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.

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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.

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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 Inuiteq 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, Ordovician, 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.

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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-

dated sediments is much less than that in the adjacent troughs, but in most places, the thickness of the rocks comprising the second stage is identical for both troughs and orogenically uplifted areas. The last fact suggests that the large vertical movements of the inner Arctic Ocean occurred mainly in late Mesozoic-Cenozoic time. It was during this time that the present morphometric form of the Arctic Ocean basin was created.

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MESOZOIC SEQUENCE IN ARCTIC ALASKA

Early Mesozoic rocks in Arctic Alaska reflect a continuation of deposition in the late Paleozoic Cordilleran geosyncline. Starting in Early Jurassic time the broad Cordilleran geosyncline was warped into 3 small geosynclines, the Colville, Koyukuk, and Kandik, separated by the east-trending Brooks Range geanticline and the narrow southwest-trending Ruby geanticline. These structural highs and lows were areas of erosion and deposition throughout the rest of the Mesozoic.

Orogeny was widespread in the Cretaceous. One major orogeny took place during the Aptian, and all post-Aptian strata lie with angular discordance on earliest Cretaceous to Devonian beds. Orogeny continued in Cenomanian time, and by late Cretaceous, folding was largely complete in the Koyukuk and Kandik geosynclines. The Brooks Range was uplifted at the end of Cretaceous time, and the rocks of the Colville geosyncline were moderately to strongly deformed. Major thrust plates developed, and the strata were thrust northward, so that rocks of similar age but widely different facies were commonly juxtaposed.

Early Triassic beds are primarily confined to northeastern Alaska, where 500–1,000 ft of strata show a distinct northward coarsening of clastic components, indicating a source in that direction. Middle and Late Triassic times are represented by widespread deposits of black phosphatic limestone, calcareous shale, and chert several hundred feet thick. These shelf deposits are similar to, and largely concordant with, the underlying Paleozoic strata.

During the Jurassic the Colville and Kandik geosynclines received 2,000–10,000 ft of monotonous dark pyritic shale, siltstone, and graywacke. At the same time, mafic igneous flows and tuffs were accumulating in the Koyukuk area. These rocks are largely discordant on older strata, and locally discordant between successive Jurassic units.

The depositional pattern established in the Jurassic continued into the Early Cretaceous, when 5,000–15,000 ft of mainly flysch-type sediments accumulated in the geosynclines. By middle Albian time, conditions favoring deposition of subgraywacke prevailed. Shifting shorelines caused better sorting in the 3,000–10,000 ft of interfingering marine and nonmarine clastic rocks deposited during the rest of Cretaceous time.

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EPI-PALEOZOIC HORST-ANTICLINORIA AND SHELF TROUGHS OF ARCTIC MARGIN OF EURASIA

The most intensively developing morphostructures of the Arctic margin of Eurasia are predetermined by mobile belts developed on ancestral Paleozoic eugeosynclines. There are horst-anticlinoria which are cut by shoreline or in places intersect it; in the latter case, they extend deeply into the Arctic shelf area (Novaya Zemlya and others). These rejuvenated mountains are replaced along their trends by graben-subsidences and then by shelf (epicontinental) troughs. The troughs are especially distinctive and varied within the Barents-Kara Sea, linking the Paleozoic synclinal zones of Scandinavia, Severnaya Zemlya, Urals-Novaya Zemlya, and Spitsbergen that extend into this part of the Arctic shelf. In the Laptevykh-Chukchi Sea sector where the mobile belts are connected only with some blocks of Paleozoic eugeosynclinal basement (Brooks, Wrangel, and others), epicontinental troughs are less prominent.

The mobile belts also are the weakened zones of tectonosphere controlling pre-fracturing and gradual subsidence of stable (intertrough) areas. Epicontinental troughs, replaced horst-anticlinoria, and graben-subsidences are replaced in turn by marginal and continental slopes. Coastal lowlands and nearshore shelves are replaced by outer shelves, avant-shelves, and bathyal and abyssal plateaus. Thus, a genetic series of linear and areal morphostructures may be distinguished; their presence proves the development of oceanization of the Arctic margin of Eurasia and the origin of the deep-water Arctic basin.

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METAMORPHIC BELTS OF NORTHWESTERN PACIFIC REGION

Metamorphic belts and complexes of the northwestern Pacific region may be subdivided into 6 types corresponding to certain types of metamorphism.

1. Early Precambrian granulitic and high-temperature migmatite gneissic massifs (Omolon, Okhotsk, Khankaiy, partly Chukotsk massifs).

2. Precambrian(?) kyanite-staurolite schist-gneissic complexes (massifs) such as Hida, Abukuma massifs, partly Chukotsk and central Kamchatka's massifs reworked by later orogeny.

3. Zonal belts of andalusite-sillimanite type, associated with granitoids and blocks of types 1 and 2: (a) Paleozoic (Pylgyn, Su-chan); (b) Mesozoic (Taygon, central Kamchatka, Kitakami-Abukuma, Kyoke belts, *etc.*).

4. Glaucophane-schistic belts, most specific, closely associated with ophiolitic belts, commonly treated as ancient boundary zones of oceanic platform. (a) Paleozoic (Pen-yin, San-gun, Matsugadaira-Motai, etc.) (b) Early Paleozoic (Pekulney-Vayega, Ganal, Susunai, Kamuikotan, Sanbagawa, *etc.*).

5. Green schistic uniformly metamorphosed rock series (such as pre-Amur Riphean rock series type).

6. Poorly metamorphosed rock series (prehnite-pumpellyitic and lomontitic facies) of different age. Treated as external zones or second-stage metamorphism of types 3–5; also as independent transient-to-low temperature metasomatosis.

Comparisons of the peculiarities found in these types, their tectonic positions and age succession, in addition to their relation with granitoids implies the validity of 2 concepts suggested by Miyashiro about paired belts and that of de Roever-Marakushev about successive age changes in the different types of metamorphism supplementing each other. This may be reflected as an idealized scheme, distinguishing zones of subsidence from zones of uplift.