

only a rate controlling factor in a partial pressure sensitive reaction. That the slopes of many of the reaction curves fall extremely close to each other in pressure-temperature space suggests extensive overlapping of stability fields and the probability of numerous instances of metastability.

TRANSMISSION ELECTRON MICROSCOPY STUDIES OF THE WALL STRUCTURE OF SOME CALCAREOUS FORAMINIFERA

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Radial walled species, Globorotalia menardii, Glubratella ornatisima, and Ammonia beccarii, and a granular walled species, Cassidulina crassa, were examined using polarizing optical microscopy, scanning electron microscopy, and high voltage (650 KV) transmission electron microscopy. Whole, broken, and etched specimens were mounted on aluminum plugs and coated with gold and silver for observation with a scanning electron microscope. For the optical and transmission electron microscopy studies, standard thin sections were made. The specimens then were transferred to a holder for thinning in an argon-ion thinning mill. After areas of the specimens were thinned to approximately 1 micron, optical and transmission studies were made.

In most species observed the organic membrane layers did not fit into a bilamellar or monolamellar construction. All of the specimens observed contained numerous inclusions of organic material. The physical appearance of the ultrastructure was very similar in all of the species. Variations in crystal size were observed within each species, ranging from very fine grained, indistinct crystals to large, optically visible crystals containing numerous subgrains. These large crystals contained less organic material than the submicroscopic crystals. In all species the large crystals are located in areas where pores do not penetrate the test and where some type of secondary thickening occurs. Since the inclusion pattern of organic material is similar in all the species observed and to that reported in molluscan shells, the pattern must not be related to wall type - granular or radial, but to crystal growth. These results appear to place new constraints on possible theories of calcification.

STRUCTURE AND GENERATION OF OCEANIC CRUST AND MANTLE

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An integrative study has been made of the layering, petrology, and structure of ophiolite complexes, and oceanic crust and upper mantle using the following data as constraints: direct observation of ophiolite sequences, seismic refraction and magnetic anomaly studies of gross oceanic layering, laboratory measurements of sound velocities and magnetic properties in oceanic and ophiolitic rocks. Dredge hauls of oceanic rocks are recovered mainly from tectonic escarpments. The petrology and fabric of these samples may reflect structural and metamorphic processes along the escarpments on which they are found. We pro-

pose the following model for layering, petrology and compressional wave velocities of oceanic crust and upper mantle from the top downwards: thin (< 500 m) unaltered pillow basalts ($V_p = 3.0-4.0$); 1.5 km meta-basalt ($V_p = 4.0-6.0$); 2-3 km sheeted dolerite complex ($V_p = 6.5-6.8$); 2-5 km of gabbroic rocks (V_p average 7.4); mantle (harzburgite, dunite, lherzolite, $V_p > 8.1$). Many ophiolite sequences are considerably thinner and may represent crust and upper mantle of rear arc basins. The petrology and internal magmatic and structural relationships of several ophiolite sequences are used to construct a model for the generation of oceanic crust and mantle. Simple calculations show that the crust is completely formed within 10 km of the ridge axis, even on fast-spreading ridges and that the existence of a large flat magma chamber of the kind envisaged by Greenbaum is a physical impossibility. This apparent paradox can be resolved by subsidence of a linear welt of mantle material away from the ridge axis. The implications of our model is that the oceanic layer will be exceedingly complex with large blocks of cumulate material in the roof and vice versa.

TWO NEW ASTROBLEMES (ONE DEFINITE, ONE PROBABLE) IN BRAZIL

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Two deformed circular structures of probable meteorite impact origin (astroblemes) occur in central Brazil. Both structures display circular uplifts, about 10 km in diameter, in which strongly deformed Devonian sediments are surrounded by overlying Carboniferous rocks. Definite shock-metamorphic effects, diagnostic for meteorite impact, have been identified at one structure.

A meteorite impact origin has not yet been established for the Serra da Ganghala structure (Lat. $8^{\circ} 05'$ S., Long. $46^{\circ} 52'$ W.). It shows a circular area of uplifted, deformed, steeply-dipping Devonian sediments. On a smaller scale, the structural pattern strongly resembles that found at Gosses Bluff, Australia, a definite astrobleme. A few samples of fine-grained sedimentary rocks, collected on a brief reconnaissance visit, show no definite shock-metamorphic effects.

The Araguaiana Dome (Lat. $16^{\circ} 46'$ S., Long. $52^{\circ} 59'$ W.) is a similar structure with a central uplift of deformed Devonian sandstone about 10 km across. In the central part of the structure there is a glass-rich heterogeneous breccia which contains inclusions of buried quartzofeldspathic Precambrian rocks. Extensive shock-metamorphic effects were observed by us in specimens of the breccia and inclusions provided by geologists of Petrobras (Petróleo Brasileiro S.A.). The shock effects, which prove a meteorite impact origin for the structure, include planar features (shock lamellae) in quartz, especially the development of $\{10\bar{1}3\}$, $\{10\bar{1}2\}$, $\{11\bar{2}2\}$, and $\{11\bar{2}1\}$ orientations. The Araguaiana Dome is the first ancient impact structure to be identified in South America. An ERTS-1 photograph indicates that the structure may be as large as 40 km in diameter, making it one of the largest known astroblemes.

LATE QUATERNARY RADIOLARIAN PALEO-OCEANOGRAPHY OF THE PANAMA BASIN, EASTERN EQUATORIAL PACIFIC

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Q-mode factor analysis of complete radiolarian thanatocoenoses in 57 surface sediment samples from the Panama Basin showed that solution,