Hortense Hot Springs. The waters issue from rocks of various compositions, ranging in age from Precambrian to Tertiary.

Sixteen surface or near-surface measurements of flow of heat from the interior of the earth have been made in Colorado and published. These measurements range from a low of 1.4 H.F.U. (heat flow units) at Yellow Creek in the northwest part of the state to a high of 3.7 H.F.U. at Ouray, Colorado, in the San Juan Mountains.

It appears, from interpreting published data, that the San Juan volcanic region of southwestern Colorado has the most potential for the development of a commercial geothermal reservoir.

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EPIGENETIC ALUNITE PISOLITES FORMED BY NATURAL GASES IN WESTERN MERCED COUNTY, CALIFORNIA

Chemical and mineralogic processes related to the migration of natural gases are of importance for petroleum geology. An unusual alteration of sedimentary formations by hydrogen sulfide-bearing natural gases in western Merced County, California, has been described. The alteration created an acidic medium (with pH values ranging from 0.5 to 4.5) containing sulfur, sulfides, sulfates, and black and white discoloration.

A peculiar layer of pisolitic sandstone was noted in the altered area near the boat-launching ramp on the southeastern shore of the O'Neill Reservoir. Individual pisolites 2-15 mm in diameter are present as an undulatory layer in a bed of light-gray, fluvial sandstone of the Tulare Formation, below the Pleistocene Corcoran Clay Member. X-ray diffraction of the sandstone cement yielded abundant alunite.

Data collected during studies of iron sulfide concretions from the same locality yielded some information on origin of pisolites. An aluminum sulfate-bearing gel was repeatedly obtained by solution of concretions in concentrated nitric acid. Aluminum was produced by decomposition of alumosilicates with sulfuric acid derived from oxidation of sulfides cement.

Alunite pisolites probably originated by decomposition of alumosilicates occurring in sandstone by reaction with sulfuric acid created by oxidation of hydrogen and/or iron sulfides in excavations. Natural gases in the area, following joints, tend to cause dome-shaped uplifts in overburden, which explains the undulatory occurrence of pisolitic layers. Their position could be controlled by a capillary uplift.

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LATE MISSISSIPPIAN CYCLOTHEMS OF HEATH FORMATION, WESTERN NORTH DAKOTA

On the south flank of the Williston basin in western North Dakota, the Heath Formation (Chester) produces from several fields including Rocky Ridge field. In 1969 Shell Oil Company discovered additional Heath production several miles southeast of Rocky Ridge. Cores cut during this drilling program provided the basic data for this study.

Lithologies represented in the cores run the complete spectrum of sandstone, siltstone, shale, limestone, dolomite, coal, and even subaerial, lateritic soils and subaquaeous, underclay soils. Mechanical log correlations create the impression of erratic depositional patterns typical of alluvial deposits. Faunal data, however, indicate oscillating brackish to shallow-marine depositional environments, the several coals and underclays indicate periods of marsh conditions, the crossbedded, conglomeratic sands are interpreted as fluvial to estuarine, and the lateritic soils are indicative of subaerial exposure. Such sequences or rock types are typical of the cyclothems of Illinois and Kansas.

At least 3 cyclothems are represented in the Heath. The initial basal transgressive sands were deposited above or at sea level in the topographic lows eroded during the preceding regression. As sea level rose, depositional environments covered a progressively greater area, depending on the amount of topographic relief. Consequently, an underclay lying on a previously formed lateritic soil may represent the basal unit of the cycle. In areas of greatest relief only the deposits of maximum transgression are represented. The complete succession of members of the classical cyclothem is present in very few places.

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SEDIMENTARY LAYER PROPERTIES OF GRADED-SHELF DEPOSITS, COLORADO GROUP (CRETACEOUS), SASKATCHEWAN

Middle Albian to Santonian detrital sediments were deposited in a shallow sea east of the Rocky Mountain geosyncline. Two transgressive phases of dominant mud deposition were separated by a major regressive phase, represented by a northeastward-thinning wedge incorporating conglomerate and sandstone.

The transgressive Joli Fou Formation is represented on the east by the Spinney Hill Sandstone, comprising cosets of planar sandy foresets and subordinate mudstone intercalations (proximal fluviomarine deposits). These grade westward into a succession of vertically repeated, sandy, fining-upward sequences (distal fluviomarine deposits) overlain by and passing laterally into mudstone. The fining-upward sequences comprise, in ascending order, planar sandy foresets, bioturbated sandstone, alternating sandstone and mudstone, and mudstone. The sequence probably reflects lateral migration of the tidal channels of an estuarine delta.

The regressive Viking Formation gave rise to deposits in which size fractionation through increase in the proportion of admixed mud northeastward is accompanied by progressive change in assemblages of sedimentary structures. A thick sequence of planar sandy foresets and subordinate mudstone intercalations (nearshore deposits) is replaced by clinobeds composed of coarsening-upward sequences (proximal shelf deposits), which northeastward grade to bioturbated, muddy sandstone (distal shelf deposits) and mudstone (shelf muds). The Flatten Lake sand displaying southwestward diminution of grain size along the erosional edge of the Colorado succession is referable to the regressive phase.

The pre-Cenomanian (Big River Formation) of the late transgressive phase is predominantly mudstone, replaced northeastward by fine-grained, horizontally laminated and micro-crosslaminated sandstone and bioturbated sandstone, with abundant discontinuous mudstone intercalations (St. Walburg Sandstone). These beds are succeeded by a thick mudstone incorporating northeastward-thinning units rich in bioclastic debris: a basal unit rich in fish remains (fish-scale marker) and 2 main calcareous units containing coccolith aggregates and pelecypod debris (Greenhorn and Niobrara equivalents). The bioclastic debris commonly is in thin, graded layers passing upward into mudstone. Lateral size fractionation within the units occurs by progressive decrease in proportion of sand and silt and concomitant increase in mud content.

The principal agents of sediment transportation recognized are tidal currents occasionally augmented by storm-surge waves giving rise to both laterally migrating channels and large-scale sand ridges. Mass movement of sand downslope apparently was confined to local salt-solution sinks.

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UTAH'S OIL-IMPREGNATED SANDSTONE DEPOSITS—A GIANT UNDEVELOPED RESOURCE

Fifty deposits or groups of deposits of oil-impregnated sandstone (tar sand) in Utah contain between 20 and 25 billion bbl of oil, about 95 % of the nation's resource. The Uinta basin, northeast Utah, is ringed by 25 deposits, estimated to contain 10.5 to 11.0 billion bbl of oil in place, with about 95 % in 4 giant