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Using Topographic Maps to Generate Topographic Profiles

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Corresponding Author:	Alan Lester UNITED STATES
Corresponding Author Secondary Information:	
Corresponding Author's Institution:	
Corresponding Author's Secondary Institution:	
First Author:	Alan Lester
First Author Secondary Information:	
Order of Authors:	Alan Lester
Order of Authors Secondary Information:	

Author Name: Alan Lester, University of Colorado Boulder
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.

    1.1. Obtain a topographic map.

    1.2. Establish a line between two specified points on the map. Call these points, A-A', or X-X', or Y-Y'.

1.3. Lay the edge of a paper strip along the cross-section line, marking the two points, A-A', with tick marks.

1.4. 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.

1.4.1. 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).

1.5. 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.

1.5.1. This generates a graph of elevation (y-axis) versus distance along the A-A' line.

1.5.2. 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).

1.6. 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.

Click here to download Photo or Graphic File: Lester_topographic_profile_figure2.JPG

Click here to download Photo or Graphic File: Lester_Topographical Profiles_Figure 1.jpg

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Comment [AW1]: Provide the more information about the profiles themselves, similar to what you did for the topographic maps.

Procedure

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1.4. 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.

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 1,000 ft. intervals, as opposed to every line that might represent smaller, 20 or 40 ft., intervals)~~.

1.4.1. The major contours (also called index contours) are those that show up on the map as bold, slightly heavier lines.

1.4.1.1. For example, major contours on a 7.5 minu~~te~~ quadrangle map are~~will~~ typically ~~be~~ used to indicate 200 f~~oo~~t. intervals on the map, with the standard contour lines representing 40 f~~oo~~t. intervals. This means that between every major contour, there are~~will be~~ 4 standard contours (representing 5 steps in elevation~~,~~ to move from one major contour to the next).

1.5. 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.

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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.

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Comment [ml2]: Not sure what you mean by "short"--- perhaps you believe that this won't take much TIME during the filming process?....
In fact, in making the video, we'll select a line (A-A') that will showcase how some topographic contours are close together and some topographic contours are further apart...AND the careful placement of the tick marks is a rather laborious process, and one that will be "long" instead of short during the filming.

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Comment [AW3]: Because this process is a bit short, demonstrate the process with an area of small and major contours.

Comment [AW4]: Provide an example of topographical profiles that do and do not require vertical exaggeration.

Comment [ml5]: No problem… I'll add a note here about the need for vertical exaggeration...and the answer is that a little bit of vertical exagg is almost always used UNLESS the profile will be the basis for a geologic cross section. SEE BELOW…

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 (1 in. on the map represents 24,000 in. in the real world) and a chosen vertical scale of 1:2400 (1 in. on the vertical scale represents 2,400 in. of vertical change), then the vertical exaggeration is simply 1/2400 divided by 1/24,000 which equals 10x vertical exaggeration.

Some vertical exaggeration is often useful, particularly when the topographic profile is being used primarily to show the “ruggedness” of the terrain. As per the previous example ~~above~~, on a 1:24000 map (the scale generally used on standard USGS 7.5 min~~ute~~ quadrangle maps), 1 in. on the lateral x-axis of the topographic profile ~~will~~ represents 2000 f~~ee~~t., and these maps (depending on latitude) are~~will be~~ around 6 ~~six~~ by 8~~eight~~ mi.~~les~~ in total (east-west versus north-south) dimension. But in many map regions, there is substantially less than 2000 f~~ee~~t. (i.e., 1 in.) of vertical relief over the entire map area~~—~~; therefore, a non-exaggerated profile ~~would~~ shows very little variation on the y~~Y~~-axis, and an exaggerated profile may~~ight~~ be desired.

~~Note:~~ For the purpose of making geologic cross-sections, where the main interest is to project rock layers into the subsurface (and less significance is given to the surficial topographic variation), it is best to use a non-exaggerated topographic profile as the base from which to make the projections. With a ~~This is because with a~~ non-exaggerated profile, the rock layer “dip-angles” do not need to be modified. ~~This is discussed in greater detail in the “Making Geologic Cross Section” video.~~

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:

~~1)~~ 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**). Sometimes ~~a~~ field-work requires making a transect through a region for the purpose of collecting samples or making geophysical measurements. A topographic

Comment [AW6]: Expand on these applications further. We need to be able to write ~30 sec blurbs about each one: briefly explaining the concept and how it relates to profiles.

Comment [ml7]: Yes,,,this was too short… hopefully a bit better now…

profile can tell the field-scientist something about the difficulty and feasibility of such a traverse.

2)

Nearly all topography on planet earth is a consequence of the interplay between uplift ((whether generated by volcanism, tectonism, tidal forcing, impact, etc.) and erosion.- As such, detailed analyses of topographic variations are a critical part of assessing geomorphic models related to terrain evolution. -For example, if a geologist wants to know why a river or glacier system exhibits significant gradient variation along its course, topographic profiles are the primary means to quantify these changes .(**Figure 2**).) – They can also be used to interpret geomorphic processes (*e.g.* fluvial or glacial erosion (**Figure 2**)) that might produce different kinds ofT topographic steps and variations can be used to indicate the relative , and resistance of rocks and soils to erosion; low areas being of greater susceptibility to erosion.

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3) Most commonly, topographicalTopographic profiles are the land-surface base for making geologic cross-sections (see video "Making Geologic Cross Sections"). A cross-section is a graphical projection of surface rock or soil layers into the subsurface.- This "side-view" of the earth's interior is crucial to interpreting all kinds of geologic features.– Geologists use cross-sectional views of the subsurface to interpret the location of ground-water reservoirs and flow regime, inndentify possible oil and gas pockets, and model mechanisms for rock deformation (folding and faulting).

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1.4.1.2. Along certain portions of the cross-section line, there may be steep topographic variation, and therefore, closely-spaced contour lines. Here, ~~it would be best to~~ mark only the major contours. Where there is little topographic variation, ~~it is best to~~ mark all contours (where they intersect~~ion~~ the cross-section line).

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Comment [AW2]: The process may be long, but only steps that have narration will be filmed, and we can only write narration of content in this manuscript. If the same couple steps are repeated, they will be condensed in the video. It might be helpful to perform the procedure and note all cautions, tips and tricks, etc. that arise.

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