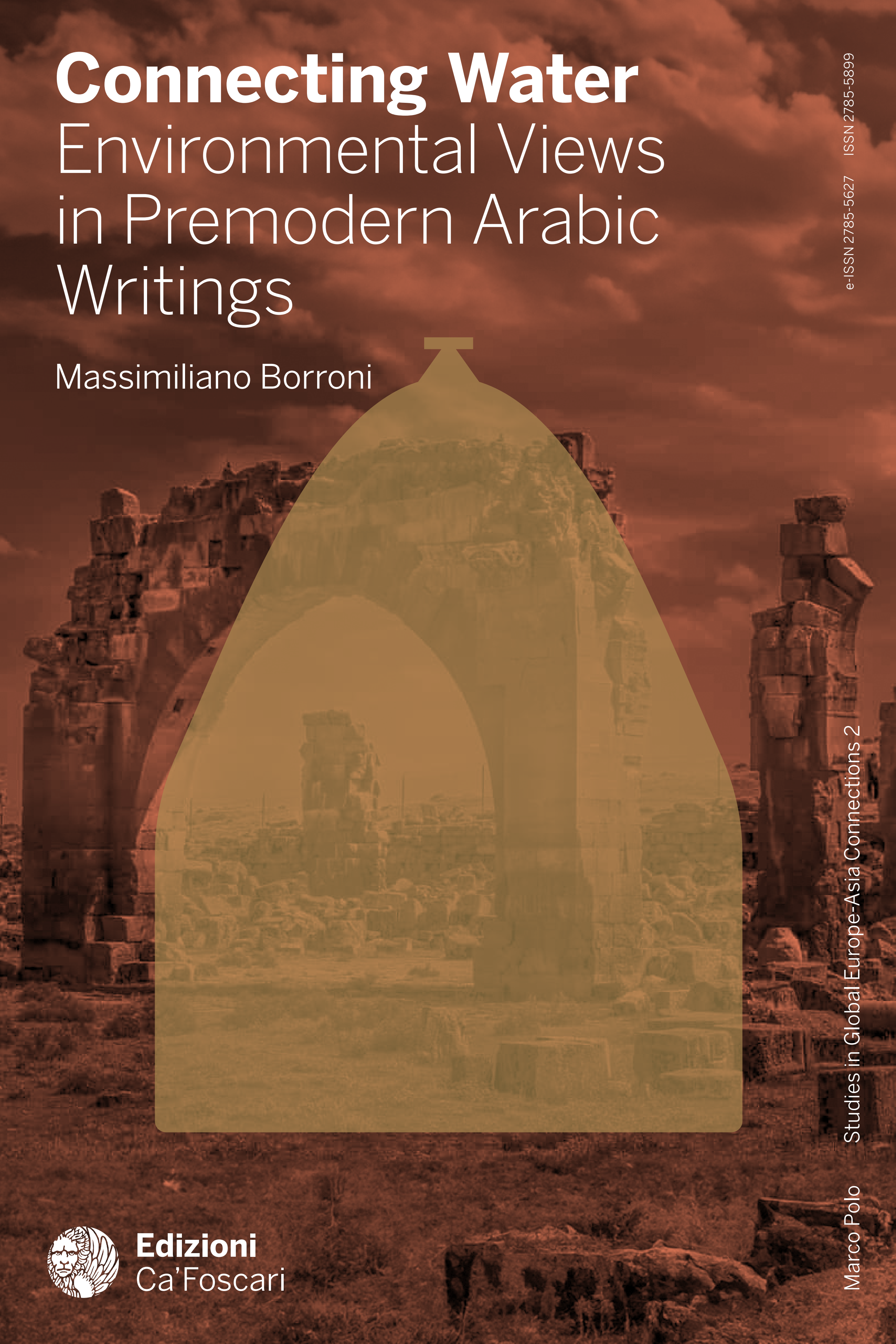
Connecting Water
Environmental Views in Premodern Arabic Writings

Massimiliano Borroni



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Massimiliano Borroni

Abstract

This book investigates how selected writers from the Abbasid-era Islamic world viewed water as a crucial element within their worldview. By examining water's role across diverse authors, *Connecting Waters* offers new insights into the various approaches to water and its importance in the natural environment, as described in Arabic sources from the Abbasid period. The study focuses on the significant works of Thabit ibn Qurra, whose research on seawater salinity and the role of mountains in precipitation phenomena laid the groundwork for future scholars in the field of hydrology. Through comprehensive analysis of these works and their reception by authors who either cited or concurred with Thabit ibn Qurra's theories on the water cycle, the book explores a wide range of subjects, from theology to natural sciences and the sea's role in sustaining global environmental equilibrium. By examining the consistency and diversity of Islamic views on water and the environment, the book seeks to challenge cultural stereotypes and offer novel insights into the Arabic literature of the premodern Islamic world. In light of current environmental challenges, this examination of water-related knowledge within the Islamic tradition could contribute to ongoing discussions about environmental ethics and the complex relationships between humans, societies, and the natural environment.

Keywords Water. Ṯābit b. Qurra. History of science. Hydrology. History of philosophy.

Connecting Water
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Massimiliano Borroni

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Preface

Simone Cristoforetti
Università Ca' Foscari Venezia, Italia

The study by Massimiliano Borroni, emerging as the second volume in the book series, sponsored by the Department of Asian and North African Studies of Ca' Foscari University of Venice through the Marco Polo Research Centre for Global Europe-Asia Connections, is the culmination of a research project for which I have had the honour and pleasure of serving as the scientific supervisor. The project is dedicated to Networks of Science and Water, and – as its title would suggest – aims to shed light on hitherto little-known or entirely unknown aspects of knowledge in relation to the theme of water produced in the Muslim world from the seventh to the eleventh century AD. This has come about following conferences under the title of *Meetings of Water*.

The general framework of this project entails the gathering of information on scientific knowledge and traditional water management techniques in the Arabic sources of the considered period. This retrieval is conducted based on innovative research systems such as the Jedli software, developed at the University of Hamburg within the scope of the ERC project The Early Islamic Empire at Work, which allows for regular expression searches in the corpus of digitised Arabic texts currently available.

The analysis of the materials thus identified has enabled the author of the present study to focus their attention on a hydrological treatise by Ṯābit. To ensure the soundness of the present analysis from a scientific standpoint, it should be noted that the study of the merely technical-scientific aspects concerning the central theme of this work has been conducted by consulting the hydrological engineer Vladimiro Boselli, author of the Afterwords in this volume. Ibn Qurra's work, composed in Iraq in the ninth century AD, is among the oldest hydrological treatises in Arabic that has come down to us and is of paramount importance for the study of hydrological skills in the considered centuries. The importance of this manuscript, which has reached

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us in a single copy preserved in the library of the Topkapı Museum in Istanbul, is confirmed by a citation from the famous polymath and Arabic scholar al-Bīrūnī, who still in the eleventh century speaks of it as a foundational text in the field of hydrology. The text, which presents interesting linguistic challenges due to the technical language used, has revealed important information on water management practices and in particular on the safeguarding of stagnant waters, as well as on the scientific skills in hydrological matters that constitute its subject.

These latter aspects, in particular, are the starting point for Borroni's analysis, which focuses on the ways in which the thorny issue of the origin of sweet water was addressed in the Muslim world during the Abbasid period. This issue has constituted one of the most challenging tests for physics up until the modern era. Indeed, it was only in the eighteenth-nineteenth centuries that the exogenous origin of the water cycle was definitively established, while for the many centuries that separate this from antiquity, in the West (which here I understand as encompassing the cultural and religious phenomenon of monotheistic Islam) the endogenous physical theory of the water cycle held credence, with its earliest and most famous formulation attributed to the authority of Ptolemy.

Well, thanks to Borroni's analysis, which has led him to patiently reconstruct an unpublished and highly significant segment of the history of water physics in the Muslim world, we now know that Ibn Qurra and his hydrological treatise represent the oldest surviving testimony of a line of thought alternative to the Aristotelian view. This line of thought later unfolds in the speculations contained in the *Epistles of the Brethren of Purity* and in the thought of other subsequent authors, such as the already mentioned al-Bīrūnī, attesting to the importance of this 'alternative view' in the physical field, which received due attention in the West only following the discoveries of modern hydrology that confirmed its absolute correctness.

The present work thus presents aspects that I do not hesitate to describe as pioneering with regard to the reconstruction of a segment that we can now define as fundamental in the history of the development of scientific knowledge in relation to water. This opens up extremely interesting prospects for analysis. It is now legitimate to ask what the relationship is between the content of Ibn Qurra's text and the hydrological tradition that flowed through that famous work primarily devoted to, but not limited to, agriculture known with the title *al-Filāḥa al-Nabaṭiyya* (The Nabatean Agriculture) and attesting a more widespread and possibly more ancient diffusion of exogenous models of the water cycle in Mesopotamia. Furthermore, whether there is a relationship between the line of thought testified by Ibn Qurra and the cosmological conceptions inherited from the Zoroastrian world, in which the water cycle – albeit described in the fabulous terms typical of mythological language with its Primordial Rain Waters that feed the archetypal River flowing from the Cosmic Mountain to nourish the Great Sea and eventually end up in the Lake-Filter, where, evaporating, they resume their cycle – recalls, for many non-secondary aspects, the exogenous vision characteristic of Ibn Qurra's thought.

Given the pressing concerns of our time, it will not surprise the reader that the theme of water may serve as a revealing thread to follow in the study of the Arabic written production of the so-called Islamic world. However, the variety (almost exhaustiveness) of approaches that can be found in the Arabic sources is easily underestimated.

But that is not all. The theme of the monograph prompts inquiries into issues ranging from theology (what is the purpose of the sea's salinity in the overall economy of divine Creation?) to natural sciences (why does stagnant water tend to become corrupted?), from the water cycle (does this cycle have an endogenous or exogenous nature?) to the dignity and self-worth of non-human life. On this latter aspect, which is of quite some importance in legal reflection within both ancient and modern Islamic contexts, one can appreciate a considerable variety of nuances in identifying not only human life but also more generally animal and plant life as the culmination of the divine work of creation, and a sense that goes beyond mere human benefit in their exploitation.

In conclusion, by adopting a methodology that eschews culturalist presuppositions, this scholarly endeavour proves to be a vital addition to the progression of research, not solely within the realm of the evolution of scientific thought, but also in addressing a multitude of inquiries spanning diverse intellectual domains, including but not limited to ethics, science, and theology within the Muslim world.

Connecting Water
Environmental Views in Premodern Arabic Writings

1 Introduction

The present book deals with water-related knowledge in two works by the Sabian mathematician and scientist Ṯābit b. Qurra (211-288/826-901), at the beginning of the so-called golden age of the *dār al-islām*. The two treatises are the *Qawl fī al-sabab al-laḏī juʿilat lahu miyāh al-biḥār māliha* (Discourse on the Reason Why Seawater Was Made Salty), and the *Risāla fī manāfiʿ al-jibāl* (Treatise on the Benefits of the Mountains), a similar work about mountains and their role in nature. The two treatises read together give us an insight into Ṯābit's view of the environment. When I say environment, I am referring to what our author calls 'creation'. He consistently uses the term (Ar. *ḫalq*) to denote the broad sphere of beings that encompasses humans and non-humans, animals and elements, phenomena and material properties both sub-lunar and supra-lunar – essentially everything except God. As will become evident, this notion of the environment as creation is primarily viewed as a system. This system is both self-balancing and divinely ordained, with water playing a pivotal role in its inner workings.

During my research for the Network of Science and Water project at the Centro di Ricerca Marco Polo – Centre for Global Europe-Asia Connections, I examined these two treatises, focusing on water-related science in al-Bīrūnī's (362-c. 440/973-c. 1048) thought in collaboration with Vladimiro Boselli, at the time an environmental engineer at Brescia University. Despite their lack of direct relevance to hydraulics and environmental engineering, it became apparent that these treatises have received relatively little attention compared to their significance within the broader history of environmental thought. Previous research on these texts has tended to approach them from a purely philosophical perspective, specifically in relation

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to the doctrine of the best possible world. The following pages present an attempt to contextualise Ṯābit's work within its historical and cultural milieu, and to identify innovative aspects or insights that played a significant role in contributing to the understanding of the environment and the role of water within the Arabo-Islamic scientific, and thus philosophical, tradition.

Water is one of the few geographical features that may justify, to some extent, the adoption of categories such as Middle East or Middle East and North Africa at any level other than the geopolitical.[1] The diverse regions identified by these terms usually span from North Africa and the Atlantic to Central Asia and the Hindu Kush. These lands are, for the most part, arid; at the same time, they often rest upon considerable subterranean water reservoirs, also known as fossil water. Aridity does not mean a complete lack of water, but rather a scarcity of precipitation. In fact, a significant portion of the lands of premodern *dār al-islām*, meaning the territories subject to Muslim authority, enjoys a steady supply of water through its rivers, such as the Nile, the Tigris and Euphrates, and the Amu Darya or Oxus. The Indus river would join this group at a later date.[2]

These four rivers have their sources either outside the territories of the caliphal *dār al-islām* or at its fringes. Nevertheless, they appear prominently on the stylised map produced by premodern Muslim geographers, such as the world map contained in the manuscripts of the early geographical work by Ibn Ḥawqal (d. after 362/973) *Kitāb ṣūrat al-arḍ* (The Image of the Earth).[3] It is not surprising that al-Bīrūnī chose the Nile, the Tigris, the Euphrates, and the Amu Darya to discuss fluvial regimes and the physical principles governing them in conjunction with geographical contingencies.[4]

The scholars responsible for the high-cultural production that is the Arabo-Islamic scientific tradition lived and worked in these environments and landscapes, especially in the early corpus of this tradition. Ṯābit was one of these individuals, and he occupies the centre stage in this book. He was neither Arab nor Muslim, but he shares with other key representatives of this learned tradition a place in the global history of scientific thought and the landscapes that informed their experience of the world.

As we will see, there is a fascinating assonance between what Ṯābit, the historian and philosopher Miskawayh (c. 320-421/c. 932-1030), al-Bīrūnī, and, to some extent, even an engineer and mathematician like al-Karağī (d. after 410-420) and the esoteric philosophers of the anonymous fraternity known as Iḫwān al-Ṣafāʾ (tenth century) had to say about what we would today call the water cycle and the environmental realities of the "eastern lands of the Caliphate". I here reference the seminal work by Guy Le

1 Bonine, *Is There a Middle East?*.

2 C.E. Bosworth mentions a "considerable confusion over the precise nomenclature of the Indus and its constituents", despite Muslim presence in the Indus valley dating back at least to the early eighth century, signalling a lack of information or attention regarding this river before Ghaznavid expansion in the Indian subcontinent. Perhaps, this may simply be a consequence of the initial imprint of Greek traditions on Arabo-Islamic geographers. However, a comprehensive analysis of how Islamic authors from the eighth to the eleventh centuries perceived the Indus has yet to be undertaken. Bosworth, "Mihrān"; Siddiqi, "Muslim Geographic Thought". For a general summary of the notions held by geographers at this time about the Indus and its valley see Le Strange, *The Lands of the Eastern Caliphate*, 330-3.

3 Ibn Ḥawqal al-Naṣībī, *Ibn Ḥawwqal's Kitāb Ṣūrat al-arḍ*.

4 See infra and Borroni, Boselli, "Hydraulics and Hydrology".

Strange[5] because its title encapsulates two crucial elements: the geographical coordinates of the environments where these thinkers lived, and the political order governing the societies that nurtured them.

Ṯābit was and remains primarily known as a mathematician and astronomer, both as a translator and as an original author. Of his original works, the most significant are those dedicated to astronomy. Of the thirty to forty titles on astronomy attributed to him, we currently have access to only eight. These are primarily focused on resolving discrepancies between mathematical astronomy and observational astronomy, specifically the observable behaviour of celestial bodies. His interest in mathematics extends beyond its application to astronomy, with his most noteworthy contributions found in calculus and the study of amicable numbers. Furthermore, as R. Rashed rightly points out, our author produced works "in all the practical sciences of his age", as demonstrated by the texts we will discuss.[6]

The socio-political context that nurtured Ṯābit matters the most when we consider in what terms his scientific and philosophical production should be understood in the broader Arabo-Islamic scientific tradition. The nodal question rests on the definition of Islamic, and, henceforth, on the definition of Islam. The topic has a very long history with historiographical and theoretical trappings, that will not be described in full here. I will just discuss the definitions adopted in the following pages. We owe to Shahab Ahmed a new, clever, and evidence-based definition of Islam and Islamic; this is the one I will rely on in this book. Ahmed understands Islam "as meaning-making for the self in terms of hermeneutical engagement with Revelation to Muḥammad as Pre-Text, Text, and Con-Text".[7] Here the Pre-Text amounts to the ultimate Truth, which lies *before* the Revelation on a logic or conceptual level. The Con-Text is the entirety of the hermeneutical projects engaging with these three elements, be they religious sciences, history and memory, art, etc.

The matter is far from settled, of course, and Ṯābit's contribution to water-related sciences in Islam only provides one specific case of this broader issue. That being said, Ahmed's understanding of Islam is meaningful and productive when applied to the question posed here, namely in what terms we can describe Ṯābit's scientific contributions as Islamic. In a sense, just as the concepts of high and low lose their meaningfulness in outer space, or as the all-important concept of time loses its validity in the infinitely small, so any definition of Islam and Islamic may prove less than functional in some research contexts, for instance if we consider Islam as a large scale historical, cultural, and religious phenomenon. This is a question of fields of applicability, that may be more or less suited to different definitions. For what concerns us here, Ahmed's understanding of Islam allows to approach the Islamic character of the Arabo-Islamic scientific tradition in a meaningful and rigorous way.

According to Ahmed, we should consider Islamic what engages hermeneutically with the Text, Con-Text, and Pre-Text of the Revelation to Muhammad. Crucially, Ahmed argues that "obviously" Non-Muslims can produce meanings

5 Le Strange, *The Lands of the Eastern Caliphate*.

6 Rashed, "T̲h̲ābit b. Ḳurra".

7 Ahmed, *What Is Islam?*, 405; for a critique of Ahmed's approach see Hughes, "New Methods, Old Methods".

that come to be incorporated in the Con-Text of the Revelation. Thus, these meanings can and should be considered Islamic in the fullest sense of the term. In this frame, natural sciences occupy a special place. Ahmed himself draws on the work of previous scholars about the intellectual history of natural sciences in Islam to fold this topic in his broader argument. The overall picture that he details shows that natural sciences in premodern and early modern Islam are linked with several other Islamic meaning-making projects, such as fine arts or poetry; moreover, they were intended as a "rational project of knowing the rational Pre-Text of the Revelation". In light of this, he continues, Aristotle is surely Islamic as a philosopher whose thought is well incorporated into the Con-Text of the Revelation and geared towards the knowledge of its Pre-Text, although perhaps under the Arabic name of Ariṣṭū.

Ahmed finely conceptualises the process more currently called Islamisation or, sometimes, 'Islamicisation'. It is a theory that works very well for the incorporation of pre-Islamic philosophers and scientist. When we apply it to Ṯābit's thought, and to the *Treatise on Why Seawater was Made Salty*, there are some further considerations to be made.

First, Ṯābit discusses the purpose of natural sciences explicitly. In his view, the study of the created world leads to the rewarding, albeit never fully attainable, comprehension of (snippets of) divine wisdom. This is a description in premodern terms of a rational project of knowing the rational Pre-Text of divine Revelation. Perhaps conveniently and surely for basic intellectual politeness, Ṯābit does not say *which* revelation. Nevertheless, he was clearly referring to something not too different from the rational Pre-Text of subsequent Islamic tradition. He was clearly aware of the fact that a large part of his audience was and would have been Muslim. It does not seem too much of a stretch to say that the knowledge project of natural sciences in Ṯābit is the same as the later Arabo-Islamic scientific tradition.

Second, we cannot make a comfortable distinction between Islamic and non-Islamic Ṯābit. We can formulate this distinction in the case of Aristotle because he was chronologically and culturally apart from his Islamic alter-ego, Ariṣṭū. On the contrary, Ṯābit worked and, at least in part, acquainted himself with natural sciences in an already Islamic social setting. His work was simultaneous with the beginning of its own incorporation in the Con-Text of the Revelation and this renders moot any attempt at a clear-cut distinction between the two.

Third, he is a foundational figure for mathematical and natural sciences. Therefore, his work has undergone a thorough process of incorporation in the Con-Text of the Revelation that lasted centuries. Since some of his works are lost and their content is known to us only in later summaries, it is impossible to differentiate between aspects of his thought that became Islamic by later incorporation and elements that already had the aforementioned hermeneutical engagement.

Lastly, and returning to Ṯābit's awareness of his audience, we cannot say if and to what extent the fact that he was talking to an audience of Muslims, at least in substantial part, influenced his presentation of scientific theses that easily border on the theological. I am not referring here to what we may today call self-censorship, of course, but this does not exclude other forms of argument-tailoring intended to make his words more persuasive for the audience.

In conclusion, this treatise on the salinity of the sea and the lost treatise *On the Benefits of the Mountains* can be considered Islamic in the sense outlined by Shahab Ahmed, i.e. in the same way that Aristotle/Ariṣṭū can be considered Islamic. It is less clear whether these works should be considered Islamic in the sense that they actively engage with the Con-Text and Pre-Text of the Revelation to Muhammad. If we apply the distinction between Islamic and Islamicate, as proposed by Marshall Hodgson, we may say that Ṯābit's work on water-related sciences was, if not Islamicate, certainly 'Islamicable' from its inception.[8]

I have so far relied on the concept of water-related sciences. The two treatises that form the core subject of this book, written by Ṯābit, discuss a range of topics that are primarily within the scope of modern hydrology. However, it should be noted that neither hydrology nor hydraulics had a clearly defined place in the premodern Islamic natural sciences. Today, hydrology is understood to be the branch of science that studies the movements, distributions, and qualities of water on Earth.[9] Meanwhile, hydraulics is a branch of continuum mechanics that examines the mechanical properties of liquids, and is commonly applied to engineering problems such as pipe flows, dams, pumps, and channel behaviour. This distinction and the delimitations of knowledge that it implies are applicable to the premodern Arabo-Islamic scientific tradition only to a limited extent.

The discipline of hydraulics, or at least applied hydraulics, has its closest analogue in the Islamic concept of *handasat al-mā'*, which is commonly translated as 'irrigation', 'water engineering', or 'hydraulics'. However, it is worth noting that in the early centuries of the caliphate, the term *handasa* was typically used exclusively to refer to *handasat al-mā'*. For instance, the founding of new cities often involved significant planning and the participation of engineers, in Arabic *muhandisūn*. These individuals were responsible for developing the water supply infrastructure for the city, while the construction of residential areas was left to the inhabitants.[10]

Furthermore, throughout the vast irrigated regions of the Mesopotamian caliphal provinces, engineers would primarily focus on irrigation infrastructure. This was also the career of Muḥammad b. al-Ḥasan al-Karağī, whose treatise on hidden waters constitutes the only known work on the subject. Despite the limited availability of technical primary sources, the topic of water-related sciences has received a considerable amount of scholarly attention. The rich archaeological evidence for premodern Islamic water supply infrastructure compensates for the lack of technical information that has been preserved. In fact, *handasat al-mā'* is likely the first thing that comes to mind to many people when thinking about water and premodern Islam.[11]

Knowledge about water extended far beyond the field of *handasa*, though. For instance, *fiqh* (jurisprudence) intervenes wherever water is subject to

8 According to Marshall G.S. Hodgson, the concept of the 'Islamicate' serves as an alternative to the commonly used term 'Islamic', in order to address the ambiguity present in the usage of the word 'Islam' within scholarship. While acknowledging the interconnectedness of religious faith and the various aspects of daily life, Hodgson argues that "the society and culture called Islamic in the second sense are not necessarily Islamic in the first". The term 'Islamicate' is intended to encompass all aspects that are influenced by Islam, but are not necessarily directly related to religious faith. This includes behaviours and ideas that may be present among non-Muslims, but are still clearly linked to Islam. Hodgson, *The Venture of Islam*, 1: 57.

9 Hydrology covers also other water on planets other than Earth, of course, but this does not concerns us here.

10 Kennedy, "How to Found an Islamic City".

11 See, for instance, the abundant space devoted to water-related engineering in Hill, *A History of Engineering*.

human use. As a hermeneutic project set to understand its various subjects in meaningful relation with the Con-Text, Text, and Pre-Text of the Revelation, *fiqh*, that is Islamic shariatic jurisprudence, deals with the water of canals, rivers, marshes and seas.

Saints and Sufis also had a keen interest in water. For example, North African Sufis were called upon to perform rituals to combat drought, which is obviously a hydrological challenge. Their work, which is recorded in bibliographical literature, has been considered as a potential source to compensate for the lack of climatological data from the 'archives of nature' about premodern Maghrib. It is scarcely relevant that the knowledge expressed by jurists or Sufis does not fall under the categories of either hydraulics or hydrology. Sufi rituals against drought described in biographical literature were an Islamic practice of water-management and part of Islamic water-related knowledge.

Most of the notions we understand today as hydrology were comprised in the general field of natural sciences, *ʿulūm ṭabīʿiyya* in Arabic. As such, they are most commonly found in scientific-philosophical works. Knowledge about the origins of sweet water, the role of precipitation, the salinity of the sea and similar subjects appear, for instance, in the *ʿUlwiyyāt* by Ibn Sīnā (370-428/980-1037), but also in al-Tawḥīdī's (d. 414/1023) collection of the philosophical answers which he received from Miskawayh on several diverse topics. Nevertheless, even works that are not programmatically devoted to philosophy or natural sciences may devote some space to water-related knowledge. This is the case of al-Bīrūnī's digression on water in the astronomical-chronological treatise titled *Kitāb al-āṯār al-bāqiya* (usually translated as *The Remaining Signs of the Past Centuries* or *Chronology of the Ancient Nations*). Even a treatise on *qanāt* construction, al-Karağī's *Kitāb inbāṭ al-miyāh al-ḫāfiyya* (On the Discovery of Hidden Waters), is introduced by a lengthy discussion of theoretical hydrological notions.[12] The *Kitāb Inbāṭ* is a highly technical treatise composed by a successful engineer who had earned his living by practicing his craft. In other words, al-Karağī was someone who would have been included in what al-Tawḥīdī (d. 414/1023) wrote about engineers:

> The engineers, when they use their knowledge as a craft become like the canal diggers, or like those who dig streams in a valley, like those who build public baths.[13]

Notwithstanding al-Tawḥīdī's disdain for applied science or the practical use of knowledge of any kind, al-Karağī's theoretical introduction shows that knowledge about water formed a continuum of interrelated meanings and applications. We can surely treat this continuum separately as hydrology or hydraulics for convenience's sake, but without forgetting that it is not a classification and delimitation shared by our authors or by engineers.

Ṯābit contributions to the development of Islamic knowledge about water are fundamental, first of all for chronological reasons. Ṯābit worked in a formative early period, when some of the earliest activities of knowledge production and Islamicisation took place. Moreover, thanks to the

12 The *qanāt* is a traditional technology for harnessing groundwater in areas characterised by uneven terrain and slopes. Sajjadi, *Qanat, kāriz*; Yazdī, Ḫānīkī, *Qanat Knowledge*.

13 Abū Ḥayyān al-Tawḥīdī, *Risālatān*, 206. Cited in Beg, "Agricultural and Irrigation Labourers", 27.

prestigious social context in which he could operate, his work holds a lasting influence on later scholars. As I argue in the following pages, the concepts expressed in the two treatises on the sea and the mountains informed a strain of thought about the place of water in the created environment that lasted centuries. This school of thought was not disconnected from the mainstream, overwhelmingly Aristotelian, view of the water cycle, and the last chapter of the book will discuss how this coexistence influenced al-Karağī's introduction in the *Kitāb inbāṭ al-miyyāh al-ḫafiyya*.

The relevance of Ṯābit's thought may extend also to some ongoing debates on Islamic environmental ethics. This debate is clearly too ample for this book to do it justice, but it may be useful to remark on a few key points. Scholars, both Muslim and non-Muslim, who work on Islamic environmental ethics and Islamic eco-theology usually rely first and foremost on the text of the Revelation to Muhammad. This has not always been the case. Most prominently, for instance, Seyyed Hossein Nasr, who is regarded as the initiator of scholarly reflection on the subject, was mostly interested in philosophical, scientific, and mystical thought about the environment within Islamic traditions.[14] Nevertheless, in recent years, many argued that Islam may give a special contributions to the global effort against the ecological and climatic crisis through shariatic measures, which may be received as more legitimate among Muslim populations and connect the legislative effort to the cultural and spiritual dimensions of the crisis.[15] Thus, Islamic environmental ethics may be flowing into Islamic ecological law, which entails that the evidence for the assumed environmental character of Islam as a religion is to be found in the most authoritative sources of Islamic jurisprudence: the text of the Revelation. On the one hand, this approach has some practical benefits in terms of environmental protection. It allows to produce actual environmental legislation that is Islamically mandated. On the other hand, it is detrimental to a broader understanding of the plurality of Islamic views on the environment, something that was crucial in Seyyed Hossein Nasr's effort, among others. This plurality is a richness very much worth investigating and it comprises sources of environmental thought beyond the text of the Revelation.

In Ṯābit we find an author of the formative age of Islamic views about nature with influential ideas. The theses on human-animal relationships and on the water cycle espoused by the Iḫwān al-Ṣafāʾ (fourth/tenth century), which are often mentioned as Islamic precursors to today's environmentalisms and hydrology, are in continuity with Ṯābit's world view, which could be a component of the efforts to understand and foster contemporary environmental ethics.

14 Nasr, *An Introduction to Islamic Cosmological Doctrines*; *The Encounter of Man and Nature*.

15 The shariatic turn is not entirely new. For instance, the S.W.A. Husaini's textbook on Islamic environmental system engineering published in 1980 opens with a discussion of Quranic environmental themes, and moves to actual engineering only after a chapter devoted to "Islamic Jurisprudence: revealed law (*shariʿa*), and derived or substantive law (*fiqh*)". That being said, S. Idllalène has rightly noted that the pressure posed by the environmental crisis, the strong religious influence, and the overall weak implementation of secular environmental laws create a strong incentive toward the elaboration and adoption of measures falling under shariatic discourses on environmental protection. Moreover, as noted by A.M. Gade, the more theological and philosophical approach to Islam and the environmental question often appears to re-construct traditional Islamic concepts in ways that do not echo contemporary Muslim understanding of those concepts and vocabularies. Husaini, *Islamic Environmental Systems Engineering*; Idllalène, *Rediscovery and Revival*, 12-19; Gade, *Muslim Environmentalisms*, 37-77.

2 Ṯābit: Seas and Mountains

Summary 2.1 Ṯābit, His Scientific Career and Impact. – 2.2 The Salinity of the Sea in Graeco-Arabic Thought. – 2.3 Ṯābit's Treatise *On Why Seawater Was Made Salty*. – 2.4 Ṯābit's Lost Treatise On the Benefits of Mountains. – 2.5 The Role of Water in the Ecosystem: Competing Theories?

2.1 Ṯābit, His Scientific Career and Impact

If we consider the significant impact of Ṯābit's extensive work in the fields of scientific translation and original research,[1] it can be argued that the available information on his life in his hometown of Ḥarrān and his adopted city of Baghdad is limited. The main source on Ṯābit's life is a biographical account written by Ibn al-Qifṭī (d. 568/1172-646/1248) in his *Ta'rīḫ al-ḥukamā'* (History of the Judges).[2] Ibn al-Qifṭī's record is based on the testimony of Ṯābit's great-grandson Abū Hilāl al-Ṣābī, who allowed him to read family documents on Ṯābit's ancestry and scholarly output. Overall, Ibn al-Qifṭī's account is not disputed by other biographical sources on Ṯābit, except for a few minor discrepancies, which will be discussed later.

Ṯābit was born in 826 in Ḥarrān,[3] located in upper Mesopotamia near the sources of the Balīḫ river in nowadays Turkey. His hometown of Ḥarrān was predominantly Hellenistic and the centre of the Sabian community,[4] to

1 Rashed, "Thābit bin Qurra: Scholar and Philosopher (826-901)".

2 Al-Qifṭī, *Ta'rīḫ al-ḥukamā'*, 115-22.

3 Arabic sources are not in agreement on this date, for a discussion on this see Rashed, "Thābit bin Qurra: From Ḥarrān to Baghdad", 24.

4 The term Sabian in Arabic sources can refer to several groups without much in common, such as the Christian Ṣabians of South Arabia or the Ṣabians of the Iraqi marshes around Wāsiṭ. Here we will always refer to the Ḥarraniān Ṣabians and their descendants in Baghdad. For an overview of the other groups see Bladel, *The Arabic Hermes*, 67.

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which Ṯābit's family belonged. The religious beliefs and practices of the Sabians have garnered significant interest in modern scholarship, as has their philosophical and scientific activity, despite the fact that we are more or less limited to external descriptions of their beliefs and practices.[5]

Arabic sources provide little information on Ṯābit's life in Ḥarrān. According to one account, he was working as a money changer when the renowned Baghdadi mathematician Muḥammad b. Mūsā (d. 259/873), on his way back from a trip to Byzantium to acquire manuscripts, met him and was impressed by his language abilities. Muḥammad b. Mūsā invited Ṯābit to live with him in Baghdad, where he and his brothers al-Ḥasan and Aḥmad, who were known as the Banū Mūsā, mentored him in the fields of science, philosophy, and particularly mathematics. While it is always advisable to approach later biographical sources with caution, the key details of this story are generally accepted: Ṯābit had exceptional language skills and formed a close partnership with the Banū Mūsā.[6]

During his time in Baghdad, Ṯābit's life and career were closely tied to the renowned translation activity from Greek and Syriac to Arabic of a sizeable corpus of late-antique philosophical and scientific text.[7]

According to Ibn al-Qifṭī (568-646/1172-1248), Muḥammad b. Mūsā allowed Ṯābit to study in his house and introduced him to the astronomers at the caliphal court. This educational and social patronage greatly benefited Ṯābit, who was previously a simple money-changer in Ḥarrān. In a few years, he rose to become one of the most influential men of science at the court of Caliph al-Muʿtaḍid (r. 892-902/279-289). This depiction of his success in Baghdad is somewhat confirmed by al-Bīrūnī, who, alone among Arabic writing authors, credits Ṯābit with nothing less than the salvation of the school of the Banū Mūsā, since, as he writes in his *Kitāb al-Āṯār al-Bāqiya*, the Harranian "was the man who steered their scientific work back to right course" in scientific and methodological terms.[8] In other words, al-Bīrūnī understood Ṯābit's contribution to the work of his patron to amount to a significant change in theoretical and methodological perspective. Broadly speaking, a certain empirical attitude may be seen as a common thread between the two scholars. This is not just a mechanical consequence of human empiricism. Just as al-Bīrūnī shaped his models of fluvial regimes on actual rivers of the *dār al-islām*, Ṯābit touches on a few practical and concrete examples and cases rooted in his Mesopotamian environmental background, even in a highly theoretical work such as the treatise *On Why Seawater Was Made Salty*. For example, he describes seafaring vessels unable to venture into a river mouth. In ninth-century Iraq, the Shaṭṭ al-ʿArab river saw the passage of seafaring vessels and coastal boats heading towards the burgeoning port

5 As noted by Jan Hjärpe, much of the available information on the religion of the Sabians in Ḥarrān is derived from Syriac Christian heresiography. Hjärpe, *Analyse critique des traditions arabes*, 43-9. Of course, some caution should be exercised when using these sources, although Arabic testimonies suggest that it can provide valuable insights into Sabianism. Bladel, *The Arabic Hermes*, 68. See also Burnett, "Ṯābit Ibn Qurra the Ḥarrānian on Talismans".

6 Abdukhalimov, *Bayt Al-Ḥikma*, 204-12.

7 Bsoul, *Translation Movement and Acculturation*; Vagelpohl, "The ʿAbbasid Translation Movement in Context"; Gutas, *Greek Thought, Arabic Culture*. On the relations or lack thereof between the translation movement and the equally famous Bayt al-Ḥikma see Di Branco, "Un'istituzione sasanide?"; Bladel, Gutas, "Bayt Al-Ḥikma"; Gutas, *Greek Thought, Arabic Culture*, 53-60.

8 Al-Bīrūnī, *Kitāb al-āṯār al-bāqiya*, 52.

of Baṣra or the older city of Ubulla. This was a common sight at the time, but not all boats coming from the sea were able to enter sweet waters due to the double threat of shallows and less buoyancy.[9] Possible precedents for the same example demonstrating the higher density of salty water do not erase the link between Ṯābit's scientific writing and the experiences or direct observations at his disposal. The validity of this connection remains regardless of whether he derived the example independently or obtained it through external sources and subsequently verified its accuracy.

Thus, Ṯābit echoes the influence of the everyday experience in his theoretical scientific writing by discussing the use of salt as a preserving agent. This pertains to an argumentative and knowledge-based method that clearly reflects the scholar's empiricist approach, with techniques that have frequently been recognised as distinctive of al-Bīrūnī.[10] He notes that it was commonly used in large quantities to treat putrescent still waters or small marshes in order to prevent the spread of pestilences. To the best of our knowledge, there is no other evidence for this widespread practice. It is worth mentioning that during the first centuries of Islamic presence in Mesopotamia, there was a significant effort to improve the state of the hydrological network, including the marshes of southern Iraq. This effort, which was costly in terms of both finances and human resources, followed the collapse of the ambitious infrastructure built by the Sasanians. This collapse took place in the decades preceding the emergence of Islam, and it may very well have led to a diffusion of putrescent ponds such as those mentioned by Ṯābit.[11]

At any rate, al-Bīrūnī's assessment of Ṯābit's overarching contribution made by Ṯābit to the scientific endeavours of the Banū Mūsā naturally begs the question of how much Ṯābit's education owed to his Sabian and Ḥarranian background. As noted by R. Rashed, the only certainty on this subject is that Arabic sources do not give the slightest hint that Ṯābit received any scientific education whatsoever in Ḥarrān or prior to his fortunate encounter with Muḥammad b. Mūsā.[12] The picture is further blurred by our ignorance about the actual scientific activity ongoing in ninth-century Ḥarrān, a religiously diverse centre with a strong classical tradition. Al-Masʿūdī (b. 280-345/b. 893-956), who visited the city some seventy years after Ṯābit left it described them as philosophers of some kind.[13] In the eighties Tardieu argued that a Platonic academy had been active in Ḥarrān.[14] His

9 Agius, *Classic Ships of Islam*, 65-9.

10 Hatami, "Empirical Horizons in Islamic Historiography"; Malagaris, *Biruni*, 84-108; Mirza, *The Quest for Knowledge*.

11 It would be an oversimplification to suggest a direct causal link between say the Aristotelian doctrine of the water cycle and the environmental features of the Mediterranean basin. The doctrine argues that precipitation alone is not sufficient to explain the availability of fresh water, and that a significant portion must be the result of underground processes. Meanwhile, the Mediterranean basin experiences more evaporation than precipitation. While these factors may be related, it is difficult to maintain a direct connection between them. Nevertheless, it also seems untenable to deny any room to the interactions between environmental contingencies and how scholars think about nature, or creation, as they inhabit those very environments.

12 Rashed, "Thābit bin Qurra: From Ḥarrān to Baghdad", 21.

13 Al-Masʿūdī, *Murūǧ al-ḏahab*, §§ 1394-5 = 2.293.1-8, trans. 2.536-7, cited in Bladel, *The Arabic Hermes*, 72.

14 Tardieu, "Ṣābiens Coraniques et 'Ṣābiens' de Ḥarrān".

thesis sparked considerable debate. We cannot hope to do it justice here. It will suffice to say that K. van Bladel conclusively argued that al-Masʿūdī's account does not in any way suggest the presence of a Platonic academy in Ḥarrān.[15] For what concerns us here, Tardieu argued that the diffusion of Platonic philosophy in Ḥarrān could be the main factor behind Ṯābit's learning. Given the Neoplatonic,[16] rather than Aristotelian, outlook of the Sabian doctrine in Baghdad, Tardieu argued that the Ḥarranian tradition played a role, but this is not sufficient to explain Ṯābit's learning in the scientific realm. This thesis seems to be far-fetched as well, since only two works by Ṯābit seem to have dealt with Plato,[17] among a production of over two hundred works.[18]

In this regard, it is worth recalling that Arabic sources describe the Sabians in particular as monotheists and star worshippers. The information about their beliefs and practices is far from exhaustive, but, according to ninth-century philosopher and scientist al-Kindī (d.c. 256/870) they maintained that

> the world has a cause who has never ceased to be, who is one, not manifold, who cannot be described by means of attributes which apply to the things caused [...] the movement of the heaven is conditioned by its free choice and intelligence.

Al-Kindī further describes the religious practices of the Sabians as astrolatrical:

> They offer sacrifices, slaughtering them in honour of the stars. Some say that it is a bad omen for the sacrifice to be offered in the name Creator; for, in their opinion, He undertook only the major task inferior matters to the mediators appointed by Him to administer the world.[19]

Moreover, the thirteenth-century historian Bar Hebraeus (Ar. Ibn al-ʿIbrī), relays a prideful praise to the Sabians in which Ṯābit himself attributes to his co-religionists unrivalled skills in a few technical and scientific realms. The list comprehends engineering, both in terms of town-building and construction of harbours and canals, occult sciences, divination and medicine, for the benefit of both the body and soul. For the purpose of the present book, it is worthy to keep in mind the connection drawn here between the Sabians and water-related engineering, even though too many centuries separate Ṯābit and Bar Hebraeus for us to lend unconditional credibility to the exact wording of this praise.

15 Bladel, *The Arabic Hermes*, 70-8.

16 Or, even better, Gnostic-Neoplatic, founded on the idea that knowledge of the self is a prerequisite for knowing in general. This Gnostic-Neoplatic strain in Sabian thought was, in Tardieu's view, diverging from the mainstream Sabian beliefs in Ḥarrān. Tardieu, "Ṣābiens Coraniques et 'Ṣābiens' de Ḥarrān", 16.

17 For instance in his treatise *On Resolving the Allegories in Plato's "Republic"* (*Risāla fī ḥall rumūz kitāb al-siyāsa*). Reisman, "Plato's 'Republic' in Arabic", 265.

18 Bladel, *The Arabic Hermes*, 78.

19 Al-Nadīm, *Kitāb al-fihrist*, 318-20. Cited in Bladel, *The Arabic Hermes*, 87.

The astrolatry of the Sabians finds confirmation in several authors[20] and makes it tempting to postulate at least some sort of scientific education during Ṯābit's Ḥarrānian years, but there is not much to confirm this. The only indirect clue that Ṯābit already had independent opinions and already belonged to the 'philosophers' of Ḥarrān met by al-Masʿūdī comes from Ibn Ḫallikān (608-681/1211-1282), a renowned biographer of the thirteenth century. The lateness of this source contributes to the uncertainty. Be it as it may, Ibn Ḫallikān mentions in his *Wafayāt al-Aʿyān* (The Obituaries of Eminent Men) that Ṯābit had to leave Ḥarrān for the nearby village of Kafr Tūṯa because he had differences with the Sabians of his native town. According to this version, Kafr Tūṯa is where he would meet Muḥammad b. Mūsā, according to the *Wafayāt*.[21]

Building on this disagreement with the Sabians in Ḥarrān, Hjärpe suggests that a split may have occurred between Ṯābit's native community and the Baghdadi Sabian community that he fostered in the following years as he took the lead of the Banū Mūsā school after the death of the two brothers. According to Hjärpe's thesis, the Baghdadis' religious tradition had been grounded more in esoteric philosophy, than the religious practices of Ḥarrān.[22] T.M. Green is probably correct in downplaying the importance of this split given that Ṯābit continued to act as a high-level advocate at al-Muʿtaḍid's court for the interests of the Ḥarranian Sabians.[23]

In sum, the precise amount of the debt owed by Ṯābit to his Ḥarranian years remains as foggy as the question is suggestive. The importance of his input to the scientific endeavours of the Abbasid age contributes to explain the interest of many modern scholars in the intellectual landscape of Ḥarrān, which could very well be one of the main entry points for Greek philosophical and scientific tradition into Abbasid learned society. Against this background, Ṯābit's stature among the scientists of ninth-century Baghdad is hardly overestimated. This is meant both in terms of the consideration that he enjoyed in his life, and the influence that his work was set to impress on later scientists in the Muslim world and beyond it. Ṯābit's work developed in agreement with the *modus operandi* of his age through a synergy between translation, innovative research, and teaching.[24]

Ṯābit's contribution to the scientific endeavours of the Abbasid age is a favourite of scholarly research on the history of science in Islamdom. His work on water-related science – we will address the status of this scientific branch in the Arabic tradition further on – has not, however, received as much attention as the three main fields of activity: astronomy, mathematics, and infinitesimal geometry. Much of the lasting impact of Ṯābit's work is due to his foundational, methodological character. An exhaustive treatment of his production is beyond the purpose of the present research, however it is useful to highlight a few aspects that give a general idea of his approach.

As an astronomer, he moved towards a reconciliation of physical and mathematical astronomy reflecting on the relationship between theory and continuous observation. As a mathematician, he pushed for a reconciliation

20 Pingree, "The Ṣābians of Ḥarrān and the Classical Tradition".

21 Ibn Ḫallikān, *Wafayāt al-aʿyān*, 1: 313.

22 Hjärpe, *Analyse critique des traditions arabes*.

23 Green, *The City of the Moon God*, 113-14.

24 Rashed, "Problems of the Transmission of Greek Scientific Thought".

of geometry and algebra, providing geometrical demonstration of algebraic procedures. Furthermore, on request of al-Qāsim b. ʿUbaydallāh b. Wahb (d. 291/904), he developed a method of invention to complement the Euclidian axiomatic method in mathematics and all demonstrative science which will influence the work of many others, such as his grandson Ibrāhīm b. Sinān (d. 335/946), al-Siǧzī (fourth-tenth century), and Ibn al-Ḥayṯām (d. 430/1039). Last but not least, it is worthwhile to mention his thought on infinity, as it bears consequences on his understanding of Creation, as we will see, and showcases Ṯābit's openness to challenge the established philosophical tradition. Ṯābit argued in a collection of answers to questions posed by Ibn Usayyid, a student of his, that, against Aristotelian tradition, there is actual infinity and that there can be one infinity larger than another infinity.[25]

Ṯābit's influence reverberated through his leadership in the school of the Banū Mūsā and the establishment of a Sabian learned community in Baghdad, whose importance is described by Ibn al-Nadīm (d. 385/995 or 388/998) in clear terms: "The source of leadership of the Sabians in this country and their proximity to the caliphs was Ṯābit".[26] In addition to this didactic and institutional influence, Ṯābit's work was conveyed by his translations and original writings. Ibn al-Nadīm mentions in his *Fihrist* (Index) – an index of Arabic books composed in 377/987-8 – only a few titles by our author. Ibn al-Qifṭī reports an impressive list of original books and treatises composed by Ṯābit in the sciences of his age. Of interest here are a book on meteorology (Ar. *anwāʾ*), which appears to be lost, a treatise on the usefulness of the mountains, of which we only have a summary by Miskawayh, and the treatise *On Why Seawater was Made Salty*. The latter is by far the most important text at our disposal to understand how this foundational figure of the intellectual and scientific life of premodern Islam understood the environment and the functioning of the natural world.

The long-term impact of Ṯābit's understanding of the water cycle and the role of water in the ecosystem cannot be assessed fully at this point of research. To accurately evaluate this impact necessitates a more profound exploration of the water cycle's conceptualisations in post-classical philosophy specifically, as well as in sources extending beyond the thirteenth century more generally. Nevertheless, the enduring success of his teachings in other branches of the sciences, and the fact that the treatise *On Why Seawater was Made Salty* was still being copied centuries later makes it credible that his views on the subject remained a point of reference. A more direct clue in this sense is that Miskawayh and al-Bīrūnī openly referred to him when discussing the same subjects a century and a half later, as we will see.

25 Rashed, "Thābit ibn Qurra sur l'existence et l'infini"; Sabra, "Thābit Ibn Qurra on the Infinite and Other Puzzles".

26 Al-Nadīm, *Kitāb al-fihrist*, 647.

2.2 The Salinity of the Sea in Graeco-Arabic Thought

Before addressing Ṯābit's ideas on the salinity of the sea, it is necessary to provide a description of the views on the subject held by the philosophical tradition of the Islamic world. This tradition draws heavily on Greek thought, particularly Aristotelian doctrine, as a starting point. This is both because of the well-known importance of Greek philosophy among Muslims and because of Ṯābit's own familiarity with Greek thought.[27] The question of the salinity of the sea is often linked with the origin of rivers, which as we have seen leads our thinkers to conceptualise different models of the water cycle. In this book we will deal with both aspects of premodern Arabo-Islamic hydrology, therefore it seems more practical to address them together here. This summary is largely based on the work of Paul Lettinck, specifically his book Aristotle's *Meteorology and its Reception in the Arab World*. Lettinck's book offers a comprehensive analysis of the Aristotelian doctrine on sublunar phenomena within the Arabo-Islamic tradition. His work provides valuable insight into the reception and interpretation of Aristotle's ideas in this context, and serves as a precious resource for understanding the role of Meteorology in shaping the understanding of natural phenomena in the Arabo-Islamic cultural space.

The outline that follows begins by examining the Aristotelian doctrine, with a focus on the concepts presented in the Arabic translation of Aristotle's works. In addition to Ṯābit and al-Bīrūnī, who are the primary subjects of this chapter and the next, other authors who addressed the issue of the salinity of the sea and the origins of rivers include Ḥunayn b. Isḥāq (192-260/808-873), Ibn Sīnā and his students Abū al-Barakāt al-Baġdādī (d. after 560/1164-5), Ibn Rušd (d. 595/1198), and Abū al-Faḍl b. al-ʿAmīd (d. 360/970). A review of their views on this topic allows for a more comprehensive understanding of the significance and relevance of the contributions made by Ṯābit and al-Bīrūnī.

Aristotle addresses the issues of salinity and the origin of rivers in the *Meteorology*. As he does with many other topics, Aristotle critiques previous theories and presents his own perspective on these subjects. For the purpose of clarity, this summary will provide an overview of Aristotle's theory on rivers and the sea, including the role of sea salinity within it and the twofold exhalation doctrine that serves as the foundation of the *Meteorology*.

The concept of two types of exhalation is a central principle of the *Meteorology*. According to this doctrine, the Sun causes the earth to emit a dry, highly flammable exhalation composed of air and earth, as well as a moist, vaporous exhalation derived from moisture. These two exhalations are responsible for various meteorological phenomena, such as winds and thunderbolts.[28] According to Aristotle, the salinity of seawater results from the contribution of both exhalations. He explains that salinity is brought to the sea through rain, which contains a mixture of these two exhalations. Aristotle further elaborates on the topic of seawater and its salinity, providing examples to demonstrate that seawater is heavier than fresh water. This suggests that salty water is a mixture of water and other substances that

27 Goodman, "The Translation of Greek Materials into Arabic", 485-6; Gutas, *Greek Thought, Arabic Culture*.

28 Frisinger, "Aristotle and His *Meteorologica*".

can exhale under the effect of the heat of the Sun and increase the weight of the water with which they are combined.

In the *Meteorology*, Aristotle addresses the issue of the source of rivers, or the origin of the water that sustains them. He rejects the idea that all rivers on Earth are fed by a single or multiple underground reservoirs of rainwater, arguing that such reservoirs would have to be as large as the Earth or larger. In contrast to this exogenous model, which posits that "no water at all is generated, but the volume of the rivers consists of the water that is gathered into such reservoirs in winter",[29] Aristotle proposes an endogenous model, in which the water that forms rivers is generated within the Earth itself. In chapters I,13-II,3 of the *Meteorology*, Aristotle discusses the idea that some of the water that sustains sources and rivers is derived from underground condensation of vaporous air, that is an ambiguous stage between water and air, in addition to being supplied by rainfall.

Aristotle's *Meteorology* was highly influential in Arabo-Islamic thought, with much of its impact owed to the mediation of Abū Zakariyyāʾ Yaḥyā b. al-Biṭrīq (d. c. 215/830). Al-Kindī, Ibn Suwār (d. a. 407/1017),[30] and Ibn Sīnā all engaged with the text based on his translation. However, Yaḥyā b. al-Biṭrīq's translation was not the only version available, and Isḥāq b. al-Ḥunayn's translation of a lost Hellenistic compendium of a Hellenistic version of the Meteorology served as an alternative source. Both translations were based on Syriac versions of the *Meteorology* and its lost Hellenistic compendium, but they differ on certain points of Aristotelian doctrine. Given our focus here, we will primarily consider the theses presented in these two Arabic versions of the Aristotelian doctrine, as they formed the foundation for the Aristotelian understanding of the water cycle within Arabic scientific and philosophical thought.

We do not know much about the origin of the family of Yaḥyā b. al-Biṭrīq, himself the son of a well-known translator, apart from the fact that they came from a Latin Christian family in the former territories of the Byzantine empire, perhaps from North Africa. Likewise, we do not know much about his life.[31] It seems that Ibn al-Biṭrīq converted to Islam at the hands of al-Maʾmūn, entering the entourage of the vizier al-Ḥasan b. Sahl (236/850-1). His work as a translator covers a dozen titles, according to Arabic biographers and mentions in the introductions of manuscripts, and, according to Ibn al-Nadīm, he authored two pharmacological treatises, one on poisons (*K. al-sumūmāt*) and the other on insects (*K. al-aǧnās al-ḥašarāt*).

Ibn al-Biṭrīq's translation of the *Meteorology* diverges significantly from the Greek text in several instances, even presenting perspectives that are not present in the Greek version. In his review of Casimir Petraidis' edition of the text,[32] Endress has suggested that the Hellenistic version on which Ibn al-Biṭrīq relied, through Syriac mediation, may have already incorporated adaptations and corrections of Aristotle's views.[33] It is also possible that

29 Arist. *Mete.* 1.13. See a summary of this in Lettinck, *Aristotle's "Meteorology" and Its Reception*, 120-7.

30 Also commonly known as Ibn al-Ḫammār.

31 On Yaḥyā b. al-Biṭrīq and his contribution to the translation movement of the Abbasid age see Dunlop, "The Translations of Al-Biṭrīq and Yaḥyā (Yuḥannā) b. Al-Biṭrīq".

32 Petraitis, *The Arabic Version of Aristotle's "Meteorology"*.

33 Endress, Review of "The Arabic Version of Aristotle's 'Meteorology'" by C. Petraitis, 506-9.

some of the deviations may be due to the Syrian translator, to Ibn al-Biṭrīq's himself or to mistranslations and misunderstandings. As a side note, it is worth considering whether there may be a connection between these mistranslations and misunderstandings and Ibn Abī Uṣaybiʿa's critical comment that Ibn al-Biṭrīq did not have a strong command of Greek, given his Latin background (Ar. *Laṭīnī*).[34]

Be it as it may, the resulting description of the origin of salt in seawater is twofold. On the one hand, it is said that the heat of the Sun acts on the warmer and thicker part of the water that does not exhale. This thicker part contributes to making seawater saltier than fresh water. On the other hand, rain water could carry some salinity to the sea, due to an admixture of dry and moist exhalations. As Fontaine noted, there is an implicit notion that, while "they do not deny that the salty part of sea water remains behind, but that in their view this fact does not explain the cause of its salinity i.e., that the presence of salinity is not due to evaporation alone".[35]

Ibn al-Biṭrīq ascribes this description of the causes of the salinity of the sea contained in the *Kitāb al-Āṯār al-ʿUlwiyya* (The Meteorological Phenomena) to Aristotle. In the case of the origin of rivers, or the water cycle, Ibn al-Biṭrīq explicitly presents his own theory, which follows an endogenous model.[36] According to Ibn al-Biṭrīq, water rising as vapour from the earth transforms into clouds and eventually falls as rain and snow. This water replenishes rivers after being stored in the depths of the earth, where air also transforms into water, allowing the two substances to mix and contribute to the sustenance of rivers. The most salient departure from the original Aristotelian doctrine in the Greek text lies in the origin of clouds, which Ibn al-Bitrīq asserts to be on land rather than at sea.

Another important translator in the transmission of Aristotelian doctrine regarding the salinity of the sea and the cycle of water is Ḥunayn b. Isḥāq, a Nestorian Christian Arab from the southern Iraqi city of al-Ḥīra who translated a Hellenistic compendium of the *Meteorology*. The relationship between this translation and Ibn al-Biṭrīq's translation of the *Meteorology* is complex. To some extent, the *Compendium* is based on the same Greek treatise, but there are substantial differences in the organisation of the subjects, the phraseology and even, at times, between the contents presented in these two treatises. Daiber compared the two texts, arguing that the *compendium* is based on a shorter version of the Greek treatise whose Syriac translation formed the basis of Ibn al-Biṭrīq's *Aṯār al-ʿUlwiyya*.[37]

With regard to the cycle of water, Lettinck pointed out that subterranean vapour condensation plays no part according to Ḥunayn b. Isḥāq's *Compendium*. This departure is marked by a rather assertive statement:

> We will mention and assert the cause of rivers, sources, and wadis: the cause of these is rain For, when much rain falls on the earth, much water gathers as a result. And when it meets with a place where (it) can pour

34 Ibn Abī Uṣaybiʿa, *ʿUyūn al-anbāʾ fī ṭabaqāt al-aṭibbāʾ*, 282. Online edition and translation Ibn Abī Uṣaybiʿa, *A Literary History of Medicine Online*, ch. 10: 3.

35 Fontaine, "Why Is the Sea Salty?", 204.

36 Lettinck, *Aristotle's "Meteorology" and Its Reception*, 134.

37 Lettinck, *Aristotle's "Meteorology" and Its Reception*, 261-6; Daiber, *Ein Kompendium der aristotelischen Meteorologie*, 6-17. See also Daiber, *Naturwissenschaft bei den Arabern* on the identity of the translator. Cited in Lettinck, *Aristotle's "Meteorology" and Its Reception*, 9.

> to some extent, the wadis and rivers arise from it; for it is a property of water to slide down. Then, when it meets soft earth in its vicinity, it perpetually seeps in until it meets hard earth or a mountain which it cannot penetrate and then stops at it. Then, when the water becomes abundant, it takes away the soft earth around it, so that it pierces its location and flows out of it. That location is then called a spring. […] Sometimes the wadis and the rivers are formed from masses of snow falling on mountains. And then, when the warmth comes to them, they gradually melt. Then the wadis and rivers are formed from them.[38]

When rain falls on soft earth, says the *Compendium*, it penetrates into the ground until it reaches solid earth or mountains that it cannot penetrate further. The water collects there, and if there is a sufficient amount, it can erode the surrounding soft earth and flow out, forming a source. If there is a large volume of water, the source will provide water year-round; if there is less water, it may dry up in the summer. Sometimes, a source may provide water for many years and then run dry, either due to a lack of rain or because the rain flows in a different direction. If the water flows away in a wide bed, the source will remain dry; if it encounters a mountain or high place, the water will be blocked and return to the source, restoring it to its previous state. Rivers and wadis may also be formed from melting snow on mountains.[39] A possible source for Ḥunayn b. Isḥāq adoption of an exogenous model of the water cycle may be Teophrastus, who is often credited with the first formulation of this model. Teophrastus' *Meteorology* is lost, but a few Arabic and Syriac translation survives, and his work was being translated precisely at the time of Ḥunayn b. Isḥāq and Ṯābit.[40] Theophrastus' influence on the *Compendium* can only be hypothetical, but it is worthwhile to note that the Peripatetic philosopher argued that compression of clouds as winds push them against the mountains as a cause of precipitation.[41] As we will see, the same argument as made by Ṯābit in his treatise *On the Benefits of the Mountains*. There is, nevertheless, reason to be cautious. The most authoritative Arabic translation, from Syriac, of Theophrastus' *Meteorology* at our disposal seems to envisage an exogenous cycle that is not purely reliant on evaporation:

> The clouds come into existence for two causes: because of the accumulation and thickness of air and its transformation into the nature of water, or because of much vapour which ascends and with which the ascending vapours of the seas as well as the remaining fluids become mixed.[42]

Returning to Ḥunayn b. Isḥāq's *Compendium*, another stark departure from Aristotelian doctrine pertains precisely to the salinity of the sea.

38 Daiber, *Ein Kompendium der aristotelischen Meteorologie*, 214-17. This represents a revised and enhanced edition of the 1975 version. Further commentary can be found in Lettinck, *Aristotle's "Meteorology" and Its Reception*, 135-6.

39 Lettinck, *Aristotle's "Meteorology" and Its Reception*, 135.

40 Daiber, "The *Meteorology* of Theophrastus".

41 Lettinck, *Aristotle's "Meteorology" and Its Reception*, 20.

42 Daiber, "The *Meteorology* of Theophrastus", 373. In passing, Daiber argues cautiously that the translator may be Ibn Ḫammār (d. after 407/1017), who met al-Bīrūnī at the court of the Ḫwarazmshāh and was equally brought to the court of Sulṭān Maḥmūd in Ghazna. His hypothesis appears rather convincing.

Interestingly, on this matter, the *Compendium* does not mention the dry exhalation. This is a remarkable omission, given the importance of dry exhalation in Aristotle's doctrine. Instead, the *Compendium* argues that salinity is an effect of evaporation, as the light and fresh part of seawater leaves behind salty and bitter parts. This also has an effect on taste. Heat causes humidity to become salty, by mixing with it, and if, heat increases enough, it can cause even bitterness.

Thus, the *Compendium* contain two departures from Aristotelian doctrine that are relevant here: the water cycle, which is endogenous in Aristotle and exogenous in the *Compendium*, and the salinity of the sea, which is not caused by dry exhalation in Ḥunayn b. Isḥāq's version. However, the *Compendium* is not the only work in which Ḥunayn b. Isḥāq touches on these two subjects. His translation of a Greek or Syriac paraphrase of Olympiodorus, commonly referred to as Pseudo-Olympiodorus, states that a portion of the water that sustains rivers "actually exists" in the depths of the earth, meaning that it is already contained there, while other parts come to be there. Pseudo-Olympiodorus's treatment of the sea is organised into eighteen paragraphs and two of them show a striking resemblance to Ṯābit's treatise on the salinity of water. Specifically, Pseudo-Olympiodorus discusses the fact that sea does increase or decrease overall, because the rivers that flow into it compensate for evaporation, envisaging a self-regulation of the marine environment. Furthermore, salt water is denser than fresh water, and Pseudo-Olympiodorus brings the same example as Ṯābit: ships that float on seawater may not float on rivers or lakes. Pseudo-Olympiodorus does not entirely neglect causal arguments, however, and posits that the salinity of the sea is caused by smoky exhalation mixed with water. A lesser cause of salinity is the presence of earthy matter in seawater. The presence of this earthy substance in seawater is precisely why salty water is denser than fresh water, as demonstrated by the example of boats floating in it.

A stricter follower of Aristotle's doctrine on these points is certainly Ibn Sīnā. In terms of water cycle, he focuses on the role of mountains in the formation of sources and clouds. According to his *Kitāb al-šifā'* (The Book of Healing), in the fifth section of the *Ṭabī'iyyāt* (Natural Philosophy), it is in the mountains or, more rarely, under solid earth, that the vapours contained in the depths of the earth rise due to the heat of the Sun and the stars. As these vapours cannot escape and disperse as they do under soft earth, they condense into the water that will eventually overflow from water sources.[43]

Ibn Sīnā does not delve into the processes that lead to the salinity of the sea in depth. He simply states that salinity in water is due to the mixture of bitter, burnt earthy particles, and notes that this causes seawater to be heavier and denser than fresh water. Interestingly, he asserts that the salinity of seawater serves a purpose: preventing water from deteriorating and spreading this corruption to all water on earth.

Disciples of Ibn Sīnā, such as the Jewish philosopher and physician Abū al-Barakāt al-Baġdādī, who converted to Islam later in life, also discussed the water cycle and salinity in seawater. Notably, in his treatise *Kitāb al-mu'tabar fī al-ḥikma* (The Book of What Has Been Established Personal

43 Ibn Sīnā, *Kitāb al-šīfā'*, 10-11.

Reflection),[44] Abū al-Barakāt rejects the theory of subterranean condensation. This work, which programmatically title as a book based on personal reflections, rarely relies on the principle of authority. Instead, as Lettinck observes, Abū al-Barakāt presents challenges and alternatives to many of the theses in the *Kitāb al-Šifā'*, including the water cycle.[45]

This is not unusual at all for Abū al-Barakāt. He is increasingly acknowledged as a significant innovator in the post-classical phase of the Arabo-Islamic philosophical tradition. Abū al-Barakāt's work has been most recently brought to prominence by F. Griffel, whose contributions this section heavily relies upon.[46] It is well-known that Abū al-Barakāt converted from Judaism to Islam around the age of sixty or seventy. However, the precise date remains uncertain. Moreover, ambiguity surrounds the exact location of his birthplace, Balad, as there were two centres with this name in Mesopotamia during that era. Abū al-Barakāt did not receive a formal education within the traditional madrasa system in his later years. Instead, his advanced studies focused on philosophy and natural sciences to support his career as a physician, which continued to be his primary means of sustenance throughout his life.

Regarding Abū al-Barakāt's conversion, Griffel posits that it was likely a meticulously planned event and possibly even officially commemorated. It definitely did not occur at the end of his life, contrary to what Ibn Ḫallikān, among others, related.[47] The lack of clarity concerning the dates of his life can be attributed to the delayed appreciation of his contributions by his contemporaries, which only increased posthumously, although he enjoyed a reputation as a philosopher even prior to his conversion. Therefore, determining whether Abū al-Barakāt's magnum opus, the *K. al-mu'tabar*, was written before or after his conversion to Islam and the adoption of Ashari views proves to be a challenging endeavour.[48] Griffel highlights that this work encompasses both Jewish and Muslim elements, although other scholars maintain differing perspectives on the matter. Nevertheless, this issue is only tangentially related to Abū al-Barakāt's views on natural philosophy, specifically the hydrological cycle, which constitutes the primary focus of this book.

It is in the chapter entitled "On Generation and Corruption" within the second book of *K. al-mu'tabar* that Abū al-Barakāt's viewpoint on the hydrological cycle is elucidated. The treatise encompasses a range of subjects within three books that focus on Logic, Natural Philosophy, and *Ilāhiyyāt* or 'rational theology', each displaying structural distinctions. Pertinent to this book is the second book, which adheres to the principal themes of Aristotelian works, featuring chapters devoted to topics such as Heaven, Generation and Corruption, and Meteorology, among others.

Although categorised as an Avicennian philosopher, Abū al-Barakāt finds himself in disagreement with numerous principles of both Ibn Sīnā's and

44 On the theoretical aspects of the *Kitāb al-mu'tabar* and Abū al-Barakāt's biography see Pavlov, *Abū'l-Barakāt al-Baghdādī's Scientific Philosophy*. See also http://www.muslimphilosophy.com/ip/rep/J008.htm which reproduces his entry in the *Routledge Encyclopedia of Religion*. Langermann, "Al-Baghdadi".

45 Lettinck, *Aristotle's "Meteorology" and Its Reception*, 84-5.

46 Griffel, "Between al-Ghazālī and Abu l-Barakāt"; *The Formation of Post-Classical Philosophy in Islam*.

47 Ibn Ḫallikān, *Wafayāt al-a'yān*, 6: 74; references to additional authors who concurred with this statement can be found in Griffel, *The Formation of Post-Classical Philosophy in Islam*, 208-9.

48 On Asharism see Shihadeh, Thiele, *Philosophical Theology in Islam*.

Aristotle's philosophies, including some fundamental aspects.[49] This is explicitly articulated in the introductory section of the work, where the philosopher and physician asserts his reliance solely on concepts he has meticulously examined and corroborated through rational inquiry. He dismisses any ideas that he has failed to comprehend or verify, even if they stem from esteemed scholars.[50] In the context of the water cycle as well, Abū al-Barakāt deviates from Ibn Sīnā's perspective. More specifically, according to Abū al-Barakāt, we can identify different exogenous sources of water for the flowing of rivers, which influence the fluvial regime:

> Some of the streams flow when rain falls upon elevated places of the earth and mountains. They cease to flow shortly after the rain has stopped. There are others that flow from snow that melts in the highest places of the mountains. These keep flowing as long as there is snow on the mountain. They increase with the increase of snowmelt and decrease according to its decrease. There are other rivers that flow from water that falls in low places and depressions as rain or snow and remains confined there. The water leaks through the lowest and least dense of these places, and it accumulates little by little until it becomes a river that flows with a continuous stream. The summer flow connects with the winter flow, and the previous one with the following one, without interruption, but rather growing and diminishing.[51] It happens that this percolation and this flowing in the depth of the earth are such that the accumulated water comes out as a gushing spring, like the water retained in elevated places that find an opening. This goes down and gushes as much as it has descended. Water arrives at its reservoir as rain, and it flows and gushes at a certain moment and not at another according to the rain. If it has come down as snow, it grows and decreases, flows, or stops depending on the melting snow, its increase or its decrease.
>
> People say and many ancient and modern philosophers believe that the air trapped inside the mountains cools down and changes into water that flows. Air is further sucked in, cooled down, and changed into water, and this happens continuously and incessantly. The answer to them is that springs dry up, and wells desiccate, and rivers and wadis cease to flow when snow or rain become too little and why they increase when the latter increases, and why they decrease as the latter decreases. The intensity of the cold is not helpful against the lack of rain and snow to increase the water in springs and wells and its persistence.[52]

All of these sources of water are ultimately exogenous. Furthermore, Abū al-Barakāt discusses the origin of water in wells, which also lies in rain and snow. Rain and snowmelt seep into cavities and this is proven by the fact that

49 Street, Abū 'l-Barakāt Hibat Allāh al-Baghdādī, "The Traditions of Arabic Logic"; Benevich, "Perceiving Things in Themselves"; McGinnis, "Mind the Gap".

50 Al-Baġdādī, *Muʿtabar*, 2: 4-7. For a translation and comment on this epistemological declaration see Griffel, "Between al-Ghazālī and Abu l-Barakāt", 66.

51 Further research is needed on what appears to be a scientific categorisation of fluvial regimes. The Arabic text mentions two flows (Ar. *jaryān*) here, one being *al-ṣayfī* and the other *al-šitawī*. It is left to wonder whether this distinction is merely a device to emphasise the river's continuous flow all year long in this particular passage or if it corresponds to a formal distinction that is useful for the study of fluvial regimes.

52 Al-Baġdādī, *Muʿtabar*, 2: 209-10; Lettinck, *Aristotle's "Meteorology" and Its Reception*, 146-7.

water can be found only in certain places, and it is not distributed equally under the earth. Abū al-Barakāt further confutes the theory of air condensation by looking at wells. He counters those who believe that air condenses into water under the effect of the coolness of the air dialectically:

> If things were like that, why do wells dry up in the summer and receive more water in the winter with the arrival of rains, increasing with the latter's increase and diminishing as they diminish? In fact, the bottom of the well is colder in summer than it is in winter. So, why does it not turn more [air into water] in the summer than in winter?[53]

Abū al-Barakāt's viewpoint on the hydrological cycle distinguishes him from his contemporaries within the Arabo-Islamic Aristotelian tradition and the *falsafa* movement. In contrast to his fellow scholars, he dismisses the notion of subterranean water formation, attributing all freshwater sources to the process of precipitation, percolation, and evaporation. To the best of my knowledge, he is the sole disciple of Ibn Sīnā to adopt an exogenous model of the hydrological cycle. Abū al-Barakāt adopts a resolute position on this issue, emerging as the only author among those examined here to question the validity of subterranean water generation. Inversely, the other authors addressed in this context seem to disregard or overlook the prominence of the endogenous model among their peers. Even the much earlier *Filāḥa Nabaṭiyya* (The Nabatean Agricolture), despite acknowledging the differing opinions, as we will see, refrains from engaging in the debate.

A less outspoken recognition of the exogenous cycle may have been recognised by Ibn Rušd, although the cycle of water received less attention in his works compared to the topic of seawater salinity. The Cordoban philosopher discusses the origin of the salty taste in seawater in his commentary on the Meteorology, titled *Kitāb al-āṯār al-ʿulwiyya*, and in his commentary on the Aristotelian *De Interpretatione*, entitled *Talḫīṣ al-āṯār al-ʿulwiyya*. Despite both works addressing the issue of seawater salinity, they differ in their explanation of the actual cause of this characteristic.

In the *Kitāb al-āṯār al-ʿulwiyya* (Short Commentary), Ibn Rušd distinguishes between the burnt earthy part (Ar. *al-ǧuzʿ al-ardī al-muḥtaraq*) of the dry exhalation and the smoky exhalation (Ar. *al-buḫār al-duḫānī*) or burnt smoky part (Ar. *al-ǧuzʿ al-duḫānī al-muḥtaraq*),[54] arguing that the first is the main cause of seawater salinity, since it is produced everywhere on earth.[55]

Interestingly, Ibn Rušd specifies that sometimes the smoky and earthy parts combine, citing the case of the Dead Sea (Ar. *buḥayr Filisṭīn*), as Ṯābit does in his own treatise. As we have seen, according to Ibn Rušd celestial bodies draw up dry exhalation and its earthy part everywhere on earth, meaning both on land and under the sea. This leads the philosopher to conclude that salinity in seawater is due to the earthy part of the dry exhalation given off by the earth under the sea and prevented from rising by the presence of the large mass of water above it.[56]

53 Al-Baġdādī, *Muʿtabar*, 2: 212.

54 Ibn Rušd did not believe in the reality of the hot and dry exhalation. Mcpeak, "Meteorology in the Islamic World".

55 Ibn Rušd, "Kitāb al-āṯār al-ʿulwiyya", 28-30.

56 Lettinck, *Aristotle's "Meteorology" and Its Reception*, 149-52.

Ibn Rušd exposes a slightly different theory in the *Talḫīṣ kitāb al-ʿulwiyya* (Middle Commentary).[57] Whereas in the *Kitāb al-āṯār al-ʿulwiyya* salinity is due to the earthy part of the dry exhalation drawn up from the seabed, in the *Talḫīṣ* it is the product of the heat of the Sun on the dry exhalation already present in seawater. This theory is of course closer to Aristotle's, but differs on when and where the salinity is produced. According to Aristotle heat produces salinity in rainwater, and according to Ibn Rušd's *Talḫīṣ* heat produces salinity in seawater directly. This contradiction between the *Kitāb* and the *Talḫīṣ* is not especially surprising. It has been noted that the latter is generally a much closer paraphrase of Aristotle than the first, which Ibn al-Rušd probably wanted to be a sort of introduction to broadly understood philosophical questions.[58] The *Kitāb* differs from Aristotelian doctrine on another point that is important here. Ibn Rušd, while admitting the possibility of water being generated from air, states that "that water of all rivers originates from the sea by means of rain, and returns to it", implying an exogenous model of the water cycle.[59]

Abū al-Faḍl b. al-ʿAmīd, a scholar known for his written production in the form of short treaties or *risālas*, addressed the topic of seawater salinity in a *risāla* written for the Buyid *amīr* ʿAḍud al-Dawla (324-356/930-967). In addition to his administrative and military duties as the vizier of Rukn al-Dawla (d. 366/976) for 32 years, Ibn al-ʿAmīd was also known as the 'second Ǧāḥiẓ' due to his literary ability.[60] Despite the recognition of the quality of his works and, according to the sources, the widespread circulation of his treatise collections, most of his production seems to be lost. It is fortunate that one of Ibn al-ʿAmīd's treatises on the topic of the salinity of the sea has been preserved and has received an edition and German translation by Hans Daiber.[61]

Ibn al-ʿAmīd discusses the salinity of the sea in a *risāla* for ʿAḍud al-Dawla "about the reason why there are drinkable wells and sweet springs on the sea islands".[62] The treatise is purposefully short and concise, since, the author informs us, he already addressed in a previous *risāla* some of the basic notions needed to understand the subject at hand. The basic notions that are omitted here are likely to include an in-depth discussion of the theories of the four elements.[63] After a customary profession of support and greetings for the *amīr* ʿAḍud al-Dawla, Ibn al-ʿAmīd deals with the question of whether the original taste of water is salty or sweet. It is imperative, he argues, to determine which one is the original taste of water before investigating how sweet water comes to be in sea islands. The matter was evidently not settled, at least among non-specialists, at the time of Ibn al-ʿAmīd, since he dedicates some space in his short treatise to a summary of the thesis, held by

57 Ibn Rušd, *Talḫīs al-āṯār al-ʿulwiyya*, 73,10-89,18. Cited in Lettinck, *Aristotle's "Meteorology" and Its Reception*, 152-5.

58 Cruz Hernández, "El sentido de las tres lecturas de Aristoteles por Averroes".

59 Ibn Rušd, "Kitāb al-āṯār al-ʿulwiyya", 28.

60 While we have limited information on Ibn al-ʿAmīd's administrative role, more is known about his military tasks. Cahen, "Ibn al-ʿAmīd".

61 Daiber, *Naturwissenschaft bei den Arabern*.

62 Daiber, *Naturwissenschaft bei den Arabern*, 48.

63 This latter treatise concerning the scientific notions to be taken into account upon founding and planning a city seems to be lost.

“one of the ancient scholars”, that the original taste of water is salty. Those who maintain that the original taste of water is salty do so, according to Ibn al-ʿAmīd, on the ground that the greatest part of each element stay true to its original characteristics since they are “only partially changeable”. In other words, if we want to look at what characteristics should be considered originary for each of the four elements, we will find them where the main part of each element resides. In the case of water, its greatest part resides of course, the sea and it is undeniably salty. Ibn al-ʿAmīd summarises this line of thought:

> the main part and the majority of water is present in the seas; for the water flowing from rivers is small and insignificant in comparison. (From this) the previously mentioned follows, namely that the taste present in the largest bodies of water, i.e. the taste of the sea, is the natural one.[64]

As we said, Ibn al-ʿAmīd disagrees with this assessment. Before explaining why the original taste of water is sweet and not salty, he notes in passing that the notion he just described makes it very difficult to explain the presence of sweet water in sea islands. Ibn al-ʿAmīd explicitly cautions the *amīr* against relying on those who believe that the original taste of water is salty, since they acratically accept premises and principles without uncovering “uncertainties and ambiguous formulations”. This warning suggests that at the very least, it was possible to encounter individuals among courtiers or other learned men who held views on the nature of water and its role in nature that differed from those of Ibn al-ʿAmīd. In this context, Ibn al-ʿAmīd warns against the danger of assuming that the nature of water is immutable, as some of his contemporaries may have believed. He asserts that, while it is true that the essential properties of an element tend to remain constant, it is not accurate to claim that elements are incapable of change altogether. Rather, this principle applies only to the fundamental nature of an element, which it does not seem to comprise taste. Therefore, according to Ibn al-ʿAmīd, it is possible for water to acquire certain characteristics, as long as the majority of water maintains its inherent qualities as water:

> For water, while it is impossible for the majority of its parts to change into air, is not prevented from coming into the state of heat, cold, compression, and rarefaction.[65]

The same can be said about water acquiring a salty taste. In this regard Ibn al-ʿAmīd further argues that “simple things come by necessity before things that are composed by them” and that salty water, similar in taste to sea water, is evidently composed by sweet water and ‘ashes’ because it is possible to break their bond by means of evaporation.

Having discussed the basics of seawater salinity, Ibn al-ʿAmīd contends that the transformation of air into water is a process that can be observed on the surface and that it is also possible for this to occur in the depths of the sea and within the cavities of the earth. He asserts that sweet water can be generated in this way on islands, although it may later acquire a salty

64 Daiber, *Naturwissenschaft bei den Arabern*, 52.

65 Daiber, *Naturwissenschaft bei den Arabern*, 53.

taste. Consequently, the generation of water in the cavities of the earth, as described by Aristotle, is one possible explanation for the presence of sweet water on islands, but it is not the only one.

Ibn al-ʿAmīd presents two additional possible explanations for the presence of sweet water on islands. The first is the existence of springs that are fed by precipitation, such as snow, hail, or rain, which may accumulate on mountain tops or within mountains and eventually feed springs that are typically seasonal. The second scenario involves seawater directly. In this case, Ibn al-ʿAmīd describes an island with sides that are higher than sea level, but with a central area that is lower than sea level, allowing seawater to filter through. These types of sources can be either sweet or salty, depending on the properties of the soil that filters the seawater, either removing or retaining the salty component. In passing, it should be noted that the same model appears also in Isodore of Seville and constituted the basis for what has been called the "reverse hydrological cycle".[66]

Ibn al-ʿAmīd illustrates his point with a real-life example that is a staple of scientific discussions on salty water:

> We can testify to this from our own experience: As often as we have the real desire to obtain sweet water from the whole of the sea, we reach for the (sea) water and then filter it several times through the sand or in pottery so that it becomes sweet. Usually, we take vessels of wax to let them sink into the sea, because the wax pores are too fine and too thin for water-mixed and compounded and thick things to pour into the vessel; in this case its (waxy) side does not remain inaccessible to the substance of the sweet water.[67]

In sum, Ibn al-ʿAmīd approaches the specific question posed to him in agreement within the framework of an Aristotelian endogenous water cycle. It is worth mentioning that, despite being familiar with the scientist and philosopher Miskawayh, who held views on the water cycle that differed from those of Aristotle and aligned with the exogenous model proposed by Ṯābit, Ibn al-ʿAmīd did not adopt or mention Miskawayh's opinion in his treatise.

This summary would not be complete without mentioning the exogenous water cycle discussed in the *Kitāb al-filāḥa al-nabaṭiyya*, a work that covers a wide range of subjects from agriculture to occult sciences and has returned to garnering significant scholarly attention in recent years.[68] The *Kitāb al-filāḥa al-nabaṭiyya*, or *The Nabatean Agriculture* as is usually referred to in English, is traditionally believed to be the Arabic translation by Ibn Waḥšiyya[69] of a Syriac text with multiple authors of uncertain history. However, Isabel Toral has proposed that the text may actually be a pseudotranslation, as no corresponding original version in Syriac has been found

66 Duffy, "The Terrestrial Hydrologic Cycle", 4; Tuan, *The Hydrologic Cycle and the Wisdom of God*, 24-5. On the water cycle in medieval Western Europe see also Squatriti, *Water and Culture*, 160-4.

67 Daiber, *Naturwissenschaft bei den Arabern*, 62.

68 Dalen, "Scientific Method in Late-Antique Paganism"; Hämeen-Anttila, *The Last Pagans of Iraq*.

69 Little is known about Ibn Waḥšiyya, whose historicity has also been debated. See Fahd, "Ibn Waḥs̲h̲iyya".

despite extensive efforts.[70] Be it as it may, and even though the *Kitāb al-filāḥa al-nabaṭiyya* surely is not the two-thousand-year old repository of agricultural knowledge that it claims to be, this monumental work is widely considered a valuable and under-investigated source on sixth-to-ninth century Mesopotamian non-Muslim scholarship.[71] Interestingly, the Nabatean Agriculture describes an exogenous cycle, as Mohammad el-Faïz has noted.[72] It is worth noting that the ideas presented in the text, which are largely incompatible with Aristotelian doctrine,[73] are in line with Ṯābit's view of the water cycle and were already prevalent in Mesopotamia outside of the Arabo-Islamic philosophical tradition.

Hydraulics and hydrology, the two branches of water knowledge identified as *savoirs de l'eau* by M. el-Faïz, are introduced at the beginning of the primary chapters dedicated to agriculture. In these chapters, essential hydraulic and hydrological concepts provide a basis for further examination of irrigation techniques and agriculture, comparable to the approach taken by al-Karajī in his later work, *Kitāb inbāṭ*. However, the discussion of the hydrological cycle is presented in later chapters focusing on meteorological phenomena.

In the *Filāḥa*, the author(s) elaborate(s) on the influence of the Sun on the natural world, notably observing that clouds form as a result of evaporation, particularly wet evaporation, which is distinct from dry evaporation. This idea closely aligns with Aristotle's doctrine of double exhalation.[74] The text further explains that clouds undergo the effects of cooling and condensation, causing their vapours to return to a liquid state. The *Filāḥa* asserts that these two processes cause rain.[75] The text then describes the typical mechanisms of water percolation within the earth, the accumulation of water, and the formation of water sources and wells.

Interestingly, the *Filāḥa* also refers to a disagreement among the Kasdānians concerning the origin of water wells, stating:[76]

> This is the reason for the presence of water in existing springs and wells after they have been dug, according to some of our Kasdānian ancestors. However, others hold a different view, asserting that springs gushing forth in wells result from the compression of the dry element present in the earth's element. The two opinions bear similarities.[77]

It is important to highlight that the minority viewpoint mentioned above seems to be based on an endogenous model of the hydrological cycle. This

70 Toral, "The Nabatean Agriculture by Ibn Waḥšiyya".

71 Dalen, "Scientific Method in Late-Antique Paganism", 517.

72 El-Faïz, *Les Maitres de l'eau*, 32.

73 A possible source of the *Kitāb al-filāḥa al-nabaṭiyya*, at least for some of its varied materials, may be the fourth century collection of agricultural practices (*Synagoge georgikon epitedeumaton*) authored by Vindonius Anatolius of Beyrut and already recognised as the main source of the tenth-century *Geoponica*. See Rodgers, "Hail, Frost, and Pests in the Vineyard".

74 Wilson, *Structure and Method in Aristotle's "Meteorologica"*, 51-72.

75 Abū Bakr Aḥmad b. ʿAlī b. Qays al-Kasdānī, *Al-Filāḥah al-Nabaṭīyyah*, 263.

76 Kasdānian refers to the Nabatean community with which Ibn Waḥshiyya himself identified. As observed by J. Hämeen-Anttila, the name bears an etymological connection to the term Chaldeans. See Hämeen-Anttila, *The Last Pagans of Iraq*, 15-16.

77 Abū Bakr Aḥmad b. ʿAlī b. Qays al-Kasdānī, *Al-Filāḥah al-Nabaṭīyyah*, 264.

observation is particularly significant, as it establishes the *Filāḥa* as the earliest known source to recognise a disagreement or incompatibility between the two models, preceding al-Baġdādī's discussion of the same topic in the twelfth century.

In conclusion, in the works of Aristotle and his Arabic-writing disciples, the focus was on understanding the causes of the salinity in seawater. These arguments, despite their differences, aimed to provide a rational explanation for the natural phenomena that lead to salty taste in seawater. This focus on causation is distinct from the approach taken by Ṯābit in his treatise *On Why Seawater was Made Salty*, in which he approaches the subject from a teleological perspective, seeking to understand the purpose or end for which the sea was made salty. In other words, the Aristotelian philosophers were concerned with understanding how salinity in seawater arises, while Ṯābit was more interested in understanding the ultimate reason or purpose for the existence of salt in seawater.[78] However, it should not be assumed that the treatise *On Why Seawater was Made Salty* by Ṯābit is purely a theological work rather than a scientific one. In fact, the treatise provides a thorough explanation of the physical necessities behind God's plan in relation to seawater.

It is worth noting that, despite our current scepticism towards teleological approaches in science, Ṯābit's approach leads him to conclusions more in line with our modern understanding of the global environment. While the Aristotelian tradition of Arabic-writing philosophers presents a now-discredited, albeit intriguing, set of scientific categories, Ṯābit not only provides a water cycle that is closer to our current understanding, but also offers a comprehensive view of the role of the sea in the global environment that strongly resonates with modern environmental concepts.

2.3 Ṯābit's Treatise *On Why Seawater Was Made Salty*

The treatise *On Why Seawater was Made Salty* is preserved in a single manuscript of the Topkapı Saray library. The manuscript, composed of 13 *folia*, is part of a miscellanea mostly covering astronomical subjects. The handwriting, in *naḫšī* style, is fairly readable and denotes an expert and swift hand. There are a few misspellings and punctuation errors, but they do not damage the readability of the text.

The title of the treatise is transparent. The text is devoted to discussing to what ends the water of the sea is salty rather than sweet or any other taste. Ṯābit approaches a question that, as we have seen, sparked considerable interest in philosophers and scientists both earlier and later than himself. The text appears to be a didactic treatise,[79] probably dictated, and approaches its subject from a finalist or teleological perspective. This has been noted by R. Rashed, who highlighted how Ṯābit departed from the long-established tradition that addressed the subject in purely materialist and causal terms. As noted by Marwan Rashed, these Aristotelian explanations focused on determining the processes and substances that caused the

78 Rashed, "Le meilleur des mondes".

79 This is also other works attributed to Ṯābit, see Brentjes, "Wilbur R. Knorr on Thābit ibn Qurra", 125.

salinity of the sea, but did not consider the ultimate cause: the will of God and His design of the natural world.[80] In contrast, Ṯābit's finalist perspective emphasises the understanding of the usefulness and beauty of this natural phenomenon within the context of the Muslim-dominated Abbasid society in which he operated. This approach to scientific endeavours, of course, was in perfect agreement with the outlook of the Muslim-dominated Abbasid high society in which Ṯābit operated, and that understood theological matters to extend well into physics.[81]

The divine imprint in creation dominates Ṯābit's view of the natural world. Human souls cannot extinguish their desire to understand the usefulness and beauty of God's design, since divine knowledge is both unquantifiable and never fully attainable. Nevertheless, its pursuit is a source of constant amazement for those who "never cease to clarify things". Vividly, Ṯābit b. Qurra describes here what we would today call curiosity-driven research, and this curiosity and urge to clarify is the stated reason why he engaged in this topic.

As it is customary for works on natural sciences, the treatise begins by discussing the four-element theory. Ṯābit states that God imposed a fine balance between them, made it so that they cannot change to the point of "becoming null", and imposed on them a balanced order in terms of weight and consequently height.[82]

The concept of stability and balance among the elements, as discussed by Ṯābit, aligns with the Aristotelian doctrine prevalent among contemporary philosophers. However, Ṯābit's description of the order of the elements includes some unique elements. According to Ṯābit, the elements are arranged in a hierarchy based on their weight, with the lightest and highest element being fire, followed by air, water, and finally earth as the heaviest and lowest element. Faḫr al-Dīn al-Rāzī (d. 606/1209) reports that Ṯābit disputed the Aristotelian theory of natural place, which posits that each body has a natural place to which it strives. In contrast, according to al-Rāzī, Ṯābit stated:

> He who believes that the Earth is seeking for the place in which it is to be found holds a mistaken belief. This is because there is no need to conceive of any particular place as having a quality that distinguishes it from others. On the contrary, if one were to imagine all places to be empty and the whole earth arriving at any one of them, it would necessarily stop

80 Rashed, "Le meilleur des mondes", 706-8.

81 Golshani, "Islam and the Sciences of Nature"; Capezzone, "Amorous or Scientific Metaphors?". It is worthwhile to note in passing that Khalid Fazlun – one of the most influential environmental Muslim activist of our time through his Islamic Foundation for Ecology and Environmental Sciences – strikes very similar notes in his magnus opus *Signs on the Earth: Islam, Modernity and the Climate Crisis*, as the title itself makes abundantly clear. Khalid, *Signs on the Earth*.

82 In Islamic thought, the concept of *mīzān*, or 'balance', plays a central role in understanding the natural world and our place within it. The idea of *mīzān* refers to the interconnectedness and interdependence of all elements within the natural world, and the importance of maintaining balance and harmony within this system. The concept of *mīzān* has important implications for Islamic environmental ethics, as it emphasises the need for humans to act as stewards of the natural world and to use natural resources in a responsible and sustainable manner. In this way, several modern thinkers maintain that *mīzān* encourages a holistic and mindful approach to the environment, one that recognises the interconnectedness of all elements within the natural world and the importance of preserving the balance and harmony of the ecosystem. Parvaiz, "Scientific Innovation and Al-Mīzān"; Koláček, "The Qur'ān as a Source for Contemporary Islamic Environmental Ethics"; Akhtar, "Towards an Islamic Approach for Environmental Balance".

> there and not move on to another [place] because this one and all other places are equivalent.[83]

Instead of relying on the theory of natural place, Ṯābit explained the order of the universe by postulating the existence of two competing forces of attraction. The first attraction postulated by Ṯābit occurs between the lunar and sublunar elements. The second attraction occurs between each and all parts of the element separately, meaning between each body and in agreement with their size. Ṯābit's theory, which fascinatingly bears some comparisons with the modern understanding of gravity and the Galileian *causa reduci ad solam gravitatem*, had a few followers, such as al-Kūhī (tenth century),[84] Ibn Buṭlān (d. 458/1066), and the aforementioned Abū al-Barakāt al-Baġdādī.[85]

Ṯābit contends that the balance between the four elements, their hierarchical arrangement, and their stability are crucial elements of the fundamental components of the natural world as ordained by God. This was intended to ensure the perpetuation of both natural and human life, which are fundamental to God's design according to Ṯābit's perspective on the created world.

While many scholars within the premodern Islamic tradition held similar views,[86] Ṯābit's position appears to transcend a purely anthropocentric perspective. Rather, he posits that the ultimate aim of God's designs is the sustention of life in its entirety, not just human life. Therefore, the value and beauty of any aspect of the natural world should be judged by its ability to sustain life.[87]

It is not surprising that water occupies a special position within this framework, given its critical role in maintaining life. Water exhibits two deviations from the otherwise perfect order and stability of the elements in the service of sustaining life. Firstly, water infiltrates the ground and can be found beneath the earth, despite being lighter than earth. Secondly, it frequently becomes impure, a process that Ṯābit believes is necessary for the maintenance of life, but is not understood by humans at the time of his writing.

Ṯābit emphasises that these two peculiarities of water would represent instances of imperfection in God's design at a theoretical level. If water were to perfectly conform to the order and behaviour of the elements, all water would belong to the sea, resulting in the dehydration and death of all "animals and plants" on dry land. Therefore, given the stated ultimate aim of creation, formal perfection must be qualified in order to achieve the best of possible worlds, as R. Rashed has pointed out.[88] In other words, Ṯābit argues that it is necessary to reject the idea of sterile, and therefore imperfect,

83 Faḫr al-Dīn al-Rāzī, *al-Mabaḥīṯ al-mašriqiyya*, vol. 2; Rashed, "Kalam e filosofia naturale"; Abattouy, "Greek Mechanics in Arabic Context". On the same passage by Faḫr al-Dīn al-Rāzī, see also Rāšid, *Ibn al-Haytham's Geometrical Methods*, 499-500.

84 Abū Sahl Wayǧān b. Rustam al-Kūhī, also known as al-Qūhī.

85 Rashed, "Al-Qūhī Vs. Aristotle".

86 Kukkonen, "Averroes and the Teleological Argument".

87 Ṯābit's biocentrism and, to some extent, anthropocentrism is in line with the today prevailing Islamic view of the ecological crisis from a theological perspective. See Bagir, Martiam, "Islam: Norms and Practices".

88 Rashed, "Le meilleur des mondes".

perfection and recognise the productive potential of imperfection in order to understand God's design and how our ecosystem functions.

In the treatise *On Why Seawater was Made Salty*, the role of water in maintaining life on Earth is presented as another manifestation of divine wisdom. According to Ṯābit, all sweet water that supports life originates from either rain or underground reservoirs, which were created by God for regions where it does not rain enough. However, this does not appear as a repeated production of water, in line with the stability of the elements he previously discussed. This argument suggests an external model of the water cycle, which is further supported by the mention that, in accordance with divine wisdom, it was optimal for water to "go in its entirety to the seas and some of it return repeatedly to the land" as sweet water to sustain life. The requirement for water to be sweet for the benefit of animals and plants on earth allows Ṯābit to proceed to the central argument of his treatise: the salinity of the sea and its role in maintaining the natural balance.

Unlike the typical Arabo-Islamic Aristotelian tradition, which seeks to understand the salinity of seawater in terms of its causes and material properties, Ṯābit does not address the source of the salinity of seawater. Instead, he asserts that the ultimate cause lies in divine wisdom and the design of God. Therefore, the author believes that the most complete understanding of this issue requires comprehending the role played by salty seawater in the overall balance of creation, as ordained by divine wisdom.

Ṯābit approaches the topic from two angles. On the one hand, he identifies two requirements that the taste of sweetness must fulfil: it must prevent water from rotting, and maintain its quantity consistently. On the other hand, he discusses the effects of the other tastes on water, demonstrating that any other option would not satisfy these requirements.

Salinity is not the only distinguishing characteristic between seawater and fresh water on land. Ṯābit explains that seawater does not flow continuously like the water of rivers, and this feature is crucial in his analysis of God's design for water. As previously mentioned, the salinity of seawater prevents this large body of water from rotting and polluting the air essential to life on earth. Ṯābit appeals to experience to illustrate this point, describing the well-known effects of decay in stagnant water and the generation of plague when stagnant water contaminates the surrounding air.[89]

This is coherent with the medical understanding of his time of the miasma theory, maintaining that pestilences were ultimately due to the corruption of water, earth, or more frequently air.[90] Ṯābit noted in his medical treatise *al-Ḏākira fī ʿilm al-ṭibb* (The Compendium on the Science of Medicine)[91] that

89 This is coherent with the commonly-held belief that plagues and epidemics were caused by miasma. See Conrad, "'Tāʿūn' and 'Wabāʾ' Conceptions of Plague and Pestilence"; Ayalon, "Epidemics".

90 The topic touched here by Ṯābit is tangent to the debate on contagion. Quṣṭā Lūqā (d. ca. 300/912-13), author of a treatise on contagion entitled *Kitāb al-iʿdāʾ*, openly acknowledges that there was a variety of opinion about whether contagion actually exists and whether it has a material or psychological basis. In the present treatise, Ṯābit mentions only the corrupted air as the direct cause of pestilence, but this is probably just a matter of briefness. In fact, he admitted the possibility of contagion in the *al-Ḏākira fī ʿilm al-ṭibb* and even expanded Galen's list of contagious diseases. Crucially, the debate on contagion has been a thorny subject in much of Islamic theology, as it is part of the wider discussion on secondary causation and (ʿAšarī) occasionalism. Stearns, *Infectious Ideas*, 70.

91 Meyerhof, "The 'Book of Treasure'". On the debate about the attribution of this text see Ullmann, *Die Medizin im Islam*, 1: 260-1.

analogous alterations of the elements can actually occur, and that meteorological events, such as excessive rain, lingering clouds, southern winds or stagnant air may cause them.[92]

Ṯābit supports the preserving effect of salinity with examples from experience. He mentions the common use of salt for preserving food, and then describes the apparently widespread practice of using large quantities of salt to prevent stagnant water from spreading pestilence. While I could not find confirmations of this practice to verify its prevalence, Ṯābit describes it as the application of "large quantities" of salt, which suggests that this practice was meant to prevent the spread of plagues and decay from stagnant stretches of water, rather than any water for domestic use that could spoil. These stretches of water seem to have been common in historic ʿIrāq, at the time of Ṯābit given the state of disarray of the hydrological network in late Sasanian times.[93]

Ṯābit discusses the level of salinity of seawater according to the biocentric principle in two ways. First, marine life requires that salinity be kept to a wise minimum, while life on land requires that the sea is salty enough to prevent the spread of pestilences, bugs, and decay similar to the case of brackish waters and swamps – it is possible that Ṯābit had in mind the Iraqi marshes of southern ʿIrāq, which were at the time at their historical maximum.[94] Second, salinity plays an important role in the stabilisation of sea levels. The first argument allows Ṯābit to conclude that not only is salty taste the best possible condition that God could impose on seawater, but that the precise measure of salinity found in the sea is the minimum and most beneficial measure. The second argument introduces an interesting discussion on the resilience of the ecosystem and its built-in ability to maintain its balance.

Furthermore, in Ṯābit's opinion, it is essential that the flow of the water cycle does not result in an increase in sea level for two reasons. The first is that all terrestrial life would perish if all water eventually ended up in the ocean, since there would not be a single drop left on earth. The second reason is that a huge rise of seawater would submerge the earth's surface; an observation that may ring familiar to modern readers.

Ṯābit is aware of the physical relation between density of a fluid and evaporation. He illustrates it again by experience, suggesting an experiment to prove that salty water evaporates more slowly than fresh water, and considering the evidence that some boats that float on the sea cannot float in rivers, thus proving that seawater is denser than sweet water.

In the treatise, the interplay of salinity, density, and evaporation showcase the ingenuity of God's design. These properties enable the water cycle to be self-regulatory. An increase in evaporation due to the decrease in salinity and, consequentially, density necessarily compensates for any increase in seawater from the discharge of fresh water from rivers, and vice versa.

Conversely, a decrease in salinity would trigger the production of harmful odours, since a small and imperceptible amount of these odours are said

92 Ṯābit, *Kitāb al-ḏaḵīra fī ʿilm al-ṭibb*, 177.

93 The subject has been most recently investigated by Peter Verkinderen. See also a blogpost by Preiser-Kappeler, who connects this with some climatological hypothesis for the Late Antique Eastern Mediterranean. Christensen, *The Decline of Iranshahr*; Preiser-Kapeller, "The Deluge"; Verkinderen, *The Waterways of Iraq and Iran*, 54.

94 On the expansion of the marsh environment in the early centuries of the Islamic age, see Eger, "The Swamps of Home".

to be produced in the sea. Such odours would have dire consequences for all life on dryland if the entire cycle of water and its properties were not designed to keep seawater salinity exactly at the minimum required to support animal and plant life.

As we said, part of Ṯābit's treatise *On Why Seawater Was Made Salty* discusses the possibility that other tastes could have been chosen to prevent corruption and other damages to life, both marine and on land. The argument begins citing a disagreement among scholars on the number of tastes, with some arguing for eight tastes and other for less.[95] At any rate and excluding the taste of sweet water, he tastes mentioned in the following discussion are six: sweet, fat, sour, astringent, bitter, and salty. Of these six tastes, only five are discussed, as sour taste is mentioned only briefly. Sweet and fat are quickly dismissed as invalid options; they do not provide lasting protection from decay and are generally unstable, as sweet can turn sour and bitter, and fat can produce vapours and odours. Astringent taste not only fails to always prevent decay, but can also produce damaging vapours, as in the case of vitriol and yellow vitriol, which are known today as copper sulphate.[96] Towards the end of the treatise, Ṯābit mentions in passing the category *ḫamriyya*, which clearly indicates substances that are fermented or otherwise alcoholic. These types of moist substances almost seem to amount to an additional taste, which is, again, unsuitable for seawater. However, they are not included in the more systematic treatment of tastes presented earlier in the text. Above all, one gathers the slight impression from the treatise that the author did not have much interest in the precise categorisation of tastes, as if he did not deem it very consequential.

Lastly, the bitter taste may appear as a more viable alternative solution to salinity, since it protects from rottenness. Despite this desirable quality, Ṯābit observes that animals disdains bitter foods, while exhibiting a preference for salty things. These two observations lead him to argue that if seawater was bitter none of the "marvellous animals" that live in the sea could have been generated. A sea devoid of life would have been deprived of a significant portion of its beauty and would have revealed less of the divine wisdom.

Ṯābit addresses also the possibility of a mixture of bitter and salty. He does so again referring to experience, in this case describing the conditions of the Dead Sea because its waters present this very combination of bitter and extreme salinity. This results, he notes, in the inhabitability for any fish, and the fact that no animal drinks it. Ṯābit is not known to have visited Palestine and reports the absence of life in the Dead Sea and in its surroundings on the authority of Galen.[97] This description serves in the economy of his discourse to prove that bitterness in seawater would be detrimental to life. Additionally, he argues that the vast size of the sea serves to prevent the detrimental effects of bitterness from overcoming its natural salinity and harming the creatures that inhabit it.

95 Baffioni, "Les sens chez les Ikhwān al-Ṣafāʾ"; Carusi, "Les Cinq Sens Entre Philosophie".

96 On this substance see Ahmad Y. al-Hassan, "Tecnologia della Chimica".

97 Galen, who is said to have visited the Dead Sea, maintained that its waters were hostile to life because they are too briny. Grant, *Galen on Food and Diet*, 22.

2.4 Ṯābit's Lost Treatise *On the Benefits of Mountains*

The exogenous model of the water cycle is also described by Abū ʿAlī Miskawayh in his response to Al-Tawḥīdī's inquiry on why God created the mountains. Miskawayh's answer seems to be largely based on the other water-related treatise composed by Ṯābit, the treatise *On the Benefits of the Mountains*. While this work is no longer extant, the summary provided by Miskawayh appears to be consistent with the ideas presented in Ṯābit's Treatise *On Why Seawater Was Made Salty*.

Miskawyh's answer is reported in the *Kitāb al-hawāmil wa al-šawāmil* (The scattered and the gathered),[98] and opens with the very same biocentric statement already familiar in the argument on salinity:

> The benefits of mountains and their arrangement on the earth's surface are very numerous. For if they did not exist, there would be no plants or animals on the surface of the earth. For the cause of the existence of plants and animals, as well as their sustenance thereafter, is the fresh water that flows over the face of the earth. And the cause of the fresh water flowing out is the constriction of the vapours in the atmosphere, I mean the clouds, and what they undergo as a compression due to the cold, until either rain, snow, or hail comes out of them. And if you were to imagine the mountains removed from the face of the earth, and imagine the earth as a circular globe without cavities or protuberances, the vapours which would have risen from this globe would not be constricted in the atmosphere, nor compressed, nor would any fresh water come out of it. Hence the end of this vapour would be to be dissolved and turned into air before that which is the reason for the settlement of the face of the earth is accomplished from it.[99]

Then, Miskawayh explains the role of mountains in supporting life, citing Ṯābit's views on the subject. According to Miskawayh, the valleys between mountains serve to concentrate vapours and inhibit the free movement of air. As a result, the vapours are compressed and cooled, eventually turning into water.

> This takes place because the ascending vapour from the earth concentrates in the depressions of the earth, between the mountains which prevent its flowing out, owing to the subjection to the motion of the sky, and owing to the causes of the wind, which constitutes the motion of the air. I mean that the pockets of the high mountains preserve the air blocked in their valleys from the movement which the sky in its entirety tends to impose upon it, as well as the stars which it contains and their tributaries and subtle rays which tend to impose upon them to flow out. If, therefore, the air is thus concentrated between the mountains, the ascending vapour which it contains is also preserved from the dislocation and movement which there would be if the air were to move, so that some of the cold which the mountains store within them during the time of winter

98 Recently translated in English. Abū Ḥayyān al-Tawḥīdī, Ibn Miskawayh, *The Philosopher Responds*.

99 Abū Ḥayyān al-Tawḥidī, *Al-Hawāmil wa al-šawāmil*, 354-6.

> cools and concentrates this vapour, and then presses it. It thus becomes water that stays there or flows

This passage may be subject to other interpretations. M. Rashed interpreted it as a summary of the Aristotelian doctrine of the endogenous water cycle.[100] However, the present author views it as describing an exogenous water cycle, or at least not envisioning any generation of water within the earth. There are some discrepancies between the English translation provided here and the French version offered by M. Rashed, which reads:

> car cela a lieu parce que la vapeur ascendante issue de la terre se concentre dans les creux de la terre, entre les montagnes qui en empêchent l'écoulement, en raison de la soumission au mouvement du ciel, et en raison des causes du vent, qui constitue le mouvement de l'air. Je veux dire que les poches des hautes montagnes préservent l'air bloqué dans leurs vallées du mouvement que tend à lui imposer le ciel dans sa totalité, ainsi que les astres qu'il contient et leurs rayons influents et subtils qui tend à leur imposer de s'écouler. Si donc l'air se concentre ainsi dans les montagnes, la vapeur ascendante qu'il contient est elle aussi préservée de la dislocation et du mouvement qu'il y aurait si l'air se mouvait, en sorte qu'une partie du froid que les montagnes emmagasinent en elles durant le temps de l'hiver condense et concentre cette vapeur, puis la pressure. Elle devient donc de l'eau par transformation, ou quelque autre corps semblable.

The first point of divergence is the origin of the vapour discussed in Miskawayh's answer. The Arabic expression *al-buḫār al-murtafiʿ min al-arḍ* should be read in agreement with the earlier phrases "wa tuḫīlat al-arḍ kura mustadīra" (imagine the earth as a round globe)[101] and "al-buḫār al-murtafīʿ min haḏihi al-kura" (the vapours which would have risen from this globe).[102] Our translation and M. Rashed's do not differ on the meaning of these two phrases, and the first one indicates that Miskawayh is using at least in one instance the word *al-arḍ* to refer to the entire globe. The second sentence indicates that this passage is considering the entirety of the vapour produced on the Earth, not limited to vapour exhaled by the earth either in its depths or in the open air.

The second point of divergence is the translation of the Arabic term *ġawr* (pl. *aġwār*), which I suggest should be understood here as 'valley' or 'depression' in the earth, as Rashed indeed does in one instance of the term. In most instances throughout the text, however, Rashed understands it as 'cavity'. On its own the term could be understood both way,[103] so it is necessary to see how this term is used in the context of Miskawayh's answer.

Miskawayh uses the term *kura mustadīra* three times in this passage. In the first instance, it is used in the phrase "wa tuḫīlat al-arḍ kura mustadīra lā nutūʾ wa lā ġawr fīhā" (imagine the earth as a round globe without protuberances or depressions). Here, it should be understood as the opposite

100 Rashed, "Le meilleur des mondes", 705-6.

101 Rashed: "et que tu imaginais la terre comme un globe circulaire".

102 Rashed: "les vapeurs qui se seraient élevées de ce globe".

103 Lane, *An Arabic-English Lexicon*, 2306-7.

of *nutū'*, meaning 'protuberance' or 'elevation', and thus as a depression or dip. Miskawayh is asking the reader to imagine an alternate Earth as a smooth, perfect sphere, with the focus being on the surface of the sphere rather than its inner structure. Therefore, it seems more appropriate to interpret "kura mustadīra lā nutū' wa lā ġawr" as "a [perfectly] round sphere without protuberances or depressions".

The term *ġawr* is used a second time in the sentence "al-buḫār al-murtafiʿ min al-arḍ yaḥṣulu bayn aġwār al-arḍ wa bayn al-jibāl allatī tamnaʿuhu al-sayalā" (the vapour that ascends from the Earth concentrates among the depressions of the earth and between the mountains which prevent its flow). The interpretation of this usage is somewhat ambiguous, but two factors suggest that it should be read as 'depression' or 'valley'. First, the use of the preposition *bayn* rather than *fī* indicates that the vapours collect *between* two or more sides rather than *within* a cavity. Second, the concentration of vapours "bayn aġwār" is presented as analogous to the concentration of vapours "bayn jabāl", which clearly refers to the space between mountains.

The third occurrence of *aġwār* appears in the sentence "aʿnī an qulal al-jibāl al-šāhiqa yaḥfaẓ al-hawā' muḥtaqan bayn aġwārihā min al-ḥaraka" (I mean that the peaks of the high mountains prevent the air blocked between their valleys from moving…). M. Rashed translates this as "leurs vallées", given that the pronoun clearly refers to the mountains. However, Rashed's interpretation of "qulal al-jibāl al-šāhiqa" as "pockets of the high mountains" (fr. les poches des hautes montagnes) is somewhat surprising, as "qullat al-jibal" (pl. *qulal al-jibāl*) is the common Arabic expression for mountain peaks and only makes sense if one is attempting to align Miskawayh's ideas with the Aristotelian endogenous water cycle. A closer reading of the text, however, suggests that Miskawayh's views on the topic, as he developed them from his reading of Ṯābit's lost treatise, support a fully exogenous water cycle or, at the very least, do not mention any underground generation of water.[104] Miskawayh goes on to explain the usefulness of this process, stating that it provides a constant source of water even during times of drought.

> And if the mountains did not exist, the waters subject to the regime we have described would not flow on the surface of the earth, at least not until the rain came and the earth absorbed it; as a result, it would happen that plants and animals would be deprived of water in the height of summer, at the very moment when they imperatively need it for their subsistence. It could then only be obtained in the same way as it is done in the remote mountain deserts, that is, by digging wells a hundred and two hundred cubits deep.

Miskawayh explicitly and specifically states the form in which this water, "subjected to the regimen we have described", is stored. He asserts that it is snow and rain that do not immediately flow to the lowlands, rather than water generated within the earth. According to Miskawayh, mountains act as reservoirs and release water gradually:

> But now, with the existence of the mountains, the rains and snows remain on these mountains. So when the mountains have absorbed them,

104 The translation provided here, therefore, is in accordance with Lidia Bettini's Italian translation of the work in question (Bettini, *Il libro dei cammelli errabondi*, 311-12).

> either immediately or after a time, springs arise at their feet; from them proceed the streams and rivers, which flow over the surface of the earth, and finally flow into the sea from north to south. And when what the rivers have used as rain during the summer runs out, they benefit from the return of winter and the rains, and the cycle begins again. The sign that springs, streams and rivers all come from mountains is that you never go up a stream or river without ending up in a mountain. As for springs, they are only ever found near mountains. The same applies to what can be inferred from small canals and the like. The mountains play the part, in causing the water from the rains to flow over the earth, of sponges or wools which are soaked with water and which bear a great deal of it, and from which, when they are laid on a spot, the water flows out little by little, until, when they have become dry, they are soaked and watered again. In this way, the moisture that runs off the surface of the earth is perpetuated, and this regime is the reason for the settlement of the world and the existence of plants and animals in it.

As previously mentioned, Miskawayh concludes his response by referencing Ṯābit's treatise on the usefulness of mountains. He cautions al-Tawḥīdī, who posed the question being addressed, that his answer only covers the most significant aspect of the value of mountains:

> Mountains have many benefits. We have only mentioned the most important of these, and let us confine ourselves to that. However, a treatise on the benefits of mountains is due to Ṯābit. Let him who wishes to master this chapter exhaustively read it, if it pleases God.

As the treatise on the usefulness of mountains by Ṯābit is lost, it is impossible to determine the extent to which Miskawayh's response in the *Kitāb al-hawāmil wa al-šawāmil* accurately reflects Ṯābit's opinions. Interestingly, Miskawayh does not mention any other relevant sources, despite the fact that at least one of his acquaintances, Ibn al-ʿAmid, held different views on the topic. The overall consistency between this text and Ṯābit's treatise on the salinity of seawater suggests that Miskawayh's response likely reflects the lost treatise fairly accurately. M. Rashed also seems to hold this view, referring to the text as a summary of Ṯābit's treatise.

Support for the idea that Miskawayh's response accurately reflects Ṯābit's lost treatise can be found in the *Kitāb al-āṯār al-bāqiya*. In a lengthy digression on hydraulics and hydrology that departs from the chronological focus of his book, al-Bīrūnī connects the salinity of the sea to Ṯābit's treatise on the usefulness of mountains, suggesting that the two treatises were complementary. Furthermore, al-Bīrūnī's explanation of Ṯābit's thesis on the role of mountains in the water cycle confirms that the Sabian philosopher held an exogenous model in mind:

> Regarding the question why the water of springs is most copious in winter, it is because the all-wise and all-mighty Creator intended to place the mountains [on earth] for a number of beneficial uses, some of them mentioned by Ṯābit in his book on why the mountains were created. This reason [that interests as here] is to fulfil [his] intention of making the water of the seas salty. Clearly, precipitation in winter is higher than in summer, and they are higher in the mountains than in the plains. When [this

> water] falls, a part of it flows away in the torrents and the remaining part seeps down into the pores in the mountain caves, and there it is stored up. Afterwards, it begins to come out from the holes that are called springs.[105]

Finally, al-Bīrūnī's digression and Miskawayh' answer to al-Tawḥīdī, show that Ṯābit's teaching on the water cycle and the role played by water in the ecosystem were still reverberating in the tenth and eleventh centuries.

2.5 The Role of Water in the Ecosystem: Competing Theories?

The foggy history of Ḥarrān makes it difficult to trace the origins of Ṯābit's understanding of the water cycle and the role of water in the ecosystem. He is the earliest known author in Arabic to propose an exogenous model of the water cycle that diverges from Aristotelian doctrine in this regard. While the Aristotelian model remained the dominant framework for understanding the water cycle among scientists and philosophers, Ṯābit had several influential followers, including al-Tawḥīdī, Miskawayh, and al-Bīrūnī.

The exogenous model of the water cycle also appears in the *Rasāʾil* of the Iḫwān al-Ṣafāʾ. The Iḫwān, a group of philosophers who assembled in Baṣra in the second half of the tenth century, composed a collection of epistles known as *Rasāʾil Iḫwān al-Ṣafāʾ* (The Epistles of the Sincere Brothers). Drawing on Shiʿī and Neoplatonist thought,[106] the *Rasāʾil* cover different branches of knowledge and are regarded as the first encyclopaedic effort of premodern Islam.[107] There is no certainty on the identities of the Iḫwān and those associated with them, but their epistles enjoyed a widespread success in both the Islamic east and west.

As it has been already noted, the multifaceted vision of the creation exposed by the Iḫwān comprised an unusually non-anthropocentric vision of the natural world, which bears some echoes of Ṯābit's own bio-centric rather than anthropocentric view implicit in his *Treatise on Why Seawater Was Made Salty*. Another point of agreement is the theory of the water cycle, described as follows in the eighteenth *Risāla*:

> The root of all these beings is vapours and juices when they are mingled with each other. Vapours are what rise in the air from the subtle parts of the water of seas, rivers, and marshes because of the warming of the Sun and of the stars with the projection of their rays on the surface of seas, rivers, and marshes. Juices seep into the depth of the earth from rain waters, are mixed with the parts of earth, and thicken, and the warmth hidden in the depth of the earth ripens them […] In fact, when the Sun and the stars warm water, irradiating the surface of the Earth as well as seas, rivers, and marshes, waters rarefy and the parts of earth become subtler and become vapour and smoke. Vapour and smoke become clouds, clouds

105 Borroni, Boselli, "Hydraulics and Hydrology", 178.

106 And much more. See de Callataÿ, *A Brotherhood of Idealists*, 73-81; Ikhwān al-Ṣafāʾ, *On the Natural Sciences*, 30-4.

107 El-Bizri, "Prologue"; Netton, "The Rasāʾil Ikhwān al-Ṣafāʾ in the History of Ideas". For a complete introduction to the thought of the Iḫwān al-Ṣafāʾ see Netton, *Muslim Neoplatonists*. On the relationship between the Iḫwān and the Sabians see Mattila, "Sabians, the School of al-Kindī".

> become rains, and when rains moisten the soil and the parts of earth are mixed with those of water, juices are formed from them.[108]

Unlike the perspectives of Abū al-Barakāt, Ṯābit, and al-Bīrūnī, the *Rasā'il* exhibit no scepticism regarding the conversion of air into water as a physical occurrence, nor any other elemental transformation. Within the same treatise, the authors assert that "the four elements undergo metamorphosis into each other, with water alternately transforming into air and earth".[109] The concept of air transmuting into water is further discussed in the *risāla* "On Mines and Minerals", where the authors expound on a process of water formation within the mountain depths. This explanation aims to account for the numerous sources found around the Bāmyān mountains, despite the region's scarcity of rain or snow:

> This is the proof that in the cavity of this mountain there are cold caves, cavers, and chasms, whose coldness is extreme, [whence] air congeals and becomes water, then it is poured into its lowest [part], is seeped from narrow pores, and from them those sources and creeks flow towards those steppes [...] this mountain is far from seas, and clouds seldom arrive here owing to the long distance.[110]

One interpretation of this phenomenon could be that it represents an exceptional and infrequent instance of subterranean water generation within the context of an otherwise externally driven cycle. Alternatively, this could be a result of the multifaceted authorship of the *Rasā'il*.[111] Intriguingly, in a later section of the same treatise, the external cycle is examined from a distinct angle.

Subsequent to an analysis of several major rivers, the swelling of their waters is exclusively attributed to precipitation. For rivers flowing from north to south, an increase in water volume occurs during spring as a result of melting snow after winter. In contrast, the Nile demonstrates a different pattern; it swells in summer due to its sources being located south of the Equator, where seasons are inverted. Consequently, the Nile's sources experience increased rainfall during the northern hemisphere's summer months. The chapter culminates in a comprehensive description of the evaporation and precipitation processes, followed by an exclusively exogenous explanation for the origin of rivers:

> The rains that fall on the tops of the mountains they recede into the fissures and interstices of those mountains, and are poured into the caves, caverns, and chasms that are found there; [these] are filled, and in the lowest [parts] of those mountains narrow openings are formed, from which those waters are seeped, flow, and assemble together becoming wadis

108 Ikhwān al-Ṣafā', *On the Natural Sciences*, 180-1. The Rasā'il translations presented in this paper are by C. Baffioni. The processes that lead to the generation of clouds is further described in Ep. 18 Ch. 8. Ikhwān al-Ṣafā', 203.

109 Ikhwān al-Ṣafā', *On the Natural Sciences*, 180.

110 Ikhwān al-Ṣafā', *On the Natural Sciences*, 241-2.

111 The issue is described as 'vexing' by G. de Callataÿ in the "Brethren of Purity" entry of the third edition of the Encyclopedia of Islam, where a comprehensive and updated summary of the matter can be found. de Callataÿ, "Brethren of Purity".

> and rivers; those snows on the tops of the mountains are melted, flow towards those wadis and rivers, and return in their course to the seas, then vapours, winds, and rains are formed from them, as it had happened the preceding year. This is the decree of the Mighty, the Omniscient.[112]

It is notable that within the same treatise, an explanation for the sea's salinity is presented, which combines the aforementioned Aristotelian causal approach (briefly examining factors contributing to the saltiness of the sea) with a discussion on the purpose of seawater salinity in relation to divine wisdom. This explanation is strikingly similar to the central argument presented by Ṯābit in his work on seawater salinity. As per the Iḫwān's account, the salinity of seawater is of the utmost importance since, without it, terrestrial plants, animals, and humans would not survive; concurrently, this salinity does not pose a danger to marine life. While Ṯābit is not explicitly referenced in these sections, it is reasonable to hypothesise that there could be a direct or indirect link between this passage from the *Rasā'il* and his treatise on seawater and its salinity.

It appears that, at least until the eleventh century, two school of thought on water and its role in the ecosystem coexisted among learned Arabic-speaking communities. On one side, we find those who followed or tried to refine Aristotelian conceptions adopting an endogenous model of the water cycle, on the other side we have those who believed in an exogenous model.

Of these authors, Ṯābit appears to be the most prominent early advocate of the exogenous model, although he may not be the first known author to have written treatises based on this model; the *Filāḥa nabatiyya* and Ḥunayn b. Isḥāq's commentary predate Ṯābit's work on the subject and express implicitly similar views. Despite this, Miskawayh and al-Bīrūnī acknowledge the importance of these earlier treatises by citing them in their own work, while the Iḫwān do not. It is noteworthy that there is no evidence of any debate or disagreement between these two groups, given that Ibn al-ʿAmīd and Miskawayh were personally acquainted and al-Bīrūnī and Ibn Sīnā engaged in a well-known philosophical correspondence. It is possible that Ṯābit's ideas about the water cycle and related topics, such as the salinity of seawater and the usefulness of mountains, were passed down through scholar networks and served as a marker of educational background for members of later intellectual elites. This suggests the existence of a diversity of perspectives on the natural environment and the natural world more broadly within this period. This plurality of views has significant implications for contemporary discussions of the environment within the Arabo-Islamic tradition, as will be explored in the following chapter.

The Arabo-Islamic tradition inspired by Aristotle generally depicted the water cycle through an endogenous model and the idea that certain elements can transform into others. Specifically, it was believed that air could turn into water and vice versa, with vapour occupying an intermediate position. This perspective was often accompanied by a strong anthropocentrism, stating that the majority or all of the elements and processes that make up the natural world are intended for the benefit of humanity.

The view of nature conveyed in the two treatises by Ṯābit that are examined here is based on an exogenous model of the water cycle, the idea

112 Ikhwān al-Ṣafāʾ, *On the Natural Sciences*, 244.

that the water in the world is a fixed quantity and not continually generated, and an implicit biocentrism. According to this biocentrism, the elements and principles of the natural world are intended for the sustenance of all life, which is itself a part of the wisdom and beauty of creation. A similar understanding can be found in Miskawayh and the Iḫwān al-Ṣāfā. In the following chapter, we will explore how al-Bīrūnī expanded upon Ṯābit's understanding of the natural world. As we will see, the concept of the environment is a central point of convergence and agreement between these two important scientists in the Arabic-Islamic tradition. This convergence takes the form, concretely, of extensive paraphrases from the two treatises of the Sabaean mathematician and scientist that we are interested in here, and, more generally, of a significant similarity in approach both to knowledge in general and to the relationship between the scholar and nature/creation as objects of study.

3 Al-Bīrūnī's Thought on Water and the Influence of Ṯābit

Summary 3.1 The Scientific Career of al-Bīrūnī. – 3.2 Climatic and Environmental Subjects in al-Bīrūnī's Scientific Production. – 3.3 Al-Bīrūnī and the *'Anwā'*. – 3.4 Hydrology in the *Kitāb al-Āthār al-Bāqiya*. – 3.5 Hydrology in the *Kitāb taḥdīd al-amākin*. – 3.6 The Water Cycle According to al-Bīrūnī, Ṯābit and al-Karağī: A Comparison.

3.1 The Scientific Career of al-Bīrūnī

According to his own account, al-Bīrūnī was born in "the city of Khwarazm" on Thursday, 3 Ḏū al-Ḥijja 362/4 September 973. The city of Khwarazm is Kāṯ, and his nisba, *bīrūnī*, derived from the term *bīrūn* for 'outskirts', has led to some speculation. The most common interpretation in modern scholarship is that this nisba indicates that al-Bīrūnī's family lived on the outskirts of Kāṯ, but other possible explanations include that it refers to the rural origin of the family or his status as an outsider in the Banū ʿIrāq family, rulers of Khwarazm, who may have taken him in at a young age or even provided a wet nurse for him, as there are hints, although not conclusive, that al-Bīrūnī may have lost his parents at an early age. Regardless, Abū Naṣr Manṣūr b. ʿAlī (d.b. 427/1035-36), a member of the Banū ʿIrāq family and a mathematician and astronomer, became al-Bīrūnī's teacher and trained him in these fields.[1]

In the late tenth century, the collapse of the Samanid dynasty brought about a change in power in Khwarazm and marked the end of the rule of the Banu ʿIrāq. As a result, al-Bīrūnī, who had a close relationship with the Banu ʿIrāq, was forced to travel between cities for a period of time. In 338/998, he joined the court of the Ziyarid ruler of Tabaristan, Shams al-Maʿāli Qābūs

1 Bosworth, "Bīrūnī, Abū Rayḥān I. Life". On the relationship with Abū Naṣr Manṣūr see Brentjes, "Abu Nasr Mansur".

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b. Wušmagir (r. 366-371/977-81 and 388-403/998-1012-3).[2] During this time, al-Bīrūnī produced several important works on astronomy, benefitting from the Ziyarid's interest in the subject, while also working on his first major work, the *Kitāb al-āṯār al-bāqiya*. Despite his success in these endeavours, al-Bīrūnī was not entirely satisfied with his situation and spent several years at the Ziyarid court.

In 394/1004 the court of Jurjāniyya, Khwarazm new capital under the rule of the Banū Ma'mūn, welcomed back al-Bīrūnī. There, the astronomer and scientist acted as boon companion, advisor and diplomat, at the same time pursuing his scientific interest but not producing much writing. The likely encounter with Ibn Sīnā happened in Jurjāniyya deserves a mention. Ibn Sīnā entered the court of Abū al-Ḥasan ʿAlī b. Ma'mūn (r. 387-399/997-1008-9) before 399/1009 and left in the winter of 403/1012-3 for the Ziyarid court, therefore it is highly likely that the two did in fact meet.

Al-Bīrūnī's years in Khwarazm came to an end, once again, with military and political changes in the region. Starting in 403/1013, tensions began to mount between Abū al-Ḥasan ʿAlī b. Ma'mūn and his brother-in-law the Ghaznavid Sulṭān Maḥmūd. As the latter required his name to be included in the *ḫuṭba* (Friday sermon), a request of recognition of his supremacy that was granted but not really applied, the Abbasid Caliph sent to the Khwarazmshāh an honorific title and robe. Al-Bīrūnī himself was sent to accept the gifts, so that a public investiture, sure to further complicate relations with Ghazna, could be avoided. This move damaged the legitimacy of the Khwarazmshāh, and when he was killed in a military revolt, Sulṭān Maḥmūd intervened on the pretext of vindicate him and installed his own officers in 408/1017.

At this time al-Bīrūnī was completing his *Taḥdīd* (*Determination*), as he testified himself, and was brought to Ghazna with little say in the matter. Although al-Bīrūnī did not leave Khwarazm of his own will, in Ghazna he enjoyed the patronage of Sulṭān Maḥmūd, who supported the study of astronomy and astrology in particular. Al-Bīrūnī also visited the Indian regions of the Ghaznavid empire where he collected the vast corpus of sources and data that allowed him to compose a book on Indian sciences and customs known as *Taḥqīq mā li-l-Hind* (known in English as *Biruni's India*).

After the death of Sulṭān Maḥmūd in 421/1030 the power transitioned to his son Masʿūd, after a brief military confrontation with the other son of the late Ghaznavid ruler. Under Sulṭān Masʿūd al-Bīrūnī maintained his position and had the chance of visiting his native Khwarazm for research purposes. He finalised a work on astronomy and astronomical geography, dedicated to the new ruler under the title of *Qanūn masʿudī* (Canon Masudicus), and later treatises on astrology, notwithstanding his lack of love for the discipline, and on mineralogy, the *Kitāb al-ǧamāhir* (*On Jem and Precious Stones*). The latter was in fact dedicated to Sulṭān Mawdūd¸ who succeeded to the throne after Masʿūd's death at the hands of his own commanders after a military defeat against the Seljuqs.

During the latter years of his life, al-Biruni devoted himself to writing an encyclopaedic treatise on pharmacology. Unfortunately, his own illness prevented him from completing the work, and he passed away in 440/1048. Throughout his life, al-Bīrūnī is known to have written 183 works, although only a small portion of these have survived to the present day. His contri-

2 Cristoforetti, "Cycles and Circumferences".

butions to the fields of geometry, mathematics, and astronomy, both within the Islamic world and in Europe, have had a lasting impact. In modern times, there has been renewed interest in al-Bīrūnī's life and the breadth of his research, leading to a revitalisation of his legacy.[3] Al-Bīrūnī's esteemed reputation today makes it particularly interesting to examine his views on the natural world, including his thoughts on water, which he studied as both an engineer and a scientist.

3.2 Climatic and Environmental Subjects in al-Bīrūnī's Scientific Production

A considerable part of al-Bīrūnī's writing on climatic and environmental subjects seems to be lost, in particular his meteorological work *Maqāla fī al-baḥṯ ʿan al-āṯār al-ʿulwīya* (Discourse on Research Concerning Meteorology). Nevertheless, a few things can be said about his view of the natural world.[4] Although extant writings do not provide us with a comprehensive definition of nature according to al-Bīrūnī, three aspects emerge from brief digressions in the *Kitāb al-āṯār al-bāqiya* and *Taḥqīq mā li-l-Hind*: Nature as a creative power, its divine design, and, consequently, the avoidance of any "lack or deficiency".[5] A passage from the *Taḥqīq mā li-l-Hind* exemplifies the three points rather clearly:

> Nature […] allows the leaves and fruit of the tree to perish, thus preventing them from fulfilling the ends for which they are intended in its system, [and] removes them to make room for others.[6]

In terms of cosmology, al-Bīrūnī follows Aristotle in distinguishing between the sublunar region and the heavens. Only in the sublunar region we have the world of change, entailing both generation and corruption, in which the creative power of nature plays its role in accordance with the divine design, though it should be noted that in his exchange with Ibn Sīnā, al-Bīrūnī expressed some scepticism about posing that the two realms have essential physical differences.[7] A similar stance of critical adoption of Aristotelian doctrine emerges in other aspects of his cosmology. A further example is his adoption of geocentrism but, at the same time, affirmation that heliocentrism would be mathematically equivalent.[8]

The concept of nature as creative power of change informs his understanding of the environments of the Earth. By merging his knowledge of

3 A few recent titles that may serve as introductions to his work are Malagaris, *Biruni*; Sanagustin, "Abū Rayḥān al-Bīrūnī"; Ataman, "Re-Reading al-Birūnī's India"; Mirza, "Bīrūnī's Thought and Legacy"; Malik, Bīrūnī, "Al-Biruni".

4 For a comparison of the scientific and philosophical divergences between al-Bīrūnī and Ibn Sīnā in the study of natural sciences see Mirza, "Believing is Seeing".

5 The first ambitious and seminal study of the cosmological thought of al-Bīrūnī is part of Hossein Nasr's monograph on natural sciences in the Arabo-Islamic tradition. Nasr, *An Introduction to Islamic Cosmological Doctrines*, 107-74.

6 Bīrūnī, *India*, 1: 400-1; al-Bīrūnī, *Hind*, 200. Cited in Nasr, *An Introduction to Islamic Cosmological Doctrines*, 123.

7 Mirza, "Bīrūnī's Thought and Legacy".

8 Mirza, "Bīrūnī's Thought and Legacy", 612.

the Greek scientific traditions with his own observations and elements of the Indian and Persian geography he argued that geological changes happen over long spans of times:

> This steppe of Arabia was at one time sea which later upturned, and the traces of that sea become evident on digging for wells and springs, because the desert then unfolds various strata of earth, sand, and soft pebbles, intermingled with pieces of pottery, glass, and bones, which could not have been buried there intentionally. Again, a variety of stones is excavated which reveals, on breaking up, definite sea products: shells, cowrie shells, and what are called 'fish ears'. These products will be found either fully preserved, or in a state of complete decay, and in the latter case they will have left their figures completely imprinted in cavities in the stones.[9]

3.3 Al-Bīrūnī and the *ʾAnwāʾ*

Weather forecasting, which should not be confused with the broader field of meteorology, is also a way of gaining insight into the understanding of the environment held by our authors. As mentioned previously, the *Kitāb al-āṯār al-bāqiya* contains some elements of meteorological forecasting. In the chapter on the *rūmī* (Byzantine, i.e. Julian) calendar, al-Bīrūnī explains the differences in weather forecasting between the *rūmīs* and Syrians on the one hand, and the Arabs on the other.

As al-Bīrūnī explains, the *anwā*',[10] or 'weather predictions', of the Arabs are based on the movements of the fixed stars. This means that the weather for a particular day is determined by the positions of the stars. In contrast, those who follow a solar calendar believe that each day of the year has a unique meteorological character, although this does not necessarily mean that a sunny day will always be sunny. These 'solar' *anwā*' are based on average weather determined by historical observations, but the actual weather experienced on given day of a certain year will be affected by other factors as well.[11]

Al-Bīrūnī cites the *Kitāb al-anwā*' (Book on the anwā'), a lost text written by Sinān (d. 331/943), son of Ṯābit, as the source for the solar *anwāʾ* included in his version of the *rūmī* calendar. This text was reportedly commissioned by the Abbasid Caliph al-Muʿtaḍid, which means it was likely produced between 892-902. It is possible to speculate that the creation of this text, which is linked to the solar calendar, may have been related to al-Muʿtaḍid's decision to adopt the solar calendar for financial purposes at the beginning of his caliphate.[12] At the very least, it may signal a broader interest by al-Muʿtaḍid in the use of the *rūmī* calendar for agricultural and fiscal purposes.

As Nallino suggested, and Samso and Rodriguez conclusively argued, the *Kitāb al-anwā*' appears overwhelmingly based on Ptolemy's phases.[13] In

9 Al-Bīrūnī, *Taḥdīd*, 44; *Determination*, 18.

10 Varisco, "The Origin of the Anwa' in Arab Tradition"; Varisco, "Anwāʾ".

11 Al-Bīrūnī, *Chronology*, 231-3.

12 Busse, "Das Hofbudget des Chalifen al-Muʿtaḍid billāh (279-892/289-902)"; Borroni, *Il nuovo giorno dell'impero*, 148-62.

13 Nallino, *ʿIlm al-falak*, 154-5; Samsó, Blas Rodríguez, "Las 'pháseis' de Ptolomeo". On Ptolemy's phases see Hall, "Horoscopes of the Moon".

addition to the *anwā'* derived from an Arabic translation of Ptolemy, there a few derived from other Hellenistic sources, and personal observations by both Sinān and al-Bīrūnī.

Fortunately, Sinān's observations are clearly identified in the text by phrases such as "Sinān said", and they are likely to relate to Ṯābit's unfinished work on the same topic. According to al-Bīrūnī, Sinān himself conducted a comprehensive study in which he observed meteorological conditions in ʿIrāq over a period of 30 years in order to refine and adapt the *anwā'* of other countries to his own region. While Ṯābit did not complete his own project on this subject during his lifetime, his approach is still important because it was recognised by al-Bīrūnī, who reported at least some of the results in his work, highlighting the close connection between these two scholars in their understanding and study of nature.

If Sinān's observations in the *K. al-āṯār al-bāqiya* are rather succinct and sparse, al-Bīrūnī devotes more space to his own. These observations are mixed with ample digressions on a variety of scientific subjects at times only loosely related with the presented *anwā'*. The first of these digressions is especially relevant to al-Bīrūnī's understanding of the natural world. On the *naw'* for 7 November, al-Bīrūnī relates that it is the first day of the rainy season, marked by the Sun entering the 21st degree of Scorpio. In this regard, and in accordance to the regional variability of the *anwā'* theorised by Ṯābit, al-Bīrūnī notes that this statement is valid only for Iraq and Syria, which as a side note suggests that it is an original *anwā'* by either Sinān b. Ṯābit or Ṯābit. He provides empirical proof of the geographical limits of applicability of the *anwā'* based on his personal observations in Khwarazm and on the accounts of the third/ninth century geographer Ibn Ḫurdāḏbayh:

> I believe, however, that this is only peculiar to the climate of ʿIrāq and Syria, not to other countries, for very frequently it rains with us in Khwarazm even before this time. ʿAbū al-Qāsim ʿUbaydallāh b. ʿAbdallāh b. Ḫurdāḏbayh relates in his *Kitāb al-masālik wa al-mamālik* that in Hijaz and Yemen it rains during June, July, and part of September. I myself have been dwelling in Ǧurǧān during the summer months, but there never passed ten consecutive days during which the sky was clear and free from clouds, and when it did not rain.[14]

The digression then goes on to describe various local climatic *ʿaǧā'ib*, or 'phenomena' that occur in specific places and are difficult or impossible to explain scientifically.[15] These *ʿaǧā'ib* include mountains in Tabaristan where the air is so humid and thick that the mere crashing of garlic can cause rain by dissolving the vapours,[16] a cave and well that cause rain when their waters become cloudy, and a rock in the land of the Turks that brings heavy, destructive rain if touched by sheep's wool. The chapter on the *rūmī* calendar includes several other similar *ʿaǧā'ib*, and al-Bīrūnī offers his interpretation of these inexplicable phenomena:

14 Al-Bīrūnī, *Kitāb al-āṯār al-bāqiya*, 245-6; al-Bīrūnī, *Chronology*, 234-5.

15 Al-Bīrūnī, *Kitāb al-āṯār al-bāqiya*, 246; al-Bīrūnī, *Chronology*, 235-6.

16 The use of garlic and other acid or pungent plants in apotropaic rites is widely attested in Persian popular culture. Peyman Matin, "Apotropaic Plants".

> These things are natural peculiarities of the created beings, the causes of which are to be traced back to the simple elements and to the beginning of all composition and creation. And it was not possible to come to understand them.[17]

Therefore, the fact that these phenomena are difficult to explain should not be interpreted as a suspension of the rational order that underlies the divine plan. Rather, they serve as a reminder of the limitations of current scientific understanding, which could potentially be overcome if we had access to a more complete understanding of the fundamental building blocks of creation. This perspective is similar to that of Ṯābit, as he presents it in his treatise on seawater salinity, who saw the pursuit of knowledge about the divine wisdom through the study of creation as an endlessly unattainable quest.

Al-Bīrūnī further confirms this perspective in a subsequent paragraph discussing the distinctive climates of larger regions. After discussing some examples of unusual meteorological phenomena on a small scale as *ʿağā'ib*, he examines regions with exceptional meteorological characteristics, such as the extremely rainy mountains of Tabaristan and the exceptionally dry region of Fustat. According to al-Bīrūnī, the climatic differences of larger regions can be explained by geographic factors such as distance from mountains and the sea, elevation, and latitude. Al-Bīrūnī suggests that global climate is influenced primarily by the geographic features of an area, and in some cases, by physical differences on a smaller scale.[18]

Of course, al-Bīrūnī's willingness to accept, at least in theory, reports of inexplicable *ʿağā'ib* should not be taken as a sign of excessive credulity. In a brief digression around 6 January, al-Bīrūnī mentions the belief that there is an hour on this day when all salty water in the world becomes sweet.[19] He rejects this notion, stating that "the qualities occurring in water depend exclusively on the nature of the soil where it is enclosed, if it is stagnant, or over which it is flowing, in the case of running [water]". He also notes that these qualities are "stable" and can only change gradually. This example illustrates that al-Bīrūnī is willing to consider reports of inexplicable *ʿağā'ib* as long as they do not contradict a general scientific principle.[20] In fact, he applies this same criterion to reports in general. This can be seen in his later discussion of hydrology and hydraulics, which will be discussed in conjunction with the continuation of this passage on the properties of salty water.

Continuing on the environmental themes discussed by al-Bīrūnī, it is worth mentioning his views on the origin of heat in the air and Sun rays. This topic is relevant in this context because it is connected to a fundamental point of agreement between al-Bīrūnī and Ṯābit. Al-Bīrūnī presents the theories held at the time on the origin of the heat of the air. He first touches on the subject discussing the coal days. These are three days when an increase in atmospheric heat occurs, due to either a spreading of subterranean heat or a change in the action of Sun according to the competing theories presented by al-Bīrūnī. Here the author does not seem to prefer a the-

17 Al-Bīrūnī, *Kitāb al-āṯār al-bāqiya*, 245; al-Bīrūnī, *Chronology*, 235.

18 On geography, orography, and their respective influence on the Arabo-Islamic reception of the classical climes theory, see Al-Azmeh, "Barbarians in Arab Eyes", 7-8.

19 Al-Bīrūnī, *Chronology*, 240.

20 On *ʿağā'ib* literature see Zadeh, "The Wiles of Creation".

ory over the other, and simply notes that according to some atmospheric heat is caused at least in part by heat from the interior of the earth, while others maintain that the only cause is Sun rays.

Al-Bīrūnī takes a position in the debate about atmospheric heat further on, discussing the weather condition of the first day of March:

> People say that [...] the heat of heaven and the heat of earth meet each other. This is a somewhat exaggerated expression for the beginning of heat, its increase and spreading, and for the air adapting to receive it. Because heat is just the rays of the Sun sent from its body towards the Earth or from the warm body touching lunar sphere called Fire.[21]

Thus, he distinguishes between two types of heat: the heat 'inherent' to sunrays and the heat of the body between the lunar and sublunar sphere, called Fire. The latter, according to al-Bīrūnī is caused by friction due to the rapid movement of the spheres.[22] Al-Bīrūnī prefers this explanation over the Aristotelian doctrine of the natural place, which would place fire above air, precisely because he adopts the view of Ṯābit on the subject:

> This explanation is in conformity with the theory that none of the existing bodies is in its natural place, that all of them are where they are only in consequence of some force being employed, and that force must of necessity have had a beginning.[23]

3.4 Hydrology in the *Kitāb al-Āthār al-Bāqiya*

The longest discussion of water-related topics found in al-Bīrūnī's works is a lengthy digression in the *rūmī* calendar chapter from the *Kitāb al-Āṯār al-Bāqiya*. This hydrological and hydraulic digression is similar those discussed above, and departs from the *naw'* of 28 April, when according to Eudoxus and Sinān there is a tendency towards rainfall and rivers grow in this period.[24] Commenting on the periodicity of fluvial regimes, al-Bīrūnī devotes a few pages to a multifaceted discussion of several hydrological and hydraulic subjects covering:

- Fluvial regime of the Oxus in comparison with the Tigris and Euphrates
- Fluvial regime of the Nile
- Seasonality of water springs
- Role of the mountain in the water cycle
- Upward movement of water

21 Al-Bīrūnī, *Chronology*, 246-8.

22 This debate was also discussed in al-Bīrūnī's correspondence with Ibn Sīnā. Starr, *Lost Enlightenment*, 260. A German translation of this passage is also available in Strohmaier, *In den Gärten der Wissenschaft*, 58-60.

23 Al-Bīrūnī, *Kitāb al-āṯār al-bāqiya*, 257; *Chronology*, 247.

24 The two sources are Eudoxus of Cnidos (ca. 408-355 BC) and of course the aforementioned Sinān b. Ṯābit. The source of the *anwā'* of Eudoxus, who appears often in the chapter and studied the periodicity of weather phenomena, may be an Arabic version of the *Ceimonos Prognostica*, a treatise on bad-weather predictions of Babylonian origin. Frisinger, *The History of Meteorology*, 10-15; Sarton, *A History of Science*, 447.

- Hydraulic machines
- Peculiar customs and places related to water

For the purposes of this discussion, we will focus on the aspects of this passage that pertain to al-Bīrūnī's views on the environment and hydrology.[25]

Al-Bīrūnī discusses fluvial regimes starting with the general statement that rivers and *awdiya* (sing. *wādī*) begin to increase in water output on 28 April. Here *wādī* should be understood as a broad term referring to streams, rather than what is referred to by the term wadi today, e.g. a typical stream in an arid region presenting occasional waterflows for very short timespans. Al-Bīrūnī notes that not all watercourses have the same regime, and he singles out four rivers to illustrate how and why fluvial regimes can vary according to seasonality:

> It is said that the south wind blows on this day, and that the streams and rivers begin to grow. This increase of the water does not happen in all streams and rivers in the same way. On the contrary, they differ a great deal from each other in this respect. For instance, the Oxus has high water when there is little water in the Tigris, Euphrates, and other rivers. This happens because [rivers] that originate from streams in colder places have more water in summer and less in winter.[26]

Al-Bīrūnī notes that the Oxus, also known as the Amu Darya, receives the water that causes its growth during the summer from snowmelt. Thus, he describes here what hydrologists today call a nivo-glacial regime. The Tigris and the Euphrates are characterised by what is today known as a pluvial regime, which al-Bīrūnī describes as a seasonal growth of the rivers caused by an increase in rainfall. The Nile also presents a pluvial regime according to al-Bīrūnī, but its geographical position makes it a peculiar case, which will be discussed in what follows. Here it is important to note how al-Bīrūnī recognises how all of the rivers that he is taking as exemplary cases grow and decrease according to the respective availability of their water sources. All of the water sources mentioned here are part of an exogenous water cycle, and there is no mention whatsoever of water generation or transformation of air into water happening in the depths of the earth. In this regard, it should be noted that al-Bīrūnī expressed his perplexities on the transformation of water into air also in his epistolary exchange with Ibn Sīnā and the latter's pupil al-Masʿūmī. In the tenth question posed to the philosopher, al-Bīrūnī inquires whether "when water transforms into air, does it become air in reality, or is it because its particles spread out until they become invisible to the sight so that one cannot see these separate particles?".[27] Ibn Sīnā's answer negates the second explanation proposed by al-Bīrūnī, referring him to Aristotle's works on the subject, and al-Bīrūnī does not comment on it.[28] Later in life, when he composed the didactic but comprehensive treatise on astronomy and astrology titled *Kitāb al-tafhīm*,

25 For an analysis of the hydraulic aspects of this passage see Borroni, Boselli, "Hydraulics and Hydrology".

26 Borroni, Boselli, "Hydraulics and Hydrology", 177.

27 Berjak, Iqbal, *Ibn Sina – Al Biruni Correspondence*, 17 [42].

28 Brentjes, "Abu Nasr Mansur", 31.

al-Bīrūnī explicated that water "becomes suspended in the air", only to regain its original liquid nature as it falls from the clouds in forms of rain.[29]

Interestingly, al-Bīrūnī appears to be correct for the wrong reason when he states that the sources of the Oxus are frozen around time when the Tigris and Euphrates grow thanks to rainfall because the Oxus originates further north than the Mesopotamian rivers. In fact, both sources are located at about the same latitude. The reason for the discrepancy between the seasonal regimes of the Tigris and the Euphrates, on one side, and the Oxus, on the other is that the sources of the latter lie at much higher altitude. Thus, they are indeed frozen in early spring when the Tigris and the Euphrates receive more rainfall. Al-Bīrūnī's interpretations appears to be linked with his conception of climates, which focused primarily though not exclusively, in latitude.[30]

Lastly, the passage features an expression to designate precipitation. Al-Bīrūnī employs here the term *wuqūʿ al-andiyya*, which is roughly translatable as 'dewfall'. In fact, this was also how Sachau rendered the term in his English version of the *Kitāb al-āṯār al-bāqiya*, but the context makes it clear that al-Bīrūnī also had in mind rain and snow, since he mentions the latter little later on in the text. Thus the terms *wuqūʿ al-andiyya* and *al-andāʾ* should be understood as referring to all naturally occurring water from atmospheric precipitation, such as rain and snow.

The Nile receives a longer treatment in the digression, since al-Bīrūnī presents two alternative explanations for his peculiar fluvial regime. The first theory assumes that the sources of the Nile are located south of the Equator. Being first and foremost an astronomer, al-Bīrūnī knows that the seasons are reversed in the southern hemisphere. This means, he notes, that the Nile receives more water during the dry season in the northern hemisphere. Alternatively, the author suggests, it could be that the sources of the Nile lie north of the Equator, in which case they would be subject to some regional rainfall regimes, as in the aforementioned case of Yemen:

> As for the Nile, it grows when Tigris and Euphrates shrink. This is because its source lies in the Mons Lunae, as it has been said, beyond Assuan – the city the Abyssians in the southern region – either at the Equator, or beyond it. This is, however, a matter of doubt, because those surroundings are not inhabited, as we said earlier. It is evident that in those regions any freezing of moist substances is impossible. Therefore, it could either be that the growth of the Nile is caused by precipitated water, as it is evident that the water does not stay where it has fallen, but flows off to the Nile at once, or that it is caused by the springs, that have the most water in winter. [In the latter case,] the Nile rises in summer, because when the Sun is near us and at our zenith, it is far away from the zenith of those regions whence the Nile originates, and it is winter there.[31]

Clearly, both theories assume a purely exogenous water cycle. Al-Bīrūnī's reliance on the model outlined by Ṯābit becomes more explicit as he moves to discuss the seasonality of water springs, which directly influence the behaviour of fluvial regimes:

29 English and Arabic text in Bīrūnī, *The Book of Instruction*, 124-5.

30 Antrim, *Routes and Realms*, 90-1.

31 Borroni, Boselli, "Hydraulics and Hydrology", 178.

> Regarding the question why the water of springs is most copious in winter, it is because the all-wise and all-mighty Creator intended to place the mountains [on earth] for a number of beneficial uses, some of them mentioned by Ṯābit in his book on why the mountains were created. This reason [that interests as here] is to fulfil [his] intention of making the water of the seas salty. Clearly, precipitation in winter is higher than in summer, and they are higher in the mountains than in the plains. When [this water] falls, a part of it flows away in the torrents and the remaining part seeps down into the pores in the mountain caves, and there it is stored up. Afterwards, it begins to come out from the holes that are called springs. That is the reason why [this water] is most copious in winter: it is because there is more of its own substance. Moreover, if these mountain caves are clean and pure, the water flows out just as it is, agreeable [to the taste]. If that is not the case, the water acquires different qualities and peculiarities, the causes of which are hidden from us.[32]

Here, al-Birūnī cites Ṯābit's treatise *On the Benefits of the Mountains*. The treatise appears today to be lost and the most detailed account of its content is the aforementioned summary by Miskawayh. The *Kitāb al-āṯār al-bāqiya* features only this reference to Ṯābit's argument that, despite its brevity, is nevertheless useful in confirming two points found in Miskawayh's summary.

First, the role of mountains as collectors of rain. Al-Bīrūnī does not delve into the details of how and why mountains are key in the production of rain, but describes the functioning of a karst system in broad strokes. Second, al-Bīrūnī maintains that precipitation is the only source of water involved in the regulation of fluvial regimes, thus excluding the endogenous model of the water cycle. This is true even though he describes the karst system, which entails subterranean waters that would be easy to explain via water generation in the depths of the earth. More broadly, the short summary provided by al-Bīrūnī confirms the teleological approach of Ṯābit's lost treatise, in agreement with the theses advanced in the treatise *On Why Seawater Was Made Salty* on a natural world functioning towards its own regeneration.

According to al-Bīrūnī, mountains and the karst systems he describes play a role in defining the characteristics of water. While he does not delve into the relation between soil and the characteristics of the water it contains in depth, this concept had already been expounded upon in his commentary to the *naw'* of 6 January. There, the author relates that some people – it would seem that these are common people rather than men of science – maintain that on this day there is an hour when all the salty water of the world turns sweet for an instant. Al-Bīrūnī dismisses this belief:

> All the qualities occurring in the water depend exclusively upon the nature of that soil by which the water is enclosed, if it be standing, or over which the water flows, if it be running. Those qualities are of a stable nature, not to be altered except by a process of transformation from degree to degree.[33]

Al-Bīrūnī further elaborates on the assertion that water can only change its qualities gradually by describing the behaviour of the lake of Tinnis, a brack-

32 Borroni, Boselli, "Hydraulics and Hydrology", 178.

33 Al-Bīrūnī, *Kitāb al-āṯār al-bāqiya*, 230; *Chronology*, 240.

ish deltaic lake in north-eastern Egypt which is today known as the lake of Manzala. He relates that the lake is sweet in autumn and winter and salty for the remainder of the year because, given the seasonality of the Nilotic fluvial regimes, the lake receives different amounts of sweet water from the river and salty water from sea according to the season.

3.5 Hydrology in the *Kitāb taḥdīd al-amākin*

The *Kitāb taḥdīd al-amākin li-taṣḥīḥ masāfāt al-masākin* is of special importance to the study of the connections between al-Bīrūnī's and Ṯābit's view of the environmental role of water. Al-Bīrūnī devoted this book to mathematical geography and expounds on it in great detail, calculating the coordinates of the city of Ghazna, where he had been brought, not entirely willingly, by Sulṭān Maḥmūd in 409/1018. Seven years after his arrival in Ghazna, in 416/1025, he completed the *Kitāb taḥdīd* as a praise of Ṣultān Maḥmūd himself. As with the *Kitāb al-āṯār al-bāqiya*, it is impossible to do justice to the wide range of subjects covered by al-Bīrūnī here.[34] Instead, we will focus on his paraphrase of Ṯābit's treatise *On Why Seawater Was Made Salty*.[35]

Al-Bīrūnī approaches the subject in the introductory chapter, where he defends the merits of knowledge in general and mathematical geography in particular. The latter, as noted by al-Bīrūnī, is essential to Islam as a tool for calculating the direction of the *qibla* for the ritual prayer. The former is first and foremost a natural need of every mind, and moreover it forms the basis for any materially beneficial activity that is morally sound. From these premises, al-Bīrūnī moves on to discuss the origin of the world and its perpetual state of change. In these pages, he relates several historical instances of the natural landscape and human civilisation influencing each other. Al-Bīrūnī reports a variety of cases from various sources in which either natural catastrophes or destructive or constructive human activities dramatically changed different waterscapes. These changes, in turn, affected the lives of cities and peoples, leading al-Bīrūnī to state that "civilisation demands water, and it shifts in pursuit of it, because the former is dependent on the latter".[36]

The reasoned recognition of the importance of water for all human civilisation serves al-Bīrūnī a basis to discuss the natural history of water and its role in the divine plan. Al-Bīrūnī draws on Aristotle, the Torah, and the Quran to explain that God changed an originally perfectly spherical, but desolate Earth by elevating and thus drying some of its parts, while water accumulated in the sea. To explain the salinity of the sea, al-Bīrūnī first turns to Ṯābit:

> He called the water that gathered in a depression a sea, and gave it the taste of salinity. This salinity, according to Ṯābit, prevents the water from getting foul, and eliminates putrefaction which would be disastrous to His intended creatures. The sea was also intended to be a reservoir of water for man's special needs, and as the lives of both man and animal, which is put in man's service, are dependent on fresh water, and as his habitation

34 For a discussion of the astronomical, mathematical, and geographical aspects of the *Taḥdīd*, see Kennedy, *A Commentary upon Biruni's Kitab Tahdid Al-Amakin*.

35 The English versions of the passages from the *K. Taḥdīd* quoted here are from Jamal Ali's translation of the book. Al-Bīrūnī, *Determination*.

36 Al-Bīrūnī, *Taḥdīd*, 52; *Determination*, 24-5.

> is far away from reservoirs, so God Almighty has designed the continuous motion of the Sun and the Moon, and commanded them both to produce motion in the water, to evaporate it, and to lift its vapour upwards.

This short summary of the central thesis of Ṯābit's treatise on seawater further confirms what has been conveyed by Miskawayh and the content of the only extant manuscripts. Interestingly, here al-Bīrūnī slightly corrects Ṯābit's biocentric approach by noting that, while the divine plan for the natural world ensures the lives of all animals, the latter are in "man's service". This slight change in outlook may suggest that Ṯābit's biocentric vision of the environment somewhat discorded with al-Bīrūnī's more anthropocentric one as a mainstream Muslim.[37]

The passage continues briefly addressing the role of heat and winds as the main forces behind the continuous cycle of waters, leading to a description of what we today call the water cycle in purely exogenous terms:

> Then He commanded the winds to drive water vapour, in the form of clouds, to desolate and waterless lands so that its rain in those lands will refresh and sustain the lives of animals and plants over there, and its rain on the mountains will penetrate and accumulate deep inside them, or will remain on their tops in the form of snow. Further, the accumulated water will form rivers which will carry it back to the seas, but their courses will run by the dwelling places of peoples and animals, who will use the water for drinking and other utilities.[38]

This paragraph is likely the clearest depiction of a purely exogenous water cycle in Arabic sources of the period. Al-Bīrūnī does not credit Ṯābit with this idea, since this paragraph does not seem to be intended as part of the summary of the Sabian's treatise. Nevertheless, it seems abundantly clear that the main source of reference for al-Bīrūnī on the matter is precisely the treatise *On Why Seawater Was Made Salty*, since he chooses to complete his discussion on seawater salinity with a dismissal of other possible tastes that clearly echoes Ṯābit's own longer discussion of the same subject:

> These benefits could not have been possible, if the solute in sea water were other than salt, because vapours of solvents, except the vapours of solvents carry the tastes of solutes dissolved in them. For example, bitter water is injurious to animals; sweet water is more readily fouled than

37 The anthropocentric character of most of the Arabo-Islamic tradition has been explained both as a response to the text of the Revelation to Muḥammad, and as a result of the adoption of the Aristotelian and Ptolemaic cosmology. It should be noted that several modern thinkers reject the idea that the Islamic Revelation expresses an anthropocentric point of view, arguing, rather, that it is theocentric and that humans only have a peculiar set of duties and rights in the Creation (*ḫilāfa*). At the same time, there is no mention of the *ḫilāfa* of humans in creation in Ṯābit's work. This concept is the cornerstone of a broader framework of Islamic discourse on ecology. Proponents of this approach understand the natural world as necessarily Muslim, that is, submitted to God's will, and humans as *ḫalīfa*, meaning stewards or viceroys. This approach is not without opposition. In the late 1990s, for instance, Kaveh L. Afrasiabi argued that this hierarchical, utilitarian, and anthropocentric interpretation should be left behind. Bagir, Martiam, "Islam: Norms and Practices"; Afrasiabi, "Toward an Islamic Ecotheology". Özdemir, "Towards and Understanding of Environmental Ethics"; Rizvi, "Islamic Environmental Ethics"; Sessions, "Anthropocentrism and the Environmental Crisis", 74.

38 Al-Bīrūnī, *Taḥdīd*, 54; al-Bīrūnī, *Determination*, 24-5.

> fresh water; acid water is repugnant, makes surfaces hard and rough, and reacts so vigorously that it changes whatever comes into contact with it, and it is sufficient to mention its action on iron and similar metals. Glory be to God, Most Omnipotent, Most Wise![39]

These passages from the introductory chapters of the *K. Taḥdīd* show a clear influence of the work of Ṯābit on al-Bīrūnī's thought on the environment and the role played by water in it. As is well-known, this relationship between the two scientists is not limited to this only subject,[40] but in this case, as we hope to have shown, it puts their views at odds with a wider tradition that was closely aligned with the Arabo-Islamic Aristotelian doctrine. It may be possible to envision a link connecting the two through the Baghdadi-based astronomer al-Buzǧānī (d. 387/997-8), who was the main teacher of al-Bīrūnī's own teacher Abū Naṣr Manṣūr.

In any case, one should not assume that al-Bīrūnī distances himself in any manner from the theses he reports, citing the authority of Ṯābit. Although it is true that in the passages mentioned, the wise Sabean is always duly cited, in al-Bīrūnī's *Kitāb al-jamāhir fī maʿrifat al-jawāhir*, he presents his own synthesis of the water cycle. He does this specifically at the beginning of the text, which is none other than an erudite treatise on the properties and origins of various precious stones and metals, complemented by a treasury of anecdotes and historical titbits related to each of these.

The introduction to the *Kitāb al-jamāhir*, however, covers a much broader range of topics, and there al-Biruni, while always relying on legends, anecdotes, historical facts, and his own reflections and personal experiences, ranges from advice for married life to political doctrine, from the foundations of economic theory (the value of gold is purely conventional) to the fundamental aspects of creation, that is, the natural world.[41] This engaging tour de force, which prepares the reader for the subsequent mineralogical discussion, begins precisely with the following words:

> All praise is for the Sustainer of the world, Who from the beginning to the end is Unique, Who has ordained the survival of *islām* which destructs ills and misfortunes, and [brings about] health and tranquillity, Who has distributed food and fixed morality, Who has made struggle the source for food in the same way in which he has made the Sun and the Moon as the actors that uplift water towards the heaven. So, when the clouds are filled and laden with rain, winds drive them towards dry land and flood it with the blessing of water. Then, the earth generates plenty which for man is wealth and for animals sustenance. Moreover, this very same water returns to the slopes and [then] the oceans. He knows what comes to the earth, what comes out of it, and what comes down from the heavens and ascends towards them. Verily, he is the Knower, and He has issued commands out of his infinite wisdom.[42]

39 Al-Bīrūnī, *Taḥdīd*, 54; al-Bīrūnī, *Determination*, 24-5.

40 See for instance their respective work on the Sun's mean position on its ecliptic and its actual position.

41 Nadvi, "Al-Birūnī and His Kitāb al-Jamāhir".

42 Al-Bīrūnī, *Kitāb al-jamāhir fī maʿrifat al-jawāhir*, 3. This English translation is a slightly edited version of H.M. Said published in Al-Beruni, *The Book Most Comprehensive in Knowledge*, 3.

Therefore, at the opening of the *Kitāb al-jamāhir*, al-Bīrūnī praises God for the wisdom expressed in the mechanism of the water cycle, which al-Bīrūnī describes once again and in his own terms as purely exogenous.

3.6 The Water Cycle According to al-Bīrūnī, Ṯābit and al-Karağī: A Comparison

Any treatment of hydrologic or hydraulic knowledge in premodern Islam is bound to find fruitful material in the eleventh-century treatise on the construction of *qanāt* entitled *Kitāb inbāṭ al-miyyāh al-ḫafīyya*. Its author, Muḥammad al-Karağī (d. after 410/1019),[43] hailed from the city of Karaj in the Iranian Jibal,[44] early in his career, moved to Baghdad. There, he entered the entourage of vizier Faǧr al-Mulk as renowned mathematicians and held several important positions working on the construction and maintenance of roads, bridges, canals, and *qanāts.* He returned later in life to Jabal and it is there that he composed the *Kitāb Inbāṭ al-miyāh al-ḫafīya* in honour of vizier Abū Ġānim Muḥammad b. Ḫalaf (deposed in 420/1029).

Al-Karağī wrote mostly on mathematics, geometry and algebra. Only a few of his works have come down to us, and the *Inbāṭ* is among what we have of his production, and it has received some attention as a technical treatise. In addition to the Arabic editions, of which the 1997 critical edition provided by ʿAbd al-Munʿim is the most valuable,[45] there is a French translation by Aly Mazaheri based on the 1941 edition in Hyderabad.[46] The *Inbāṭ* is devoted to illustrating in detail the construction and upkeep of the *qanāt*. These underground channels of Iranian origin are a key feature of the irrigated landscape and urban water-provisioning of the Islamic world from Central Asia to the Western Mediterranean. Al-Karağī introduces his treatment of the technical knowledge involved in infrastructure building and maintenance with a concise but meaningful discussion of the general hydrological principles that govern the natural world. The description of the water cycle and the role of water in the ecosystem that emerges from the introductory chapters of the *Inbāṭ* bears interesting comparisons with the theses expounded by al-Bīrūnī and Ṯābit before him. Al-Karağī meant to provide the reader with a general idea of the scientific consensus on the hydrology of the natural world, on which *qanāt* technology is obviously based. Doing so, he also conveys a clue on why it appears that scholars who affirmed the endogenous and exogenous models of the water cycle did not actually debate each other.

Al-Karağī adopts a purely Aristotelian starting point, stating both the impossibility of void and the doctrine of the natural place, rejected by both al-Bīrūnī and Ṯābit, as we have seen:

> And God, who is blessed and glorified, created the universe as solid, with no voids, and He established for everything, meaning the celestial orb,

43 Vernet, "Al-Karadji̱".

44 Until the 1930s he was considered to be born in the Baghdadi suburb of Karḫ, and for this reason modern scholarship knows him also under the incorrect name of al-Karḫī; Solignac, "Mohamed Al-Karagi, ingénieur hydrologue (m. 410/1019)". On his life and work see also Solignac, *Mohamed Al-Karagi, ingénieur hydrologue*; Ferriello, "Problemi di storia della scienza".

45 Al-Karağī, *Inbāṭ*.

46 Al-Karajī, *Eaux cachées*.

> the stars, fire, air, water, and earth, a specific location for each; a location that it seeks through its motion, if it becomes separated from it. Therefore, dense bodies such as water and earth seek the centre, and the denser body precedes the other.[47]

Al-Karaǧī, who is only interested in water, explains that the irregular shape of the Earth enables water to flow. Both earth and water strive to move towards the centre of the universe, thereby attempting to achieve a spherical shape. As a result, water placed in higher reservoirs will eventually flow:

> When God, may He be glorified, decreed that water flowed and that it would be moved from one place to the other, and that the Earth had both dryland and sea, and that both dryland and sea had animals, seeds, fruits and the various plants, minerals and other things that are necessary to the prosperity of the earth and the life of the creatures upon it; together with the food, drink, clothing, and the many gems and medicines that they need, He created the earth with mountains, valleys, alluvial flans, peaks, gullies, highlands, and chasms; all of these from many different types of stone and soil, so that the distance between the centre of the earth and its surface would have been unequal and that water flows from locations distant from the centre of the earth to locations close to it.[48]

Here, we can appreciate a subtle echo of the biocentric principle that upholds Ṯābit's thesis in both the *Treatise on Why Is Seawater Salty* and the *Treatise on the Usefulness of Mountains*. More importantly, this passage brings al-Karaǧī to deal with the all-important question of how water in high elevations is replenished:

> Water flows continuously from [higher] places to areas closer to the centre of the Earth, with the transformation of air to water during cold periods and in cold locations, and the transformation of water to air when it becomes rarified during warm periods and in warm places.

This picture offers a partial and simplified version of the Aristotelian doctrine envisioning the transformation of water into air and vice versa, although it would seem to ignore the subterranean generation of water and describe an overall exogenous water cycle. However, in two further passages al-Karaǧī describe this component of the endogenous model.

The first time he does so in a dubious fashion, presenting the generation of water in the depths of the earth as a real possibility but with limited impact on the overall cycle of water:

> A philosopher has expressed the opinion that in the bowels of the air (sic) which is transformed into water – on condition that the soil is very cold – which gives rise to springs flowing along natural underground channels and forming stagnant pools.[49]

47 Al-Karaǧī, *Inbāṭ*, 29.

48 Al-Karaǧī, *Inbāṭ*, 30.

49 Al-Karaǧī, *Inbāṭ*, 32.

In the second passage dealing with subterranean water generation, al-Karağī resorts to it as a possible explanation the reports of lakes and springs on mountaintops. Here the author is dealing with same question that preoccupied Ibn al-ʿAmīd, the presence of sources on mountain islands. Al-Karağī first argues that such sources rely on a subterranean connection with a faraway reservoir that lies higher the source on the island. Then, he completes the picture by mentioning a different opinion:

> Scientists have said: It is possible that the substance of springs on mountaintops is from the penetration of a great deal of vapour in the interior of the mountain, which rises to the top and transforms into water, which in turn appears on the summits.[50]

This explanation is not intended to be fully contrarian to the circulation of water through long-distance subterranean networks. Instead, al-Karağī strives to provide a general but complete picture of the scientific understanding of his time. In this broader context the split between endogenous and exogenous models blurs. In fact, in accordance with the customs of *adab* literature, the text presents the original opinions of al-Karağī and all others that are deemed valuable and authoritative by the author.[51]

The broad picture provided by al-Karağī suggests that a debate about the endogenous and exogenous models did not actually occur scholars could easily find ample middle ground between the two models. Among the texts at our disposal, this happens most clearly in the introductory chapters of the *Inbāṭ*, where al-Karağī espouses a substantially exogenous model, while allowing a complementary place to the hallmark of the endogenous model that is the subterranean generation of water. In doing so, al-Karağī shows both a partial departure from the Aristotelian doctrine, in which subterranean generation of water plays a very important role in the workings of the natural world, and a hybridisation of the ideas on the water cycle put forth by Ṯābit and later by al-Bīrūnī.

Ṯābit and al-Bīrūnī are at the extreme of this spectrum, as they do not consider the contribution of subterranean water generation even in limited cases. The divergence between al-Karağī and al-Bīrūnī becomes clear if we compare al-Karağī's discussion of sources on island mountain-tops, which we just analysed, and al-Bīrūnī's discussion of the lake of Sabzarūd, today known as *Chasmeh Su*. Al-Bīrūnī mentions this small lake, located on a mountain top not far from Ṭūs, in his digression on water from the *Kitāb al-Āthār al-Bāqiya*. After discussing that water may only flow downwards, al-of this lake, or indeed any lake, on a mountaintop, by agreeing with the "distant reservoir" hypothesis that we find in al-Karağī. Al-Bīrūnī envisions three possible explanations for the presence of this lake, all relying on the same principle of the communicating vessels: water may come from a distant "reservoir higher than the lake itself", or from a reservoir "which lies on the same level with the lake", or from a natural mechanism similar to self-feeding lamps.[52]

50 Al-Karağī, *Inbāṭ*, 141.

51 Ghersetti, *La letteratura d'adab*; Salvatore, "The Islamicate Adab Tradition".

52 Borroni, Boselli, "Hydraulics and Hydrology", 174-5.

Al-Bīrūnī further mentions two lakes on mountaintops, which suggests that he extended his description of the possible origin of the water of the Sabzarūd to be generally applicable to all similar cases. Now, while he's opinion on the matter is clearly in agreement with the main discourse by the coeval al-Karağī, he does not mention the possibility of subterranean water generation. This further confirms that he did not take it into consideration, showing how different opinions on the water cycle existed on a continuum.

For instance, the Buwayhid vizier Ibn al-ʿAmīd, whom we cited earlier in reference to his *risāla* on the presence of sweet water sources on islands, held beliefs closer to the Aristotelian doctrine than al-Karağī, as he identifies the most important source for water on islands in the process of subterranean generation of water from air. Nevertheless, he provides two other possible explanations. In some cases, water may simply be caused by precipitations stored in the mountains, or, he argues, sweet water could be seawater filtered by the particular soil of some islands which does not allow the salty part percolate. In Ibn al-ʿAmīd's thought, these two possibilities appear as only complementary to the more important generation of water that takes place in the depths of the earth.

4 Conclusions

As we have seen, the treatise on *Why Seawater Was Made Salty* allows us to understand several important aspects of Ṯābit's thought about nature. It is particularly useful to read this text in conjunction with the summaries of the treatise *On the Benefits of the Mountains* that appear in later sources.

One dominant aspect of both works, as already noted by Marwan Rashed, is Ṯābit's teleological and finalistic approach to natural sciences.[1] This teleological perspective constitutes a significant difference from the generally causal discourse of many thinkers in the Arabo-Islamic Aristotelian tradition. The finalistic character of both works leads Ṯābit to explicitly state the end or purpose of creation.

Throughout the treatise *On Why Seawater Was Made Salty*, the ultimate end or purpose is life in all its forms and beauty, encompassing plants, animals, and humans on equal footing. Rather than thinking of animals and plants primarily in terms of human needs, Ṯābit understands them as the collective ultimate beneficiaries of God's design. This same argument is laid out as the basis for the treatise *On the Benefits of the Mountains*, according to extant summaries.

Thus, Ṯābit sees the divine plan as perfectly rational and knowable, if its end is duly considered. This assumption forms the basis for the scientific enterprise. This knowledge program is characterised by a mixture of empirical observations and reasoning, both of which seem to be necessary: reasoning because the divine plan is rational, and observations because some of its components – such as water – do not strictly follow theoretical principles. The end of this effort is clearly stated: human souls long for knowledge

1 Rashed, "Le meilleur des mondes".

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of the divine wisdom enshrined in creation. Ṯābit considers the intellectual struggle in pursuit of this knowledge to be rewarding and never-ending. However, he also seems to imply that no single part of the divine wisdom showcased by nature is per se forbidden or unattainable in principle.

In both treatises, Ṯābit's attention focuses on water as a prominent part of creation. Unfortunately, we do not have access to the full content of the treatise *On the Benefits of the Mountains*, as Miskawayh states that his summary is only partial. However, based on what we can surmise, it mainly revolved around the origin of fresh water on dry land and the role played by mountains in these processes. Regardless, it is clear that Ṯābit sees water as a special component of the divine plan. Its behaviour, even in everyday observations, escapes the otherwise perfect but sterile order of the elements. Thanks to this exceptionality, water acts as the connecting element between dry land, the sea, and the atmosphere, playing a fundamental role in sustaining life.

Seawater salinity helps to maintain balance in this perpetual movement, which is another defining feature of creation. The cycle of water is clearly understood here as exogenous, meaning that it excludes the generation of water in the depths of the earth. While this position is not unique to Ṯābit, he appears to have been one of its strongest proponents. Important authors such as al-Bīrūnī and Miskawayh referred to him on the matter. The relative success of these two treatises in the following centuries, in the face of the more widespread adoption of the Aristotelian endogenous model of the water cycle, may have contributed to the downplaying of subterranean water generation by other authors in the Arabo-Islamic tradition. As we have seen, the exogenous model also appears in the *Rasā'il* of the Iḫwān al-Ṣafā' – a collective who interestingly also shares with Ṯābit a similar biocentric view of the natural world – and al-Karağī tempers his account of the scientific consensus of his time on the endogenous cycle with some reluctant scepticism about the contribution of subterranean water generation. Al-Karağī acknowledges that philosophers and scientists assert that air transforms into water through condensation within the earth's depths. Since the hydrological discussion in the *K. inbāṭ* serves as a supplementary component to the book's primary objective, he does not extensively or emphatically explore the subjects. His exposition allows for the coexistence of endogenous and exogenous models. Rather than adopting definitive positions, the engineer presents a circulatory system of global waters that operates effectively, whether or not it includes subterranean water generation. Overall, the system primarily functions due to the well-established closed cycle of evaporation, precipitation, and percolation. Simultaneously, the theoretical possibility of continuous condensation of water from air is left open, although it is not deemed necessary.

Fascinatingly, the most vehement opposition to the endogenous model arises from within the Aristotelian faction itself, with Abū al-Barakāt al-Baġdādī standing as the most overt critic. It is important to emphasise that his rebuttal is grounded in empirical evidence. As Griffel noted, Abū al-Barakāt embraced the Ġazalian critique of the *falsafa* movement, and similar to al-Bīrūnī, he dismissed Avicennian *taqlīd* (imitation) in favour of individual inquiry and validation. Although Abū al-Barakāt often accentuates a philosopher's independent reasoning, in this particular case, he demonstrates a predilection for empirical evidence over authority, even when such authority is embodied by distinguished figures like Aristotle and Ibn Sīnā. This preference enables him to surpass mere rational conjectures.

A general acceptance of what has been called 'ambiguity' likely led to the blurring of boundaries between the endogenous and exogenous models, as seen most clearly in al-Karaǧī. The endorsement of the exogenous model within the hydrological cycle seems to be a minority position, yet it is sufficiently prevalent among various authors, with a focal point in the Mesopotamian regions of the caliphate. This observation, however, could potentially be a consequence of a well-known selection bias in the surviving Abbasid sources, due to Baghdad's central role in cultural production at large. Undoubtedly, the exogenous model is more prominent in Arabic sources than in Western European thought during the same period or even later. Future research may examine the development of this seemingly harmonious coexistence between the exogenous and endogenous models within the *dār al-islām*. This approach might be particularly revealing for authors influenced by Abū al-Barakāt al-Baġdādī, who, in a sense, disrupted this tranquillity, but the later developments of Islamic understanding of the water cycle after the eleventh and twelfth centuries have yet to be explored. It is my hope that this book may serve as a useful starting point, highlighting how premodern reflections on the role of water in the ecosystem can provide valuable insights into how past societies and intellectuals viewed the environment and our place in it.

Afterword

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In today's contemporary world, a walk through the epistemology of the hydrological cycle can help us frame many current problems within a broader framework, reminding us to remain humble. Among all the scientific concepts taught in schools of all types and levels across the globe, the water cycle is one of the concepts that stays in our minds long after the end of compulsory education. The ease of remembering this theory can be attributed to its relative simplicity: water evaporates from lakes, seas, and oceans; the vapour forms clouds; from the clouds come rain and snow that feed glaciers and surface and underground waterways, which in turn return to the oceans, and so on.

However, the mechanism is only seemingly simple. In my training as a hydrologist and hydraulic scientist, I learned the hard way how much studying and communicating the complexity hidden behind hydrological science requires patience and dedication. Modern hydrology, in the western world, can be considered to have emerged at the end of the seventeenth century, thanks to two members of the Académie Royale des Sciences: Pierre Perrault (1611-80) and Edme Mariotte (1620-84).

The treatises of these two authors, *De l'origine des fontaines* (Perrault 1674) and *Traite du mouvement des eaux et des autres corps fluides* (Mariotte 1686), can be considered the first attempts to verify, through quantitative analyses, the actual ability of precipitation to supply rivers and sources. Before Mariotte's work, it was difficult to recognise the Sun as the exclusive engine of the hydrological cycle; before making accurate measurements on the amount of precipitation and the drained areas, the belief was that simple precipitation could not fully feed the flow of rivers. Thus, it was considered necessary to 'integrate' the water flows derived from precipitation with complementary theories borrowed from Aristotle's Metaphysics or subsequent theories such as those of Pliny.

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Aristotle's complementary theory to the hydrological cycle generated by the Sun is based on the theory of humours, and he believes that water is generated in underground cavities by condensation. Pliny's theory alludes to a correspondence between the microcosm (man) and macrocosm (planet), where water plays an analogous role to blood by vivifying the earthly body. These latter theories were particularly successful during the Renaissance period and were also adopted by Leonardo da Vinci.

In the meantime, however, if we analyse Islamic and pre-Islamic sources in parallel, we note that, despite having a good knowledge of European and Greco-Roman hydrological notions, they espouse a decidedly more modern conception of the hydrological cycle. The Avestan tradition that sees the sea as a purifying filter and the water cycle triggered by the Sun represents an absolutely contemporary conception of the hydrological cycle, albeit framed within an idea of cosmic order.

A few years ago, together with Massimiliano, I had the opportunity to work on the technical translation of a passage from Āthār al-Bāqiya by al-Bīrūnī. In it, I observed an absolutely contemporary conception of the water cycle, complete with an explanation of the different flow regimes of rivers. I had already read *L'estrazione delle acque nascoste. Trattato tecnico-scientifico di Karaji* by Giuseppina Ferriello, a critical translation of *Inbāṭ al-miyāh al-ḫāfiya* enriched by epistemological and historical analyses, as well as extensive notes and references. I was fascinated by the modernity of scientific ideas and the reasonableness and intelligence of some technical devices in the management of water resources. Speaking with several fellow hydrologists, I began to question why a modern vision of hydrology had developed significantly earlier in the Islamic world than in the Greco-Roman European world. The simple answer is that there is, on average, less water in those regions. However, this is clearly a hasty answer from a technician and does not truly address the question, as the two worlds communicated strongly with each other. Considerations on the aridity of the climates might be true, but they are only marginally relevant if not supported by some evidence. Even Ancient Greece faced serious challenges regarding aridity and water scarcity.

Today, when it comes to the hydrology of arid areas, the term 'wadi hydrology' is often used, as if to emphasise hydrological studies in arid areas as secondary to a hydrological science that was born in the heart of Europe at the dawn of the Age of Enlightenment. Hydrology, born and developed as an applied science in France, the United Kingdom, and the rest of Europe in particularly water-rich areas, introduces a series of interpretative and operational tools that, when applied in different contexts (e.g. those specific to wadi hydrology), may lead to incorrect conclusions.

Just to name a few interesting authors, I suggest looking for Nick Cullather, who has collected excellent work on the modernisation of the Helmand basin, demonstrating the results of an epistemological and technopositivist bias in the hydrological field. Sara B. Pritchard has carried out similar work on the interventions of French hydrologists in the arid colonies of France in North Africa, which were unsuccessful from the perspective of water resource management.

It is therefore clear how a deep study of the epistemological development of a discipline, especially when it is an applied discipline, is particularly interesting for understanding a series of errors and bad habits that can easily manifest themselves in present times through the discipline itself. The challenges posed by the future are related to the management of ecosystems and natural resources. Since most observers agree that future wars will be waged over water, it becomes interesting to dissect hydrology and natural sciences dealing with water at both historical and cultural levels.

When I came across the treaty of Ibn Qurra on seawater salinity quoted by al-Bīrūnī, with Massimiliano, I realised how much the relationship between sea salinity and the water cycle is a particularly current topic. Especially in the Middle East and North Africa, desalination is considered a solution to water scarcity; however, for every litre of fresh water, at least one litre of brine is obtained – a highly corrosive and sterilising waste that must be disposed of in some way. When disposing of the brine waste on land, one must ensure that it does not percolate and salinate the aquifer; discharging it into the sea risks sterilising entire stretches of sea due to excess salinity. Many countries, especially those in the Gulf region, currently face these technical problems.

The relationship between humans and sea salinity resurfaces strongly here, making the translation of an unpublished treatise like the one studied here particularly interesting, even for those with a more technoscientific background like myself.

Appendix A
English Text

In the name of God, the merciful, the compassionate, *The Discourse on the Reason Why Seawater Was Made Salty*, by Ṯabit b. Qurra. He said: it happened between us, may God honour us, to mention seawater, the reason why it was made salty, and what traces of knowledge there are in it, and two are the evidences that can be counted in it. Now, were it not for the fact that investigation, observation, and contemplation of knowledge and understanding of its causes is an important matter for the self, and a virtue among its virtues, and striving for knowledge of what has been hidden from us, there would be many things that we see, in which we would not see these signs of the subtle wisdom of God in clear matters that are not hidden from those who understand.

Regarding what the scholars have already deduced from this subject and sufficiently investigated, I mean on similar questions, despite everything that people have mentioned about it and despite its abundance and extent, we consider it to be of little value in terms of the wisdom of God in His creation, which cannot be enumerated or exhausted. The souls continue to constantly discover something about His affairs that they examine and gain knowledge of, and they continue to be amazed by what stands before them.

This is what prompted us to engage in the current discussion about why seawater is salty. However, what drives this inquiry is the desire to understand the wisdom of God, as evidenced by the abundance of its traces that one can find, no matter where one directs their gaze or strains the intellect. What man obtains from [the study of] the affairs of God is patience, and from his wisdom [he obtains] marvel, and this is a recognition of His glory and a praise to Him. The scope of this chapter is to introduce the knowledge of the reason why the seas were created. We will begin with this.

We say that it pertains to the wonderful wisdom of God to have created the four elements: Fire, Air, Water, and Earth. He made their strengths

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balanced, equal, and resistant to each other by a well-devised measure, so that none of them could be predominant and overcome one of the others, changing its nature over the course of time until it is altered and nullified. If this were to happen, it would cancel the existence of people, animals, plants, and other things on Earth. Because God made all existence from the four elements and in them lies its permanence and endurance.

Moreover, God placed these elements where they are suitable for them. He made it so that the lighter elements are always on top of the heavier, and the more subtle are on top of the thicker, surrounding the latter like a sphere. He made the nature of fire, which is the lightest among them, the highest, and the nature of earth, which is the heaviest, the lowest underneath. He made the nature of air lower than the nature of fire. It would be necessary, based on this logic, that water is on top of the earth and between the latter and the air which surrounds it, before any examination.

It is one of the wonders of God's wisdom and the proofs of his power that, since it was more useful and good, in the case of this element alone among the others, he took care that the element of water would diverge from the natural course that applied to the others. Thus, water does not stay on top of the earth as the air surrounds the water and earth, and as the nature of fire surrounds the air, it is sent away from much of earth's surface and collected together. He made it into places of collection, courses, and deep places on its surface, which we call seas and rivers. He made earth's surface higher than all of those.

He also placed some of it inside the earth. We said that the most useful and good was for this element, I mean the element of water, to become impure and seep away on the surface of the earth. Since the earth was established as the dwelling of the animals and the support of the plants that are its ornament and its beauty and are securely established on it, it was necessary that water become unclean with whatever it becomes unclean of. These things and their identity are not known.

What God imposed on water was preferable than what would have occurred to its state according to the aforementioned ordering, meaning that all water would go to the seas that he made the deepest place on earth. If water was to be removed from the earth, dryness and thirst would spread, and the animals and plants that are on it would be greatly ruined if all water was collected in the seas.

God made sufficient water descend on the dry land in the streams of its valleys, in various places, and in rivers to wet the earth, preserve the plants, and quench the thirst of the animals so that they may live. Also, he placed some water in its interior, which evidently fulfils the benefits that we mentioned: the wetting of the earth even in those places from whose surface water is removed. He does not make it burst or cast light on it as he would do if he was doing it openly on its surface and he does not cancel in this what the intention that he decreed and we mentioned earlier, that is the resistance of the elements to each other. This action is also strengthened by the rains that he makes fall on the earth's surface, wetting and humidifying it.

Since it was the most beneficial and preferable, in the case of water, that it went to the seas and some of it returned repeatedly to the land in sufficient quantity to quench the thirst of the animals, plants, and population of the earth, and to humidify the latter, this other water returning to the earth had to be drinkable, sweet, pleasant, and suitable to the natures of the animals and plants.

This does not apply in the case of the sea, since the residence of the people, animals, and plants is on dry land. He made this water sweet and it was not necessary for seawater to be sweet. Had it been like that, all the water on the surface of the earth would spread corruption and damage to the air, were it not for what our Lord, the almighty, did with His subtle wisdom by preventing it. This will be understood thoroughly and completely in what follows.

About the fact that the water that is on the surface of the earth would spread corruption and damages to the air and to what is on the earth, and destruction to the animals and plants, this can be learned clearly from experience. If we find sweet water and it stays still for a long period of time, it putrefies, rots, and changes its odours to the point that it corrupts the air that surrounds it unless we cover it. This causes many grave illnesses, pestilence and plague. We already saw pestilence occur in certain regions caused by stagnating waters that corrupted the air to the point that it caused rapidly spreading death.

About this, among the astonishing things that we saw in certain regions, is that the smelly water. Some of it flowed to a streamlet nearby and in every village that the streamlet crossed along its course there was a great pestilence, while a place that was distant enough from its shores remained unaffected, if it remained at a distance. The gravity or triviality of the pestilence was proportionate to how close or distant the village was to the river. There are many similar cases, famous and well-known among the people, proving what we just told.

The stagnating waters that stay still for a long time are in small quantities and remain still for a brief period. We can imagine that if the waters of the seas and the rivers were to experience the utmost and greatest corruption over a long period, it would not remain anything on the earth were it not that God, in His subtle wisdom, regulated this ruling, preventing that corruption from occurring.

About the water of the rivers that traverse the earth, it was necessary that it be sweet, suitable to drink, and to sustain the flourishing of life. He prevented it from rotting by making it flow constantly, and He made their waters regenerate in their sources from whence they come. He made it fresh because He nullified its stay and did not affect it with the corruption that affects concealed water that does not flow. Moreover, He made it so that, if it flows long enough on the earth, it pours into the seas. About the seas, as it does not flow, but instead water descends into it, the ruling explained before does not apply. This way, all the reasons that lead to corruption are already reunited in it.

The first reason is that a lot of the water in it is from the water that is required, as we said before, to resist the other elements. If this corrupts, its corruption would be given to whatever air or other element is near or far from it. The second reason is that since it is necessary, as we said, that there is plenty of water according to its proper measure, it is also necessary that this quantity is collected in one place so that it does not cover or inundate all the earth. It would not be possible for these places to have a great depth, [[so water extends over it and is illuminated by light over its extension.

If there is much depth in a place, its purpose is to be hidden where there is a lot of water, this also results in one of the reasons that lead to a quick corruption of what is in similar places.]][1]

1 The translation between double brackets is very tentative.

The third reason is that the water of the seas does not flow, and the length of its permanence in its places surpasses every imaginable measure of water stagnating or otherwise. These smaller cases do not make apparent the size of the damage and danger that would be in them were it not that God made this right by making this large mass salty which, as we will explain, is the taste that keeps corruption and the deterioration of the air and its change at bay and its removal, in favour of freshness when this is necessary, causes no harm. In fact, it is necessary that water is sweet only on dry land, as we explained earlier. This taste that was given to the sea, as we have mentioned, protects it from corruption and deterioration, also maintains the proper measure of the sea, which should not increase nor decrease, as we will explain in what follows. Nothing is more astonishing than the fact that He made this taste of seawater something that preserves both its state and measure as it is desirable, and with further ensuing benefits.

That the salty taste prevents corruption and putrefaction is something that all people know. For this reason, they obtain, if they fear that something may be corrupted, putrefied or change its odour, as in the case of meats and others, salinity by adding salt. Nothing more effective has been found.

This can be seen in the case of stagnating waters that may, perhaps, have developed pestilence or corruption. A lot of salt is thrown in it, so that its water becomes salty like seawater. [This practice] is done to cure the water and stop the corruption that it was spreading. This thing that people do as an expedient to protect things from corruption, was already decreed by God. It is most perfect what God did, in the case of the seas, as he placed in them the character of salinity, that stops fearsome corruption from spreading to the air and to what surrounds it, to the point that there is no remaining fraction of bodily health and wellbeing among what resides on seashores and elsewhere.

Moreover, if man considers all the tastes, he won't find one that is better for this purpose, for the properties that salty taste has together against corruption, and because it does not cause damage under another aspect: the part of odour that has in it separates from the odours of what it is mixed. There is no taste more suitable than that salty taste that is in the sea by that measure of salinity that is proper to it.

More precisely, of the philosophers who occupied themselves with the fundamentals of tastes in terms of enumerating them, some say there are eight tastes, some say there are seven tastes, and some others even less. If man detracts from them the taste of sweet water, since it does not prevent corruption but instead rots, as we said, when its stay still for a long time, stagnating and not flowing, he would find that the water of the sea must not gain that taste, that corruption was prevented in it, and change was distant from it. Furthermore, that water should not carry the odour of the taste with it, and should not change the taste of the air. Now, the fact is that the sour and spicy tastes give to the air odours emanating from them, damaging the animals and changing the air strongly. As for sweet and fatty, change and corruption gradually affect them.

Moreover, the sweet over the course of time becomes bitter or sour, as natural scientists explain. As for the fatty taste, over the course of time it gives off odours and begins to smell. These two tastes are not suitable to be the taste of seawater. So, three tastes remain: astringent and salty. The astringent can produce a lot of odour while dry, and, mixed with water, does not prevent corruption. It may have many harmful, unseemly and disgusting odours, like the spirits that are said to be smelled at the sources of vitriol and yellow vitriol and other astringent things because there are strong humidity and harmful odours in those places.

It remains to be discussed if it would be more beneficial for seawater to be salty, bitter, or a taste assembled from them all. However, while bitterness protects from corruption, it has a downside: many animals avoid it. On the other hand, saltiness is pleasing and closer to the nature of most animals, which consume a lot of it. If seawater had been made bitter, none of the wonderful animals that live there would have been generated, and the creation would have been void and empty of the divine wisdom that is revealed in the creation of those animals and the benefits are derived who employ them.

About what God made in the small sea that is in the country of Palestine, that which they call Dead Sea: it proves what we have said. The salty taste is mixed with bitterness, and God made the lake's salinity so strong that no animal or plant can survive in it, according to Galen. He said: "Animals shy away from it, and all fish in the rivers that flow into it flee when it comes close to them. If someone tries to introduce fish into the lake, they will not multiply and instead will die quickly". This is what would happen to seawater if there was a trace of bitterness in it, or if its salinity exceeds its proper bounds. This proves that the most beneficial taste is the salty taste given to it in the proper measure, not more.

We will now discuss the possibility that seawater was salty in a lesser measure. It is clear that if the salinity were to diminish, its odours would deteriorate. Instead, its saltiness has already been set at the least measure possible, and the proof is that this measure of salinity does not fully achieve the goal of completely eliminating the odours of the sea and instead something of it remains, but in a measure that is not harmful. This proves that the measure of salinity in seawater is the desired one. If it increases, it harms marine animals, injuring and killing them. If it decreases, it damages the animals on dry land that are reached by its odours. It is clear to us that the most beneficial taste in seawater is that salty taste, and in the measure that is given to it, not less and not more.

Furthermore, if [seawater's] salinity were to be reduced, seawater would resemble the water in swamps, generating many worms, leeches, and other organisms found in stagnant water. It would become polluted, and bugs and mosquitoes would proliferate around it. This would be extremely harmful. This proves what we have said, that it is not best for seawater to be only salty, but that it is best for it to be salty by the measure that is given to it, and that the salinity should not be less or more than this. What we have mentioned proves that the best and most suitable for seawater is not only to be salty, but also to have the proper degree of salinity, neither less nor more. If it deviates from this, it causes harm to animals on land or in the sea.

We have already stated that one of the benefits of this taste is that it maintains seawater at a stable level, preventing it from increasing over time and overflowing and submerging its surroundings. This would be in contrast with the purpose for which it was created. Seawater does not decrease or increase, it maintains its quantity as it was made.

The evidence that the salinity of seawater is one of the factors that preserves its measure, as it was given to it, is that all the rivers flow into it constantly adding to its measure, while the heat and evaporation constantly diminishes its measure. Because its water is salty, it becomes denser, which works against its further evaporation and dissolution due to its increased density. In fact, dense [liquids] evaporate and dissolve more difficultly than thin [liquids.]

As long as the sea receives the benefit of the fresh water that mixes into it from the rivers, it increases its quantity but this swiftly evaporates away due to its thinness and does not remain there for long. Eventually, the increased quantity of water is nullified, and the dense salty water returns to its original state, dissolving and evaporating with difficulty. Seawater remains in this condition, without having undergone significant changes, [although] it decreases until it is joined by another addition of fresh water.

If someone wants to verify this statement, they can take a certain measure of seawater or salty water that resembles it, mix an equal amount of fresh water or less and leave it in the Sun or elsewhere for a few days, and check on it every day. They will find that the weight of the fresh water that was added dissipates quickly. Afterwards, it stabilises and does not decrease further, except for a small diminution over a long period of time.

The evidence that seawater is dense is based on the weight of the objects that float on it and that do not float on fresh water, such as eggs or similar objects. Heavy ships float on seawater and do not sink, and are buoyed by it. Objects that cannot be buoyed by seawater, sink in fresh water. As we explained, ships and boats are safer in seawater than in fresh water.

There is another remarkable aspect of God's wisdom in making the taste of seawater salty among all tastes. This aspect is known to those who have received our account of the elements, because it relates to some of what we discussed at the beginning of our discourse. I do not see any harm in briefly mentioning it again to keep our discourse systematic and maintain its order.

We have already explained that it is necessary that the strength of the four elements is balanced in resisting each other. Given that, the element of water has a measure that is sufficient for resisting the remaining elements, it would not be acceptable for it to be more or less than that and exist together with the remaining elements.

It was also necessary to that [water] traverses much of the surface of the earth, gracing it and come to be renewed in its reservoirs so that animals and plants have a place [to live]. As things stand, since plants and animals on dryland need water to live, rivers come from the water of the dryland, and it was necessary that their water was sweet. This was not necessary in the case of the sea, because the animals and plants which require sweet water are strictly located on dryland. As we explained, the seas, the rivers, and all which is wet would spread corruption, decay, and deterioration to the air and to all that is on the earth, was it not for what was done on them to make them suitable.

The water or rivers was made suitable by making it flow. In the case of the waters of the seas, it was not desirable that it flowed, and so it was more prone to corruption and deterioration because, as we said, several reasons for it were put together. This fact rendered necessary to preserve [seawater] from corruption. Now, only an overpowering taste would be able to preserve seawater, overwhelming any other by being stronger, not lacking in strength, and overwhelming and controlling the corrupting thing. This [taste] is what we have been talking about so far, in the terms required.

If the mass of water was slimy, it would have been necessary to divert it from the land, and dryness would have spread on it, while the sea would have increased its water, exceeding its proper measure, as if earth and water were specific to two distinct places. Water would have covered the earth for days until all the water disappeared, with the rivers thinning them out, and the seas would have grown without a clear limit. God prevented these two things from happening through His knowledge by making the water of the sea evaporate and rise into the air through the heat of the air and Sun. This creates clouds, which return to the land bringing rain and snow. All this flows like in a cycle.

Here are the two things that are necessary in this chapter. They are [that if] wetness is removed from the land, as it thins out, and dryness triumphs over it, the rivers are emptied, and their water that benefits the land is no more. [The other is that] the water of the sea does not increase more than it is desirable, and it is necessary that the taste of seawater is a strong, prevailing one to prevent its corruption. It is also necessary, as we said, that a vapour rises from it, generating moisture on the land, moistening and humidifying it, thus preventing dryness and lack of water, and that this ascending vapour has already separated from that taste and got rid of it, becoming sweet and pleasant, so that it does not have a strong taste or smelly odours, as this is necessary for the water that comes from the clouds, the rain and the snow.

These two characteristics would not be present in seawater devoid any taste, except for the salinity that was made in it. This is because all the wet substances that have a foul taste, if they evaporate, will inevitably carry some of their taste and odours with them. This would result in a damaging taste and odour in the water and it would not be suitable for drinking. The only exception to this are wet substances that have a salty taste. The reason for this is that the salty component is removable from them, it is earthy, dense, and it seeks to move downwards, so that it does not evaporate with them or from them.

If one wants to test this, he can observe wet substances that evaporate due to fire. If he examines this, he will find that in what has evaporated there are tastes different from the taste of sweet water, except in the case of water that has this salinity. If the latter is evaporated, it becomes sweet water, like drinking water. This does not happen with any other taste, because sour substances, such as vinegar, and astringent substances, such as rose water, and fermented substances, such as wine and drinks, maintain their taste and are damaging if their tastes and odours are evaporated or exceed in intensity and strength, as those tastes, which are not salty, remain in them after the evaporation. They may also gain another taste and other odours, while the wet substances like seawater, if they are made to evaporate, they gain a taste of sweet water. This is something that can be proven by experiment and confirmed by measurement.

Moreover, it is not only through evaporation that the salty taste leaves seawater. Instead, it can also leave it through sand [filtering]. Thus, if the coasts are sandy, the water that is collected in it comes out as sweet water. Nothing is more wonderful than the fact that the taste that God chose for seawater has in itself the force to overwhelmingly prevent corruption and deterioration, for as long as it is needed, and where salty taste is not needed and there is a need to purify sweet water from it, it is separated as the water evaporates without odours or taste.

From this water come rain and snow on dryland, pure and without taste. Animals and plants have everything they need in terms of drinking water and moist soil, and perhaps it could be said that God could have made the taste of seawater another strong taste, other than salty, of those that become attached to the wet substances and remain in them during the evaporation, [but] altering them or changing them so that no taste or odour remains in that water. There two fundamental answers to this.

One answer is that God does not do anything without sense, and creating a taste that does not have the two properties that were mentioned would be a deed without sense, since there is a taste that has those two properties is the salty taste, without going against natural order. The other answer is that if God had made it for water like we described, it would have been evidence of His power only, and not of His wisdom because he would have showcased His power, had he brought that to completion without wisdom in the arrangement. The fact that things are such that [seawater] is salty is one of the signs of both His wisdom and power.

Here ends the totality of what was presented to me and I understood of the subtle wisdom of God in making seawater salty for this purpose and for this compelling reasons that make it necessary. If there are further benefits, they are not the first and main principles. Rather, they descend from what we said. [Here] the book by Ṯābit on seawater ends.

Appendix B
Arabic Text

The following text is based on a single manuscript housed in the Topkapı Saray library collection. This manuscript consists of 13 folios and is part of a broader compilation primarily focused on astronomical subjects. The script, executed in the *naḫšī* style, is characterised by its readability and the skillful penmanship of the scribe, with only a few minor misspellings and punctuation errors that do not hinder the overall text's clarity.

[f. 195b]

بسم الله الرحمن الرحيم
قول في السبب الذي جعلت له مياه البحر مالحة لثابت بن قرة
قال قد كان جرى بيننا اعزك الله ذكر ماء البحر والسبب الذى له ومن اجله جعل مالحًا وما فى ذلك من اثر الحكمة فالثنى اثبات ما حصى فى منه ولولا ان التفتيش والنظر والخوض على معرفة الاشياء وفهم اسبابها أمر عزيزى للنفس وفضيلة من فضائلها وينازع بها الى علم ما استتر عنها لقد كان فى كثرة ما تراه ونشاهذه من اثار حكمة الله اللطيفة فى الامور البينة التي لاتخفى عن ذى فهم وفيما قد دونه العلماء من ذلك و هو ما كفى التسبر منه واعنى عن مثل هذا المطلب وان كان ما قد ذكره الناس جميعا من ذلك مع كثرته وسعته نروا حقيرا من حيث ما عليه حكمة الله فى خلقه لا يحصى ولا يتناهى صارت الانفس لا تزال ابدا يستبين شيئا من اموره تحت الفحص عنها ومعرفتها ويكثر التعجب مما يقف عليه منها.
فهذا ما كان دعا الى الكلام الذى جرى في ذكر السبب الذى له جعل ماء البحر مالحا الا ان ذلك ما يضطرّ اليه الحاجه فى معرفة حكمة الله مع كثرة ما يجده الانسان من اثارها كيف ما صرف نظره وقلت فكره وان كان اخذ ما يزداد الانسان بامور الله صبرة و من حكمته تعجبًا وكان تمجيدا من تمجيده وثناء عليه ولما كان البحث عن هذا الباب يحتاج الى ان يتقدمه معرفة السبب الذى من اجله خلقت البحار بدانا اولا بذلك//
قلنا ان من حكمة الله تعالى العجيبة ان خلق الطبائع الاربع فهى النار والهواء والماء والارض فجعل قوامها متكافية متعادلة يقوم بعضها بعضا موزن مستقصى ليلا يكون احدها

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[f. 196a]

الغالب فيقهرباقها ويغيّره على طول الايام حتى يقلبه الى طبيعته ويبطل الاخر وهذا امر لو وقع لبطل قوام الناس والحيوان والنبات وغير ذلك مما على الارض لان الله جعل قوام جميع ذلك من اربع الطبائع فيها ثباته وبقاؤه ثم وضع هذه الطبائع فى المواضع التى تليق بها وتصلح لها فجعل الخفيف بينها ابدا فوق الثقيل واللطيف فوق الغليظ محيطا به كالكرة فجعل طبيعة النار التى هى اخفّها فى اعلى العلوّ وطبيعة الارض التى هى اثقلها فى اخفض السفل وجعل طبيعة الهواء اسفل من طبيعة النار وكان الواجب بحسب مراتب الطبائع على ظاهر هذا القياس وقبل التفتيش ان يكون الماء فوق الارض فيما بينها وبين الهواء محيطا بها فكان من عجائب حكمة الله ودلائل قدرته انه لما كان الاصلح والاجود في هذه الطبيعة الواحدة من بينها اعنى طبيعة الماء ان يخرج الامر فيها عن المجرى الطبيعىّ الذى فى غيرها فعل ذلك بها فلم يصر الماء فوق الارض كما صير الهواء محيطا بالماء وبالارض من فوقها وكما جعل طبيعة النار محيطة بالهواء من فوقه لصرفه عن كثير من وجهها وجمعه وجعله في حفائر ومجارى ومواضع منها عميقة عن وجهه وهى التى تسمى البحار والانهار وجعل وجهها ارفع من جميع ذلك وجعل بعض ايضا في باطنها وانما قلنا ان الاصلح والاجود كان فى هذا الطبيعة اعنى طبيعة الماء ان ينجس فينضب عن وجه الارض لان الارض لما كانت هى قدرت مسكنًا للحيوان ومعرشا للنبات الذين هما زينتها وجمالها عليها مستقر بها دعت الحاجة الى ان ينجس الماء عما انجس عنه منها فلا يعرف هذه الاشياء ونفسها فكان ما اجرى الله عليه الامر من ذلك احسن ما يخطر بباله من التقديرات وهو ان جميع المياه

[f. 196b]

الى البحار التي جعل مواضعها اعمق مواضع في الارض والدليل على عمقها ان مياه الانهار التي تخترق الارض كلها انما يقبض و ينصب الى البحار ولما كان ما يخسر عليه الماء من الارض بسبب ذلك يعرض جفاف وعطش وما عليها من الحيوان والنبات يعرض فساد لو جمع جميع الماء الى البحار نزل الله فى البر ما يكفيه من الماء فى مجارى جرفها فى مواضع مختلفة منه وفى الانهار ويترطب الارض بذلك و يثبت النبات ويشرب الحيوان منها فيعيش وجعل ايضا فى باطها من الماء شيئا يظهر عند الاختفار لهذه المنافع التى ذكرنا لترطب ايضا الارض فى المواضع التى انحسر فيها الماء عن وجهها فلا تفحل وتنور لها ذلك عما كان يفعله لو كان يفعله ظاهرا على وجهها فلا يبطل عند ذلك ما قدره من المعنى الذى ذكرنا انفا وهو مقاومة الطبائع بعضها لبعض واعان على هذا الفعل ايضا وقواه بالامطار التى جعل يقع على وجهها فتبلها وترطبها فلما كان الصلج والافضل فى امر المياه ان يكون على ما وصفنا من جميع جملتها الى البحار ويحتلف شيء منها في البر بمقدار الكفاية ليشرب الحيوان والنبات وعمارات الارض وترطيبها كان الامر يحوج الى ان يكون هذا الماء المختلف في الارض ماء شروبا عذبا لذيذا موافقا الطبائع الحيوان والنبات ولم يكن الامر محوجا الى ذلك كثيرا جاحة في البحار اذ كان مسكن الناس والحيوان ومواضع النبات البر فحعل هذه المياه عذبة ولم يكن الحال يجوح من هذا الوجه الى ان يكون مياه البحار عذبة//

فلما كان ذلك كذلك كانت المياه كلها التى على وجه الارض تعرض فساد وافساد للهواء لولا ما جعله ربنا عز وجلّ فيها تلطيف حكمته مما يزيل ذلك ونحوط ونوفى منه

[f. 197a]

على ما سنبين من بعد واما ان المياه التى على وجه الارض كانت يعرض فساد وافساد للهواء ولما على الارض واهلاك للحيوان والنبات فيعلم علما ظاهرا بينا من نفس التجربة وذلك انا نجد المياه العذبة الا اجنّه اذا طال لبثها عفنت وفسدت وتغيرت روائجها حتى انها تفسد الهواء الذى جولها / ومن اعجب ما رأينه من ذلك فى بعض المواضع ان هذه المياه كانت تنتن ويجرى شيء منها الى نهير كان هناك فكافى القرى كلها التى تمر بها ذلك النهر وباعظم على طبل النهر وسلم مكان على بعد منه الى الناحيتين ولو على بعد يسير و كانت شدة الامر فى الوبأ وخفته على حسب قرب تلك القرى منه وبعدها ولذلك نظائر كثيرة مشهورة معروفة عند الناس بدل على ما نحدثه الاخر والمستنقعات التى يطول لبثها من الفساد وهلاك الحيوان هذا على صغر مقدارها وقلة لبثها فما كان الذى يقع في الظن ان مياه البحار والانهار كانت تحدث من الفساد على كثرتها و طول لبثها فكان لا يبقى على الارض شيء مما عليها الافسد لولا ان الله بلطيف حكمته دبر في ذلك تدبيرات منع بها من وقع الفساد اما فى الانهار التى تخترق الارض فانها كانت تحتاج الى ان تكون عذبة يصلح للشرب والعمارة فانه ازال الفساد عنها بان جعلها جارية جوبة دائمة وجعل مياهها تتجدد تولدها في مخارجها التى منها تأتى فيكون طرية لم يبطل للبثها فلا يعرض لها ما يعرض المياه الاجنة

[f. 197b]

التى لا تجرى من الفساد وجعل اخر امرها اذا طال جريتها في الارض ان يصب في البحار و اما البحار فانها لما لم تكن جارية بل مغيصها لما تجرى من المياه لم يصلح فيها التدبير و كانت مع ذلك قد اجتمعت فيها الاشباب١ كلها الداعية الى الفساد احدها كثرة ما فيها من الماء الذى اجتيح اليه كما قلنا انفا لمقاومة نظائره من الطبائع وانه لو فسد لاستوفى ما كان يكون منه من الفساد على جميع ما يلى البحار و ما يبعد منها من الهواء و غيره والسبب الثانى انه لما كان الواجب كما قلنا ان يكون الماء كثيرا بالمقدار الذى هو عليه واحتيح مع كثرته الى جمعه الى موضع ماء حتى لا يبسط ولا يفيض على جميع الارض لم يكن يمكن ان يكون لتلك المواضع عمق كثير يسع به ذلك الماء و ينور له على الانبساط اذا كثر العمق فى موضع غرض فيه ان يكون ذفنا فى الثر الامور صار ذلك ابضا سبب اخر من الاسباب الداعية الى سرعة فساد ما يكون فى مثل هذه المواضع والسبب الثالث ان مياه البحار لا تجرى وطول مقامها في مواضعها بتجاوز كل مقدار بتوهم لمستنقع او غيره وفى اقل من هذه الاشياء ما دل على عظم الضرر والخطر الذى كان تكون فيها لولا ان الله وفى من ذلك بان جعل هذا العظم المالح الذى سببين انه ابعد الطعوم من الفساد و من افساد الهواء وتغيره ولم يكن فى ازالته اياه عن العذوبة ضرر اذ كانت الجاحة انما تضطر الى عذوبة المياه فى البر فقط كما بينا فيما تقدم وقد جمع فى هذا طعم الذى جعله لماء البحر معما ذكرنا من حفظه له من الفساد و الافساد له سبب من الاسباب التى تحفظ على المقدار الذى هو عليه من العظم هتى لا يريد ولا ينقص زيادة او نفصانا مثفاوتا و سنبين ذلك فى ما بعد

[f. 198a]

واى شىء يكون اعجب من انه جعل هذا الطعم الذى هو لمياه البحر سببا بحفظ جالها ومقدارها جميعا على ما ينبغى مما هو عليه مع منافع اخر تابعة لتلك فاما في الطعم المالح من المنع من الفساد والعفونة فشىء قد عرفه جميع الناس وبهذا السبب صاروا اذا خافوا على بعض الاشياء الفساد والعفونة وتغير الرائحة مثلا للحمان وغيرها ملوحة بالملح فلم يجدوا شيئا احفظ له من ذلك حتى ارى انه لو تسبّا٢ فى المستنقعات التى ربما حدث بينها الوبا والفساد ان يطرج فيها الملح الكثير حتى يصير ماؤها مالحا مثل ما البحر لاصلح ذلك منها وازال الفساد الذى يعرض بينها والشى الذى يفعله الناس من ذلك على طريق الحيلة للحفظ من الفساد قد احكمه الله واتقنه فى امر البحار ما جعل الله فيها بالطبع من الملوحة التى تزيل ما كان يخاف من افسادها للهواء ولما جولها حتى انه ليس بين ما يسكن في سواحل البحر وبين غيرهم كسر فرق فى صحة الابدان وسلاماتها وايضا فان الانسان اذا اخطر بباله جميع الطعوم ولا يجد فيها طعما واحدا اصلح لما قصد له من ذلك لما يجتمع فيه من انه يمنع من الفساد وانه لطعم لا يعود بضرب من وجه اخر وانه مقطع الرائحة فى نفسه قاطع لرائحة غيره مما يخالطه ولا اوفق من هذا الطعنم المالح الذى هو للبحر وهذا المقدار من الملوحة الذى هو عليه ذلك ان اصول جميع الطعوم على ما احصاها من عنى من ذلك من الفلاسفة ثمنية طعوم بعضهم وسبعة على قول اخرين واقل من ذلك على قول اخرين فاد انزل الانسان منها الطعم الذى هو للماء العذب يسبب ما فى ذلك

[f. 198b]

من انه لا يمنع من الفساد بل يفسد كما قال اذا طال لبثه مستنقعا غير جارى على ما كان تحت ان يكون ماء البحر لم يجتمع له فى شىء من الطعوم ان يكون مانعا من الفساد بعيدا من التغير وان يكون هو مع ذلك لا يؤدى برائحته و لا يغير الهواء غير طعم ماء البحر وذلك ان الطعوم الحامضة والطعوم الحريفة الحارة يعطى الهواء روائحا يفوح منها فيؤذى الحيوان و يغير الهواء تغيرا قويا واما الحلو والدسم فيندرج اليهما التغير والفساد اما الحلو فانه على طول المدة يصير مرا او جامضا على ما يبين اصحاب علم الطبيعة واما الدسم واما الدسم٣ فانه على طول المدة تريح وتتشّم فلم يكن يصلح هذان ايضا ان يكونا طعما لماء البحر فقد يقيت ثلثة طعوم وهى القابض والمالح والقابض منها ما دام يابسا فقد يمكن الاياتر منه كثير رائحة فاما اذا اختلط بالماء فانه لا يمنع من الفساد بل يفسد ويحدث له رائحة مؤذية ردية كريهة مثلا الروائح التى يقال لها يشم في معادن الزاج والقلقطار وما سببها من الاشياء القابضة لانها في تلك المواضع رطبة و روائحها شديدة الاذى فبقى اذا ان يكون اصلح ما يجعل اليه طعم ماء البحر مالحا او مرا او طعما مركبا منها جميعا منها جميعا٤ الا ان المر وان كان يحفظ من الفساد فانه يعود بضرب اخر وهو انه عدد الحيوان قابل الكثر منه واما الشىء المالح فمقبول قريب من الطبيعة عامة الحيوان يأكله كثيرا فلو جعل طعم البحر مرا لما تولد منه شىء من الحيوان العجيب الذى نجده فيه وكان يكون خلوا اصفرا من جميع الحكمة التى يظهر فى خلق ذلك الحيوان ومن المنافع التى ينالها منه من استعمله وفيما قد جعل الله عليه من البحيرة التى فى بلاد الفلسطين وهى التى يسمى البحر المنتنة دليل على ذلك لانه لما خلط بمائها مع الطعم المالح طعما مرا وجعل ملوحته ملوحة قوية صار لا يتولد فيها شىء من الحيوان فيما

[f. 199a]

ذكر جالينوس ولا يثبت حولها النبات وقد قال انه قد بلغ من نفور الحيوان منها ان جميع السمك الذى فى الانهار التى تصب اليها اذا قرب ودنا منها هرب فلم يدخلها وان الانسان اذا رام ان يحول اليها شيئا من السمك وهى حى لم يعشر فيها بل يموت بسرعة ولذلك كان يعرض

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1 اشرار

2 Corrupted word

3 Repeated in the manuscript.

4 Repeated in the manuscript.

لماء البحر لو كان مع ملوحة من اثرالمرارة اذ افرطت ملوحته وزادت على ما هى عليه فدل ذلك على ان اصلح الطعوم هذا الطعم المالح الذى هو عليه وبهذا المقدار الذى هو عليه لا اكثر من ذلك فاما انه لم يكن الاصلح ان يكون ملوحته وطعمه اقل من هذا المقدار فتبين من انه لو نقصر طعم ملوحته عما هو عليه لكان يكون ردى الرائحة بل قد جعلت ملوحته على اقل المقادير التى تحتمل ان يكون عليها والدليل على ذلك ان هذا المقدار من الملوحة لم يبلغ بعد مبلغا يقطع رائحة البحر وهو منه قطعا تاما بل قد بقى منها بقية يسيره لا يضر ضررا اذ اقدر فدل ذلك على ان المقدار الملوحة فيه هو المقدار القصد الذى ان زاد على ذلك عاد يضرب على الحيوان البحرى فافسده وقتله وان يقصر من ذلك عاد بضرب من الحيوان البرى الذى يناله رائحته وبين لنا ان اصلح الطعوم فى ماء البحر هو هذا الطعم المالح وهذا المقدار الذى هو عليه منه لا اقل و لا اكثر وايضا فان ملوحته لو نقصر مقدارها عما هو عليه لشبّه ماء البحر بالمياه التى فى المستنقعات وتولد فيها شيء كثير من الدود والعلق وغيره مما يتولد فى المياه الردية حتى يستوفى عليه ويفسد وتولد حوله من البق والبعوض و غيره مما يكثر اذاة و ضرره امرعظيم جدًّا فقد دل ما ذكرنا على انه ليس انما الاجود والاصلح ان يكون ماء البحر مالحا فقط بل الاجود ان يكون على هذا المقدار الذى هو عليه من الملوحة لا اقل منه ولا اكثر وانه لو زال

[f. 199b]

عن ذلك لعاد بضرب على الحيوان البرى او البحرى وقد كما قلنا٥ فيما يقدم ان من منافع هذا الطعم انه يحفظ ايضا مقدار ماء البحر على ما هو عليه من الكثرة فلا يزداد على طول لايام ويفيض فيغرق ما حوله ويبطل السبب الذي له صرف عن وجه الارض ولاينقص ويفيض فيقص عما له جعل مقداره هذا المقدار و الدليل على ان الملوحة التى فيه هى احد ما يحفظ مقداره على ما هو عليه ان الانهار كلها يفيض اليها ويزيد فى مقداره دائما والحرارة وما ينحل ويتصاعد منه ينقصان منه دائما فلما كان ماؤه مالحا صار غليطا يعسر تحلّله وتصاعده لغلظه لان الغليظ من كل شيء اعسر تصاعدا وانجلالا من اللطيف فما دام فى البحر فضله من الماء العذب الذى يخالطه من الانهار زائده على ما كان عليه يحلل ذلك منه للطفاته بسرعة فلم يطل لبثه على الزيادة حتى اذا فنى ذلك وحصل على ما بدا المالح الغليط غير تحلله وتصاعده ووقف على حاله فلك يسرع اليه ذلك فينقص الى ان يلحقه زيادة اخرى من الماء العذب وان احب احد ان يمتحن ذلك قدرعليه بان ياخذ مقدارا من ماء البحر او ماء الملح الذى يشبهه فيربه ويخلط به مقدارا مثله او اقل من الماء العذب ويترك ذلك فى الشمس او غيرها اياما وينفذه في كل يوم فانه ستجد الوزن الذى زيد فيه من الماء العذب نفيأ بسرعته ثم يقف ولا ينقص بعد ذلك الا نقصا ناخفيا فى الزمان الطويل واما ان ماء البحر غليط القوام قام بدل عليه نقل وزنة يطفوا فوقه من الاجسام ما لا يطفو فوق الماء العذب مثل البيض وما اشنهه فانه يطفوا فوقه

[f. 200a]

ولا يغرق ويجمل من السُقُز البقيل ما لا يجمله ماء البحر اذا صارت الى الماء العذب غرقت وقد بينن ما وصفنا ان سلامة البسُقن والمراكب فى ماء المالح اكثر من سلامتها فى الماء العذب وايضا فانها هنى معنى اخر عجيبا من حكمة الله فى تصير طعم ماء البحر الطعم المالح من بين جميع الطعوم وهو معنى يعلمه من كان له خبرنا من الطبيعة ولان الشيء الذى يتبين به ذلك يتصل ببعض ما قدمناه في اوائل كلامنا فلم ار باسا باعاحة ذكرة رؤوس ما يحتاج اليه منه هاهنا ليكون القول فيه منتظما لا ينقطع نسقه قد بينا انه كان يحتاج الى ان يكون قوى الاربع الطبائع متعادلة يقاوم □□بعضها بعضا وان ذلك اذ كان كذلك فان يجمله طبيعة الماء مقدارا هو اللذى يكتفى□□٦ به مقاومة سائر الطبائع لا يجوز ان يكون اقل منه ولا اكثر وانه من بين سائر الطبائع فقد احتيج معه الى ان يعبر عن كثير من وحه الارض ويتمنن فيصير على جدة في حفائر منها ليكون للحيوان والنبات موضع له وان ذلك لما كان كذلك وكان ما فى البر من الحيوان والنبات محتاجا الى الماء ليحيا به نزل من الماء فى البر النهار فاضطرت الحاجة الى ان يكون عذبة ولم يضطر الحاجة الى ذلك فى البحار لان الحيوان والنبات اللذين هما المحتاجان الى عذوبة الماء انها مستقرمها البر وبينا ان البحار والانهار وجميع الرطوبات كانت يعرض فساد وتعفّن وافساد للهواء ولجميع ما على الارض لولا ما جعلت عليه واصلحت به اما مياه الانهار فانها اصلحت فانها جعلت □□جارية واما□□٧ مياه البحار فانها لم تكن ينبغى ان تكون جارية وكانت اشد استعدادًا

[f. 200b]

للفساد والافساد لانه قد اجتمع فيها كما قلنا اسباب كثيرة يوجب ذلك احتيج فيها اليه تسلم من ذلك ولم تكن تسلمها من ذلك الا طعم قوى قاهر يغلب و يستولى على غيره و يشتد به ولا يضعف عنه فيغلب و يستولى الشيء المقسد فهو ما ساق اليه الكلام المتقدم فمما يحتاج اليه هاهنا ولو كان ذلك كذلك وكان حمهور الماء وحلة قد احتيج الى تنحية عن البر وجمعه في البحار كان البر يعرض استيلاء اليبس عليه وعليه فيه وكان البحر يعرض كثرة الرطوبة فيه وتزيدها اذ كانا متميزين فى موضعين مختلفين وكان الواجب ان يستولى على الارض على طول الايام حتى ينسف ما عليها من المياه والانهار فنحف كلها وان يكثر مياه البحار على حده بلا معنى فمنع الله من وقوع هذين الامرين بطيف حكمة بان جعل مياه البحار تتحلل و تتصاعد فى الهواء انما نالها من حرارة الهواء والشمس ويحدث الغيوم التى ترجع الى البر فاتى بالمطار وبالثلوج ويجرى ذلك على شبيه تدور فيكون فى ذلك الامران اللذان يحتاج اليهما فى هذه الباب وهما ان ابعد من البر الرطوبة ونحف فيغلب عليه

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5 كتاقلتا in the manuscript.

6 The text between double brackets appears twice in the manuscript

7 Repeated in the manuscript.

اليبس ويبطل الانهار والمياه التى ينتفع بها فيه فلا يكثر مياه البحار باكثر ما ينبغى فلما احتيج فى مياه البحار الى ان يكون طعمها طعما قويا قاهرا لمنع[8] ذلك من الفساد واحتيج مع ذلك كما قلنا الى ان يتصاعد منها بخار يتولد منه في البر رطوبة تبله وترطبه ويمنع من الجفاف ومن عدم المياه وان تكون تلك الرطوبة التى تتصاعد قد تميّرت وتخلصت من ذلك الطعم فصارت عذبة مقبولة ليس لها طعم قوى ولا رائحته تننة اذا كان هذا هو الذى يحتاج اليه فى المياه التى تتولد من الغبوم والمطر والثلج لم يكن ان يوجد

[f. 201a]

هذان الامران متجمعين فى ماء البحر بشىء من الطعوم الا بان يجعل طعمه على ما هو عليه من الملوحة وذلك أن كل الرطوبات التى لها طعوم تننة لا بد لها اذا صوعدت من ان يتعلق بما يتصاعد منها شىء من طعومها ومن روائحها وان يحدث ويتولد لها طعم او رائحة أخرى ردّية لا يصلح في الماء الذى يشرب ما خلا الرطوبات التى طعمها مالح وسبب ذلك ان الشىء الذى فيه الطعم المالح هو الحر منها الارضى الغليظ الذى يبغى اسفل فلا يتصاعد معها يتصاعد منها فان اراد احد ان يعلم صحة ذلك بالمحنة فليعلمه من الرطوبات التى تتصاعد بالنار فانه اذا امتحن ذلك وجد فيها بعد الصعيد من طعومها غير طعم الماء العذب ما خلا الرطوبات التى لها هذه الملوحة فانها اذا صوعدت صارت عذبه كطعم الماء الذى يشرب واما غير المالح فلا يكون كذلك لان الاشياء الجامضة مثل الخل و القابضة مثل الورد والخمرية مثل النبيذ والشراب تحفظ وتؤذى اذا صوعدت طعومها وروائحها او يزداد شدة وقوة وتلك الطعوم الباقية غير المالحة يبقى فيها بعد التصعيد من طعومها وروائحها او تكسب طعما اخر ورائحة اخرى فاما الرطوبات المالحة التى احدها ماء البحر فانها اذا صوعدت صارت عذبة وهذا الشىء تصححه المحنة ويشهد عليه القياس وليس انما يذهب عن هذه المياه الملوحة بالتصعيد فقط بل قد يذهب عنها ذلك ايضا اذا صعدت بالرمل ولذلك اذا صارت السواحل الرملية اذا احتفرت فيها حفائريرسخ اليها الماء خرج منها عذب فاي شىء اعجب من ان الطعم الذى اختاره الله لماء البحر قد جمع قوة الطعم التي هى سبب قاهر يمنعه من الفساد الافساد وانه مع ذلك ما دام يحتاج اليه فهو على ما وصفنا فاذا استغنى عنه واحتيج الى تمية

[f. 201b]

ومخلص الماء العذب منه عذب تصاعده يخلّف هو وصعد الماء عذبا لا رائحة له ولا طعم فكانت منه الامطار والثلوج في البر عذبة ليس لها طعم فتممت ما يحتاج اليه الحيوان والنبات من الشراب وترطب البر ولعلّ قائلا ان يقول ان الله قد كان يقدر يجعل طعم ماء البحر طعما قويا من الطعوم الاخر التى ليست مالحة وان كانت مما يتعلق بالرطوبة ويبقى فيها التصعيد لم تحتيلها ويغيرها عند التصعيد حتى لا يبقي منها في ذلك الماء طعم ولا رائحة فى ذلك جوابان سببيان[9] احدهما ان الله لا يفعل شىء لغير معنى وهذا الفعل شىء لا معنى له اذ كان يوجد هاهنا طعم يجتمع فى الامران جميعا اللذان ذكرنا وهو الطعم المالح من غير ان يخرج الامر عن المجرى الطبيعى والجواب الاخر ان الله لو فعل ذلك على ما وصفنا بالماء كانت يكون فى ذلك دليل على قدرته فقط لا على حكمته لانه يفصل القدرة كان يتم ذلك لا بحكمة التدبير فاما ما قد اجرى عليه الامر فى تصيره اياه مالحا فانه من اثار الحكمة والقدرة جميعا و سد ما حضر لى ووقفت عليه من لطيف حكمة الله في تصيره ماء البحر مالحا الى هذه الغاية ومن الاسباب الاضطرات به التى تحوج الى ذلك وان كانت هاهنا منافع اخر ليست المنافع الاولى المقصودة لكن منافع تابعة لما قلناه تم كتاب ثابت بن قرة في مياه البحار.

8 متبع in the manuscript.

9 سبيان in the manuscript.

Bibliography

Abattouy, M. “Greek Mechanics in Arabic Context: Thābit Ibn Qurra, al-Isfizārī and the Arabic Traditions of Aristotelian and Euclidean Mechanics”. *Science in Context*, 14(1-2), 2001, 179-247. https://doi.org/10.1017/S0269889701000084.

Abdukhalimov, B. *Bayt Al-Ḥikma Wa al-Našāṭ al-ʿilmī Li-ʿulamāʾ Āsiyā al-Wasaṭī Fī Baġdād*. Transl. by Komiljon Rakhimov. Tashkent: Maṭābiʾ wizārat al-iʿlām, 2021.

Abū Bakr Aḥmad b. ʿAlī b. Qays al-Kasdānī. *Al-Filāḥah al-Nabaṭīyyah. Al-tarǧama al-manḥūla ilā Ibn Waḥshīyya* (The Nabatean Agriculture. The Translation Attributed to Ibn Wahshiyya). Ed. by F. Toufic. 3rd ed. Damascus: Institut Français de Damas, 1993.

Abū Ḥayyān al-Tawḥidī. *Risālatān: al-risāla al-ūlā fī al-ṣadāqa wa al-ṣadīq wa al-risāla al-ṯāniya fī al-ʿulūm* (Two Treatises: The First Treatise on Friendship and the Friend, and the Second Treatise on the Sciences). Constantinople: Maṭbaʿat al-Jawā’ib, 1301.

Abū Ḥayyān al-Tawḥidī. *Kitāb al-hawāmil wa al-šawāmil* (The Scattered and the Gathered). Ed. by A. Amīn, S. Saqr. Cairo: Lağnat al-Taʾlīf wa al-Tarğama wa al-Našr, 1951.

Abū Ḥayyān al-Tawḥīdī; ʻAlī ibn Muḥammad; A. Ibn Miskawayh. *The Philosopher Responds: An Intellectual Correspondence from the Tenth Century*. Ed. by B. Orfali, M.A. Pomerantz. Transl. by S. Vasalou, J.E. Montgomery. New York: New York University Press, 2019.

Afrasiabi, K.L. “Toward an Islamic Ecotheology”. Foltz, R.; Denny, F.M.; Azizan Haji Baharuddin (eds), *Islam and Ecology. A Bestowed Trust*. Religions of the World and Ecology. Cambridge (MA): Center for the Study of World Religions, Harvard Divinity School; Harvard University Press, 2003, 281-96.

Agius, D.A. *Classic Ships of Islam. From Mesopotamia to the Indian Ocean*. Leiden: Brill, 2007. https://brill.com/display/title/11513.

Ahmad Y. al-Hassan. “Tecnologia della Chimica”. *Enciclopedia Treccani.* Vol. 3, *Storia della scienza.* Vol. 2, *La civiltà islamica*, 2002. https://www.treccani.it/enciclopedia/la-civilta-islamica-teoria-fisica-metodo-sperimentale-e-conoscenza-approssimata-tecnologia-della-chimica_%28Storia-della-Scienza%29/.

Ahmed, S. *What Is Islam? The Importance of Being Islamic*. Princeton; Oxford: Princeton University Press, 2015.

Akhtar, M.R. "Towards an Islamic Approach for Environmental Balance". *PSN: Sustainable Development (Topic)*, 3(2), 1996, 57-76.

Al-Azmeh, A. "Barbarians in Arab Eyes". *Past & Present*, 134, 1992, 3-18.

Al-Beruni. *The Book Most Comprehensive in Knowledge on Precious Stones: Al-Beruni's Book on Mineralogy* (*Kitāb al-Jamāhir Fī Maʿrifat al-Jawāhir*). Transl. by Hakim Mohammad Said. Islamabad: Pakistan Hijra Council, 1989.

Al-Bīrūnī, A.R.M. *Kitāb al-jamāhir fī maʿrifat al-jawāhir* (The Book of Precious Stones). Ed. by F. Krenkw. Haydarabad, 1355.

Al-Bīrūnī, A.R.M. *The Chronology of Ancient Nations: An English Version of the Arabic Text of the Athar-Ul-Bâkiya of Albîrûnî or 'Vestiges of the Past'*. Transl. by C.E. Sachau. London: W.H. Allen & Co., 1879.

Al-Bīrūnī, A.R.M. *The Determination of the Coordinates of Positions for the Correction of Distances Between Cities*. Transl. by J. Ali. Beirut: National Lebanese Printing, 1967.

Al-Bīrūnī, A.R.M. *Kitāb al-āṯār al-bāqiya ʿan qurūn al-ḫāliya* (The Book of the Remaining Signs of Past Centuries). Ed. by E. Sachau. Leipzig: Otto Harassowitz, 1923.

Al-Bīrūnī, A.R.M. *Kitāb al-Bīrūnī fī taḥqīq mā li-l-Hind min maqūlah maqbūlah fī al-ʿaql aw marḏūla* (al-Bīrūnī's Book on Verifying What of India's Discourse is Acceptable in Reason or Rejected). Ed. by E. Sachau. Rev. ed. Hyderabad. India: Printing House of the Council of the Uthmaniyah Encyclopedia, 1958.

Al-Bīrūnī, A.R.M. *Kitāb Taḥdīd Nihāyat al-Amākin li-Taṣḥīḥ Masāfāt al-Masākin* (Determining the End of Places for Correcting the Distances Between Dwellings). Ed. by P.G. Bulgakov, I. Ahmad. Frankfurt: Institute for History of Arabic-Islamic Science, [1962] 1992. Islamic Geography 25.

Al-Karağī. *Inbāṭ al-miyāh al-ḫafīya*. Ed. by ʿAbd al-Munʿim. Al-Qāhirah: Maʿhad al-Maḫṭūṭāt al-ʿArabiyya, 1997.

Al-Karajī. *La civilisation des eaux cachées. Traité de l'exploitatiôn des eaux souterraines*. Transl. by A. Mazahéri. Nice: Université de Nice, Institut d'études et de recherches interethniques et interculturelles (I.D.E.R.I.C), 1973.

Al-Masʿūdī. *Murūǧ al-ḏahab wa maʿādin al-ǧāwhar* (Meadows of Gold and Mines of Gems). Ed. by C. Pellat. Beyrut: al-Ǧāmīʿa al-Lubnāniyya, 1966.

Al-Nadīm. *Kitāb al-fihrist*. Ed. by R. Tajaddud. Tehran: Movi, 1971.

Antrim, Z. *Routes and Realms: The Power of Place in the Early Islamic World*. New York: Oxford University Press, 2012.

Aristotle. *Meteorology*. Translated by E.W. Webster. Altenmünster: Jazzybee Verlag, 2015. https://nbn-resolving.org/urn:nbn:de:101:1-2015112511590.

Ataman, K. "Re-Reading al-Birūnī's India. A Case for Intercultural Understanding". *Islam and Christian-Muslim Relations*, 16(2), 2005, 141-54. https://doi.org/10.1080/09596410500059623.

Ayalon, Y. "Epidemics in Premodern Middle Eastern Society and Thought". *History Compass*, 19(3), 2021, 1-9. https://doi.org/10.1111/hic3.12651.

Baffioni, C. "Les sens chez les Ikhwān al-Ṣafāʾ et l'héritage aristotélicien". *Micrologus*, 10, 2002, 463-76.

Baġdādī, A. al-Barakāt al-. *Kitāb al-muʿtabar fī al-ḥikma* (The Considered Book on Wisdom). Ed. by S. Yaltakaya. Hyderabad: Dāʿirat al-Maʿārif al-ʿUṯmaniyya, 1939.

Bagir, Z.A.; Martiam, N. "Islam: Norms and Practices". Jenkins, W.J.; Tucker, M.E.; Grim, J. (eds), *Routledge Handbook of Religion and Ecology*. London: Routledge, 2016, 79-87.

Beg, M.J. "Agricultural and Irrigation Labourers in Social and Economic Life of Iraq during the Umayyad and Abbasid Caliphates". *Islamic Culture*, 47(1), 1973, 15-30.

Benevich, F. "Perceiving Things in Themselves: Abū l-Barakāt al-Baġdādī's Critique of Representationalism". *Arabic Sciences and Philosophy*, 30(2), 2020, 229-64. https://doi.org/10.1017/S095742392000003X.

Berjak, R.; Iqbal, M. (transl.). *The Medieval Arabic Era: Ibn Sina – Al Biruni Correspondence*. 2003. https://www.academia.edu/30512389/The_Medieval_Arabic_Era_Ibn_Sina_Al_Biruni_Correspondence.

Bettini, L. *Il libro dei cammelli errabondi e di quelli che li radunano*. Venice: Edizioni Ca' Foscari, 2017.

Bīrūnī, M. ibn A. *Alberuni's India An Account of the Religion, Philosophy, Literature, Geography, Chronology, Astronomy, Customs, Laws and Astrology of India About AD*

1030. Transl. by E.C. Sachau. Cambridge: Cambridge University Press, 1888. Cambridge Library Collection. South Asian History. http://dx.doi.org/10.1017/CBO9781139207270.

Bīrūnī, M. ibn A. *The Book of Instruction on the Elements of the Art of Astrology*. Transl. by R.R. Wright. London: Lund Humphries & Co., 1933.

Bladel, K. van. *The Arabic Hermes. From Pagan Sage to Prophet of Science*. Oxford; New York: Oxford University Press, 2009.

Bladel, K. van; Gutas, D. s.v. "Bayt Al-Ḥikma". *Encyclopaedia of Islam, Three*. Leiden: Brill, 2009. http://dx.doi.org/10.1163/1573-3912_ei3_COM_22882.

Bonine, M.E. *Is There a Middle East? The Evolution of a Geopolitical Concept*. Stanford (CA): Stanford University Press, 2012.

Borroni, M. *Il nuovo giorno dell'impero*. Venice: Edizioni Ca' Foscari, 2017. https://doi.org/10.14277/978-88-6969-159-1/EUR-9.

Borroni, M.; Boselli, V. "Hydraulics and Hydrology in a Passage of the 'Kitāb al-Āṯār al-Bāqiya by al-Bīrūnī'". *Arabic Sciences and Philosophy*, 31(2), 2021, 159-82. https://doi.org/10.1017/S0957423921000059.

Bosworth, C.E. s.v. "Bīrūnī, Abū Rayḥān I. Life". *Encyclopædia Iranica*, IV, 3, 2010, 274-6. http://www.iranicaonline.org/articles/biruni-abu-rayhan-i-life.

Bosworth, C.E. s.v. "Mihrān". *Encyclopaedia of Islam*. 2nd ed. 2012. https://doi.org/10.1163/1573-3912_islam_SIM_5185.

Brentjes, S. "Abu Nasr Mansur b. ʾAli b. ʿIraq (Lived Circa 950-1036) and Abu l-Rayhan al-Biruni (Lived from 973-After 1050) as Students, Teachers, and Companions". *Models & Optimisation and Mathematical Analysis Journal*, 3(1), 2015, 28-35.

Brentjes, S. "Abu Nasr Mansur b. ʾAli b. ʿWilbur R. Knorr on Thābit ibn Qurra: A Case-Study in the Historiography of Premodern Science". *Aestimatio: Sources and Studies in the History of Science*, 1, 2021, 113-72. https://doi.org/10.33137/aestimatio.v1i1.37604.

Bsoul, L.A. *Translation Movement and Acculturation in the Medieval Islamic World*. Cham: Palgrave Macmillan, 2019.

Burnett, C. "Ṯābit Ibn Qurra the Ḥarrānian on Talismans and the Spirits of the Planets". *La Corónica: A Journal of Medieval Hispanic Languages, Literatures, and Cultures*, 36(1), 2007, 13-40. https://doi.org/10.1353/cor.2007.0030.

Busse, H. "Das Hofbudget des Chalifen al-Muʿtaḍid billāh (279/892-289/902)". *Der Islam*, 43, 1967, 11-36.

Cahen, C. s.v. "Ibn al-ʿAmīd". *Encyclopaedia of Islam*. 2nd ed. Leiden: Brill, 2012. https://referenceworks.brillonline.com/entries/encyclopaedia-of-islam-2/ibn-al-amid-COM_0315?s.num=4&s.f.s2_parent=s.f.cluster.Encyclopaedia+of+Islam&s.q=ibn+al-%27amid.

Callataÿ, G. de. *Ikhwan Al-Safa': A Brotherhood of Idealists on the Fringe of Orthodox Islam*. Oxford: Oneworld Publications, 2005.

Callataÿ, G. de. s.v. "Brethren of Purity". *Encyclopaedia of Islam, Three*. Leiden: Brill, 2013. https://referenceworks.brillonline.com/entries/encyclopaedia-of-islam-3/brethren-of-purity-COM_25372?s.num=0&s.f.s2_parent=s.f.cluster.Encyclopaedia+of+Islam&s.q=brethren+of+purity.

Capezzone, L. "Amorous or Scientific Metaphors? Abū Nuwās, the Beginning of the End of the Aristotelian Cosmos, and an Incoherence by al-Naẓẓām". *Studia Islamica*, 111(1), 2016, 1-19.

Carusi, P. "Les Cinq Sens Entre Philosophie et Médecine (Islam Xᵉ-XIIᵉ Siècles)". *Micrologus*, 10, 2002, 87-98.

Christensen, P. *The Decline of Iranshahr: Irrigation and Environments in the History of the Middle East, 500 BC to AD 1500*. Copenhagen: Museum Tusculanum Press, 1993.

Conrad, L.I. "*Tāʿūn* and *Wabāʾ* Conceptions of Plague and Pestilence in Early Islam". *Journal of the Economic and Social History of the Orient*, 25(3), 1982, 268-307. https://doi.org/10.2307/3632188.

Cristoforetti, S. "Cycles and Circumferences. The Tower of Gonbad-e Kāvus as a Time-Measuring Monument". Pellò, S. (ed.), *Borders: Itineraries on the Edges of Iran*. Venezia: Edizioni Ca' Foscari, 2016, 89-115. Eurasiatica 5. http://doi.org/10.14277/6969-100-3/EUR-5-5.

Cruz Hernández, M. "El sentido de las tres lecturas de Aristóteles por Averroes". *Atti dell'Accademia Nazionale dei Lincei*, 8(28), 1973, 567-85.

Daiber, H. (ed.). *Ein Kompendium der aristotelischen Meteorologie in der Fassung des Ḥunain ibn Isḥâq*. Leiden: Brill, 1975. https://brill.com/view/title/17303.

Daiber, H. (ed.). *Naturwissenschaft bei den Arabern im 10. Jahrhundert n. Chr.: Briefe des Abū l-Faḍl Ibn al-ʿAmīd (gest. 360/970) an ʿAḍudaddaula. Mit Einleitung, kommentierter Übersetzung und Glossar. Naturwissenschaft bei den Arabern im 10. Jahrhundert n. Chr.* Leiden: Brill, 1993.

Daiber, H. (ed.). "The *Meteorology* of Theophrastus in Syriac and Arabic Translation". *From the Greeks to the Arabs and Beyond: Volume I: Graeco-Syriaca and Arabica*. Leiden: Brill, 2021, 308-418. https://brill.com/display/title/38870.

Dalen, E. van. "Scientific Method in Late-Antique Paganism. The (Rational) Empiricism of al-Filāḥa l-Nabaṭiyya (The Nabatean Agriculture)". *Arabica*, 68(5-6), 2021, 510-56. https://doi.org/10.1163/15700585-12341624.

Di Branco, M. "Un'istituzione sasanide? Il Bayt al-ḥikma e il movimento di traduzione". *Studia Graeco-Arabica*, 2, 2012, 255-63.

Duffy, C.J. "The Terrestrial Hydrologic Cycle: An Historical Sense of Balance". *Wiley Interdisciplinary Reviews: Water*, 4(4), 2017, 1-21. https://doi.org/10.1002/wat2.1216.

Dunlop, D.M. "The Translations of Al-Biṭrīq and Yaḥyā (Yuḥannā) b. Al-Biṭrīq". *Journal of the Royal Asiatic Society of Great Britain and Ireland*, 3-4, 1959, 140-50.

Eger, A.A. "The Swamps of Home: Marsh Formation and Settlement in the Early Medieval Near East". *Journal of Near Eastern Studies*, 70(1), 2011, 55-79. https://doi.org/10.1086/659093.

El-Bizri, N. (ed.). "Prologue". *Epistles of the Brethren of Purity: The Ikhwan al-Safaʾ and Their Rasaʾil. An Introduction*. Oxford: Oxford University Press, 2008, 3-5.

El-Faïz, M. *Les Maitres de l'eau: Histoire de l'hydraulique Arabe*. Arles: Actes Sud, 2005.

Endress, G. "Casimir Petraitis, The Arabic Version of Aristotle's 'Meteorology'". *Oriens* 23-4(1), 1971, 497-509. https://doi.org/10.1163/18778372-02302401038.

Fahd, T. s.v. "Ibn Waḥshiyya". *Encyclopaedia of Islam, Second Edition*. Leiden: Brill, 2012. https://referenceworks.brillonline.com/entries/encyclopaedia-of-islam-2/ibn-wahshiyya-COM_0346?s.num=0&s.f.s2_parent=s.f.book.encyclopaedia-of-islam-2&s.q=wahshiyya.

Faḫr al-Dīn al-Rāzī. *al-Mabaḥīṯ al-mašriqiyya*. Tehran: Maktabat al-Asadī, 1966.

Ferriello, G. "Problemi di storia della scienza nel trattato medievale di idraulica del persiano Karağī". *Oriente Moderno*, 14(75), 7/12, 1995, 267-85.

Fontaine, R. "Why Is the Sea Salty? The Discussion of Salinity in Hebrew Texts of the Thirteenth Century". *Arabic Sciences and Philosophy*, 5(2), 1995, 195-218. https://doi.org/10.1017/S0957423900002022.

Frisinger, H.H. "Aristotle and His *Meteorologica*". *Bulletin of the American Meteorological Society*, 53(7), 1972, 634-8. https://doi.org/10.1175/1520-0477(1972)053<0634:AAH>2.0.CO;2.

Frisinger, H.H. *The History of Meteorology: To 1800*. Boston: American Meteorological Society, 1983.

Gade, A.M. *Muslim Environmentalisms: Religious and Social Foundations*. New York: Columbia University Press, 2019.

Ghersetti, A. *La letteratura d'adab*. Roma: Istituto per l'Oriente C.A. Nallino, 2020.

Golshani, M. "Islam and the Sciences of Nature: Some Fundamental Questions". *Islamic Studies*, 39(4), 2000, 597-611.

Goodman, L.E. "The Translation of Greek Materials into Arabic". Latham, J.D.; Young, M.J.L.; Serjeant, R.B. (eds), *Religion, Learning and Science in the 'Abbasid Period*. Cambridge: Cambridge University Press, 1990, 477-97. https://doi.org/10.1017/CHO9781139424912.030. The Cambridge History of Arabic Literature.

Grant, M. *Galen on Food and Diet*. London: Routledge, 2000.

Green, T.M. *The City of the Moon God: Religious Traditions of Harran*. Leiden: Brill, 1992. https://brill.com/view/title/1320.

Griffel, F. "Between al-Ghazālī and Abū l-Barakāt al-Baghdādī. The Dialectical Turn in the Philosophy of Iraq and Iran During the Sixth/Twelfth Century". Adamson, P. (ed.),

In the Age of Averroes: Arabic Philosophy in the Sixth/Twelfth Century, vol. 16. London; Turin: Warburg Institute; Nino Aragno, 2011, 45-75. Warburg Institute Colloquia.
Griffel, F. *The Formation of Post-Classical Philosophy in Islam*. New York: Oxford University Press, 2021.
Gutas, D. *Greek Thought, Arabic Culture. The Graeco-Arabic Translation Movement in Baghdad and Early Abbasid Society (2nd-4th/8th-10th C.)*. London; New York: Routledge, 1998.
Hall, C. "Horoscopes of the Moon: Weather Prediction as Astrology in Ptolemy's Tetrabiblos". *Early Science and Medicine*, 26(3), 2021, 231-53. https://doi.org/10.1163/15733823-02630018.
Hämeen-Anttila, J. *The Last Pagans of Iraq: Ibn Waḥshiyya and His Nabatean Agriculture*. Leiden; Boston: Brill, 2006. Islamic History and Civilization. Studies and Texts 63.
Hatami, A.H. "Empirical Horizons in Islamic Historiography: Abū Rayḥān Al-Birunī". *Quartely Research Journal of Islamic History*, 8(29), 2018, 27-51.
Hill, D.R. *A History of Engineering in Classical and Medieval Times*. London: Routledge, 1996. http://catdir.loc.gov/catdir/enhancements/fy0649/96025528-d.html.
Hjärpe, J. *Analyse critique des traditions arabes sur les Sabéens Ḥarraniens* [PhD dissertation]. Uppsala: Uppsala University, 1972.
Hodgson, M.G.S. *The Venture of Islam.* Vol. 1, *The Classical Age of Islam*. Chicago: The University of Chicago Press, 1974.
Hughes, A.W. "New Methods, Old Methods in the Study of Islam: On the Importance of Translation". Aghdassi, A. (ed.), *New Methods in the Study of Islam*. Edinburgh University Press, 2022, 11-35. https://doi.org/10.1515/9781399503518-007.
Husaini, S.W.A. *Islamic Environmental Systems Engineering: A Systems Study of Environmental Engineering and the Law, Politics, Education, Economics, and Sociology of Science and Culture of Islam*. London; Indianapolis: Macmillan; American Trust Publications, 1980.
Ibn Abī Uṣaybiʿa, A. b. al-Qāsim. *A Literary History of Medicine Online*. Ed. by E. Savage-Smith. Leiden: Brill, n.d. https://doi.org/10.1163/9789004545564.
Ibn Abī Uṣaybiʿa, A. b. al-Qāsim. *ʿUyūn al-anbāʾ fī ṭabaqāt al-aṭibbāʾ*. 2 vols. Ed. by A. Müller. Cairo: Al-Maṭbaʿa al-Wahbiyya, 1299.
Ibn Ḫallikān, Š. al-dīn. *Wafayāt al-aʿyān wa anbāʾ abnāʾ al-zamān*. 8 vols. Ed. by Iḥsān ʿAbbās. Beirut: Dar Ṣādir, 1968.
Ibn Ḥawqal al-Naṣībī, A. al-Q. b. ʿAlī. *Ibn Ḥawwqal's Kitāb Ṣūrat al-arḍ: Opus geographicum*. Ed. by J.H. Kramers. Leiden: Brill, 2014. Bibliothecae geographorum Arabicorum.
Ibn Rušd, A. al-W.M. "Kitāb al-āṯār al-ʿulwiyya" (The Book on Meteorological Phenomena). *Rasāʾil Ibn Rušd*, vol. 4. Hyderabad: Maṭbaʿat Dāʾirat al-Maʿārif al-ʿUṯmāniyya, 1366.
Ibn Rušd, A. al-W.M. *Talḫīs al-āṯār al-ʿulwiyya* (Summary on Meteorological Phenomena). Ed. by Jamāl al-Dīn al-Alawī. Beirut: Dār al-Ġarb al-Islāmī, 1994.
Ibn Sīnā. *Kitāb al-šifāʾ, al-Ṭabīʿiyyāt 5: al-maʿādin wa al-āṯār al-ʿulwiyya* (The Natural Sciences 5: Minerals and Meteorological Phenomena). Ed. by A. Muntaṣir, S. Zāyid, A. Ismāʿīl, I. Madkūr. Cairo: Al-Hayʾa al-Miṣriyya al-ʿAmma lī-l-Kitāb, 1964.
Idllalène, S. *Rediscovery and Revival in Islamic Environmental Law. Back to the Future of Nature's Trust*. Cambridge: Cambridge University Press, 2021. ASCL Studies in Comparative Law.
Ikhwān al-Ṣafāʾ. *Epistles of the Brethren of Purity. On the Natural Sciences. An Arabic Critical Edition and English Translation of Epistles 15-21*. Ed. by C. Baffioni. Oxford: Oxford University Press in association with the Institute of Ismaili Studies, 2013.
Kennedy, E.S. *A Commentary upon Biruni's Kitab Tahdid al-Amakin: An 11th Century Treatise on Mathematical Geography*. Beirut: American University of Beirut, 1973.
Kennedy, H. "How to Found an Islamic City". Goodson, C.; Lester, A.E.; Symes, C. (eds), *Cities, Texts and Social Networks, 400-1500*. Aldershot: Ashgate, 2010, 45-63. https://doi.org/10.4324/9781315572130-3.
Khalid, F. *Signs on the Earth. Islam, Modernity and the Climate Crisis*. La Vergne: Kube Publishing Ltd, 2019. https://public.ebookcentral.proquest.com/choice/publicfullrecord.aspx?p=5725862.

Koláček, J. "The Qurʾān as a Source for Contemporary Islamic Environmental Ethics". *Archiv Orientální*, 88(2), 2020, 221-48. https://doi.org/10.47979/aror.j.88.2.221-248.

Kukkonen, T. "Averroes and the Teleological Argument". *Religious Studies*, 38(4), 2002, 405-28. https://doi.org/10.1017/S0034412502006224.

Lane, E.W. *An Arabic-English Lexicon Derived from the Best and Most Copious Eastern Sources*. London: Williams & Norgate, 1863.

Langermann, Y.T. s.v. "Al-Baghdadi, Abu ʾl-Barakat (Fl. c.1200-50)". *Routledge Encyclopedia of Philosophy*. London: Taylor and Francis, 1998. https://www.rep.routledge.com/articles/biographical/al-baghdadi-abu-l-barakat-fl-c-1200-50/v-1.

Le Strange, G. *The Lands of the Eastern Caliphate. Mesopotamia, Persia, and Central Asia from the Moslem Conquest to the Time of Timur*. Frankfurt: Institute for the History of Arabic-Islamic Science at the J.W. Goethe University, 1993.

Lettinck, P. *Aristotle's 'Meteorology' and Its Reception in the Arab World, with an Edition and Translation of Ibn Suwār's Treatise on Meteorological Phenomena and of Ibn Bājja's Commentary on the Meteorology*. Leiden: Brill, 1999.

Malagaris, G. *Biruni*. New Delhi: Oxford University Press, 2021. Makers of Islamic Civilization.

Malik, G.R. "Al-Biruni. A Universalist". *Journal of Central Asian Studies*, 10(1), 1999, 87-94.

Matin, P. "Apotropaic Plants in the Persian Folk Culture". *Iran and the Caucasus*, 16(2), 2012, 189-200. https://doi.org/10.1163/1573384X-20120006.

Mattila, J. "Sabians, the School of al-Kindī, and the Brethren of Purity". Lindstedt, I.; Nikki, N.; Tuori, R. (eds), *Religious Identities in Antiquity and the Early Middle Ages. Walking Together & Parting Ways*. Leiden; Boston: Brill, 2022, 92-114. Studies on the children of Abraham 9.

McGinnis, J. "Mind the Gap. The Reception of Avicenna's New Argument Against Actually Infinite Space". *Illuminationist Texts and Textual Studies. Essays in Memory of Hossein Ziai. Compiled by Ahmed Alwishah, Ali Gheissari, John Walbridge*. Brill, 2018, 272-305. Iran Studies. https://www.proquest.com/books/mind-gap-reception-avicennas-new-argument-against/docview/2088325204/se-2?accountid=17274.

Mcpeak, W.J. "Meteorology in the Islamic World". Selin H. (ed.), *Encyclopaedia of the History of Science, Technology, and Medicine in Non-Western Cultures*. Dordrecht: Springer Netherlands, 2016, 3218-21. https://doi.org/10.1007/978-94-007-7747-7_8789.

Meyerhof, M. "The 'Book of Treasure' an Early Arabic Treatise on Medicine". *Isis*, 14, 1930, 55-76. http://dx.doi.org/10.1086/346485.

Mirza, M. "Bīrūnī's Thought and Legacy". *Religion Compass*, 5(10), 2011, 609-23. https://doi.org/10.1111/j.1749-8171.2011.00301.x.

Mirza, M. "Believing is Seeing: The Universe in the Eyes of al-Bīrūnī and Ibn Sīnā". Elias, J.J.; Orfali, B. (eds), *Light upon Light: Essays in Islamic Thought and History in Honor of Gerhard Bowering*. Leiden: Brill, 2019, 366-82. https://doi.org/10.1163/9789004410121_016.

Nadvi, S.H.H. "Al-Birūnī and His Kitāb al-Jamāhir Fī-Maʾrifat al-Jawāhir. Ethical Reflections and Moral Philosophy". *Islamic Studies*, 13(4), 1974, 253-68.

Nallino, C.A. *ʿIlm al-falak – taʾrīḫuhū ʿinda al-ʿarab fī al-qurūn al-wusṭā* (The Science of Astronomy – Its History Among the Arabs in the Middle Ages). 1911th ed. Rome: Publications of the Institute for the History of Arabic-Islamic Science, 1998.

Nasr, S.H. *An Introduction to Islamic Cosmological Doctrines. Conceptions of Nature and Methods Used for Its Study by the Ikhwān al-Ṣafā, al-Bīrūnī, and Ibn Sīnā*. Bath: Thames & Hudson, 1964.

Nasr, S.H. *The Encounter of Man and Nature. The Spiritual Crisis of Modern Man*. London: Allen & Unwin, 1968.

Netton, I.R. (ed.). "The Rasāʾil Ikhwān al-Ṣafāʾ in the History of Ideas in Islam". *Epistles of the Brethren of Purity. The Ikhwan al-Safaʾ and Their Rasaʾil: An Introduction*. Oxford: Oxford University Press, 2008, 123-38. http://bvbr.bib-bvb.de:8991/F?func=service&doc_library=BVB01&local_

base=BVB01&doc_number=017087333&line_number=0001&func_code=DB_RECORDS&service_type=MEDIA.

Netton, I.R. *Muslim Neoplatonists. An Introduction to the Thought of the Brethren of Purity (Ikhwān al-Ṣafāʾ)*. London: Routledge, 2016.

Özdemir, I. "Towards and Understanding of Environmental Ethics from a Quranic Perspective". Foltz, R.; Denny, F.M.; Azizan Haji Baharuddin (eds), *Islam and Ecology. A Bestowed Trust*. Religions of the World and Ecology. Cambridge (MA): Center for the Study of World Religions, Harvard Divinity School; Harvard University Press, 2003, 3-37.

Parvaiz, M.A. "Scientific Innovation and Al-Mīzān". Foltz, R.; Denny, F.M.; Azizan Haji Baharuddin (eds), *Islam and Ecology. A Bestowed Trust*. Cambridge (MA): Center for the Study of World Religions, Harvard Divinity School; Harvard University Press, 2003, 393-401. Religions of the World and Ecology.

Pavlov, M.M. *Abūʾl-Barakāt al-Baghdādī's Scientific Philosophy. The Kitāb al-Muʿtabar*. London; New York: Routledge, 2017. Routledge Jewish Studies Series.

Petraitis, C. (ed.). *The Arabic Version of Aristotle's "Meteorology"*. Beirut: Dār al-Mašriq, 1967.

Pingree, D. "The Ṣābians of Ḥarrān and the Classical Tradition". *International Journal of the Classical Tradition*, 9(1), 2002, 8-35.

Preiser-Kapeller, J. "The Deluge of 628 AD and the Collapse of Ancient Iraq". *Das Andere Mittelalter*, 2016. https://www.dasanderemittelalter.net/news/the-deluge-of-628-ad-and-the-collapse-of-ancient-iraq/.

Qifṭī, ʿAlī b. Yūsuf al-. *Taʾrīḫ al-ḥukamāʾ* (The History of Philosophers). Ed. by J. Lippert. Leipzig: Dieterich'sche Verlagsbuchhandlung, 1903.

Rashed, M. "Kalam e filosofia naturale". *Storia della scienza III, la civiltà islamica*. Roma: Istituto della Enciclopedia Italiana Treccani, n.d., 49-72.

Rashed, M. "Thābit ibn Qurra, la Physique d'Aristote et le meilleur des mondes". Rashed, R. (ed.), *Thābit ibn Qurra. Science and Philosophy in Ninth-Century Baghdad*. New York; Berlin: De Gruyter, 2009, 675-714. Scientia Graeco-Arabica 4.

Rashed, M. "Thābit ibn Qurra sur l'existence et l'infini: les réponses aux questions posées par Ibn Usayyid". Rashed, R. (ed.), *Thābit Ibn Qurra. Science and Philosophy in Ninth-Century Baghdad*. New York; Berlin: De Gruyter, 2009, 619-73.

Rashed, R. "Problems of the Transmission of Greek Scientific Thought into Arabic. Examples from Mathematics and Optics". *History of Science*, 27(2), 1989, 199-209. https://doi.org/10.1177/007327538902700204.

Rashed, R. "Al-Qūhī vs. Aristotle. On Motion". *Arabic Sciences and Philosophy*, 9(1), 1999, 7-24. https://doi.org/10.1017/S0957423900002587.

Rashed, R. "Thābit bin Qurra: From Ḥarrān to Baghdad". Rashed, R. (ed.), *Thābit Ibn Qurra. Science and Philosophy in Ninth-Century Baghdad.* New York; Berlin: Walter de Gruyter, 2009, 15-26. Scientia Graeco-Arabica 4.

Rashed, R. "Thābit bin Qurra: Scholar and Philosopher (826-901)". Rashed, R. (ed.), *Thābit Ibn Qurra. Science and Philosophy in Ninth-Century Baghdad*. New York; Berlin: Walter de Gruyter, 2009, 3-14. Scientia Graeco-Arabica 4.

Rashed, R. s.v. "T̲h̲ābit b. Ḳurra". *Encyclopaedia of Islam, Second Edition*. Leiden: Brill, 2012. https://referenceworks.brillonline.com/entries/encyclopaedia-of-islam-2/thabit-b-kurra-SIM_7507.

Rāšid, R. Ḥafnī. *Ibn al-Haytham's Geometrical Methods and the Philosophy of Mathematics*. Transl. by J.V. Field. London: Routledge, 2017. A History of Arabic Sciences and Mathematics 5.

Reisman, D.C. "Plato's 'Republic' in Arabic a Newly Discovered Passage". *Arabic Sciences and Philosophy*, 14(2), 2004, 263-300. https://doi.org/10.1017/S0957423904000104.

Rizvi, A.M. "Islamic Environmental Ethics and the Challenge of Anthropocentrism". *American Journal of Islam and Society*, 27(3), 2010, 53-78. https://doi.org/10.35632/ajis.v27i3.366.

Rodgers, R.H. "Hail, Frost, and Pests in the Vineyard. Anatolius of Berytus as a Source for the Nabataean Agriculture". *Journal of the American Oriental Society*, 100(1), 1980, 1-11. https://doi.org/10.2307/601382.

Sabra, A.I. “Thābit Ibn Qurra on the Infinite and Other Puzzles. Edition and Translation of His Discussions with Ibn Usayyid”. *Zeitschrift Für Geschichte Der Arabisch-Islamischen Wissenschaften*, 11, 1997, 1-33.

Sajjadi, S.M.S. *Qanat, kāriz: storia, tecnica costruttiva ed evoluzione*. Tehran: Istituto Italiano di Cultura, Sezione Archeologica, 1982. Quaderni. https://search.proquest.com/docview/44117838?accountid=17274.

Salvatore, A. “The Islamicate Adab Tradition vs. the Islamic Shariʿa, from Pre-Colonial to Colonial”. *Working Paper Series of the HCAS’ Multiple Secularities – Beyond the West, Beyond Modernities* (13 April 2018). Leipzig: Leipzig University. https://doi.org/10.36730/2020.1.msbwbm.3.

Samsó, J.; Blas Rodríguez, J. “Las ‘pháseis’ de Ptolomeo y el ʿKitāb al-Anwā’ de Sinān b. Tābit”. *Al-Andalus*, 41, 1976, 15-48.

Sanagustin, F. “Abū Rayḥān al-Bīrūnī: un rationaliste à l’épreuve de l’altérité”. *Bulletin d’études orientales*, 55, 2003, 249-63.

Sarton, G. *A History of Science. Ancient Science through the Golden Age of Greece*. Cambridge (MA): Harvard University Press, 1960.

Sessions, G.S. “Anthropocentrism and the Environmental Crisis”. *Humboldt Journal of Social Relations*, 2(1), 1974, 71-81.

Shihadeh, A.; Thiele, J. (eds). *Philosophical Theology in Islam. Later Ashʿarism East and West*. Leiden; Boston: Brill, 2020. Islamicate Intellectual History 5.

Siddiqi, A.H. “Muslim Geographic Thought and the Influence of Greek Philosophy”. *GeoJournal*, 37(1), 1995, 9-15.

Solignac, M. “Mohamed Al-Karagi, ingénieur hydrologue (m. 410/1019)”. *Revue de l’Institut des belles lettres arabes*, 37(134), 1974, 315-28.

Squatriti, P. *Water and Society in Early Medieval Italy, AD 400-1000*. 1st ed. Cambridge: Cambridge University Press, 1998. https://doi.org/10.1017/CBO9780511583094.

Starr, S.F. *Lost Enlightenment. Central Asia’s Golden Age from the Arab Conquest to Tamerlane*. Princeton: Princeton University Press, 2015.

Stearns, J.K. *Infectious Ideas. Contagion in Premodern Islamic and Christian Thought in the Western Mediterranean*. Baltimore: Johns Hopkins University Press, 2011.

Street, T.; Abū ’l-Barakāt Hibat Allāh al-Baghdādī. “Abū l-Barakāt al-Baġdādī and the Traditions of Arabic Logic”. *Studia Graeco-Arabica*, 11(2), 2021, 41-66.

Strohmaier, G. *Al-Bīrūnī. In den Gärten der Wissenschaft*. Leipzig: Philipp Reclam jun., 1988.

Ṯābit b. Qurra, A. al-Ḥasan. *Kitāb al-ḏaḵīra fī ʿilm al-ṭibb* (Compendium on Medical Science). Ed. by G. Sobhy. Cairo: al-Ǧāmiʿa al-Miṣriyya, al-Maṭbaʿa al-Amīriyya, 1928.

Tardieu, M. “Ṣābiens Coraniques et ‘Ṣābiens’ de Ḥarrān”. *Journal Asiatique*, 1, 1986, 1-44. https://doi.org/10.2143/JA.274.1.2011565.

Toral, I. “The ‘Nabatean Agriculture’ by Ibn Waḥšiyya, a Pseudo-Translation by a Pseudo-Translator. The Topos of Translation in Occult Sciences”. Gutas, D. (ed.), *Why Translate Science? Documents from Antiquity to the 16th Century in the Historical West (Bactria to the Atlantic)*. Leiden: Brill, 2022, 377-96. https://brill.com/edcollbook/title/55210.

Tuan, Y.-F. *The Hydrologic Cycle and the Wisdom of God. A Theme in Geoteleology*. Toronto: University of Toronto Press, 1968. https://doi.org/10.3138/9781487584535.

Ullmann, M. *Die Medizin im Islam*, Bd. 1. Leiden: Brill, 1970. Handbuch der Orientalistik 6.

Vagelpohl, U. “The ʿAbbasid Translation Movement in Context. Contemporary Voices on Translation”. Nawa, J. (ed.), *ʿAbbasid Studies II: Occasional Papers of the School of ʿAbbasid Studies* (Leuven, 28 June-1 July 2004). Leuven: Peeters en Departement Oosterse Studies, 2010, 245-67.

Varisco, D.M. “The Origin of the Anwaʾ in Arab Tradition”. *Studia Islamica*, 74, 1991, 5-28. https://doi.org/10.2307/1595894.

Varisco, D.M. s.v. “Anwāʾ”. *Encyclopaedia of Islam, THREE*. Ed. by K. Fleet, G. Krämer, D. Matringe, J. Nawas, E. Rowson, 2007. https://referenceworks.brillonline.com/entries/encyclopaedia-of-islam-3/anwa-SIM_0222.

Verkinderen, P. *The Waterways of Iraq and Iran in the Early Islamic Period. Changing Rivers and Landscapes of the Mesopotamian Plain*. London: I.B. Tauris, 2015.

Vernet, J. s.v. “Al-Karad̲j̲ī”. *Encyclopaedia of Islam, Second Edition*. Leiden: Brill, 2012. https://referenceworks.brillonline.com/entries/

encyclopaedia-of-islam-2/al-karadji-SIM_3903?s.num=0&s.f.s2_parent=s.f.cluster.Encyclopaedia+of+Islam&s.q=karadji.

Wilson, M. *Structure and Method in Aristotle's "Meteorologica". A More Disorderly Nature*. 1st ed. Cambridge: Cambridge University Press, 2013. https://doi.org/10.1017/CBO9781107337121.

Yazdī, ʿAlī Aṣġar Simsār; Ḫānīkī, M.L. *Qanat Knowledge: Construction and Maintenance*. Dordrecht: Springer, 2017. http://www.gbv.de/dms/tib-ub-hannover/877808805.pdf.

Zadeh, T. "The Wiles of Creation: Philosophy, Fiction, and the ʿajā'ib Tradition". *Middle Eastern Literatures*, 13(1), 2010, 21-48. https://doi.org/10.1080/14752620903566095.

Marco Polo

1. Olivieri, Luca M. (2022). *Stoneyards and Artists in Gandhara. The Buddhist Stupa of Saidu Sharif I, Swat (c. 50 CE)*.

The present volume examines key authors' views on nature in the Arabic-Islamic tradition, focusing on Thābit ibn Qurra's insights into water's role in the natural world. This work delves into early Arabic discussions on the water cycle, humanity's role in creation, and the diversity of scientific and philosophical opinions within this tradition. It features the translation of Thābit ibn Qurra's treatise, highlighting one of the earliest descriptions of the water cycle and the genesis of a hydrological thought school that persisted for centuries.

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