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GEOLOGIC MAPPING
by means of
GRAPHIC LOCATOR

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INTRODUCTION

The writer has designed a graphic locator for rapid and accurate preparation of geologic maps. He describes it and how it is used, and enumerates the inherent errors and advantages of its use.

The preparation of a detailed geologic map of any particular area implies that a geologist observes the vertical and horizontal patterns and relationships of the various rock formations that are present at or near the surface within the boundaries of the area being mapped. He determines by visual evidence and logical deduction the geologic composition of all physical features within the area, from the bottom of the lowermost valley to the top of the highest hill or mountain. As he progresses in his survey he sketches the geologic detail on a topographic map base that has been prepared in advance of the geologic survey. Thus, the geology is superimposed on the topographic map in contrasting colors that depict the extent, thickness, and "lay" of individual bedrock units at each and every point within the area being mapped.

The accuracy of the geologic map depends not only upon the accuracy of the topographic base, but upon the ability of the geologist to determine correct locations on the map in tracing the contacts of the different rock formations across country. In areas of low relief, few difficulties arise unless the rock surface is greatly obscured by blanketing surface materials. In rugged or mountainous terrain, it is often impossible to plot accurately all geologic information on topographic maps because of inaccessibility of certain critical positions that can be neither reached on foot nor determined by standard instrumental survey methods. In such places it is possible only to estimate the vertical and horizontal position of the points in plotting them.

To overcome this inherent deficiency in orthodox geologic mapping technique, the writer and Arthur H. Frazier of the Geological Survey have constructed a "graphic locator" for field use in geologic mapping. The graphic locator eliminates the need of a stadia rod in determining the position on a topographic map of any point within the range of visibility of the observer. Used in conjunction with a surveying alidade it will not only locate points that are inaccessible with a rod, but will greatly speed the accurate mapping of loose surface materials that do not justify tedious rod shots but would otherwise be difficult to sketch accurately.

Properly used, the graphic locator technique allows the preparation of geologic maps that are automatically adjusted to the topographic base map, though it does not effect the absolute delineation of certain special features such as mineral veins and igneous dikes. With the graphic locator the intersection of a line of sight with the surface of the ground can be plotted directly on the topographic map, thus fixing any desired point within the limits of accuracy of the map itself.

The technique has been successfully used in the field by the writer. It has been found to give locations that are sufficiently accurate for most geologic work. It is definitely a time-saving technique and makes possible much closer control of mapping in difficult terrain. Although the graphic locator was designed for use in rugged country, it can also be used in rolling terrain or in areas of moderate relief provided the line of sight makes an angle of more than 15° with the surface of the ground.

DESCRIPTION OF THE GRAPHIC LOCATOR

The graphic locator consists of a single rectangle of xylonite or other transparent plastic material, about 3 inches square and 1/16 inch thick.

Two scales, graduated in divisions corresponding to the contour interval of the topographic map with which it is to be used, are marked or engraved on the under side of the rectangle, one at the right and one at the left edge. Because of the simplicity of its construction, sets of these graphic locators can readily be made for use with maps having any specified contour intervals

or horizontal scales. The accompanying drawing (fig. 1) illustrates the graphic locator used in mapping an area in the San Juan region, Colorado, on a topographic map having a contour interval of 25 feet and a horizontal scale of 1 inch to 1,000 feet. The scale divisions on the model, computed from the equation $25 \times 12 \times \frac{1}{1,000 \times 12} = 1/40$ inch, are 1/40 inch apart. The etched areas B and B', on figure 1, between the major scale divisions, are used for recording with pencil the range of elevations for any particular setup.

PROCEDURE FOR USING THE GRAPHIC LOCATOR

The procedure for using the graphic locator (see fig. 1 for example) is as follows:

1. Location of the plane table setup point A is plotted on the topographic map by resection or other suitable means.

2. Elevation of the alidade ("HI") is determined to be 12,150 feet.

3. Reference elevations are written in the opaque areas B and B' on the graphic locator, assuming that the range in elevations for the shot used in this example will be between 10,000 and 13,000 feet.

4. Telescopic alidade is sighted at point to be plotted; ray A-C is drawn on map, and the vertical angle read. If an open-sight alidade is used, the line of sight is drawn and the angle is read with a Brunton compass.

5. From the ray A-C the vertical angle CAD is plotted with an 8-inch protractor and a segment of the line A-D drawn. In the example the angle is 18°.

6. The graphic locator is placed over the ray A-C so that the scale readings at both edges (E and E') correspond to the HI of the instrument (12,150 feet). While held firmly in this position the straightedge of the alidade base is placed against either the top or bottom edge to serve as a guide for shifting the graphic locator laterally.

7. The locator is then shifted along the straightedge until the edge of the scale at E intersects line A-C at the estimated position on the map of the point being shot.

8. Next, it is noted whether the scale reading at F (the point where line A-D crosses the edge of the scale) is greater or less than the contour reading at E. If, for example, the contour elevation of the estimated position at E is 10,900 feet the scale reading at F would be approximately 10,975 feet. This means that the line of sight has not yet intersected the ground surface at point E. A profile of the ground surface, G-G', has been added to figure 1 to indicate the relation of the ground surface to the line of sight.

9. If the graphic locator is moved farther to the left so that the scale reading at E is 11,000 feet, then the scale reading at F will read approximately 10,930 feet, meaning that the line of sight has penetrated the surface and the point as located by this second estimate lies beneath the ground surface. The point sought must, therefore, lie between the 10,900- and 11,000-foot contour lines on line A-C. The range between the trial points is then quickly reduced by moving the graphic locator back and forth between the 10,900- and 11,000-foot contour lines.

10. When the position of the graphic locator is such that the contour elevation at E is the same as the scale reading at F (10,950 feet in the example) the point of intersection at E is the point on the map that is sought.

INHERENT ERRORS AND ADVANTAGES

The degree of accuracy with which points may be determined with the graphic locator depends upon the accuracy of the topographic map, upon the accuracy of manipulation of the instrument, and upon the relief of the terrain.

In order to evaluate the combined errors that may be inherent in the construction and manipulation of the graphic locator, a number of shots were taken between points on a topographic map whose position and elevation had previously been determined by topographers. The contour map was therefore very accurate in the immediate vicinity of these known points and any error in relocating these points by the process described above would be inherent either in the instrument, the procedure, or a combination of both. The test was carried out in the office on 32 known points. Angles were computed from the horizontal and vertical distances as scaled from the map and plotted with an 8-inch protractor. The operation was thereafter completed in exactly the same manner as would normally have been done in the field.

It was found that a major source of error between the measured distance and distance as determined by the graphic locator lies in the angle that the line of sight makes with the surface of the ground in the vicinity of the point that is being located. The distribution of points plotted on figure 2 shows that at low angles (grazing shots) large errors may occur because the point at which the line of sight intersects the ground surface is generally difficult to determine. Conversely, at higher angles location becomes increasingly more accurate. The solid line in figure 2 represents approximately the upper limit of error at any angle of the line of sight with the ground surface, and the dashed line the approximate mean error. It can be seen that for angles greater than 25°-30° the error is consistently less than 1 percent and that for angles greater than 15° the mean error is less than 1 percent.

Although the absolute error in feet may tend to increase with length of shots, owing to possible errors in plotting the vertical angle, the percentage error showed no definite relation to the length of shot. The 32 shots plotted on figure 2 range from 1,220 feet to 5,900 feet; they average 3,100 feet in horizontal distance. Accurate results cannot be expected with a 13-foot rod at such a distance. The graphic locator cannot be used effectively if the line of sight makes an angle of less than 15° with the surface of the ground in the vicinity of the point being located. This circumstance generally limits the use of the graphic locator to regions of moderate to great relief.

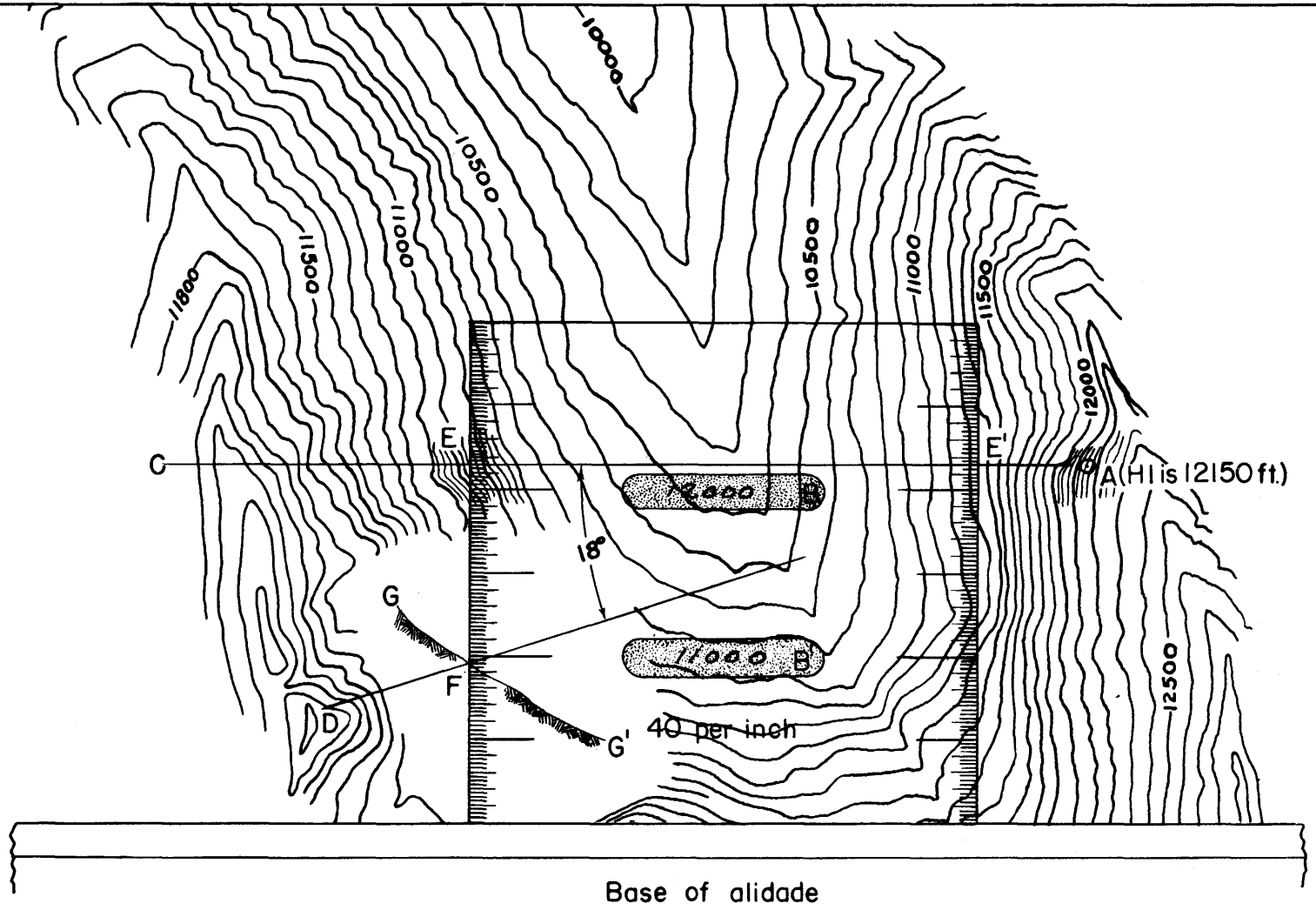

Figure 1. —Graphic locator technique.

25 foot contour lines omitted except near set-up and point being located

Scale of map

0 1000 2000 3000 4000 FEET

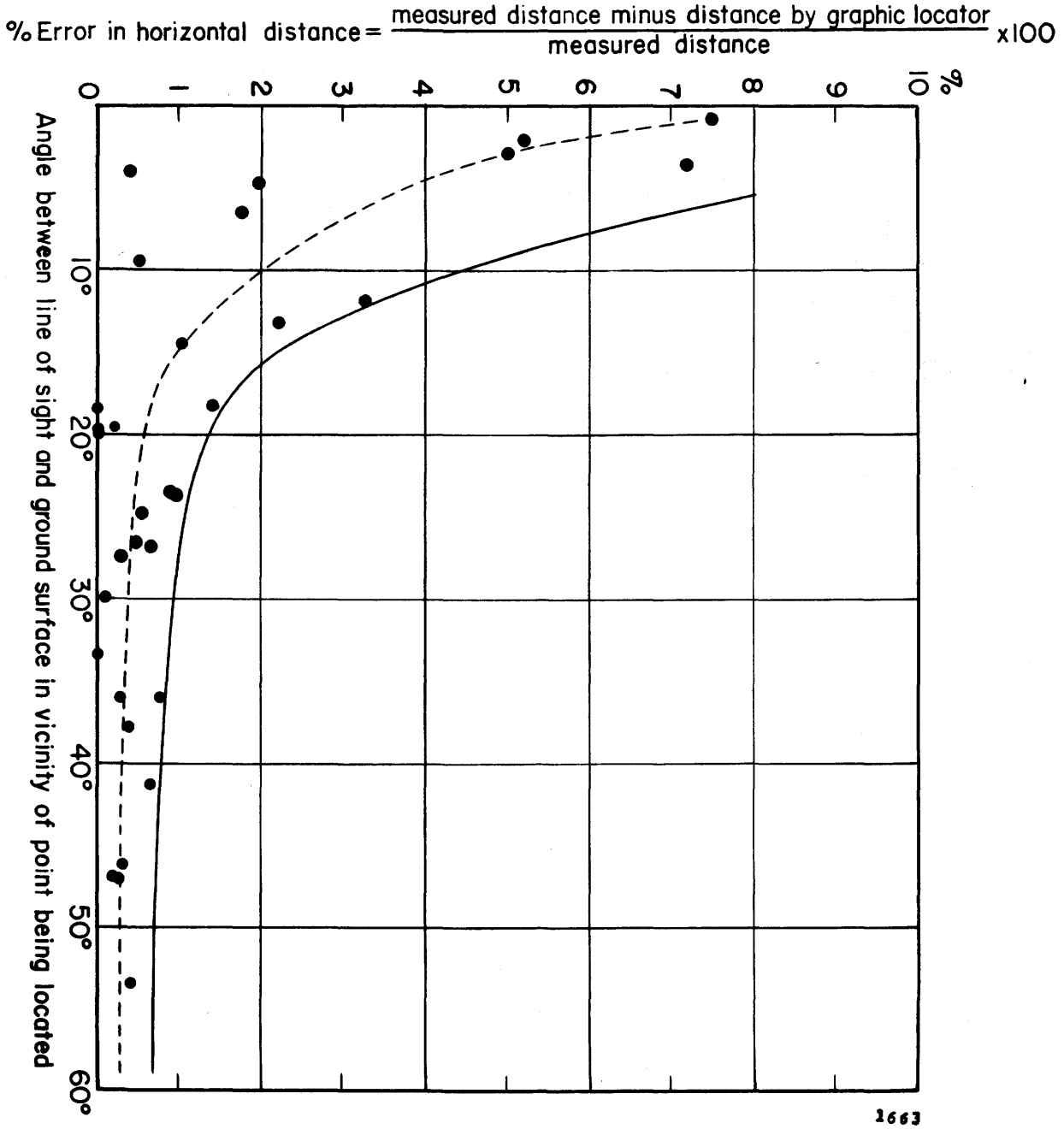

Figure 2.—Range of observed errors.

The field tests made with the graphic locator indicate that the following advantages may be expected through its use:

1. Familiarity with the use of the graphic locator makes possible the fixing of a location within 3 minutes after the alidade is set up and the position and elevation of the point of observation are determined.

2. Results obtained with the graphic locator have been checked with actual rod determinations in the course of geologic mapping and have been found to be approximately the same. Where the rod cannot be used, the graphic locator offers an equally reliable alternative.

3. The graphic locator is especially suited for long shots, beyond the range of the rod.

4. The locator is valuable for checking rod shots.

5. The instrument is useful for determining from a topographic map alone the area visible from any selected point.

6. Use of the graphic locator results in a great saving of time in mapping rough terrain because the number of rod shots required is reduced. The services of a rodman are not required.

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