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## **A Changing Earth. Strabo and Leonardo's Scientific Humanism**

Domenico Laurenza

Leonardo and Michelangelo produced representations of the Deluge almost in the same years. It is difficult to imagine something more opposite (fig. 1-2). The human figure dominates Michelangelo's anthropocentric vision, with the landscape reduced to just a few hints. On the other hand, in Leonardo's image, the human presence is lost in the preponderant landscape and in the dynamism of the natural elements of earth and water. This dynamic vision was also at the very center of Leonardo's geological studies, one of the most original yet least studied aspects of his scientific work.

Mountains first formed and then were eroded by water to form valleys, caverns, and ravines. Rocks turned into smaller stones and then grains of sand. Lands first covered by the sea were then exposed to the air. Above all, the initial, sudden and catastrophic emergence of the mountains and the dry land from a sea that at the beginning occupied the whole surface of the earth. According to Leonardo, the body of the earth, in the likeness of the human body, undergoes continuous processes of change, birth, growth, consumption and aging.

For centuries an opposite vision had prevailed. In antiquity, according to the ancient Greek philosopher Aristotle (384/383-322 B.C.), the universe and the earth were eternal, with no beginning and no end and therefore with *no history* of their own. All the changes happening on the earth were cyclical, secondary, superficial and merely local phenomena. Later, a biblical and Christian vision spread the idea of a

land which had remained substantially unchanged from the moment of divine creation, apart from the unique episode of the Deluge.<sup>1</sup>

From an historical point of view the idea that the Earth changed over time, that it had a ‘history’ and its present aspect was not the one created by God, is one of the most important innovations contained in Leonardo’s work..

What I wish to show in the following pages is that in the case of Leonardo, this new geological vision also had an important classical, humanistic root.

Among the more interesting expressions of Leonardo’s historical vision of the earth are the spectacular passages of the Codex Leicester (Seattle, Bill and Melinda Gates Collection) in which he describes the past, present and future history of the Mediterranean Sea.<sup>2</sup>

According to Leonardo, in the beginning the Mediterranean was a sea completely closed, with no connection to the ocean. Surrounded, like a mighty lake, by a continuous ring of lands, it was fed by the great rivers of Europe, Asia and Africa. In this ancient period its water level was higher and it covered many Italian

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<sup>1</sup> P. Duhem, *Le Système du Monde. Histoire des doctrines cosmologiques de Platon à Copernic*, 10 vols., Paris 1913-59, in part. vols. 8 e 9; F. Ellenberger, *Histoire de la Géologie*, Tome 1, *Des Anciens à la première moitié du XVII<sup>e</sup> siècle*, Paris 1988; E. Grant, *In Defense of the Earth’s Centrality and Immobility: Scholastic Reaction to Copernicanism in the Seventeenth Century*, Philadelphia 1984; Idem, *Planets, Stars, and Orbs: The Medieval Cosmos, 1200-1687*, Cambridge 1994, Chapter 20; D. Wootton, *The Invention of Science. A New History of the Scientific Revolution*, Penguin Books 2016. pp. 110-159; L. Bianchi, *L’inizio dei tempi. Antichità e novità del mondo da Bonaventura a Newton*, Firenze, 1987; C. P. E. Nothaft, 'Origen, Climate Change, and the Erosion of Mountains in Giles of Lessines’s Discussion of the Eternity of the World (C. 1260)', *The Mediaeval Journal* 4 (2014), no. 1, 43–69. I. Dal Prete, ‘ “Being the World Eternal ...”: The Age of the Earth in Renaissance Italy’, *Isis*, 105 (2014), no. 2, 292-317.

<sup>2</sup> D. Laurenza, *Geology in the Codex Leicester*, in P. Galluzzi (ed.), *Leonardo da Vinci's Codex Leicester: Water, the Microscope of Nature*, cat. exh Florence (Uffizi), Florence 2018, pp. 154-169; Idem, ‘*Of the earth in itself: Leonardo’s “geology” or towards a history and anatomy of the earth*’, in D. Laurenza and M. Kemp (eds.), *Leonardo da Vinci. The Codex Leicester. A New Edition*, 4 vols., Oxford forthcoming.

lands, including most of the Apennines, with only the higher summits emerging like islands. In Egypt Memphis was on the seacoast and in North Africa the sea reached the Atlas Mountains.<sup>3</sup>

Subsequently a more or less sudden and catastrophic event occurred, precipitated by a long period of action on the land by weather and erosion from water. The dam-like rocks at Gibraltar ruptured and the waters of the Mediterranean began to stream into the ocean. As a consequence of this opening at Gibraltar, the level of the Mediterranean Sea decreased, disclosing lands that were previously submerged. This is one of the causes adduced by Leonardo to explain the presence of marine fossils in mountains.

A drawing in the Codex Atlanticus (fol. 901r; fig. 3) represents the first part of this history: the Mediterranean Sea, indicated by the tinted wash, covers wide areas of North Africa, together with Piedmont, Lombardy and Tuscany and part of the Roman area in Italy. The wash covers inland areas of Italy where Leonardo had found marine fossils, and the map is therefore based at least in part on direct observations.

Leonardo also outlines the ultimate end of the history of the Mediterranean. Eventually the rivers that created it with their waters will also cause its end: by unloading sediments in it, they will cause an advancement of the coastline and a progressive silting up of the sea. Eventually the bed of the Mediterranean will be completely exposed to the air.

The Codex Leicester contains similar reconstructions of the history of the Black Sea, the Danube valley (f. 1v), the Adriatic Sea with the river Po (ff. 10r, 27v), the Red Sea (f. 31r) and the Persian Sea (f. 31r).

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<sup>3</sup> Codex Leicester, fols. 10v, 31r, 17v.

The description of the changes that had occurred in these areas contain very precise geographical names, following Ptolomy's *Geography*.<sup>4</sup> But the *Geography* by Ptolomy, the great Greco-Roman mathematician, astronomer and geographer who lived in the second century A.D. does not explain Leonardo's historical account of the Black Sea. Ptolemy's book is basically a list of names of places with indications of their correct representation in a map. It is neither descriptive nor historical geography. These are instead the main features of another masterpiece of classical science, the *Geography* by Strabo, who lived between the end of the first century B.C. and the beginning of the first century A.D. (58 B.C.-c. 25 A.D.). The humanists rediscovered both works in the Renaissance.

Lucretius (*De Rerum natura*, esp. Book 3), considers an origin and an end of "our" world, but within a philosophical and cosmological discourse, devoid of "geological" and "geographical" data. The latter are present in Seneca (*Quaestiones naturales*, esp. books III, IV and VI) but as a description of the current state of the earth without a general historical sense, moreover neutralized by the Stoic cyclical conception of a continuous birth, death and rebirth of a world that is always equal to itself.

In general the birth of modern science in the Renaissance drew upon humanistic roots. The rediscovery of the great classical scientific works provided models to be emulated and even surpassed by modern scientists. The new geography benefitted from the rediscovery of Ptolemy, just as the new anatomy and geometry benefitted respectively from the rediscovery of the classical anatomist Galen and of the classical mathematician, Euclid. By contrast, the specific role played by the humanistic rediscovery of Strabo for the birth of modern geology and his influence on

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<sup>4</sup> G. Calvi (ed.), *Il Codice di Leonardo da Vinci della biblioteca di Lord Leicester in Holkham Hall*, Milan 1909, xix-xxii.

Renaissance geography has not been fully elucidated<sup>5</sup> and this explains why the importance of Strabo for Leonardo's geological vision has been underestimated so far.<sup>6</sup> Strabo's *Geography* was translated from Greek into Latin for the first time toward the middle of 15th century by the humanist Guarino da Verona (1370-1460). This translation was printed in several editions, starting in 1472, and the reception of Strabo was particularly strong in Tuscany and papal Rome<sup>7</sup>.

Strabo's treatise, especially Book 1, contains extensive description of changes that occurred in two geographical regions: the Mediterranean Sea and the Black Sea. The starting point for these descriptions are the marine fossils found far from the sea, in inland Egypt and in the inland of areas to the South and East of the Black Sea (corresponding approximately to modern Turkey and Armenia).<sup>8</sup> Correctly understanding fossils as evidence of ancient marine animals, Strabo concluded that in the past these regions were covered by the Mediterranean Sea and by the Black Sea.

One thing has to be underlined: Strabo considers these changes as specifically local, with no wider implications for the general history of the earth. He writes: 'such changes...do not in any particular alter the earth as a whole; changes so insignificant

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<sup>5</sup> P. Gautier Dalché, The reception of Ptolemy's Geography, in D. Woodward, *The History of Cartography*, Chicago 1987, 285-364, esp. 311 n. 175: 'The history of the Italian humanist' confrontation of Ptolemy's and Strabo's opinions has not yet been written; there are no real studies of the reception of Strabo'.

<sup>6</sup> Short mentions in E. Solmi, 'Le fonti dei manoscritti di Leonardo da Vinci', in: *Scritti Vinciani*, Florence 1976 (1908 e 1911) 267; Calvi *op. cit.* (note 4) xxi and n. 1; P. Duhem, *Léonard de Vinci. Ceux qu'il a lus et ceux qui l'ont lu*, Paris 1906-1913, 2nd serie 1909, 293-4; V. P. Zubov, *Leonardo da Vinci*, Cambridge 1968, 229.

<sup>7</sup> E. B. Fryde, *Humanism and Renaissance Historiography*, London 1983, 55-82; H. L. Jones, *The Geography of Strabo*, London 1917, xli-xlii; Gautier Dalché *op. cit.* (note 5) and Idem, *La Géographie de Ptolémée en Occident (IVe-XVIe siècle)*, Brepols 2009, 246-7 and 403; , G. Aujac, 'La géographie grecque durant le Quattrocento : l'exemple de Strabon', *Geographia antiqua : rivista di geografia storica del mondo antico e di storia della geografia*, 2 (1993), 147-169; J. Larnier, 'The Church and the Quattrocento Renaissance in geography', *Renaissance Studies*, XII (1998), 26-39; D. Dueck (ed.), *The Routledge Companion to Strabo*, London/New York 2017.

<sup>8</sup> *Geography*, 1.3.4; ed. Jones, *op. cit.* (note 7).

are lost in great bodies'.<sup>9</sup> The general vision is therefore still that of Aristotle, namely the anti-historical vision of an earth with no beginning or end, altered only by superficial changes.

Notwithstanding his reservations, the space given by Strabo to local changes is much greater than, for example, in Aristotle's *Meteorology* and its later tradition. Strabo, besides presenting his own theories, quotes and examines critically those by previous authors (Eratosthenes, Strato and Xanthus of Lydia). In so doing, he reports a series of possible explanations for the lowering of the Mediterranean Sea and of the Black Sea. According to the theory by Strato (c. 335-269 a. C.), shared by Eratosthenes (276-194 a.C.), there was once no communication at the Bosphorus between the Black Sea and the Mediterranean, and no connection at Gibraltar between the Mediterranean Sea and the ocean. It was the long-term pressure of the waters unloaded by the rivers into the Black Sea and into the Mediterranean that was to rupture the rocky barriers at those two points, enabling the waters of the Black Sea and the Mediterranean to surge outwards, leaving uncovered extensive regions in Turkey and Egypt.<sup>10</sup>

Thus, Strabo's *Geography* contains a rich reconstruction of the changes that occurred over time in the Mediterranean and the Black Sea. This dynamic vision, though limited in scope to local factors and inserted into an eternalist and anti-historical vision of the earth, exerted a strong influence on and inspiration for Leonardo's geological vision.

Leonardo's notable use of Strabo, like any act of scientific humanism simultaneously involves imitating and surpassing. Let's examine the former aspect first.

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<sup>9</sup> *Geography*, 1.3.3; ed. Jones, *op. cit.* (note 7).

<sup>10</sup> *Geography*, 1.3.4. Ed. Jones, *op. cit.* (note 7).

Leonardo's description of the opening of Gibraltar due to the pressure of the water in the Mediterranean and the consequent lowering of that sea, mentioned at the beginning of this paper, is very close to that attributed by Strabo to Strato. Even Leonardo's conception of the end of its history, with the Mediterranean almost totally silted up (Codex Leicester, ff. 10r, 17r, 20r) is basically an extension of Strato's theory on the future of the Black Sea. In fact, most of folio 31r of Leonardo's Codex Leicester is a free and original development of topics treated by Strabo in a section of Book 1 of his *Geography*.<sup>11</sup> For example, Strabo reconstructs the history of the Red Sea in relation to the Mediterranean.<sup>12</sup> In origin the Mediterranean poured into the Red Sea, but later on, after the opening of Gibraltar, it was lowered, the communication between the two seas ceased and the Red Sea remained at the same height as the external ocean. This is Strabo's reconstruction. Similarly, Leonardo writes, 'the Mediterranean water poured for long time into the Red Sea', until 'Hercules came to open the sea to the west [at Gibraltar], and then the marine waters began to pour into the western ocean, and, because of this great lowering, the Red Sea remained higher'.<sup>13</sup>

It is also apparent that the way Leonardo lists marine fossils (for example: 'oysters and sea snails and turbinated shells and bivalves' -- *l'ostriche e li nichi e bovoli e cappe* 1v) is close to that provided by Strabo ('mussel-shells, oyster-shells and scallop-shells' -- *concharum ostreorumque & cheramydum multitudo*<sup>14</sup>). Strabo also notes the remains in inland Egypt of ships (*fragmenta navium*), just as Leonardo

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<sup>11</sup> *Geography*, 1.3.11-15. Ed. Jones, *op. cit.* (note 7).

<sup>12</sup> *Geography* 1.3.11 and 1.3.13. Ed. Jones, *op. cit.* (note 7).

<sup>13</sup> Codex Leicester, fol. 31r. Transl. from Laurenza and Kemp edition, forthcoming.

<sup>14</sup> Book 1, p. xiiiir in the Latin edition published in 1510. English transl. from Jones edition, 1917, p. 181.

describes the finding of the remains of ancient ships in inland locations in North Italy (9v).<sup>15</sup>

But the influence of Strabo is only one side of the coin. The work by Strabo is for Leonardo a model to be developed and corrected in emulation of the *principles* of investigation demonstrated by such ancient authors. Just as Andreas Vesalius, the great reformer of Renaissance anatomy, can be seen as more truly ‘galenic’ in spirit than the more literal Renaissance galenists--subjecting the great classical anatomist to admiration and criticism in equal measure--Leonardo can be said to be more ‘strabonian’ than Strabo. Leonardo extended his historical reconstruction to geographic areas not considered by his classical model. Strabo and other ancient writers concentrated on two inland regions where the finding of marine fossils suggested the former presence of seas: North Africa in the vicinity of the Mediterranean, and the regions immediately surrounding the Black Sea (Turkey, Caucasus, Caspian Sea and mouths of the Danube). Leonardo instead studied marine fossils in inland Italy and he also considered marine fossils along the Danube valley, from the Black Sea as far inland as Austria. Then, emulating his classical model, and using such empirical data, Leonardo reconstructed the geological history of these regions.

If the fossils found in Tuscany and other areas on the Tyrrhenian side of Italy confirmed the lowering of the Mediterranean as suggested by Strabo, the fossils found in other areas allowed for new hypotheses for areas not considered by Strabo. For example, fossils in Lombardy and Piedmont were evidence for the fact that the Adriatic Sea once touched the Alps. Later on the sea was lowered and left lands

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<sup>15</sup> See, for comparison, Ovid (*Metamorphoses*, book 15, 262-265): “Often sea-shells lie far from the beach, and men have found old anchors on mountain-tops” (“Et procul a pelago conchae iacuerunt marinae, et vetus inventa est in montibus ancora summis”).

uncovered, traversed only by the waters of the river Po (Codex Leicester, ff. 10r and 8v). In the future the remaining waters of the Adriatic Sea will also completely disappear, because of the processes of silting up due to the Po.<sup>16</sup>

Likewise, Leonardo formulated a magnificent vision of the reconstructed history of the Danube valley and the Black Sea in the light of new travels and fresh empirical findings of marine fossils in Northern Europe. To the south the area later corresponding to the Danube valley was limited by a long mountainous chain that extended along the Balkans. This continuous chain of mountains prevented most of the water of the Black Sea from exiting. As a consequence in the distant past the sea once extended a long way to the north, even as far as Austria. Then, over time, erosion by water permanently augmented the previously narrow exit, causing more and more water to flow into the Mediterranean. The Black Sea was thus lowered, uncovering Austria, the Balkans and the Carpathians and leaving only the Danube. The finding of marine fossils led Leonardo to include these regions among those formerly occupied by the Black Sea.<sup>17</sup>

Therefore, by emulating Strabo's model, Leonardo radically extended the geo-historical map of the world, substantially increasing the submerged regions as previously defined by the classical geographer.

On the basis of his expanding knowledge of distant countries, Leonardo emulated and extended the classical model of Strabo, and devised one of the earliest theories of a history of the earth. And he went much further, by developing, on the basis of Medieval authors such as Buridan, a much wider vision of global change in

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<sup>16</sup> 'How the river Po in short time will cause the Adriatic Sea to dry up, in the same way it dried up a great part of Lombardy' (fol. 27v). Transl. from Laurenza and Kemp edition, forthcoming.

<sup>17</sup> Codex Leicester, f. 1v.

the history of the earth, with the mountains rising from an earth originally totally covered by water.

Coming back to Strabo, we do not necessarily have to assume that Leonardo read in detail all the Latin text of Strabo's *Geography*. It is possible that a learned friend discussed Strabo with him or that he had access to a paraphrase of the classical geographer's general ideas, especially those outlined at the beginning of his long treatise (Book 1). It is known that Leonardo studied the ancient classical mathematician Euclid in this way, with the help of his friend and mathematician Luca Pacioli. However, by the time of the Codex if not before he could probably struggle his way through Latin if he had to, and there are many signs here and elsewhere that he drew upon Latin sources that were not translated.

A good number of Tuscan humanists were interested in Strabo. A possible indication of contact with this cultural context is a memorandum from the time of the Codex Leicester in which Leonardo reminds himself to ask 'Maestro Maffeo' about the periodic flood of the river Adige (F, first cover verso: 'ask maestro Mafeo why the river Adige rises every 7 years and lowers every 7'; *da maestro Mafeo perché 7 anni l'Adice alza e 7 abbassa*, c. 1508). This might refer to Raffaello Maffei (1451-1522), author of an encyclopedia published in 1506, which included geographical sections in the descriptive style of Strabo. Maffei was Roman, but was in frequent contact with Tuscany where he died, and he was buried in Volterra<sup>18</sup>.

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<sup>18</sup> S. Benedetti, 'Raffaello Maffei', in *Dizionario Biografico degli Italiani*, vol. 67, Rome 2006; G. Toliás, *Maps in Renaissance Libraries and Collections*, in Woodward, *op. cit.* (note 5), 637-660.

Strabo's treatise is not among Leonardo's surviving book lists, nor he is explicitly quoted in his manuscripts.<sup>19</sup> Leonardo's booklists seem to signal books specifically in store and do not necessarily include all the books he possessed. Moreover, the absence of a book from a private library does not necessarily imply ignorance of a text.

In any case, Strabo's role as a stimulus for Leonardo's elaboration of a new dynamic vision of the earth was, as I hope to have shown, remarkable.

Regarding the artistic repercussions of this dynamic geological vision elaborated in the margin of Strabo's classic model, there are studies, usually the work of geologists or historians of geology, which have attempted to accurately identify the shape of rocks and stones in masterpieces such as the Virgin of the Rocks. I would personally be more prudent. The careful representation of rocks and pebbles is an aspect common to many other Renaissance artists. Both as an artist and as a scientist, Leonardo is not very interested in representing the details of rocks, stones and fossils, unlike other Northern European artists and later scientists. Perhaps, in Leonardo's late landscapes behind the Mona Lisa or the Louvre Saint Anne, it is the pictorial sense of fluidity that retains, portrays, something of his geological vision, rather than the detailed representation of rocks and stones.

However a more direct artistic transfiguration of his geological vision is represented by the drawings of the Deluge series. It is probably not by chance that they are drawings of a more private nature. Some of the Deluge drawings actually look like artistic images based on the recombination of events focused on his

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<sup>19</sup> The most important lists of books are in Codex Atlanticus, fol. 559r and Codex Madrid II, fols. 2v-3v. See C. Vecce, *La biblioteca perduta. I libri di Leonardo*, Roma 2017.

scientific research. Leonardo seems to give an account not only of the destructive effects of the dynamic water-earth interaction, but also of the constructive ones. For example, the rocks shaped like blocks seem to allude to their original formation as layers of silt and sand deposited at the bottom of the sea. Some art historians have pointed out some ‘pagan’ or classical aspects of Leonardo’s Deluges, for example based on their connection with passages he wrote on mythological subjects.<sup>20</sup> Likewise, one of the roots of the earth's dynamic vision that Leonardo develops in his geological studies is of classical origin and seems given, as I have tried to demonstrate, by the dynamic geography transmitted by Strabo.

## FIGURES

### Figure 1

Leonardo da Vinci, *Deluge*, drawing, black chalk, pen and ink, wash, with touches of white heightening, mm. 270 x 408, Windsor Castle, Royal Collection RCIN 912376 (photo: Windsor Castle, Royal Collection), c. 1513-16.

### Figure 2

Michelangelo, *Diluvio universale*, fresco, Rome, Sistine chapel ceiling, c. 1508-10.

### Figure 3

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<sup>20</sup> P. C. Marani, *Leonardo. Una carriera di pittore*, Milano 1999, 321-335.

Leonardo da Vinci, *Geologic map of the Mediterranean*, drawing, pen and ink and wash on coarse brown paper, Codex Atlanticus, fol. 901r, mm. 86-104 x 155-229, detail, Milan, Ambrosiana Library (photo: Ambrosiana Library), c. 1515.



