NORTHWESTERN UNIVERSITY

*Technical Report No. 5*

# PHOTO INTERPRETATION OF LANDFORMS IN A DRY GRASSLAND MARGINAL TO GLACIATED PLAINS

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# PHOTO INTERPRETATION OF LANDFORMS IN A DRY GRASSLAND MARGINAL TO GLACIATED PLAINS

By

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A Contract Between

Geography Branch, Earth Sciences Division
Office of Naval Research, Navy Department

and

Northwestern University

Project No. NR 387 005
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# PHOTO INTERPRETATION OF LANDFORMS IN A DRY GRASSLAND MARGINAL TO GLACIATED PLAINS

## Introduction

The following report is based on research during the summer field season of 1951 under Office of Naval Research Contract N7 onr 45-005, contracted by Northwestern University and directed by Dr. Clyde F. Kohn and his associate, Dr. William E. Powers. The study is a sequel to their Technical Report No. 2, entitled, "A Key for the Photo Identification of Glacial Landforms and Associated Landform Patterns in the Lake Michigan Region and Comparable Areas" prepared by W. E. Powers and based on studies in five selected glaciated areas adjacent to Lake Michigan during the summer field season 1951.

## Objectives and Methods

The present study was planned to extend the photo interpretation methods developed in the previous key to a region of light rainfall and natural grassland vegetation marginal to the limit reached for the former continental glacier in North America.

The area selected lies in the Northern Great Plains

in Teton, Chouteau, and Cascade counties, Montana, from 40 to 70 miles east of the Rocky Mountains, but closer to several small outlying mountain groups such as the Highwood Mountains on the east and the Little Belt Mountains on the south. Through the area runs the Missouri River, principal stream of the northern Great Plains, and its important tributaries from the north, the Teton and Sun Rivers. The margin of relatively thick deposits of glacial drift from the continental glaciers of central Canada crosses the eastern part of the area selected. However, landforms of glacial drift do not dominate the topography except in certain plains on the northeast -- elsewhere the landscape is dominated by such bedrock features as buttes, mesas, canyons, ravines, and dissected cliffs or escarpments, and particularly by extensive flat plains or benches at several levels marking former times when streams wandered back and forth at these levels. Such benches were formed before the erosion of the canyon in which the Missouri River now lies. The area as a whole stands in marked contrast to those landscapes in the Lake Michigan region where landform features of glacial drift are predominant.

For detailed study and for illustrating the principles developed by this report, twelve individual areas each

3 to 4 miles long by 1 to 1.2 miles wide were selected. Four of these lie in the Fairfield quadrangle map area of the U. S. Geological Survey, partly in Teton and partly in Cascade county (Figure 1), in a region dominated by irrigation wheat farming. Two others lie in the Dent Bridge quadrangle map area, Chouteau county, while the six remaining ones lie in the Portage quadrangle map area, one extending into Chouteau county and the rest wholly within Cascade county. In the Dent Bridge and Portage quadrangles, dry farming of wheat is the major land use. Although wheat dominates the farm economy, a certain amount of hay is raised and dairying, beef cattle, and sheep may also be found.

The following report is organized in a manner different from Technical Report No. 2, "A Key for the Photoidentification of Glacial Landforms and Associated Landform Patterns in the Lake Michigan Region and Comparable Areas". In the latter, the areas analyzed were presumed to be dominated by glacial landform features of numerous distinctive types, and the small size of many of those permitted individual landforms to be analyzed and identified through a fixed procedure based on the presence or absence of exact criteria. Such a method is not well

adapted to the Montana Great Plains area considered herein. Here the landform types do not, in general, consist of individual forms different from those surrounding them, but rather are grouped in extensive areas in which many individual features collectively comprise the landform type. For example, rough dissected areas consist of deep ravines and minor valleys separated by ridges and spurs not yet removed by agents of erosion. To separate such an area into its component ridges, spurs and valleys is of little value for the purposes of this report, inasmuch as the entire dissected area forms essentially a unit with respect to man's access and use. The photo interpreter should not attempt first to identify small individual landscape features but should strive from the beginning to recognize broad landform types. Each of these may then be analyzed with respect to the minor landform features that it contains. Although such an approach draws heavily on the background and experience of the photo interpreter, it leads him to quick and significant generalities concerning the region that may be of great influence in his interpretation of minor features. Such an approach cannot be developed without giving the photo interpreter some knowledge of the genetic relationships of the areas with which he deals.

For example, he must understand that rough and rolling dissected areas in this region have resulted from erosion by rainwash and streams, either in areas adjecent to a deep master stream valley such as the Missouri River, or where the bordering cliff or escarpment of a higher plain is being eroded by streams and rainwash descending to a lower plain or basin. Such an understanding of origins not only enlightens the photo interpreter's interpretations, but may point to many significant details of the landscape that might otherwise escape notice.

The writer wishes to acknowledge the aid, advice, and criticism of Dr. Clyde F. Kohn of Northwestern University, Department of Geography, Director of ONR Project N7 onr 45-005; Mr. Henry Nowicki, field and research assistant; and Dr. Richard Lemke of the U. S. Geological Survey, whose store of information concerning the glacial and geomorphic history of the region proved invaluable.

## Use of Photos and Maps

In this report use is made of twelve field areas which are shown, first, on the topographic maps (Figures 2-8); second, in vertical aerial photopairs or stereograms (Airphotos 1-A and 1-B to 12-A and 12-B); and third, in

part by ground photographs in stereopairs (Ground Photos 13-A and 13-B to 34-A and 34-B). Principal emphasis is placed on the airphotos. These should be studied with a lens stereoscope. Points referred to on these airphotos will be located either by letter (A, B, etc.) or the left-hand photo or by means of x and y coordinates measured in inches and tenths, respectively eastward and northward from the lower left-hand corner of the left-hand airphoto. The position of ground photographs is indicated by a "V"-shaped symbol indicating the field of view of the photographer, who stood at the apex of the "V". The number of the ground photograph pair is given within the "V". A graphic scale is also indicated on the left-hand airphoto. The topographic maps are intended chiefly for reference and to enable the photo interpreter to check altitudes and heights and to identify features which may not be mentioned in this report.

## Initial Appraisal of Air Photographs in Stereogram

It is believed that the photo interpreter will be led most rapidly into an understanding of the types of features characteristic of the Montana region by an initial examination of a pair of airphotos and an attempt to interpret the landscape which they show. For this purpose the

photo interpreter is requested to refer to Airphotos 5-A and 5-B and the map, Figure 5-B.

## Deductions With Respect to General Conditions in the Area

A preliminary inspection of Airphotos 5-A and 5-B shows that the area includes an upland in the north, a butte at right and a larger mesa at left in the south center; and a broad valley crossing the north central part of the area and extending into the southeast corner. Further inspection reveals information regarding the following elements of the landscape.

(1) Natural vegetation: No wooded areas are present and the only trees seem to be several rows in a windbreak at ranch at 1.3 - 5.5. Most of the area apart from the cropped fields, therefore, appears to be in grass or without vegetation cover.

(2) Drainage: No permanent streams are seen. A dry stream course bordered by zonal vegetation extends from 0.5 - 4.0 to 2.4 - 4.0. Small dry gullies are numerous on the steeper slopes, as illustrated by the gully leading northward at 1.0 - 2.2.

(3) Climate: From the grassland vegetation and drainage characteristics the climate is inferred to be

dry. This conclusion is strengthened by the presence of irrigation ditches such as that entering the area at the south at 0.5 - 0.0. This ditch winds northward on the contour around the butte at 2.1 - 3.2. The banded pattern in tilled areas in the north and southeast is not contour cropping but appears to be the type of strip cropping in which alternate fallow and planted strips are used in the dry farming of grain. An earth dam reservoir for cattle at 0.5 - 2.6 also suggests the need for water. All such criteria indicate a dry climate but with sufficient rainfall for dry farming and for ranching; therefore, semiarid rather than desert. In this latitude such climate probably has from twelve to fifteen inches of precipitation per year.

(4) Rock Structure: The flat-topped mesa and butte bounded on all sides by steep bluffs suggest horizontal bedrock strata. These actually show on the bare sloping surface of the mesa from 0.9 - 1.5 to 1.5 - 2.0.

(5) Quarries and Gravel Pits: Rock quarries and gravel pits are not present. Their absence implies that the bedrock is soft, shaley, and probably poor for building purposes and that gravel for roads is not generally available within this area. The borrow pits at 2.1 - 2.9 and 2.2 - 2.8 probably furnished earthen fill for the grade of highway at 2.3 - 2.5

(6) Thickness of Soils: Note that bare rock strata show on the slope at 1.3 - 2.0 and that a rock terrace is present in the scarp at 0.3 - 5.3. One infers that soils are thin or absent on steeper slopes and probably on the mesa and butte. They are probably thin on the upland plain at north and possibly thick in the broad valley bottom in the north center and southeast.

(7) Relief: This is difficult to judge from the air-photos without the presence of trees, silos or other tall reference objects. Where scale of photo, focal length of camera and height of camera are known, the relief can be easily computed. Note that here the butte and mesa appear to attain about the same level as the upland on the north and that the lowlands appear approximately level. If the road grade in south at 1.2 - 0.7 is estimated to be fifteen feet high, the mesa appears to be ten to fifteen times as high, thus giving a relief of 150-225 feet. The contour map (Figure 5-B) shows that this estimate is of the correct order of size.

(8) Road Pattern: The road pattern shows terrain changes by adjustments to slope and to topographic details. The generally straight north-south course of the road from 1.2 - 0.0 to 1.2 - 7.8 indicates much flat topography and

a government township and range system of land survey. Near 1.5 - 2.1 this road curves eastward to cross the saddle of ridge on a favorable grade. In ascending scarp to upland, from 1.2 - 5.7 to 1.1 - 6.4, the road follows a ravine, the bottom of which gives a favorable grade. The newer diagonal highway from 0.8 - 0.0 to 2.4 - 2.8 follows the flat belt of relatively well-drained land near foot of the slope from mesa and butte. A new well-graded road links this diagonal main highway with the north-south older road from 2.3 - 2.9 to 1.2 - 4.5. The light colored ditches along this link indicate standing water or bare mud, showing necessity for fill across the lowlands in north center of the area.

(9) Rural Economy: This appears to be based mainly on grain farming but in part on ranching. Only three ranchsteads (that is, central building groups for ranches) are present, at 0.5 - 5.2, 1.3 - 5.5, and 1.2 - 7.4. Large barns are not present. A tall building on each ranch (see 0.6 - 5.2) suggests a granary rather than a silo. The irrigation works, both the ditch entering from the south previously mentioned, and the ditch crossing face of scarp bounding the northern upland from 0.0 - 5.0 to 2.4 - 6.4, appear to be out of repair and unused at

present. No alfalfa fields can be definitely identified as such from the photos. Cattle are probably carried mainly on the open range much of which appears to have a low carrying capacity. The best of the flat land is in the dry-farmed wheat and fallow strips. No orchards or kitchen gardens can be identified.

(10) Rural Population: This appears to be very sparse with only three ranches on an area of approximately four square miles. No communities are present within the area.

## Interpretation of Landforms

The mesa and butte at south rise to approximately the level of the flat northern upland and suggest that erosion has developed the broad valley across the north center of area and at southeast. If so, the butte and mesa are erosion remnants and their steep gullied side slopes are still undergoing erosion. The gullied scarp bounding the northern upland is similarly inferred to be undergoing erosion and is thus in process of retreat. The flat valley floors may be due primarily to the accumulation of stream wash from the eroded higher areas. The extreme flatness of the valley floor at the north suggests the possibility of blocked drainage and the former presence of a lake in which fine sediments may have accumulated.

Such sediments, if present, would create unstable soil conditions in the broad northern valley with respect to the bearing of vehicles.

The flat upland surface from which the lowland valley areas were developed by erosion is of uncertain origin. Such a surface might have been originally a glacial drift plain, an erosional surface developed by streams, an uplifted coastal plain, a volcanic plain, or an alluvial plain due to the accumulation of stream deposits. The absence of high erosional remnants is an argument against its origin by stream erosion. There is no indication that this area recently had a coastal position and could have developed as a coastal plain. No features suggesting volcanic action are present and none suggest the channels, bars, and fan-like deposits characteristic of alluvial plains. It seems possible that this upland surface may be a flat till plain of glacial origin inasmuch as continental glaciation is known to have extended approximately to this area in central North America. A low swell or ridge forms a rim parallel and just north of the scarp bounding the upland. This suggests a till ridge. The irregular mottled soil patterns characteristic of till plains do not show clearly in the flat upland but such

patterns are never well developed in dry glaciated plains such as this. It therefore seems likely that the northern upland is a remnant of glacial till plain of low relief.

## Photo-Classification of Landform Types in this Region

From an examination of airphoto stereograms such as Airphotos 5-A and 5-B and from ground studies throughout the region treated in this report, ten basic landform types have been identified and may be recognized from the airphoto alone. These ten types may be grouped into four classes, namely, upland plains, valley plains, steeply sloping margins of plains and benches, and erosion remnants controlled in form by bedrock structure. Although the region is marginal to the glaciated plains of central North America, and was in part actually covered by glacial advance, the glacial effects were feeble and show mainly in the relatively flat or rolling till plain areas in the north. Farther south the effects of erosion by running water predominate and drift deposits, even though present at places, do not show clearly as such in the topographic forms. Of the four groups of landform types present here, all but the last may be subdivided into several types. These ten landform types are summarized in the following table and their description and recognition will be treated in the following section of this report.

TABLE I

THE TEN LANDFORM TYPES IN THIS REGION

Group 1. Upland Plains

Type (1) High and intermediate flat benches

Type (2) Rolling glacial till plains

Group 2. Valley Plains

A. Along present streams

Type (3) Flood plains

Type (4) Terraces or second bottoms

B. Not associated with present streams

Type (5) Flat-floored channels without streams, associated with rolling glacial plains.

Type (6) Basin plains - enclosed alluvial or lacustrine areas.

Group 3. Steeply Sloping Margins of Benches or Plains

Type (7) Relatively straight, only slightly dissected scarps.

Type (8) Gently rolling dissected areas.

Type (9) Rough dissected areas including steep ragged scarps, canyons, and ravines.

Group 4. Erosion Remnants Controlled in Form by Bedrock Structure

Type (10) Buttes and mesas

## Examples of the Ten Landform Types Shown in Stereopairs of Air and Ground Photos and on Topographic Maps

Twelve stereograms of airphotos (Airphotos 1-A and 1-B to 12-A and 12-B) have been selected to illustrate the appearance of the ten principal landform types as well as a much larger number of minor topographic and cultural details of the landscape. The area covered by each stereogram of airphotos is outlined on a topographic map (Figures 1 to 8-B) showing the larger setting. The topographic map shows at a glance elevations and relief, drainage and the direction of flow of streams, and many cultural features, and serves to answer many questions which may occur to the photo interpreter. Ground photographs in stereopair (Ground Photos 13-A and 13-B to 34-A and 34-B) illustrate the appearance to the ground observer of the major landform types as well as many minor details. The position of the photographer and direction of view for eachpair of ground photographs is indicated on the left-hand airphoto by ground photo number and by a "V" marking the field of view of the camera.

### Procedure

Each pair of airphotos will be described in turn. First, the general appearance and features of the landform

type illustrated will be described. Next, the features of this landform type shown by the ground photos will be pointed out. Then, the airphoto stereogram will be examined and all characteristic features of that landform type will be enumerated, together with other physical and cultural features that show clearly on the airphcto stereogram. It is believed that this procedure will acquaint the photo interpreter thoroughly with the major landform types characteristic of this type of region. Where necessary, coordinates will be used to locate points or areas on the airphotos, but as far as possible letters (A, B, etc) placed on the left-hand airphoto will be used to indicate features referred to.

It is believed preferable to analyze each pair of airphotos for all those landform types best shown on them, rather than to treat the ten landform types in an established sequence which necessarily involves the partial study of certain stereograms with a return to them later.

In describing the features of each landform type that appear on either the ground photographs or the airphotos, the features shown will be given the same numbers listed under the General Appearance of the landform type. Features listed under the General Appearance which do not appear on the ground photos or airphotos will bear no descriptions under the latter and their numbers will be omitted.

## Description of Individual Areas

Airphotos 1-A and 1-B

VALLEY PLAINS - FLOOD PLAINS - LANDFORM TYPE (3)

General Appearance: This landform type is associated with present streams. The following features are characteristic:

1. Always adjacent to a present stream. A sluggish meandering stream is characteristic.

2. Part of a broad valley, with floor only slightly above stream level. May be flooded in high water.

3. Generally a steep bluff or abrupt rise to higher ground on side opposite stream.

4. Bluff on landward side may be curved or scalloped in plan, due to erosion by meanders of stream at former time.

5. Surface of flood plain commonly underlain by gravel or sand - a deposit of the stream.

6. Abandoned shallow channels showing former stream course may cross surface of flood plain.

7. Soil patterns may show light areas (sand bars and gravel deposits) and dark areas (commonly lower channels). Such channels may also be outlined by vegetation patterns.

8. Drainage may be poor. Driest areas tend to have linear pattern, as on ridges or sand bars parallel to stream course.

9. Roads tend to follow such dry linear areas.

10. In a dry area, trees may be present on flood plains even though absent on dry grassed upland areas.

Appearance in Ground Photos 17-A and 17-B: The following characteristic features may be seen in these photos:

1. Low flood plain in left foreground is adjacent to river seen in left middle distance.

2. This flood plain lies within the broad valley shown.

3. Steep bluff with trees and bushes bounds the flood plain seen in left foreground.

4. The steep bluff is smoothly curved in plan.

6. An abandoned shallow channel follows edge of flood plain in left foreground, just below steep bluff.

7. Vegetation is light (grass) on drier ground of flood plain in left foreground, and darker in the old channel below bluff.

8. Drainage is poor, as shown by standing water in old channel below the two heavy dark bushes.

10. Grove of trees on flood plain in left distance.

Appearance on Airphotos 1-A and 1-B: The broad bottom of valley crossing this photo area from 0.0 - 4.5 to 2.5 - 3.1 consists in part of flood plain, in part of higher terrace or second bottom. The flood plain shows these features:

1. Adjacent to the Teton River (see Figure 2), a meandering stream.

2. Part of a broad valley plain.

3. The wooded flood plain area at A is bounded on south by the steep bluff shown in Ground Photos 17-A and 17-B.

4. Bluff at edge of flood plain is curved at many points, as B. C. and D.

5. Gravel underlying flood plain surface shows at E.

6. Abandoned channels show clearly at C and at F.

7. Light and dark soil tones may be seen at G and H.

8. Drainage is poor, as shown by absence of active drainage lines.

10. Trees are abundant, as at A.

Airphotos 1-A and 1-B

VALLEY PLAINS - TERRACE OR SECOND BOTTOM - LANDFORM TYPE (4)

These are commonly associated with lower flood plains, as in Airphotos 1-A and 1-B and ground photos 17-A and 17-B.

General Appearance: The following features are characteristic:

1. Adjacent to and above a lower flood plain.

2. Generally part of a broad valley.

3. Bounded by steep descent leading to flood plain, and by steep ascent or bluff to higher ground outside of valley.

4. May occur at more than one level above the flood plain.

5. Bluffs above such terraces may show gullies or ravines, rather than smoothly curved plan.

6. Abandoned shallow channels may be present, and may show in vegetation patterns.

7. Such areas are very favorable for irrigation, with respect to slope and form of surface and water supply.

8. Gravel may form surface deposit.

9. Soils may show light and dark tones in bar-like or channel-like patterns.

10. Drainage may be poor, though soils are commonly drier than on flood plains.

11. Such areas may be good agriculturally.

Appearance in Ground Photos 17-A and 17-B: In this view the terrace or second bottom lies between flood plain in left foreground and steep valley wall in right foreground and right middle distance. The following features may be seen:

1. Adjacent to the lower flood plain on left.

2. Part of a broad valley.

3. Bounded by steep descent to flood plain on left, and ascent to higher upland on right.

4. Only one terrace is present here.

5. Higher bluffs in right distance are gullied.

7. The ditch at right is unused irrigation ditch, indicating former irrigation of the area.

9. A dark linear stripe in soil in front of bluff in right distance may be due either to vegetation differences or to different soil tones.

10. No drainage lines are present; drainage is therefore poor.

Appearance on Ground Photos 30-A and 30-B: These photos show the following characteristic features of a terrace or second bottom:

1. Lower flood plain of river shows in right distance.

2. The area is part of a broad valley.

3. A steep low bluff descending to flood plain lies to right of two trees near middle of photos, while steep ascent to higher ground is seen at left.

5. Higher bluff in left distance is gullied.

6. An abandoned channel (dark grass) shows clearly in center foreground. On both sides of it is higher ground with sagebrush in addition to grass.

8. Gravel shows among grass, in right foreground.

10. Drainage is poor.

Appearance on Airphotos 1-A and 1-B: The following features may be seen on the airphotos:

1. The upper bottom at 2.0 - 2.9 (within field of view of Photos 17-A and 17-B) is adjacent to lower flood plain on north.

2. The area is part of a broad valley (note Figure 2).

3. Steep bluff descends to flood plain on north, and another ascends to upland on south of area at 2.0 - 2.9.

4. The second bottom at 2.0 - 2.9 is higher above river than second bottom at 1.0 - 3.1.

5. Higher bluffs at I and J are cut by gullies and ravines.

6. Abandoned former channels show clearly in darker vegetation patterns at K and L.

7. Old irrigation ditch at M was formerly used to irrigate the terrace immediately downstream (i.e., on east).

9. In places, soils show light (higher bar-like areas) and dark (lower areas) tones, as at N.

10. The areas are generally flat and poorly drained.

Airphotos 2-A and 2-B

ROLLING GLACIAL TILL PLAIN - LANDFORM TYPE (2)

General Appearance: This landform type is characterized by the following features:

1. Rolling surface with basins and swells.

2. Perceptible though rather low relief, rarely exceeding 25 to 75 feet.

3. Poor drainage; marshes, swamps or lakes may be present.

4. Good agricultural soils.

5. Road pattern commonly shows little or no adjustment to topography.

6. Soil patterns are mottled with lighter colors on rounded swells and darker colors in lower areas between. Fallow strips may show light soil tones even on swells in the topography. In certain places, wash of light sediment on to low ground has given a light tone there, rather than dark.

7. Drainage pattern is generally aimless and wanders without order or plan.

Appearance on Ground Photos 15-A and 15-B: The following features of rolling till plain may be seen on these ground photos:

1. The surface is rolling with basins and swells.

2. Relief is low; apparently 30 to 40 feet.

3. No drainage lines are seen in foreground; surface drainage is probably poor.

4. The good wheat in foreground indicates good soils.

5. Road is straight and shows no adjustment to topography.

Appearance on Airphotos 2-A and 2-B: The following features are characteristic of a large area of rolling till plain in the central part of these airphotos. The southern limit of this rolling till plain follows the margin of valley from 0.0 - 2.4 to 1.9 - 0.0. The northern margin is near heads of developing ravines, from 0.0 - 5.7 to 2.5 - 5.5.

1. Surface is rather strongly rolling with basins and swells.

2. Relief is moderate though very marked (see Figure 3).

3. Drainage is generally poor, with some closed basins as at A. Some integration of these basins by erosion of intervening divides, as at B.

4. The good soils are indicated by the extensive strip farming of this area to wheat.

5. The road pattern conforms to the government township and range system with almost no adjustment to topography.

6. Soil patterns are mottled. Lighter tones prevail on swells, as at C; darker tones in lower slopes and depressions, as at D. A basin filled with sediment of light tone is illustrated at E.

7. Drainage pattern is generally aimless and lacks symetrically arranged branches of decreasing size. For example, the broad basin at E drains southward though a narrow channel to F, and then northward into the valley at G that winds in a northeasterly direction off the photo area.

Airphotos 2-A and 2-B

## VALLEY PLAIN - FLAT FLOORED CHANNEL WITHOUT STREAM - LANDFORM TYPE (5)

General Appearance: This laniform type originated as a drainage channel for glacial waters during the final melting of the continental glacier. Generally the size of channel is far too large for any postglacial stream that may occupy it, inasmuch as the volume of glacial meltwater far exceeded present sources for streams. The following features are generally present:

1. Channel is associated with glaciated plain, and may be parallel to former margin of glacier.

2. Form is broad channel with flat floor of uniform grade. Shallow longitudinal furrows or minor channels may divide bar-like swells on floor. Side walls are commonly steep.

3. Streams if present are underfit in size to channel.

4. Several streams may occupy parts of the channel; there may be no continuous stream throughout its length.

5. Side walls of channel may be gullied or ravined.

6. Small alluvial fans may be built out on to channel floor where such ravines enter.

7. Soil patterns tend to be uniform.

8. Soils are commonly good to fair.

9. Land use patterns, as field strips or road patterns, tend to follow length of channel.

Appearance in Ground Photos 24-A and 24-B: The following features are evident in the view shown in these ground photos:

2. Broad channel form, with shallow furrows extending from right to left. Side wall of channel in middle distance is moderately steep.

5. Distant side wall of channel is trenched by broad ravines on left.

7. Soil appears to be uniform in tone.

8. Harvested grain field at left of road suggests good soil.

Appearance on Airphotos 2-A and 2-B: The following features may be observed on these airphotos:

1. The channel extending from 0.0 - 7.6 to 2.5 - 6.2 is associated with rolling glacial till plain areas on north (see 1.0 - 7.7) and on south (see 1.7 - 5.0). The southeasterly trend is probably that of former glacial margin in this region (see Figure 3).

2. Form is broad flat valley bottom with shallow present stream channel in floor, as at H. Side walls are steep, as at I and J.

3. Stream at H is greatly underfit to size of channel.

4. The tiny stream at H enters from south just west of that point; the channel at K has no present stream.

5. Both side walls are cut by ravines and gullies, as on east and west of both I and J.

6. Fan in channel bottom at L is built at mouth of ravine dammed by earth dam at M.

7. Soil tones are fairly uniform. White spots at N are probably areas of fresh mud or standing pools of water.

8. Location of farmstead at 0.3 - 6.9 suggests that soils of this channel bottom are pretty good. More direct evidence is lacking.

9. A secondary road follows south margin of channel flow from farmstead at 0.3 - 6.9 eastward to edge of airphoto area.

Additional Example of Flat-Floored Channel: Another excellent example of this landform type crosses southwest corner of Airphotos 2-A and 2-B, from 0.0 - 2.1 to 1.6 - 0.0. It shows most of the characteristic features enumerated above. Especially noteworthy are (a) the absence of any present stream, and (b) the pattern of strip cropping which runs parallel to the length of the channel.

Airphotos 3-A and 3-B

## VALLEY PLAIN - FLAT-FLOORED VALLEY WITHOUT STREAM - LANDFORM TYPE (5)

Another good example of Landform Type (5) is shown on Airphotos 3-A and 3-B and Figure 4.

General Appearance: Flat-floored valleys without streams are characterized by the following features, enumerated under Airphotos 2-A and 2-B, and repeated here:

1. Channel is associated with a glaciated plain, and may be parallel to former margin of glacier.

2. Form is broad channel with flat floor of uniform grade.

3. Streams if present are underfit in size to channel.

4. Several streams may occupy parts of the channel; there may be no continuous stream throughout its length.

5. Side walls of channel may be gullied or ravined.

6. Small alluvial fans may be built out on to channel floor where such ravines enter.

7. Soil patterns within channel tend to be uniform.

8. Soils are commonly good to fair.

9. Land use patterns, as field strips or road patterns, tend to follow length of channel.

Appearance in Ground Photos 18-A and 18-B: The following features may be seen in the view shown in these ground photos:

1. The higher plain in distance beyond channel is slightly rolling and resembles a glacial till plain.

2. The channel has a broad flat floor with moderately steep valley wall on opposite side.

3. No stream is present in this part of channel (See Figure 4).

7. Soil in fallow strip on left of road appears uniform in tone.

8. The use of this area for strip cropping of wheat (current year wheat is in strips of dark tone) suggests that soil is good.

Appearance on Airphotos 3-A and 3-B: These photos should be examined in connection with the map, Figure 4, which shows that the principal present drainage lines cross rather than follow the channel referred to. This strongly suggests that the channel follows a former ice margin that lay transverse to natural drainage lines. The following characteristic features may be observed in Airphotos 3-A and 3-B:

1. Channel is associated with glacial till plain indicated by rolling surface, and aimless drainage pattern in northern part of photo area, and undrained depression at A.

2. Flat floor and uniform grade of channel show clearly at B.

3. Present streams such as that at C are underfit to size of channel.

4. Streams at C and D are in separate parts of the channel.

5. Side walls are ravined and gullied, as at E and F.

7. Soil patterns appear generally uniform, as at B.

8. Grain strip cropping in the area at G suggests at least moderately good soils.

9. Land use patterns tend in part to follow the channel, as large field from B to C, and road at H.

Additional features that show clearly on Airphotos 3-A and 3-B are:

Ranchsteads or farmsteads at 0.5 - 6.3; 0.8 - 5.7; 0.3 - 1.8; and 0.6 - 1.3.

A large hay field at I, shown by "hip-roof" pattern; and a smaller, recently cut hay field at J, with cut hay in windrows.

Two small earth fill dams and reservoirs for pastured cattle at K and L.

Airphotos 4-A and 4-B

## ROUGH DISSECTED AREAS - LANDFORM TYPE (9)

General Appearance: Rough dissected areas may display some or all of the following characteristics:

1. Much of the area is in relatively steep slopes.

2. Rock ledges and even vertical cliffs may occur where resistant bedrock beds are present.

3. Summit areas may include relatively flat ridges or other remnants of the original land area before it was dissected by erosion.

4. In a dry region, bushes and trees may occur on the steeper slopes of a rough dissected area, even though the surrounding dry plains may be grassland.

5. Bare soil may show on steeper slopes.

6. Such areas are generally in pasture or waste land. Cultivated fields are uncommon.

7. Road patterns may show close adjustment to topography, because favorable grades must be selected into and across such areas.

8. Fills and bridges are often necessary for roads and railroads.

9. Rural population is sparse in such areas.

Appearance on Ground Photos 22-A and 22-B: These photos show the following characteristic features of rough dissected areas:

1. Much of the area is in fairly steep slopes.

2. Rock ledges are suggested by the appearance near crest of highest ridge in view at left of photos, both near left edge and center of view.

3. The ridge just mentioned has a relatively flat top suggesting original surface.

5. Bare stony soil shows clearly on far side of ravine in foreground.

6. Area is in pasture or waste land.

8. A large earth fill for a railroad grade is visible in right middle distance.

9. No human habitations appear within the view; population is sparse.

Appearance on Ground Photos 33-A and 33-B: Another view within the same areas is shown in these photos. The following features are clearly shown:

1. Area is mainly in steep slopes.

2. Vertical rock ledge shows at top of slopes in foreground.

3. Upland surface in background has undissected flat top.

4. Bushes and small trees are present under cliff at left, and in right foreground.

5. Bare rocky soil shows on slopes in foreground.

6. Area appears to be waste land.

7 and 8. Old carriage road descended stone causeway at right into ravine.

9. Rural population is evidently sparse.

Appearance on Airphotos 4-A and 4-B: The rough dissected area is associated with the erosional development of the ravines in south central part of area (See Figure 5-A). The following features are shown on these airphotos:

1. The dissected area is marked by steep slopes, as at A.

2. Rock ledges are suggested by the excessive steepness at B and C.

3. Summit areas not yet dissected by erosion are relatively flat, as at E and E.

4. Some bushes may be seen in ravine at F, in contrast to grassland vegetation elsewhere here.

6. The rough dissected area is seen to be almost wholly in pasture or waste land. The cropped areas (in strips) are almost wholly confined to the flat uplands.

7. Road from G to H avoids roughest part of dissected area by crossing shallow heads of ravines.

8. High fills are necessary for this road at I and J, and for the railroad at K and L.

9. The few ranchsteads indicate sparse rural population. One is in ravine at 0.3 - 2.3, and two others on upland at 1.1 - 3.8 and 1.5 - 6.0.

The rolling surface of the upland in north half of Airphoto area, with faint mottled soil pattern and undrained basins (as at M) indicate that this is a glacial till plain.

Airphotos 5-A and 5-B

VALLEY PLAIN - BASIN PLAIN - LANDFORM TYPE (6)

Basin plains are enclosed valley plains of alluvial or lacustrine origin. The flat surface of the basin has been built up by deposits of alluvium washed in and dropped by streams, or of lacustrine sediments that have settled in the waters of a former lake. It is often difficult to distinguish alluvial from lacustrine basins without a direct examination of the sediments, but lacustrine basins are generally flatter and lack the fan-shaped marginal deposits built directly by inflowing streams.

General Appearance: The following features are characteristic of basin plains, whether alluvial or lacustrine:

1. Enclosed drainage - center of basin is below outlet, if any.

2. Flat floor, with steeper slopes to higher ground on some sides of basin.

3. Poor drainage; ground may be wet in rainy season; standing water may be present.

4. Vegetation cover is usually complete; bare soil or rock is rare.

5. Grasses rather than bushes or trees predominate, in an area of dry climate.

6. Vegetation may be zoned in concentric bands about margins of basin, or along water channels within basin.

7. Such areas are generally used for pasture.

8. Roads crossing basin plains may be elevated on fills.

Appearance on Ground Photos 19-A and 19-B: These show the basin plain (stippled area in Figure 5-B) from the top of a butte more than 200 feet above basin surface. The following features may be seen in the ground photos:

1. Drainage is evidently enclosed, as shown by standing water.

2. The basin floor is flat, with a steeper slope visible beyond strip cropping in left distance.

3. Drainage is poor as shown by standing water.

4. No bare soil is visible.

5. Grass predominates.

6. The light and dark tones in center and right center indicate some kind of vegetation zoning.

7. Central area in photo appears to be pasture land, though grain farming is indicated by strip cropping in left background.

8. Road in foreground and that crossing center of photo have been elevated on fills.

Appearance on Ground Photos 27-A and 27-B: A view of another part of the same basin plain, taken from the same butte, is shown in these ground photos. The following features may be seen:

1. Area appears to have enclosed drainage, though this is not proved by these photos.

2. The floor is very flat, rising in a steep bordering slope beyond strip cropped area in distance.

3. Drainage is poor, as shown by standing water near road in center of plain.

4. Vegetation cover is complete.

5. Grass is the chief vegetation.

6. The light belt across center of photo suggests a zoning of vegetation.

7. The greater part of the area is in pasture, though the strip cropped area in distance is in grain.

8. The road crossing basin is elevated on a fill.

Appearance on Airphotos 5-A and 5-B: The following features of basin plains are evident on these airphotos:

2. The floor of the basin is very flat, as at points A and B.

3. Drainage is poor, as shown by lack of drainage channels, and by standing water at C and D.

4. Vegetation cover appears to be complete on flat floor of basin.

5. Grass is vegetation type.

6. Vegetation shows marked zoning in lower areas, as at E, F, and G.

7. Pasture predominates in the basin plain, though wheat is strip cropped at B and field at H appears to be in alfalfa.

8. The diagonal road across basin plain is on a fill. The white line along each side of this road, as at I, is a ditch made white by the bare soil of the excavation and by standing water. Road at J is also on a fill.

Airphotos 5-A and 5-B

## BUTTES AND MESAS - LANDFORM TYPE (10)

These features are residual areas left by the erosion of a higher area. Flat-lying bedrock layers commonly control the form of the feature, a resistant "caprock layer" often giving rise to a relatively flat summit area.

General Appearance: The following features are characteristic of mesas and buttes, though not universally present:

1. A relatively flat top, with steep side slopes rising from lower surroundings.
2. A resistant caprock often shows in a vertical or steep cliff near upper part of side slope.
3. Soils may be thin or lacking on steep sides.
4. Bare rock layers may show on sides.
5. Bushes and trees may be present on side slopes, where climate is dry.
6. Sides may have gullies or ravines, indicating water erosion.
7. Areas are usually waste land, or poor pasture.

Appearance on Ground Photos 29-A and 29-B: The following characteristic features of this landform type appear in these ground photos, which show a typical butte:

1. Top of butte is relatively flat.
3. Soil appears to be lacking on much of the side slope of the butte.

4. Horizontal rock layers show clearly, particularly at left end of butte.

5. A few bushes appear on upper part of side slopes.

6. Gullies are present on side slopes.

7. Area is not cropped and appears to be waste land.

Appearance on Airphotos 5-A and 5-B: The following features appear on these airphotos:

1. Top of butte is flat.

2. The photos indicate that one resistant horizontal layer forms the top of this butte, and that another forms the side shoulder or berm on the lower slopes of the butte at the level of the saddle connecting it to mesa on southwest, at K.

3. The light tone and lack of vegetation on south, at L, suggest lack of soil.

4. The horizontal banded pattern of light and dark tones at M suggests that rock structure shows there.

5. Bushes show sparsely on upper side slopes, as at N.

6. Gullies are numerous on side slopes, as at O.

7. Area appears to be waste land or poor range land. The earth dam and cattle reservoir at P suggest that cattle are raised in the area.

Airphotos 6-A and 6-B

GENTLY ROLLING TILL PLAIN - LANDFORM TYPE (2)

General Appearance: Glacial till plains may be strongly rolling, or may be nearly flat and very gently rolling. The example here considered, in the north part of the airphoto area, is of the latter kind. The following features are characteristic of this landform type:

1. Rolling rather than flat land surface.
2. Small to slight relief.
3. Basins without outlets may be present.
4. Mottled soil patterns, light in tone on swells and dark in lower areas.
5. Aimless drainage pattern, where present.
6. Road pattern shows little or no adjustment to topography.
7. Soils are generally good.
8. Areas may be largely under cultivation.

Appearance in Ground Photos 14-A and 14-B: The following features may be observed in the view shown by these ground photos:

1. Surface is a very gently rolling plain.
2. Relief is very small.
6. Road pattern shows no adjustment to topography.
7. Soils appear to be agriculturally productive.
8. Entire area shown in view is strip cropped to wheat, save for roadway.

Appearance in Airphotos 6-A and 6-B: This rolling till plain area lies north of the dissected south-facing scarp in the north part of the airphoto area (Figure 5-C). The following features may be seen on the airphotos:

1. Surface is rolling, as at A.

2. Relief is small.

3. Small enclosed basins appear to exist, as at B.

4. Soils show light and dark tones in mottled pattern, as at C, D.

5. Drainage pattern is aimless rather than systematically organized.

6. Road pattern (E, F, G) shows no adjustment to topography.

7. Soils appear to be good, from their complete agricultural utilization for wheat strip farming.

8. All of area is under cultivation.

Other landform types shown on Airphotos 6-A and 6-B:

The south-facing scarp at north is an excellent example of landform type (10), rough dissected area, as at H.

The large flat area of light tone at I is part of a basin plain of lacustrine origin. A dredged outlet channel bordered by ridges of the excavated material on each side is at J.

Airphotos 7-A and 7-B

## BUTTES AND MESAS - LANDFORM TYPE (10)

General Appearance: Buttes and mesas are eroded remnants of an older, higher land area, a vestige of which often is preserved on the flat summit of the landform. Their general characteristics were previously enumerated under Airphotos 5-A and 5-B, and will be repeated here:

1. Relatively flat top, with side slopes rising from lower surroundings.

2. A resistant caprock layer that often shows in a steep cliff near upper part of side slope.

3. Soils may be thin or lacking on the steep sides.

4. Bare rock layers may show on sides.

5. Bushes and trees may be present on side slopes, in a dry area of predominant grassland vegetation.

6. Sides may have gullies or ravines, indicating water erosion.

7. Areas are usually waste land or poor pasture.

Appearance in Ground Photos 23-A and 23-B: These show a distant view of the large butte near center of Figure 5-D. The following characteristics may be observed:

1. Top of butte is relatively flat.

2. The flat top strongly suggests a resistant caprock layer, though a steep rimming cliff is not visible.

3. Where bedrock layers show on slopes at west end and near center of butte, soils must be absent.

4. Bare rock layers show on the side slopes at several points.

6. Side slopes show moderate gullying.

7. Butte is uncultivated, so far as Ground Photos 23-A and 23-B indicate.

Appearance in Ground Photos 31-A and 31-B: These photos show a close view of the side slope at southeast corner of the butte. The following features may be seen:

3. Soils are lacking over the large light-toned bare areas.

4. Horizontal tone patterns in these bare areas suggest outcrops of shaly rock.

5. A few bushes are seen near top of slope.

6. Slope shows a few shallow gullies.

7. Area appears to be waste land.

Appearance on Airphotos 7-A and 7-B: The following features show clearly on the airphotos:

1. Top of butte is relatively flat, as at A, with a suggestion of lower terrace-like benches at B and C presumably caused by a resistant rock layer lower than the caprock.

2. Flat top with steep rimming slopes strongly suggests a resistant caprock.

3. Soils are evidently thin or wanting on the side slopes, especially at such areas at D.

4. Horizontal rock layers show on side slopes at E and elsewhere.

5. A few bushes show on south slope near top, as at F.

6. Sides are strongly gullied, as at G.

7. Area is uncultivated and appears to be waste land or pasture.

Airphotos 8-A and 8-B

ROLLING GLACIAL TILL PLAIN - LANDFORM TYPE (2)

ROUGH DISSECTED AREA - LANDFORM TYPE (9)

BUTTE - LANDFORM TYPE (10)

These Airphotos illustrate the three landform types mentioned above, which may be recognized by the characteristics enumerated below (See Figure 5-E):

Rolling Glacial Till Plain: This occupies the northern third of the airphoto area, and the southern third north and south of the dissected area of valleys and tributaries. The following features serve to identify this rolling till plain:

1. Rolling surface with basins, as at A, B, and swells, as at C, D.

2. Low relief.

3. Poor drainage, as shown by lack of drainage pattern in an area near A and C.

4. Soils in area at north are all under cultivation and may be presumed good.

5. Road at E shows no relationship to landforms.

6. Soil patterns are faintly mottled, as near A and B.

7. No well-defined or integrated drainage pattern is present in these areas.

Rough Dissected Area: The stream valley and tributaries at south form a good example of a rough dissected area. The following characteristics are evident from the airphotos:

1. Much of area is in steep slopes, as at F.

2. Rock ledges appear to be present at G.

3. Summit areas are in part relatively flat remnants of former upland, as at H.

6. Area is not cultivated and appears to be pasture or waste land.

7. No road is present in area, indicating difficult slopes for roadbuilding.

9. No ranches occur in the area.

Butte: A good example occurs in west central part of airphoto area. The following characteristics are easily observed on the airphotos:

1. Sides of butte are steep, as at I, though little is left of original flat summit.

2. A resistant rock layer appears to cap butte, as at J.

3. Soils are evidently thin on gullied side slopes, as just below I.

4. Bare horizontal rock layers show on side slope at K.

6. Sides are gullied, as at I.

7. Area is waste land or pasture.

Additional features: These airphotos show at L an excellent example of an alluvial fan, made of light-toned sediment washed from higher up slope by running water. This fan is crossed by an irrigation ditch marked by a dark line of vegetation.

Airphotos 9-A and 9-B

## VALLEY PLAIN - FLOOD PLAIN - LANDFORM TYPE (3)

General Appearance: The characteristic features of flood plains have been enumerated under Airphotos 1-A and 1-B, and will be repeated here:

1. Adjacent to a stream, generally sluggish and meandering.

2. Part of a broad valley, with floor only slightly above stream level.

3. Steep bluff or rise to higher ground on valley-ward side or sides.

4. Bluff may be scalloped due to erosion at meander of stream.

5. Surface may be underlain by gravel or sand.

6. Abandoned shallow former stream channels may show on surface of flood plain.

7. Soil patterns may show light and dark areas corresponding to sand bars and old channels.

8. Drainage may be poor.

9. Roads tend to follow dry linear belts, often near and parallel to stream.

10. Trees may be present, even though surrounding region is a dry grassland.

Appearance on Ground Photos 16-A and 16-B: The following features of flood plains may be seen in these photos:

1. Broad valley bottom is adjacent to the meandering stream shown.

2. The area is a broad valley, with bottom near stream level.

3. A steep, dissected bluff adjoins flood plain on farther side.

7. Soil patterns show light and dark areas.

8. Drainage of the flood plain is poor.

Appearance in Ground Photos 34-A and 34-B: The following features may be seen in this pair of ground photos:

1. Area is adjacent to a meandering stream.

2. Area is a broad valley, close to stream level.

3. A steep dissected bluff rises above flood plain on farther side.

6. Abandoned former channels are present just beyond stream in center foreground.

7. Soil patterns show light and dark tones.

8. Drainage is poor.

Appearance on Airphotos 9-A and 9-B: The following features show clearly on the airphotos:

1. The flood plain crossing south-central part of area is a broad valley floor with a meandering stream, A.

2. The broad valley floor is only slightly above level of stream.

3. Steep bluffs rise above flood plain on north, as at B, and on south, as at C.

5. Fan-like area in front of tributary stream at D strongly suggests that alluvium underlies valley floor as a whole.

6. Lower ground at E appears to be an abandoned former stream channel.

7. Soil pattern includes dark areas, as F, and light areas, as G.

8. Flood plain is flat and drainage is evidently poor.

9. Roads follow drier, higher belts, as at D and H. Railroad I shows little relationship to flood plain details.

Other features shown on Airphotos 9-A and 9-B:

Much of northern part of area is an excellent example of a rough dissected area, as at J and K.

The area south of the flood plain is an excellent example of high benches, as at L and M.

See Map, Figure 6, and the descriptions of these landform types on previous pages of this report.

Airphotos 10-A and 10-B

STRAIGHT, SLIGHTLY DISSECTED SCARPS - LANDFORM TYPE (7)

General Appearance: Straight, slightly dissected scarps generally separate higher bench lands from lower. Generally there is no stream at the base of the scarp. Such features are due to past conditions when gravel-laden flood waters were developing the bench surfaces at more than one level. The following features are characteristic of slightly dissected scarps:

1. Moderate slope.

2. Relatively straight plan without salients or indentations.

3. Little gullying or erosion.

4. The form generally marks a descent from a higher plain or bench to a lower.

5. Roads may show little adjustment to this landform type, but irrigation ditches, if present, must descend by controlled drops or checkweirs.

6. Such scarps may be cultivated and even irrigated.

Appearance in Ground Photos 20-A and 20-B: The following features may be seen in these photos:

1. The scarp descends with a very moderate slope from right to left, where it joins lower bench with dark fields.

2. The scarp extends away from photographer in a nearly straight pattern.

3. No gullies may be seen.

4. The scarp connects a lower bench, at left, with a higher one beyond field of view on right.

5. The road in foreground descends scarp without adjustment to slope.

6. Scarp is in part cultivated, as shown by field beyond fence in right middle distance.

Appearance in Ground Photos 25-A and 25-B: These photos show another view of same scarp, looking more nearly downslope to the lower bench at foot. The following features may be seen:

1. Slope is gentle rather than steep.

3. No gullies are seen.

4. The scarp connects the lower bench, seen in distance, with a higher bench behind photographer.

5. Road is seen to have no adjustment to slope.

Appearance on Airphotos 10-A and 10-B: The scarp trends diagonally across the photo area from A to B. The following features may be seen:

1. The descent to north is everywhere uniform and relatively gentle, between A and B.

2. The scarp is nearly straight between A and B, without indentations or salients.

3. There are no gullies.

4. The scarp marks a descent from higher bench at C to lower bench at D.

5. Road pattern shows no adjustment to this landform type, as seen at E and F. Irrigation ditch at G evidently has checkweirs or other devices for restraining flow of water.

6. The scarp itself is irrigated at A, and cultivated without irrigation at B.

Airphotos 11-A and 11-B

## GENTLY ROLLING DISSECTED AREA - LANDFORM TYPE (8)

General Appearance: This landform type has generally been formed by the erosional dissection of a higher upland area, and often forms a retreating scarp area separating a higher undissected plain from a lower plain formed by more or less complete erosion. The following features are characteristic of this landform type:

1. Moderate relief and moderately steep slopes.
2. Integrated gullies and ravines due to stream erosion.
3. Adjacent to upland plain which is retreating under erosional attack.
4. Soils may be thin and stony.
5. Road pattern is generally adjusted to slopes, at least in part.
6. Area is rarely suitable for cultivation but is generally used for pasture.

Appearance on Ground Photos 21-A and 21-B: These ground photos show the following features of this landform type:

1. Moderate relief and moderately steep slopes.
2. Gullies and ravines due to stream erosion. The pattern of these cannot be distinguished in a ground view.
3. The area is adjacent to flat, retreating upland on left.

4. Soils are thin and stony, as shown on knoll in foreground.

5. Road in foreground is adjusted to most favorable slope.

6. Area is used for pasture.

Appearance in Airphotos 11-A and 11-B: The gently rolling dissected area crosses photos from east to west at north, in vicinity of Ground Photos 21-A and 21-B. The following features may be seen on the airphotos:

1. Slopes are moderate to steep, and relief is moderate. Near heads of ravines some slopes are steeper, as at A.

2. Gullies and ravines form branching, integrated pattern, as at B and C.

3. Area is an eroded belt on south side of upland plain D, which is retreating under erosion by rain and streams.

4. Light colors on the steeper slopes, as at E, suggest thin soils.

5. The better roads avoid the area. Poorer roads are present and are closely adjusted to the most favorable slopes, as at F and G.

6. Area is all under pasture.

Airphotos 12-A and 12-B

## HIGH AND INTERMEDIATE FLAT BENCHES - LANDFORM TYPE (1)

General Appearance: High and intermediate level flat bench lands are characterized by the following:

1. Flat surface, without basins or swells, but with occasional shallow valleys leading downslope if bench is not horizontal.

2. A level higher than surroundings on at least one and sometimes all sides.

3. Margins are ordinarily scarps in process of retreat, as shown by gullies and ravines.

4. Drainage lines few and drainage poor.

5. Soil patterns are relatively uniform without dark and light mottling.

6. Surface may be underlain by gravel layer, often with white coating of caliche (deposit of salts by evaporating ground water) on pebbles.

7. Often dry soil conditions, due to excessive drainage in gravel and height of bench above possible sources of gravel. Irrigation works, if present, indicate need for water.

Appearance on Ground Photos 13-A and 13-B: These photos show a typical high bench land in northern part of Airphotos 12-A and 12-B (Mpa, Figure 8-B). This view shows the following features:

1. Very flat surface, without swells or basins.

4. No drainage lines; poor drainage.

7. Dry surface soil, shown by areas of bare soil and by sparse stand of wheat, a typical dry farming crop.

Appearance of same area on Airphotos 12-A and 12-B:

The contour map, Figure 8-B, should be examined in connection with Airphotos 12-A and 12-B. The high bench land at north, ending at rough scarp extending from 0.0 - 5.0 to 2.5 - 5.2, shows following features:

1. Surface is generally flat. Shallow valleys lead to heads of ravines, as at A.

2. Surface is higher than lower ground south of bounding scarp.

3. The scarp at south is gullied and clearly undergoing erosion and retreat.

4. No drainage lines are present, save near heads of ravines, as at A.

5. Soil patterns appear very uniform. The dark and light stripes, as at B, are cropped and fallow wheat farming strips. An older north-south strip pattern shows faintly through present east-west pattern at C.

6. White caliche-coated gravel underlying the surface is indicated by white color or roadside ditches at D and by white gravel pit at E. White gravel shows also along the rim of the southern scarp, as at F.

7. The strip crop pattern (B) indicates dry farming methods, hence dry soil conditions. Absence of trees confirms this. During rainy weather, water may stand on flat fields and give wet soil conditions. An indication of this is the high fill of highway between white ditches from 0.2 - 6.9 to 2.5 - 5.7.

Appearance on Ground Photos 26-A and 26-B: These show an intermediate bench land lying in south of Airphotos 12-A and 12-B. According to Figure 8-B, the level is nearly 300 feet below high bench at north, and rises above lower land on the southeast. The ground photos show the following features:

1. Flat surface, shown in right and left distance.

4. No drainage lines can be seen.

5. Soil pattern appears very uniform.

6. Gravel shows in bank of irrigation ditch at right, and in road embankment made of material excavated from ditch.

7. Large irrigation ditch indicates that natural soil conditions of area are dry.

Appearance of same area on Airphotos 12-A and 12-B:

The following features may be seen on Airphotos 12-A and 12-B:

1. South of a diagonal north-facing escarpment from 0.0 - 1.8 to 1.9 - 3.2 is a relatively flat plain ending in a steep southeastward declivity at 2.3 - 0.3. A broad shallow valley leads eastward at G.

2. The area rises above lower ground on the north and southeast, as stated under 1.

3. The southeast margin at 2.3 - 0.3 is a relatively smooth, gentle scarp. The northwest margin is a steep retreating scarp with gullies as at H.

4. Most of area is flat without natural drainage lines. Two broad shallow valleys extend from I to J and from K to L, respectively. The latter is shown by a dark soil pattern.

5. Soil patterns are generally uniform with some exceptions where lower ground is dark, as the valley from K to L.

6. The presence of an underlying caliche-coated gravel layer is indicated by white line at rim of scarp, as at M.

7. The extensive system of irrigation ditches indicates dry natural soil conditions. Good examples are the deep ditch with bordering embankments at N, the curved major ditch at O with a smaller parallel ditch on its south side, and the small laterals irrigating alfalfa field at P.

Airphotos 12-A and 12-B

## ROUGH DISSECTED AREA - LANDFORM TYPE (9)

General Appearance: The scarp forming north margin of flat intermediate bench, and extending from 0.0 - 1.8 to 1.8 - 3.2 on Airphotos 12-A and 12-B, is a good example of a moderately rough dissected area, formed by erosion of the higher land on the south. Such rough dissected areas are marked by:

1. Steep slopes of ground surface.

2. Closely spaced gullies, ravines and valleys forming a topography of fine texture.

3. Gullies and ravines have connected, branching pattern.

4. Lower margin of area may grade into flat plain, or may pass into rolling dissected plain of lesser relief than rough dissected area.

5. Grade of individual ravine or gully commonly increases headward, and may end in steep rim marking margin of area undergoing dissection.

6. Underlying rock structure and white caliche soil zone may show on bare slopes.

7. Soils are thin in places and may show light and darker patches.

8. Road patterns are adjusted to more favorable positions within the rough area.

9. Little agriculture is carried on in such areas.

Appearance in Ground Photo 32: This view shows part of the dissected scarp in south central portion of Airphotos 12-A and 12-B. As indicated by map, Figure 8-B, the relief is approximately 100 feet. Ground Photo 32 shows the following features:

1. Moderately steep slope to lowland in middle distance.

4. Lower slopes appear to merge into a rolling plain that extends to scarp in distance.

6. White caliche-coated pebbles of gravel cap show on surface in foreground.

7. Soils are thin, as shown by gravel, and show light and dark patches.

8. Railroad in middle distance is adjusted to most favorable slopes, in part by a high fill.

9. Most of area is not farmed. Wheat planted in gravel in foreground is an exception.

Appearance on Airphotos 12-A and 12-B: This rough dissected area as seen on Airphotos 12-A and 12-B displays the following features:

1. Steep slopes.

2. Closely spaced gullies and ravines; examples are at H and Q.

3. Branching, connected pattern of gullies, as shown at Q.

4. Lower margin of area is separated by shallow stream channel from rolling dissected area of small relief crossed by railroad from R to S.

5. Grade of gullies and ravines increases headward to steep headwall, as at H and Q.

6. White caliche zone of gravel capping upland on south, shows at upper margin of dissected area, as at M.

7. Mottled light and dark soil patterns indicate thin soils, where light.

8. Railroad ascends dissected area in favorable position at T.

9. Practically no farming shows in this area on the 1946 Airphotos, though the old irrigation ditch and distributaries on rounded ridge at U indicate some former farming on flatter parts.

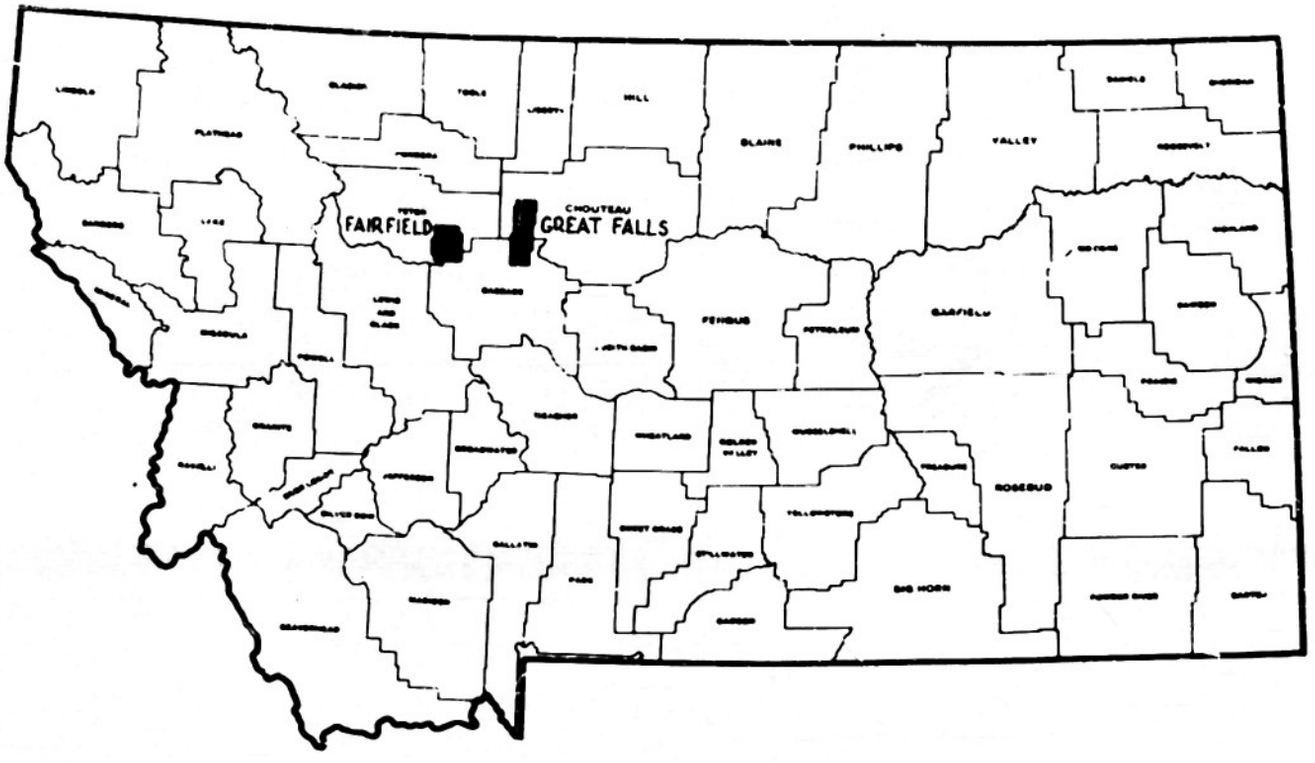



Figure 1. Location Map Showing Fairfield and Great Falls (Portage-Dent Bridge) Areas, Montana.

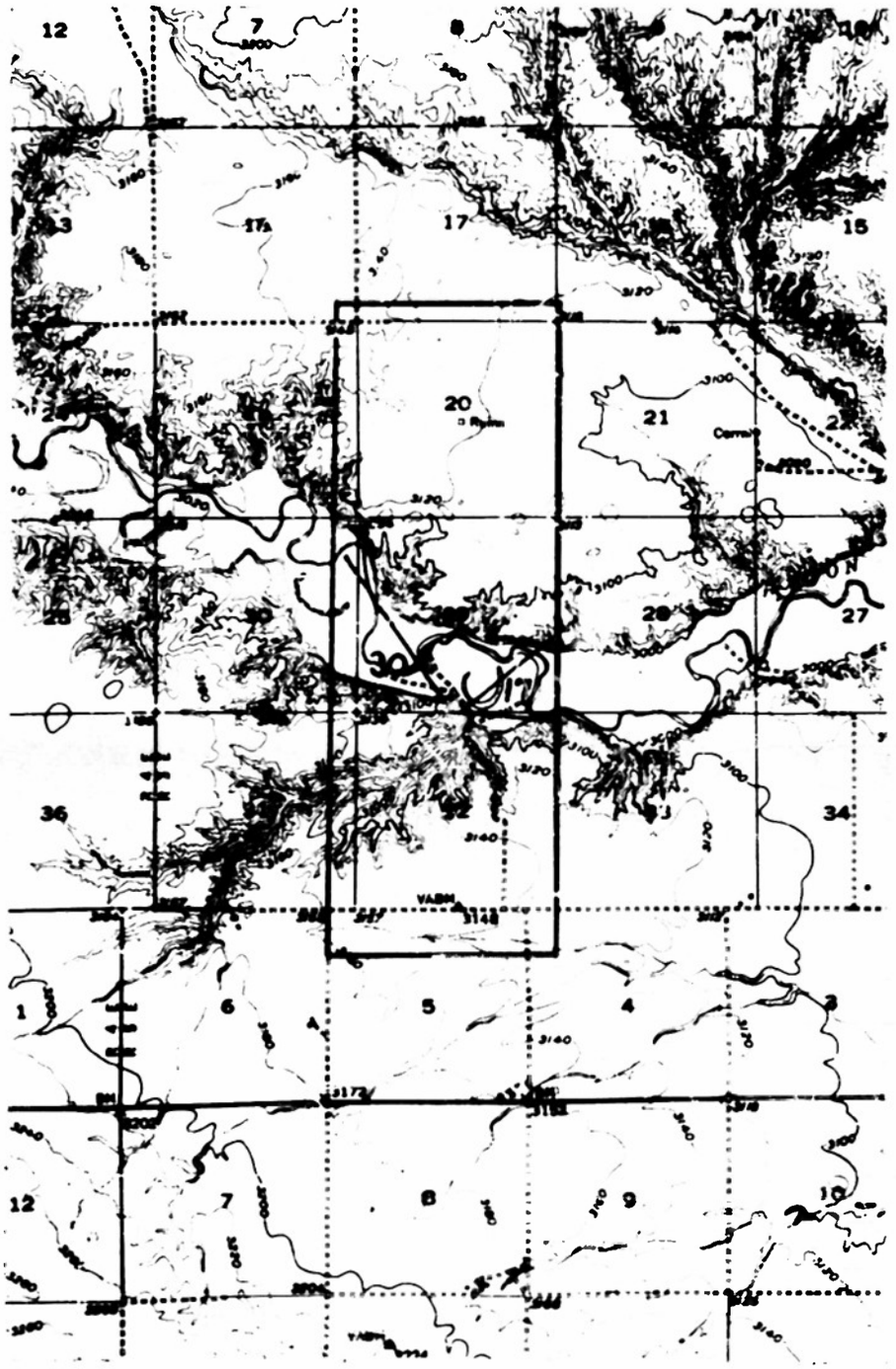



Figure 2. Area chiefly in Sections 20, 29, and 32, T. 25 N., R. 5 E., Dent Bridge quadrangle, Montana. Covered by stereogram, Airphotos 1-A and 1-B.

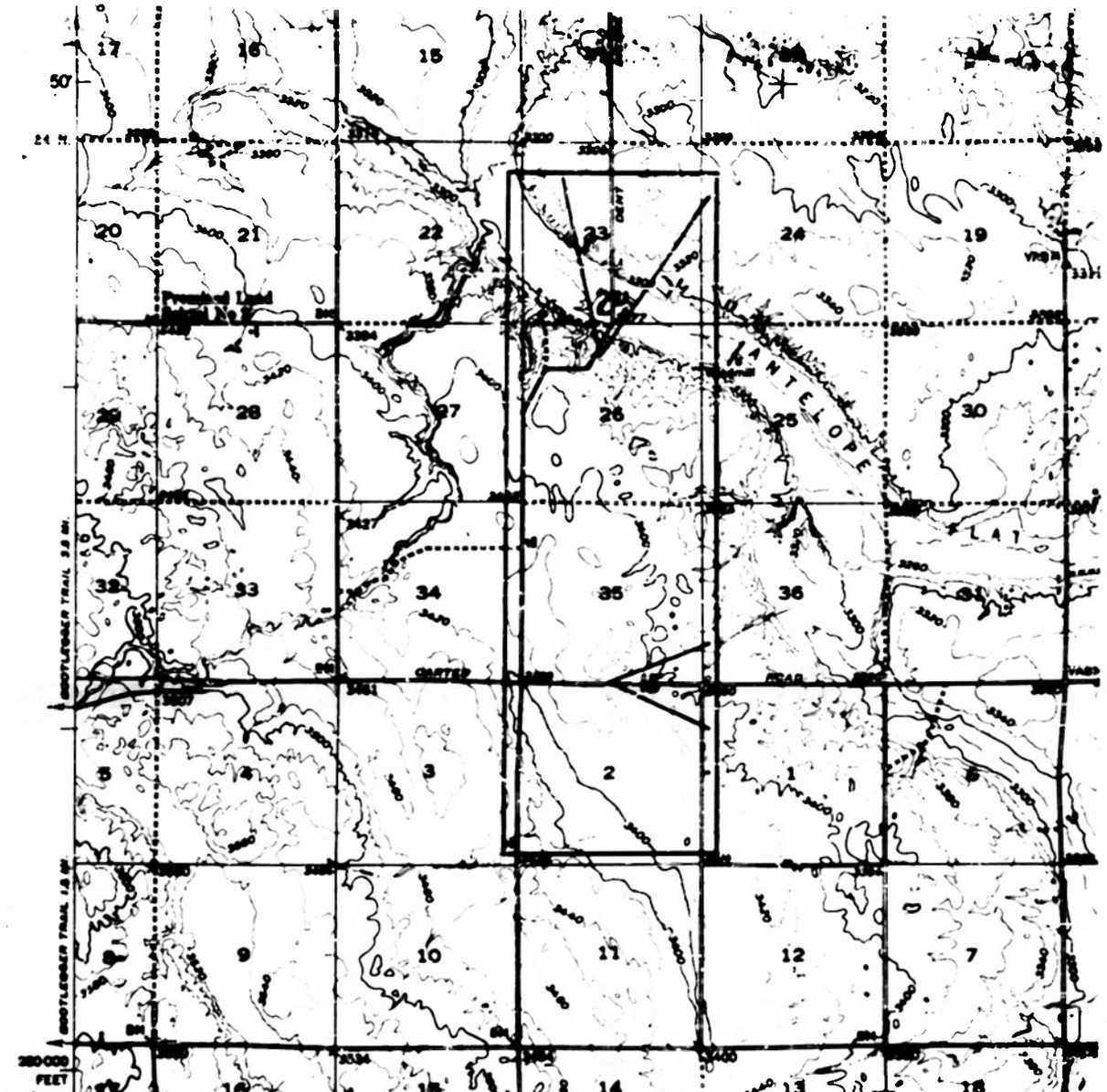



Figure 3. Area chiefly in Sections 23, 26, and 35, T. 24 N., R. 4 E., and Section 12, T. 23 N., R. 4 E., Dent Bridge quadrangle, Montana. Covered by stereogram, Airphotos 2-A and 2-B.

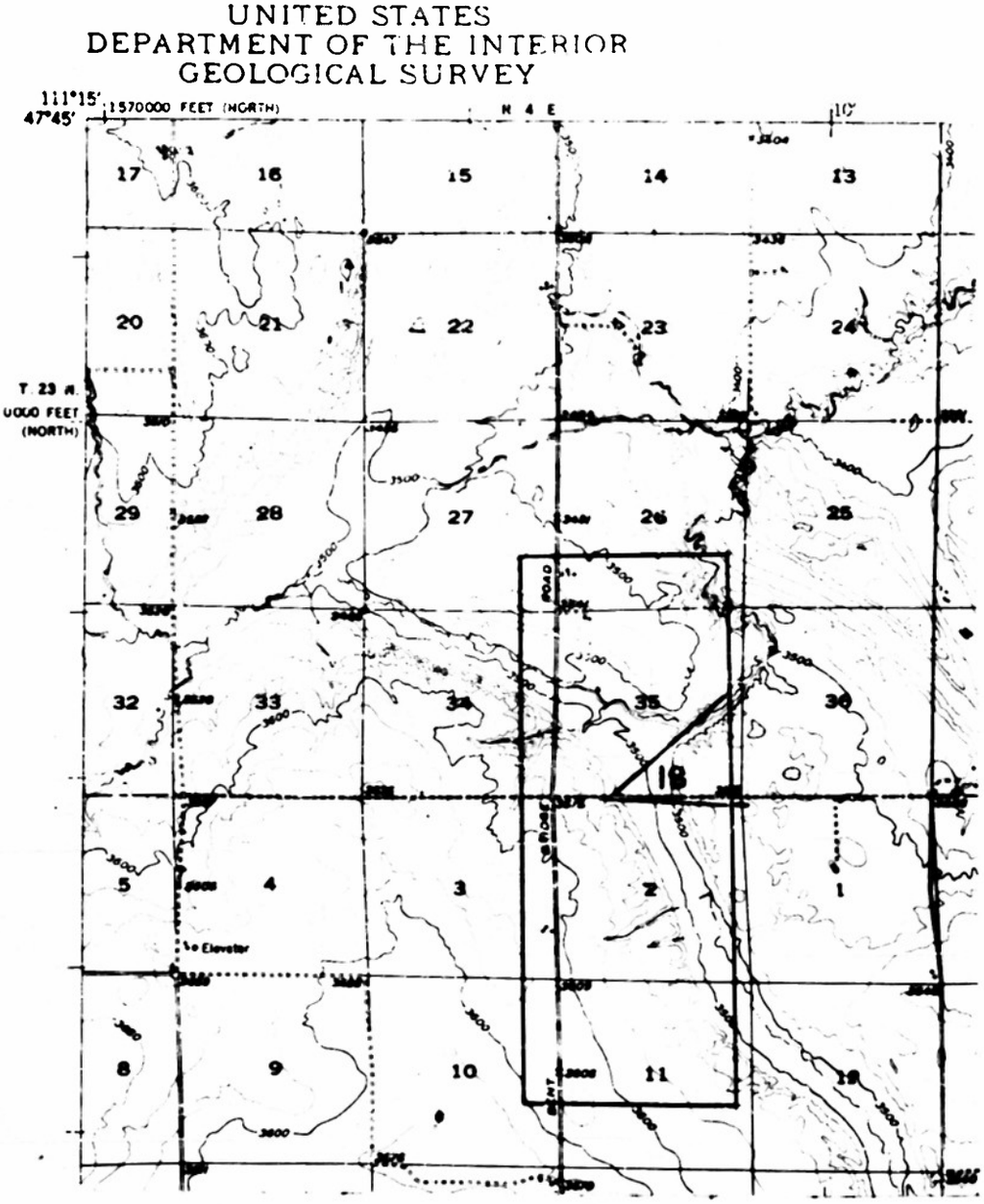



Figure 4. Area chiefly in Section 35, T. 23 N., R. 4 E., and Sections 2 and 11, T. 22 N., R 4 E., Portage quadrangle, Montana. Covered by stereogram, Airphotos 3-A and 3-B.

Figure 5-A, B, C, D, E. Five areas in Portage quadrangle, Montana.

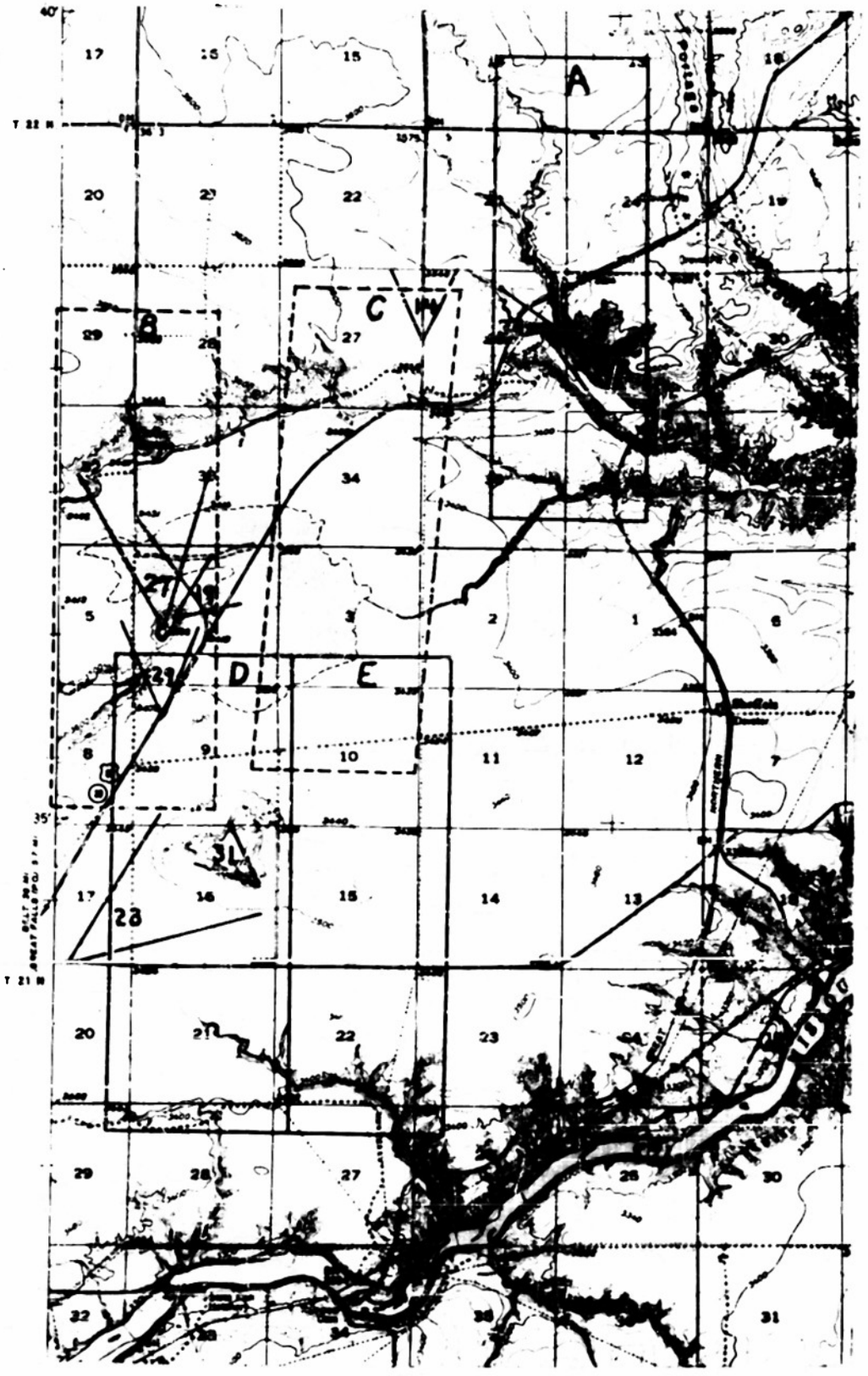
A, area in Sections 13, 14, 25, 26, 35, and 36, T. 22 N., R. 4E. Covered by stereogram, Airphotos 4-A and 4-B.

B, area in Sections 28, 29, 32, and 33, T. 22 N., R. 4 E., and Sections 4, 5, 8, and 9, T. 21 N., R. 4E. Covered by stereogram, Airphotos 5-A and 5-B.

C, area chiefly in Sections 27 and 34, T. 22 N., R. 4 E., and Sections 3 and 10, T. 21 N., R. 4 E. Covered by stereogram, Airphotos 6-A and 6-B.

D, area chiefly in Sections 9, 16, and 21, T. 21 N., R. 4 E. Covered by stereogram, Airphotos 7-A and 7-B.

E, area chiefly in Sections 10, 15, and 22, T. 21 N., R. 4 E. Covered by stereogram, Airphotos 8-A and 8-B.




Figures 5-A, B, C, D, E. (See opposite page)

Figure 6. Area in Sections 29, 30, 31, and 32, T. 23 N., R. 2 W., and Sections 5, 6, 7, and 8, T. 22 N., R. 2 W., Fairfield quadrangle, Montana. Covered by stereogram, Airphotos 9-A and 9-B.

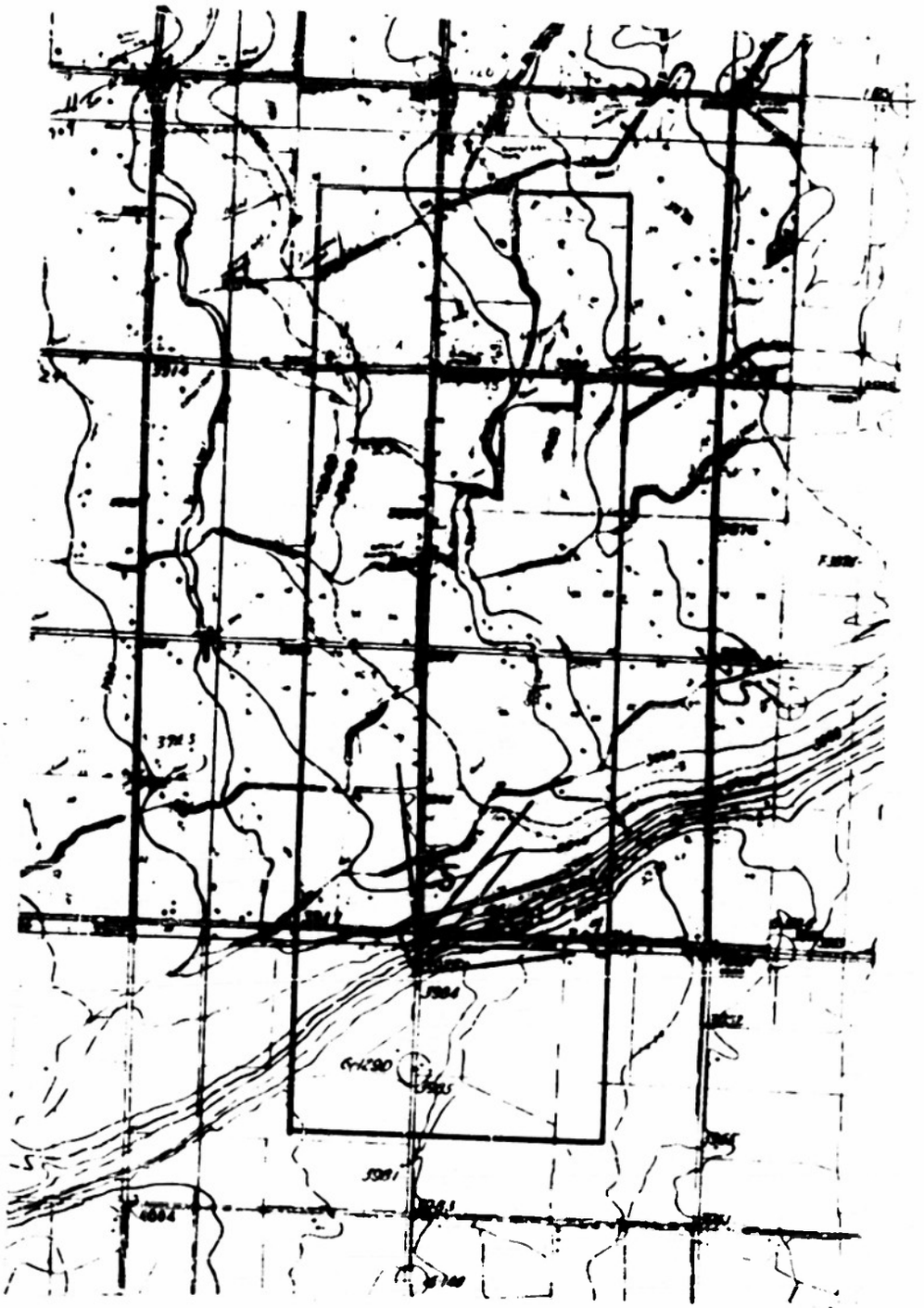


Figure 7. Area in Sections 17, 18, 19, 20, 29, 30, 31, and 32, T. 22 N., R. 2 W., Fairfield quadrangle, Montana. Covered by stereogram, Airphotos 10-A and 10-B.

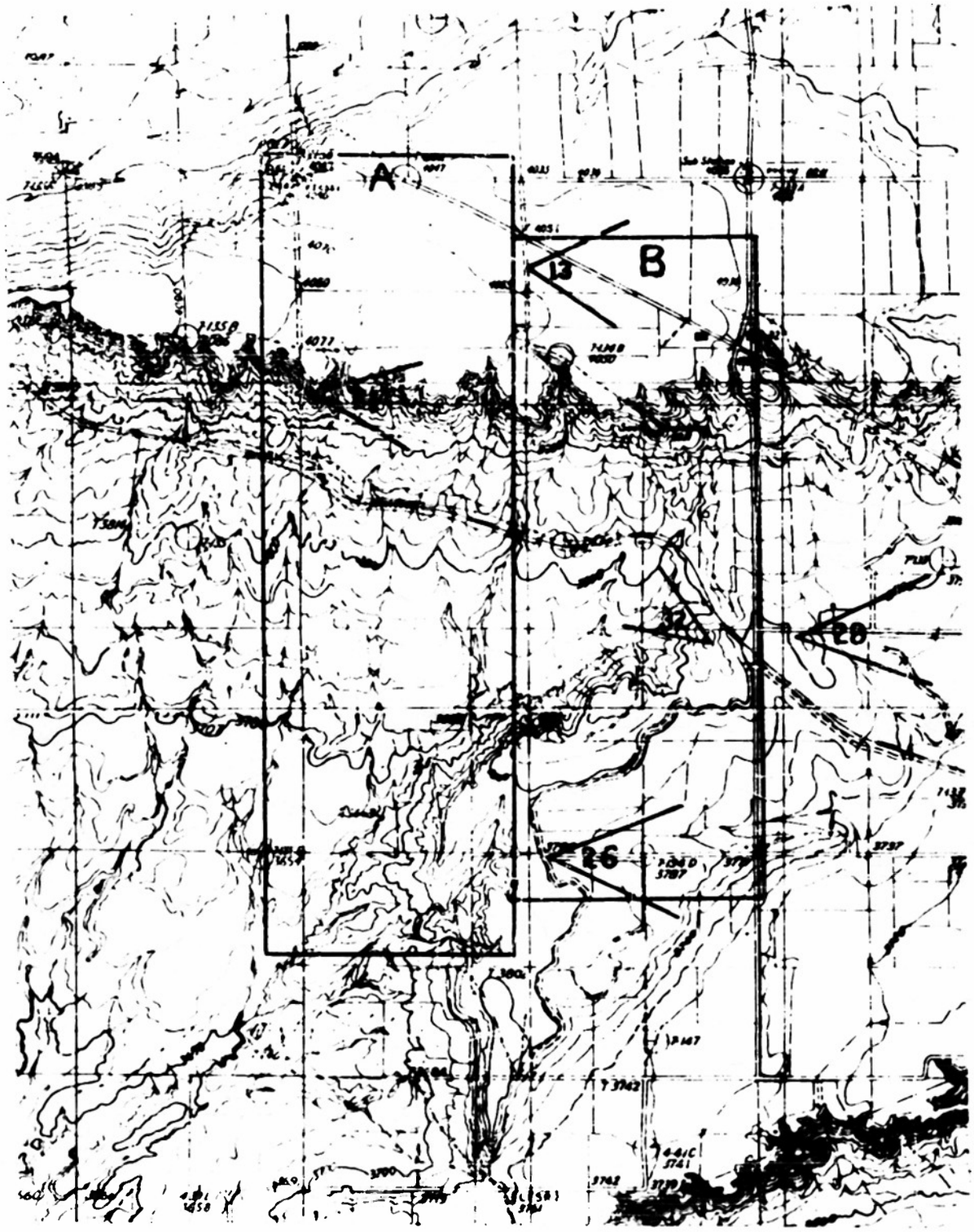
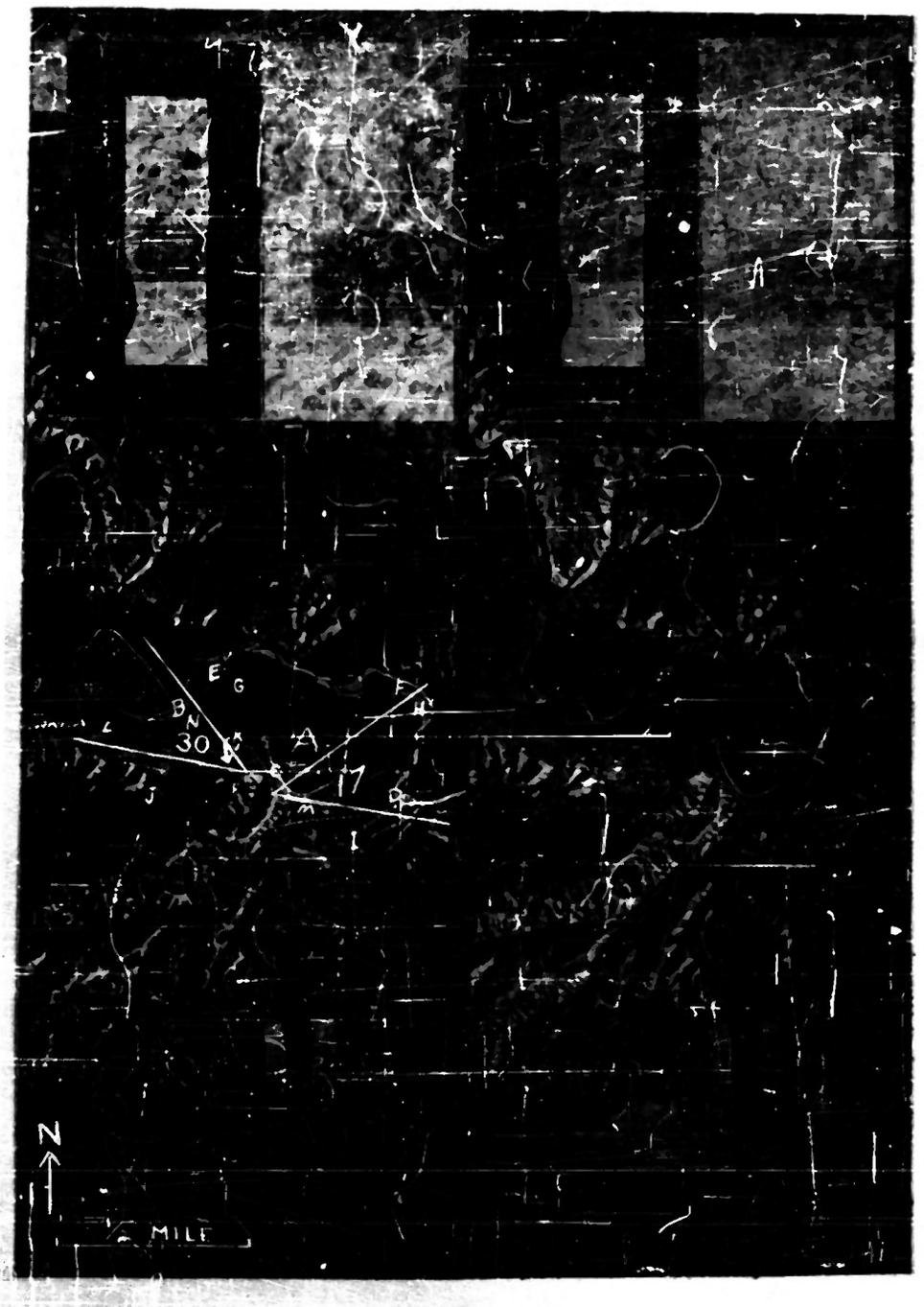


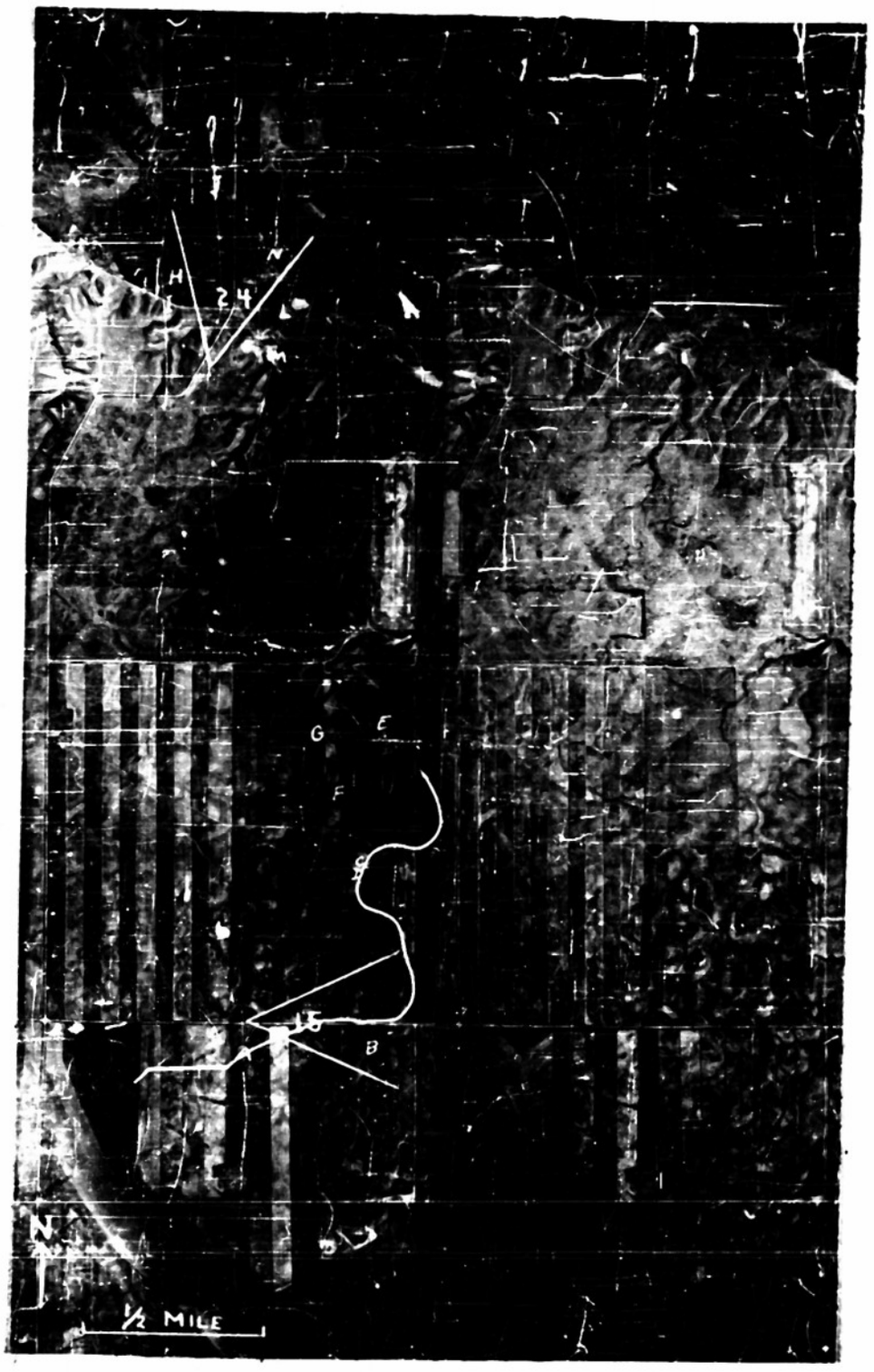

Figure 8-A, B. Two areas in Fairfield quadrangle, Montana.

A, area chiefly in Sections 9, 16, 21, and 28, T. 21 N., R. 2 W. Covered by stereogram, Airphotos 11-A and 11-B.

B, area chiefly in Sections 10, 15, 22, and 27, T. 21 N., R. 2 W. Covered by stereogram, Airphotos 12-A and 12-B.

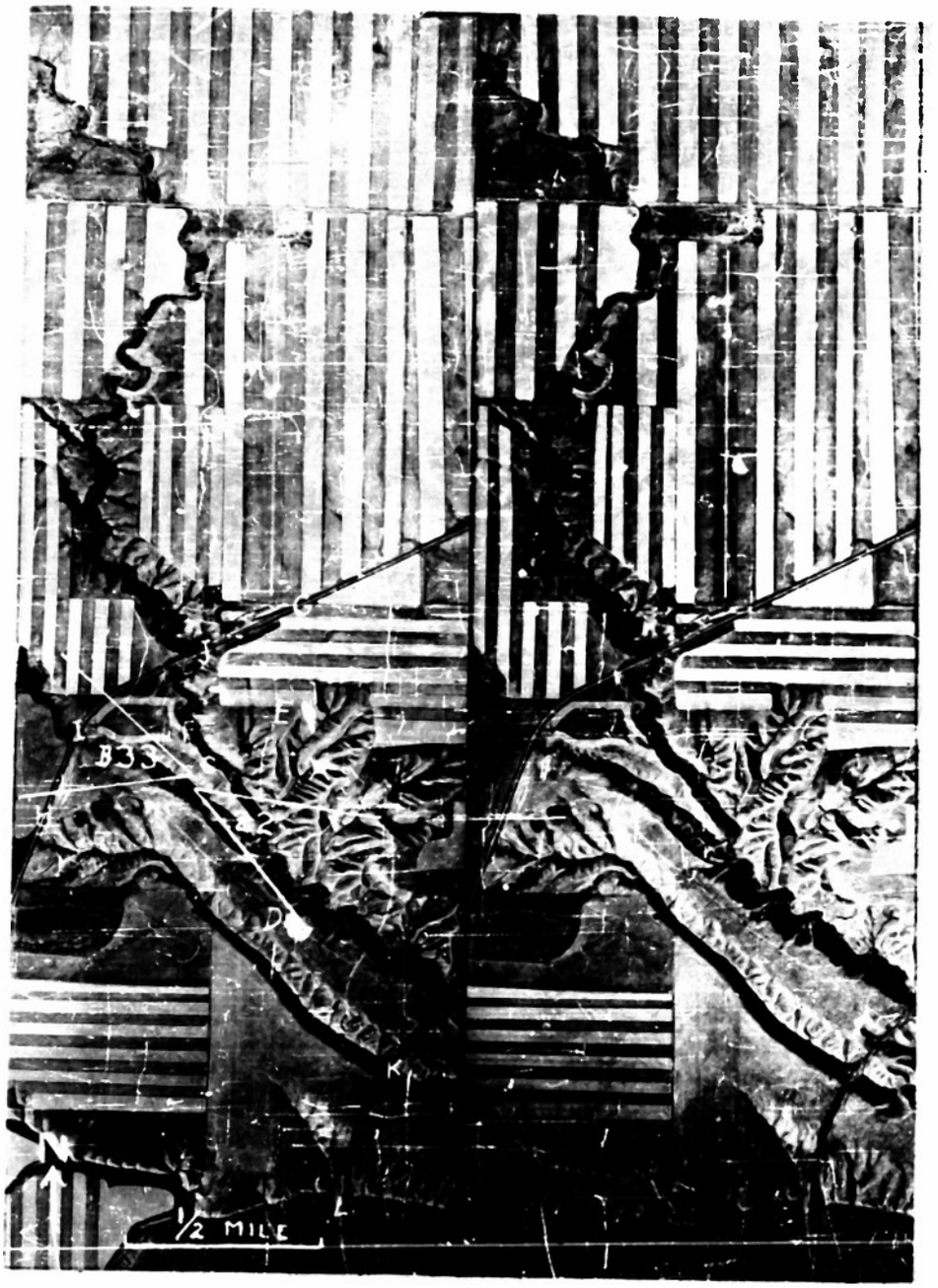



Airphotos 1-A and 1-B. Stereogram of area chiefly in Sections 20, 29, and 32, T. 25 N., R. 5 E., Dent Bridge quadrangle, Montana. (See map, Figure 2)

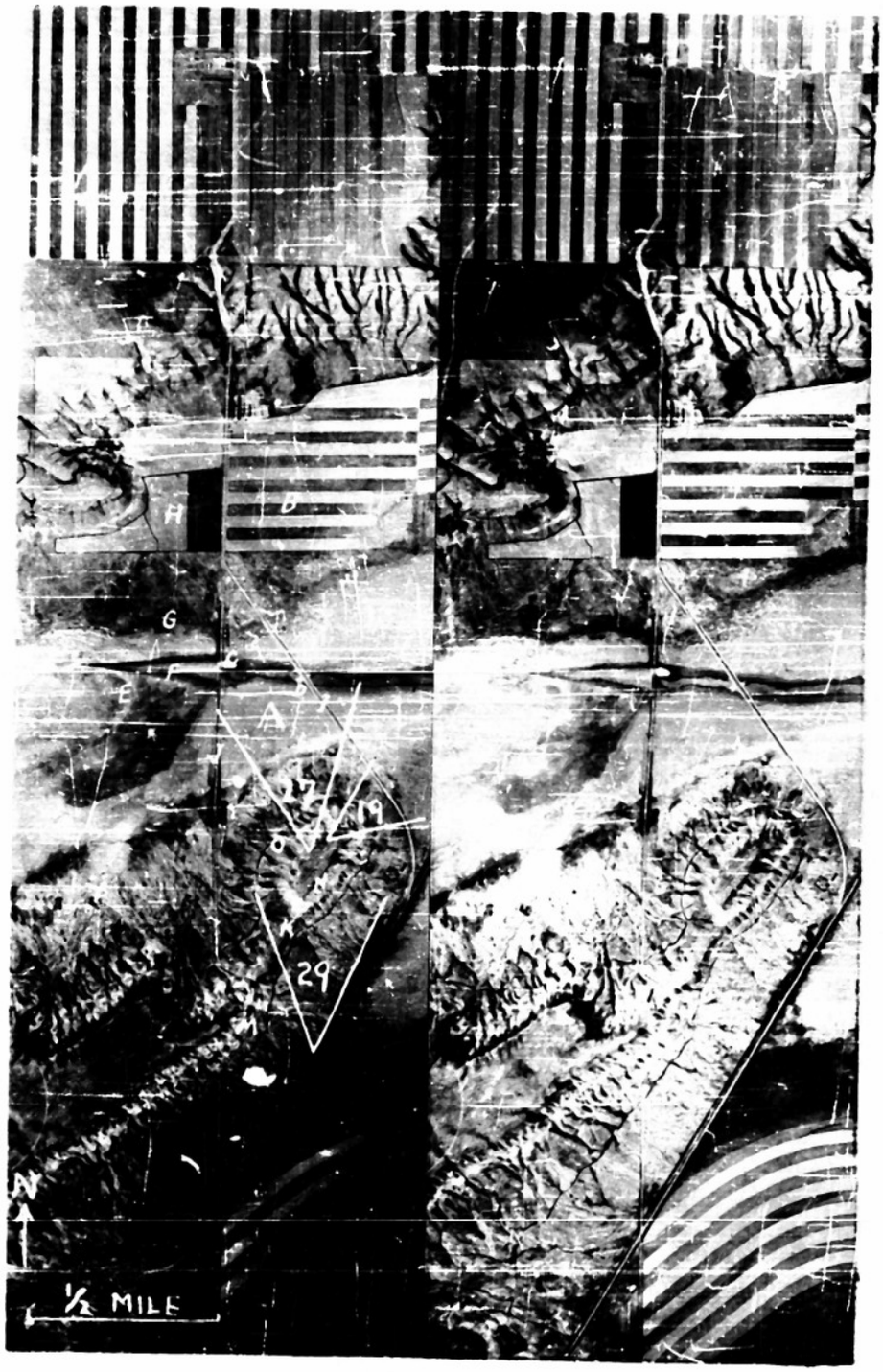



Airphotos 2-A and 2-B. Stereogram of area chiefly in Sections 23, 26, and 35, T. 24 N., R. 4 E., and Section 12, T. 23 N., R. 4 E., Dent Bridge quadrangle, Montana. (See map, Figure 3)


Airphotos 3-A and 3-B. Stereogram of area chiefly in Section 35, T. 23 N., R. 4 E., and Sections 2 and 11, T. 22 N., R. 4 E., Portage quadrangle, Montana. (See map, Figure 4)

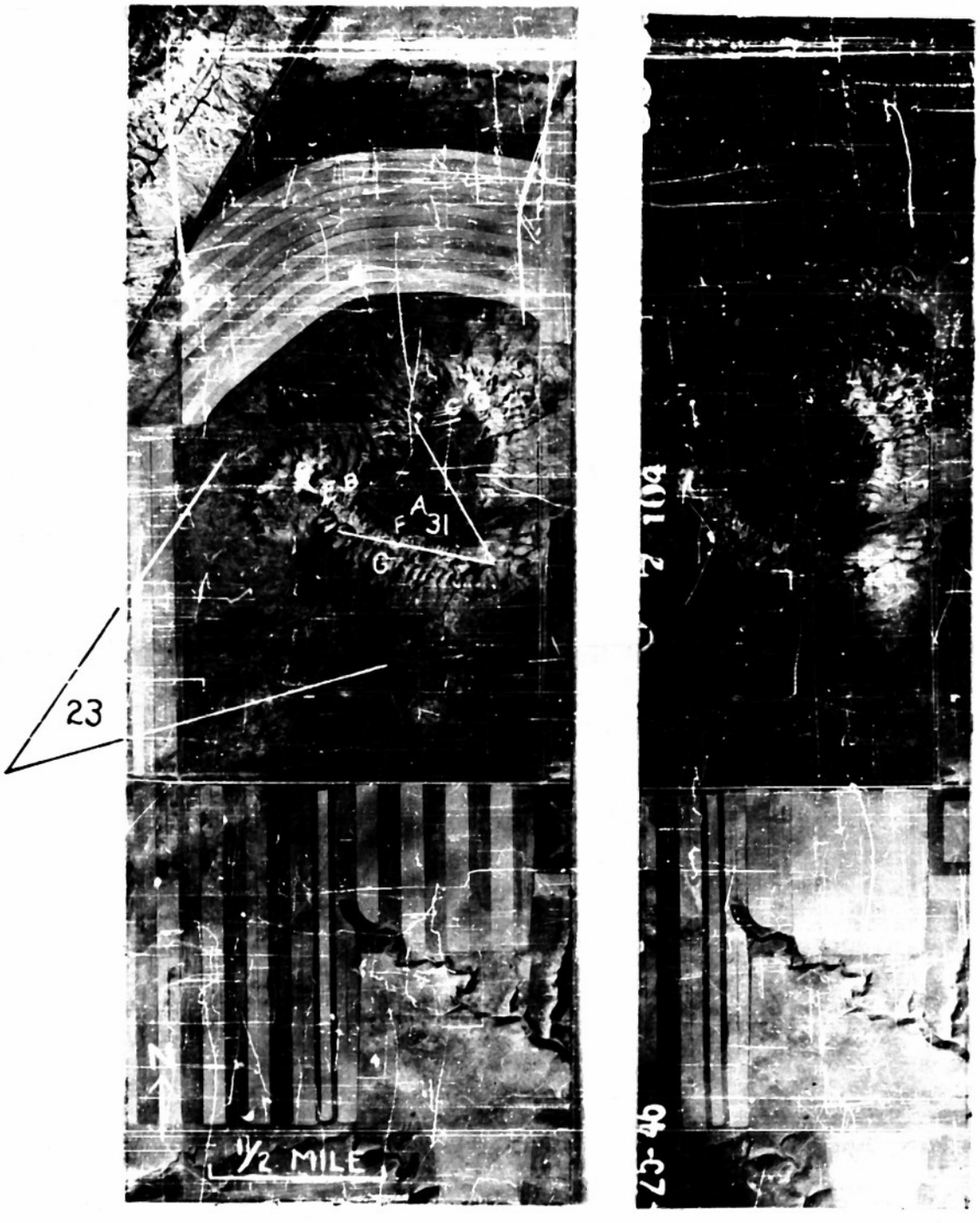



Airphotos 4-A and 4-B. Stereogram of area in Sections 13, 14, 25, 26, 35 and 36, T. 22 N., R. 4 E., Portage quadrangle, Montana. (See map, Figure 5-A)




Airphotos 5-A and 5-B. Stereogram of area in Sections 28, 29, 32 and 33, T. 22 N., R. 4 E., and Sections 4, 5, 8, and 9, T. 21 N., R. 4 E., Portage quadrangle, Montana. (See map, Figure 5-B)

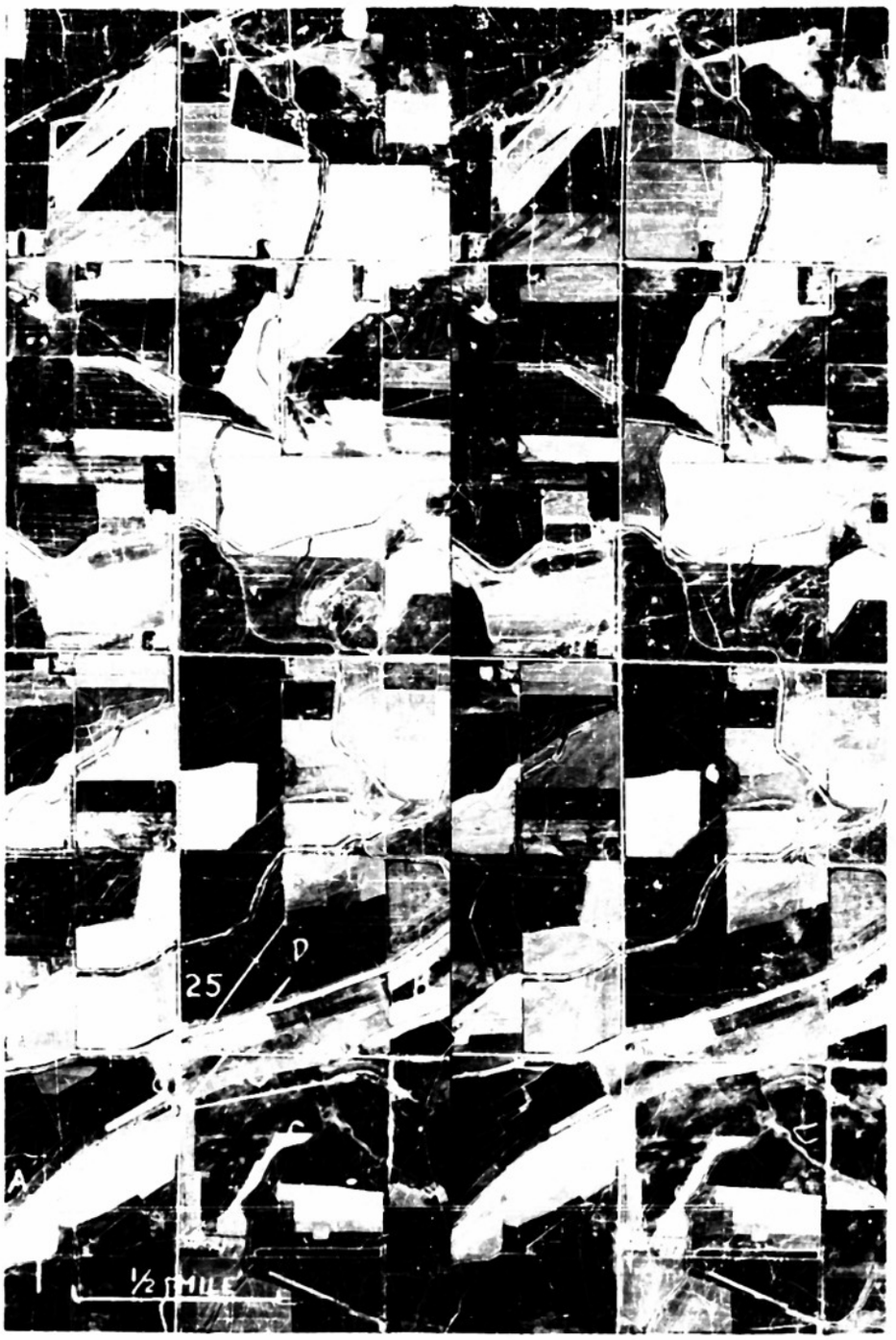

Airphotos 6-A and 6-B. Stereogram of area chiefly in Sections 27 and 34, T. 22 N., R. 4 E., and Sections 3 and 10, T. 21 N., R. 4 E., Portage quadrangle, Montana. (See map, Figure 5-C)




Airphotos 7-A and 7-B. Stereogram of area chiefly in Sections 9, 16, and 21, T. 21 N., R. 4 E., Portage quadrangle, Montana. (See map, Figure 5-D)


Airphotos 8-A and 8-B. Stereogram of area chiefly in Sections 10, 15, and 22, T. 21 N., R. 4 E., Portage quadrangle, Montana. (See map, Figure 5-E)

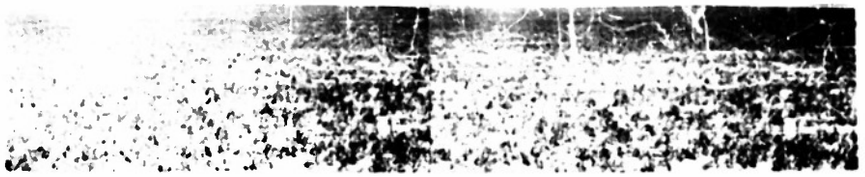
Airphotos 9-[illegible] 9-[illegible]. Stereogram of area in Sections 29, 30, 31 [illegible], T. [illegible] N., R. 2 W., and Sections 5, 6, 7, and 8, T. [illegible] N., R. 2 W., Fairfield quadrangle, Montana. (See map, Figure 6)




Airphotos 10-A and 10-B. Stereogram of area in Sections 17, 18, 19, 20, 29, 30, 31, and 32, T. 22 N., R. 2 W., Fairfield quadrangle, Montana. (See map, Figure 7)

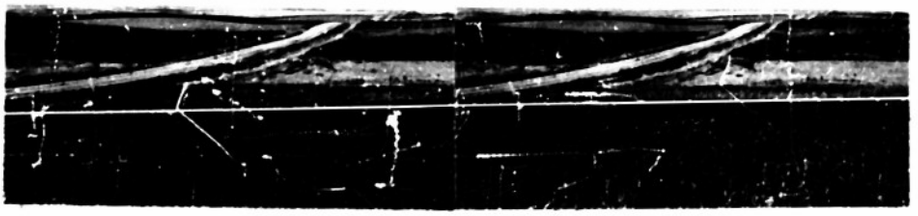

Airphotos 11-A and 11-B. Stereogram of area chiefly in Sections 9, 16, 21, and 28, T. 21 N., R. 2 W., Fairfield quadrangle, Montana. (See map, Figure 8 A)

Airphotos 12-A and 12-B. Stereogram of area chiefly in Sections 10, 15, 22, and 27, T. 21 N., R. 2 W., Fairfield quadrangle, Montana. (See map, Figure 8-B)

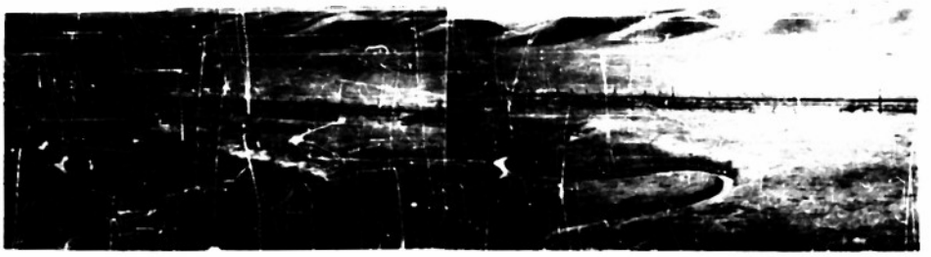


Ground Photos 13-A and 13-B. Stereopair of view to east on high plain or bench, from center west line S. W. 1/4, N. W. 1/4, Section 10, T. 21 N., R. 2 W. (See map, Figure 8-B, and Airphotos 12-A and 12-B)

Ground Photos 14-A and 14-B. Stereopair of view of flat till plain on older drift, looking north along road in N. W. 1/4 Section 26, T. 22 N., R. 4 E. (See map, Figure 5-C, and Airphotos 6-A and 6-B)

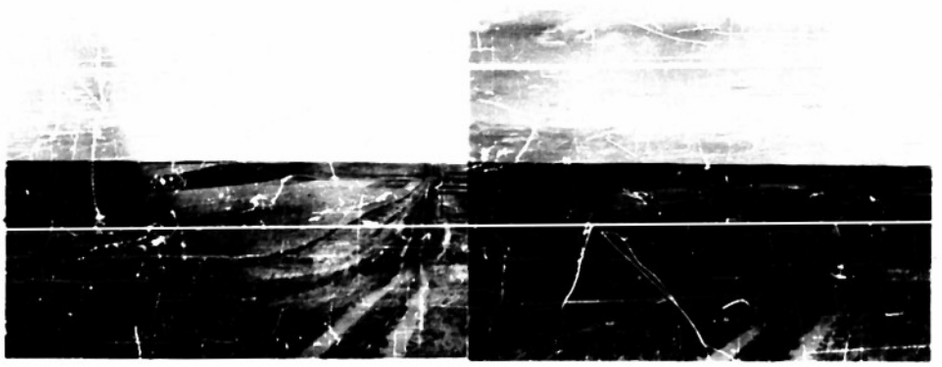


Ground Photos 15-A and 15-B. Stereopair of view of rolling till plain, looking east in N. E. 1/4 Section 2, T. 23 N., R. 4 E. (See map, Figure 3, and Airphotos 2-A and 2-B)



Ground Photos 16-A and 16-B. Stereopair of view to northwest to flat stream valley with meandering stream, and dissected margin of high bench in distance, from northwest corner of Section 6, T. 22 N., R. 2 W. (See map, Figure 6, and Airphotos 9-A and 9-B)

Ground Photos 17-A and 17-B. Stereopair of view of flood plain and a second bottom or terrace of Teton River, from top of spur in south part of Section 29, T. 25 N., R. 5 W. (See map, Figure 2, and Airphotos 1-A and 1-B)

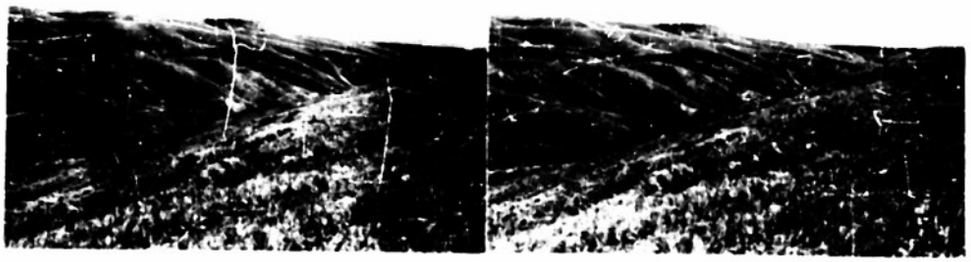


Ground Photos 18-A and 18-B. Stereopair of view of Portage Coulee, a valley plain or glacial channel, looking east in S. W. 1/4 Section 35, T. 23 N., R. 4 E. (See map, Figure 4, and Airphotos 3-A and 3-B)

Ground Photos 19-A and 19-B. Stereogram of view to northeast across lake plain, from butte in W. 1/2 Section 4, T. 21 N., R. 4 E. (See map, Figure 5-B, and Airphotos 5-A and 5-B)

Ground Photos 20-A and 20-B. Stereogram of view of smooth scarp separating lower plain or bench on left, from higher, on right, looking northeastward from N. E. corner Section 31, T. 22 N., R. 2 W. (See map, Figure 7, and Airphotos 10-A and 10-B)

Ground Photos 21-A and 21-B. Stereopair of view of scarp of high plain and gently rolling dissected area below, looking east from S. W. corner of Section 9, T. 21 N., R. 2 W. (See map, Figure 3-A, and Airphotos 11-A and 11-B)



Ground Photos 22-A and 22-B. Stereopair of north-facing slope area of Blackfeet Gulch and its tributary valleys, looking southeastward from point near center N. 1/2 Section 26, T. 22 N., R. 4 E. (See map, Figure 5-A, and Airphotos 4-A and 4-B)

Ground Photos 23-A and 23-B. Stereopair of view of Black Butte, in Section 16, T. 21 N., R. 4 E., looking to northeast from road in S. E. 1/4 Section 17. (See map, Figure 5-A, and Airphotos 7-A and 7-B)

Ground Photos 24-A and 24-B. Stereopair of view of Antelope Flat, a valley plain looking to north in W. W. 1/4 Section 26, T. 24 N., R. 4 E. (See map, Figure 3, and Airphotos 2-A and 2-B)

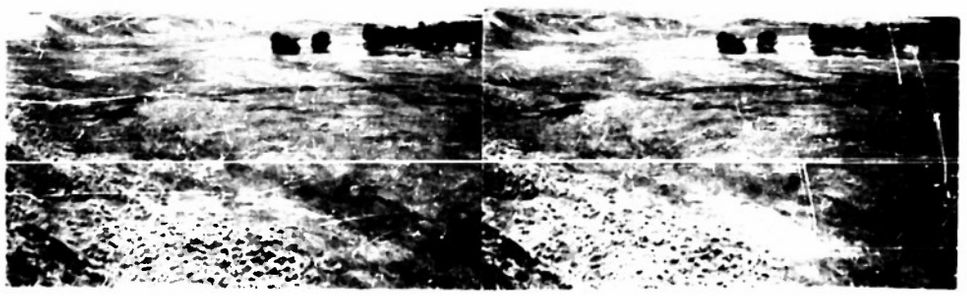
Ground Photos 25-A and 25-B. Stereopair of view to northeast from N. E. corner Section 31, T. 22 N., R. 2 W., showing smooth scarp marking descent to lower plain or bench. Note farmstead, irrigation ditches, and wheat fields. (See map, Figure 7, and Airphotos 10-A and 10-B)

Ground Photos 26-A and 26-B. Stereopair of view to east near S. W. corner Section 22, T. 21 N., R. 2 W., showing intermediate bench or plain, wheat field with shallow irrigation trenches, and deep irrigation ditch along road which is on ridge. (See map, Figure 8-B, and Airphotos 12-A and 12-B)

Ground Photos 27-A and 27-B. Stereopair of view to north from top of butte in W. 1/2 Section 4, T. 21 N., R. 4 E., showing basin plain with water in center, strip cropping, ditches, and scarp of high bench or plain in distance. (See map, Figure 5-B, and Airphotos 5-A and 5-B)

Ground Photos 28-A and 28-B. Stereopair of view to east from knoll at N. W. corner Section 23, T. 21 N., R. 2 W., showing irrigation ditches on an intermediate plain or bench. (See map, Figure 8-B. Same ditch 1/2 mile west shows in Airphotos 12-A and 12-B)

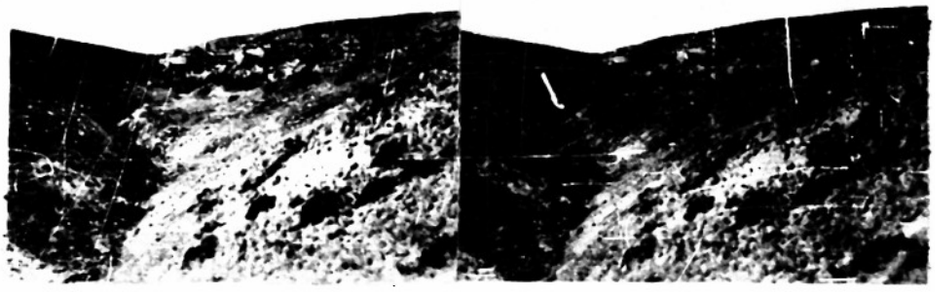
Ground Photos 29-A and 29-B. Stereopair of view of butte in Section 4, T. 21 N., R. 4 W., from road on south, showing outcropping clay, shale, and sandstone strata and sparse vegetation. (See map, Figure 5-B, and Airphotos 5-A and 5-B)



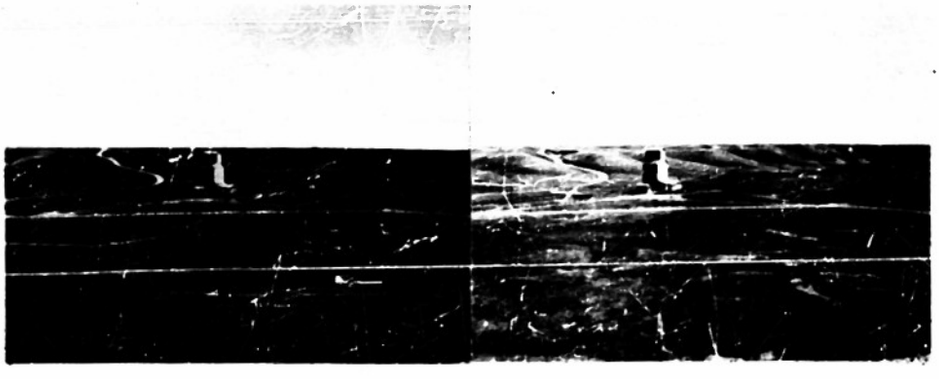
Ground Photos 30-A and 30-B. Stereopair of view to northwest from spur in center south line Section 29, T. 22 N., R. 5 W., showing old floodplain of Tater River with [illegible] meander with dark grass in contrast to bare soil, sage, and short grass on higher parts of floodplain. (See map, Figure 2, and Airphotos 1-A and 1-B)

Ground Photos 31-A and 31-B. Stereopair of view of south slope of Black Butte in Section 16, T. 21 N., R. 4 E., showing bare clay or shale surface strewn with rock fragments. Maximum slope 25°. (See map, Figure 5-D, and Airphotos 7-A and 7-B)

Ground Photo 32. Stony soil in N. E. 1/4 Section 22, T. 21 N., R. 2 W. Stones are coated with white incrustation or "caliche. (See map, Figure 8-B, and Airphotos 12-A and 12-B)



Ground Photos 33-A and 33-B. Stereopair of view to northwest to head of Blackfeet Gulch in Section 26, T. 22 N., R. 4 E., showing vertical rock cliffs. Old road on causeway descended into canyon from right. (See map, Figure 5-A, and Airphotos 4-A and 4-B)



Ground Photos 34-A and 34-B. Stereopair of view of grain elevator at railroad station of Cleve, in N. W. 1/4 Section 5, T. 22 N., R. 2 W., showing floodplain with dissected escarpment beyond. (See map, Figure 6, and Airphotos 9-A and 9-B)