave lengths of about 800 m and amplitudes of about 25 m. In the western part of plate 5, the Devonian beds tend to crop out on hilltops, whereas the Ordovician beds tend to be exposed in the valleys. A striking man-made landscape feature of this plate is the concentration of partially excavated Devonian barite deposits along the ridges.

Plate 6 is a small slice of the Pennsylvanian part of the siliceous Vuelta Colorada Formation. Bounding thrust faults strike northeast and dip southeast. Intense fracturing of this plate prevents determination of bedding attitudes.

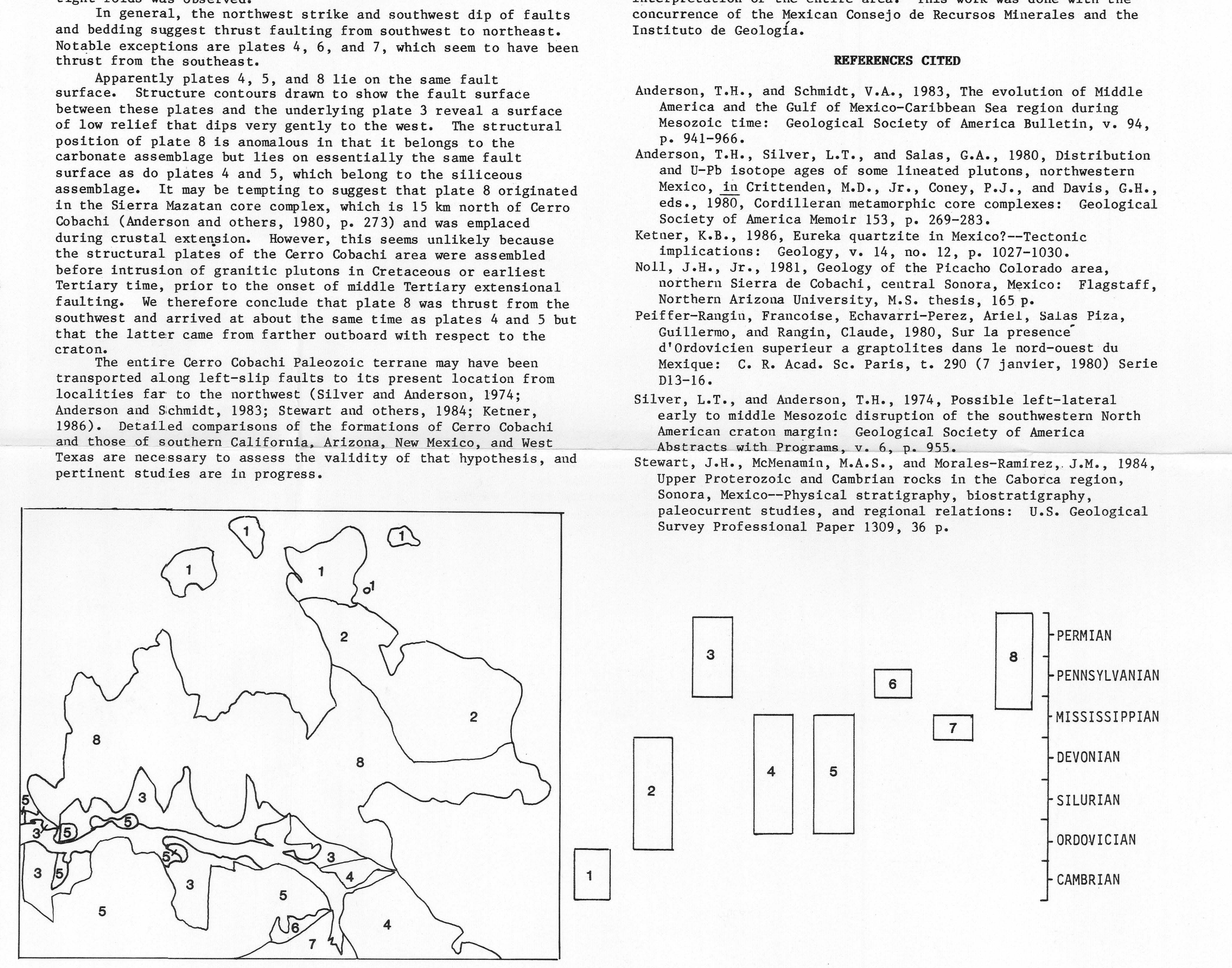
Plate 7 within the map area, and for a distance of about 2 km south of the map boundary along Arroyo San Clemente, consists of latest Devonian and Mississippian rocks of the Guayacan Group that strike northeast-southwest and are nearly vertical.

Plate 8, composed entirely of the Picacho Colorado Formation, is a homoclinal sequence internally sliced by faults subparallel to bedding. Although two of these are evident from direct observation, others are inferred to be present from the fact that paleontologically dated beds are out of normal sequence. Beds consistently strike northwest and dip southwest. No evidence of tight folds was observed.

In general, the northwest strike and southwest dip of faults and bedding suggest thrust faulting from southwest to northeast. Notable exceptions are plates 4, 6, and 7, which seem to have been thrust from the southeast.

Apparently plates 4, 5, and 8 lie on the same fault surface. Structure contours drawn to show the fault surface between these plates and the underlying plate 3 reveal a surface of low relief that dips very gently to the west. The structural position of plate 8 is anomalous in that it belongs to the carbonate assemblage but lies on essentially the same fault surface as do plates 4 and 5, which belong to the siliceous assemblage. It may be tempting to suggest that plate 8 originated in the Sierra Mazatan core complex, which is 15 km north of Cerro Cobachi (Anderson and others, 1980, p. 273) and was emplaced during crustal extension. However, this seems unlikely because the structural plates of the Cerro Cobachi area were assembled before intrusion of granitic plutons in Cretaceous or earliest Tertiary time, prior to the onset of middle Tertiary extensional faulting. We therefore conclude that plate 8 was thrust from the southwest and arrived at about the same time as plates 4 and 5 but that the latter came from farther outboard with respect to the craton.

The entire Cerro Cobachi Paleozoic terrane may have been transported along left-slip faults to its present location from localities far to the northwest (Silver and Anderson, 1974; Anderson and Schmidt, 1983; Stewart and others, 1984; Ketner, 1986). Detailed comparisons of the formations of Cerro Cobachi and those of southern California, Arizona, New Mexico, and West Texas are necessary to assess the validity of that hypothesis, and pertinent studies are in progress.



Locations and stratigraphic ranges of structural plates. Structural positions of the plates range from 1 (lowest) to 8 (highest).

ACKNOWLEDGMENTS

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PRELIMINARY GEOLOGIC MAP OF THE CERRO COBACHI AREA, SONORA, MEXICO

By

Keith B. Ketner and John H. Noll, Jr.

1987

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