Editor's Note:

At the XVII General Assembly of the I.A.G., Special Study Group 0.67, History of Geodesy, was established under the presidency of J.J. Levallois. Though the Bulletin Géodesique normally publishes only original scientific contributions, it was agreed that historical articles written by members of the study group would also be considered for publication. It is hoped that such papers will provide an occasional pleasant oasis. Comments are solicited.

Irene K. Fischer
301 Philadelphia Ave.
Takoma Park, Md. 20012

AT THE DAWN OF GEODESY

Abstract

The first land surveyors were rope stretchers and rope knotters, remembered in ancient documents and tomb paintings and also in some terminology. The L-shaped carpenter's square, one of the earliest and most versatile basic tools, represents the observed direction of the plumb line versus the water level and appears as the shadow-casting gnomon and also as the geometrical gnomon in magically-restricted enlargements of altars. The related "Pythagorean" theorem was known in antiquity centuries before Pythagoras, with algebraic proofs in Babylonia and China. The spherical shape of the earth, deduced from the observation of circumpolar stars, was part of a complete equatorial astronomical system in ancient China. But although shadow measurements were generally used to establish north-south distances, only the Greeks derived from them the size of the earth. The striking difference between the abstract, geometric approach of Greece and the concrete, algebraic approach of Babylonia and China represents not a difference in talents but a difference in culture-bound interests.

"Where wast thou when I laid the foundations of the earth?
Declare if thou hast the understanding.
Who determined the measures thereof, it thou knowest?
Or who stretched the cord upon it?
Whereupon were the foundations thereof fastened?
Or who laid the cornerstone thereof .... ?

Hast thou surveyed unto the breadth of the earth?
Declare if thou knowest it all.
Where is the way to the dwelling of light,
And as for darkness, where is the place thereof
That thou shouldst take it to the bound thereof,
And that thou shouldst know the paths to the house thereof?
"

Job, 38: 4–6, 18–20.

1. Ropes and Knots

The cord is the oldest surveying tool. In fact, it is a thing of many uses. No wonder that the skill of making cords and ropes from twisted fibers has been known for many thousands of years. Extant evidences are fishtrap nets of eight thousand years ago, the hauling of huge stone blocks on ancient tomb pictures, twisted rope bridles on animals, rope bridges and hunters rope traps in ancient European and South African cave drawings, etc. Its age-old use for surveying is seen on a wall painting of an ancient Egyptian tomb (−1400) where men equipped with ropes and writing material are shown measuring a grain field. A reel of rope of a specific length is mentioned in various ancient documents as a length unit. Laying the cornerstone for an Egyptian temple was a royal function and the ceremony is mentioned in documents and depicted in paintings: a king and a goddess stretch a cord between them to establish the base line, and drive stakes into the ground to fix the corners. Or the king sights the polestar through a cleft stick and the goddess holds the cord which will lay down a north–south line as the reference for the other corners. In Lagash, Sumer, a tablet was found dating from −3100, which shows also a Sumerian king laying the cornerstone.

"To stretch the rope" thus meant surveying for distance as well as direction; and tying knots into it at certain intervals will fix a length, as is familiar to us from the nautical knot, a unit for a ship's speed per hour. Knots and systems of knotted strings played a role in several cultures, not only as symbols of magic power and amulets as antidotes, but as a means, e.g., of counting the days before an awaited event by opening one knot as each day passes (Herodotus, IV, 98), of keeping tax records and business accounts, giving tax receipts, and also noting down the measurements of a survey, etc. The Incas of Peru had no writing but managed with elaborate systems of knotted strings, called quipus (meaning "knots" in their language) which name has been adopted for similar systems in other cultures. A quipu consisted of a horizontal main cord from which several strings in various colors dangled at various intervals. Knots tied into these strings varied in distance from the main cord, in size, and type of knotting. The possible combinations of all these variables under an agreed code provided mnemonic aids for the quipucamayas, the Inca government record keepers, to maintain information on administrative laws, surveys, historical traditions as well as to keep numerical accounts. Chinese records of the −3rd century tell that people in the most ancient times were governed by the aid of the quipu. Specimens of advanced quipus exist which use a positional decimal system: a special—type single knot means 1 if it is in the row most distant from the main cord, but the same knot means 10 if it is in the next nearer row, 100 in the next; there were nine strings to accommodate nine numbers in the same row of a power of 10. In another system, the type of the knot indicates the power of ten. In Egypt, the existence of professional harpedonapts (Greek: Harpedone means "rope"), that is, rope stretchers and rope knotters, is evident from inscriptions going back to −1400. The rope stretchers were the first land surveyors; they delineated boundaries at field distributions, protected the extent of private property, and were involved in the laying of cornerstones. The rope knotters were the counters and recorders. The harpedonapts may well be considered our professional geodetic ancestors.

Their fundamental role is still recognizable in some terminology. The word "line" (German: Linie; French: ligne) comes from the Latin linea, meaning basically "linen thread" (i.e. made of linum = linen, flax), and then the builder's and carpenter's rope. The Sumerian word for "line" meant "rope". The Sumerian, Akkadian, and old Egyptian words for a certain length unit meant "cord"; so did the Greek length unit.