related to the development of the Neogene (and modern) water mass regimes at that time. One of the major radiolarian zoogeographic anomalies, since the initiation of the Neogene water mass regimes and their contained radiolarian faunas, has been the isolation of relict radiolarian species in the warm water sphere of the North Atlantic. This oceanographic realm has been semi-isolated from the world ocean for about the last 3 to 3.5 m.y. and contains a relict (and expatriated) radiolarian fauna. Of special interest in the relict fauna are the presence of the species *Lamprocyrtis heteroporos*, *Didymocyrtis penultimus*, *D. avitus*, and *Spongaster pentas*—all, until recently, thought to be extinct.

CERCONE, KAREN ROSE, and KYGER C. LOHMANN, Univ. Michigan, Ann Arbor, MI

Regional Aspects of Diagenesis in Niagaran Pinnacle Reefs, Northwest Michigan: Evidence for Differential Fluid Migration

The Middle Silurian pinnacle reef system of northwest Michigan consists of a narrow, northeast-southwest-trending band of isolated reefs encased in thick Upper Silurian evaporites. All reefs display a similar pattern of diagenetic evolution: neomorphism of metastable carbonate components followed by precipitation of a closure cement; modification of porosity by a combination of cementation, solution and dolomitization; and emplacement of hydrocarbons and stylolitization. The exact sequence of diagenetic events and the resulting texture of the carbonate rock vary considerably from reef to reef, but several regional trends can be identified.

There is an obvious change in reef mineralogy *across* the reef trend, from predominantly calcitic reefs basinward to predominantly dolomitic reefs near the shelf. There appears to be a corresponding increase in $\delta^{13}C$ and $\delta^{18}O$ isotopic ratios shelfward, both in matrix limestone, according to Sears and Lucia in 1979, and in the neomorphic replacement of former marine cements. A change in the mineralogy of closure cements is observed *along* the reef trend, from calcite-pyrite in the southwest to pyrite or dolomite-quartz in the northeast. Oil emplacement also varies along the reef trend. Sparry dolomite and pyrite mineralization are associated with bitumen in the southwest parts of the reef trend, whereas leaching appears to accompany or just predate oil entry in the northeast. Finally, the dominant pore-filling phases in each reef vary in an irregular fashion throughout the trend from calcite and halite in some reefs to anhydrite and laminated dolomite in others.

These variations on a diagenetic theme appear to be related only to the presence or absence of diagenetic fluids in the reef's history, not to the lithology involved. Differential migration of fluids, caused by different hydrostatic heads on each fluid or migration through different pathways, would account for the diversity of diagenetic sequences in the pinnacle reef system. Careful petrographic and chemical analysis of each individual reef is needed to identify the local diagenetic history, and these local histories must be correlated in order to infer the larger picture of basin development.

CHAFETZ, HENRY S., Univ. Houston, Houston, TX, and BRUCE H. WILKINSON, Univ. Michigan, Ann Arbor, MI

Freshwater Carbonate Cements

Freshwater carbonate cements in nonmarine sediments form in a diverse assemblage of settings, including fluvial, lacustrine, pedologic, spring, and spelean environments, giving rise to a plethora of textures and structures. Many deposits exhibit both phreatic and vadose zone textures. Cement mineralogy and composition vary considerably from deposit to deposit, as well as within individual deposits, depending on water chemistry and environmental setting. Similarly, cement habits range from highly acicular to nearly equant. The wide variety of textures, mineralogies, and compositions exhibited by both cement and associated sediments suggests that freshwater carbonate precipitation may involve complex processes. A survey of our present knowledge indicates that such cements are most commonly composed of low magnesian calcite as crystals with rhombohedral terminations. Among those features which appear to be unique to freshwater carbonate cements are crystals displaying trigonal prisms, rhombohedrons ornamented with parallel sharp spikes, and crystals with thorn-shaped vacuoles. Although variation in crystal habit may be influenced by either magnesium or total cation or anion concentrations in the precipitating fluid, the concentration of solutes does not appear to be the sole controlling factor. Growth rate, influenced by a variety of parameters, such as P_{CO_2}, may be the most important factor in predicting crystal habits in freshwater carbonate cements.

CHAMBERLAIN, ALAN K., Placid Oil Co., Salt Lake City, UT

Surface Gamma Logs: A Helpful Correlation Tool

Gamma logs of measured surface sections provide an excellent correlation tool in wildcat areas where well control is sparse and outcrops are abundant. Gamma logs of measured surface sections can be correlated with gamma logs of any nearby wells that have penetrated the same strata. Subtle changes in lithology that may have been missed during routine section measuring are detected by surface gamma measurements. Furthermore, gamma measurements over covered intervals may give clues to the nature of the buried lithology.

A portable scintillation counter is used to take gamma measurements. These measurements are recorded along with lithologic descriptions. Five-foot-intervals provide the best results.

Surface gamma logs are successfully used in correlating members of the Jurassic Twin Creek Limestone from wells in the northern Utah Overthrust to outcrops in north-central Utah. They are also useful in correlating upper Paleozoic rocks in the Basin and Range province.

CLIFTON, H. EDWARD, U.S. Geol. Survey, Menlo Park, CA

Channel-Levee-Overbank Sequence in Paleocene Submarine Canyon Fill, Point Lobos, California

Vertical sequences characterized by upward decreases in the grain size and bed thickness of turbidites are commonly attributed to laterally migrating channel-levee-overbank systems. A probable Paleocene example of such a sequence is superbly exposed at Pebbly Beach, Point Lobos, California. Contact relations indicate that the Paleocene deposits fill a steep-walled sinuous valley carved into underlying granodiorite of Late Cretaceous age. The few fossils found in the Paleocene rocks indicate deposition in water depths of 100 m (328 ft) or more and suggest that the sediment accumulated in a submarine canyon. Although most of these Paleocene deposits are conglomeratic, the upper part of the section exposed at Pebbly Beach consists of a 30-m (98-ft) thick fining-upward sequence from conglomerate through sandstone to mudstone. About 10 m (33 ft) of predominantly thick-bedded sandstone grades upward through a transitional sequence of about 2 m (6 ft) of thin-bedded sandstone into