GEOMORPHOLOGY IN STRABO'S *GEOGRAPHY*

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Modern advances in geomorphology command so much attention that ancient writings on this subject are often overlooked. Excellent works in the history of science, such as the geological source book of Mather and Mason,[1] frequently include only contributions of the past three or four centuries. Although, apparently, little heed is now paid to early considerations of landforms and their development, this was not always the case. Some of the greatest contributors to earth science in the nineteenth century were well aware of the considerable understanding among the ancients regarding geomorphological processes. Thus, Sir Charles Lyell[2] commends Strabo of Amasia for anticipating some of the conclusions of modern earth science. Strabo is praised by Alexander von Humboldt[3] and Sir Archibald Geikie[4] also calls attention to the sagacious observations of Strabo upon the physical earth.

Among ancient writings on geomorphology Strabo's *Geography* is of special value because, in addition to stating his own views, the author comments upon or summarizes earlier work in earth science, much of which is lost to us in the original. An examination of Strabo's writings, therefore, provides a good basis for understanding early concepts of landform genesis, process and change.

Our knowledge of Strabo's life is based on scattered references in his *Geography*. He was born at Amasia in Pontus (northeast Turkey) about 63 B.C. Strabo was partly Greek by ancestry and received a good Greek education; at different periods of his life he was a student of Aristodemus (tutor of Pompey's sons), of Tyrannion (tutor of Cicero's sons) and of Xenarchus. Probably under these teachers Strabo developed an interest in the physical earth, but this was undoubtedly stimulated by his extensive travels. According to his own testimony, Strabo journeyed from Armenia to Tuscany and from Pontus to Ethiopia (2:5:11).[5] He was familiar with a number of the important cities of the Mediterranean and resided for considerable periods in Rome and Alexandria. While in Egypt he traveled up the Nile as far as the First Cataract.

It was probably after his return to Pontus that Strabo devoted himself to the writing of his encyclopedic *Historical Memoirs*. This great compilation, which consisted of forty-three volumes on ancient history, is lost to us except for fragments included in the work of other authors or in Strabo's

[1] Kirtley F. Mather and Shirley L. Mason, *A Source Book in Geology* (New York, McGraw-Hill, 1939), p. vii.

[2] Charles Lyell, *Principles of Geology* (London, J. Murray, 1830), Vol 1, p. 18.

[3] Alexander von Humboldt, *Kosmos* (Stuttgart and Tubingen, J G. Cotta, 1845), Vol. 1, p. 223.

[4] Archibald Geikie, *The Founders of Geology* (London, Macmillan, 1905), p. 18.

[5] Numbers in parentheses within the text refer respectively to book, chapter, and paragraph in *The Geography of Strabo* (Loeb Classical Library) with an English translation by H. L. Jones (London, William Heinemann).

own surviving writings. After finishing the history Strabo commenced his *Geography,* which may have been completed only a short time before his death in 20 A.D.

Except for minor omissions, Strabo's *Geography* has come down to us complete. The whole work consists of seventeen books in which the author attempts to bring together all geographical knowledge of his day. The first two books, which are topical and systematic in character, form a general introduction to the subject. In the remaining fifteen books Strabo is concerned mainly with regional description, treating first Europe, then Asia and finally Africa.

It is difficult to form any reliable estimate of Strabo's own contribution to earth science. Mathematical geography he neglects entirely except where he disputes the opinions of others or reports their findings, but as the result of this we are indebted to Strabo for part of our knowledge of the work of Eratosthenes, Hipparchus and Poseidonius. In addition to these authorities, Strabo cites the work of a score of other Greek natural philosophers. Strabo's *Geography* was a popular work among European scholars in the later Middle Ages. Among more recent admirers of Strabo's writings was Napoleon Bonaparte, who authorized an important French translation of the *Geography*.

Accepting cosmological ideas prevailing among Greek philosophers who preceded him, Strabo believed in the geocentric theory of the universe (2:5:2). Although according to this view the earth is regarded as a motionless planet, Strabo understood that the *surface* of the earth is constantly undergoing change. He reports the opinion of Eratosthenes that successive changes in the form of the earth have been occasioned by water, fire, earthquakes and eruptions, but criticizes the earlier author for over-emphasizing the magnitude of the resulting surface irregularities (1:3:3).

Echoing the ideas of other writers, Strabo asserts that land and water do not remain in fixed places. As evidence of that he notes the occurrence of marine fossils and salt beds at considerable distances from the sea, and quotes the opinions of several earlier authorities on the matter. In particular, Strato the Philosopher is cited by Strabo as believing that the water levels of different seas vary and that there had been changes of water level in the past (1:3:4). The Black Sea, Strabo suggested, was formerly without an outlet and had received so much water from rivers emptying into it that the surrounding land had been flooded.[6] Eventually a natural passage was forced through the Dardanelles, the water level lowered, and fossils which had been deposited along the old shore zone were revealed to view. Strato applied a similar explanation to the Mediterranean Sea which, he thought, had broken its banks at Gibraltar and left large areas, especially in the Levant, dry, fossiliferous and saline. Strabo rejects Strato's thesis, and proposes instead that it is the level of the *strata* on which the waters rest, rather than the water level itself, which changes (1:3:5). Of this idea of Strabo's, Lyell[7] writes enthusiastically.

[6] The hydrological cycle was not understood until the late seventeenth century, notably under Edmund Halley.

[7] Lyell, *loc. cit.*

Strabo had unusually good opportunities for observing the effects of vulcanism in Italy, and gives accounts of the phenomena in that country, in Sicily and in Greece. He was aware of the volcanic nature of the Naples area and in his description of Vesusvius informs us that the character of the rocks suggests that in the past it had been in an active state (5:4:8).[8] However, like his predecessors he believed that volcanoes became extinct because of lack of fuel. Strabo noted the similarity between the Naples region, the Lipari Islands and the region around Etna in Sicily. In one place he expresses the opinion that certain of the offshore islands were built up from the sea by volcanoes rather than broken off from the mainland as suggested by other authorities (1:3:10). Before the formation of Etna, Strabo reports, the Strait of Sicily suffered greatly from earthquakes, but, because the large crater and its subsidiary cones act as safety valves, shocks had become less frequent and less severe (6:1:6). Commenting upon this, Geikie[9] observes, "The doctrine that volcanoes are safety valves, which was once thought to be a modern idea, is thus at least as old as the beginning of the Christian era." Strabo relates Poseidonius' eye-witness account of the formation of a small volcano in the Lipari archipelago. In this connection Strabo comments on the relationship between winds and vulcanism, a belief widely held by the ancients. Volcanoes were thought to be caused by winds trapped below the earth which were fanned into activity by surface winds (6:2:8).

Most of the allusions to vulcanism in the *Geography* refer to the Tyrrhenian region, while his examples of seismic activity are taken largely from the eastern Mediterranean. Strabo calls attention to a number of cases of the destruction of cities by earthquakes (1:3:19,20). There are some references to the opening up of fissures, to the effects of seismic sea waves and to temporary or permanent disturbance of drainage patterns. Examples are noted of earthquakes associated with and of those independent of vulcanism. He reports that certain peaks in Laconia were said to be broken off during an earthquake shock. The same agency is reported to have been responsible for the destruction of Helice and of an extensive coastal plain seaward of the city (8:7:2).

A specific example of the alteration of drainage resulting from diastrophic activity is cited as occurring in Arcadia, where the Ladon River apparently had its sources stopped for a short period (8:8:4). More dramatic was the case of the Peneius River of Tempe in Thessaly which, after a chasm had been formed following an earthquake, changed its course to drain an area that had formerly been the bed of a lake (9:5:2). Strabo reports several cases of rivers going underground after earthquakes had taken place, but makes no clear distinction between that type of occurrence and underground drainage resulting from solution in limestone country. Hot springs are described in several localities, and examples are noted of the formation of minor features attributed to the deposition of materials carried in solution (13:4:14).

It is not surprising that there are many myths concerning the origin and development of rivers since they are so important to human life. As in

[8] Vesuvius was soon to demonstrate again its destructive powers (79 A.D.).
[9] Geikie, *op. cit.*, p. 19.

the case of other features, Strabo regales his readers with fabulous accounts of streams, but is usually careful to label them stories. Strabo discusses the character of many European and Asiatic rivers; his treatment of the Nile delta, an area he knew well, is particularly detailed. It has already been suggested that, apparently, the ancients did not understand the hydrological cycle; the significance of evaporation escaped them, but the more obvious parts of the cycle—precipitation, to stream, to sea—are well treated in the *Geography*. Strabo is aware of the causes of seasonal variation in the flow of river water, indicates the character of streams in different parts of their courses, and even hints at valley formation. There are also many references to delta construction in the *Geography*.

Since there was knowledge of the sources as well as the courses of European rivers, perhaps the most satisfactory explanation of the nature of streams is in connection with those. For example, Strabo notes that the Po River rises in the Alps, where it is a mountain torrent, becomes gentler in its middle course and is sluggish in its lower reaches where material is deposited along the banks (4:6:5). He mentions that the current of the Rhine is so swift that it is difficult to bridge the river and that its lower floodplain is as wide as Germany (7:1:3). Mediterranean streams are described as being most swollen and having greatest erosive power in winter.

The tortuous and changing course of the Maeander River is vividly described by Strabo. He attributes its serpentine nature to the fact that it traverses a level plain where it becomes choked by the materials it brings down. The plains of the Hermus, Cayster and Caicus, as well as that of the Maeander, have all been formed of soft soil deposited by the rivers which flow through them, Strabo asserts. A few instances are given of erosion in the upper parts of streams; for example, the headwaters of several rivers of Thessaly are specially mentioned as forming the ravines through which they flow (9:4:14).

In his introduction Strabo calls attention to the age-old problem of the sources of the Nile and suggests that the river rises in the Ethiopian Mountains. He quotes Herodotus' statement to the effect that Egypt is the gift of the Nile, a reference to the fact that the region of fertile soils is coincident with the margin of the alluvium deposited during annual inundations (1:2:23, 24). Strabo describes a device for measuring the rising of the Nile, a nilometer, and observes that, although there is variety from year to year, there is also a certain order and regularity in the flow of water (17:1:48). He is aware that the plain of the Nile has been built up by accumulations of silt over long periods of time.

When considering the origin of the Stony Plain in Southern France, Strabo reports Aristotle's diastrophic and Poseidonius' aqueous explanation of the development of the feature; he admits the reasonableness of both of these theories (4:1:7).

Strabo merely describes the dry-land features of Asia without attempting to explain their development, since he had not visited these desert areas. However, in an account of a sandstorm in Egypt Strabo hints at the abrasive action of particles of sand carried by the wind. Depositional work of the wind is recognized as being responsible for the formation of

sand dunes which resulted in the partial burial of the sphinxes (17:1:32).

The ephemeral nature of lakes appears to be understood by Strabo. He reports a number of cases of plains being flooded; conversely, several level areas are recognized as the beds of former lakes.

In few locations are the dynamics of geomorphology better displayed than on coasts. The margins of the almost tideless Mediterranean Sea, however, are not prime areas for observing the work of wave erosion, one of the most potent processes in coastal development. It is quite otherwise with coastal deposition, which is well exemplified in the Mediterranean region, and the causes and effects of sedimentation are treated in some detail in the *Geography*. Strabo, depending on the accounts of others, informs us of the great tidal ranges experienced along the Atlantic coasts of Spain and Mauretania (17:3:3). He describes the ria coasts of Spain and calls attention to the rapidity with which tide water fills and flushes those inlets. Like earlier writers, Strabo was aware of a relationship between the phases of the moon and the tides, but could not provide an adequate explanation for that phenomenon (3:5:8).

Within the Mediterranean itself, Strabo notes the effects of the configuration of the coasts on the course of currents. The manner in which waves break he attributes to the character of the sea floor immediately offshore (17:1:6). In discussing deltas, Strabo continually makes comparisons with the great example he knew best, the Nile delta. He mentions that Homer did not consider it worth mentioning that the Nile has many distributaries, since that is a common feature of other rivers (1:2:30). Strabo gives an excellent description of the form of the Nile delta and observes that at the time of flood it resembles a sea with the higher spots, where settlements are located, appearing as islands (17:1:4). All rivers, he assures us, show a tendency to deposit materials at their mouths, but the amount of deposition is determined by the quantity and speed of the water, and the character of the materials over which the river flows (1:3:7).

Strabo calls attention to the flatness of the country around the Rhone delta, where channels have to be artificially cleared of sediments to render the port of Marseilles navigable (4:1:8). Similar reports are made of the Po delta, and in both instances attention is paid to the salt water lagoons of these coastal areas. The formation of the numerous lagoons at the coastal margins of the Po delta Strabo atrributes to the ebb and flow of the tide at the head of the Adriatic, the only area in the Mediterranean which he believes has tidal conditions at all comparable with those in the Atlantic (5:1:5).

Constructional features described in the *Geography* include alluvial coastal plains and spits. The Tiber, Strabo suggests, brings down material deposited to form the coastal plain seaward of Ostia and Antium. These two cities were formerly ports, he notes, but by his time had lost that function due to the accumulation of sediments resulting in the formation of coastal marshes. When considering the Troad in Asia Minor, Strabo estimates the amount of growth of a coastal plain in a given time (13:1:36). It is his belief that there is a definite limit to the distance to which sediments can be carried into the sea, being prevented from further migration by the ebb and flow of tides (11:3:8, 9). There are several

references in the *Geography* to the attachment of offshore islands to the mainland by spits. A complex tombolo is reported as developing at the mouth of the Achelous river, where some of the Echinade Islands have already been captured, a fate, Strabo assures us, which awaits all of them.

Whatever opinions we may entertain with respect to Strabo's original contribution to geomorphology, we may well be impressed by the range of features he discusses and by some of the explanations offered. He deals with cataclysmic and, perhaps more important, with progressive change. Strabo recognizes a dual dichotomy in geomorphology, a science at once descriptive and nomothetic, systematic and chorographic. If, at times, Strabo was less critical than were those whose work he reports, at least we should be grateful to him for providing us with those accounts. Strabo's considerations of landforms contained in the *Geography* might have been expected to stimulate investigations from which more sophisticated conclusions might be drawn, but many centuries elapsed before great advances were made in geomorphology, even though promised so early by the efforts of the Greeks.