phean) of the USSR. The nonrepetitive changes in microstructural assemblages through the Riphean may be understood in terms of the community organization of blue-green algae. The presence of distinctive microstructures which survived for long periods of time implies the presence of very highly biologically accommodated communities of blue-green algae, *i.e.*, of assemblages of algal species with high levels of physiologic and biochemical accommodation among species. The time range of each community and microstructure was determined by the timing of major regressions or of major reorganizations in the distribution of shallow seas. Biologically accommodated communities were broken down during these regressions or reorganizations. Microstructural assemblages had broad areal distributions within the USSR, as well as specific time ranges. Paleogeographic reconstructions of the USSR indicate that areas with similar microstructural assemblages were in open-water contact during the corresponding time period. Open-water connection accounts for the synchroneity of microstructural assemblages in the USSR, but similarity of hydrographic conditions throughout the Precambrian world ocean is improbable. Therefore, time-stratigraphic microstructural units defined in the USSR should not be used for worldwide correlation until paleogeographic relations are established firmly.

GOOLSBY, D. A., U.S. Geol. Survey, Tallahassee, Fla.

Geochemical Effects and Movement of Injected Industrial Waste in a Limestone Aquifer

Abstract *in* Am. Assoc. Petroleum Geol. Bull., v. 55, no. 11, p. 2084.

GORDON, W. A., Dept. Geol. Sci., Univ. Saskatchewan, Regina, Sask.

Physical Controls on Marine Biotic Dispersal in Jurassic

Oxygen isotope studies and biogeographic distributions indicate that the Jurassic Period was a time of only moderate latitudinal variation in temperature. Seasonal change was less well marked than at present. On land, vegetation varied geographically, but less so than at other times in earth history. Tetrapods from widely spaced land areas were quite similar. By contrast, marine invertebrates including forams, ammonoids, belemnoids, and pelecypods show distinct provincialism, and the boundaries of the marine invertebrate provinces shift through time. Physical controls that could have produced this provincialism include salinity and temperature differences in the sea, the distribution of shelf seas and deep water areas, and the geographic arrangement of sea and land, or a combination of these. Consideration of likely geographic positions of the continents during the Jurassic (assuming that they have drifted since that time), and of the likely pattern of ocean currents of the time, explains many features of the pattern of biotic dispersal. It suggests that differences in water temperature were a prime physical control on the distribution of marine Jurassic life. In particular, it indicates that the Boreal realm was not a sea area of salinity lower than average as has been suggested previously. Analogy with other Mesozoic times, and certain evidences of bipolarity in biogeographic patterns in the Jurassic, further support the view that temperature difference was a prime physical controlling factor.

GREENE, H. G., U.S. Geol. Survey, Menlo Park, Calif.

Sedimentary Features and Nearshore Processes of Arctic and Sub-Arctic Beaches

Arctic beaches show characteristic sedimentary features that readily distinguish them from beaches in more temperate zones. Along the Alaska coastline in the eastern Arctic and subarctic regions of the Bering Sea, many exotic microtopographic structures may persist throughout summer, if spring and summer weather conditions are mild enough. On prograding sections of the coast, similar features might be preserved in the stratigraphic cross section of the beach.

Microrelief features develop in spring and early summer as a result of dynamic processes associated with breakup of sea ice and thawing of kaimoo, permafrost, snow banks, and stranded blocks of ice. On the beach 2 different types of microrelief occur. Along the backshore and the upper foreshore, small streamlets and mud flows fed by melting snow and thawing permafrost produce micro-outwash and microdeltaic deposits. In the swash zone, movement of grounded sea ice by wind and waves produces ice-push ridges; melting of kaimoo ice leaves a kaimoo ridge, and melting of stranded gravel- and sand-rich brash ice creates sea-ice kettles and sea-ice sand and gravel cones. Within the nearshore areas, close to the shoreline, sea ice locally scours the bottom sediment into small randomly oriented ridges and troughs. Farther offshore, small randomly spaced hummocks of coarse sand and gravel form where ice-rafted sediment drops from grounded or stabilized melting sea ice.

GROAT, C. G., and J. H. McGOWEN, Bur. Econ. Geol., Univ. Texas, Austin, Tex.

Van Horn Sandstone, West Texas—Early Paleozoic Alluvial-Fan System

Sediment comprising the Cambrian(?) Van Horn Sandstone was derived from a highland source area of rhyolite, granite, and metamorphic and sedimentary rocks. Detritus ranging from boulders to silt was transported southward through canyons by high-gradient streams under rapid-flow and surge-flow conditions. South of the canyon mouths, the sediment was spread across the fan surface by shallower, less-confined braided streams; mud-flow deposits are absent. Three gradational facies, from north to south, are recognized in the fan deposits.

Proximal facies are deposited in the feeder canyons and near their mouths. This facies consists of massive cobble and boulder beds overlain by thinner, horizontally bedded pebble, cobble, and boulder gravels.

Mid-fan facies consist of gravels and sands. Gravel lenses are interpreted as longitudinal bars (parallel-bedded, convex-upward deposits) and channel fills (convex-downward deposits). Mid-fan sands occur as channel fills, across the tops of gravel bars, and in lows flanking them. Foreset and trough crossbeds are the dominant sedimentary structures in these sands which are interpreted as transverse bars with dunes.

Distal facies is a sand sequence in which three subfacies have been delineated: (1) braided mainstream deposits containing both foreset and trough crossbeds; (2) braided distributary deposits characterized by a relatively high content of muddy sand units, well-preserved channel cross sections, some ripple cross-laminae, and soft-sediment and injection structures; and

(3) braided interlobe deposits which are nearly mud-free, thick sand sequences made up almost exclusively of small trough crossbeds.

GUTSCHICK, R. C., Dept. Geol., Notre Dame Univ., Notre Dame, Ind., and L. J. SUTTNER, Dept. Geol., Indiana Univ., Bloomington, Ind.

Sandstone and Chert Columns in Permian Rocks of Southwest Montana: Biogenic or Inorganic?

Enigmatic columnar structures of sandstone, cherty sandstone, and chert in the Phosphoria Formation were studied at 18 localities in southwest Montana. The structures have circular to elliptical cross sections, diameters of 0.5 to 8 in. and are up to 13 ft long. Most have irregular external annulations, perhaps due to compaction; others are smooth sided.

The structures are in and can be traced through a variety of host rocks. They are most common and best developed in the nonglauconitic littoral to sublittoral facies of the Shedhorn Sandstone. In the sandstone they are almost always oriented perpendicular to bedding. In the intercalated shale or chert host rock, approximately 50% are inclined at very low angles to the bedding. Up to 95% of a host bed may consist of the columns.

The high-density packing of the columns, their morphology, highly variable composition, and association with several host-rock types indicate the structures are organic, probably burrows, rather than inorganic in origin. Their great length, sparse bulbous bases, and the presence of other poorly preserved patterns suggest that the organisms that formed the structures mainly were escaping sediment influx by moving upward rather than burrowing downward. If so, the structures may have important implications about rates of sedimentation on the Permian platform of western United States, if the life span of the organism that produced them can be determined. However, no organism capable of producing the burrows has been found preserved within one.

HAGMAIER, J. L., Humble Oil Refining Co., Denver, Colo.

Groundwater Flow and Uranium Deposition, Powder River Basin, Wyoming

The relation between regional groundwater flow, hydrochemistry, and uranium distribution in the Powder River basin indicates that uranium was deposited during the Tertiary Period in groundwater recharge areas where the groundwater changed from a sulfate-bicarbonate water to a bicarbonate-rich water.

The regional recharge and discharge areas of present groundwater-flow systems have about the same locations as the recharge and discharge areas of the Tertiary groundwater-flow systems. The present groundwater is recharged in the eastern, western, and especially the southern margins of the basin and is discharged in the valley of the Powder River, especially in the north. Flow nets for the groundwater were constructed on the basis of piezometric data from existing water wells in the Powder River basin.

The groundwater chemistry of this area during the Tertiary was probably similar to that of today because the groundwater flowed through the same sediment as present groundwater. Anions in the present groundwater undergo the following sequence of hydrochemical changes along the regional flow path from the southern recharge area to the northern discharge area:

$$HCO_3^- + SO_4^{--} \rightarrow SO_4^{--} + HCO_3^- \rightarrow HCO_3^-.$$

Major unoxidized uranium deposits in the Powder River basin occur near the transition zone between the $SO_4^{--} + HCO_3^-$ and HCO_3^- facies. The uranium is transported in solution by groundwater in the $HCO_3^- + SO_4^{--}$ and the $SO_4^{--} + HCO_3^-$ facies and precipitated in the transition zone between the $SO_4^{--} + HCO_3^-$ and HCO_3^- facies. Precipitation occurs where strong reducing conditions exist around abundant organic material in which sulfate-reducing bacteria may live and multiply.

HAMILTON, W. B., U.S. Geol. Survey, Denver, Colo.

Plate Tectonics of Southeast Asia and Indonesia

The plate-tectonic evolution of a region can be deduced by following the assumptions that (1) subduction zones are characterized by ophiolite, mélange, wildflysch, and blueschist; (2) intermediate and silicic calc-alkaline igneous rocks form above Benioff zones; and (3) truncations of orogenic belts indicate rifting. Interrelations provide cross checks, as do marine geophysical data.

Southeast Asia and "Sundaland" are an aggregate of small continental fragments. Late Paleozoic subduction westward beneath Malaya and Thailand (recorded by granites in eastern Malaya, and by mélanges in western Laos and Cambodia) ended when Indochina collided with them. Early and Middle Triassic subduction was eastward, beneath the west side of the aggregate. Late Triassic and Jurassic subduction from the north ended in collision of the aggregate with China. Early Cretaceous subduction was also from the west. Late Cretaceous subduction was beneath the east side of the aggregate and followed continental rifting there. Cenozoic subduction, from the west once more, ended in the north when the aggregate collided with India, but subduction still continues in the south. Borneo similarly reflects changing subduction patterns.

The Philippines, Sulawesi, and Halmahera consist wholly of upper Mesozoic(?) and Cenozoic island-arc subduction and magmatic complexes and lack old continental foundations. The scrambled fragments of the Philippines came from several arc systems, including 2 extending to Borneo. Sulawesi and Halmahera record primarily subduction from the east and may be rifted and contorted fragments initially continuous with southeast Borneo and central Java.

In the early Tertiary, Australia and New Guinea, which then had a stable-shelf northern margin, moved northward until they collided with a southward-migrating island arc, behind which had formed the Caroline oceanic plate. Late Cenozoic tectonics in New Guinea have been dominated by southward subduction of the Caroline oceanic plate beneath the Australian-New Guinea continent, and by left-lateral strike-slip faulting. Such faulting tore the Sula Islands from northwest New Guinea and carried them to Sulawesi.

The islands of the outer Banda arc are formed of mélanges of the shallow-water sediments of the New Guinea and Australian continental shelf, which is now disappearing beneath the active arc.

HAMMOND, C. W., Sun Oil Co., Richardson, Tex.

Space Photography's Role in Exploration

Space, or hyperaltitude, photographs are defined as