interaction and the geochemical characteristics of glaciomarine sediments.

Glaciomarine sediments in southeast Alaska consist predominantly of feldspar, quartz, illite, and chlorite. Kaolinite is not a weathering product in this area. Interstitial waters from bottom grab samples showed a substantial decrease in sodium ions compared with the overlying waters. Significant variations in Na^+ concentration with depth also were found in interstitial waters obtained from cores. Laboratory and field observations suggest that primary glacial clays are saturated with H^+ and Ca^{++}. During transport and early stages of burial in marine environment, cation exchange of H^+ and Ca^{++} from glacial and fluvial sediments for Na^+, K^+, and Mg^{++} of seawater is the major process causing changes in the interstitial water. No mineralogic alterations of clay were observed from the glaciofluvial to marine environment. Cationic concentrations in interstitial waters can be related to the bulk mineralogy and particle size of sediments, the environment of deposition, and the path length the sediments follow before deposition.

SHEARMAN, DOUGLAS J., Imperial College, London, England

Evaporite-Carbonate Relations in Basin Development

Petrographic studies of marine evaporites reveal that the initial assemblages of evaporite minerals were generated in 2 distinctly different ways. Some grew or accumulated at the sediment surface where they were evidently precipitated from an overlying brine; others were emplaced within a preexisting, unconsolidated, host sediment, and were formed in response to conditions that prevailed beneath the sediment surface within the interstitial waters of the sediment itself. The latter mode of origin characterizes supratidal sabkha-facies evaporites, which have been found to be an essential constituent of many marginal evaporite complexes. In the sabkha environment there is no overlying body of brine and the evaporite minerals are emplaced within the sediment from marine-derived groundwater.

This same mode of genesis of evaporite minerals can be demonstrated for some of the anhydrite, halite, and potash deposits in several "basin-facies" evaporites. The possibility arises therefore that these units record phases of emergence and, as such, suggest that the whole evaporite assemblage was deposited in an environment of shoal water and emergent banks, and not beneath a deep body of brine as previously envisaged. In view of the evident relief within some of the basins, as inferred for example from the thickness of the carbonate reefs relative to the floor on which the evaporites were deposited, such an interpretation requires that profound changes in water level may have occurred within the basins.

The evaporites of the Middle Devonian Elk Point basin are reviewed in terms of the various modes of evaporite-mineral genesis, as a background to discussion on the carbonate-evaporite relations within the complex.

SHINN, EUGENE A., Shell Development Co. Exploration and Production Research Center, Houston, Tex.

Submarine Formation of Bored Surfaces (Hardgrounds) and Possible Misinterpretation in Stratigraphic Applications

Bored and encrusted surfaces, generally called "hardgrounds," are common in some ancient limestones. Proper identification of the environment of lithification in ancient hardgrounds is important because it can greatly influence the interpreted depositional history of the associated limestones. In addition, proper identification of the environment can determine the usefulness of hardgrounds as stratigraphic markers.

The presence of bored and encrusted Holocene submarine cemented layers in the Persian Gulf suggests that some ancient hardgrounds could have formed underwater and not by exposure to meteoric water. Holocene hardgrounds covering hundreds of square miles in the Persian Gulf commonly occur as multiples of bored beds (as many as 4 have been observed) interbedded with noncemented carbonate grainstone or mud. Each hardground bed is thoroughly cemented by fibrous aragonite and/or magnesium calcite at the upper surface and generally the degree of cementation decreases downward. Each hardground bed contains pelleted geopetal internal sediment which commonly lies on fibrous aragonite. Similar features, now altered by calcite, may be the key to understanding the origin of many ancient hardgrounds.

SHOULDICE, DAVID H., Shell Canada Ltd., Calgary, Alberta

Geology of Western Canadian Continental Shelf

Shell Canada Limited geologists and geophysicists have made a study of the stratigraphy of the Tertiary strata in the Tofino and Queen Charlotte basins of Canada's Pacific shelf. Data was obtained from Mesozoic and Tertiary outcrops along the shoreline margins of the basins, 6 Richfield Oil Corporation wildcats on the Queen Charlotte Islands, Shell Canada's aeromagnetic, reflection, and refraction seismic surveys, and 14 offshore wildcats drilled between May 1967 and May 1969.

The pre-Tertiary framework of the shelf consists of a thick and complex sequence of Mesozoic sedimentary, metamorphic, and intrusive and extrusive igneous rocks. Little is known about the early Tertiary history but data from the Tofino basin suggest widespread early-middle Eocene submarine volcanic activity, initial uplift followed by subsidence in late Eocene time, distinct transgressions of Oligocene–early Miocene seas, followed by a middle Miocene period of crustal deformation, uplift, and regression.

There was a major transgression in late Miocene time and a lesser one in early Pliocene time followed by a regressive phase in late Pliocene-Pleistocene time. The early Tertiary volcanism in the Tofino basin spread northward and continued, at least sporadically, in the Queen Charlotte basin to the end of the Miocene and perhaps into the early Pliocene. Tertiary deposition in the Queen Charlotte basin began early in the Miocene and, although interrupted by perhaps 2 periods of uplift and erosion, continued through the Pliocene into the Pleistocene.

The maximum thickness of Tertiary strata is more than 15,000 ft. The strata range from deep-water, open-marine sequences of shale, siltstone, and sandstone in the Tofino basin, through both deep- and shallow-marine deposits in Queen Charlotte Sound, to a thick nonmarine sequence of sandstone, shale, siltstone, and coal in Hecate Strait and the Queen Charlotte Islands. The sandstones in both basins are composed primarily of feldspars and quartz, and those of the Queen Charlotte basin are characterized by high porosity and low permeability values.

There is a wide variety of structural styles including