tallized, although the calcite mosaic of converted superficial frontal aragonite layer still contains solid inclusions of the original aragonite.

The presence of such aragonite inclusions, or the numerous pits which result when they are dissolved (*e.g.*, during etching or Feigl solution treatment), may be useful in recognition of older examples of *in situ* conversion of aragonites.

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Paleogeology in 21st Century

When the archivists of the 21st century dig back into the history of the science of the earth, they will fail to see some of the distinctions of which we today are acutely conscious. Geology, geophysics, geochemistry, paleontology, and their brethren will have blurred into a single mature and rather noncontroversial discipline.

We can expect that the various earth sciences of today will continue to undergo the accelerating maturation processes that have been followed in the older sciences. The trends are clearly visible today—the descriptive and taxonomic in geology, the intuitive and subjective in geophysics are surely losing ground to the postulational and mathematical approaches of physics and chemistry. Today much of our basis for differentiation among earth sciences lies not in what those scientists are studying but in the tools that they use. Such distinctions cannot prevail. By the 21st century (only 29 years away), the successors of today's geological journals will be as full of mathematics as are today's geophysics journals. The neo-geophysical journals will be steeped in geological ideas.

Those of us in both fields who fail to adapt to the new trends will be available as subjects of study by the paleoscientists of the next century for we shall surely be fossilized.

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Geologic History of Blue-Green Algae: A Paradigm of Evolutionary Conservatism

Approximately 185 occurrences of fossil blue-green algae (excluding stromatolites and similar organo-sedimentary structures) have been reported since 1855. More than half of these occurrences have been described during the past 5 years and more than 75% since 1950. This recent, major expansion of the known cyanophytic fossil record is a direct result of the recent upsurge of interest in Precambrian paleobiology; nearly two thirds of all occurrences and 95% of those reported during the past 5 years are of Precambrian age. The majority of reported fossil cyanophytes are cellularly preserved in microcrystalline cherts. Evidence of ecologic setting, growth habit, general morphology, detailed cellular anatomy, and mode of reproduction is rather commonly present. Comparison of fossil and living taxa indicates that in all of these features, and presumably in ultrastructure and biochemistry as well, many of these primitive prokaryotes have evolved little or not at all since the Precambrian. The marked evolutionary conservatism of the Cyanophyceae is attributable to the wide ecologic tolerance, versatile physiology, and unusually stable genetic system characteristic of the class; a suitable ecologic niche, relatively free from competitors, has been accessible to these highly adaptive microorganisms since early in earth history. Evidence now available suggests that the earliest blue-green algae were unicellular coccoids, first appearing during the early Precambrian; that mat-building, filamentous cyanophytes had become established as early as 2.8 b. y. ago; that the class reached its zenith in evolutionary diversification and ecologic importance during the late Precambrian; and that the subsequent appearance of heterotrophic, mobile eukaryotes (protozoans and metazoans) resulted in adjustment of ecologic relations and a marked reduction in distribution and abundance of cyanophytic communities early in the Paleozoic.

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Geologic Implications of River-Pattern Variability

Experiments were performed in a large flume at constant discharge to determine the effect of slope on channel patterns. At very low slopes ($<0.2\%$), the model channels remained straight, but a meandering-thalweg channel formed at steeper slopes (between 0.2 and 1.3%), and braided channels formed at the steepest slopes ($> 1.3\%$). These experiments demonstrate that channel patterns can change from straight to meandering to braided at critical values of slope.

The results also are applicable to the problem of the downstream variability of river patterns. Most alluvial rivers flow on surfaces (valley floor or alluvial plain) whose slopes have been determined by past conditions of flow and sediment load, by tributary effects, and/or by warping. As channel patterns are sensitive to changes of slope, other conditions being similar, a steeper reach of valley slope usually will cause an increase in channel sinuosity, as the river attempts to maintain a relatively constant gradient. Experimental results and Mississippi River data support this conclusion, which may be of practical value in identifying reaches of a river system influenced by neotectonics or structure.

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Geology of Wagon Wheel Nuclear Stimulation Project

Project Wagon Wheel, if executed will be an attempt to stimulate gas reservoirs of the Pinedale anticline by means of nuclear explosives. The Pinedale field, located in the northern Green River basin of southwest Wyoming, is potentially productive from a section totaling nearly 10,000 ft of lower Fort Union, Lance-Lewis, and Mesaverde sandstone equivalents. Attempts to produce the field conventionally have proved uneconomical due to low permeability.

Because its requirements exceeded the state of nuclear technological development, Wagon Wheel was not selected for the first gas stimulation experiment. Project Gasbuggy, in northwest New Mexico, was detonated in 1967 using a 26 kiloton device. Data produced in Gasbuggy were utilized in planning Wagon Wheel, which is an actual attempt at economic use of nuclear energy.

Wagon Wheel No. 1 was drilled to 19,000 ft to evaluate the entire Mesaverde section. Gas was detected by mud-logging equipment below 7,972 ft depth throughout the basal Fort Union, Lance-Lewis, and Mesaverde. The well has been plugged back to 11,700 ft leaving approximately 3,700 ft of proved gas-bearing section available for stimulation. This interval will accommodate the 5 100-kiloton explosives planned. In-place gas reserves for this section are calculated at 252 billion cu ft/sq mi.

Extensive logging, coring, and testing have been carried out in the program, including special logs for rock mechanics study. Cores were compared with those from Gasbuggy as to compressive strength, shear behavior, and potential for fracturing. Petrographic analyses indicate better fracture potential at Wagon Wheel due to a higher degree of grain to grain contacts and lower clay content.

Environmental protection studies include examination of surface waters, springs and wells, man-made structures, mines, flora, fauna, and general land use. The most important aspect from a geologic standpoint is protection of the extensive groundwater aquifers above the gas reservoir. Two wells, in addition to the Wagon Wheel No. 1, were drilled for the purpose of evaluating those aquifers. Potable water extends to a depth of approximately 3,600 ft. Salt water occurs from 3,600 to approximately 5,200 ft. Low quality subpotable water extends from 5,200 to about 7,200 ft. The saltwater zone is interpreted to be in a tongue of Wasatch Formation extending from the west into Eocene arkoses derived from the Wind River Range on the east.

Plans call for sequential detonation of 5 explosives spaced at intervals from 9,220 to 11,560 ft to produce a more or less continuous chimney from about 8,700 to about 11,600 ft. There will be a safety margin of 1,500 ft between the top of fractures and the bottom of known aquifers.

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Phosphate Deposition Seaward of Barrier Islands at Edge of Phosphoria Sea in Northwestern Wyoming

Four elongate tongues of the Shedhorn Sandstone of Permian age extend southeastward from the Yellowstone Park area into the Gros Ventre, Hoback, and Wyoming Range area. These tongues represent barrier-island complexes that built southwestward in the Phosphoria sea, creating a lagoon on their northeast side. The lagoonal facies includes algal laminated and ostracodal limestone and dolomite and a greenish-gray shale. The barrier island facies consists of crossbedded quartz sandstone which contains abraded thick-shelled fossils. The marine facies southwest of the barrier island facies includes chert, quartz sandstone, calcarenite containing a siliceous sponge, brachiopod, and bryozoan fauna, and phosphorite containing a brachiopod and fish fauna. Major phosphate deposition was restricted to the marine environment seaward of the barrier islands, and was absent in the lagoonal environment.

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Bedded Zeolites in United States—Potential Industrial Minerals

Zeolites are among the most common authigenic silicate minerals in sedimentary deposits. Zeolites occur in rocks that are diverse in age, lithology, and depositional environment, but they are most common in sedimentary rocks that originally contained abundant vitric material. Of the more than 30 naturally occurring zeolites, 6 commonly occur in bedded deposits that have not been subjected to deep burial or hydrothermal activity. These are analcime, chabazite, clinoptilolite, erionite, mordenite, and phillipsite. They are generally more siliceous and more alkalic than their counterparts that occur in mafic volcanic rocks. Most zeolites in sedimentary rocks formed during diagenesis mainly by reaction of vitric material with interstitial water, which may have originated as either meteoric water or connate water of a saline, alkaline lake. Formation of zeolites is favored by a relatively high pH and high activities of alkali ions in the interstitial water. Most zeolitic sedimentary rocks consist of 2 or more zeolites with authigenic clay minerals, silica minerals, or feldspars, and relict glass and crystal and rock fragments. Extensive and relatively pure beds of zeolite, however, occur in upper Cenozoic lacustrine deposits of the western United States.

The ion exchange, adsorption, and molecular sieve properties of zeolites, coupled with a seemingly low cost of mining, suggest a variety of industrial applications. Potential uses include purification and drying of gases and liquids, chemical separations, catalysis, decontamination of radioactive wastes, removal of ammonia from wastewater, and numerous other uses in agriculture and animal husbandry. Potential uses of these zeolites could be considerably increased by chemical and structural modifications of the natural materials.

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Marine Diagenesis of Carbonate Sediment, Bonaire, Netherlands Antilles

A discontinuous layer of lithified carbonate sandstone underlies a small part of the Lac, a large lagoon on the southeastern coast of Bonaire. The layer lies 35 cm below the sediment surface, varies from 5 to 20 cm in thickness, and is restricted to an area beneath a broad intertidal and subtidal flat. Beachrock crops out in the high intertidal zone.

The lithified layer consists of grainstone cemented by acicular aragonite. Numerous lines of evidence indicate the cementation occurred in the marine environment. The lithified layer is at present continuously saturated with normal seawater. The submarine-cemented rocks lack the gray algal coating which is characteristic of beachrock and subaerially exposed coral rubble. Carbon-14-dating of the rock indicates cementation occurred less than 900 years ago. Study of the constituent particles of the lithified layer and the sediment above and below indicates continuous marine sedimentation.

Several distinct types of micrite are present in the beachrock and submarine-cemented layer. The most common is a high- and low-Mg calcite which coats single and multiple skeletal fragments with a sharp contact between the grain and micrite. The coating results from micritization of the high-Mg calcite of the encrusting coralline algae. Electron microprobe and X-ray diffraction analysis of these coatings demonstrated that as micritization proceeds and the microstructure of the algal coating is destroyed, the mineralogy changes from high- to low-Mg calcite.

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Oil Boom in Indonesia—Too Optimistic?

Since the awarding of Indonesia's first offshore-production sharing contract to IIAPCO in August 1966 the boom has been on. Never before have so many