sions proposed recently by Bovee and Jahn designate axopodia to separate sarcodines at a subclass level. Yet these are only one of several types of pseudopodia seen in planktonic Foraminifera.

Living Globigerinidae collected off the southern California coast were observed in agnotobiotic cultures for periods up to three months. Healthy globigerinids exhibit a gradual change in the morphology and function of their pseudopodia which is related to the development and secondary calcification of the whole organism. The pseudopodia differ considerably from those of benthonic Foraminifera, except in the bidirectional protoplasmic movement.

Newly formed pseudopodia are short, radiate, anastomosing, and motile, emanating from the sarcode through the test pores. Development of an internal axial core greatly lengthens individual pseudopodia, thereby increasing exposed protoplasmic surface, and providing support for flotation of the organism. The initial axial core is extremely flexible (probably entirely proteinaceous), resulting in tenuous pseudopodia which anastomose distally on contact with one another. Such pseudopodia are readily regenerated following loss by an actively metabolizing young foraminifer.

During development, the pseudopodia increase slightly in width and become brittle as calcification hardens the inner core. At this stage, pseudopodia may be broken by handling, rather than tangled as in young specimens. Anastomosing occurs only in a few specimens by means of slender, temporary connections near the pseudopodial tips. There the protoplasm and granular contents commonly flow undisturbed beyond the tapering end of the solidified core to form an actively motile, retractable probe.

The pseudopodial granular contents range from numerous large, angular particles in new pseudopodia, to relatively few regular and flattened shapes after calcified cores have developed. Calcification increases pseudopodial core diameter while decreasing pore-opening diameter. This restricts the flow of protoplasm along the pseudopodia, and limits the size and shape of transported particles. Finally, as the axial cores become thicker and heavier, globigerinid pseudopodia no longer anastomose. The cores, originating in protoplasm, are trapped by their expansion in the gradually closing pores to form the "spines" referred to in the literature.

The pseudopodia of planktonic Foraminifera thus originate as specialized rhizopodia, which develop into axopodia as growth of the organism proceeds. With such a pseudopodial continuum occurring within one species, classification based on the pseudopodial differences outlined by Bovee and Jahn would cut across specific life cycles. Accordingly, the proposed taxonomy is considered inadequate with regard to the Foraminiferida.

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### Injection Water Sources, Wilmington and East Wilmington Oil Fields

Although most of the Wilmington structure lies under or near the Pacific Ocean, water of the quality necessary for waterflooding has to be produced from near-surface deposits.

These deposits may be divided into two parts in the developed Wilmington area: the Gaspur zone, a Recent channel fill of the ancestral Los Angeles River, and the Pleistocene shallow-water deposits down to about 500 feet. These Pleistocene deposits include the "200-foot sand" and the "400-foot gravel" of the San Pedro Formation. All of these sands are salt-water invaded in this area. About 600,000 bbls./day of injection water currently are being produced from 45 wells completed primarily in the Gaspur or "400-foot gravel" zones. Water salinities range from about 1,000 ppm. chloride to approximately that of sea water. Because of the natural filtration of the beds, the oxygen and suspended solids contents are low, but the water has to be treated with bacteriacides prior to injection.

Ditch samples from eight exploratory core holes in the undeveloped East Wilmington field showed the water source beds to be missing in part of the area. Two of the four drilling islands probably will be located where the salt-water-bearing sands are missing. In order to insure an adequate injection-water supply, the islands may have to have an interconnecting water system that ties with additional source wells on Pier "J."

Near the eastern end of the Wilmington structure in the vicinity of the Humble-Texaco Belmont Island, the San Gabriel River flows through the "Alamitos Gap." The shallow river-channel deposits here are neither so deep nor so sharply defined as those of the Los Angeles River. Adequate salt-water-bearing sands are present in the lower San Pedro Formation, which is the equivalent of the Silverado zone on the west.

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### Pacific Offshore Drilling and Completion Techniques

(No abstract submitted.)

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### Faunal Evidence of Miocene-to-Recent Paleoclimatology in Antarctic

Two independent lines of faunal evidence indicate intermittent if not continuous polar ice in Antarctica from Pliocene or latest Miocene to Recent, an interval of about 11 million years. First, the area of subarctic and Antarctic planktonic Foraminifera extended far into the temperate regions during the Pleistocene; changes of almost equal magnitude are now recorded for the middle Pliocene and the latest Miocene. Second, evaluation of data from deep-sea cores in the southern Indian Ocean and the Antarctic shows dominant Antarctic cold-water radiolarians spanning the interval from latest Miocene to Recent. These data are in agreement with the isotope data by Emiliani that abyssal waters of the Pacific Ocean were reduced to about 2°C. during the Pliocene, as conditioned by low surface temperatures in polar seas. Also, studies in Antarctica by Rutford, Craddock, and Bastien show possible tillites below volcanic rocks that have been dated radiometrically to be approximately latest Miocene or earliest Pliocene.

It is proposed that the upper limit of the Miocene in Antarctic deep-sea cores corresponds approximately

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to the upper limit of *Prunopyle titan,* a cosmopolitan radiolarian that is an index to the later Miocene of California. It is further proposed that in the Antarctic the Pliocene-Pleistocene boundary is located approximately at the upper boundary of *Saturnulus planetes,* a level which is just below the extinction level of discoasters. Marked telescoping of faunal zones indicates significant gaps in the depositional record of some Antarctic deep-sea cores, probably caused by slumping or non-deposition of sediments at different times. A transition from red clay to diatomaceous sediments occurrred within the Pliocene Epoch.

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TIME-TRANSGRESSIVE PROBLEMS OF CALIFORNIA CENOZOIC

A significant change from dextral to sinistral populations of *Globigerina pachyderma* occurred at the Pliocene-Pleistocene boundary in southern California, as recorded in deep-water deposits. By using modern populations as a basis for comparison, it can be shown that this represents a major shift from dextral warm temperate to sinistral subarctic populations, and it defines a point in time which should coincide more dependably with the Pliocene-Pleistocene boundary than a boundary based upon benthic species. Use of this method shows that the upper limit of the Wheelerian Stage, which is based on the upper limits of the *Epistominella pacifica-Uvigerina peregrina* faunas, ranges from more than 200 meters below to more than 300 meters above the Pliocene-Pleistocene boundary.

A second problem is recorded in the Eocene of the Santa Barbara embayment. Planktonic Foraminifera suggest that the Eocene Narizian Stage, based primarily on benthic species, is as young as late Eocene in the Santa Rosa Hills and as old as middle Eocene elsewhere. Similarly, planktonic Foraminifera indicate that the Ulatisian Stage, also based upon benthic species, is early to middle Eocene in some places and is entirely middle Eocene in others.

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RECONNAISSANCE GRAVITY AND OTHER GEOPHYSICAL DATA FROM CONTINENTAL END OF ALEUTIAN ARC

On the Alaskan continental shelf between the Shumagin Islands and Prince William Sound, ships of the U. S. Coast and Geodetic Survey have made about 12 traverses while recording gravity, sparker, magnetic, and bathymetry data, and about 12 other traverses while recording magnetic and bathymetry data alone. These marine measurements have been combined with gravity and geologic data obtained by the U. S. Geological Survey on adjacent shorelines to make a reconnaissance gravity map which provides new information on the structure of the continental end of the Aleutian arc.

The gravity anomalies associated with the oceanic part of the arc do not extend very far onto the continental shelf. A gravity high over the Aleutian Islands diminishes gradually near the continental margin, and negative Bouguer anomalies are present among the volcanoes of the eastern Aleutian Range and the southern Alaska Range; the gravity low associated with the inside edge of the oceanic trench is replaced by a gravity high that extends along the entire northern edge of the continental-margin trench. Between the eastern Aleutian gravity low and the continental-shelf gravity high is a series of elongate anomalies that parallel the tectonic trend and may be correlated with sedimentary and volcanic rock units.

Small gravity depressions in areas of positive gravity anomalies on the continental shelf indicate the presence of Cenozoic sedimentary deposits east of Kodiak and west of Middleton Island. Sparker data show that these deposits thicken northwest of a shelf-edge anticline where the free-air anomalies are greatest. However, a much larger decrease of 125–200 mgal. occurs at the southern edge of the Chugach Mountains geosyncline, which lies north of a coastal belt of lower Cenozoic submarine volcanic rocks (largely non-magnetic). These rocks cause local highs that are especially well developed in Prince William Sound and account for the steep gravity gradient between the continental shelf and Chugach Mountains. This 125–200-mgal. gravity change nearly coincides also with the line separating the emergence and subsidence areas of the 1964 Alaska earthquake. That earthquake increased the positive continental-shelf anomalies south of the gradient. At the northern edge of the Chugach Mountains geosyncline, another gravity high coincides with a belt of lower Mesozoic submarine volcanic rocks (largely magnetic); this high separates the Chugach Mountains low from a low caused by sedimentary rocks in Cook Inlet and Shelikof Straights. Although the gravity data indicate the presence of several thick sedimentary bodies, the large gradients associated with the volcanic and tectonic arcs make estimation of the thickness of the sedimentary column difficult.

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PROPOSED ORIGIN OF SUBSURFACE THERMAL BRINES, IMPERIAL VALLEY, CALIFORNIA

Saturated Na-Ca-KCl thermal brines (380°C @ depth) of unique chemistry (reported by D. E. White) are recovered by geothermal wells near the Salton Sea in the Imperial Valley—a tectonically active graben area of high heat flow at the north end of the Gulf of California. The reservoir chamber consists of alternating fractured greenschist and zeolitic facies metamorphic rocks at depths of 3,900–8,000 feet. The shallow waters adjacent to and overlying this and many other thermal anomalies are dilute $NaHCO_3$-Cl waters, high in B. $NH_4$, I, and F are present; the Na/K ratio is less than in the brines. $CO_2$ is abundant. The similarity of the deuterium content of these brines and various surficial waters of the Imperial Valley as determined by H. Craig and reported by White indicates that the waters of these brines are dominantly meteoric.

The most critical geochemical questions concern the mechanism by which the brines are concentrated to such a high degree, the origin of the Cl ion within the brine, and the surprisingly high Ca/Na, K/Na, and Cs/K ratios of the brine. The arkosic sedimentary fill of the graben contains ample material to provide by solution every chemical found within these thermal brines with the exception of the Cl ion. The high $^{18}O$ of the brines and its impoverishment