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

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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.

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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.

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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.

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SPACE PHOTOGRAPHY'S ROLE IN EXPLORATION

Space, or hyperaltitude, photographs are defined as