Bear River marine shales grade upward into marine shales of the Aspen Formation, deposited when the Mowry sea transgressed across the thrust belt region. Lack of significant tectonic activity during this time is suggested by the paucity of sand in the Aspen Formation.

Aspen strata pass upward through marginal marine strata into a thick sequence of meandering stream deposits of the Frontier Formation that were derived from erosion of subdued Paris-Willard highlands. Subsequent transgression of the Greenhorn sea westward covered the entire region, producing extensive Frontier marginal marine sandstones and marine shales. Renewed intensive uplift in the source area caused rapid eastward progradation of the Greenhorn sea shoreline and concurrently deposited cobble conglomerates in northeastern Utah. Coarse detritus was deposited in eastward-flowing braided streams near the source area (northeastern Utah) and in meandering stream channels farther eastward (western Wyoming). The Niobrara sea subsequently covered much of the region, and synorogenic sedimentation related to the Paris-Willard thrust system was thus completed.

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Trace Fossils as Environment Indicators in the Rocky Mountains

Ichnology is the study of the traces ancient organisms have left in or on the substrate. These traces, or lebensspuren, are in the form of tracks, burrows, trails, or borings, and are important clues in determining ancient rock environments.

Throughout time, organisms have left various types of traces while engaged in different activities. The two major types of lebensspuren were made by suspension feeders found in turbulent water where organic matter is held in suspension, and by deposit feeders whose habitat is found in quiet, deeper waters where large quantities of organic matter settle from suspension.

The different activities which occur in these two environments are the cause of the traces found in sediments. These include escape structures resulting from degradation or aggradation of sediments, feeding structures, dwelling structures, grazing traces, crawling traces, and resting traces.

The use of trace fossils in hydrocarbon exploration is especially helpful in the Cretaceous sandstones of the Rocky Mountains because of the relative abundance of outcrops and the scarcity of body fossils. By combining the interpretation of physical processes with the biological traces, one more tool is made available in the determination of rock environments as an aid in hydrocarbon exploration.

Materials exhibited include 8 × 10 color prints of different Cretaceous lebensspuren, hand-drawn "cartoons" of the six different trace activities, and a regional cross section of the Eagle sandstone illustrated by photographs of different traces near each location, as well as a variety of rock samples.

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Color Infrared Imagery as an Aid to Regional Geological Mapping

Frontier areas, particularly, lend themselves to initial phase study via remote sensing imagery. The many types of satellite imagery have the advantage that large areas of the earth's surface may be studied quickly, cheaply, and thoroughly enough to lead directly into more detailed photogeology and/or surface mapping. Imagery can be acquired in various spectra, the most useful of which are normal color, normal black and white, color infrared, black and white infrared, and side-looking radar. Perhaps the best single imagery for most geological mapping is the band 7 "False Color" infrared, at the scale of 1:250,000. Each photo measures approximately 29 in.^{2} (187 cm^2) and covers 115 mi (185 km) on a side; the cost in 1982 was $80 per photo.

Using the 1:250,000 band 7 color infrared images, good sharpness and color contrast are retained, yet enough magnification is present to allow visual recognition of roads, small towns, smaller lakes and streams, railroads, and agricultural features. Recognition of such physical features is necessary for satisfactory ground control.

Geologic and geomorphic features such as tonal, color, and drainage anomalies, linears, and more direct features such as actual geologic structures, faults, and regional structural dip directions often may be recognized. In areas of sparse well control and/or limited geophysical data, recognition of such features and geological data is of extreme importance and is a good beginning step in studying remote areas.

I have selected two 1:250,000 band 7 color infrared images from central and north-central Montana to display the variety of geologic, geomorphologic, and physical features that may be determined. Easily denoted features include regional dip; domal and anticlinal structures; tonal, drainage, and color anomalies; regional lineations; fault traces, and igneous activity. Subtle features are shown such as noses, subtle anticlines, and radial and concentric fracture patterns associated with the Bearpaw and Little Rockies uplifts. Follow-up work was performed using 1:20,000 stereo pairs, and several examples are available for inspection. In many situations, the leads from color infrared imagery subsequently proved to be bonafide geologic features.

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Landsat Linear Features in Montana Plains

Multispectral scanner images obtained from satellites provide a unique regional perspective of geologic features on the earth's surface. Linear features observed on Landsat images are particularly conspicuous and can be mapped easily. In Montana, east of long. 110°W and in adjoining parts of Canada, the Dakotas, and Wyoming, linear features have been mapped on 14 images. Black and white film products in bands 5 and 7 at a scale of 1:1,000,000 were employed. Specific linear features observed on both bands were compiled on a mosaic covering more than 90,000 mi^2 (233,000 km^2). Trends to the northwest and northeast are most common, but north-south and east-west linear features are also observed.

Four separate tectonic regions of the Montana plains seem to be characterized by different populations of linear features. In an area 100 mi (160 km) wide along the Canadian border, linear features trending northwest are common, and only a few local structures, such as Poplar and Bowdoin domes, are present. In the vicinity of the Central Montana uplift, east-west linear features are associated with features trending northwest and northeast. An area 80 mi (129 km) wide along the Wyoming border has linear features which trend dominantly north-south and east-west, although northeast and northwest trends are also present. This part of southern Montana includes the northern flanks of the Big Horn uplift, Powder River basin, and Black Hills uplift. In eastern Montana the western margin of the Williston basin has linear features which trend mainly northeast and northwest; north-south and east-west trends are rare.

Published syntheses of geophysical, structural, and stratigraphic data can be used to establish the geologic significance of specific linear features. Magnetic, gravity, and seismic data suggest that linear features may reflect basement structural elements such as fault-bounded blocks. Some specific geologic structures shown on structure contour maps are marked by linear features. Examples include Bowdoin dome, portions of Cat Creek, Lake basin, and Nye-Bowler fault zones, Cedar Creek anticline, and the Brockton-Froid fault zone. Paleotectonic features interpreted from stratigraphic maps have surface expression on Landsat that have not been recognized previously. For example, the southern margin of the Alberta shelf (Mississippian) appears to correspond with a zone of concentrated east-west linear features in north-central Montana.

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Late Cretaceous marine deposition in the western interior of the United States occurred in an epicontinental seaway elongate in a north-south direction. In central Montana, the western side of the seaway was characterized by a broad, tectonically active shelf. In eastern Montana and the western Dakotas, an actively subsiding basin was located in the central part of the seaway. In western and central South Dakota, the eastern side of the seaway was a more stable west-sloping ramp. Distinctive facies belts in the Eagle Sandstone and equivalent rocks are found in each of these tectonic settings, and some specific tectonic features have expression in the facies patterns. However, paleotectonism was even more important than suggested by these regional patterns. Selected study areas