GEOMORPHOLOGY LABORATORY MANUAL

With Report Forms

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PREFACE

Why a geomorphology laboratory manual? For the simple reason that I believe one is needed. Although many geomorphologists exchange ideas informally, it is time for someone to put into print some of the basic geomorphic techniques and methods of analysis.

All the exercises included here are developed from those used in various classes as I have taught geomorphology. The most difficult problem was in selecting which of the many were "typical" problems. What I have finally included are exercises planned to introduce the student to a variety of experiences and techniques and to show him (or her) some practical aspects of the discipline. In many of the labs I have used a problem approach as I believe students are interested in solving problems. Many exercises are, or can be, oriented towards the environment.

Since an understanding of maps and an interpretation of air photographs are fundamental to geomorphologists, these tools are used extensively. The first two exercises are concerned with these and may be omitted if the students are already capable of reading maps and air photos. A variety of other types of maps is also introduced, including geologic, soil and hydrographic maps.

In solving many of the problems, the student will become acquainted with some quantitative approaches and statistical techniques, necessary for modern geomorphic research. I have tried to explain clearly, with a step-by-step routine, how to cope with statistical and mathematical manipulations. It is most important that the student grasp not only the technique but also the reasons for the use of this particular approach and the broader understanding its use brings.

There are more exercises than there are weeks in a semester or quarter, since it is expected that the instructor will choose from among the labs presented. I sincerely hope that this manual will be useful as it is or that it will supply the germ of an idea which can be adapted to some particular situation or locale.

Although I have tried to make the coverage as broad as possible, I realize that I may have omitted a favorite topic or technique. Again, this is where the individual instructor can use his favorite exercise. I would like to emphasize that no students can be taken out in the field too often.

My sincere appreciation to Art Bloom, George Crowl, Ed Roy, Jr., and Stan Schumm for their earnest efforts to steer me on the right path. Their advice and comments on the draft were invaluable. If I have strayed, it is not their fault. Kathleen Bennett helped with the typing of the final manuscript and Olga Kurty did some of the drawings.

And finally, my thanks to all my students through the years who suffered as I tried new, and amended old, exercises. Their response and enthusiasm have made teaching worthwhile and it is to them that I dedicate this manual.

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CONTENTS

FIGURES

FIGURES (Continued)

FIGURES (Continued)

QUADRANGLES

QUADRANGLES (Continued)

TABLES

1 AIR PHOTOGRAPHS AND TOPOGRAPHIC MAPS, A REVIEW

Maps, as representations of the earth's surface, are the best way of studying a region that we cannot visit, or of studying beforehand a place we are going to visit. Therefore, a knowledge of maps and map reading is indispensible to a geomorphologist. In order to understand or read a map, you must first learn the conventional form in which it is presented. Many of these are obvious and they are usually explained on the map itself by a legend. Most important is the scale, which is the ratio between distance on the map and distance on the surface of the earth. The most common scales of maps made by the U.S. Geological Survey are printed to the scale of 1:62500 which is approximately one mile to the inch (or 26 km to the inch) or the scale of 1:24000 which is approximately 0.38 miles to an inch (or 0.6 km to an inch).

Topographic maps are a special kind of map which adds a third dimension, depicting relief by means of contour lines. A contour is a line traced on a map, connecting all points on the ground which have the same elevation above sea level.

Although much can be learned about a region from contour maps, there are limits to what they can tell us. The use of air photographs adds efficiency to both geologic work and the interpretation of landforms. Indeed, air photographs are the next best thing to being there.

Vertical air photographs are taken so that they overlap each other to provide stereovision. Stereovision results when each eye views an object from a slightly different position and the two images are fused. The overlap of the two photographs allows two images to be seen, one with each eye. Most users need to view air photographs through special stereoscopes. Perhaps after you become experienced you can develop the ability to "see" air photographs without the stereoscope.

OBJECTIVE

You have probably seen and used contour maps in a basic geology or physical geography class or perhaps as a fisherman or hiker. The purpose of this first exercise is to review some principles of topographic map reading. We will examine some topographic quadrangles to recall how contours give us an idea as to the shape and character of the topography of a region. In addition we will review methods of profiling and obtaining stream gradient from a contour sheet since these are handy tools which a geomorphologist uses quite often.

Another objective of this exercise is to familiarize you with techniques of air photograph viewing and interpretation (or to review them). Ability to read and use air photographs comes only with experience.

PROCEDURE

1. Read the explanatory text circular (or some other assigned reading). This circular is distributed by the U.S. Geological Survey which publishes the topographic quadrangle maps.

2. Your instructor will provide local topographic quadrangles and questions to be answered on it. You should become thoroughly familiar with the geomorphology of your local area, both as represented on maps and also in the field.

3. Study the air photographs and topographic maps provided and answer the question sheets for each.

Before you do any of this, finish reading the explanations which follow.

Township and Range

In the north central and western parts of the United States, the country has been surveyed according to a standard system, and the boundaries of these divisions, shown on topographic maps, form a convenient grid for locating any given point. Figure 1.1 shows the arrangement and numbering of *townships* and *ranges,* measured from a *principal meridian* and a *base line.* Each township is 6 miles square, and its position is designated by a township number *north* or *south* of the base line, and its number in a *range, east* or *west* of the principal meridian established for that part of the survey. On a topographic map, townships and ranges are numbered on the margins of the quadrangle. The shaded area in Figure 1.1 is township 2 North, Range 3 West (usually abbreviated T.2 N., R.3 W.). Each township is further subdivided into 36 *sections,* each one mile square, numbered as shown. In flat country, the roads are commonly laid out along section lines. Each section in turn is broken into quarters (see insert).

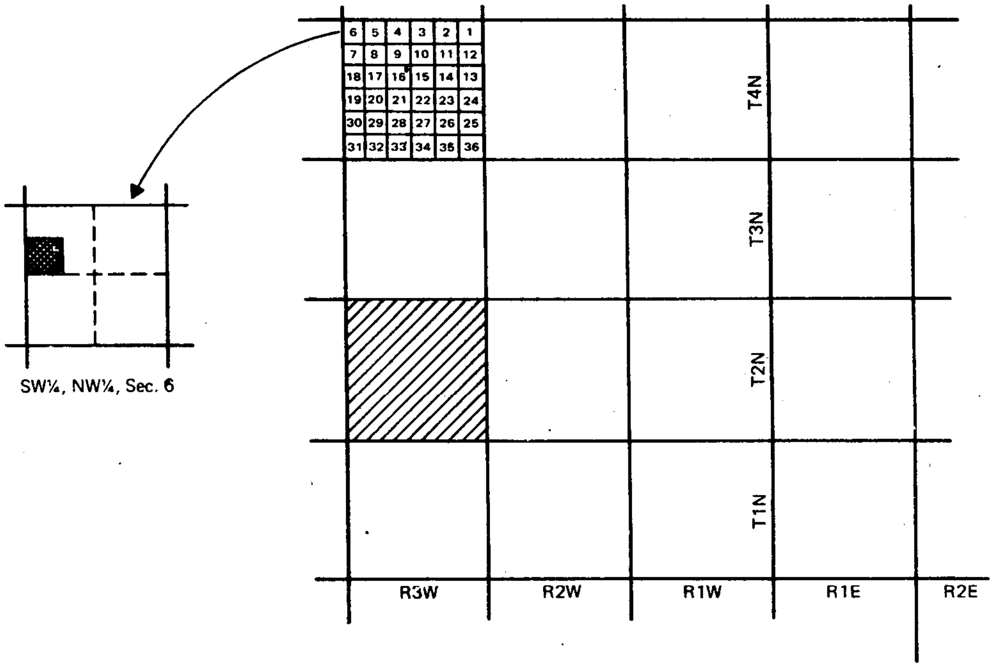


Figure 1.1. Arrangement and numbering of township and range on topographic maps.

Profiles

A profile is an expression of the slope along a certain line. It shows how the edge of a landform appears in silhouette looked at from the side. A profile to scale is an accurate picture of the landform along the given line.

In drawing profiles from a contour map, the scale of the map is commonly used as the horizontal scale. If, however, relief is small, the vertical scale may need to be exaggerated in order to emphasize the surface features. In a region of great relief, no exaggeration may be needed. So total relief should determine the vertical scale.

The vertical exaggeration is easily calculated:

$$\text{Exaggeration} = \frac{\text{horizontal scale}}{\text{vertical scale}}$$

To draw an accurate profile to scale, follow these steps:

(1) Mark off the vertical scale on a strip of graph paper.

(2) Place the graph paper along the line through which you are to draw the profile.

(3) From the point where the contour lines cross the line of section, drop perpendiculars to the appropriate elevations, as measured by the vertical scale.

(4) Connect the points with a continuous line representing the land surface.

This procedure is illustrated in Fig. 1.2.

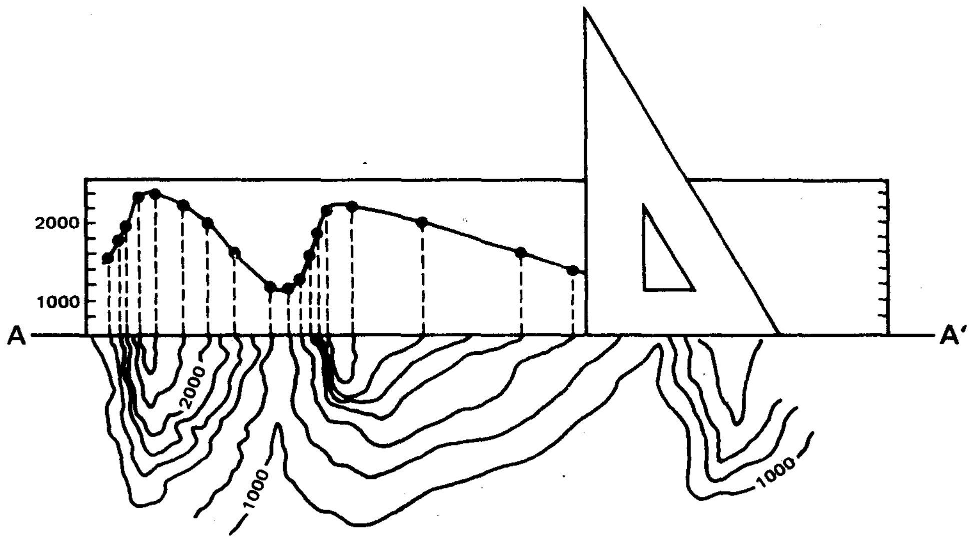


Figure 1.2. Drawing a profile to scale.

Stream Gradient

All streams flow downhill in their valleys. This is obvious, yet many students forget it. Recall that contour lines bend upstream, and the closer together the contours, the steeper is the slope. The slope of the stream is called its gradient. We can determine this from the map by taking the altitude at some point on a stream where a contour crosses it near the head. Then move downstream to the mouth and read the elevation where a contour crosses again. Subtracting these two elevation readings gives us the fall of the river. Next determine the distance between the two contours by measuring along the stream. Be sure to measure all the bends to get the complete length. This can be done by using a piece of string or marking the edge of a paper as the stream turns. The mechanical minded may use a map measurer. The fall in meters per kilometer (or feet per mile) is the gradient.

Drainage Development

When a land surface is uplifted and exposed to erosion, streams will be guided by and flow down the initial surface slope. Hence a series of consequent streams will form, presenting a parallel drainage pattern. Tributary streams will erode headward developing the drainage basin. If the underlying rock is homogeneous or flat-lying sediments, a dendritic or tree-like pattern will be formed. In general, the topography, as well as the drainage pattern, will be randomly directed with no pronounced orientation.

Horizontal strata often occur with alternating layers of different resistance to erosion. The harder layers will, thus, form cliffs and the softer layers are eroded into gentler slopes. This presents a type of topography with alternating cliffs and terraces (benches) called "cliff and slope" topography. In humid regions cliff and slope topography is often covered by mass movement over the slope but in arid regions cliff and slope topography is quite striking.

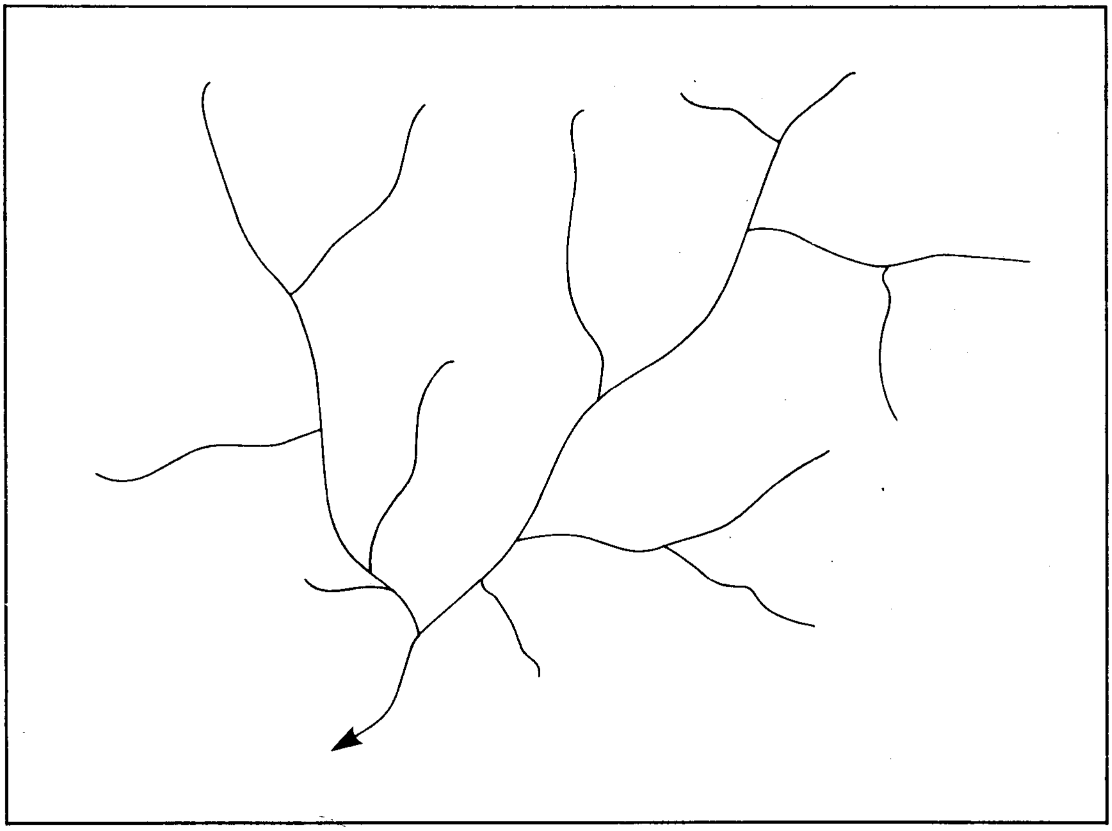
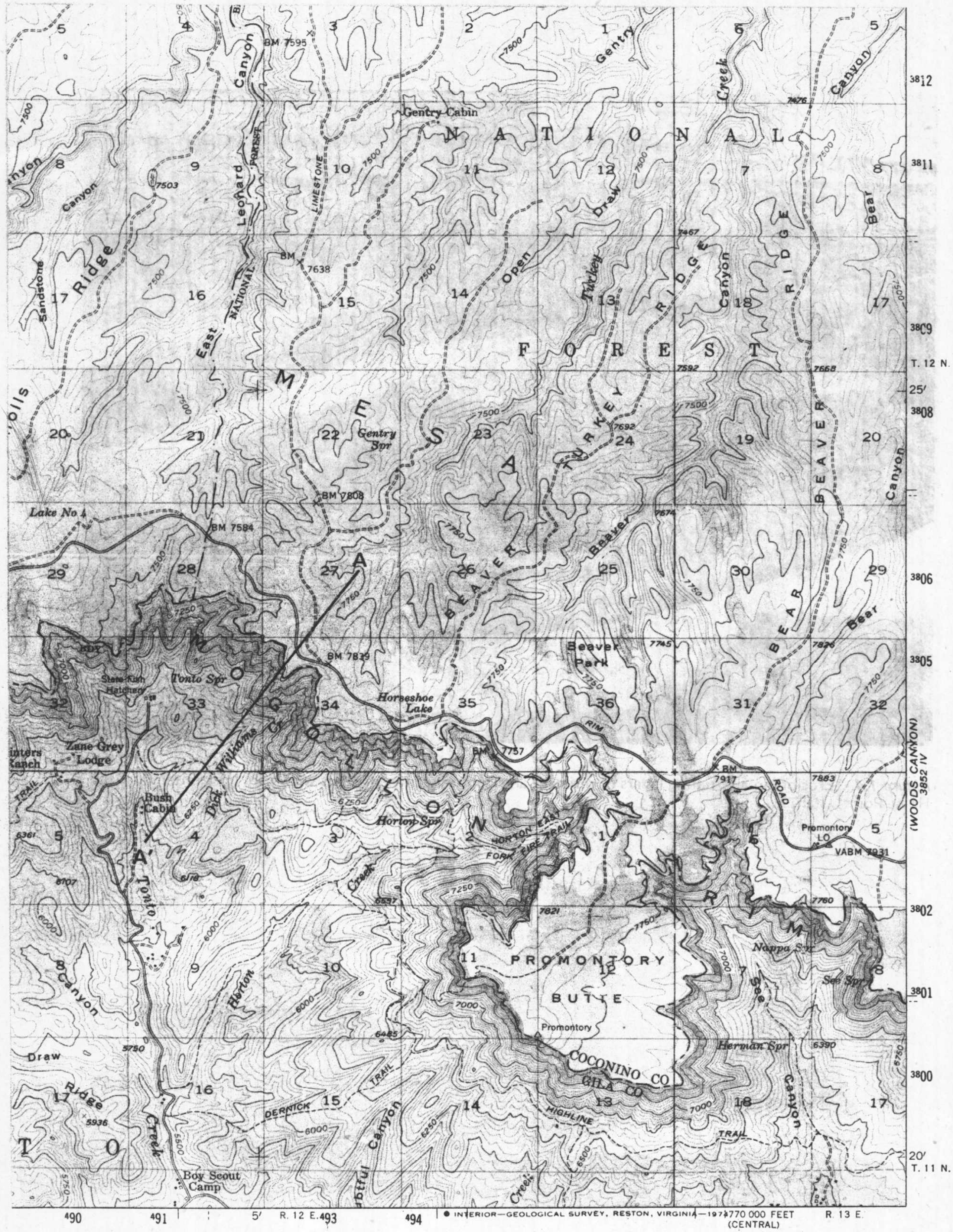


Figure 1.3. A dendritic drainage pattern.

Figure 1.4. Erosion on alternating layers of resistant and non-resistant sediments which are horizontal. At Dead Horse Point, Utah.



SCALE 1:62500

1 ½ 0 1 2 3 4 MILES

3000 0 3000 6000 9000 12000 15000 18000 21000 FEET

1 .5 0 1 2 3 4 5 KILOMETERS

CONTOUR INTERVAL 50 FEET
NATIONAL GEODETIC VERTICAL DATUM OF 1929

PROMONTORY BUTTE, ARIZ.
N3415—W11100/15
1952
AMS 3752 I—SERIES V798

 NAME ______________________________

PROMONTORY BUTTE, ARIZ.

Locate the following explicitly:

Zane Grey Lodge

Gentry Cabin

What is the highest elevation on the map? The lowest?

What is the direction of slope of the mesa surface?

Of the streams on the mesa?

Therefore what genetic type of stream might these be?

What is the pattern of the drainage on the mesa?

What is the gradient of Beaver Canyon?

Of Tonto Creek?

What is the geomorphic name for the feature called Mogollon Rim?

Note the edge of the Mogollon Rim. What do the alternating steep and gentle slopes signify about the rock underlying the area?

What is the future of Promontory Butte?

Draw a profile to scale along AA′. Label the escarpment. Indicate the underlying rock structure on the profile. The surface is underlain by Tertiary lava flows that cover the underlying Pennsylvanian sediments.

Note the drainage pattern of Tonto Creek and its tributaries. It is dendritic.

FACTORY BUTTE, UTAH

(Figure 1.5a,b)

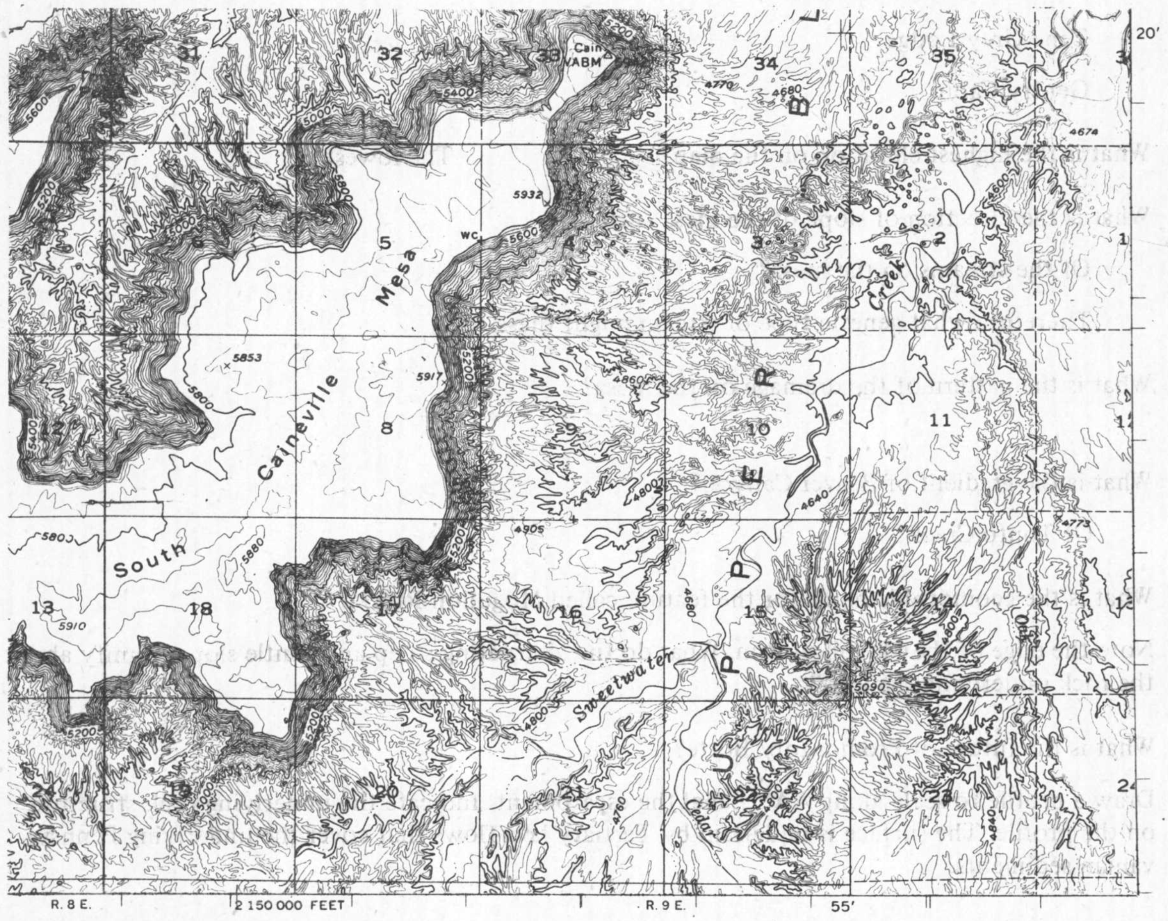


Figure 1.5a. Part of Factory Butte, Utah quadrangle.

CONTOUR INTERVAL 40 FEET
DATUM IS MEAN SEA LEVEL

The air photograph shows South Caineville Mesa. What is the scale of the photograph? Map scale is 1:62,500 and each section is one square mile.

The mesa is capped by a very resistant sandstone layer. What is the height of the cliff?

Note the exaggeration of relief on the air photograph. What is the relief from the Sweetwater River to the mesa top?

Other things to note are the minor dissection on the mesa top and the intricate dissection on its sides and below it. Compare the way this is shown on the photograph and the map.

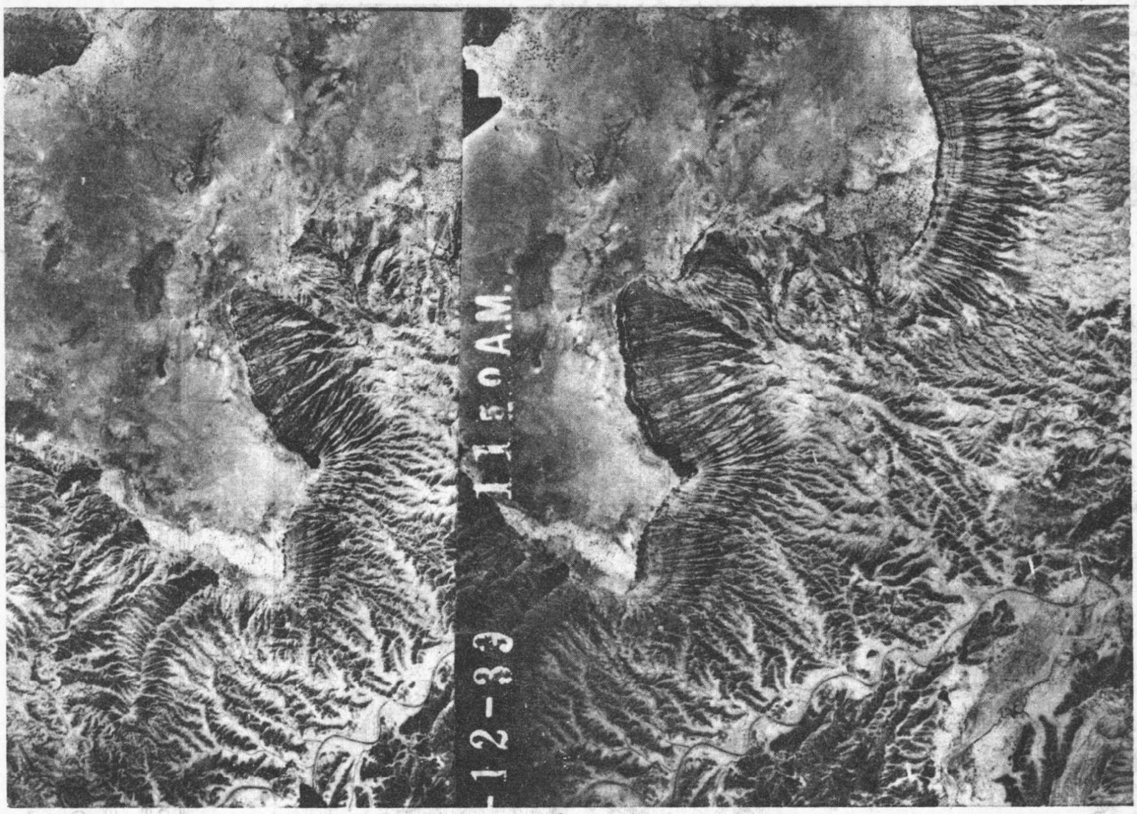
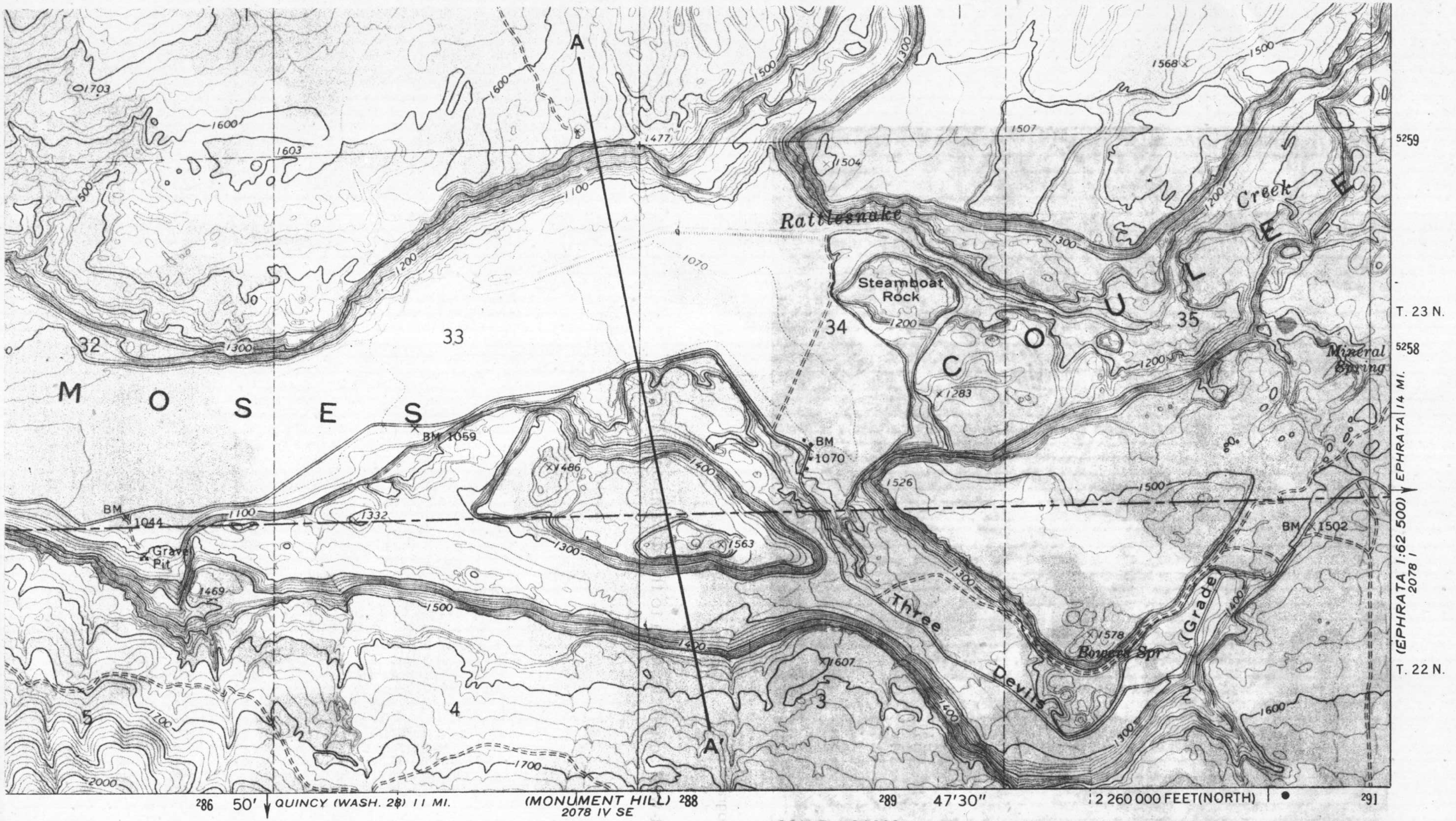


Figure 1.5b. Air photograph of 1.5a.

Sketch a profile east-west across the mesa to the streams on each side.



SCALE 1:24000

1 ½ 0 1 MILE

1000 0 1000 2000 3000 4000 5000 6000 7000 FEET

1 .5 0 1 KILOMETER

CONTOUR INTERVAL 20 FEET
DOTTED LINES REPRESENT 10-FOOT CONTOURS
DATUM IS MEAN SEA LEVEL

RATTLESNAKE SPRINGS, WASH.
N4722.5—W11945/7.5

1966

AMS 2078 IV NE—SERIES V891