

cause productivity of plankton can reflect climatic changes, careful plots of "abundance intervals" of *G. pachyderma* have been constructed. The time of greatest abundance of *G. pachyderma* shows some variation from core to core but in general two "abundance intervals" are present. The most recent occurs in the upper 20–30 cm of the cores and suggests that the present warming trend (indicated by slightly greater number of dextrally coiled Foraminifera) is the cause. The second "abundance interval" occurs at or above the level represented by the Brunhes-Matuyama magnetic reversal (690,000 years ago). At other positions in the cores, *G. pachyderma* and other forms constitute only a few percent of the total coarse fraction.

Apparently, there have been only 2 intervals of substantial *G. pachyderma* abundance during the past 3 m.y. and these intervals are difficult to correlate with the Pleistocene glacial cycles known on the continents. In spite of previous attempts to show a relation, it appears that there is no real correlation between the 4 glacial and interglacial stages represented in Pleistocene deposits of the continents and the *G. pachyderma* abundances in the Pleistocene Arctic Ocean sediments.

COOK, DONALD G., Geol. Survey Canada, Calgary, Alta., and JAMES D. AITKEN, Dept. Geol., Univ. Calgary, Calgary, Alta.

#### TECTONICS OF NORTHERN FRANKLIN MOUNTAINS AND COLVILLE HILLS, DISTRICT OF MACKENZIE, CANADA

The northern Franklin Mountains and the Colville Hills, District of Mackenzie, are a series of ridges of divergent trends, separated by broad, mostly drift-covered valleys. Some ridges are supported by thrust plates, others by asymmetric anticlines. These structures, which represent shortening of the sedimentary cover, record tangential compression. Despite a variety of structural trends, there is no evidence for more than one phase of compression.

The structural province is characterized by enigmatic "reversals" in the sense that a southwest-dipping thrust plate, traced along strike, can be replaced abruptly by a northeast-dipping plate. In most cases the opposing blocks are separated by a transverse fault which indicates longitudinal shortening of the range in addition to the more obvious shortening perpendicular to it.

Anticlines are asymmetric but the sense of asymmetry changes from one range to another. In one case an asymmetry reversal takes place along trend, from northeast directed to southwest directed. This geometric similarity to the pattern of thrust plates is taken to signify a common genesis for the thrust and fold structures. These reversals along the trend of a particular range are inadequately explained, but the close geometric relation between reversals and transverse faults suggests an interrelated origin dependent on longitudinal shortening in conjunction with lateral shortening.

Most of the northern Franklin Mountains appear to be floored by a *décollement* zone in shale and evaporite beds of the Cambrian Saline River Formation. Structures above the zone probably are accentuated by tectonic thickening of Saline River. The *décollement* is assumed to extend beneath the Colville Hills about 175–200 mi northeast of the Mackenzie Mountain Front. In the McConnell Range on the south and the Mackenzie Mountains on the southeast, the *décollement* zone must be at a lower stratigraphic level, because beds older than Saline River Formation are exposed in structures.

CREAGER, JOE S., RONALD J. ECHOLS, MARK L. HOLMES, and DEAN McMANUS, Dept. Oceanography, Univ. Washington, Seattle, Wash.

#### CHUKCHI SEA CONTINENTAL SHELF SEDIMENTATION

The topography of the Chukchi Sea continental shelf south of Herald Shoal is and has been dominated since at least Wisconsin time by Hope Valley (which trends northwest through the central part of the area) and by structural and sedimentary spit-like features trending offshore from Point Hope and Cape Prince of Wales. During the Wisconsin time of lowered sea level, Hope Valley was retrenched and most pre-Wisconsin Pleistocene sediments were stripped from the interfluvies. The drainage system was considerably more complex than indicated by the present bathymetry. High-frequency (12 kHz) subbottom profiles and gravity and piston core sediments indicate 1–26 cm post-Wisconsin sediment deposited mostly in a large estuarine environment produced as Hope Valley was inundated. The main sources of sediment initially were the Kobuk-Noatak river system and the shores; smaller amounts were derived from lateral river discharge. Approximately 13,000–14,000 years ago, sea level had risen sufficiently to connect the Bering and Chukchi Seas. After the 2 seas were connected, a major source of sediment was introduced from the Yukon through Bering Strait into the central Hope Valley estuary. A period of rapid deposition followed. Deltaic deposits came from both the Noatak-Kobuk and Yukon sources. In addition, significant deposition north of Point Hope and Cape Prince of Wales resulted from the prevailing current established through Bering Strait. Transgressive sands, open-shelf facies, paralic sediments, and residual deposits can be recognized when related to the modern shelf sediment environment. The total post-Wisconsin deposition has buried numerous small Wisconsin stream valleys, displaced Hope Valley northward through the building of the Bering Strait "delta," produced thick deposits of current-derived sediment on the downstream lee sides of Point Hope and Cape Prince of Wales, and subdued the more rugged Wisconsin subaerial topography.

CRORY, FREDERICK E., U. S. Army Cold Regions Research and Engineering Lab., Hanover, N. H.

#### SETTLEMENT ASSOCIATED WITH THAWING OF PERMAFROST

Unique engineering problems are encountered in the design, construction, and maintenance of facilities in permafrost areas. Changes to the thermal regime of permafrost produces corresponding changes in the mechanical and physical properties of the soils. Degradation of permafrost can result in large settlements which commonly are differential and hence more damaging or detrimental to the operation and performance of structures, utilities, roads, and airfields. The degradation of permafrost may be caused by building heat or from disturbance to the ground cover, solar radiation, drainage, underground utilities, groundwater flow, or by construction methods. An assessment of the potential settlement associated with the thawing of permafrost is therefore essential, and requires a thorough understanding of frozen soil mechanics.

The known occurrence and distribution of ice in permafrost and the basic relations between volume and weights of frozen and thawed soils can be shown in diagrams and sections, and can be expressed by appropriate equations. Laboratory test results on thaw-con-

solidation of undisturbed frozen cores from several locations are of considerable interest. Although most frozen soils tested contained freshwater ice, some plastic silt and clay samples containing significant quantities of brine also were tested. The latter samples were obtained at Kotzebue and Point Barrow, Alaska.

The writer shows the identity between the consolidation theory advanced by Terzaghi for thawed soils, using void ratios, and the relation between frozen and thawed dry unit weight of soils. On the basis of this identity, one may estimate quantitatively the total settlement from information in single boreholes and the differential settlement between 2 or more adjacent borings. There also are methods for building in ice-rich permafrost areas, including methods of preserving the frozen state or pre-thawing and consolidating.

DARBY, DENNIS A., Dept. Geol. and Geophys., Univ. Wisconsin, Madison, Wis.

#### CARBONATE CYCLES IN ARCTIC OCEAN SEDIMENT CORES

Gasometric determination of the carbonate fraction from generally continuous intervals of cores from the Canada basin and Alpha Cordillera reveal as many as 18 significant fluctuations during the past 3 m.y. The duration and number of these cyclic carbonate fluctuations are very similar to those reported from the equatorial Pacific. However, carbonate peaks in the Arctic sediment cores do not correlate with faunal increases as they do in the Pacific. Poor correlation between carbonate peaks and organic carbon content also suggests that these peaks are not caused by increases in organic productivity. Examination of the coarser fraction associated with the carbonate layers indicates that detrital calcite and dolomite are present. One possible explanation for the increase of detrital carbonate during the Pleistocene could be periodic lowering of sea level which would expose carbonate outcrops of the continental shelf to ice plucking. If so, such events may be correlated with Pleistocene events elsewhere.

DAWES, PETER R., Geol. Survey Greenland, Copenhagen, Denmark, and N. J. SOPER, Dept. Geology, Univ. Sheffield, Sheffield, England

#### PRE-QUATERNARY GEOLOGY OF NORTH GREENLAND

In North Greenland a geologic section is present that contains Precambrian crystalline basement, and strata of Precambrian, early Paleozoic, late Paleozoic, Mesozoic, and Tertiary strata.

The crystalline basement, which is exposed at places adjacent to the Inland Ice, is overlain with angular unconformity by the late Precambrian to early Paleozoic sedimentary section. These sediments have a gentle north dip and comprise a large platform area that extends from the west to the east coast. The oldest sedimentary formation of this platform (the Inuitq Sø Formation) is at least 1,000 m.y. old, and the youngest strata are late Wenlockian-early Ludlovian. The lower Paleozoic strata, if traced northward, are part of the North Greenland fold belt, which occupies an approximately E-W-trending zone of folds and metamorphic rocks along the extreme northern coast of Greenland. In Peary Land, where the broadest section across the folded zone is exposed, metamorphic and deformational effects increase northward.

In eastern Peary Land, the folded Cambrian, Ordo-

vician, and Silurian sediments are overlain unconformably by less severely deformed Pennsylvanian, Permian, Triassic, and Cretaceous-Tertiary strata. This younger cover shows the effects of Tertiary earth movements. In northern Peary Land, a bedded sequence of dominantly rhyolitic lava and tuff (the Kap Washington Group) crops out. These volcanic rocks post-date the main Paleozoic diastrophism of the surrounding metasediments, but are affected by later folding and thrusting. A minimum K-Ar age of 35 m.y. has been obtained from the lavas.

The metasediments of the North Greenland fold belt have been subjected to a complex structural and metamorphic history, which is not completely understood. Two distinct periods of deformation and metamorphism can be recognized: Paleozoic (between Late Silurian and Late Devonian times) and Cretaceous-Tertiary. Paleozoic orogenesis involved polyphase deformation in northern Peary Land with the second- and third-order folds facing northward, toward the assumed interior of the orogen. Cretaceous K-Ar ages of the metamorphic rocks suggest a subsequent thermal episode which produced Abukuma-type mineral assemblages, but no structural events can be assigned to this period. Tertiary movements are indicated by the northward thrusting of the metamorphic rocks over the Kap Washington Group, with accompanying mylonitization.

DEMENITSKAYA, R. M., YU. G. KISELEV, G. I. GAPONENKO, and S. S. IVANOV, Research Inst. Geol. of Arctic, Leningrad, USSR

#### FEATURES OF SEDIMENTARY COVER OF ARCTIC OCEAN

1. The part of the earth's crust surrounded by three large pre-Paleozoic platforms (the eastern European, middle Siberian, and Greenland-Canadian) is the Arctic basin, and the presence of these 3 platforms was the initial basis for the origin and development of the Arctic Ocean. The existence of these platforms and their surrounding fold belts created conditions favorable for sedimentary accumulation in the inner regions of the ocean.

2. The various sedimentary frameworks in different parts of the ocean show the different types of tectonic movements that affected the area, and indicate specifically the history of reconstruction of the former continental features into oceanic ones.

3. Oceanic margins—the regions of the present shelf—represent, according to tectonic data, vast parageosynclinal basins nearly of isometric shape, composed of thick sedimentary layers of different ages and structures. In a west-east direction one may observe the successive rejuvenation of the sedimentary cover and the progressive decrease in the degree of consolidation of the cover sediments.

4. The sedimentary framework of the eastern sector of the inner Arctic Ocean basin differs from that of the western sector. A double stage structure of the sedimentary sequence is typical for the eastern sector of the Arctic Ocean basin. Unconsolidated sediments with seismic velocity values of 1.6–2.5 km/sec are everywhere underlain by consolidated rocks with velocity values of about 3.5–4.5 km/sec. In the western Arctic basin, the unconsolidated sediments overlie either relict folded basement with seismic velocity values of 5.0–6.0 km/sec, or basaltic basement with seismic velocity values of 6.3–6.7 km/sec.

5. In large arched uplifts, the thickness of unconsoli-