four cycles of sedimentation, producing a multistory fluvial sandstone sequence similar to two- and three-story sand bodies described from the middle Carboniferous of the Donets basin (USSR).

As noted by D. Swann and P. Potter the Highland and other fluvial complexes represent the Michigan River system that flowed across the basin from the northeast for as much as 250×10^6 years. The long-continued geographic stability of successive, often reestablished, channel courses is evidence of the subsidence history of the Illinois basin, its lack of southern closure, and its relation to the Mississippi Valley embayment.

Certain Pennsylvanian channel sandstones are productive in the Illinois basin, but those of the Highland fluvial complex are not, presumably because of high, uninterrupted permeability, shallow burial, and lack of associated source beds. The multistory sand bodies, however, are accompanied by low-permeability overbank silts and crevasse splays which appear to seal adjacent coals from contact with marine waters and consequent sulfate contamination.

Multistory sands are possible exploration targets in other cratonic basins. They are identifiable by detailed facies analysis, core drilling, and high-resolution seismic surveys.

PALMER, SUSAN E., Florida Atlantic Univ., Boca Raton, Fla.

Porphyrins in Subbituminous and Bituminous Coals

Chlorophyll and its porphyrin derivatives have been shown to be sensitive markers of organic diagenesis and serve as indicators of maturation. It has previously been suggested that coals of the HVC to HVB bituminous rank are at a maturation stage equivalent to early catagenesis in petroleum source rocks. However, comparisons of the mass spectrometric data of coal porphyrins with that of petroporphyrins result in some striking differences. Coal porphyrins lack carbon numbers above C_{32}, do not contain the DPEP (308 + 14n monocyclanoalkano) porphyrin series, and have an irregular mass spectral envelope owing to the predominance of even numbers of carbons (C_{32}, C_{30}, C_{28}) in the 310 + 14n etioporphyrin series. Furthermore, the centroid of the envelope systematically shifts from C_{32} to C_{30} to C_{28} with increasing coal rank. In contrast, petroporphyrins usually have carbon numbers ranging from C_{36} to C_{25} and a broad symmetrical envelope with a centroid at C_{32} or C_{31}. Both the DPEP and the etio series are typically present. From the data it is speculated that early chlorophyll diagenesis in coals follows an oxidative rather than a reductive pathway. During early catagenesis, dealkylation of coal porphyrins causes a shift in the centroid to lower carbon numbers. "Transalkylation," the free-radical mechanism by which alkyl groups are randomly added and removed from the tetrapyrrole ring during petroleum genesis, must not be operative in coal porphyrin catagenesis.

PALMER, SUSAN E., Florida Atlantic Univ., Boca Raton, Fla.

Copper Porphyrins in Deep-Sea Sediments

Copper porphyrins have been isolated from deep-sea sediments collected during six DSDP/IPOD legs. These pigments are present in areas receiving high inputs of terrestrially derived organic matter which is either slowly accumulated, deposited from oxygenated bottom waters, or oxidized before deposition. Such areas include the Cretaceous sediments of the Bay of Biscay, Blake-Bahama basin, and Bermuda; slumped Miocene deposits off Cape Bojador on the west coast of Africa; and lower Pleistocene sediments of the Black Sea. Copper porphyrins are absent from sediments that accumulated under anoxic conditions, of which Cretaceous sediments of the Cape, Angola, and Moroccan basins are examples. Copper porphyrins coexist with products of varying states of chlorophyll diagenesis (chlorins, free-base, nickel, and vanadyl porphyrins) which typically form under reducing conditions. The mass spectral envelope is markedly different from that of nickel and vanadyl porphyrins; copper porphyrins are usually etioporphyrins with carbon numbers of C_{32} to C_{23} and a centroid at C_{28} to C_{25}. The DPEP series is usually absent. In contrast, carbon numbers of C_{32} to C_{30} and presence of both the DPEP and etio series are characteristic of nickel and vanadyl porphyrins. Their occurrence with a range of chlorophyll diagenetic products and their distinctive mass spectral envelope suggest that copper porphyrins are derived from a different source. Their association with sediments containing terrestrially derived organic matter which has undergone a period of oxidation suggests that copper porphyrins may be potential indicators of oxidized terrestrial organic matter.

PARRISH, JUDITH TOTMAN, KIRK S. HANSEN, and ALFRED M. ZIEGLER, Univ. Chicago, Chicago, Ill.

Atmospheric Circulation and Upwelling in Paleozoic, with Reference to Petroleum Source Beds

Liquid hydrocarbons are formed from phytoplankton deposited in marine sediments. Phytoplankton are not distributed uniformly throughout the ocean surface waters. They are sparse over most of the area of the ocean, but are abundant in zones of upwelling where water rich in nutrients is brought to the lighted surface waters. Locations of these organically productive upwelling zones in the past can be predicted using a combination of paleogeographic and paleo-oceanographic modeling. This provides valuable information on likely times and geographic areas in which oil source beds were deposited.

Upwelling is caused by steady, prevailing winds resulting in divergence of currents or the movement of currents away from landmasses. These winds are parts of major atmospheric circulation systems. Their characteristics depend on latitude, season, and the sizes and positions of oceans and continents, but have a physical basis. They can, therefore, be modeled for past continental configurations, and it follows that upwelling can also be predicted.

Atmospheric circulation and upwelling maps for seven stages in the Paleozoic, using new paleogeographic reconstructions, show that upwelling zones of each stage are related to regions with source beds of that age. Although upwelling does not automatically result in source beds and all source beds do not occur in ancient