ANAXIMANDER'S LEGACY AND THE STABILITY OF THE EARTH

Carlo Rovelli, *Anaximandre de Milet ou la naissance de la pensée scientifique* (Paris: Dunod, 2009).

Anaximander openly criticized Thales. One of the main themes of Rovelli's study is that the discovery of free critique and dialogue was the cultural basis of the birth of science. This open criticism, which never loses respect for the one who is criticized, is the essence of the scientific method (p. 96). Having read these lines I felt free to write this rather critical review. It does not mean that I do not agree wholeheartedly with Rovelli's main thesis about the conclusive importance of Anaximander's legacy.

Anaximandre de Milet ou la naissance de la pensée scientifique is a book written by a theoretical physicist working in the field of quantum gravity who tries to evaluate Anaximander's work from the position of a modern scientist. It is the (slightly revised) translation of the Italian original that is freely available on the Internet: http://www.cpt.univ-mrs.fr/~rovelli/anassimandro. An extract in English, *Anaximander's Legacy*, can be found in *Collapse. Philosophical Research and Development*, Volume V, ed. by Damian Veal (Falmouth U.K.: Urbanomic, 2009) 50–71. The author has the sympathetic intention to help narrowing the abyss that nowadays separates the two cultures of the humanities and the sciences, which are so stupidly blind for one another (p. 55). His main thesis is that Anaximander stood at the cradle of science. The book consists of two parts. The first is a discussion of some of Anaximander's ideas as a kind of science awakening. The second part contains the author's ideas of what science really is. The scope of *Hyperboreus* does not allow to go too deep into the second part, so I will restrict myself mainly to the first one.

Rovelli uses Anaximander to illustrate his own ideas about what science and scientific method are or should be. The great religious disciples (the prophets of the Old Testament, Paul of Tarsus, Kaundinya, Mencius) never criticized their masters (Moses, Jesus, Buddha, Confucius), Anaximander, however, criticized his master Thales by denying that water is the principle of everything. This is essentially the scientific attitude which consists in studying and understanding the masters, rectifying their errors, and accordingly understanding the world somewhat better (p. 80–82). I wonder whether the dividing line is so sharp as Rovelli maintains. One may, for instance, truthfully read the teachings

of Jesus and Paul in the New Testament as a respectful criticism of the Old Testament of Moses and the prophets: Jesus is the fulfillment of Moses' law, he is the new Adam, he is the promised Messiah, his message is not only for the Jews, but for all mankind, etc.

For Rovelli science, which consists of exploring the ways of understanding the world, always being prepared to challenge our so-called certainties, is one of the most beautiful adventures of mankind (p. 124). This attitude is expressed by the awareness of our fundamental ignorance, which allows us to question what we think to know and thereby to learn more (p. 122). This is how Anaximander, as Pliny says, "opened the gates of nature": he initiated a revolution by opening the way of scientific thinking (p. 7, 104, 129).

God or gods don't play a role in Anaximander's treatise about nature, and the same holds for science. The essence of Anaximander's achievement, Rovelli says, we find already in the way he describes meteorological phenomena like rain, thunder, and lightning, which are explained without making an appeal to the gods (p. 46). This is, in short, what characterizes science: looking for nothing but natural explanations for natural phenomena. In other words: understanding the world without appealing to the gods (p. 139–150). An important way of scientifically understanding nature is to imagine theoretical entities that are not directly perceptible to the senses, but are postulated to account for the complexity of the phenomena. This is, according to Rovelli, the role Anaximander attributed to the *apeiron* (p. 72–74). A central idea of natural science is the concept of laws that govern the world *according to necessity* and according *to the order of time*, as is stated in the only surviving text of Anaximander. It is only recently, and especially in Rovelli's own scientific work, that even this doctrine has been challenged (cf. p. 125).

In the first chapter the author gives a vivid introduction to the cultural context in which the early Ionian philosophers lived. In chapter 7 he supplements this with a description of the origin of the Greek alphabet, about a century before Anaximander's birth. This alphabet, which uses not only consonants but also vowels, was the first completely *phonetic* one in the history of mankind. It was the first technology capable of conserving a copy of the human voice, which made it possible that everyone in principle could read and write, and not only a learned elite of scribes who kept that skill a secret (p. 91–93). Rovelli notices here the same open-mindedness as in the originating scientific approach of the Ionian philosophers (p. 94). Perhaps this optimism has to be counterweighed by the observation that an obvious inconvenience of phonetic writing is that it is understandable only for those who speak the same language, but inaccessible for foreigners unless they take the trouble to

learn that language. An example is Rovelli's very book, which had to be translated twice in order to make it understandable for non-Italian-speaking people. The great advantage of the Chinese way of writing, for instance, is that it can be read by people all over the big Chinese empire who do not understand each other's spoken language, precisely because the writing is not phonetic.

A central point in Rovelli's treatment of Anaximander concerns his conception of the earth floating free in the center of the cosmos, and the argument he is said to have put forward for it. I will take the opportunity to dig somewhat deeper into the problem of the stability of the earth. Rovelli rightly states that from the point of view of science the gigantic conceptual leap, the big cosmological revolution, was not so much to find out the precise shape of the earth (cylindrical or spherical), but rather to recognize that the earth floats free in space (p. 55–57). When the earth is thought of as free-floating, the question necessarily arises why the earth does not fall. Here Rovelli quotes the well-known argument, ascribed to Anaximander by Aristotle in *De Caelo* 295 b 10 ff. (= DK 12 A 26): "But there are some who say that it stays where it is because of symmetry, such as among the ancients Anaximander. For that which is situated in the center and at equal distances from the extremes has no inclination whatsoever to move up rather than down or sideways. And since it is impossible to move in opposite directions at the same time it necessarily stays where it is".

This argument has often been called the first instance of an argument based on the principle of sufficient reason. It has been praised as "clear and ingenious", or "überraschend und großartig".[1] Rovelli echoes these qualifications and calls it "extraordinary and perfectly correct" (p. 60). One may doubt, however, whether this was Anaximander's argument at all. It seems to presuppose a spherical earth (for otherwise it is not, strictly speaking, everywhere at equal distances from the extremes), as well as a spherical universe (for otherwise the reference to 'the extremes' makes no sense), both of which do not fit in with Anaximander's conceptions.[2] Actually, a similar argument is used in Plato's *Phaedo* 108 e 3 – 109 a, and here explicitly in the context of a spherical earth.[3] Accordingly, Simplicius already made the suggestion

[1] J. Barnes, *The Presocratic Philosophers*. I: *Thales to Zeno* (London 1982) 25; K. von Fritz, *Grundprobleme der Geschichte der antiken Wissenschaft* (Berlin – New York 1971) 24.

[2] Cf. D. Furley, *Cosmic Problems* (Cambridge etc. 1989) 24: "I think it likely that the author is presupposing a spherical earth".

[3] Aetius ascribes a similar argument to Parmenides and Democritus (DK 28 A 44). This reference, however, is doubtful, at least as regards Democritus,

that Aristotle used Anaximander to oppose an argument of Plato, obviously out of respect for his teacher.[4] It is remarkable that Aristotle, who handed down the argument, does not seem to be very impressed by its strength. On the contrary, he makes fun of it, saying that by the same argument "a hair that is subject to an even pulling power from opposite sides would not break, and that a man, being just as hungry as thirsty, placed in between food and drink, must necessarily remain where he is and starve to death".[5] In a similar version the argument is known since the Middle Ages as 'Buridan's ass'. It is understandable that Aristotle did not want his teacher Plato to be associated with an argument that he was about to deride, and that he chose instead the first one who maintained that the earth floats in the center of the universe, Anaximander, as his target. Against this background it is perhaps possible to call the argument ascribed to Anaximander 'extraordinary', but hardly 'perfectly correct'. After all, the argument must be fallacious, because the earth does *not* stay in the center of the universe.

More serious is that Rovelli takes the argument to mean that according to Anaximander there is no absolute 'up' and 'down' (p. 61). To support his view he quotes a text of the *Corpus Hippocraticum* that is said to show Ionian influences. This text says that for the antipodes 'up' and 'down' have changed places, and that the same is the case all around the earth. However, J. Mansfeld has argued persuasively that the whole treatise belongs to a much later date, quite late in the Hellenistic period, so that it cannot be used to illustrate an aspect of Anaximander's cosmology.[6] Moreover, Rovelli takes the alleged argument to imply that according to Anaximander things do not fall perpendicular to the upper

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because he not only taught that the earth is flat (and somewhat concave), but also that it is supported by the air beneath it. See Aristotle, *De Caelo* 294 b 13 (= DK 13 A 20) and Simplicius, *In Aristotelis De Caelo Commentaria* 520, 28 Heiberg (= DK 59 A 88).

[4] Simplicius, *In Aristotelis De Caelo Commentaria* 532.

[5] Aristotle, *De Caelo* 295 b 21 ff. T. Heath, *Aristarchus of Samos. The Ancient Copernicus* (Oxford 1913) 25, calls this argument 'amusing'. In "῞Ομοιος and ὁμοιότης in Thales and Anaximander", *Hyperboreus* 1 (1994): 1, 28–55, at p. 35, D. Panchenko seems not to recognize Aristotle's humor when he writes: "Aristotle makes it clear once again when illustrating the theory".

[6] J. Mansfeld, *The Pseudo-Hippocratic Tract Περὶ ἑβδομάδων ch. 1–11 and Greek Philosophy* (Assen 1971). See also Furley (n. 2) 21. Rovelli obviously borrowed his quotation from Ch. Kahn (*Anaximander and the Origins of Greek Cosmology* [1960; Indianapolis – Cambridge ^{2}1985] 84–85), who in the second edition of his work unfortunately did not take the opportunity to revise his text according to Mansfeld's findings.

surface of the earth, in other words, that Anaximander already taught a centrifocal theory of falling. This makes the alleged argument, which is meant to answer the question why the earth does not fall, into an argument why things fall to the center of the universe, which is the flat earth. Furley has already in 1989 articulated the absurdities to which a centrifocal theory of falling under the supposition of a flat earth leads: "It is difficult to combine a flat earth with centrifocal dynamics. (….) If lines of fall truly converge on the centre from all directions, and the earth, being flat, lies in the centre, it follows that falling bodies arrive at the earth's surface at all angles from horizontal to vertical. Even supposing the Greek world is the centre of the earth, so that at Delphi all lines of fall might be thought of as theoretically vertical, at the extremes of the known world falling bodies should have been observed to fall at an angle. The contradiction of the theory with observable phenomena seems too obvious for the theory to be credible".[7] Furley's point can best be illustrated by picture 1, which shows that at the outskirts of Anaximander's earth – say, at the Pillars of Hercules – things (rain, stones, etc.) would fall at an unbelievable angle of about 20 degrees in relation to the earth's surface, which means almost horizontally.

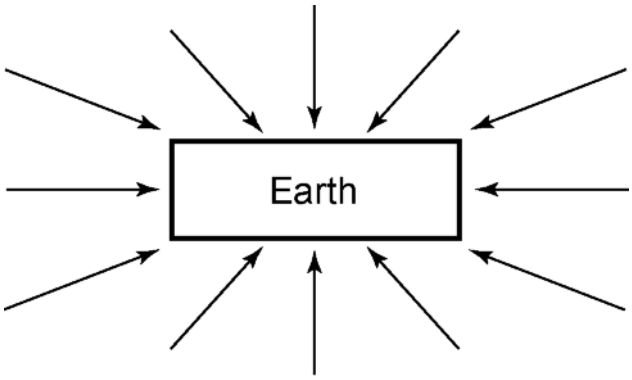

Figure 1. Alleged centrifocal dynamics on Anaximander's earth

Rovelli's illustrations, however, conceal rather than elucidate the problem of his interpretation. In the article in *Collapse* and in the *Internet*-version of the book he draws a disk-shaped earth, but without saying he changes the dimensions of Anaximander's earth into 1 : 2 instead of 1 : 3 (see figure 2).

[7] Furley (n. 2) 21.

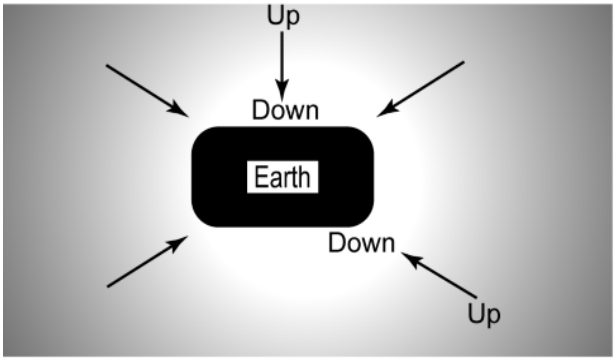

Figure 2. Alleged centrifocal dynamics on Anaximander's earth according to Rovelli (1)

The result is that the angle of falling looks less. In the French edition of his book Rovelli even draws an ovoid-shaped earth, so that it looks as if everywhere the direction of falling on the earth is vertical (see figure 3). Such an ovoid shape is not based on any text of the tradition on Anaximander. I think it is a bad procedure to adjust your illustrations so that they fit your theory or hide the problems it involves.

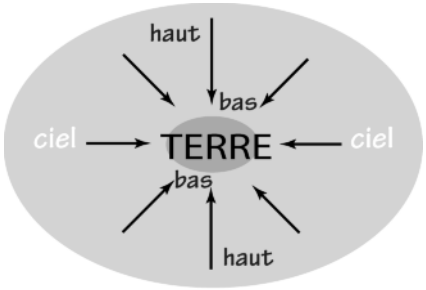

Figure 3. Alleged centrifocal dynamics on Anaximander's earth according to Rovelli (2)

With the possible exception of Parmenides, all Presocratics we know of preserved the concept of a flat earth. And, as far as we know, none of them combined this conception with centrifocal dynamics, in which there is no longer a universal 'up' and' down', but 'up' and 'down' are relative to the earth, which means that the concept of 'beneath the earth' makes no sense (cf. p. 62). On the contrary, according to Aristotle himself not only Anaximander's successor Anaximenes,

but even thinkers as late as Anaxagoras and Democritus, who also believed that the earth is flat, did not know of a relativity of up and down. They taught, as Aristotle says, that "its flatness causes the earth to stay where it is, so that it does not cleave the air *beneath* it, but rests on it like a lid, as is usual for flat objects".[8] According to these Presocratics "the flat earth *is upheld by* the air *beneath*", says Simplicius.[9] It would be strange and historically incomprehensible if Anaximander, the first of them all, were the only exception, teaching a centrifocal theory of falling.

Actually, Rovelli's interpretation of Anaximander's alleged argument comes very close to Aristotle's theory of falling. What we call 'falling' is, according to Aristotle, nothing but the natural movement of that which is heavy toward its natural place. Precisely because the heavy element, earth, falls toward the center of the spherical-shaped cosmos, the earth stays there immovably. The spherical shape of the earth is also the consequence of Aristotle's theory of falling, for the sphere is the stereometric body in which all parts of its circumference have the shortest possible distance to its center. It would be strange if Aristotle would deride an argument that is virtually the same as his own. One reason why Aristotle ridicules the argument he ascribes to Anaximander might have been that it does not explain why it is precisely *the earth*, and not any other body, which dwells in the center of the cosmos. In other words, even granted that the argument suffices to explain why the earth remains in the center, it does not explain how the earth got there. One of the attractive features of Aristotle's theory of falling is that it is able to explain this as well. All things taken together I conclude that even if Anaximander was the originator of the argument why the earth floats free in the center of the cosmos, its meaning cannot have been the one Rovelli proposes.

As regards the authenticity of the argument I am doubtful. In contradistinction with Rovelli, Furley draws from his exposition of the consequences of a centrifocal dynamics on a flat earth the conclusion that the

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[8] Aristotle, *De Caelo* 294 b 16 (= DK 13 A 20).

[9] Simplicius, *In Aristotelis De Caelo Commentaria* 520, 28 f. Heiberg (= DK 59 A 88). A possible exception is 374, 32 (not in DK), where the sky is said to be kept from falling downward by the force of the cosmic vortex. In this text 'downward' seems to imply 'toward the central earth'. Here, however, Simplicius is saying more than is in Aristotle's words on which he comments (*De Caelo* 284 a 14 ff.). Moreover, in 375, 25 (not in DK), commenting on the same text, Simplicius speaks of the downward tendency of the heavens *and of the earth*, which implies a non-centrifocal falling.

argument cannot have been Anaximander's. I do not agree with Furley, however, that the argument necessarily implies a centrifocal theory of falling. Panchenko already pointed out the overhasty inference that is at stake: "The idea that such a heavy body as the earth does not fall because it is in the middle of the cosmos does not imply the idea that all heavy bodies have a tendency to move toward the centre of the cosmos", or in other words, the argument does not necessarily imply a centrifocal dynamics.[10] The reason why I hesitate to ascribe it to Anaximander is another, namely, as said earlier, that it presupposes a spherical earth within a spherical cosmos. Panchenko, on the contrary, concludes "that the Aristotelian exposition of Anaximander's theory of the earth's stability appears yet as very reliable and even reflecting Anaximander's original wording".[11] He bases this conclusion mainly on a thorough analysis of the archaic use of ὅμοιος as meaning 'identical' in a geometric sense and not just 'similar', which means that in Aristotle's account of Anaximander "ὁμοιότης should be translated as 'equidistance'".[12] However, although Panchenko's analysis makes it plausible that Anaximander used the word ὅμοιος in this geometric sense, this does not automatically involve that he used the argument as rendered by Aristotle. Panchenko states without explanation: "I believe that Anaximander's cosmos was spherical too".[13] It is hard to see, though, how Anaximander's cosmological picture of celestial wheels, with the stars nearest to the earth, can be reconciled with a spherical cosmos. I think a more natural explanation is that Anaximander's so-called argument is a no longer understood instruction for drawing a map of his universe. On such a map the earth is geometrically equidistant (ὅμοιος) to the concentric rings of the celestial wheels.[14] Aristotle, then, took the opportunity of a text saying that the earth has to be drawn ὅμοιος to the concentric rings of the celestial wheels, to deride Anaximander instead of his teacher Plato.

Bodnár's conclusion that we should stick to Aristotle's testimony about ὁμοιότης is not convincing either, as he maintains that on the

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[10] Panchenko (n. 5) 31.

[11] *Ibid*., 29.

[12] *Ibid*., 34.

[13] *Ibid*., 51. In note 12 on p. 32 Panchenko even writes: "(…) and doxographic tradition informs us that Anaximander had such a theory (sc. of the celestial sphere)". I wonder which doxographic tradition he is hinting at. A spherical cosmos presupposes that the stars are in the periphery of the cosmos, whereas in Anaximander's conception they are nearest to the earth.

[14] See, e. g., the drawing in H. Diels, "Über Anaximanders Kosmos", *Archiv für Geschichte der Philosophie* 10 (1897) 236.

other hand "there really is a tension between a theory on the lines of *homoiotēs* and a parallel model of gravitation, which is apparently implied by a flat surface Earth".[15] He even argues that the ὁμοιότης-argument not only holds for the earth, but for the celestial rings as well and he sees this as the reason why Anaximander imagined the celestial objects as rings or wheels.[16] Here, too, a more natural explanation is possible. Once he realized that the celestial bodies do not stop at the horizon but make full circles around the earth, Anaximander had to answer the question what the nature of these bodies could be that makes them move in circles. Most things in motion that he could observe moved in straight lines, for instance falling objects. Some made strange curves, such as thrown objects, but only circular objects like wheels or rings were able to move naturally in a circle. It was a bold, but reasonable association that made him conclude that the celestial bodies, too, must be wheels.

The conception of the free-floating earth was obviously the consequence Anaximander drew from his fundamental insight that the celestial bodies do not stop at the horizon, but make full circles around the earth. These circles he visualized as huge celestial wheels. My guess is that Anaximander was so convinced by the evidence of his idea of the celestial bodies making full circles that he also took the consequence of a free-floating earth, even though he was not able to deliver a conclusive proof of how this was possible. Moreover, when we take it that Anaximander did not use a convincing argument to explain why the earth does not fall, it also becomes easier to understand why his successor Anaximenes let the earth rest on the air like a lid to prevent it from falling.[17] This does not mean, as Rovelli seems to think, that without his interpretation Anaximander's explications are absurd (note on p. 62). Nor does it detract from Rovelli's thesis that Anaximander stood at the cradle of science. We may compare Anaximander's situation with that

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[15] I. M. Bodnár, "Anaximander on the Stability of the Earth", *Phronesis* 37 (1992) 337, 341.

[16] I. M. Bodnár, "Anaximander's Rings", *CQ* 38 (1988) 49–51, esp. p. 51. See also Bodnár (n. 15) 339. In *Anaximander in Context* (Albany 2003) 208, I still subscribed this idea without mentioning, however, Bodnár's name, for which I now apologize.

[17] DK 13 A 6, 13 A 7, and 13 A 20. In a half-hearted testimony Simplicius ascribes also to Anaximander the theory of the air supporting the earth (Simplicius, *In Aristotelis De Caelo Commentaria* 532, 14 Heiberg, not in DK). This must be wrong, as another source speaks of "a sphere of fire that grew around *the air that surrounds the earth*, like the bark around a tree" (DK 12 A 10 [33]). See also Kahn (n. 6) 55.

of Copernicus and his followers (Galilei, Kepler), who maintained that the sun, and not the earth is in the center of the universe, although they were not yet able to deliver a convincing theory to replace Aristotle's theory of falling, which had convinced people for two millennia that it must be the earth which is in the center of the universe. For such a new theory mankind had to wait until Newton formulated his laws of gravitation.

In quoting his sources Rovelli is not always careful. It is, e. g., on p. 34, not Aelius, but Aelian, or in full Aelianus, who reports that Anaximander has founded a colony, which is not called Amphipolis, but Apollonia.

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Карло Ровелли рассматривает наследие Анаксимандра с точки зрения современного ученого-естественника. Он убежден, что Анаксимандр стоял у истоков науки. Анаксимандр говорил о природных явлениях – таких, например, как дождь, гром, молния, – не ссылаясь на богов; он свободно полемизировал со своим учителем Фалесом. Его подход, таким образом, был подлинно научным. Анаксимандр ввел в научное понимание природы идею теоретически постулируемой, хотя и недоступной для чувств сущности (Апейрон), а также идею законов, которые правят миром "согласно необходимости" и "согласно предписанию времени". Однако теорию Анаксимандра о том, почему Земля пребывает в пространстве не падая, Ровелли трактует менее убедительно. Обсуждение этого вопроса затрагивает и недавние статьи Дмитрия Панченко и Иштвана Боднара.