A HANDS-ON APPROACH TO UNDERSTANDING TOPOGRAPHIC MAPS AND THEIR CONSTRUCTION

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Abstract

This topographic map exercise is designed for a lab session of two or three hours in an introductory geology course. Students are taught the basic principles of topographic map construction in lab and are then required to make their own map of a very small section of our campus quadrangle using a Brunton-compass level bubble, Jacobs staffs, pencils, and string. The data thus collected are used to produce computer-graphic mesh maps that can be viewed in three dimensions using standard stereo viewers. The hands-on approach has improved student performance on tests and has resulted in a deeper understanding of maps and the process of map production.

Keywords: Apparatus; areal geology—maps, charts, photographs; education—computer assisted; geology—teaching and curriculum.

Introduction

Perhaps one of the more perplexing "chores" that students in a first-year geology course are asked to do is to learn how to read topographic maps and develop an understanding of the processes used to create maps. This is a very important phase of my course since we spend a great deal of time studying maps that represent various geomorphic terrains, from streams and glaciers to ocean shorelines and volcanoes. Failing to develop the skills necessary for topographic-maps interpretation magnifies the problems students have as more sophisticated geomorphology is studied. I have used numerous laboratory manuals, and exercises and techniques ranging from submerging plastic models of landforms in water to stereo photos, but students still seem to miss the beauty and value of the map, its expression through the use of contour lines, and its importance in fields other than geology. As a consequence of varying degrees of frustration (mine as well as theirs), approximately three years ago, after teaching the standard approach to understanding topographic maps for nearly 20 years, I tried to put myself in the place of my students in order to learn where the problems were and how I could make improvements. I spoke to my students and listened to their comments. Besides the obvious "not relevant" comment we all hear from time to time, I realized that students could not see the plastic models or laboratory manual exercises as "reality." The stereo photos, although quite exciting at times, did little to clarify the problem. A new approach was clearly needed, and I wondered whether a limited field-mapping experience would help. However, because of time constraints, it would be most effective if we could have the field time during our normal two-hour laboratory session.

Success at Last!

I found the solution to my problem right outside our science building's door. On our campus, which is located in north Philadelphia, there is a grassy quadrangle that was constructed a few years ago. Rather then simply flattening off an area and planting grass, the administration had enough foresight to place on the quadrangle three elongated hills, with different shapes, each with about a meter of relief. They obviously realized years ago that this would be an excellent outdoor laboratory in which to teach students topographic map making.

The method I use is quite simple. I still introduce students to the basics of topographic map interpretation in lab. We discuss what contour lines are, what they do, what they do not do, and I discuss the process that we will be using to map the quad. I introduce them to the Brunton compass (although a simple level bubble attached to a meter stick will do), and teach them how to find a horizontal surface in the field. It never ceases to amaze me how little students know about compass directions and how to find a horizontal surface. Once all of this preliminary instruction is accomplished, we head outside.

A word of note here. If it is raining, do something else. It serves no useful purpose to conduct this laboratory exercise in inclement weather. Besides teaching the students about maps, I am also trying to provide them with an exciting and interesting experience in geology. Low temperatures and wind are fine, but rain would prevent many objectives from being fulfilled. I always have a backup plan and only go out if the weather allows.

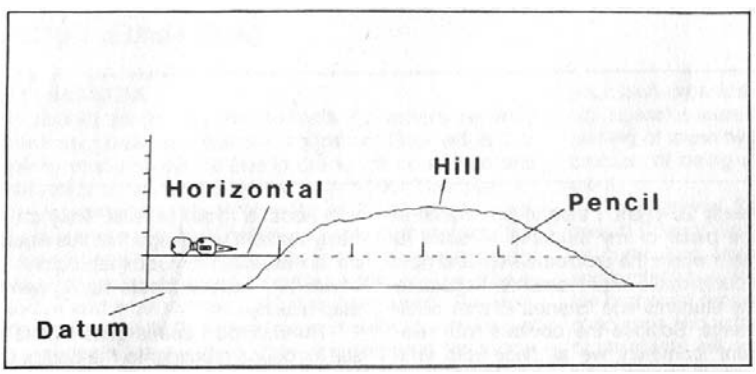

Figure 1. The surveyed hill showing the datum and pencil positions.

If conditions are satisfactory, my approach is to have the students survey a 30-centimeter contour around their assigned hills. This is done by holding a vertical Jacobs staff, marked off in 30-centimeter increments, adjacent to the hill. A second staff, which is kept horizontal, is held at the 30-centimeter mark on the vertical staff and intersects the hill (Figure 1). The orientation of the intersecting staff is critical, and it is kept horizontal by using the level bubbles on the Brunton. Where the horizontal staff contacts the hill is exactly 30 centimeters above the datum (which is the adjacent sidewalk or grass surface). A student is then instructed to push a pencil or stick into the hill surface at this intersection. This process requires at least three students, but once the group gains some experience the process moves along rapidly. A second survey point is then selected a few meters away from the first. This is surveyed the same way using the sidewalk as a datum, or it can be surveyed by getting a horizontal from the previous pencil location.

After the 30-centimeter contour is completed the students connect all the pencils with a continuous string. They have thus completed their first contour line. At this point I usually discuss the configuration of the line and ask the students some questions such as: What happens when the string crosses gullies on the hill? What problems were encountered in surveying the line? Should points be surveyed closer together? Is the string line jagged or a smooth curve, and so forth? I emphasize the fact that contours connect points of equal elevation, and if an ant were to walk on the string around the hill it would not be changing its elevation above the datum. The 60-centimeter contour is surveyed from the adjacent sidewalk using a process similar to that used to find the 30-centimeter line, or it is surveyed by using the 30-centimeter line as the new datum. Once again upon completion, the pencils are connected using string and a discussion ensues.

The process continues until the hills are completely contoured, usually requiring three or four sets of strings. A final benchmark is established by surveying the highest point on each hill. We discuss why a benchmark is needed and why a new line is not required if the elevation of the top of the hill is less than that of the next higher contour.

The last step of the field experience is to place each hill in its proper position on the map of the quadrangle so that the students will have a complete map when each group contributes its survey data. This is done by stretching measuring tapes along the sides of the quadrangle. One student stands by the pencil stuck in the hill, a second student stands along the tape on the south border of the quadrangle, and a third student stands along the tape on the west (or east) border. Each pencil is then visually located from a 0,0 origin (in the southwestern corner) and plotted on a field map. The results of the exercise are then discussed in lab, and completed maps of the quadrangle are prepared by each student.

I have recently added an additional phase to the project by having the students enter their data into the topographic mapping program, *SURFER*, produced by Golden Software of Golden, Colorado. This adds a measure of technology and excitement to the exercise by allowing the students to see the computer image of their data and providing them with a mesh map which can be viewed from many different angles and with vertical exaggerations (see Figure 2). The computer graphic is then printed on a Hewlett-Packard plotter. I have also discovered that if two mesh maps are plotted with an angle of 10 degrees between them, it is possible to view them with stereoscopes and get a three-dimensional effect. The students are usually impressed by the various perspectives and scales that they can use to represent the quadrangle. This phase of the exercise provides us with a good opportunity to discuss scales and exaggerations. *SURFER* even allows us to use a built-in profile program to make “slices” across the maps.

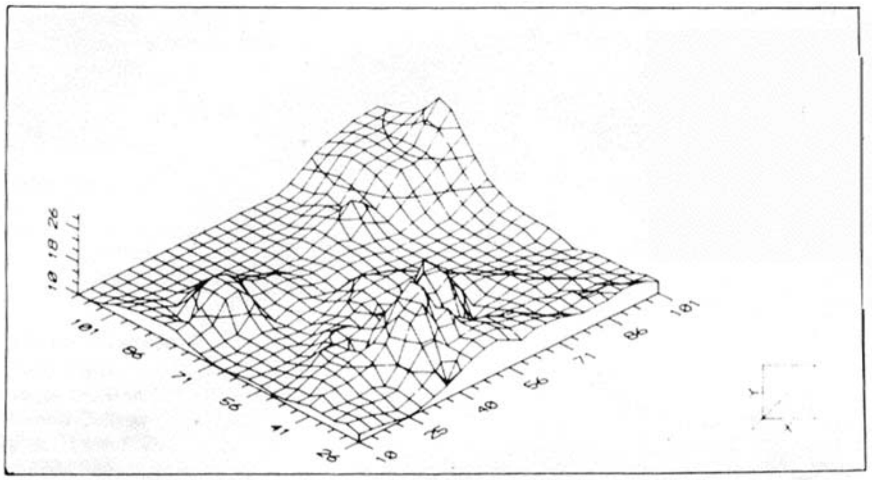

Figure 2. A typical mesh map created from student data. Vertical exaggeration 1.5X. *SURFER* can plot such maps from various directions and students can view them with stereo viewers for a 3-D effect.

Conclusion

I believe this exercise can be performed on almost any campus and adds a great deal to student understanding of an abstract concept. After doing the exercise, students often remark to me how their understanding of the process is much clearer. They actually walk the string lines and come to understand why contours bend toward higher contours when crossing a gully on the hill, and they know why the spacing of lines is a reflection of the hill's slope since they mapped it. Some added benefits that I had hoped for are that students seem to enjoy the process of surveying, they perform better on our standard topographic map tests, and lastly, a large segment of the student body views the exercise since it is done in the middle of campus. A little public relations can go a long way. I am often asked by students I do not know if they will have the opportunity to "survey the quad" if they sign up for my class. It seems they believe geology will be interesting and exciting, and of course my answer is always, "Absolutely!!"

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