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UNITED STATES GEOLOGICAL SURVEY
DEPARTMENT OF THE INTERIOR

Base from U.S. Geological Survey State base map, Montana, 1:500,000, 1966

Geology from Ross and others (1955)

SCALE 1:500,000

0 20 40 60 MILES

0 20 40 60 KILOMETERS

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LINEAR FEATURES DETERMINED FROM LANDSAT IMAGERY IN MONTANA

By

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IDENTIFICATION AND PLOTTING OF THE LINEAR FEATURES

This map is one of a series of linear-features maps compiled for the U.S. Geological Survey's Northern Great Plains Regional Aquifer System Analysis (U.S. Geological Survey, 1979). This map shows the linear features that were recognized in Montana. Other maps in the series cover South Dakota (Cooley, 1983a), Wyoming (Cooley, 1983b), and North Dakota (Cooley, 1983c).

Linear features occur on the Earth's surface as straight or slightly curved lines. These features often are referred to as linear trends or lineaments, some of which extend across Montana. The linear features shown on this map are not identified as to type or origin, although most probably reflect fractures or fracture zones, including joints and faults. Fracture zones affect the movement of water or other fluids through the rock.

The linear features were determined from visual inspection of color-infared composites of Landsat imagery at a scale of 1:500,000. The imagery used was the best available as determined by the Geological Survey EROS Data Center at Sioux Falls, South Dakota. The images were obtained during the spring and autumn and are free of cloud cover. All images have been enhanced to remove scan lines that tend to mask some of the features, including linear features.

Physiographic features and tonal differences in vegetation and soils observed on the imagery were used to identify the linear features. Physiographic features include straight segments of escarpments, ridges, canyons, and valleys and the ridge-and-valley topography of badlands. Vegetation growing on flood plains accentuates the configuration of shallow valleys in areas of low relief. On plains and broad slopes that have slight surface relief, tonal contrasts in color patterns of different vegetation and soils helped in the recognition or extension of some of the linear features.

The linear features were plotted as dashed lines on transparent overlays on the Landsat images only in the locations where they were observed. Dashed lines were used because most of the linear features were observed as discontinuous lines. The most conspicuous linear features were plotted first and, except for mountainous and upland areas, were usually the longest linear features.

The major and subordinate linear features were classified according to length into the four groups shown on the map. Determination of the length of the linear features that extend beyond Montana was aided by plotting the linear features from a mosaic of Landsat imagery of the United States (scale 1:5,000,000) compiled by the U.S. Soil Conservation Service (1974).

REFERENCES

Cooley, M. E., 1983a, Linear features determined from Landsat imagery in South Dakota and parts of adjacent states: U.S. Geological Survey Open-File Report 83-548, map, scale 1:500,000.

—— 1983b, Linear features determined from Landsat imagery in Wyoming: U.S. Geological Survey Open-File Report 83-935, map, scale 1:500,000.

—— 1983c, Linear features determined from Landsat imagery in North Dakota: U.S. Geological Survey Open-File Report 83-937, map, scale 1:500,000.

Keefer, W. R., 1974, Geologic map of the Northern Great Plains, in Regional topography, physiography, and geology of the Northern Great Plains: U.S. Geological Survey Open-File Report 74-50, plate A-3, scale 1:1,000,000.

Ross, C. P., Andrews, D. A., and Witkind, I. J., 1955, Geologic Map of Montana: U. S. Geological Survey map, scale 1:500,000, 2 sheets.

U.S. Geological Survey, 1979, Plan of study for the Northern Great Plains Regional Aquifer-System Analysis in parts of Montana, North Dakota, South Dakota, and Wyoming: U.S. Geological Survey Water-Resources Investigations Report 79-34, 20 p.

U.S. Soil Conservation Service, 1974, Mosaic of imagery from Earth Resources Technology Satellite-1 of the conterminous United States: U.S. Geological Survey map, scale 1:5,000,000.

EXPLANATION

CORRELATION OF MAP UNITS

Qs		Quaternary	CENOZOIC
Ts	Tv	Tertiary	CENOZOIC
	TKb	Cretaceous to Cambrian	MESOZOIC AND PALEOZOIC
	Kb	Cretaceous to Cambrian	MESOZOIC AND PALEOZOIC
	Kv	Cretaceous to Cambrian	MESOZOIC AND PALEOZOIC
KpEr		Cretaceous to Precambrian	MESOZOIC AND PALEOZOIC / PRECAMBRIAN
	pEr	Precambrian	PRECAMBRIAN

DESCRIPTION OF MAP UNITS

Qs UNCONSOLIDATED DEPOSITS OF QUATERNARY AGE--Clay to gravel. Quaternary deposits include thick valley-fill deposits, glacial, glacial-fluvial, and glacial-lucustrine deposits in the western mountains; generally thin terrace, pediment, glacial, and flood-plain alluvial deposits in the foothill area and high plains. These deposits mask many of the linear features that are present in the underlying rocks. At places, such as near Flathead Lake, the trends of moraines can be mistaken for linear features.

Ts SEDIMENTARY ROCKS OF TERTIARY AGE--Shale, sandstone, and gravel. Tertiary sandstone rocks form broad, gentle surfaces in much of the Great Plains of eastern Montana and form slopes of moderate relief elsewhere. Linear features are easily seen, except where the surface relief is low.

Tv VOLCANIC ROCKS OF TERTIARY AGE--Basalt to andesite. Tertiary volcanic rocks are present at different localities in western Montana. They include some Quaternary volcanic rocks in south-central Montana. Linear features are easily seen in the volcanic rocks. In general, the volcanic rocks show fewer conspicuous linear features than the Cretaceous to Precambrian sedimentary rocks.

TKb IGNEOUS ROCKS OF THE BOULDER BATHOLITH OF TERTIARY TO CRETACEOUS AGE--Granite and gniess. The batholithic and basement rocks are present in the cores of mountain ranges in western Montana. Linear features in these igneous rocks are easily seen, particularly in areas where the rocks have been dissected extensively by canyons and valleys.

Kb IGNEOUS ROCKS OF THE IDAHO BATHOLITH OF CRETACEOUS AGE--Granite and gniess. The batholithic and basement rocks are present in the cores of mountain ranges in western Montana. Linear features in these igneous rocks are easily seen, particularly in areas where the rocks have been extensively dissected by canyons and valleys.

Kv VOLCANIC ROCKS OF CRETACEOUS AGE--Rhyolite to andesite. Cretaceous volcanic rocks are present in places in western Montana. Linear features in these rocks are seen easily on Landsat imagery, but are not as conspicuous as the linear features in the Tertiary volcanic rocks.

KpEr SEDIMENTARY ROCKS OF CRETACEOUS TO PRECAMBRIAN AGE--Shale, sandstone, and minor limestone. These rocks are exposed in much of the plains of central Montana and in the mountains of western Montana. Linear features in these rocks generally are seen easily on Landsat imagery.

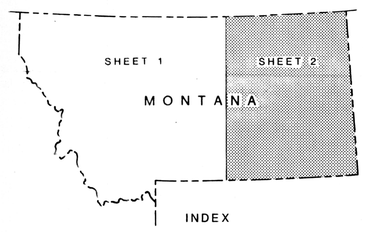
pEr BASEMENT ROCKS OF PRECAMBRIAN AGE--Granite and gniess. The batholithic and basement rocks are present in the cores of mountain ranges in western Montana. Linear features in these igneous rocks are easily seen, particularly in areas where the rocks have been extensively dissected by canyons and valleys.

••••••• GENERALIZED SOUTHERN LIMIT OF THE WIDESPREAD QUATERNARY GLACIAL DEPOSITS--Northern Montana (Keefer, 1974; Ross and others, 1955). The glacial deposits mask many of the linear features in the underlying rocks.

– – – – GENERALIZED NORTHEASTERN BOUNDARY OF VERY TIGHTLY FOLDED AND FAULTED ROCKS--Northwestern Montana, including the trace of the Lewis Overtrust.

+++++++ DIKE OF TERTIARY AGE--Rhyolite to basalt. Includes some pre-Tertiary dikes in the western mountains.

⊥⊥⊥⊥ GENERALIZED DIRECTION OF STRIKE AND DIP OF THE SEDIMENTARY ROCKS.

LENGTH OF LINEAR FEATURES

- Less than 30 miles
- 30 to 200 miles
- 200 to 500 miles
- More than 500 miles