characteristics of data stored at EDC can be determined by requesting a geographic computer search using latitude and longitude of the area of interest.

A new all-digital system for handling and processing LANDSAT data is in operation at EDC. The data are radiometrically corrected for detector gain and offset and geometrically corrected to a Space Oblique Mercator (SOM) map projection, using cubic convolution resampling techniques. Upon request, the user can obtain data which are corrected to the Universal Transverse Mercator (UTM) or Polar Stereographic (above 65° lat.) map projections with the nearest neighbor resampling technique. The user may also request geometrically uncorrected high-density digital tapes. When placing an order for LANDSAT image products, the user may select or omit contrast and edge enhancements. Film and digital tape products from the LANDSAT multispectral scanner system (MSS) and return beam vidicon (RBV) camera are available in a variety of formats and scales.

LANDSAT data over areas outside the United States are available at EDC; these data are acquired by receiving stations in Canada, Brazil, Italy, and Iran and are also available from these countries. Scale, format, and prices of LANDSAT products from foreign receiving stations are similar to those distributed by EDC.

Other federal and state agencies duplicate aerial photographs for users on request. Scale, area coverage, and film type vary. The most common aerial photography is panchromatic at a scale of about 1:20,000 and in a 9 × 9-in. format. Some color and color infrared photographs also may be available.

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Characteristics of Remotely Sensed Data Acquired from Aircraft

Remote sensing technology has advanced rapidly during the past 2 decades, to the point where sensor systems are capable of acquiring data in wavelength bands from the ultraviolet through the visible and infrared to the microwave. Imaging sensor systems used in aircraft can be grouped into three general catagories: camera, optical-mechanical scanner, and sidelooking radar.

The aerial camera records radiation reflected from features on the earth's surface on black-and-white, normal color, and false-color infrared films. Black-and-white films are used frequently for mapping purposes; however, usage of color films is increasing. Normal color films have advantages in ease of interpretation because surface features are displayed in colors similar to those observed by the human eye. However, atmospheric scattering of incident solar radiation can have a significant deleterious effect upon the processed color photograph. False-color infrared films record reflected radiation in the near-infrared, red and green portions of the electromagnetic spectrum. The false-color photograph displays healthy vegetation as red, water as dark blue to black and red rocks or soil as a hue of yellow. Advantages of false-color infrared photography include less sensitivity to atmospheric scatter; greater contrast between vegetated and nonvegetated areas, moist and dry soils, clear and turbid water, and fresh and old snow; and, in some situations, an enhanced depiction of variations in vegetation owing to stress or species differences.

Optical-mechanical scanners employ photo-electric sensors to record radiation reflected from the earth's surface. The instantaneous-field-of-view (IFOV), normally expressed in milli-stereradians, and the altitude of the aircraft determine the ground resolution (size of the area on the ground that is sampled at any instant of time). Multispectral scanners record reflected and emitted energy in a number of wavelength intervals within the ultraviolet, visible (0.4 to 0.7μm) and infrared (0.7 to 14μm) portions of the electromagnetic spectrum. The infrared (IR) region generally is subdivided into two parts: the reflected IR (0.7 to 3.0μm) and the thermal IR (3.0 to 14.0μm). Thermal IR scanners record emitted radiation in two atmospheric windows (generally 3 to 5μm and 8 to 14μm). The apparent temperature of earth materials is a function of their emissivity and their absolute temperature. Conventional thermal infrared images display variations in apparent surface radiant temperatures in shades of gray with light tones representing warm temperatures and dark tones representing cool temperatures.

Side-looking airborne radar (SLAR) is an active imaging system because if transmits electromagnetic energy that illuminates the terrain. Radar systems operate in the 0.8 cm to 1 m wavelength range of the spectrum. They can be used during day or night and under most weather conditions. Direction and angle of illumination can be controlled to enhance topographic expression of geologic features. The interaction between terrain materials and the transmitted pulse of electromagnetic energy is complex and depends on orientation, surface roughness, and electrical properties of terrain features. Conventional SLAR images display the intensity of the energy returned to the radar received in tones of gray: light tones represent high intensity returns (such as buildings and slopes facing the antenna) and dark tones indicate low intensity returns (such as smooth water, dry lake beds, and roads). Radar has several advantages for regional analysis of geologic structure and terrain analysis: control of illumination direction, day and night and all-weather capability, suppression of surface detail, and continuous image strips.

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Origin and Characteristics of Pennsylvanian-Age Multistory Fluvial Sandstones of Illinois Basin

Continuing studies of Illinois basin Pennsylvanian stratigraphy have revealed a fluvial sandstone body of Desmoinesian age in the central and southern part of the Illinois basin. The sand body is a series of multistory or "stacked" sandstones that aggregate more than 300 ft (100 m) thick, as much as 2 mi (3.2 km) wide, and more than 100 mi (160 km) long, making part of a series of interrelated sandstones that constitute the Highland fluvial complex. The sand complex includes as many as 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.

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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.

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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.

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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