ANALYSIS OF LINEAR PHOTO ELEMENTS BIGHORN-PRYOR MOUNTAINS, MONTANA-WYOMING

D. L. Blackstone, Jr.
Department of Geology
University of Wyoming
Laramie, Wyoming 82070

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16. Abstract

A comparison of the azimuths of photo linear elements in Precambrian rocks of the Bighorn-Pryor Mountains uplift with the azimuth of anticlinal axes in the Bighorn Basin shows essentially no correlation. These results contrast strongly with results of a similar study for the Laramie Basin and Laramie Mountains in which a strong correlation between photo linear elements and fold axes was demonstrated.

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Figure 2. Technical Report Standard Title Page

ANALYSIS OF LINEAR PHOTO ELEMENTS

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D. L. Blackstone, Jr.

INTRODUCTION

The Bighorn-Pryor Mountains area lies between latitude 43° and 46° North and longitude 108°30' and 106°30' West latitude in north-central Wyoming and south-central Montana (Fig. 1). The ERTS-1 imagery of this area provides a synoptic view of considerable utility in regional tectonic analysis. Directional relationships between linear features in Precambrian crystalline rocks of the Laramie Mountains and structures on the surrounding basins prompted investigation of other areas for similar relationships. The goal of the Bighorn-Pryor Mountains study summarized in this report was to investigate possible relationships between basin structures and linear features in the Bighorn and Pryor Mountains.

IMAGERY UTILIZED

In a continuing study of linear photo elements in the exposed Precambrian rocks on the core of several Wyoming mountain ranges the following ERTS images were examined:

1013 - 17291 - 5	5 August, 1972	(Fig. 2)
1030 - 17235 - 5	22 August, 1972	(Fig. 3)
1211 - 17302 - 5	19 February, 1973	(Fig. 4)
1013 - 17291 - 4, 5, 7	Color Composite	

Note: The term photo linear feature is used here to describe any markedly linear element observable on the imagery irregardless of cause. In this particular situation the linear features have a geomorphic expression.

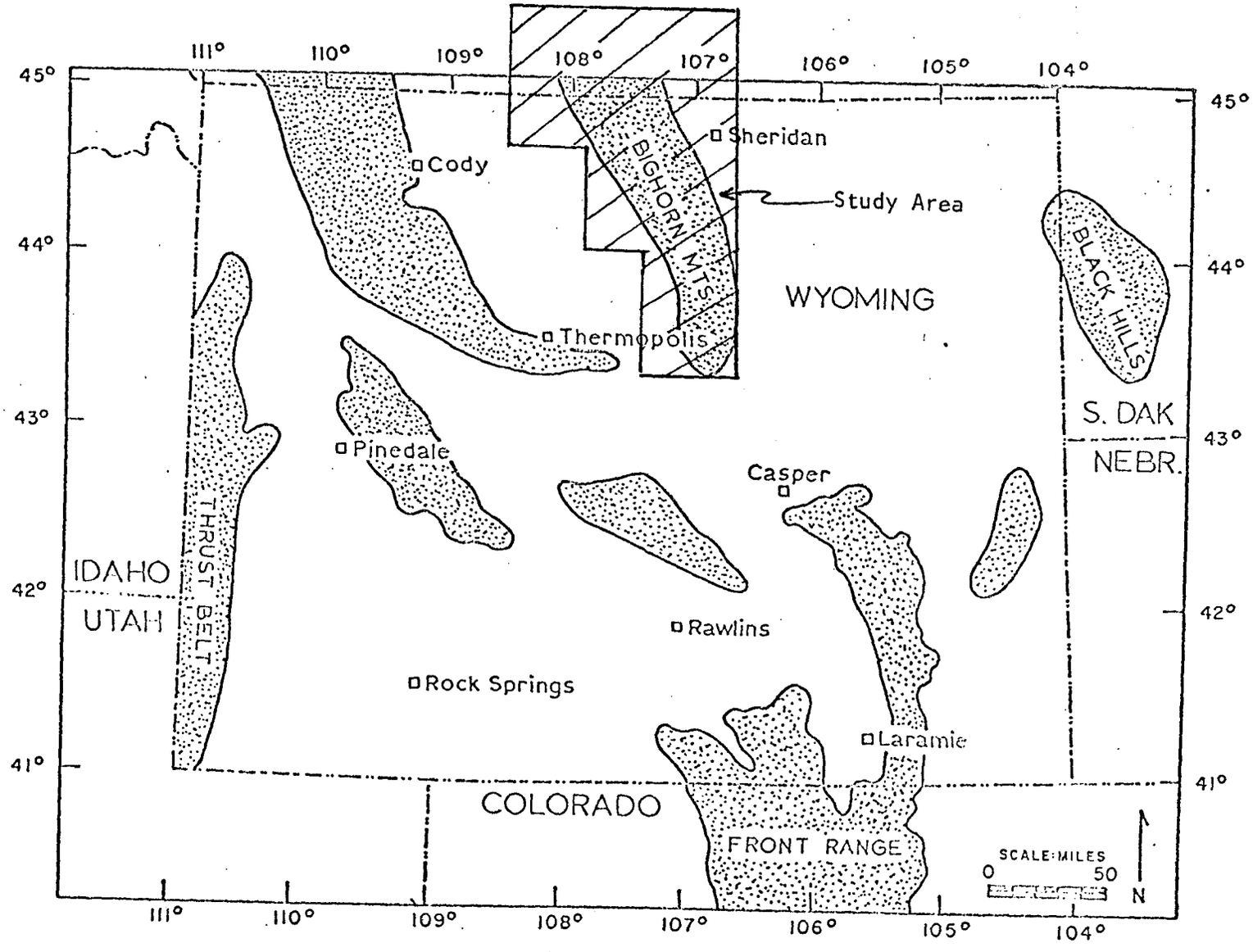

Figure 1. Index map of the Bighorn-Pryor Mountains study area.

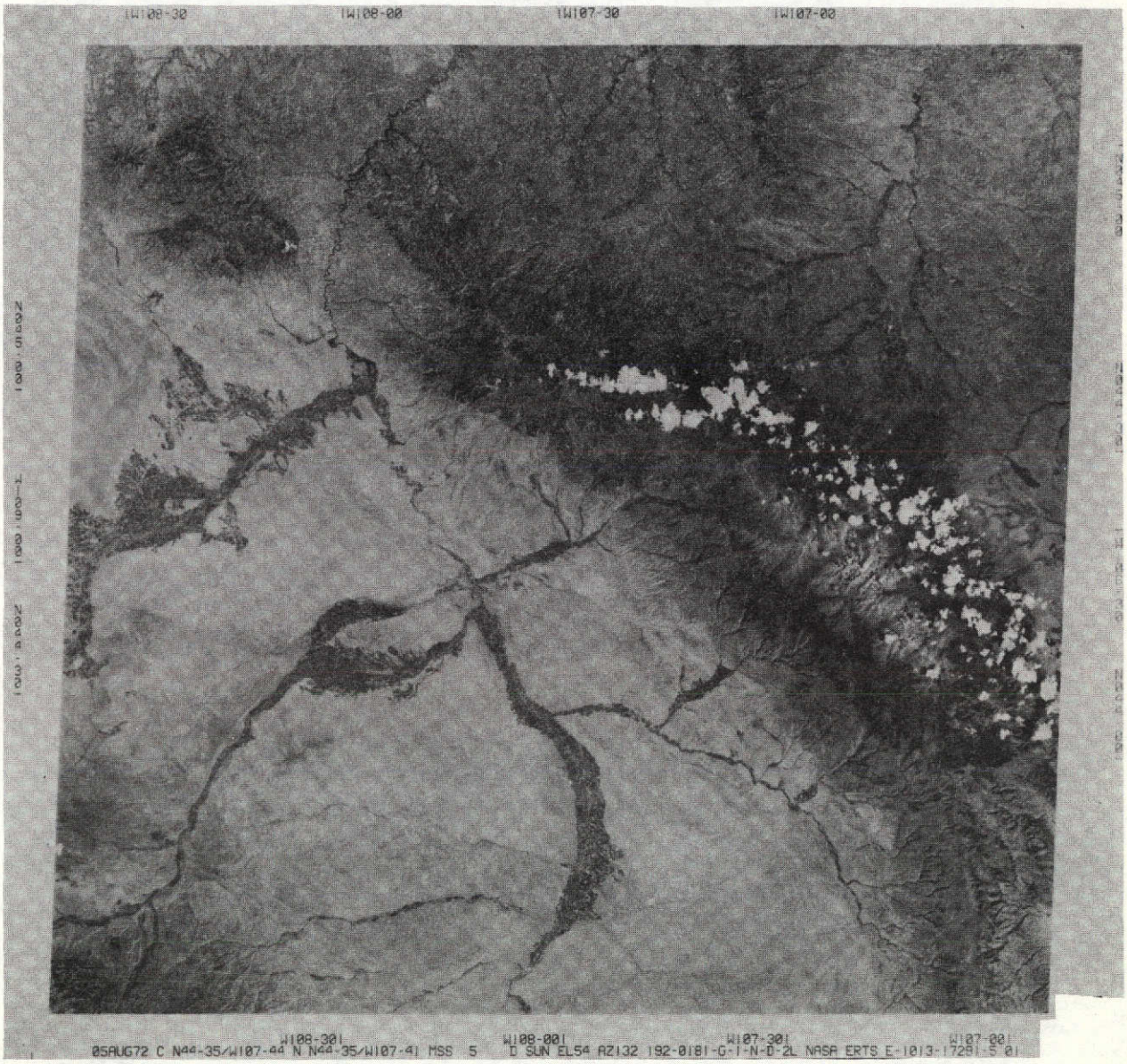

Figure 2. ERTS-1 image 1013-17291-5, showing the Pryor Mountains and northern Bighorn Mountains.

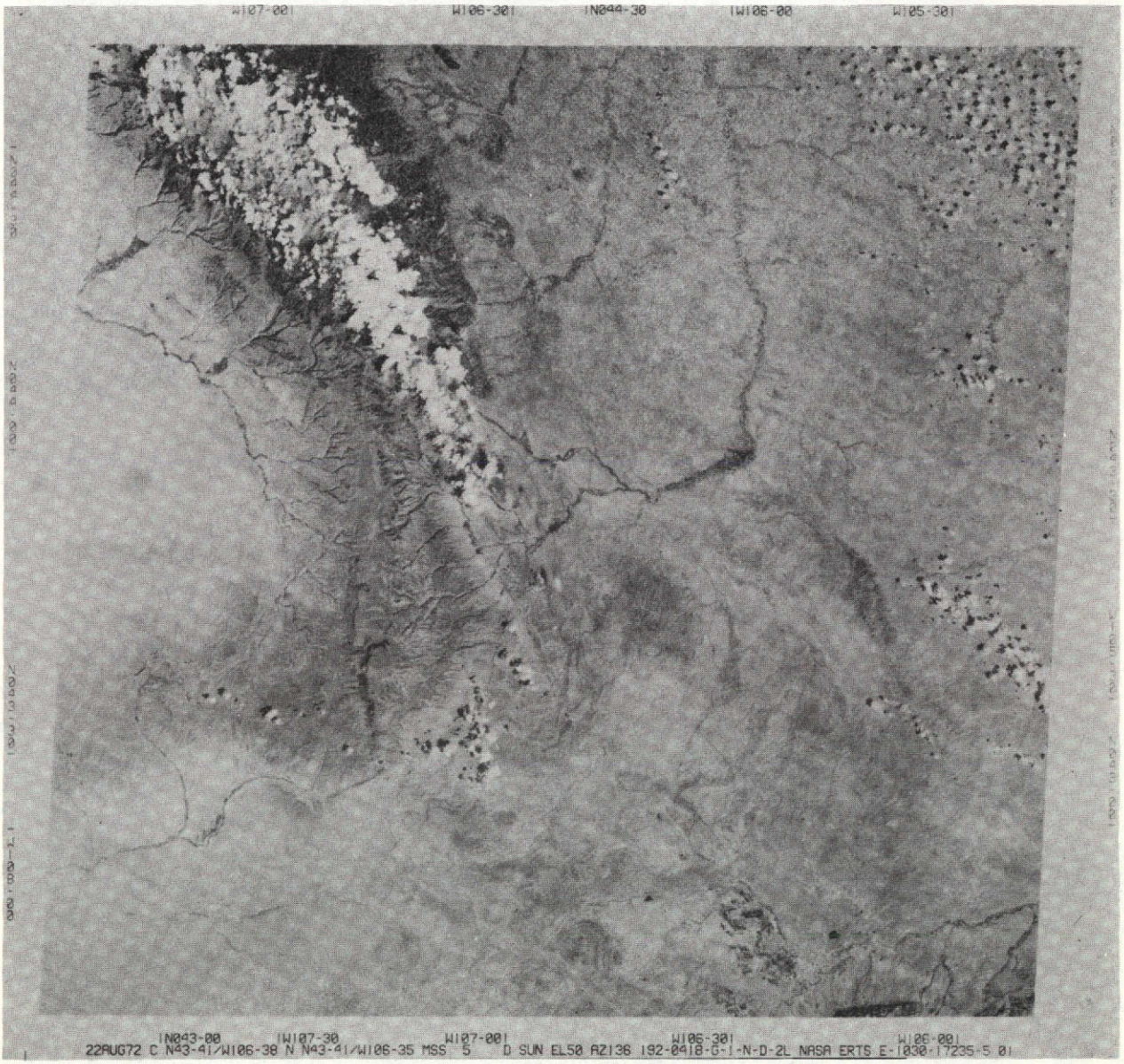

Figure 3. ERTS-1 image 1030-17235-5 of the southern Bighorn Mountains, Wyoming.

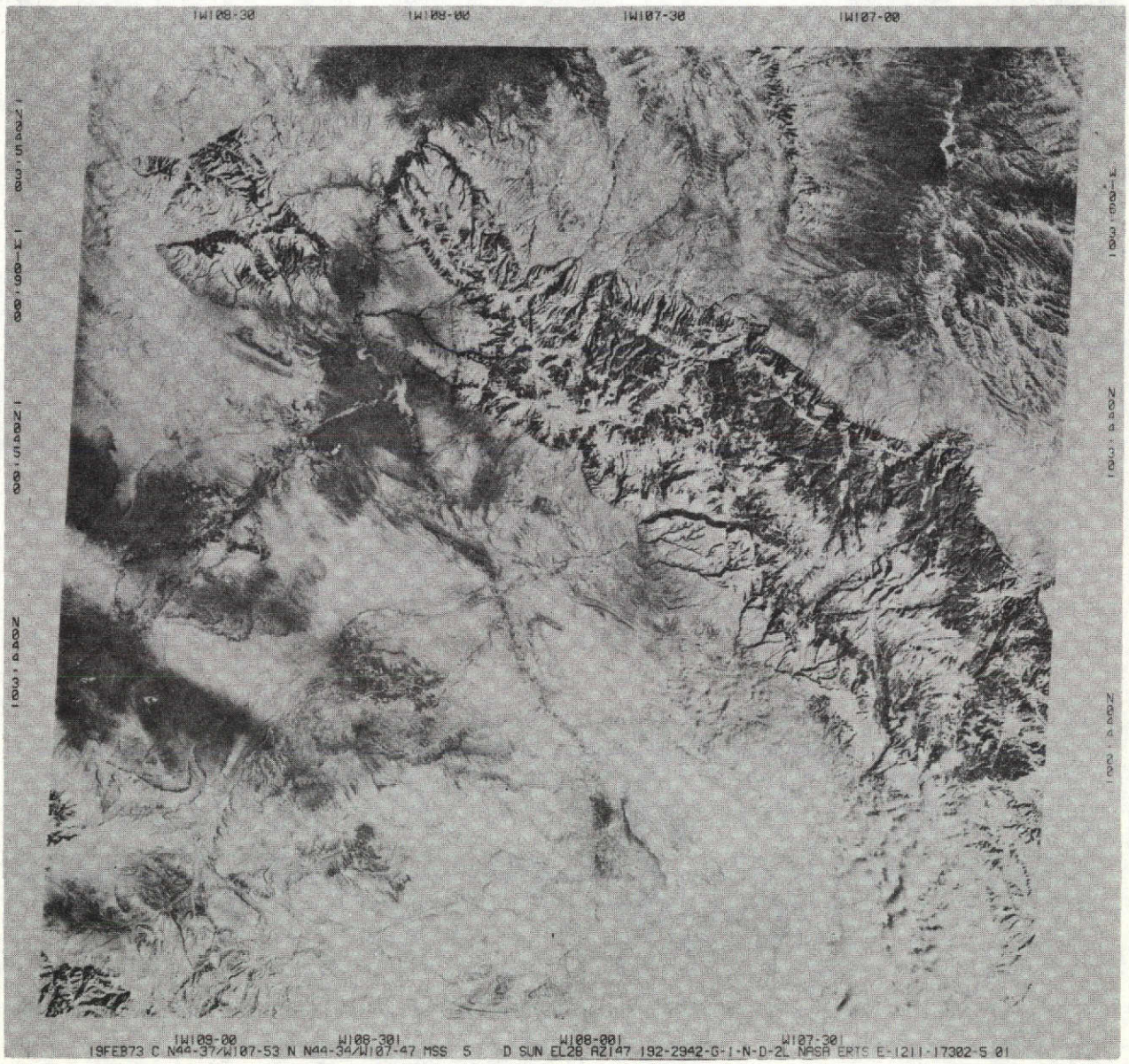

Figure 4. ERTS-1 image 1211-17302-5, showing the Pryor Mountains and northern Bighorn Mountains under light snow-cover.

All well defined linear photo elements were plotted on overlay sheets at the same scale as the imagery (approximately 1:1,000,000). The elements observed range from a few miles to tens of miles in length. The August imagery is essentially free of cloud cover whereas the February imagery has complete snow cover. Certain elements were accentuated by the snow cover.

OBSERVATIONS

Fifty-two major linear elements were located on a map with some geographic data (Fig. 5), Included in the plots were monoclinal features involving the Lower Paleozoic sedimentary rocks on the assumption that they reflect basement features, as has been demonstrated by previous ground-mapping in both the Pryor and Bighorn Mountains.

No data was taken from the folded sediments in the Bighorn Basin proper. No ground check has been made subsequent to the examination of the ERTS imagery. However, the writer has had extensive field experience in these areas.

PLOTTING DATA

The azimuths of fifty-two (52) linear photo elements were plotted on a rose diagram in order to visually portray the concentration and orientation of the elements. A scale of 1 cm. equals two (2) percent of the total population was used. Figure 6a is the final plot.

The plot indicates that the majority of the observed linear elements have a northeast-southwest orientation with a bimodal distribution. One concentration of azimuths lies between longitudes N 55° E and N 65° E and the other concentration centers near N 25° E. The two sets thus intersect at an acute angle of approximately 45 degrees.

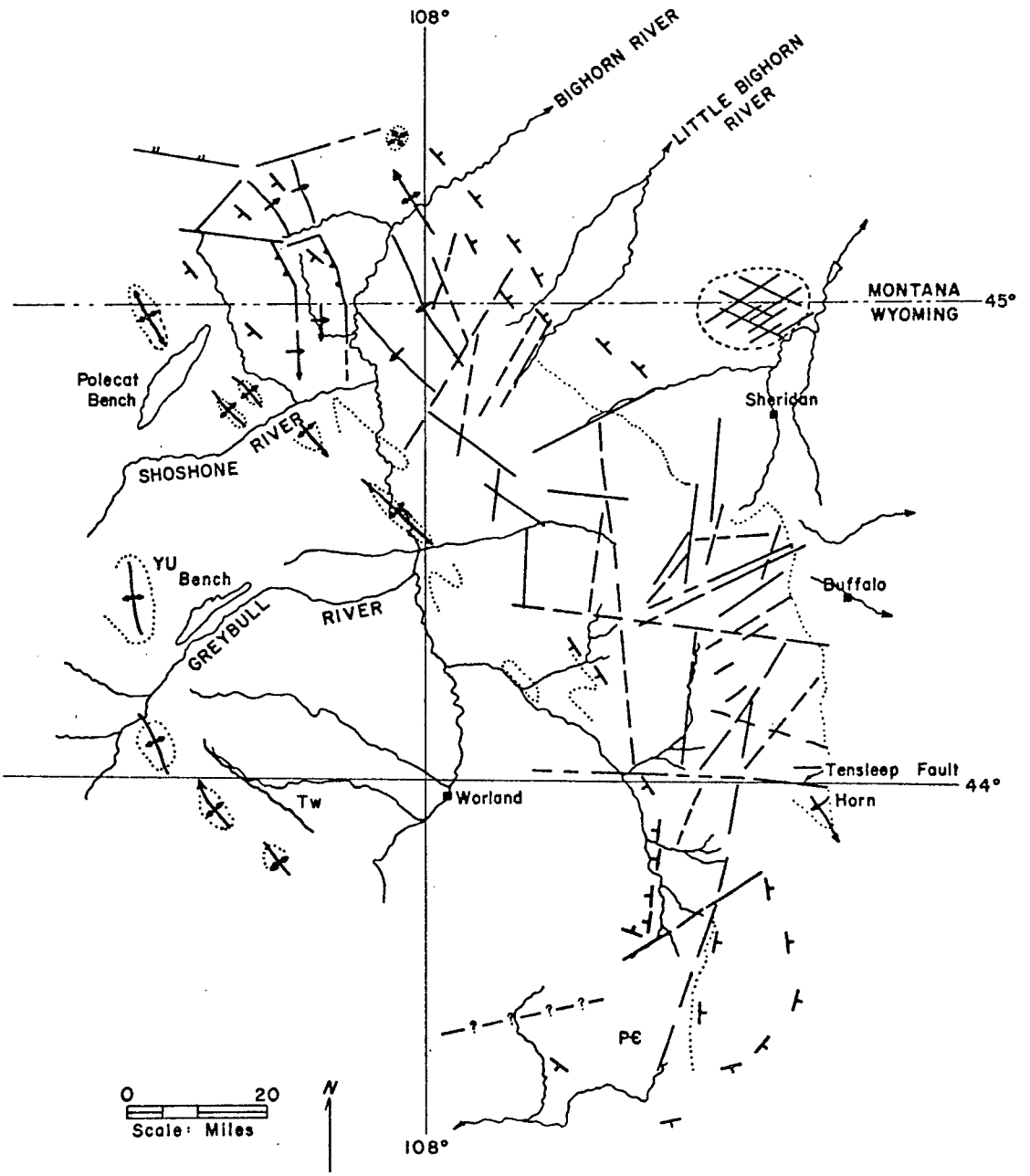

Figure 5. Major linear elements of the Pryor and Bighorn Mountains.

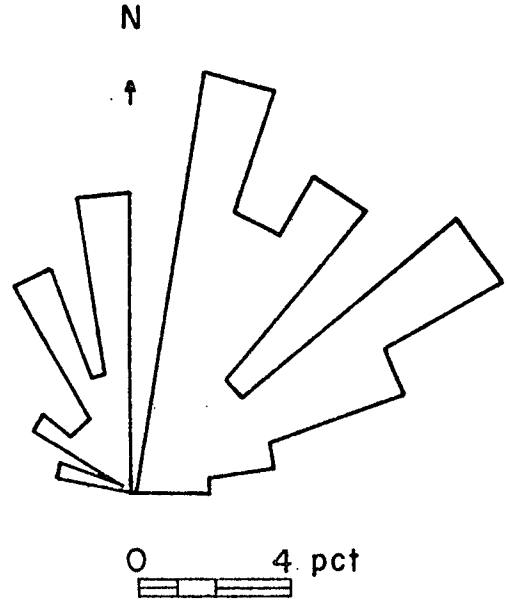

Figure 6a. Rose diagram showing trends and orientations of observed linear elements.

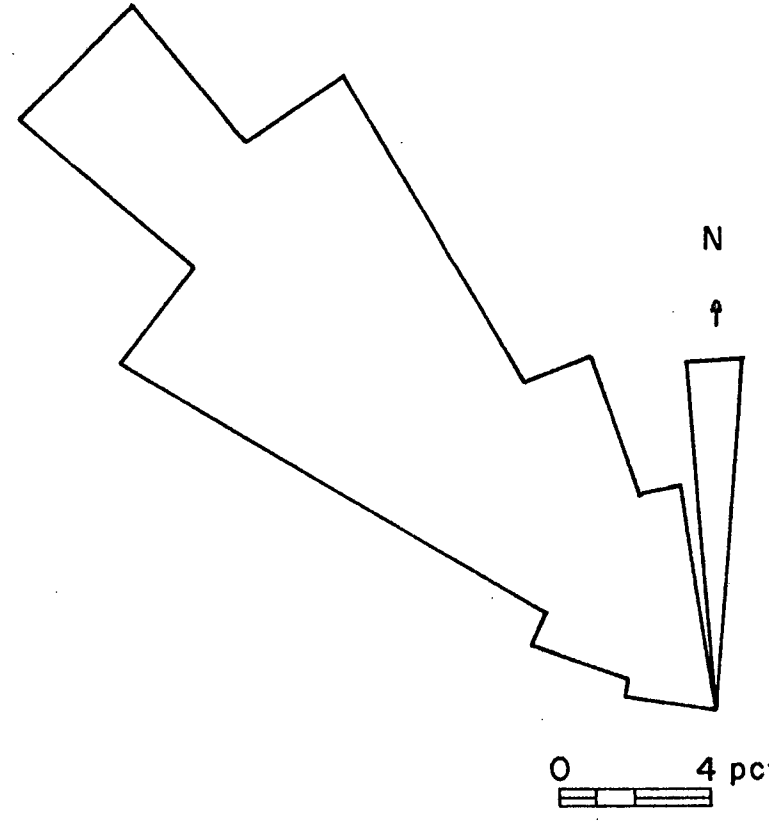

Figure 6b. Rose diagram showing the orientations of fold axis in the Bighorn Basin.

A lesser concentration of linear elements has a northwest-southeast orientation with the azimuths concentrated between N 10° W and N 30° W.

SPECIAL FEATURES

In the course of the examination of the imagery one unusual area in the sedimentary rocks of the Powder River Basin was noted. The area is roughly elliptical (Fig. 5) and is approximately 15 miles in its longer dimension. The area centers near 45° North latitude and 107° West longitude. The exposed rocks are the Fort Union and Wasatch Formations (Baker, 1929).

Within the area there are subdued northeast-southwest trending linear elements with an azimuth of N. 60° E. The linear elements trending northwest-southeast (N. 65° W.) are fewer in number, but are more clearly defined. Baker (1929), in mapping the coal beds of the northern extension of the Sheridan coal field, indicated a northeast trending synclinal structure essentially paralleling the valley of the lower Tongue River. No cause and effect can be determined at this time.

REGIONAL SIGNIFICANCE

Many investigators have studied the problem of basement control upon the overlying sedimentary succession during the Laramide orogeny.. Chamberlin (1945), in a classical paper, discussed the problem as it applies to the Bighorn Basin region. One facet of this problem is the role that fractures, shear zones, etc. in the Precambrian basement rocks might have played in Laramide deformation by being reactivated.

If the observed photo linear elements are ancient Precambrian features, and if the pattern, in the basement rocks continues westward beneath the sedimentary rocks of the Bighorn Basin, then the possibility exists of testing the relationship between basement control and orientation of Laramide folds.

The writer utilized two maps prepared by the U. S. Geological Survey:

Oil and Gas Investigations Preliminary Map No. 3. "Structure contour map of the Big Horn basin, Wyoming and Montana" by David A. Andrews, William G. Pierce and Jewell J. Kirby, 1944.

Oil and Gas Investigations Map OM 182. "Structure and contour map of the Tensleep Sandstone in the Bighorn Basin, Wyoming and Montana" by A. D. Zapp, 1956.

From these maps the trend (azimuth) of 83 known and well defined anticlines in the Bighorn Basin was determined, and then plotted on a rose diagram in the same fashion that data concerning the photo linear elements were plotted.

The plot of the azimuth of the axes of the folds is presented in Figure 6b. The dominant trend direction is northwest-southeast with a strong maximum (24%) concentrated between N. 40° W. and N. 50° W.

By comparison with Figure 6a, it is readily apparent that the trend of the anticlinal axes lies at an angle of about 80° to the principal concentration of trends of the photo linear elements. The only coincidence of trends is at a bearing of about + or - five degrees from true north. Approximately 7% of the photo linear elements and approximately 9.6% of the fold axes have this trend.

The preliminary conclusion is that the photo linear elements reflect major fracture systems in the Precambrian age basement rocks, but that they do not directly control the orientation of folds in the sedimentary rocks overlying the basement in the Bighorn Basin.

A further conclusion is that the folds in the Bighorn Basin have a remarkably consistent trend of the anticlinal axes, that is related in some as yet undetermined fashion to the Laramide downfolding of the basin as a whole.

COMPARISON WITH OTHER RANGES

A similar study using ERTS imagery was done involving the northern Medicine Bow Mountains, the Laramie Basin, and the Laramie Mountains. This was done by the writer assisted by Mr. James Sears and Mr. Hamed Bekkar. The purpose of the study was to compare the relationship of the photo linear elements in the Precambrian rocks of the core of the Laramie Mountains with the orientation of fold axes, faults, etc. in the sedimentary rocks of the Laramie Basin. The results of this study are given in Preliminary Report:

Blackstone, D. L., 1973, Analysis of photo linear features Laramie Mountains, Wyoming from ERTS-1 imagery: University of Wyoming, Department of Geology, Report ERTS-1-S73-3.

The correlation of the results of these two studies is illustrated by comparison of the rose diagrams for the Bighorn Mountains and the Bighorn Basin to Figure 7 which is a similar plot for the Laramie Mountains and the Laramie Basin. All data are plotted to the same scale.

The data indicate that the Laramie Mountains are either much more strongly fractured, or the vegetational cover is sparser, allowing better distinction of the linear elements.

The plots further indicate that there is excellent correlation between fracture patterns in the Precambrian rocks of the Laramie Mountains and the Laramide folds in the basin suggesting that basement control is indeed real, and plays a major role in subsequent deformation.

Control of Laramide deformation by earlier Precambrian fracture patterns is very weak in the Bighorn Basin area.

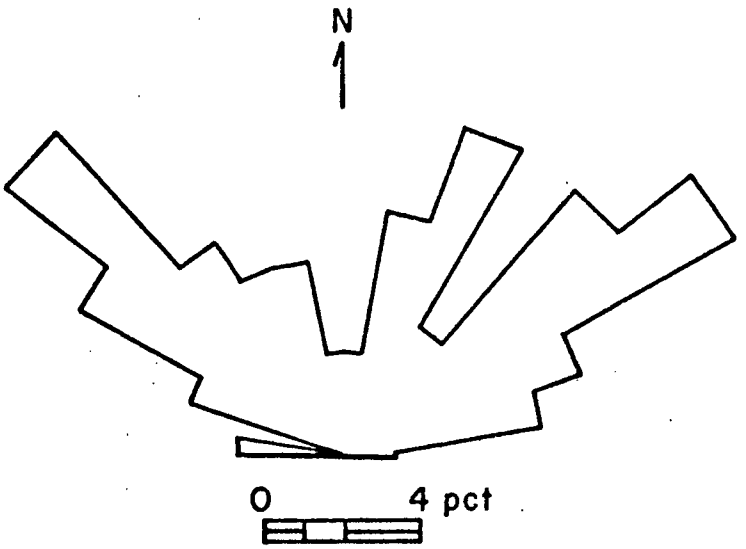

Figure 7. Rose diagram indicating trends in faults and folds of the Laramie Basin and Laramie Mountains.

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Baker, A. A., 1929, The northward extension of the Sheridan coal field, Bighorn and Rosebud Counties, Montana: U.S. Geol. Survey Bull. 806-B, p. 15-68.

Chamberlin, R. T., 1945, Basement control in Rocky Mountain deformation: Am. Jour. Science Vol. 243-A, p. 98-116.