New Mexico Geological Society

Downloaded from: https://nmgs.nmt.edu/publications/guidebooks/35



Structural controls on basin-margin sedimentation--Pennsylvanian Taos trough, New Mexico, and contemporary Belize, Central America

Patricia W. Dickerson

1984, pp. 101-105. https://doi.org/10.56577/FFC-35.101

in:

Rio Grande Rift (Northern New Mexico), Baldridge, W. S.; Dickerson, P. W.; Riecker, R. E.; Zidek, J.; [eds.], New Mexico Geological Society 35th Annual Fall Field Conference Guidebook, 379 p. https://doi.org/10.56577/FFC-35

This is one of many related papers that were included in the 1984 NMGS Fall Field Conference Guidebook.

Annual NMGS Fall Field Conference Guidebooks

Every fall since 1950, the New Mexico Geological Society (NMGS) has held an annual Fall Field Conference that explores some region of New Mexico (or surrounding states). Always well attended, these conferences provide a guidebook to participants. Besides detailed road logs, the guidebooks contain many well written, edited, and peer-reviewed geoscience papers. These books have set the national standard for geologic guidebooks and are an essential geologic reference for anyone working in or around New Mexico.

Free Downloads

NMGS has decided to make peer-reviewed papers from our Fall Field Conference guidebooks available for free download. This is in keeping with our mission of promoting interest, research, and cooperation regarding geology in New Mexico. However, guidebook sales represent a significant proportion of our operating budget. Therefore, only *research papers* are available for download. *Road logs*, *mini-papers*, and other selected content are available only in print for recent guidebooks.

Copyright Information

Publications of the New Mexico Geological Society, printed and electronic, are protected by the copyright laws of the United States. No material from the NMGS website, or printed and electronic publications, may be reprinted or redistributed without NMGS permission. Contact us for permission to reprint portions of any of our publications.

One printed copy of any materials from the NMGS website or our print and electronic publications may be made for individual use without our permission. Teachers and students may make unlimited copies for educational use. Any other use of these materials requires explicit permission.

This page is intentionally left blank to maintain order of facing pages.

STRUCTURAL CONTROLS ON BASIN-MARGIN SEDIMENTATION: PENNSYLVANIAN TAOS TROUGH, NEW MEXICO, AND CONTEMPORARY BELIZE, CENTRAL AMERICA

PATRICIA WOOD DICKERSON
Conoco, inc., P.O. Box 1959, Midland, Texas 79702

INTRODUCTION

Regional structural influences on mixed carbonate—siliciclastic basin-margin sedimentation in the Pennsylvanian Taos trough were analogous in several respects to influences on sedimentation in contemporary Belize. Common elements include episodically rising granitic highlands at the basin margins, supplying siliciclastic sediments, as well as faults and fault-bounded ridges active during carbonate-platform sedimentation and localizing reef or mound development.

Beyond the basin margins, however, the differences are significant. There was no wave-resistant organic barrier to snorkel along at the Pennsylvanian platform edge, as there is in Belize. Subsurface data are sparse, but apparently the carbonate platform of the southern Taos trough sloped gradually basinward. Additionally, whereas the Taos trough was relatively narrow and almost surrounded by highlands, the Gulf of Honduras east of Belize opens into the abyssal depths of the Cayman trench and the Caribbean Sea. There, siliciclastic sediments commonly bypass the shelf and are carried out through channels in the reef to be deposited at the foot of the steep slope or beyond.

The observations on basin-margin structure and sedimentation presented here are based upon several years' work in the Sangre de Cristo, as well as on a recent aerial and surface reconnaissance and underwater sampling in Belize.

TAOS TROUGH

Structural and Geographic Setting

Taos trough was part of the suite of Pennsylvanian to Early Permian basins and uplifts in New Mexico and Colorado generally referred to as the Ancestral Rockies. In places the older uplifts coincide with Cenozoic Rocky Mountain uplifts; in New Mexico, however, the Paleozoic features are found considerably east and west of the younger ones. A narrow extension of the Central Colorado trough, the Taos trough was a maximum of 140 km long and 165 km wide (Fig. 1; Baltz, 1978). Its depth varied in response to periodic movements of the surrounding highlands, the influences of which will be discussed below.

In contrast with the situation in Belize, northern New Mexico was not at the convergence of major crustal plates during the Pennsylvanian, although some workers suggest that the tectonism there may represent a response to late Paleozoic plate convergence farther to the southeast (Woodward and Ingersoll, 1979). Both the uplifts and the basins have foundations 1.5-1.7 b.y. old, primarily granitic and metamorphic continental crust; there is no evidence for late Paleozoic crust, either continental or oceanic, in the region.

Siliciclastic sedimentation predominated in the northern trough, where roughly 5,000 m of sediment accumulated. Casey's (1980) exemplary lithologic and paleoenvironmental study of the siliciclastic sediments should be consulted for details. Shallow-platform carbonate deposition characterized the southern part of the trough, and those strata attain thicknesses of about 1,000 m (Sutherland, 1963). Predictably, an area of mixed carbonate—siliciclastic sedimentation intervened. Kues (this guidebook) presents an excellent discussion of the evolution of Pennsylvanian stratigraphic nomenclature applied to this complex sedimentary suite.

In Pennsylvanian time, the area was at tropical latitude and the climate was one of high air and water temperatures and heavy rainfall. Those conditions resulted in rapid mechanical and chemical weathering of the granitic and metamorphic rocks that were sources of siliciclastic sediments. To the south, away from major siliciclastic influxes, the warm and well-oxygenated waters of moderately elevated pH favored extensive carbonate-platform development, and biologic productivity was generally high in the basin (Kues, this guidebook; Toomey, 1980; Sutherland and Harlow, 1973).

Uncompahgre Uplift

The principal structural element of the region during Pennsylvanian time was the Uncompahgre uplift, the eastern margin for part of which was the Pecos—Picuris fault zone (Fig. 2). That zone, intermittently active throughout the Pennsylvanian, had its origins in the Precambrian and continued its activity at least through Tertiary times (Miller and others, 1963; Robertson and Moench, 1979).

With each pulse of uplift along the west side of the trough, braided streams, alluvial fans, and fan-delta complexes carried coarse detritus progressively farther eastward into the basin (Casey, 1980; Figs. 3, 4). Headwaters of the streams were rising more or less continually and distances from headwaters to trough were not great; thus, braided streams developed, stream channels were relatively straight and confined, and the sediment load was coarse.

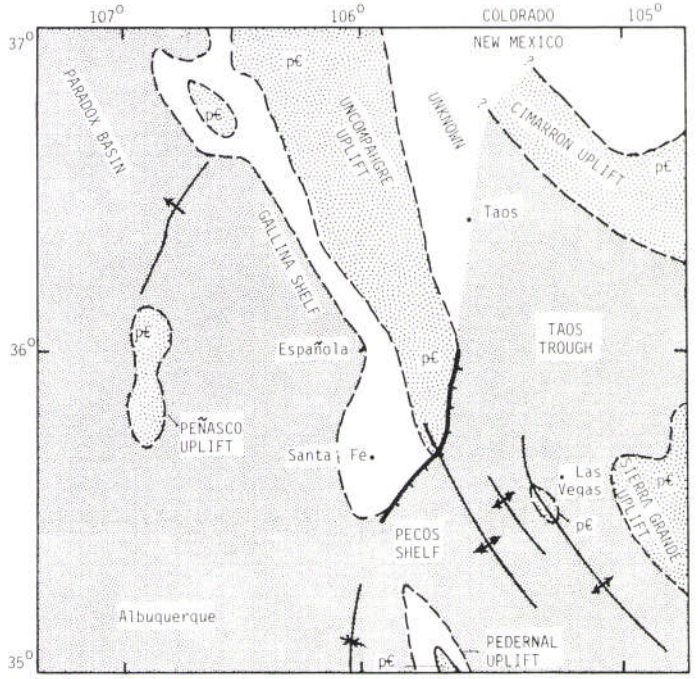


FIGURE 1. Pennsylvanian structural elements of north-central New Mexico. Portion of Pecos–Picuris fault zone coincident with eastern margin of Uncompahgre uplift shown with ticks on downthrown side (after Baltz, 1978; Woodward and Ingersoll, 1979).

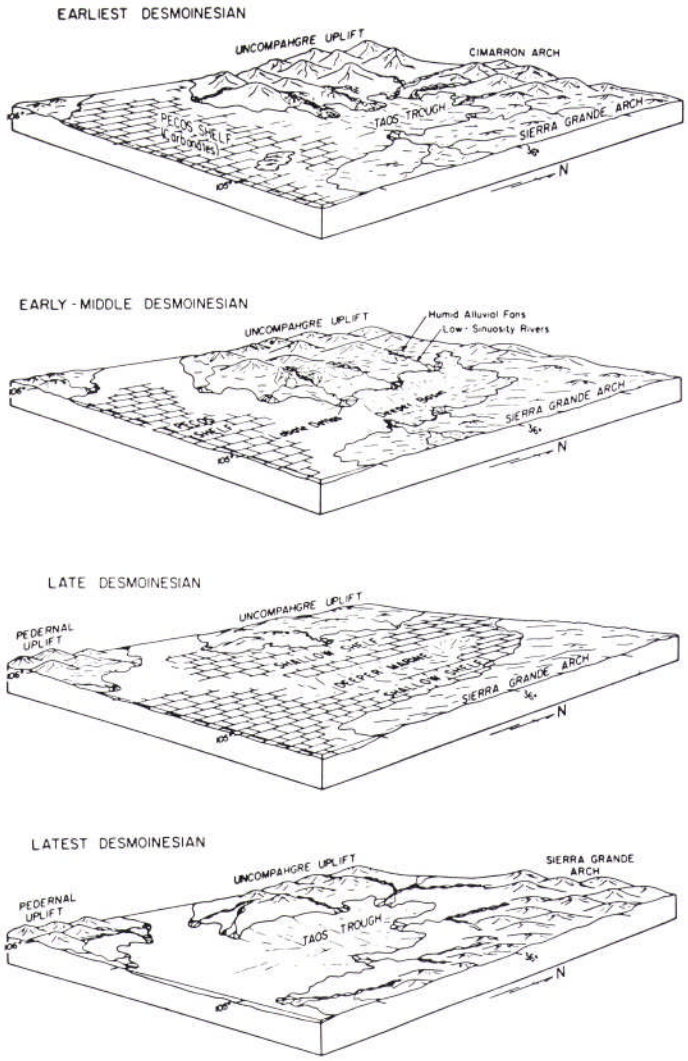


FIGURE 2. Desmoinesian paleogeography, north-central New Mexico (Casey, 1980).



FIGURE 3. Braided-stream-dominated humid alluvial-fan deposits (mid-Desmoinesian) about 4 km northwest of Tres Ritos along Rio Pueblo on N.M. 3. (For detailed description see Casey, 1980.)

Pedernal Uplift

From the Pedernal uplift, a broad platform extended north- and northeastward to the Uncompahgre and Sierra Grande uplifts (Fig. 2); about 1,000 m of primarily carbonate sediments accumulated on that platform (Sutherland, 1963). The Precambrian-granite-cored Pedernal uplift did not become a significant source of siliciclastic sediment until mid- to late Desmoinesian time and never rivaled the Uncompahgre in either elevation or volume of sediment supplied.

Although the Pedernal was quiescent during Early Pennsylvanian deposition, immediately east and subparallel to the Pecos—Picuris fault zone a series of fault-bounded ridges and basins formed concurrently with movement on the Pecos—Picuris zone (Booth, 1976, cited *in* Lisenbee, Woodward, and Connolly, 1979; Baltz and Bachman, 1956). Either erosion from, or nondeposition over, the ridges resulted in incomplete Pennsylvanian sections on those positive features. For example, one limestone unit (late Atokan—early Desmoinesian) that is approximately 235 m thick in the basin becomes only 45 m thick on one of the ridges north of Lamy and west of Apache Canyon fault (Booth, 1976, cited *in* Lisenbee, Woodward, and Connolly, 1979).

Where less prominent positive areas were present within the platform sequence, deposition may have been continuous, but higher-energy carbonate facies developed. Phylloid algal mounds flourished on shoals, scarps, and other slightly elevated areas of Pennsylvanian sea floors. The large mid-Desmoinesian algal mound at Montezuma (Toomey, 1980; Fig. 5) appears to have grown on an earlier north-trending Pennsylvanian ridge in the position now occupied by the Creston anticline. A sequence of stacked mounds exposed on Johnson Mesa is of similar trend; the possible influence of relict structure on mound development there and at other localities in the southern Sangre de Cristo is now being examined. Analogous colonization on elevated fault blocks within a carbonate platform takes place today in Belize and will be discussed below.

Northward along the western portion of the platform, progressively more clay, silt, and fine sand became mixed with the carbonate sediments. The sequence on Johnson Mesa comprises at least three cyclic sets of mixed siliciclastic/carbonate deposits; each set grades upward from phylloid algal mound to mound—debris shoal, marl, siltstone, and finally coal. Between cycles there was a brief depositional hiatus before submergence resulted in re-establishment of an algal community. In the region of mixed sedimentation, algae commonly colonized levees and bars of abandoned fan-delta lobes (Casey, 1980); Choi and Ginsburg (1982) describe similar colonization by corals occurring presently in the southern shelf lagoon of Belize.

Sierra Grande Uplift

The Sierra Grande was another Precambrian-granite-cored uplift, which formed the eastern margin of the Taos trough during the Pennsylvanian. The uplift was relatively stable, sloping gradually westward



FIGURE 4. Slope and basin calcareous siltstones and shales (mid-Desmoinesian) near crest of Holman Hill on N.M. 3. The thin, more competent sandstone beds are interpreted as prodelta turbidite deposits. (For detailed description see Casey, 1980.)



FIGURE 5. Phylloid algal mound (early Desmoinesian) near Montezuma, just northwest of Las Vegas, New Mexico. Length 183 m, height 18 m.

into the trough, until late Desmoinesian time when both the Sierra Grande and Pedernal uplifts were rejuvenated. Sands that were shed from the Sierra Grande mass are arkosic (microcline is particularly abundant) and much finer grained than those from the Uncompahgre and Cimarron source areas (Casey, 1980). The sand-body geometries on the east side of the basin are characteristic of a lower-relief coastal plain: terrigenous shelf, shallow marine, and fluvial–deltaic deposits. Carbonate buildups formed in places on the shelf. Following the late Desmoinesian pulse of uplift, an apron of coarser arkose was deposited on the flanks of the structure.

Cimarron Arch

By earliest Desmoinesian time the Cimarron arch had emerged as a major positive feature along the northern margin of the trough. From those highlands, as from the Uncompahgre to the west, coarse siliciclastic sediments were carried into the basin and deposited in braided-stream channels and fan deltas. This high block also supplied sediment in Late Pennsylvanian to Early Permian time, as south-flowing streams gradually filled the trough (Casey, 1980).

Thus, the Pennsylvanian sedimentary rocks of the Taos trough record the following depositional history: (1) Morrowan—fine-grained siliciclastic and platform carbonate sediments were deposited in the northern and southern parts, respectively, of a shallow epicontinental sea. (2) Atokan—coarser sands and gravels accumulated in a deepening depressions along the west side of the trough, while platform carbonate deposition took place along the south and east sides. (3) Desmoinesian (Fig. 2)—still coarser sands and gravels were shed from the west and north, while finer sands began to be supplied to the shelf and trough from the east; the trough axis migrated eastward and deepened further. The carbonate shelf persisted along the southern margin; then in the late Desmoinesian, a major marine transgression resulted in platform carbonate deposition throughout the basin. (4) Latest Desmoinesian through the remainder of the Pennsylvanian—the seas retreated southward and the trough was gradually filled with coarse-grained detritus by southward-flowing braided streams. Deltaic sedimentation continued into Early Permian time along the southern margin.

BELIZE

Structural and Geographic Setting

Belize, Central America, occupies the southeastern corner of the Yucatan Peninsula and is near the convergence of three crustal plates: the North American, the Caribbean, and the Cocos (Fig. 6). A major left-lateral strike–slip fault system (the Motagua–Polochic–Cayman trench system) separates the Yucatan continental block of the North American plate, on which Belize is located, from the Honduras continental block of the Caribbean plate (Molnar and Sykes, 1969).

The flat Yucatan platform, consisting of a sequence of Triassic to Early Jurassic red beds overlain by Cretaceous carbonates and evaporites, constitutes the northern half of Belize; the late Paleozoic Maya Mountains, composed of granite and minor low-grade metamorphic rocks, form the southern half (Fig. 7).

The continental margin comprises the shelf lagoon, with a maximum depth of 50 m, that extends some 260 km along the coast, as well as several elongate, fault-bounded ridges which generally support coral reefs. For example, the reef buildup on the ridge beneath Turneffe Island, the central of the three large ridges (Fig. 7), is as much as 1,219 m thick where penetrated in wells. Troughs between ridges are filled to varying extents with sediment (Silver and others, 1980; Dillon and Vedder, 1973)—both carbonate sediment from the shelf and siliciclastics carried from the coast down the slope and into the troughs.

Belize lies within the tropics at 15°45'-18°45'N latitude and is an area of high temperatures (24-27°C most of the year) and abundant rainfall (125-450 cm/yr). Structural controls on sedimentation can be

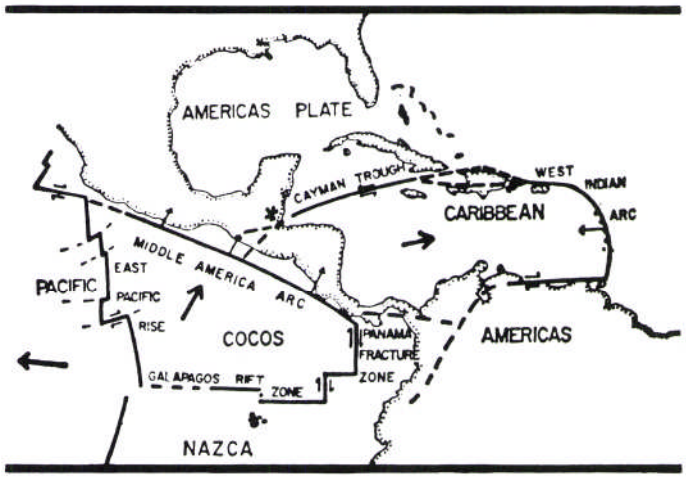


FIGURE 6. Location and plate-tectonic setting of Belize, Central America; asterisk on southeast side of Yucatan Peninsula marks position of Belize (Molnar and Sykes, 1969).

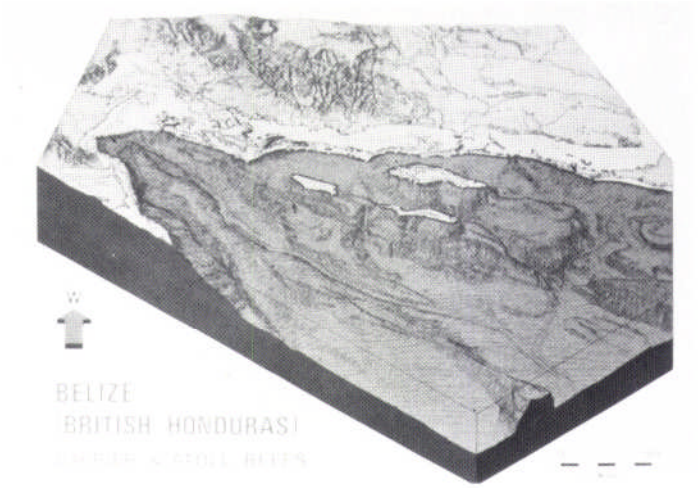


FIGURE 7. Block diagram illustrating physiographic features on- and offshore Belize (Dillon and Vedder, 1973). View is to the west. Maya Mountains are highlands in left center. The large ridge closest to the viewer is that of Glovers Reef–Lighthouse Reef. The middle ridge is that of Turneffe Island and the southern barrier. The distant ridge is that of Ambergris Cay and the northern shoreline.

readily observed, and carbonate and siliciclastic sedimentation proceed side by side. Indeed, to one schooled in the distinctness of carbonate and siliciclastic depositional environments it was enlightening to stand on an arkose beach composed of angular grains 2 or 3 mm across and to see the clear, aquamarine waters where carbonate deposition was taking place a scant hundred meters away. That is the depositional setting observed at Stann Creek, midway down the mainland coast near the mouths of two streams that drain the granitic highlands of the Maya Mountains.

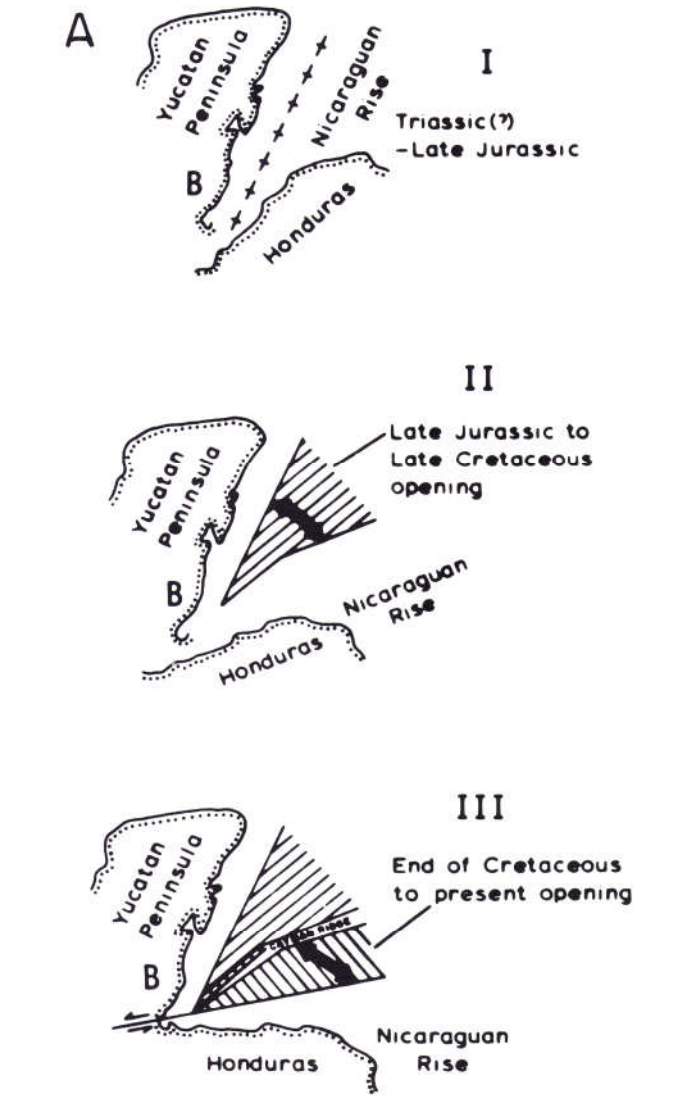
Maya Mountains

As was the case for the Uncompahgre uplift along the western margin of the Taos trough, the Maya Mountains (elevation 1,200 m) consist of granite with some minor low-grade metamorphic rocks; mechanical and chemical weathering are rapid; and the streams draining the uplift are straight, have steep gradients, and carry coarse sediment. The mainland coastal beach mentioned in the preceding paragraph is about 20 km from the mountains. Much of the sediment is deposited in lobate deltas in the shelf lagoon, then reworked by strong longshore currents. A band of silt- and clay-laden water extends about 100 m into the lagoon from the mainland coast, beyond which carbonate deposition takes place. Lagoonal carbonates situated near the mouths of streams commonly contain quartz silt or clays formed during the breakdown of feldspars.

The shelf southeast of the Maya Mountains is an area of mixed carbonate—siliciclastic deposition. The southern lagoon is shallow and structurally unstable; therefore, any slight vertical tectonic adjustment can change the local depositional from a carbonate to a siliciclastic regime, or vice versa. Choi and Ginsburg (1982) document such a situation, in which patch reefs have developed on levees and channel- mouth bars of an abandoned delta lobe. An alternate interpretation is emerging, though, based upon subsequent drilling by those authors. The area they described in 1982 is part of an abandoned delta lobe; however, instead of colonizing on siliciclastic substrates, the patch reefs are growing on older carbonate mud banks (P. M. Harris, written comm. 1984).

Motagua—Polochic—Cayman Trench Faults

Along the southern shelf margin, faults of that system bound major ridges and troughs (Fig. 8; Dillon and Vedder, 1973). The sedimentary section varies greatly from ridge to trough and from one trough to the next, as with those of the southern margin of the Taos Basin. In contrast



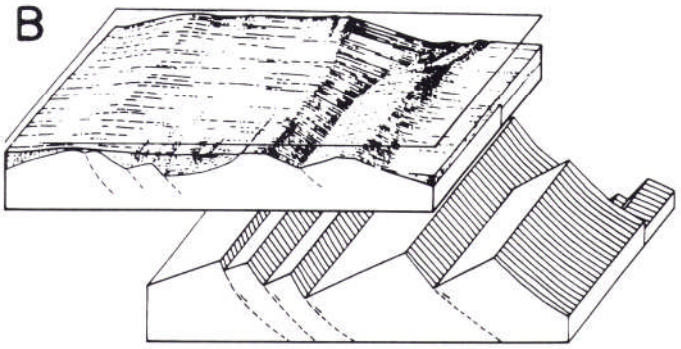


FIGURE 8. **A,** Widening of the bight of the Gulf of Honduras from Mesozoic to present. B = location of Belize (Dillon and Vedder, 1973). **B,** Formation of ridges during extension in the Gulf of Honduras (Dillon and Vedder, 1973). Ridge crests are favored sites for reef development, as waters are well oxygenated and within the photic zone; upwelling currents provide a continuous supply of nutrients.

with the Pennsylvanian ridges, however, those of Belize rise as much as 3,000 m above flanking trough floors.

More importantly, the fault-controlled ridges determine the positions of the barrier reef and large atolls (Fig. 7). The westernmost ridge forms the foundation for the northern portion of the barrier reef, Ambergris Cay, and the shoreline north of Ambergris. On the middle one are Turneffe Island and the southern barrier reef. The eastemmost ridge extends beneath Glovers Reef and Lighthouse Reef.

Within the shelf, particularly in the southern lagoon, coral patch reefs develop on topographically higher areas, just as algae colonized higher areas of the Pennsylvanian shelf of the southern Taos trough. Where faults of the Motagua–Polochic system cut the shelf, rhombic blocks form between fault strands during strike–slip deformation. Coral communities thrive along the edges of elevated blocks where the waters are better oxygenated and increased current assures a continuing supply of nutrients. The array of straight-sided, generally rhombic patch reefs and atolls is particularly striking from the air.

CONCLUSIONS

Basin-margin sedimentation in the Pennsylvanian Taos trough took place under tropical climatic conditions; there, as in contemporary Belize, carbonate and siliciclastic deposition proceeded side by side, and large volumes of both types of sediment accumulated.

Episodic uplift of granitic highlands adjoining the Taos Basin, and rapid mechanical and chemical weathering under tropical conditions continually supplied siliciclastic sediments. Headwaters of streams draining the highlands were rising and distances to the basin were not great; thus, straight braided streams with steep gradients carried a load of coarse sediment into the trough. The same conditions prevail today, as straight streams with headwaters in the granitic Maya Mountains carry coarse arkosic sediments into the shelf lagoon of Belize. However, the Taos trough was confined among highlands, whereas the shelf lagoon of the Gulf of Honduras opens into the abyssal depths of the Caribbean Sea; thus, particles are commonly carried past the shelf and settle at or beyond the foot of the slope in a large ocean basin.

Formation of fault-bounded ridges and troughs during deposition on the southern shelf of the Pennsylvanian Taos Basin resulted in highly variable platform carbonate sequences from ridge to trough and from one trough top the next. Early Pennsylvanian ridges and fault scarps provided favored colonization sites for later Pennsylvanian algal buildups. Similarly, faults of the Motagua–Polochic–Cayman trench system bound ridges and troughs in the southern shelf of Belize. Elevated blocks, formed between fault strands during strike–slip deformation, provide colonization sites for thriving coral patch reefs. In contrast with those of the Taos trough platform. the ridges of the Belize margin rise as much as 3,000 m above the flanking trough floors; they control the positions of the barrier reef and large atolls along the entire shelf margin. The Taos trough platform apparently sloped gradually basinward and lacked a wave-resistant organic barrier, so the fauna was not treated to the sound of surf crashing on the reef.

ACKNOWLEDGMENTS

I am particularly thankful to Elmer Baltz for the grand tour he provided through the Pennsylvanian stratigraphy and structure of the Sangre de Cristo early in my work there; his willingness to discuss his knowledge of the area transcended even the fact that I resided in the state neighboring New Mexico on the southeast. Thanks, too, go to Burr Silver for a similarly thorough immersion (literally) in the geology of Belize. Ongoing dialogs with Bill Muehlberger on Sangre de Cristo structure and with Stan Frost on Belize sedimentation continue to enhance my understanding of those areas and the world at large. This paper benefited greatly from reviews by C. A. Ross and P. M. Harris, whose efforts I gratefully acknowledge.

REFERENCES

Baltz, E. H., 1978, Resume of Rio Grande depression in north-central New Mexico: New Mexico Bureau of Mines and Mineral Resources, Circular 163, pp. 210-227.

__, and Bachman, G. 0., 1956, Notes on the geology of the southeastern Sangre de Cristo Mountains, New Mexico: New Mexico Geological Society, Guidebook 7, pp. 96-108.

Casey, J. M., 1980, Depositional systems and paleogeographical evolution of the late Paleozoic Taos trough, northern New Mexico; *in* Fouch, T. D., and Magathan. E. R. (eds.), Paleozoic paleogeography of the west-central United States: Rocky Mountain Section. Society of Economic Paleontologists and Mineralogists, Rocky Mountain Paleogeography Symposium I, pp. 181-196.

Choi, D. R., and Ginsburg, R. N., 1982, Siliciclastic foundations of Quaternary reefs in the southernmost Belize lagoon, British Honduras: Geological Society of America, Bulletin, v. 93, pp. 116-126.

Dillon, W. P., and Vedder, J. G., 1973, Structure and development of the continental margin of British Honduras: Geological Society of America, Bulletin, v. 84, pp. 2713-2732.

Kues, B. S., 1984, Pennsylvanian stratigraphy and paleontology of the Taos area, north-central New Mexico: This guidebook.

Lisenbee, A. L., Woodward, L. A., and Connolly, J. R., 1979, Tijeras–Cationcito fault system—a major zone of recurrent movement in north-central New Mexico: New Mexico Geological Society, Guidebook 30, pp. 89-100.

Miller, J. P., Montgomery, A., and Sutherland, P. K., 1963, Geology of part of the southern Sangre de Cristo Mounains, New Mexico: New Mexico Bureau of Mines and Mineral Resources, Memoir 11, 106 pp.

Molnar, P., and Sykes, L. R., 1969, Tectonics of the Caribbean and Middle America regions from focal mechanisms and seismicity: Geological Society of America, Bulletin, v. 80. pp. 1639-1684.

Robertson, J. M., and Moench, R. H., 1979, The Pecos Greenstone Belt: a Proterozoic volcano-sedimentary sequence in the southern Sangre de Cristo Mountains, New Mexico: New Mexico Geological Society, Guidebook 30, pp. 165-174.

Silver, B. A., Neese, D., Koch, J., Goldhammer, R., and Stewart, G., 1980, The Belize carbonate complex: shelf margin model for hydrocarbon exploration: Institute for Energy Development. Tulsa. 212 pp.

Sutherland, P. K., 1963, Paleozoic rocks; *in* Geology of the southern Sangre de Cristo Mountains, New Mexico: New Mexico Bureau of Mines and Mineral Resources, Memoir 11, pp. 22-46.

_, and Harlow, F. H., 1973, Pennsylvanian brachiopods and biostratigraphy in southern Sangre de Cristo Mountains, New Mexico: New Mexico Bureau of Mines and Mineral Resources, Memoir 27, 173 pp.

Toomey, D. F., 1980, History of a Late Carboniferous phylloid algal bank complex in northeastern New Mexico: Lethaia, v. 13, pp. 249-267.

Woodward, L. A., and Ingersoll, R. V., 1979, Phanerozoic tectonic setting of Santa Fe country: New Mexico Geological Society, Guidebook 30, pp. 51-58.



A longer than usual mixed freight climbs slowly up the 4% grade of Barranca Hill from the Rio Grande valley (photo by Bob Richardson).