# POSIDONIUS' COSMOLOGY

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## ABSTRACT

Posidonius incorporated important concepts of Peripatetic physics into his system. Posidonius adopted a finitist cosmological model where the extra-cosmic void was not infinite but just as large as the cosmos' size at the time of the conflagration (F 84/97a E−K). He accepted the idea that there are absolute directions towards which the elements naturally tend to move and in which they will naturally remain (F 93 E−K). Similarly, Posidonius conceived the four elements as interactive given the new relationship of mutual contrariety, and adopted a physicalist approach where the hot elements are active (F 93, F 101 E−K). The analysis of the long fragments preserved in Strabo (F 229 E−K) and Priscianus Lydus (F 219 E−K) has further shown the significance of heat as an active power in Posidonius' physics.


**Keywords:** Stoic Cosmology. Posidonius. Peripatetic Physics.


## RESUMO

Possidônio incorporou significantes conceitos da Física Peripatética em sua teoria. Ele adotou um modelo cosmológico finitista aonde o vácuo extra-cósmico não é infinito, mas vasto como o tamanho do cosmos no momento da conflagração cíclica. Ele aceitou a ideia de que há direções absolutas para onde os elementos tendem a se mover (F 93 E–K). Possidônio concebeu os quatro elementos como interativos, dado o relacionamento de mútua contrariedade e adotou uma abordagem fisicalista aonde os elementos quentes são ativos (F 93, F 101 E−K). A análise dos longos fragmentos preservados em Estrabo (F 229 E–K) e Prisciano Lydus (F 219 E–K) ademais mostram a importância do calor como potência ativa na Física de Possidônio.


**Palavras-chave:** Cosmologia Estoica. Possidônio. Física Peripatética.

Current scholarship has identified and analysed the fundamental concepts in the physics of the early Stoics (i.e. from Zeno to Chrysippus). These concepts could briefly be summarised as follows. The cosmos and its components consist of an active and a passive factor (See Diogenes Laertius vii 134 'τὸ ποιοῦν καὶ τὸ πάσχον') [cf. Long and Sedley 44]. The world was

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composed in three successive stages of cosmogony (See Stobaeus 1. 129.2 ff. ‘τριχῶς δὲ λεγομένου κατὰ Χρύσιππον τοῦ στοιχείου’) [L & S 46 and 47]. Fire is the element *par-excellence* because the remaining ones are constructed by change out of it (See Stobaeus 1. 129.2 ff. ‘τὸ δὲ <πῦρ> κατ’ ἐξοχὴν στοιχεῖον λέγεσθαι διὰ τὸ ἐξ αὐτοῦ πρώτου τὰ λοιπὰ συνίστασθαι κατὰ μεταβολήν’) [L & S 46 and 47]. The four elements are the primary ingredients of the more complex substances that constitute the universe (See Stobaeus 1. 129.2 ff. ‘καὶ πάντων τὰ λοιπὰ συνέστηκε, διὰ μὲν τῶν τεττάρων’) [L & S 47]. The elements are essentially differentiated according to their degree of density (See Alexander *De Mixt.* 216,14-218, 6 ‘τό τε πῦρ καὶ τὸν ἀέρα, λεπτομερῆ τε καὶ κοῦφα καὶ εὔτονα ὄντα, διὰ τῶν δύο, γῆς τε καὶ ὕδατος, παχυμερῶν καὶ βαρέων…’) [L & S 48]. The qualities of the compounds were the result of the action of the pneumatic active elements over the material ones (See Galen *On Bodily Mass* 7, 525. 9 – 14 ‘ὅθεν ἀέρα μὲν καὶ πῦρ συνέχειν φασὶ, γῆν δὲ καὶ ὕδωρ συνέχεσθαι’) [L & S 47]. The motion and arrangement of the elements within the cosmos is due to centripetal ‘structural’ forces (See Stobaeus 1.166,4-2 2 ‘πάντα τὰ μέρη τοῦ κόσμου ἐπὶ τὸ μέσον τοῦ κόσμου τὴν φορὰν ἔχειν’) [L & S 47 and 49]. Finally, the universe (*to Pan*) consists of a cosmos plus an infinite (or ‘isotropic’) extra-cosmic void (See Plutarch’s *On Stoic Self-contradictions* ch. 44 Ὅτι τοῦ κόσμου κενὸν ἐκτὸς ἄπειρόν ἐστι’) [L & S 44 and 47].

Our research leads us to the ‘middle’ Stoicism of Posidonius of Apamea. Posidonius was a Stoic, and most of his views on physics are in accordance with the doctrines of the founders of the school. There are points, however, where his physical theory conflicts with orthodox Stoicism. Some of his texts specifically indicate a partial return to Aristotelian ideas. To begin with, Posidonius abandoned the Stoic system of ‘isotropic universe and motion according to the structure of the body’ and followed the Aristotelian pattern of ‘finite universe and motion according to absolute directions’. The adoption by Posidonius of a finitist cosmological model (F 84/97a E−K) has already been acknowledged by current scholarship. Still, his germane position of elemental motion following absolute directions has not been observed so far. Most of this paper is devoted to demonstrate that Posidonius *did* make this logical shift.

Posidonius maintained the doctrine of the Early Stoa that the void subsists only outside the cosmos as an enveloping empty space. But he advanced the novel claim that this extra-cosmic void is not *apeiron*, not infinite or unlimited; rather, the void is precisely the size occupied by the cosmos when it expands in its periodic conflagration. This doctrine is preserved in the testimony of Aetius' *Placita* on Posidonius. The chapter is headed 'On what is outside the cosmos, whether there is void' (Εἰ ἔστι κενὸν ἐκτὸς τοῦ κόσμου). I show below all the *lemmata* of the chapter in the version of Ps.-Plutarch (*Placita* 2. 9).[2]

1. The followers of Pythagoras <say that> outside the cosmos there is a void in which the cosmos exhales and out of which <it inhales>.
2. The Stoics <say that outside the cosmos there is void> into which the cosmos is dissolved at the conflagration; it is infinite.
3. Posidonius <maintains that> it is not infinite, but just as large as is sufficient for the dissolution of the cosmos. In the first book of the 'On the Void' (F 84/97a E−K).
4. Aristotle said that there is no void.
5. Plato <said that> there is a void neither outside nor inside the cosmos.

This rather strange doxa of Posidonius has raised doubts about the text. Kidd proposes emending 'but just as large' to 'insofar as' (cf. 1988, 391–94), but Algra has gathered sufficient evidence to show that the testimony is genuine (cf. Algra 1993 and 1995, 321–29; White 2007, 49–51). The structure of the chapter strongly suggests that Aetius opposed the Posidonian doxa to that of the Stoics (options 2 and 3 above). It is implausible that Aetius would provide Posidonius with a separate lemma next to the other Stoics if his opinion were not original. It is also telling that such doxa of an extra-cosmic void 'just as large as is sufficient for the dissolution of the cosmos' is similarly found in other astronomical handbooks (Achill. *Isag*. 8 and Anonn. i *In Arat*. 3), where it is attributed to the Stoics in general. Since the ascription of this theory to the Stoics flatly contradicts a well-attested concept of the school, it is very likely that the organisers of these

[2] There are almost identical versions of this chapter in Eusebius and Qosta ibn Luqa. For the slightly different versions see Algra 1995, 323.

patchy summaries (which are related to the Aetian *Placita*) carelessly extended the specific doxa of Posidonius to the Stoics in general.

In addition to these compelling arguments above, Algra speculates about the philosophical motives for the theoretical shift of Posidonius. He points out (1993, 496□504) that the polemical passage of Plutarch (*SR* chapter44) shows that the Chrysippean concept of the void was susceptible to doubt and criticism. On the one hand, it closely resembled the Epicurean concept of void: a self-subsistence space which is independent of any possible space-filler. On the other, the concept of the specific *chora* of the cosmos (… καὶ ἡ τῆς χώρας κατάληψις, οἷον διὰ τὸ ἐν μέσῳ εἶναι … [cf. Algra 1995, 263–307; Furley 1995, 70–71]) resulted in the awkward position that the cosmos is surrounded by two distinct forms of void: both an inner void that is finite and determinate, and then beyond that, another void that is infinite and isotropic. The finite void of Posidonius would represent a logical shift in the sense that it solves both difficulties. Firstly, it eliminates the second, outer void. For Posidonius, the extra-cosmic void is definitively limited to the finite space larger than the cosmos, which surrounds and encompasses it, providing room for the cosmic body during the conflagration. Moreover, it rendered the Stoic theory of void in line with that of 'place'. The finite void is an inseparable aspect (or ontologically derivative) of a corporeal reality (i.e. the cosmos).

Algra further suggests that Posidonius' return to a finitist cosmology was partly due to the influence of Platonic and Aristotelian physics: 'the situation of the cosmos [for Posidonius] at the time of the conflagration is analogous to that of a Platonic or Aristotelian cosmos: it is finite and yet not surrounded by anything else. The difference only becomes apparent *after* the conflagration when the cosmic mass shrinks, leaving a still *finite* void space behind' (cf. 1995, 334 n190 and 281). Yet, it escaped scholars so far that such a return logically requires a parallel shift in the concept of elemental motion. In contrast to the Stoic and Chrysippean universe, the Posidonian one does have a central point that establishes Aristotelian-like 'absolute' directions in the totality (*to Pan*). As I have shown above, the logical articulation conceived by ancient (Plutarch) and modern (Furley) critics categorically sets the two groups apart: 'isotropic' universe ≅ motion accor-

ding to the structure of the body; finite universe ≅ motion according to absolute directions. Accordingly, there is sufficient evidence to suggest that Posidonius also incorporated the Aristotelian idea for elemental motion into his version of Stoicism. The hard evidence that his position in this topic was similar to the Aristotelian one is preserved in Simplicius' commentary of *De Caelo*. Simplicius associates Posidonius, Aristotle and Theophrastus on the topic of elemental motion.

And the whole development of the argument is the following: (1) what moves to its proper place moves to what contains it, and what moves to what contains it moves to its like. Having said that 'place is the limit of what contains', he adds 'all things which move up or down (and not absolutely all things which move) are contained by the extremity and the centre'; for the body which moves in a circle is itself the extremity, and is not contained by the extremity and the centre, only the things which move up or down are. I do not think that he has added this qualification for no reason, but in order to indicate that of the things which move upward, the one which lies above contains the one which lies below, as fire contains air, and that of the things which move downward the one which lies below <contains the one which lies above it>. For these things are nearer to what contains, that is, to the extremity and the centre. He says that what contains is in a way the form of what is contained – he says it is contained because it lies adjacent. For if the upper region gives form to light things which come to be when they come to be there and similarly the lower region gives form to the heavy things, then for fire the upper extremity is the form because fire has its completeness in it, and for air fire is the upper extremity because air moves up as far as fire, and again for earth the centre is the form and for water earth is, because when water has come to be in earth and taken in its form with respect to weight it rests. And the analogues of form are the extremes because they give form to what lies adjacent to them, and the analogues of matter are the intermediates because they are given form by the extremes. For fire endows air with lightness, and earth endows water with heaviness. This is one way of dividing the four elements into formal and material; (2) another is that in which heavy and cold things have the role of matter, light and hot things of form, as Aristotle himself says elsewhere and Theophrastus says in

*On the coming to be of the elements*. Posidonius the Stoic borrows it from them and uses it all the time.' (F 93 E−K = Simplicius *In Aristotelis De Caelo* iv 3. 310 b1 [translation in Ian Mueller 2009])

The E−K fragment stands as printed above. It can be effortlessly analysed as containing two sections or doctrines (see Kidd 1988, 375–79). The first section (1) is rather confused because the main concepts are continually repeated while few explanations are gradually attached. It can be briefly summarised (see Kidd 1988, 376): the form-inductive elements are the 'extreme' elements of fire (or upper limit) and earth (or the bottom) since the 'intermediary' elements of air and water, which are analogous to matter (form-induced), move in their respective directions (or natural places) and are 'contained' by them (i.e. by fire and earth). Simplicius here focuses on the relationship of similarity (i.e. likeness) occurring within the groups of heavy (water – earth) and light (fire – air) elements.

The second section (2) is more succinct. It differs from the first one in the sense that in addition to matter, form, weight, and lightness, Simplicius adds the categories of hot and cold. Furthermore, the functions have partially changed. Whereas in the first section the roles of form and matter are respectively attributed to the 'extreme' and 'intermediary' elements, here they are respectively performed by the hot (fire and air) and cold (earth and water) elements.

At last, the attribution of the systems to the philosophers comes after the second text: 'αὐτός τε Ἀριστοτέλης ἐν ἄλλοις λέγει καὶ Θεόφραστος ἐν τῷ Περὶ τῆς τῶν στοιχείων γενέσεως, καὶ Ποσειδώνιος ὁ Στωικὸς παρὰ τούτων λαβὼν πανταχοῦ χρῆται'.

Kidd analyses and translates the passage as though Simplicius contrasted both doctrines 1 and 2 above (cf. Kidd 1988, 377; Sharples 1998, 120–21 and Mueller 2009, 161 n260). According to this reading, the name of Posidonius is associated with the second doctrine alone. However, a careful analysis of the text and context of the fragment shows that both doctrines (1 and 2 above) are complementary components of a *single* system. Correspondingly, Simplicius associates Posidonius' name with a system which combines both doctrines.

If we start by analysing the original text, we should see that nothing precludes the hypothesis that *In Aristotelis De Caelo* 699, 13 – 700, 8 (= F 93 E−K) conveys a single scheme combining both divisions. On the one hand, the sentence of transition between both doctrines (1 and 2) does not necessarily convey an idea of opposition ('ἄλλος δὲ οὗτος ὁ τρόπος ἐστὶ τῆς εἰς τὰ εἰδικὰ καὶ ὑλικὰ τῶν τεσσάρων στοιχείων διαιρέσεως καὶ ἄλλος ἐκεῖνος…'). On the other, there is no objective pronoun in the attributions specifying that the philosophers are being associated with only one of the divisions. The verbs in question might be referring to both systems, and the original text above can easily read: 'as Aristotle says elsewhere and Theophrastus says in ... Posidonius the Stoic borrows the doctrines from them and uses it all the time'.

Likewise, apart from not being mutually contradictory, the doctrines could easily be conciliated. Air plays the role of matter for fire, and it is form for water and air. Earth is form for water, yet it is matter for fire and air. That is, the doctrines might be allocating the roles of formal and material elements according to *relative* and *absolute* parameters. Within the partial groups (earth – water) (fire – air), the former members play the *relative* role of form; within the larger group involving the four elements, the light ones are *absolutely* formal. Now, as I said, the context further reveals that the fragment conveys *complementary* subdivisions. Immediately after the fragment, one reads that Alexander of Aphrodisias equally attributes the formal and material roles according to *relative* and *absolute* parameters.

> *... Posidonius the Stoic borrows it from them and uses it all the time* (F 93). The exegete Alexander points out that the division concerning the material and formal elements which is now being set out is different. He says that water is form for earth and not vice versa in the way I think. He writes this: "Therefore earth and water are material, fire and earth formal, if they are spoken in absolute terms, but, relative to one another and as proximate forms and as proximate matters, the <elements> which are close to each other vary slightly with respect to being material, since, although water is in a way form for earth, water is itself also material because it is related in this way to earth"' (*In de Caelo* 700, 9 – 16)

The interpretations of Simplicius (699, 13 – 700, 8) and Alexander (700, 9 – 16) are different in the sense that for Alexander 'although water is in a way form for earth, water is itself also material … to earth'; that is, the

adjacent elements here alternate in performing the functions. Yet the interpretations of Simplicius and Alexander follow the same pattern as they assign formal and material functions according to partial (earth – water)(fire – air) and overall (i.e. 4 elements) groups. Indeed, contrary to the reading of Kidd, which was subsequently accepted, doctrines (1) and (2) of F 93 E−K (= *In de Caelo* 699, 13–700, 8) are not contrasting; rather, they are *complementary* subdivisions of a single system. Conversely, the logical reading of F 93 E−K is 'as Aristotle says elsewhere and Theophrastus says in *On the coming to be of the elements*; Posidonius the Stoic borrows the doctrines from them and uses them all the time.'[3]

In Simplicius (F 93) one reads that Posidonius incorporates the Aristotelian and Peripatetic idea of *topos* guiding elemental motion in his physical system (doctrine 1). As I have said, his finite extra-cosmic void (F 84/97) requires the concept of elemental motion following 'absolute' directions since it establishes qualitative differences in space. So, the Aristotelian (or Peripatetic)[4] dynamics described in Simplicius (doctrine 1) is also observed in another Posidonian fragment that similarly involves Aristotle: the passage regarding the phenomenon of the stony ground of la Plaine de la Crau. After reporting the remarkable features of the place, Strabo conveys the explanations of Aristotle, Posidonius and Aeschylus for the natural phenomenon.

> Between Marseille and the mouths of the Rhone, there is a plain, circular in shape, up to 100 stades from the sea, and that distance also in diameter. It is called The Stony Plain from its conditions: for it is full of stones of a size to fill a man's hand, with an undergrowth of rough grasses which supply abundant pasture for cattle. There is water at the centre, salt springs, and lumps of salt … Aristotle says that the stones were thrown up onto the surface by earthquakes of the kind called *brastai*, and slid together into the hollow parts of the areas. Posidonius says that because it was a marsh it solidified after the surge [of lava], and because of that it was divided into a number of stones (Ποσειδώνιος δὲ λίμνην οὖσαν

[3] Interestingly, the first section (1) of the excerpt is ambiguous regarding the final destination of the element fire: 'For if the upper region gives form to light things which come to be when they come to be there … then for fire the upper extremity is the form because fire has its completeness in it'. In fact, the 'upper region' here could be describing either the outer, yet still sublunary, layer of hot exhalations (as in Aristotle's *Meteorologica*) or the fiery superlunary heaven of the Stoics.

[4] In fact, there are differences between the system in F 93 and the actual theory of Aristotle's cosmology. See below for further details concerning the divergences.

> παγῆναι μετὰ κλυδασμοῦ, καὶ διὰ τοῦτο εἰς πλείονας μερισθῆναι λίθους). These are like pebbles in the beds of the rivers and on the shore; they are similar to each other both on their smoothness and in uniformity of size (καθάπερ τοὺς ποταμίους κάχληκας καὶ τὰς ψήφους τὰς αἰγιαλίτιδας, ὁμοίους δὲ καὶ λείους καὶ ἰσομεγέθεις <πρὸς> τῇ ὁμοιότητι·). So both writers have given an explanation of the cause of the feature, and the account in both cases is plausible. For stones formed in this fashion of course cannot of themselves either change from fluid to solid …' (*Geography* iv 1, 7 = F 229 E−K)

Scholars agree that the whole passage was copied from Posidonius' work; that is, the description of the place and of Aristotle's explanation also derive from one of his books.[5] Posidonius visited the Mediterranean region of ancient Gaul, and it is likely that his work contained the vivid description and the three respective accounts about the place.[6] Here one has an instance of what Strabo himself defines as the aetiological project or the Aristotelianism in Posidonius (Strabo ii 3, 8 = T 85 E−K). Following Aristotle, Posidonius tries to establish the ultimate nexus of causation for the natural phenomena. A careful analysis shows that an Aristotelian elemental motion as seen in Simplicius (*In de Caelo* 699, 13–700, 8 = F 93) underpins Posidonius' explanation.

Firstly, one should realise that Posidonius accepts Aristotle's doxa. He comments on Aristotle's explanation from the viewpoint of Aristotelian Physics.[7] Aristotle is first credited with the theory that the stones were thrown up onto the surface by earthquakes of the kind called *brástai*. Next, we read in the original '… Ποσειδώνιος δὲ λίμνην οὖσαν παγῆναι μετὰ κλυδασμοῦ …' As one can read above, I translate: 'Posidonius says that, because it was a marsh, it solidified after the surge …' In other words, Posidonius complements Aristotle's explanation by stating that the marsh solidified with the surge of the lava following the earthquake mentioned by Aristotle. Here I disagree with the reading of Kidd's commentary for the following reasons.

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[5] Jacoby thinks that Strabo iv 1, 7 is derived from *History* (F 90 in his edition of fragments), yet it could also come from a scientific work such as *On Ocean* (See Kidd 1988, 813). The area still preserves the features portrayed here.

[6] See Kidd (1988, 86–7, commentary to T 101/102 E−K) for Posidonius' interest in the development of ideas and doxographies.

[7] See Sandbach 1985, 60: '(Posidonius) if responsible for Strabo's information about Aristotle, himself drew it from *Meteorologica*, adding details which he believed Aristotle, had he so wished, might have inserted'. See also Steinmetz 1962, 263.

To begin with, λίμνην should be translated as marsh and not lake (as in Kidd) since it is more plausible that a muddy marsh solidifies (παγῆναι) than a liquid lake.[8] Likewise, in Aeschylus' subsequent excerpt [Fr. 199 Nauck²; 32ᵇ Mette] we hear that 'the whole place is (was) soft soil' before the shower of stones. Next, κλυδασμοῦ (singular) makes more sense if understood rather as the single event of the flow of lava than as the recurrent lap of waves (Kidd's translation: '… as waves continued to lap, and the solidifying wave ridges …'). Accordingly, the seismic phenomenon described here would be fully consistent with Posidonius' own theory. Besides knowing that lava can erupt from chasms on the ground,[9] Posidonius incorporated into his own system the kind of earthquake that Aristotle proposes to explain the phenomenon (vertical shocks, *Brástai*[10] ≅ *Brasmatías*, F 12 and F 230 E−K).

Posidonius develops Aristotle's doxa by adding further particulars. Now, the Aristotelian concept of elemental motion as seen in F 93 underlies the explanation for the physical phenomenon of the plain of la Crau (F 229), that is, for the genesis of the stony place. To demonstrate it, I shall first list the topics of the natural phenomena which one can gather combining both explanations. Subsequently, the Aristotelian theory underlying the description of the process shall be identified. The list is the following. (Topic 1) Strabo summarises the transformation (or genesis) of the place, as understood by Posidonius, as the change from fluid to solid: 'For stones formed in this fashion of course cannot of themselves[11] either change from fluid to solid … (ἀνάγκη γὰρ τοὺς οὕτω συνεστῶτας λίθους οὐ καθ' ἑαυτοὺς ἢ ἐξ ὑγροῦ παγέντας μεταβαλεῖν)'. (Topic 2) The cause of the transformation was, as we have seen, a seismic event triggering the eruption (or surge) of lava. (3) The erupting lava solidified the overlying marsh and divided it into a num-

[8] As one reads in Diogenes vii 142 ('… then the thicker parts of the moisture condense and end up as earth …'), the idea of water becoming earth would not seem strange to a Stoic. Notice that nowadays there is a subsoil of calcareous mud under the cap of stony ground. See Kidd 1988, 815.

[9] Cf. 'an earthquake engulfed a city above Sidon … The island continued to shake in parts until a chasm opened in the Lelantine plain and vomited a river of lava'. (Strabo i 3, 16 = F 231 E−K)

[10] Aristotle deals with this particular earthquake in *Meteorology* ii 8, 368b. See text in n46 below.

[11] Strabo's point here is that fluid cannot change to solid on its own or without interference ('cannot of themselves'). The process needs a trigger.

ber of stones (‘εἰς πλείονας μερισθῆναι λίθους’). (4) The stones which were thrown onto the surface slid together into the hollow parts of the area (‘εἰς τὰ κοῖλα τῶν χωρίων’ from Aristotle’s doxa). (5) The distribution of the stones is ‘like pebbles in the beds of the rivers and on the shores; they are similar to each other both on their smoothness and in uniformity of size’. And, finally, (topic 6) the precise location of the place: ‘between Marseille and the mouths of the Rhone, there is a plain, circular in shape, up to 100 stades from the sea, and that distance also in diameter’.

Aristotle’s and Posidonius’ explanations can be effortlessly combined. I shall now identify the scientific theory underpinning it. Specifically, the whole process, as Posidonius describes it across the fragment (F 229), has a counterpart in the dynamics of Aristotle. It is noticeable that the process is consistent with the standard passage of Aristotle regarding elemental motion: the passage of *De Caelo* which Simplicius (*In de Caelo* 699, 13–700, 8 = F 93 E−K) comments.

> The local movement of each body into its proper place must be regarded as similar to what happens in connection with other forms of generation and change. There are three kinds of movement, affecting respectively the size [i.e. quantity], the form [i.e. quality], and the place of a thing, and in each it is observable that change proceeds from a contrary to a contrary (or between intermediaries) ... Now, that which produces upward and downward movement is that which produces weight and lightness, and that which is moved is that which is potentially heavy or light, and the movement of each body to its proper place is motion towards its own form. It is best to interpret in this sense the common statement of the older writers that 'like moves to like, for it is not as state that is true in every sense.’ (*De Caelo* 310 a 21–b 2)[12]

My position is that the explanation of natural phenomenon of la Crau (F 229) was made in accordance with the physical theory seen here. If we start by the very nature of the event, we will see that it involves ‘a form of generation and change’ as conceived in Aristotle’s *De Caelo*. The event means ‘change from fluid to solid’ state as Strabo reports it (topic 1); that is, the generation of solid, dry stones out of the moist marsh.

Next, the trajectory of the stones after the eruption clearly shows that Posidonius follows Aristotelian dynamics. We hear from both Aristotle

[12] Cf. also *Physics* viii 4 (255a 24–28). See Algra (1995, 208–21) for a good analysis of the passages.

and Posidonius that the stones 'slid together into the hollow parts of the area' (topic 4) and are 'like pebbles in the beds of the rivers and on the shores' (5). Accordingly, Posidonius' simile (5) qualifies Aristotle's account (4) by referring to the 'likeness' dynamics as seen in *De Caelo* ('the movement of each body to its proper place is motion towards its own form … "like moves to like"'). Specifically, the distribution of pebbles on the shores of Posidonius' simile ('καθάπερ τοὺς ποταμίους κάχληκας καὶ τὰς ψήφους τὰς αἰγιαλίτιδας') stands for the traditional example of the 'like moves to like'.[13] The implied idea is that, after the eruption, the stones slid together according to the 'likeness' principle.[14] Likewise, the last details of his explanation make sure that Posidonius' conception of the 'like into like' directly stems from Aristotelian physics: 'they are similar to each other both on their smoothness and in uniformity of size (ὁμοίους δὲ καὶ λείους καὶ ἰσομεγέθεις <πρὸς> τῇ ὁμοιότητι)'. As for Aristotle ('there are, in fact, three kinds of movement, affecting respectively the size, the form, and the place of a thing … It is best to interpret in this sense the common statement of the older writers that 'like moves to like'), motion to its like for Posidonius specifically means the actualisation of a potential location, quality ('λείους'), and quantity ('ἰσομεγέθεις').

Further, the corresponding idea that an absolute goal (or location) matches the quality and quantity of a certain element is observed in the picture of the natural phenomenon (topic 6): 'between Marseille and the mouths of the Rhone, there is a plain, circular in shape, up to 100 stades from the sea, and that distance also in diameter'. In fact, the details of the description most likely convey the power of absolute directions as Aristotle and Posido-

[13] See, for instance, S. E. vii 117–18: 'And the same applies to non-living things, as can be seen with seeds being sifted with pebbles at the beach… while in the other case, by way of the motion of the waves, oblong pebbles are pushed into the same place as oblong ones, and round ones into the same place as round ones, as if similarity in these cases had a sort of uniting force over things.' Cf. Sedley 1992, 31 n26. For the hypothesis that the doxography in Sextus (vii 89–140) is derived from a Posidonian work, see Kidd 1988, 342.

[14] It is noticeable that the Democritean 'like into like' was also latent in Aristotle's explanation for the phenomenon: 'Wherever an earthquake of this kind does occur a quantity of stones comes to the surface of the earth (as when you throw up things in a winnowing fan), as we see from Sipylus and the Phlegraean plain and the district in Liguria, which were devastated by this kind of earthquake (*Meteorology* ii 8, 368b)'. Specifically, the process by which the winnowing fan sorts out the grain is one of the examples of 'like into like' in Democritus: 'For in the one case, by way of the whirling of the sieve, lentils are arranged separately with lentils …' (S. E. vii 117–18).

nius understand it.[15] It is noticeable that there are two 'maps' or diagrams here: the geographical (or cosmic) position ('between Marseille and the mouths of the Rhone …up to 100 stades from the sea …') and the geometric diagram of the phenomenon itself ('there is a plain, circular in shape, … and that distance also in diameter'). Accordingly, the detailed picture establishes the qualitative differences of space that guide the elements. The stones (or solidified earth) are distributed according to smoothness and size within these precise limits.

One could also regard the surge of lava, or the process described in topics (2) and (3), as the Aristotelian efficient cause: it is the 'by what' of the phenomenon.[16] The efficient cause in *De Caelo* is conveyed by the idea of 'that which produces upward and downward movement is that which produces weight and lightness'. Yet, as is well known, the typical example of the efficient cause is the fire which boils the kettle. The fire heats the kettle turning water into air.[17] So in F 229, the efficient causation consists in the heating and transformation of natural elements. The earthquake triggers the flow of lava (stage 2) which heats and dries up the marsh turning the fluid mud into solid stones (3).

The survey of the Posidonian fragments so far reveals the extension of Posidonius' concessions to the philosophy of Aristotle and followers. Specifically, he abandoned altogether the orthodox Stoic concepts of isotropic universe and motion of elements according to the structure of the body. As we have seen in the beginning of this section, his finitist cosmological model (F 84/97 E−K) logically required the Aristotelian idea of elemental motion following absolute directions. This inference was subsequently verified. On one hand, Simplicius (F 93) reports that he used the Aristotelian (or Peripatetic) dynamics involving natural places. On the other, the analysis of F 229 shows that the same dynamics underlies the explanation for the phenomenon in la Crau. Now, the full picture of Posidonius' shift towards Aristotelian physics is realised as one considers further conceptual details of F

[15] '…for something to move to its own place is for it to move to its like', *De Caelo* 310 b11 ≅ 'what moves to its proper place moves to what contains it, and what moves to what contains it moves to its like', Simplicius' *In de Caelo*, F 93 E−K

[16] See below for more about the efficient cause in Posidonius' Stoicism.

[17] For the idea that the kettle simile is implied in 310 a32, see, for instance, Sorabji 1988 222 n14.

93 E−K. As we have seen above, the second doctrine (2) complements the first one.

'(2) another is that in which heavy and cold things have the role of matter, light and hot things of form, as Aristotle himself says elsewhere and Theophrastus says in *On the coming to be of the elements*. Posidonius the Stoic borrows it from them and uses it all the time.'

If Posidonius really stood for the theory of elements which is proposed here, it is clear that his particular theory was again in conflict with the orthodox Stoa. Kidd notices that in his commentary about the passage (comm. 377–78). He observes that though the attribution of the active role to air and fire seems consistent with the pneuma concept of the Early Stoa,[18] the respective connections of heat with air and of cold with earth and water conflicts with the Stoic orthodoxy.[19] Correspondingly, Kidd concludes by mistrusting Simplicius' report (F 93) given that 'there is no other evidence that Posidonius abandon the orthodox Stoic equation of air and cold'. However, there is sufficient evidence that Posidonius also advocated this second doctrine (2) of F 93. The first proof that he conceived the elements fire and air as hot and active is the doxa preserved in Aetius where he equates god with fiery pneuma (i.e. most probably fire plus air):

> Posidonius [said that god is] intelligent and fiery pneuma, not having a form but transforming into what it wishes and co-assimilating itself to all things.' (Aetius 1. 1. 29b = F 101 E−K)[20]

Similarly, we can observe this particular doctrine operating in Posidonius' physical system by considering all the details and theoretical implications of the doctrine. To start with, it is noticeable that the division between form and matter, active and passive elements in F 93, is not really consistent with the activity of the orthodox pneuma as Kidd understands it. Although the division where air and fire are active and earth and water pas-

[18] Kidd adduces the usual fragments of the *SVF* collection regarding the concept of pneuma. Some of them I have printed above. Galen (*SVF* ii 439): 'And so they say that air and fire sustain, and earth and water are sustained.' Galen *SVF* ii 440; also Plutarch *SVF* ii 449; Nemesius *SVF* ii 418; etc …

[19] For cold air, he mentions the Plutarch *SVF* ii 430, II 429, Galen *SVF* ii 431; for moist water and dry earth, D. L. vii 137. Air is the cold component of the mixed pneuma (fire plus air).

[20] White (2007, 42–44) thinks that Posidonius' intention with the equation of god and 'fiery pneuma' was to resolve the unclear relationship between the concepts of principles, pneuma and the four elements in orthodox Stoic theory.

sive remains the same, active and passive elements are now conceived as interactive given the new relationship of mutual contrariety: earth and water are cold, air and fire hot elements. Conversely, as we have seen in the previous section, in orthodox Stoic theory the elements water and earth do not interact with fire and air. As the embodiment of passive matter, they are basically regarded as a three-dimensional inert medium.[21] Likewise, following the list of orthodox qualities in D.L. vii 137 (fire = hot, air = cold, earth = dry, water = moist), the pneumatic elements do not interact with the material ones since interaction only occurs with mutual contrariety.[22]

Next, there is a logical implication in the doctrine (2) where active and passive elements are interactive. It entails the Aristotelian model of elemental change where something hot (e.g. air) can come from something cold (e.g. water) and vice versa. Specifically, as we have previously seen, the qualification of the elements was intrinsically connected to the theoretical idea of elemental change. On the one hand, the constitutive elemental properties of Aristotle (hot and cold, dry and moist) matched his idea of elemental change via heating and cooling. On the other, since the Stoics essentially differentiated the elements according to their density, they used rather contractions and expansions to explain the change of elements.[23] To summarise, the shift of qualities described in F 93 comprehensibly changes the internal dynamics of the theory of elements.

Now, a strong indication that Posidonius stood for doctrine (2) that Simplicius ascribes to him is actually his extensive meteorological research. This doctrine granted to Posidonius the appropriate theoretical background to speculate in this field. The Aristotelian model of elemental change via heating and cooling are naturally correlated with atmospheric phenomena. Conversely, the inadequacies of orthodox Stoic theory to study the change

[21] 'They [the Stoics] say that earth and water sustain neither themselves nor other things, but preserve their unity by participation in a breathy and fiery power, …' (Plutarch *On common conceptions* 1085c□d = *SVF* ii 444)

[22] Cf. for instance Alex. *On mixture* 229 18–20: 'interaction, then, occur among bodies with … a mutual contrariety'.

[23] As Galen puts it (*On natural faculties* 1. 3), the Stoic system was in conflict with the Aristotelian one since the Stoics 'attribute the change of elements to certain dissolutions and condensations' whereas Aristotle 'used the four qualities for the genesis of the elements'.

of elements in the atmosphere are witnessed in the few and unsubstantial material of the Early Stoa regarding meteorology.[24]

And Posidonius' meteorological fragments do provide plenty of evidence that he advocated this specific Aristotelian-like doctrine (2) where heat alone works as active principle. Posidonius consistently conceives the fiery pneuma (air plus fire) as the efficient cause of elemental motion and change. The clearest evidence is found in his explanation for the three observable cycles of sea tides: diurnal, monthly, and annual. The Posidonian tidal theory is again reported in Strabo's *Geography* (F 217/218/220 E−K), yet the geographer alludes to causal factors only in passing. The proper physical explanation for the phenomenon is preserved in the book of Pricianus Lydus, *Solutiones ad Chosroem*, which survives only in a Latin translation. Like Simplicius, Priscianus Lydus was a neo-platonic philosopher of the sixth century who commented on the work of Aristotle. As we see in the text below, the summary starts by inquiring about the cause of the phenomenon. Why does it happen? This is the 'Aristotelising' in Posidonius: the search for aetiological explanation.[25] Again, heat emerges as the active power underlying the elemental processes in this passage full of Aristotelian reminiscences.

> Why does the Red Sea every day and night flow high for a time and then recede, and the tides vary from more to less with the moon? And why is it neither increased[26] during flow tide, nor is its water decreased during ebb tide? … Those who seem to have provided explanations for this kind of effect are the Stoic Posidonius of Assyria and those who share his view, whose Arrian also endorse … Therefore searching for the explanation for these phenomena, the Stoic Posidonius, who personally investigated this kind of interaction (*reciprocationis*), distinguishes its main cause as being the moon and not the sun. For the sun's fire is pure (*sincerum*) and has its greatest power (*summae virtutis*); thus, however much vapour it raises up (*vapores … sublevat*) from the earth and sea is soon destroyed by its fire (*ab igne demolitur*). But the moon's fire (*lunae ignem*) is not pure but weaker and mild, and hence more productive

[24] Few and unsubstantial fragments of Chrysippus regarding meteorology are found in the doxography of Arius Didymus. Notice that Seneca does not mention either Chrysippus or Cleanthes (Zeno is mentioned only once, 7. 19. 1) in the *Naturales Quaestiones*. Cf. Hine 2010, 29.

[25] See White 2007, 69: 'Both questions [in Priscianus] centre on explanations: each reports some puzzling phenomena and asks 'why' (*quare*, probably for *dià tí*) they occur.' I print his translations.

[26] 'Increased' and 'decreased' should be understood in this sentence in terms of quantity of water.

> on things on the earth; it is incapable of using up what it heats, and it can only elevate liquids (*elevare umida*) and produce waves (*fluctificare*) by driving them with its heat, but without reducing them, due both to the weakness of its heat and its great moisture. That is why any [water] heated by the moon putrefies more readily; likewise, when water in a kettle is heated gently, it first swells, rises and flows (*mensurate primum intumescit et extollitur fusa*); but if fire is applied steadily, the water is used up and decreases. Likewise the ocean is affected by the sun just as water in a kettle is by intense heat, but by the moon as water is by a weak initial heat. Thus the ocean's tide also goes round together with the moon.' (*Solutiones* vi = F 219. 1–4, 77–95 E−K)

In order to observe the theory of elements underlying the explanation for the meteorological phenomena[27] I shall first isolate the interrelated yet distinct physical processes of the description. Priscianus' report explains the occurrence of tides as follows. The moon is the primary factor in the occurrence of sea tides because the weak heat emitted by the moon (*lunae ignem*) just expands the spatial volume of the sea water (*elevare umida et fluctificare*). Conversely, the sun's heat is too strong and, as a result, it can transform water into vapour (*vapores ... sublevat*). The Aristotelian (*Meteo*. 355a 15f) analogy between the power of solar heat over the sea and water in a warmed kettle helps to illuminate in the micro-scale the contrasting physical transformations undergone by the element water. On the one hand, the action of the kettle gently warming water matches the moon's effect; the water swells, rises and flows (*mensurate primum intumescit et extollitur fusa*). On the other, when the kettle intensely heats water, it matches the sun's effect; the water is used up (*consumata*) and decrease (*consumata subsidit*). To summarise, the description of the physical processes shows that the ocean follows the same courses of elemental transformation which the element water itself undergoes when exposed to heat. On the one hand, the mild intensity (i.e. the moon's heat) just expands the volume of the element (*elevare umida; extollitur fusa*).[28] On the other, the strong intensity (i.e. the sun's heat) makes the water go up too (*vapores ... sublevat*); however, its strength actually results in elemental change (*ab igne demolitur*; *consumata*).

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[27] The ocean's tide should be considered a standard case of meteorological phenomenon in the sense that it reflects the effect of the motions of the skies on earth. See Taub 2003, 77. Notice also that it is very likely that the account ultimately derives from Posidonius' *Meteorology* (T 72 E−K).

[28] See *fusa* used as the dissolution or expansion of the element in Cicero's *De Natura Deorum* ii 101.

Regarding the theory of elements underlying the description of the phenomena, it is noticeable that the doctrine of F 93 sounds more relevant to this account than early Stoic theory. It is very difficult to correlate the orthodox pneuma concept with these processes of transformation: elemental change is explicitly related to heating here.[29] Given that the tide naturally means the action of the atmosphere over the ocean; how are the elements in discussion (air and water) supposed to interact?[30]As we have seen, the orthodox theory of elements is inadequate to analyse the proper interaction of active and passive elements. Conversely, the doctrine of F 93 provides a theoretical background for the analysis of the phenomena. The phenomenon of tide could be basically analysed as follows. The sea tide means hot air (cf. F 101) moderately heating and expanding cold water. Yet when the cold water is exposed to a stronger intensity of heat, it crosses a certain threshold and becomes hot air. Again, Posidonius needed an Aristotelian-like theory of elements to undertake meteorological research as seen here. Any thoughtful speculation regarding atmospheric occurrences required a theory where heating and cooling play a decisive function.

Posidonius' account for the diurnal cycle of tides as seen above introduces most of the details concerning the physical explanation of the phenomenon. Yet, the specific role which heat plays as the single active power is properly understood as we combine the account for the three cycles (diurnal, monthly, and annual) of tides with the explanation for some hydrological phenomena at the end of the fragment. As we shall see, the active power of heat turns up as the linchpin for the activity of the elemental masses. Again, the Aristotelian background of Posidonius' meteorology is clear.

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[29] Hahm (1985) does not analyse this passage. In fact, it is not clear whether his paper includes Posidonius and post-Posidonian Stoicism among the Stoics. He analyses some (few) passages of Seneca's *Naturales Quaestiones*.

[30] Todd realises that the action of the orthodox pneuma over the passive material elements required a qualitative distinction between both: 'For although relative to the pneuma this matter [the elements] may be inert (*SVF* ii 449), it still has a quasi-independence through having evolved in the cosmogony, and it is not therefore identical with the concept of matter, prescribed in the theory of principles, as a logically distinguishable aspect of a single body' (1978, 154). However, this logical 'quasi-independence' which Todd refers to was not properly formulated in theoretical terms so that the active and passive elements could function as interactive counterparts.

> In the monthly account too, the explanation for the increase in tides is that their power also corresponds to the moon; hence the tide is greatest at full moon and conjunction since then the power of the moon (*lunae virtus*) is also great. For at the full moon, all of the side facing the earth is lighted by the sun (ll. 97–109)

Similarly, the explanation for the annual increases is the moon at the equinoxes; for at both times, the sun is in Aries or Libra, and the power of the moon is at the same time also great at the conjunction with the sun … Yet the time of the year can also have this power from the nature of the moon; for it is hot and moist, and the tides are raised by that power; and next to that, winter follows the moist, but summer the contrary, whereas spring and autumn are moderately moist and hot (ll. 109–127)… Well the nature of water is like that, and not only in the Ocean but in very many other places too ... There is another lake in Palestine, often called the Asphalt lake, and also named the dead sea as nothing lives in it, bitumen is produced from it. And in other places in the world rivers or springs have a natural salty current, and some are warm and turbulent. So the cause of all this has been said to be a fiery element inherent or innate in them (*horum igitur omnium causam dixerit quis connaturalem et unitam seu ingenitam naturam ignis*), because burnt earth produces different forms of exhalations depending on the degree of combustion (ll. 136–45)' (F 219 E−K)

It is important to realise that these passages of the fragment in Priscianus are closely interlinked although there are intervals (as we can see) between them. The account concerning the interaction between the sea tides and the monthly phases of the moon (F 219 ll. 97–109) comes immediately after the diurnal cycles (ll. 77–95). This passage is followed in turn by the report about the annual increases of the tides at the equinoxes (ll. 109–127). Respectively, the concluding part of the fragment, the passage above which begins with 'Well the nature of water is like that …' (ll. 136–45), is also connected with the previous accounts. This passage basically reiterates Posidonius' interest in hydrology.[31] Accordingly, its connection with the accounts about the ocean tides is that the properties of the unusual terrestrial waters that are reported there, both the salinity and the hot temperature ('rivers or springs have a natural salty current, and some are warm', 'a fiery element

[31] Cf. especially F 279 E−K which also concerns the Dead Sea.

inherent or innate in them'), are introduced as replicating the properties of the waters of the ocean. This reading sounds clear as we notice that the section preceding ll. 136–45, which Kidd omitted (p. 74.6–75.22 Bywater),[32] similarly focuses on the inherent salinity and heat of the ocean. We first learn there that the sea is naturally hot as the heat of its salt is said to be responsible for drying up the waters of incoming rivers (*aqua ex fluminibus ... influens siccatur multidudine et calidissima virtute salitatis* 74. 17).[33] Subsequently, the inherent salinity (and heat) of the sea is said to be providential (*mari connaturale esse salsum pro omnium salute in terra animalium* 75. 16). Finally, this last view is directly connected with the concluding section regarding terrestrial waters (ll. 136–45): '*And thus the sea was created providentially salty*. (F 219) Well the nature of water is like that, and not only in the Ocean but in very many other places too … the cause of all this has been said to be a fiery element inherent or innate in them (*itaque et hoc provide in mari factum est ... natura autem aquarum est talis … connaturalem et unitam seu ingenitam naturam ignis*).

The heat or fire which is inherent or innate to the sea waters (... *calidissima virtute salitatis*; ... *ingenitam naturam ignis*) is the detail which clarifies the dynamics of a theory of interactive elements where heat is the single active power (F 93). The processes of change and transformation of the elements in meteorological phenomena in discussion essentially correspond to the circulation or reciprocal exchange (*reciprocatio*) of heat. This process is clear in the analogy of the kettle and the contrasting effects of the moon and the sun. The effect of the moon (or the gently warmed kettle) means the moon's heat moderately warming up the 'flame' which is inherent to the sea (*submoventem*[34] *ea a caliditate*). Conversely, the sun's heat is too strong (*sincerum*) and the internal 'flame' transforms water into vapour (*vapores ... sublevat*).[35] As we see, both processes are accomplished due to the

[32] He thinks that the material is Aristotelian. Yet notice that there is a section regarding anathymiasis which sounds rather Stoic than Aristotelian ('… *multis enim vaporibus sursum ductis de mari et aliis sideribus et sole*…').

[33] This theory answers the question of why the sea level does not go up with the incoming rivers.

[34] Notice that *submovens* conveys the idea of moving from inside.

[35] Again, *sublevare* conveys the internal idea ('carry from below').

heat which is inherent to the sea waters.[36] This is actually a sympathetic interaction between the ocean and the heavenly bodies.[37] Now, the circulation of heat is further observed in the account of the monthly cycle. One learns there that the power of the moon (*lunae virtus*) is dependent on the sun's rays; that is, the better the exposure to the emission of sun's heat the more powerful the moon's heat (*unde in plenilunio et coitu extollitur maxima unda, quoniam et lunae tunc magna adest virtus*).[38]

As I have said above, the fragment in Priscianus (F 219) provides a well-defined picture of the elemental dynamics underlying the doctrine of F 93. Yet the notion of heat working as a sort of efficient cause which transforms the elemental masses is recurrent in Posidonius' meteorological writings. As evidence of this, I select two passages from the reports of Seneca's *Naturales Quaestiones*.[39] In the first fragment, one observes that the process of heating turns up as the causal factor in the Posidonian theory of thunderstorms (F 135). Again, this theory essentially follows the Aristotelian meteorological tradition. One further witnesses the significance of heat in Posidonius' geological research. The rising of an island in the Aegean is explained as the pressure of the heat mixed within earth (F 228).

'Now I return to the view of Posidonius … Any dry, smoky exhalations that reach the atmosphere do not tolerate being enclosed in clouds but burst through what confines them; that is the cause of the sound we call thunder. (54. 2) But also, in the air itself, whatever is rarefied at once becomes dried and heated. This too, if enclosed, equally seeks to escape, and emerges noisily. If it bursts out altogether, there is a more violent sound than

[36] Notice that the inherent heat of water seen here can be conciliated with the coldness and passivity of water (F 93) in the sense that heat and cold are considered as relative parameters.

[37] The general idea underlying the phenomenon of tides is described across the fragment (F 219) as the sympathetic interaction between the ocean and the heavenly bodies (*Oceani passio ad motum lunae* l. 19–20; *compassio astrorum*, p. 70. 23 Bywater, in the *Solutiones*).

[38] The implicit theory here is that when the moon is in quadrature it both absorbs substantially less solar heat (since its distance from the sun is over half the maximum) and emits substantially less heat of its own (since its illuminated face is reduced by half). See White 2007, 72–73.

[39] Cf. also the theory of comets (F 132 E−K) in Seneca and F 234, 279 and 229 (above) in Strabo. See also the meteorological account which Seneca attributes to Asclepiodotus, the pupil of Posidonius (*NQ* ii 30. 1).

if the air emerges bit by bit and gradually'. (*NQ* ii 54. 1– 55. 3 = F 135 E−K)[40]

'As Posidonius retailed it, an island rose in the Aegean Sea while the sea foamed during the day and smoke poured up from the depths. Finally night brought fire, not a continual glow but intermittent flashes like lightning, as often as the heat from below overcame the weight of water on top of it … Finally the peak of a burned mountain emerged … Why have I brought up this up? To make it clear that fire is not extinguished even with sea on top of it, and a huge weight of water does not prevent its force from bursting out.' (*NQ* ii 26. 4−7 = F 228 E−K)

As we have repeatedly seen, Posidonius' physical system conflicts with Stoic orthodoxy and incorporates concepts of the Aristotelian philosophical school. I shall finish this article by making two final observations. Firstly, it is important to note that the interpretation which Simplicius conveys of *De Caelo* iv 3, 310b 1–15 (or F 93 E−K of Posidonius) better suits the Theophrastean physical system than the Aristotelian one. Additionally, I shall analyse the implications of the theoretical shift of Posidonius as regards the Stoic school.

So, even though Simplicius also attributes doctrine (2) to Aristotle, this attribution runs into serious difficulties.[41] On the one hand, the concept that hot and cold stand respectively for active and passive powers is strange to Aristotle's physics as we know it.[42] On the other, the idea that both fire *and air* are active is not found in any of Aristotle's extant works either.[43] Regarding the attribution to the other Peripatetic philosopher, Theophrastus ('… καὶ Θεόφραστος ἐν τῷ Περὶ τῆς τῶν στοιχείων γενέσεως …'), scholarship is cautious about its accuracy. In the commentary of this fragment of

[40] Translations in Kidd 1999. Hine (1981, 321□22) analyses the importance of heat in the Posidonian theory of thunderstorm as portrayed by Seneca.

[41] Note that the attributions at the end of the fragment imply the difficulties surrounding the attribution: αὐτός τε Ἀριστοτέλης ἐν ἄλλοις λέγει … The reflexive pronoun (αὐτός) is emphatic. It sounds as though it was needed in order to assert that Aristotle himself (*ipse*) proposes or contemplates at some point (ἐν ἄλλοις) these variations.

[42] The clearest statement of Aristotle regarding the interaction of the elements in nature is found in *De generatione et corruptione.* Here he takes the view that hot and cold qualities are active, moist and dry passive. See, for instance, Sharples 1998, 114. Hot emerges as active in the biological works of Aristotle (e.g. *De generatione animalium*) yet such an active role is far from clear.

[43] Simplicius himself, commenting on *De Caelo* iv 5 (312a 22), ascribes to Aristotle the view that *fire only* is formal. Cf. Simplicius' *In de Caelo* 718, 32–34. Cf. also *GC* ii 8.

Theophrastus (*In de Caelo* 700, 3−8 = F 171 FHS&G) Robert Sharples (1998 114−15, 120−21) notices that although heat works as the active principle in Theophrastus' physical system,[44] the connection of air with heat is problematic since Theophrastus regards air as cold (*De Igne* 26). But, as we have seen above, it has escaped scholars so far that *In de Caelo* 699, 13−700, 8 conveys complementary doctrines (1 and 2) of a single system. Accordingly, this single system seems to be in line with Theophrastus' retreat from pure Aristotelianism.

To accept that we should first realise that doctrine (1) conveys another slight yet significant modification of the Aristotelian dynamics. The commentary (*In de Caelo* 699, 13−700, 2) of the relevant passage of Aristotle is clearly not a paraphrase since it confines the relationship 'like moving towards like' to the pair 'intermediary → extreme': water → earth, air → fire. Specifically, the original idea of *De Caelo* iv 3 that the intermediary elements (water and air) work as natural directions (i.e. form) to each other is not present in this doctrine (1). Whereas Aristotle says 'water, I mean, is like air, and air like fire … thus air is like water, but water is like earth ...', the commentary holds to the idea that only the elements of the extremities (fire and earth) work as natural directions (or form) to the adjacent ones.[45] The upshot of the modification becomes clear when we read both doctrines (1 and 2) as a single system that reinterprets *De Caelo* 310b 1–15. It actually means the substitution of what we might call a physicalist explanation for a formal 'mathematical' one. Whereas the upwards movement of water and the downwards movement of air are not grounded by the geometrical concept of the straight line (or natural directions) anymore, the temperature of the bodies (hot and cold) now dictates the overall division between active and passive elements.[46]

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[44] Cf. also the recent analysis of the treatise *De Igne* by M. van Raalte (2010, 174□83).

[45] Notice that doctrine (1) conflicts with the standard commentary of *De Caelo* iv 3, 310b 1–15, Stocks (1930): 'The gár in l. 11 forestalls an objection. "There remain the [the natural tendency of the] intermediate bodies: what of them?" These are given form or determined by the extreme bodies, and thus mediately determined by the "place" ... In this sense water is like air which is like fire, and air is like water which is like earth ...' Solmsen (1960) and Gill (2009) subscribes to his interpretation of the passage. Cf. also Algra 1995, 216 n58 and n59.

[46] Notice, for instance, that air only plays the role of form for water in the category of hot element (and not as similar element, or natural direction).

This sort of physicalist reassessment of Aristotle´s dynamics seen in F 93 can be better understood when one considers the views of Xenarchus of Seleucia. This Peripatetic philosopher of the first century BC who taught in Rome at the time of Augustus raised objections regarding Aristotle's methodology for what he takes to be an improper reliance on geometry in physics: [47] 'Finally in this connection Xenarchus complains that, while talking about natural things we [the Aristotelians] give mathematical demonstrations, since we have used kinds of lines in making the causes of the simple motions depend on the simple lines (Simplicius´ *In de Caelo* 1. 2. 25, 11–13).' Such revision of 'Aristotelem per Aristotelem' is germane to the text of F 93 in the sense that in the Posidonian fragment the geometrical concept of the straight line (or natural directions) does not ground either the upwards movement of water or the downwards movement of air as it occurs in *De Caelo* 310b 1–15.

Respectively, the elemental dynamics which Posidonius is said 'to borrow and use all the time' seems to be in line with Theophrastus' reassessment of Aristotle's natural philosophy.[48] As we know, Theophrastus concentrated on the physical rather than the formal (and metaphysical) aspects of the research of the founder of the Peripatetic school.[49]The other passage of Posidonius preserved in Simplicius, *In Physica* ii 2, 193 b23 (= F 18 E−K), correspondingly supports the idea that the Stoic philosopher followed the physicalist approach of the post-Aristotelian Peripatos. In this famous excerpt (F 18) one essentially learns that Posidonius established a hierarchical distinction between physical philosophy and mathematical astronomy 'taking his starting point from Aristotle':[50] 'the physicist will prove each point from the substance and power, or because it is better, or from their gene-

[47] For the analysis of his fragments see Hankinson 2002/3 and Kupreeva 2009, 150□56.

[48] For further connections between Posidonius and Theophrastus see the presence of Theophrastus' lemma in Posidonius' doxography concerning the origin of the Milky Way (F 130 E−K).

[49] See Gottschalk 1961, 79. See also the analysis of Marlein Van Raalte (1988) regarding the significance of Theophrastus' *Metaphysics*: 'The remarkable parallel between his criticism of the ultimate moving cause and that of the final cause (which amounts to what may be called a rehabilitation of passivity and matter) I consider a case in point (p. 197)'. Cf. also Sharples 1998, 119.

[50] The idea that Posidonius' methodological approach was consistently debated in the Peripatetic school is strengthened as we notice that both fragments (F 93 and F 18) may come from Alexander. Cf. F 18: 'Alexander diligently quotes a passage from Geminus, which came from his *Epitome* of Posidonius …' See White 2007, 39 n9.

ration and transformation, but the astronomer will prove each point from the attributes of the shapes or sizes … the physicist will grasp the explanation by considering the active power; but the astronomer, whenever his proofs are from external attributes, is not an adequate observer of the explanation …'. As White pointed out (2007, 60−62), Posidonius here emphasizes what we might call 'substantial' or dynamic explanation to the detriment of formal 'mathematical' explanation. And, in fact, the priority of physical philosophy seen in F 18 E − K specifically underlies the reinterpretation of Aristotle's elemental dynamics observed in F 93 E−K: the substitution of a physicalist or 'substantial' explanation for a formal 'geometrical' one.[51]

We have observed throughout the second section of this article that Posidonius incorporated important concepts of Peripatetic physics into his system. Posidonius adopted a finitist cosmological model where the extracosmic void was not infinite but just as large as the cosmos' size at the time of the conflagration (F 84/97a E−K). He correspondingly accepted the idea that there are absolute directions (up for fire and air, down for earth and water) towards which the elements naturally tend to move and in which they will naturally remain (F 93 E−K). Similarly, Posidonius conceived the four elements as interactive given the new relationship of mutual contrariety (hot fire and air, cold water and earth), and adopted a physicalist approach where the hot elements are active (F 93, F 101 E−K). The analysis of the long fragments preserved in Strabo (F 229 E−K) and Priscianus Lydus (F 219 E−K) has further shown the significance of heat as an active power in Posidonius' physics (especially meteorology). The processes of transformation of the elements essentially correspond to the circulation of the heat which is inherent to the elemental masses.

I conclude by making some final observations about the implications of Posidonius' shift towards Aristotelianism. The first point is that despite the new concepts concerning space and the structure of matter Posidonius

[51] Notice that this reinterpretation may underlie the original theory concerning the formation of hail outlined by Posidonius (F 136 E−K = Seneca's *NQ* iv b 3. 1□2): *Posidonius tibi auctoritatem promittet tam in illo quod praeterit quam in hoc quod secuturum est*. *grandinem enim fieri ex nube aquosa iam et in umorem uersa sic affirmabit tamquam interfuerit*. Cf. the paragraph of n79 above. For the difference between the theories in both meteorological systems see Kidd's commentary (514). According to Williams (2012, 151□2), Seneca's report stresses that Posidonius was interested in the process of becoming in the different stages of hail formation.

could uphold the core concepts that defined the Stoa. To begin with, by adopting the notion of absolute directions in space guiding elemental motion he did not disregard the essential corporealism of the school where only bodies 'can act and be acted upon' (cf. *i.a.* Cicero *Ac. Post*. i 39). In fact, the existence of 'natural places' does not necessarily imply that the incorporeal 'place' works as a cause of movement. Here he just had to follow the writings of Aristotle who is quite unambiguous that place is not one of the four causes (cf. *Phys.* iv, 209 a18−22; viii 255b; *De Caelo* iv 3). He describes the goal of elementary motion not as 'natural place' but as the element *being in a natural place*. The goal-directed character of natural motion is, so to speak, programmed into the elements own constitution (see Algra 1993, 208−21; M. Mathen 2009, 127−133).

Posidonius could also maintain the general Stoic concept that all things (including cosmos and earth) are held together by an internal *hexis* (*SVF* i 99 #1). Interestingly, Cicero's *De Natura Deorum* ii 115−17 presents a Stoic cosmological theory (without specific attribution) where both the internal *hexis* and the notion of absolute directions guiding the elements are combined. Yet the fact that the structural force of the *hexis* turns up exclusively as a principle of cohesion is telling. Moreover, the structural pull seems to pose an apparent contradiction to the notion of the absolute directions guiding the elements:[52] 'nothing is more remarkable than that the cosmos shows such stability and coherence that it is impossible even to think of anything better adapted to exist. For from all sides all its parts gravitate with a uniform pressure towards the centre … the sea … *though* above the earth, *nevertheless* seeks the earth's centre (*cum … tamen*… ) … the air, *it is true*, travels upward in virtue of its lightness, *but at the same time* (*quidem … sed* …) spreads horizontally in all directions, and thus while contiguous and conjoined with the sea, it has a natural tendency to rise to the sky'. In fact, these 'natural laws' were not mutually contradictory in the sense that whereas each element had its specific natural tendency, the structural pressure (the *hexis*) providentially acted upon the cosmos as a whole.

Likewise, the physicalist elemental theory adopted by Posidonius actually meant the return to some ideas which had been introduced by Clean-

[52] Algra (1988, 167□68) suspects that the theory here belongs to Posidonius (n21).

thes yet neglected by Chrysippus.[53] Indeed, Posidonius' elemental theory has some points in common with the Cleanthean theory which is outlined in Cicero's *Natura Deorum* ii 23−32.[54] Posidonius' notion that the active fiery pneuma is ingrained in the elemental masses (F 219: … *connaturalem et unitam seu ingenitam naturam ignis*) essentially follows the Cleanthean theory that fire is mixed within the remaining elements (cf. ii 24: ... *caloris naturam vim habere in se vitalem per omnem mundum pertinentem*). Accordingly, it is also very likely that he could find in this Stoic predecessor a non-orthodox theory that presupposed the interaction of independent elements. As scholars have noted, the emphasis of Cleanthes in *ND* ii 23−32 is laid not on the monist notion that the other elements are *made out of* fire but on the notion that they *contain* the fire that acts upon them from inside (see Salles 2009, 129; Todd 1978, 150−60).

As we see, the new concepts concerning matter and space did not cross the boundary and were still at home in the Stoic school. I have mentioned above the theoretical advantages attending Posidonius' shift. It is noticeable that the elemental theory of F 93 contrasted with the orthodox theory in the sense that the new concept of matter provided a suitable speculative framework for the analysis of the natural phenomena. Whereas the orthodox theory prescribes virtually qualityless material elements (water and earth) which work as just a *principle of extension* for the active ones, the Aristotelian-like theory of Posidonius prescribes the interaction of the elements via the contrariety of their primary qualities (hot and cold).[55] Accordingly, it seems that the meteorological research undertaken by Posidonius was logically matched by a concern with material and efficient causes which were neglected by the early Stoics.[56] The important role of meteorology (geology,

[53] For the connection between Theophrastus and the early Stoics see, for instance, Van Raalte 1988, 204□08.

[54] I leave aside the hypothesis defended by Mansfeld (1971, 88□96) that *ND* ii 23□32 is a Posidonian fragment.

[55] For the distinct yet related concepts of mixture in Aristotle ('a quality meets a quality') and Zeno ('body goes through body') see Mansfeld 1983.

[56] The neglect of material and efficient causes and the corresponding scientific shortcomings of the early Stoics in relation to Aristotle (and his school) were properly described by Hahm (1977, 39): 'Matter for him [Aristotle] was the substrate of a particular change, such as the transformation of the elements, or it was the material from which a particular thing, such as a bronze statue, comes to be. The Stoics, on the other hand, used matter as a cosmic constituent; it is the material that underlies the cosmos as a whole as well as all that is in the cosmos. The Stoics thus universalised what for Aristotle was a concept of particu-

hydrology, etc.) in his philosophical system required the new 'independent' physical status[57] of the material elements.[58]

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larized application. What this reflects is a difference in personal outlook. Aristotle was a researcher seeking to understand the natural phenomena; the Stoics were teachers of philosophy, appropriating scientific theories and forging from them a world view that would conform to the latest scientific researches.'

[57] Further evidence that the Posidonian notion of matter was similar to the Aristotelian one emerges in his slightly unorthodox doxa about matter found in Arius *fr*. 20 (F 92 E−K) and Calcidius 294. 13□15 (which most probably exposes his particular concept: *Plerique etiam hoc pacto silvam et substantiam separant, quod asseverant essentiam quidem operis esse fundamentum, ut mundi fore merito dicatur atque existimetur essentia, silvam vero contemplatione opificis* [cf. ἐπινοίᾳ μόνον of F 92] *dictam, quod eam fingat et formet*). See analysis of Reydams-Schils 1999, 463–65.

[58] See also above the suggestions of Keimpe Algra for the motives underlying the new finitist cosmological model of Posidonius. He remarks that the finite extracosmic space rendered the Stoic theory of void in line with that of 'place'. The finite void is now ontologically derivative of a corporeal reality (i.e. the cosmos).

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