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**Earth Science Education Title:** Using Topographic Maps to Generate Topographic Profiles

**Overview**

Topographic maps are “plan-view” representations of Earth’s three-dimensional surface. They are a standard type of map-view that provides an overhead, or aerial, perspective.

Among the defining features of a topographic map are the contour lines that indicate locations of constant elevation. The elevation interval between the contour lines is dependent on the level of detail provided by the map and the kind of topography present. For example, regions with significant topographic variation might require contour lines separated by 10-20 ft., whereas generally flat-lying regions with little topographic variation might have more broadly separated 40-100 ft. contours.

To an experienced user of such maps, the patterns made by the topographic lines are representative of various landform patterns, such as ridges, valleys, hills, and plateaus.

Although modern three-dimensional imagery (e.g. digital elevation models, Google Earth) can be useful as a means to get a rapid and general impression of a landscape, these images are subject to distortion and cannot be used to extract quantitative elevation data. In contrast, a topographic map can provide a distortion-free source of information regarding altitudes for discrete points over the entire map area.

This ability to extract dependable elevation data for any point on the topographic map allows for the construction of topographic profiles. These are cross-sectional views (perpendicular to the standard plan-view or map-view) that define a continuous series of elevations along a line, connecting two points on the map. Along the profile, one can easily see how the land surface rises and falls. The perspective of the topographic profile is very useful; it provides a starting point to project inferences about the orientation of rock layers or rock structures into the subsurface.

**Procedure**

1. Make a Topographic Profile.

* 1. Obtain a topographic map.
  2. Establish a line between two specified points on the map. Call these points, A-A’, or X-X’, or Y-Y’.
  3. Lay the edge of a paper strip along the cross-section line, marking the two points, A-A’, with tick marks.
  4. Place a tick mark where each of the contour lines intersects the line of the cross-section. Add notations that indicate the elevations of those contour lines.
     1. If there is substantial topographic variation along the chosen line, A-A’, it might be best to start by only marking the intersection of the line with the major contours (i.e. at 100 or 1000 ft. intervals, as opposed to every line that might represent smaller, 20 or 40 ft., intervals).
  5. Set the paper with the tick marks along the x-axis of a piece of graph paper. Transfer the elevation marks onto the y-axis with a dot.
     1. This generates a graph of elevation (y-axis) versus distance along the A-A’ line.
     2. The scale of the x-axis is defined by the map itself. The scale of the y-axis can be chosen to be equivalent to the map scale (resulting in no vertical exaggeration), or it can be chosen such that the small elevation variations are effectively “stretched out” (resulting in vertical exaggeration).
  6. Smooth the profile by connecting the dots, recognizing that most topographic variation in the real world does not exist in abrupt steps.

**Results**

Once properly smoothed and checked against the map itself (for elevation details between points), the resulting topographic profile is a representation of the highs and lows of a landscape, between the defined points.

When topographic profiles are used as a base for projections of geologic features into the subsurface, it’s generally best to avoid vertical exaggeration — in other words, the horizontal and vertical axes should have the same scale. However, when there is very little vertical variation across the topographic profile line, it might be useful (in order to visualize topography) to have a different vertical scale, effectively stretching out the vertical topographic variations.

The degree of vertical exaggeration is equal to the vertical fractional scale divided by the horizontal fractional scale. For example, if one is using a typical U.S. Geological Survey topographic map with a horizontal scale of 1:24000 (one inch on the map represents 24,000 inches in the real world) and a chosen vertical scale of 1:2400 (one inch on the vertical scale represents 2,400 inches of vertical change), then the vertical exaggeration is simply 1/2400 divided by 1/24,000 which equals 10x vertical exaggeration.

**Applications**A topographic profile provides a visual representation of the topographic highs and lows across a line segment on a map, from one point to another. Such profiles are used to evaluate the “ruggedness” of terrain, which is useful in assessing the difficulty of travel (driving, biking, or hiking as transportation modes for field-work) (**Figure 1**). They can also be used to interpret geomorphic processes (e.g. fluvial or glacial erosion (**Figure 2**)) that might produce different kinds of topographic steps and variation, and they can suggest possible regions of relatively more-resistant versus less-resistant rock or soils. Most commonly, topographical profiles are used as a land-surface base from which projections are made into the subsurface. These projections can entail evaluation of geologically significant parameters — for example, ground-water reservoirs, rock or soil layers, and rock structures (folds and faults).

**Legend**

Figure 1: An example of terrain that would require topographic evaluation.

Figure 2: Deep, eroding glaciofluvial deposits alongside the Matanuska River, Alaska.