triacantha and *P. bispinosa*, with thin, fragile shells were absent from the sediments but are known to inhabit the deep waters in low and middle latitudes.

The present study shows that pteropods as a group are useful for paleoecological interpretations of their fossil assemblages on the ocean floor.

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TECTONIC HISTORY OF THE BOOTHIA ARCH

Boothia arch is a northerly trending, Lower Devonian horst in which Precambrian crystalline rocks have risen over 5,000 feet. Cambrian to Lower Devonian clastic and carbonate rocks dip gently away from the exposed basement complex, which rose mainly by vertical movement along major thrust and normal faults rather than by flexure. Northerly trending folds and faults in Cornwallis Fold Belt on Bathurst and Cornwallis Islands and on Grinnell Peninsula are continuations of the Boothia basement structures.

Cambrian to Devonian rocks were deposited over the site of the arch under conditions of quiescence and gradual subsidence; correlative formations in the Franklinian geosyncline are thicker and indicate more rapid subsidence. Principal movement on Boothia arch and Cornwallis Fold Belt is dated by unconformities within the Lower Devonian at three places: (1) on Cornwallis Island the Snowblind Bay formation rests in places conformably and in other places with angular unconformity on Lower Devonian rocks; (2) on Bathurst Island the Driftwood Bay formation lies with angular unconformity upon rocks as young as Lower Devonian and grades laterally into the conformable sequence of Bathurst Island and Stuart Bay formations; and (3) on Prince of Wales and Somerset Islands the Peel Sound formation variously rests with gradational contact and with angular unconformity on the Middle Silurian to Lower Devonian Read Bay formation. Conglomerates in the Peel Sound formation contain boulders of lower Palaeozoic and Precambrian rocks, and are themselves cut by horst-forming faults.

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PEMBROKE BRECCIA: SOLUTION—COLLAPSE OF THE LOWER WINDSOR GROUP (MISSISSIPPIAN) IN CENTRAL NOVA SCOTIA

The Pembroke Breccia disconformably overlies the basal limestone of the Mississippian Windsor group in central Nova Scotia and has previously been considered a primary breccia in the Windsor group. The breccia is estimated to be as much as 100 feet thick. It is absent in deep borings; at depth, the basal limestone is apparently conformably overlain by interbedded limestone and anhydrite.

The Pembroke typically is a jumbled mass of unsorted angular limestone fragments in a matrix of muddy massive limestone. Most of the fragments are similar to the basal laminated limestone of the Windsor group, although some are of massive limestone and red marl apparently derived from beds higher in the section. Irregular pipes, channels, and masses of sandy breccia containing scattered quartzose pebbles occur within the typical breccia. In a few exposures the breccia contains relict beds; in others, thin graded calcarenite beds appear to fill pockets in the breccia.

Late Paleozoic regional deformation extensively folded the Windsor group; the Pembroke Breccia is younger than this deformation. Stratification in floored cavities is virtually horizontal and is independent of the attitude of the adjacent Windsor strata. The deformation produced veins normal to bedding in the Windsor limestone; many rotated fragments within the breccia contain similar veins normal to their bedding. Metamorphic fabric, absent in the breccia matrix, varies in nature and orientation from fragment to fragment. Sand grains, pebbles, and heavy minerals within sandy parts of the breccia appear to have been derived from Triassic rocks, suggesting that the breccia originated in either Triassic or post-Triassic time.

It is here proposed that the breccia formed only near an erosion surface by collapse and disintegration following solution of anhydrite interbeds and part of the limestone. The sandy breccia appears to be composed of surficial debris which filled solution channels within the typical breccia.

Because the Pembroke Breccia was formed long after the deposition of the Windsor group, it should not be regarded as a stratigraphic unit of the group. The actual depositional sequence of the basal Windsor is (in ascending order): limestone, interbedded limestone and anhydrite, anhydrite, and halite.

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SEDIMENTARY STRUCTURES: MISSISSIPPI RIVER DELTAIC PLAIN

Minor sedimentary structures were studied in cores and exposures from the deltaic and marginal deltaic plains of the Mississippi River. Selected active environments were sampled, and the occurrence of sedimentary structures from each was recorded. Individual structures were found to occur in more than one environment; however, suites of structures were characteristic. Within the study area the following twelve depositional environments have been investigated: shelf, prodelta, delta front (distal bar, distributary mouth bar, channel, and subaqueous levee), subaerial levee, marsh and swamp, interdistributary bay, mudflat, and fresh-water lake.

Shelf deposits consisted of: (1) fine-grained clastics, burrowed and showing parallel laminations and (2) marine organic debris. Prodelta deposits are similar to clayey shelf deposits, but contain lenticular and parallel lamination with finely divided plant inclusions. The delta front is a complex of sub-environments constituting the advancing locus of active deposition of the prograding delta. The sloping seaward margin on this zone—the distal bar—exhibits current structures such as trough cross-laminations and current ripples as well as parallel and lenticular laminations, wave ripples, and burrows. The silty and sandy distributary mouth bar is characterized by a variety of small-scale, multi-directional cross-laminations and gas-heave structures. Channel deposits exhibit trough cross-laminations, scour and fill, and distorted laminations, whereas subaqueous levees contain abundant ripple and unidirectional cross-laminations, parallel, wavy, and distorted laminations. In addition, subaerial levees are burrowed and oxidized. Marsh and swamp deposits are distinguished by abundant plant remains, burrows, and parallel laminations. Lenticular laminations, wave ripples, burrows, shell, and plant remains are characteristic of both interdistributary bay and fresh-water lakes. The mudflat assemblage of structures includes lenticular laminations, current and wave ripples, burrows, and shell remains.

Not only are associations of sedimentary structures important in recognizing individual environments of deposition; equally important is the association of the environments to one another. This relationship must be understood for correct paleogeographic reconstruction of ancient deltaic deposits. The manner in which a sequence of marine and deltaic deposits might accumulate in a segment of a basin with resulting stratigraphic relationships of associated environmentally determined facies, is illustrated.

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ORIGIN AND VARIATION OF FESTOON OR TROUGH CROSS-STRATIFICATION WITH PARTICULAR REFERENCE TO SEDIMENTS OF THE SYDNEY BASIN, AUSTRALIA

Recent papers on the origin and classification of cross-stratification by Allen have revived and stimulated interest in the use of cross-stratification as a tool for the interpretation of paleocurrents and environment of deposition. Cross-stratification has been described throughout the geological literature in numerous articles. Relationships between individual sets of large-scale cross-strata of relatively small size (5–30 cms. thick) have been frequently observed in outcrops that are sufficiently well preserved to allow a reconstruction of the pattern of the sets in three dimensions. However, descriptions of the stratification patterns of large (1–3 m. thick) cross-stratified units are rare. This is understandable since such units outcrop over large areas, and the outcrops required for the measurement of these units occur very infrequently.

Large cross-stratified units are well preserved along the coastline of eastern New South Wales in the vicinity of Sydney where sandstones of Triassic age, forming part of the Triassic-Permian Sydney basin, outcrop in horizontal or nearly horizontal attitudes along the rocky cliffs and headlands. At many localities it is possible to measure the areal extent of individual sets of cross-strata, enabling the construction of diagrams showing the cross-stratification pattern in three dimensions. Large individual sets of cross-strata commonly appear to be planar in random sections or in surfaces of small areal extent, but where they can be seen preserved over large areas, they are generally trough-shaped. The shape and distribution of the troughs may lend support to the theory that they have been formed due to migration of very large-scale linguoid or lunate asymmetrical ripples as suggested by Allen.

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RESIDUAL GRAVITY ANALYSIS OF THE MID-CONTINENT GRAVITY HIGH

The high speed computer has many uses in the geophysical industry. Early techniques of analysis of data which required much of the time of the geologist and geophysicist are now routinely done by the computer. New techniques which were impossible by desk calculator are now possible through the speed of these machines.

Important advances have been made possible by the computer in the analysis of gravity data. A new technique of gravity analysis involving the fitting of non-orthogonal polynomial surfaces to a collection of gravity data by the principle of Least Squares has been developed. This was suggested by Simpson (1954), Grant (1957), and others using surfaces of 2nd, 3rd, and 4th order to fit the gravity data. For small areas and small amounts of data these low-order surfaces were sufficient. More recent work by Haubrich (1960) developed the technique to the 7th order on the IBM 650. In modern usage, for large areas and several thousand data, high-order surfaces up to the 15th order are used. The use of these larger areas, and high-order surfaces, allows better geologic interpretation of an area as a whole rather than trying to fit together several small pieces. And, in fact, through the use of several polynomial surfaces of varying order, the small geologic or structural features may be separated from the large so-called regional features.

As an example of the use of this technique, we may examine the Mid-Continent gravity high in Iowa, Nebraska, and Kansas. The polynomial analysis shows a detailed correlation of the gravity residuals with both basement geology and Paleozoic structure. This area is an example of Precambrian structure controlling Paleozoic deformation. Features such as the Abilene anticline in Kansas, the Thurman Redfield structural zone in Iowa and other Paleozoic structures are directly tied to Precambrian fault zones along which later adjustment has taken place. Paleozoic synclines and basins reflect Precambrian structural lows. It is apparent in this area as in many others that this relationship of old zones of weakness to younger movement is the norm rather than the exception.

Unfortunately, the lack of drill holes makes study of the basement geology difficult. This leaves the task to geophysical methods. The use of the computer and new techniques of analysis improves our efforts but it is only through a combination of the geophysical methods, computers, and all available geologic information that we can get the most nearly accurate answer.

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DEEP-WATER SEDIMENTARY STRUCTURES, PLIOCENE PICO FORMATION, SANTA PAULA CREEK, VENTURA BASIN, CALIFORNIA

The Pliocene Pico Formation, according to paleogeographic and paleoecologic interpretations, was deposited in marine waters at least 300 m. deep. Sedimentation of mud, sand, and some gravel was largely the result of bottom-following underflows generally traveling west. Resulting sedimentary structures—some viewed in stilled-stages of development—are: stratification with eroded and deformed contacts, internal stratification, graded bedding, small-scale cross-stratification, disturbed bedding, fossils with preferred orientation, imbricated clasts and shells, ripple marks, flame structures, pull-aparts, load pockets, load waves, and many others.

Ideal graded bedding is generally rare, but most sandstones display grading superposed on other structures such as internal lamination. Thin but persistent strata with signature sedimentary structures imply infilling on a nearly horizontal sea floor by bottom-contact currents tending to level the accretional surface. Eroded and deformed contacts at the base of beds imply vigorous current impact and drag. Larger disruptions such as deformed or disturbed zones, several beds thick, may result from current drag rather than from gravity-induced downslope slumping. Accordingly, some penecontemporaneous folds are less reliable indica-