IS THE CROSS-SECTION OF A GLACIAL VALLEY A PARABOLA?

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In the geomorphological literature, glacial valleys are often described as parabolic or U-shaped. Accordingly, the author has given a method [1] for computing the parabola which gives the best approximation for the cross-section of any glacial valley. However, as far as is known to the author, no attempt has been made to determine the *type* of curve which best represents the cross-section of a glacial trough, and this paper presents some points of view on this subject.

If we start at the lowest point of a uniform glacial valley, without hiding the underground deposits too much, we can express the increasing height of the valley wall as a function of the horizontal distance from this lowest point. These values for the height increase steadily, and form a monotonic series of figures. If we suppose the cross-section of the glacial valley to be approximately of the form $y = ax^b$ (each half of the section being treated separately with x measured as positive from the central line of the valley), then the question is, in each separate case, to determine the coefficient a and the exponent b in such a way that the approximation will be the best possible. The exponent b determines whether the cross-section of the valley is parabolic or not.

The above power law can be written

$$\log y = \log a + b \log x.$$

If we put $Y = \log y$ and $X = \log x$ and $A = \log a$, then the equation connecting Y and X becomes

$$Y = A + bX.$$

To compute the constants A and b in this linear relation, the method of least squares can be applied. By this method the sum of the squares of the differences between the observed values of Y and those calculated from the formula is minimized. This minimizing of the sum of squares of the residuals gives a unique solution for A and b:

$$A = \frac{\Sigma X\, \Sigma XY - \Sigma Y\, \Sigma X^2}{(\Sigma X)^2 - n\, \Sigma X^2}\;;\quad b = \frac{\Sigma X\, \Sigma Y - n\, \Sigma XY}{(\Sigma X)^2 - n\, \Sigma X^2}$$

where n is the number of observations.

The author has determined the parameters for the glacial valley Lapporten in northern Sweden using the above method. In order to eliminate local post-glacial unevennesses of the slope as far as possible, the x values are the averages for three cross-sections, taken at a short distance from each other.*

The calculation resulted in the following equations:

$$y = 0\cdot000402\, x^{2\cdot046} \text{ and } y = 0\cdot000172\, |x|^{2\cdot177}.$$

From the equations deduced, it can be seen that the shape of the trough is not quite symmetrical. The close agreement with a parabola is, however, evident. Particularly in the first equation, the deviation of the exponent from the value 2 is only slight.

It would not be appropriate to draw a general conclusion for all glacial valleys from this example. It is to be hoped that a number of valleys could be examined and the results correlated, from which the question of their type could be discussed.

It might seem unimportant to find out the exact shape of the well-known glacial valley;

* A photogrammetic map (scale 1 : 10,000, contour interval 20 m.) was used for the measurements.

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but it is the author's opinion that if anything is to be revealed from the shape of the glacial rock surface concerning ice dynamics at the bottom of glaciers and ice sheets—and knowledge on this subject is still incomplete—discussions must proceed on the basis of accurately expressed observations.

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EARLY DISCOVERERS

XI

BERNARD PALISSY ON FROST SHATTERING AND RIVER ICE

PALISSY lived in France from about 1509 to about 1590. His two books [1, 2] are of particular interest to geographers and geologists.[3]

Palissy argues that God did not create the earth to be idle and though he supplied *all* materials on earth at the time of the Creation, the *form* of these materials is constantly changing. The "growth" of rocks from salt-charged "congelative water" is therefore exactly balanced by frost shattering and other processes. Frost shattering, like the "growth" of very hard rocks, occurs mainly in cold districts, such as the Ardennes, the Black Forest, the Pyrenees and the Auvergne; but the marl of the Paris Basin is also "dissolved" by frost. The incidence of frost is directly related to orientation and site.

When held up to the light, water, ice and quartz all reveal internal sparkles and are alike in weight, colour and coldness. They are therefore all made of the same materials—salt and water. Ice is merely water that has congealed or petrified because it contains a particular type of salt.

According to Palissy, a popular contemporary belief was that rivers froze from the bottom upwards. Palissy objects that river ice does not bear the impress of the river bed, does not contain mud and pebbles in its lower layers, and is free from the bodies of hibernating fish killed by pressure when the water froze. Moreover, it is from the air and not from the earth that the cold for freezing comes, and so the bottom water cannot freeze until all the upper water has frozen and current flow has ceased. In fact the bottom water is *warmed* by the earth's heat and by little springs.

Ice first forms at the sides of a river, on the surface. As more ice forms the river level falls and the original ice, its sides and surface laden with detritus from the banks, sinks to the bottom. There, melting occurs, releasing the detritus, so that the ice rises buoyantly once more and drifts downstream until blocked by some obstruction. When a number of floes are so halted the water upstream can freeze across its full width.

H. R. THOMPSON

1. Palissy, B. *Recepte véritable par laquelle tous les hommes de la France pourront apprendre a multiplier et augmenter leurs thresors.* La Rochelle, Barthelemy Berton, 1563. 130 p.
2. ——— *Discours admirables, de la nature des eaux et fonteines, tant naturelles qu'artificielles, des metaux, des sels et salines, des pierres, des terres, du feu et des emaux.* Paris, Martin le Jeune, 1580. 361 p.
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