Jurnal Ilmiah **ISLAM FUTURA**
Vol. 23. No. 2, August 2023, 235-262

WILL ARABIA BECOME GREEN AGAIN? A GEOLOGICAL & METEOROLOGICAL APPROACH TO CONFIRMING PROPHETIC HADITH

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Abstract

As a Muslim, the guidance used in worship comes from the Quran and Hadiths. One of the authentic Hadiths by Muslim states that Arabia will turn green again. This research aims to explain the greening of Arabia in the past and future perspectives from a geological and meteorological point of view. The method used in this study is a review study, combining the theory of plate tectonics on the Arabian Plate and the meteorological cycles that will occur in the future using the theory of natural radiative forcing in climate change. Discoveries of mollusks and fossils that lived in water in hot deserts provide evidence of past wet conditions before it turned hot again. There have been 18 warm climate cycles and 17 climate cycles since 5.3 million years ago. The results of this research indicate that Arabia will turn green again, both from a geological and meteorological approach. The geological approach estimates that Arabia will turn green again in approximately ~25 million years, while the meteorological approach suggests at least 13,000 years in the future when the Earth reaches its opposite precession peak. The influence of meteorological cycle periods is shorter compared to the long-term effects of plate movements. The possibility of Arabia turning green in the future is indeed true, in line with the statements of the Prophet's Hadith.

Keywords: *Arabian Plate; climate change; green Arabia; plate tectonics; precession; prophetic hadith.*

Abstrak

Sebagai Muslim, petunjuk yang digunakan berasal dari Alquran dan hadits. Salah satu hadits shahih Muslim mengatakan bahwa Arabia akan berubah menjadi hijau kembali. Penelitian ini bertujuan untuk menjelaskan hijaunya Arabia pada masa lalu dan masa yang akan datang dari sudut pandang geologi dan meteorology. Metode yang digunakan pada studi ini adalah review study, menggabungkan antara teori tektonik lempeng pada Lempeng Arabia dan siklus meteorologi yang akan tterjadi di masa depan menggunkan teori natural raditive forcing pada perubahan iklim. Penemuan moluska dan fosil yang hidup di air pada gurun yang panas membuktikan adanya kondisi basah pada masa lalu sebelum berubah menjadi panas kembali. Terdapat 18 kali siklus iklim hangat dan 17 kali siklus iklim sejak 5,3 juta tahun yang lalu. Hasil dari penelitian ini adalah Arabia akan kembali menghijau baik dari

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Citation: Hikmy, Isbram Ginanjar and Rangga Tri Nugraha. "Will Arabia Become Green Again? A Geological & Meteorological Approach to Confirming Prophetic Hadith." *Jurnal Ilmiah Islam Futura* 23, no. 2(2023): 235-262.

10.22373/jiif.v23i2.17063

pendekatan geologi dan meteorologi. Perhitungan dari pendekatan geologi menghasilkan sekitar ~25 juta tahun yang akan datang Arabia akan menghijau kembali sementara itu pendekatan meteorologi menghasilkan seidaknya 13.000 tahun yang akan datang saat bumi mencapai puncak presesi yang berlawanan. Pengaruh periode siklus meteorologi lebih pendek daripada pengaruh dari pergerakan lempeng yang terlalu lama. Kemungkinan hijaunya Arabia di masa depan memang benar adanya, sejalan dengan pernyataan hadits nabi.

Kata Kunci: *Lempeng Arabia; perubahan iklim; hijaunya Arabia; tektonik lempeng; presesi; hadts nabi.*

مستخلص

كمسلم، يأتي التوجيه المستخدم في العبادة من القرآن والأحاديث النبوية. واحدة من الأحاديث النبوية الصحيحة المروية في صحيح مسلم تقول إن الجزيرة العربية ستعود للونها الأخضر مرة أخرى. تهدف هذه الدراسة إلى شرح عودة الجزيرة العربية إلى اللون الأخضر من منظور جيولوجي وجوي ماضٍ ومستقبلي. والطريقة المستخدمة في هذه الدراسة هي دراسة استعراضية، تجمع بين نظرية الصفائح التكتونية للصفيحة العربية ودورات الأرصاد الجوية التي ستحدث في المستقبل باستخدام نظرية القوة الإشعاعية الطبيعية في تغير المناخ. اكتشافات المحار والأحافير التي عاشت في المياه في الصحارى الحارة تقدم دليلاً على الظروف المبللة في الماضي قبل أن تصبح حارة مرة أخرى. هناك ١٨ دورة مناخية دافئة و١٧ دورة مناخية منذ ٥.٣ مليون سنة مضت. نتائج هذه الدراسة تشير إلى أن الجزيرة العربية ستعود للونها الأخضر مرة أخرى، سواء من الناحية الجيولوجية أو الجوية. تقدير النهج الجيولوجي يشير إلى أن الجزيرة العربية ستعود للونها الأخضر في حوالي ٢٥ مليون سنة قادمة، بينما يشير النهج الجوي إلى ما لا يقل عن ١٣٠٠٠ سنة في المستقبل عندما تصل الأرض إلى ذروة الطوفان المعاكس. تأثير فترات دورات الأرصاد الجوية أقصر مقارنة بتأثيرات الحركات الطويلة الأمد للصفائح. إمكانية عودة الجزيرة العربية للونها الأخضر في المستقب

الكلمات الرئسية: خضرة شبه الجزيرة العربية ; دورات المناخ ; الأرصاد الجوية ; أرابيان بليت; الديناميكا الجيولوجية.

A. INTRODUCTION

In Islam, there are six pillars of faith that must be believed by a believer. They are faith in Allah, His angels, His messengers, His holy books, the Judgment Day itself, and the latest is qodho and qadar. All of them are to be discussed in parallel. In this article, we will discuss one of these pillars: the Judgment Day or the Day or The Last Hour. The Day is broadly mentioned in the Holy Qur’an and Hadith as guidelines for Muslims to have faith in the future. There are many signs that are revealed and exist before the Day, according to those guidelines. One trusted Hadith coming from Imam Muslim states:

وَحَدَّثَنَا قُتَيْبَةُ بْنُ سَعِيدٍ، حَدَّثَنَا يَعْقُوبُ، – وَهُوَ ابْنُ عَبْدِ الرَّحْمَنِ الْقَارِيُّ – عَنْ سُهَيْلٍ، عَنْ أَبِيهِ، عَنْ أَبِي هُرَيْرَةَ، أَنَّ رَسُولَ اللَّهِ ﷺ قَالَ " لاَ تَقُومُ السَّاعَةُ حَتَّى يَكْثُرَ الْمَالُ وَيَفِيضَ حَتَّى يَخْرُجَ الرَّجُلُ بِزَكَاةِ مَالِهِ فَلاَ يَجِدُ أَحَدًا يَقْبَلُهَا مِنْهُ وَحَتَّى تَعُودَ أَرْضُ الْعَرَبِ مُرُوجًا وَأَنْهَارًا " .

“Abu Huraira reported Allah's Messenger (way peace be upon him) as saying: The Last Hour will not come before wealth becomes abundant and overflowing, so much so that a man takes Zakat out of his property and cannot find anyone to accept it from him and till the land of Arabia reverts to meadows and rivers.**”** [Narrated from Abu Hurayrah (may Allah be pleased with him), Muslim (157)] it quoted in hadith (saying of Prophet Muhammad – Peace be Upon Him) sahiih, among the major sign of the Day of Judgement.

The Hadith refers to Muslim, who is a member of the seven reliable Hadith narrators for Muslims. It is clear that the Day of Judgement is a day that will happen in the future, as stated in the Holy Quran, Surah Ali-Imran verses 87: "Allah, there is no god but He – He will most certainly gather you together on the resurrection day, there is no doubt in it; and who is more true in word than Allah?" and other Surahs and verses. Stowasser[1] said there is an apocalyptic edge to some of the Qur'anic revelations, especially the Meccan revelations, when they expound that the end is near according to the Holy Quran. It is stated several times in the Holy Quran, for example: "The Hour has drawn near, and the moon has been cleft asunder" (the people of Makkah requested Prophet Muhammad SAW to show them a miracle, so he showed them the splitting of the moon), Surah Al Qamar 54 verse 1. However, only God has knowledge about the hour, as stated in the Holy Quran: "They ask you, [O Muhammad], about the Hour: when is its arrival? Say, 'Its knowledge is only with my Lord. None will reveal its time except Him. It lays heavily upon the heavens and the earth. It will not come upon you except unexpectedly.' They ask you as if you are familiar with it. Say, 'Its knowledge is only with Allah, but most of the people do not know'" (Surah A'raf 7 verses 187). Based on this background, there is no reason for Muslims to deny the existence of the Hour. The issue is that we only know the signs of the Hour, and it is coming closer according to the Holy Quran.

In this article, we focus on the indicator of the greenery of Arabia mentioned in the hadith in the first paragraph. Our focus is based on natural phenomena that drive changes in landmass. The hadith explicitly states that the changing landmass of Arabia will return to being green. To explore this statement, we approach it from two perspectives of natural sciences, namely geological and meteorological features. Some scholars have written articles about the past greenery of Arabia, but they have excluded the hadith and did not integrate it. Therefore, we integrate insights from these natural sciences and the hadith to uncover the most likely reasons why Arabia will become green in the future.

This article is a review study that examines the movement of the Arabian Plate towards north in a counter-clockwise rotation, which will later affect its latitude position. The new latitude position will change the regional climate, directly influencing the thriving of

[1] Barbara Freyer Stowasser, “The End Is Near: Minor and Major Signs of the Hour in Islamic Texts and Contexts,” n.d.

plants due to the integration of weather, humidity, soil water content, and other bio-chemical processes that lead to changes in landmass. On the other hand, we also consider meteorological climate cycles that affect Arabia and cause landmass changes over relatively short periods. Through this article, we aim to draw a conclusion that proves the hadith using two different perspectives and determine which one is more favorable. We also assess the probability of when the Arabian Peninsula will become meadows with rivers flowing on the landmass, using geology and meteorological approaches.

Climate change is a significant factor that can rapidly alter landmasses worldwide, including the Arabian Plate. The amount of specific greenhouse gases can either decrease or increase temperatures, leading to changes in the landmass of different regions. Climate change is a result of radiative forcing (RF), which represents the net energy balance of the Earth's system between incoming and outgoing energy. This energy can come from the sun and the Earth itself. An imbalance in the incoming and outgoing energy creates radiative forcing that affects the climate system. Positive radiative forcing occurs when incoming energy is greater than outgoing energy, resulting in heating of the Earth, while negative radiative forcing occurs when outgoing energy is greater than incoming energy, leading to cooling of the Earth.

RF is expressed in watts per square meter over an average period of time. Although it is usually difficult to observe, calculated RF provides a simple quantitative basis for comparing aspects of the potential climate response to different factors, especially global mean temperature. Therefore, it is widely used in the scientific community[2]. However, an alternative definition of RF is the change in net downward radiative flux at the tropopause, considering the readjustment of stratospheric temperatures to radiative equilibrium while holding surface and tropospheric temperatures and state variables such as water vapor and cloud cover fixed at their unperturbed values[3]. In simpler terms, solar irradiation can be considered the main player in measuring the flux value.

RF can be classified into two sub-classes: Anthropogenic Radiative Forcing and Natural Radiative Forcing. Anthropogenic Radiative Forcing is driven by human activities, such as the increased amount of carbon dioxide, carbon monoxide, methane, nitrogen oxide, and other chemical formulas. Natural Radiative Forcing, on the other hand, is driven by natural activities including volcanic eruptions, asteroids, and sun-earth alignments In this article, we focus solely on Natural RF, which will affect the climate cycle regardless of any

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[2] Intergovernmental Panel On Climate Change, ed., "Anthropogenic and Natural Radiative Forcing," in *Climate Change 2013 – The Physical Science Basis*, 1st ed. (Cambridge University Press, 2014), 659–740, https://doi.org/10.1017/CBO9781107415324.018.

[3] Intergovernmental Panel On Climate Change.

human interruption based on previous research by Lourens[4], Jalihal[5], Caccamo & Magazu[6], and Pokras[7]. This limitation is based on the consideration that if Anthropogenic RF causes an abrupt change in the climate cycle, it could be resolved as soon as possible due to dynamic human behavior.

Natural RF is mainly measured through volcanic eruptions and solar irradiance, while the impact of asteroids is excluded due to the high uncertainty surrounding their effects. Volcanic eruptions, which release a significant amount of sulfur dioxide into the atmosphere, are a well-known natural cause of climate change that can last for years or even decades. One of the most notable climate changes caused by a volcanic eruption occurred in 1815 following the eruption of Mount Tambora. The eruption emitted 60 to 80 megatons of SO2 to the stratosphere (44 km high)[8]. The spread of SO2 across the tropics and its oxidation to form H2SO4, known as sulfate aerosols, blocked sunlight from reaching the Earth's surface and caused global effects. The year 1816, known as the "year without summer" in Europe, and the ensuing depressed situation in Europe and epidemic disease in Bengal are examples of the impacts of the 1815 Tambora eruption.

Furthermore, the alignment of the sun and Earth, known as Milankovitch Cycles, plays a strategic role in Earth's climate. One of the clearest effects of these cycles is the occurrence of Ice Ages. Milankovitch cycles consist of eccentricity, obliquity, and precession. Eccentricity refers to the shape of Earth's orbit, which has a cycle period of 100,000 years. The change in Earth's orbit is influenced by the gravitational pulls of Jupiter and Saturn, resulting in different seasons in the subtropical zone. Obliquity represents the tilted angle of Earth relative to its orbital plane, ranging from 22.1 to 24.5 degrees with a cycle period of 41,000 years. This variation in tilt angle leads to differences in climate at specific latitudes, resulting in cooler summers and hotter winters or vice versa. Currently, obliquity is slowly

[4] Lucas J. Lourens, "The Variation of the Earth's Movements (Orbital, Tilt, and Precession) and Climate Change," in *Climate Change* (Elsevier, 2021), 583–606, https://doi.org/10.1016/B978-0-12-821575-3.00028-1.

[5] Chetankumar Jalihal et al., "The Response of Tropical Precipitation to Earth's Precession: The Role of Energy Fluxes and Vertical Stability," *Climate of the Past* 15, no. 2 (March 19, 2019): 449–62, https://doi.org/10.5194/cp-15-449-2019.

[6] Maria Teresa Caccamo and Salvatore Magazù, "On the Breaking of the Milankovitch Cycles Triggered by Temperature Increase: The Stochastic Resonance Response," *Climate* 9, no. 4 (April 18, 2021): 67, https://doi.org/10.3390/cli9040067.

[7] Edward M. Pokras and Alan C. Mix, "Earth's Precession Cycle and Quaternary Climatic Change in Tropical Africa," *Nature* 326, no. 6112 (April 8, 1987): 486–87, https://doi.org/10.1038/326486a0.

[8] Achmad Djumarma Wirakusumah and Heryadi Rachmat, "Impact of the 1815 Tambora Eruption to Global Climate Change," *IOP Conference Series: Earth and Environmental Science* 71 (June 2017): 012007, https://doi.org/10.1088/1755-1315/71/1/012007.

decreasing and will impact hotter winters for at least 9,800 years away[9]. Precession refers to the wobbling of Earth's axis of rotation caused by tidal forces from the Sun and Moon. This wobble causes Earth to bulge at the equator and affects its rotation. The current wobble leads to moderate seasonal variations in the Northern Hemisphere and more extreme seasons in the Southern Hemisphere[10]. Roughly 13,000 years from now, this condition will flip, resulting in more extreme seasons in the Northern Hemisphere and moderate seasons in the South.

Earth's precession is one important agent delivering sunlight to the Earth. In the Northern Hemisphere, the current movement affects less hotter summers and colder winters while the latitude remains constant. Thus, a flip in the direction of the precession angle for the next 13,000 years will obviously result in more extreme weather, including in the Saudi Arabian Peninsula. The sunlight received by Earth will affect the Inter-Tropical Convergence Zone (ITCZ), a region at a specific latitude that carries global winds and circulates hot and mild air. The position, structure, and migration of the ITCZ influence ocean-atmosphere and land-atmosphere interactions on a local scale, the circulation of the tropical oceans on a basin scale, and various features of Earth's climate on a global scale[11]. Simply put, it leads to changes in climate and the reformation of landmasses.

Another factor that will affect solar irradiance is plate tectonics, a theory proposed by Alfred Wegener in the early 20th century known as continental drift[12]. nitially, the theory was not accepted by other researchers due to the existence of another well-known theory at that time. However, decades later, most researchers admitted its validity, and it now stands as the last and strongest theory in the geological framework. The theory introduces the idea that Earth's landmasses comprise plates that move either toward or away from each other, shaping the evolution of landmasses. This has been studied by Plasienka[13], Verstappen[14], and Ziegler[15]. The Arabian Plate, in particular, is a counter-clockwise moving plate that had a different position relative to its current position. Although plate movements take millions of

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9 Alan Buis, "Milankovitch (Orbital) Cycles and Their Role in Earth's Climate," February 27, 2020, https://climate.nasa.gov/news/2948/milankovitch-orbital-cycles-and-their-role-in-earths-climate.

10 Buis.

11 D.E. Waliser and X. Jiang, "TROPICAL METEOROLOGY AND CLIMATE | Intertropical Convergence Zone," in *Encyclopedia of Atmospheric Sciences* (Elsevier, 2015), 121–31, https://doi.org/10.1016/B978-0-12-382225-3.00417-5.

12 Alfred Wegener, "Die Entstehung der Kontinente," *Geologische Rundschau* 3, no. 4 (July 1912): 276–92, https://doi.org/10.1007/BF02202896.

13 D Plasienka, "Plate Tectonics and Landform Evolution," *EARTH SYSTEM: HISTORY AND NATURAL VARIABILITY* Vol. II (2009).

14 Herman Th. Verstappen, "Indonesian Landforms and Plate Tectonics," *Indonesian Journal on Geoscience* 5, no. 3 (September 28, 2010): 197–207, https://doi.org/10.17014/ijog.v5i3.103.

15 Martin A. Ziegler, "Late Permian to Holocene Paleofacies Evolution of the Arabian Plate and Its Hydrocarbon Occurrences," *GeoArabia* 6, no. 3 (July 1, 2001): 445–504, https://doi.org/10.2113/geoarabia0603445.

years with variations in slip rates ranging from several millimeters to centimeters per annum, it is clear that the plates are indeed moving. In 1966, Wilson[16], proposed the theory of the Wilson Cycle, which serves as a basic explanation for plate tectonics. It outlines the concept in which the repeated opening and closing of ocean basins along the same plate boundaries is a key process in the assembly and breakup of continents and supercontinents.[17]

Both the geological and meteorological approaches are explained in detail in the discussion chapter.

B. DISCUSSION

1. Regional Geology and Meteorology of Arabia

Arabia is a peninsula which considered as single plate namely Arabian Plate. Plate is a massive rock blanket liquid masses of internal earth. The position of Arabian Plate is bordered with rigorous Zagros Mountains lies to the west and vast East Africa depression along with steep Red Sea to the east. Arabian Peninsula is comprising wide of Pre-Cambrian igneous and metamorphic complex covering one third of the peninsula, then deposited thick sea-sedimentary layers (fig. 1). [18]

Arabian Plate interior has some of current active faults, reveal the current motion of entire plate is affected by regional stresses throughout the plate during Mesozoic and Cenozoic[19] such as Najd Strike-Slip System.[20] Particularly for the plate borders, which actively move for different number of millimeters per year due to regional position. To the west, a northwest directional Red Sea is lying which compromised by Dead Sea Fault system[21] and sharpen the Gulf of Aqaba. The Red Sea itself is a pull-apart-product from the African Plate and Arabian Plate, which being rotated anti-clockwise with a pole near 17 ^{o} N

[16] J. Tuzo Wilson, "Did the Atlantic Close and Then Re-Open?," *Nature* 211, no. 5050 (August 1966): 676–81, https://doi.org/10.1038/211676a0.

[17] R. W. Wilson et al., "Fifty Years of the Wilson Cycle Concept in Plate Tectonics: An Overview," *Geological Society, London, Special Publications* 470, no. 1 (January 2019): 1–17, https://doi.org/10.1144/SP470-2019-58.

[18] R.W Powers et al., "Geology of the Arabian Peninsula Sedimentary Geology of Saudi Arabia," Professional Paper, 1966.

[19] Graham Brew et al., "Tectonic and Geologic Evolution of Syria," n.d.

[20] Ahmed Salem and Mohammed Y. Ali, "Mapping Basement Structures in the Northwestern Offshore of Abu Dhabi from High-Resolution Aeromagnetic Data: Mapping Basement Structures," *Geophysical Prospecting* 64, no. 3 (May 2016): 726–40, https://doi.org/10.1111/1365-2478.12266.

[21] Sam Joffe and Zvi Garfunkel, "Plate Kinematics of the Circum Red Sea—a Re-Evaluation," *Tectonophysics* 141, no. 1–3 (September 1987): 5–22, https://doi.org/10.1016/0040-1951(87)90171-5.

latitude amidst the sea.[22] To the south, trends of Gulf of Aden from west to east fence the Arabian Plate[23], along with northeastern-direction of Owens fracture zone which divided the Arabian and Indian Plate. The most eastward line of the plate is Zagros Fold-thrust Belt emerging the range of mountainous Iranian highland. All the borders are recently formed during middle and late Tertiary.[24]

Figure 1. Arabian plate location relative to other surrounding major plates, green and dark grey indicate Precambrian Arabian Shield and Cenozoic Basalt.[25]

Positioned latitude 12.5^{o} to 37.5^{o}, the peninsula has different types of regional climates. The climate of Arabia is mainly hyper-arid and arid which lead to wide desert cover most of region, and famous as subtropical desert belt. Yet, moist is easily find in the north where latitude is getting higher and temperature is getting colder. These types of climates comply of changing latitudes. Tropical climate will affect the equatorial and surrounding area both up and down latitudes. This climate has highest precipitation up to 59 inches per annum caused most of tropical forest and varies of plant are very-well thriving. Getting latitude higher for about 20^{o} to 30^{o}, climate become drier and precipitation rate is getting lower. This dry climate mostly has lower moisture and water vapor because of rapid evaporation than the smaller latitude. However, plants become more restricted to thrive due to lack of water. The dry climate is the most suitable desert to grow up. Go far from the equator, temperate climate

[22] Robert Reilinger and Simon McClusky, "Nubia-Arabia-Eurasia Plate Motions and the Dynamics of Mediterranean and Middle East Tectonics: Mediterranean and Middle East Geodynamics," *Geophysical Journal International* 186, no. 3 (September 2011): 971–79, https://doi.org/10.1111/j.1365-246X.2011.05133.x.

[23] Abdullah ArRajehi et al., "Geodetic Constraints on Present-Day Motion of the Arabian Plate: Implications for Red Sea and Gulf of Aden Rifting," *Tectonics* 29, no. 3 (2010): 1–10, https://doi.org/10.1029/2009TC002482.

[24] A.S. Alsharhan and A.E.M. Nairn, "The Geological Histroy and Structural Elements of the Middle East," in *Sedimentary Basins and Petroleum Geology of the Middle East* (Elsevier, 2003), 15–63, https://doi.org/10.1016/B978-044482465-3/50003-6.

[25] Peter R. Johnson and Beraki Woldehaimanot, "Development of the Arabian-Nubian Shield: Perspectives on Accretion and Deformation in the Northern East African Orogen and the Assembly of Gondwana," *Geological Society, London, Special Publications* 206, no. 1 (January 2003): 289–325, https://doi.org/10.1144/GSL.SP.2003.206.01.15.

take shape on higher latitude from dry climate. This zone is typically ranging from 30^o to 50^o and has humid and warm summer. The precipitation relatively higher than dry climate. Hence, region which lie on these latitudes have more type of plants. The rest climates are continental and polar climate which have higher latitude position respectively (fig. 2).

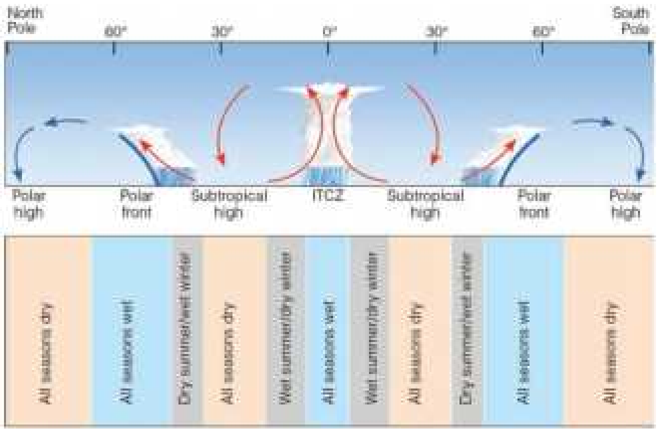

Figure 2. A vertical cross section of ideally global climate from North to South Pole. The upwelling and downwelling patterns are influencing region precipitation and its cloud development[26].

The tropical region carries winds to converge near the equator and surrounding areas mentioned as Inter-Tropical Convergence Zone (ITCZ)[27]. This type of wind produces rising air then make up abundant tower clouds. Consequently, where the cloud is being condensed at the high elevation its temperature decrease, high amount of rainfall will follow throughout a year. Off the equator, near latitude 30^o, the subsidence air of the subtropical highs produces a "dry belt" around the globe, although not all of earth region will have 30^o desert. The Arabian Desert of Arabia which we studied and the Australian Desert of the Greater Land of Australia lie within this belt. In these regions, precipitation is limited during a year with humidity is lower than equators tropical climate, and rain is scarcely falling, the arid region is emerged and advanced to be a desert (fig. 3). However, desert also can be constructed by topography due to forcing air rise along their windward slopes called orographic uplift. Therefore, the windward side of mountains tends to be wet. As air descends and warms along the leeward side, there is less likelihood of clouds and precipitation. Thus, the leeward or downwind side of mountains tends to be dry called rain shadow[28]. Two types of desert genesis answer the vast and arid Arabian Desert covering most of the peninsula. It also will answer why the Hijaz and Asir mountains are considered as favorable destination during hot summer in the Arabia will reveal in this article.

[26] C. Donald Ahrens and Robert Henson, *Meteorology Today: An Introduction to Weather, Climate, and the Environment*, Twelfth edition (Boston, MA: Cengage, 2019).
[27] Ahrens and Henson.
[28] Ahrens and Henson.

Desert has actually myriad term based on several sources. Edgell[29] defined desert as a temperate region that receives an average annual rainfall of less than 250 mm a year, generally infrequent, where evaporation exceeds precipitation. The Arabian Desert southernmost part located in Yemen, on the tip of peninsula facing towards Gulf of Aden. To the east, Gulf of Persia, a narrow-elongated sea fences east coast of desert and light northward of the gulf edge Biltis-Zagros Mountain Range cease the desert grains.

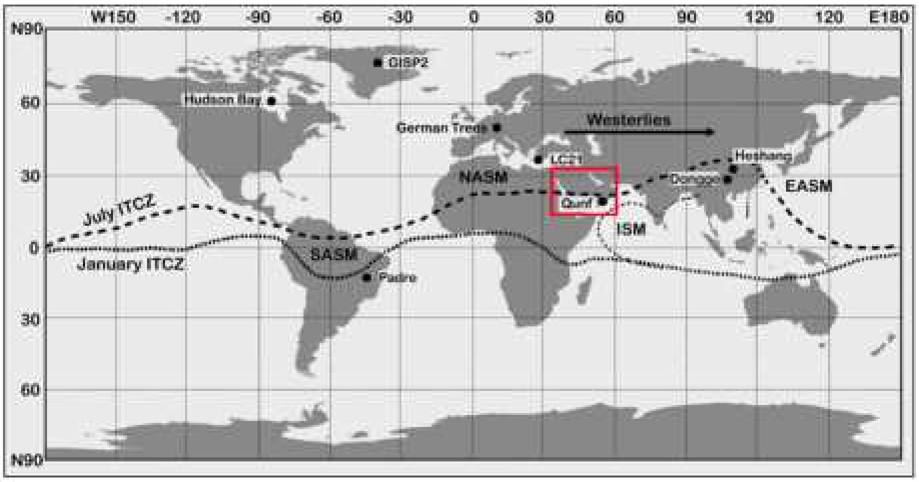

Figure 3. Annual global ITCZ pattern shows the southern line during winter January and northern dashed during summer July[30]. Northern dashed line is crossing southern of Arabian Peninsula marked by red box.

Precipitation threshold were hyper-arid region when rainfall less than 25 mm, arid when rainfall in between 25 to 200 mm and, semi-arid when it excess 200 mm and up to 500 m.[31] Interestingly, almost all part of Arabian peninsulas fits these parameters. Annual precipitation of Arabian Peninsula is generally much lower than 300 mm, except southwestern region of Raymah -a southern region of the Capitol Sana'a and northern-center peninsula of Hafar Al Batin whose 300 mm to maximum 600 mm[32] with exceptionally for Lebanon, Palestine and Syiria. Yet the coverage of peninsula's desert only less of one-third of sand dunes, rest of it comprise arid plains, rocky deserts, clay flats, and lesser salt flats.[33] According to Koppen-Geiger climate classification, the peninsula and adjacent area are mostly classified as Bwh category of dry, arid, hot, low-latitude deserts. The second largest is

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[29] H. Stewart Edgell, *Arabian Deserts: Nature, Origin and Evolution* (Dordrecht: Springer, 2006).

[30] Bernhard Weninger et al., "Neolithisation of the Aegean and Southeast Europe during the 6600–6000 CalBC Period of Rapid Climate Change," *Documenta Praehistorica* 41 (December 30, 2014): 1–31, https://doi.org/10.4312/dp.41.1.

[31] A.T Grove, "The Geography of Semi-Arid Lands," *Philosophical Transactions of the Royal Society of London. B, Biological Sciences* 278, no. 962 (May 3, 1977): 457–75, https://doi.org/10.1098/rstb.1977.0055.

[32] Richard P. Jennings et al., "The Greening of Arabia: Multiple Opportunities for Human Occupation of the Arabian Peninsula during the Late Pleistocene Inferred from an Ensemble of Climate Model Simulations," *Quaternary International* 382 (September 2015): 181–99, https://doi.org/10.1016/j.quaint.2015.01.006.

[33] Edgell, *Arabian Deserts*, 2006.

BSh classification fill up north part of peninsula and slope of Zagros Mountain Range. Rest of them are H points out the highland area with relatively high precipitation such as Yemen Highland and Asir Mountain, and Csa considered as mild near with Mediterannean.

Out of ITCZ of Middle East, arid weather also can be found out by presence of rain shadow. Rain shadow desert of the peninsula was found along the eastern of Precambrian metamorphic and igneous rocks complex, in the western part of Peninsula elevated from 1000 up to 4000 m above sea level. The humid and rich-water-vapor which evaporated from Red Sea in the west are transporting to the west. When the altitude getting higher throughout Hijaz, Asir and Yemen highlands, water vapor will be easily condensed and forming rainfall (fig. 4). After that, the wind will keep push upward bypassing top of the mountain range with less water content and drop to the other side. As a result, the drier wind with very less water vapor envelop leeside of the range, make up dry and arid environment which sometimes lead rain shadow desert. This scenario possibly covers small part of Arabian desert near to the northwestern-southeastern mountain range.

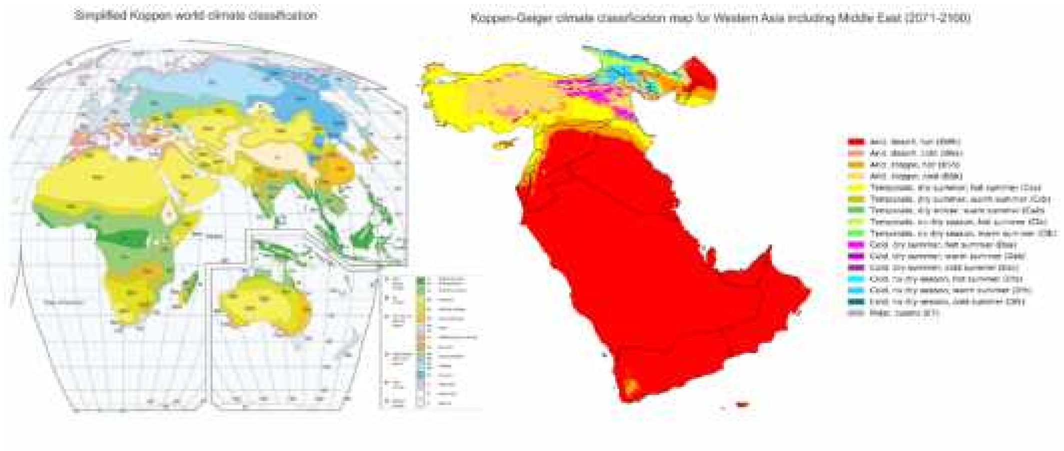

Figure 4. Simplified Koppen world climate classification map[34] and Koppen-Geiger climate classification map for far future of Western Asia including Middle East.[35] At present day the Arabian Peninsula is facing arid hot desert with a small area experiences highland climate in the southwestern tip of peninsula in Yemen and Hijaz-Asir-elongated shape highlands.

In this article, we review some scenarios how the Middle East, particularly Arabian Landmass once was used to be greeneries and lushes, then absolutely will be the same way in the future. Both geology and meteorological visions is applied to the hadith to overcome and project what will happen in the future which means more than centuries, hundred thousands of years, or even million years to go. An agent that will change the peninsula is plate motion of

[34] Ahrens and Henson, *Meteorology Today*.

[35] Hylke E. Beck et al., "Present and Future Köppen-Geiger Climate Classification Maps at 1-Km Resolution," *Scientific Data* 5, no. 1 (October 30, 2018): 180214, https://doi.org/10.1038/sdata.2018.214.

Arabian Plate towards anti-clockwise north[36] which later unraveled by Arrajehi[37]. Besides, ancient paleo-climate and paleo-environment also take a part of shaping the peninsula being environmentally harsh. Garzanti et al[38] said that winds are major agent to make the dusty desert of Arabia, overlying from Oman to the south and Syiria up the north. Nevertheless, the presence of paleo-climate and paleo-environment of Arabia in the past that decayed into hydrogeological features in present day tell about waters and lithologies are connected one each other beyond surfaces.

2. Geological Approach

Using plate motion theory, Arabia will experience a change in latitude from its current position. The Arabian Plate is a puzzle piece that began separating from the African Plate during the Oligocene period.[39] This separation is considered a special type of rifting known as the "RRR triple junction," which refers to the three directions of extensional product at the junction. A triple junction is a place where three lithospheric plates intersect and meet [40] another boundary. These three directional separations are located in Afar, a wide depressional land in Djibouti, Africa. The motion of magmatic fluid in the convergent cell beneath the lithospheric mantle caused the African Plate to gradually separate approximately 25 million years ago[41], and this process is still ongoing today. As a result, the giant African Plate separated into the Nubian Plate, which moved relatively northwest, and the Somalian block, which settled to the south[42]. The Arabian Plate itself is located east of the Nubian Plate.

The Arabian Plate has been driven away from the African Plate due to the rifting phase, which later transitioned into the spreading phase. The spreading phase is a result of the extensional regime that transformed the continental crust into oceanic crust. The distinct layer positions, with the oceanic crust always being pushed onto the continental crust, suggest a complex and ideal movement of the Arabian Plate from its ancestor. The Red Sea rift is

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[36] Mark R. Hempton, "Constraints on Arabian Plate Motion and Extensional History of the Red Sea," *Tectonics* 6, no. 6 (December 1987): 687–705, https://doi.org/10.1029/TC006i006p00687.

[37] ArRajehi et al., "Geodetic Constraints on Present-Day Motion of the Arabian Plate: Implications for Red Sea and Gulf of Aden Rifting."

[38] Eduardo Garzanti et al., "Provenance and Recycling of Arabian Desert Sand," *Earth-Science Reviews* 120 (May 2013): 1–19, https://doi.org/10.1016/j.earscirev.2013.01.005.

[39] J. M. Gaulier and P. Huchon, "Tectonic Evolution of Afar Triple Junction," *Bulletin de La Société Géologique de France* 162, no. 3 (May 1, 1991): 451–64, https://doi.org/10.2113/gssgfbull.162.3.451.

[40] Vincent S Cronin, "Chapter 11. Types of Triple Junctions," 2012.

[41] Reilinger and McClusky, "Nubia-Arabia-Eurasia Plate Motions and the Dynamics of Mediterranean and Middle East Tectonics."

[42] U. Kumar, C. P. Legendre, and B. S. Huang, "Crustal Structure and Upper Mantle Anisotropy of the Afar Triple Junction," *Earth, Planets and Space* 73, no. 1 (December 2021): 166, https://doi.org/10.1186/s40623-021-01495-0.

considered the boundary between the Arabian and Nubian Plates, while the Gulf of Aden separates the Arabian and Somalian Plates.[43]

The opening of west-east directional Gulf of Aden and northwest-southeast Red Sea indicated as soon as ~31–30 Ma[44]. This continental break-up triggered the splitting among Africa and Arabia Peninsula during Early Miocene[45], or slightly earlier in the Oligocene.[46]

The break-up driven plate is likely due to different vector value amidst these plates since 30-35 Ma though they were moving together within level rate of 3 cm/year at 65 Ma.[47] Even all have the equal direction to anti-clockwise northeast, it is African plate which slows its velocity during Early Oligocene. The wider plate has been reduced it to 1 cm per annum compared to the narrower Arabian plate which has constant vector value of 3 cm each year. Latest precise geodetic study conducted by Arrajehi[48] stated that the opening Red Sea and Gulf of Aden was conformably caused by different vector rate, where the Nubia block are moving by 6.6 mm/year and Arabian Plate are sliding out by 20.6 mm/year. These differences emerged coincidently to the opening of the seas (fig. 5).

Matter of the deduction of African Plate are still in enigma.[49] However, there are some reasons to reveal this high-impact-phenomenon. Reilinger & McClusky[50] summarized (1) pulling of the trailing plate towards the trench due to the sinking of the ocean lithosphere along subduction zones, (2) extension of the overriding plate due to migration of the trench towards the subducting plate called slab rollback, (3) pushing of the plate along mid-ocean ridges due to gravitational sliding of the plate down the oceanic isotherm defining the oceanic lithosphere–asthenosphere boundary, (4) traction forces due to relative motion between the lithosphere and underlying asthenosphere, (5) retarding forces due to continent–continent collision and (6) forces due to friction along strike-slip boundaries (i.e. transform faults).

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[43] William Bosworth, Philippe Huchon, and Ken McClay, "The Red Sea and Gulf of Aden Basins," *Journal of African Earth Sciences* 43, no. 1–3 (October 2005): 334–78, https://doi.org/10.1016/j.jafrearsci.2005.07.020.

[44] William Bosworth and Daniel F. Stockli, "Early Magmatism in the Greater Red Sea Rift: Timing and Significance," ed. Ali Polat, *Canadian Journal of Earth Sciences* 53, no. 11 (November 2016): 1158–76, https://doi.org/10.1139/cjes-2016-0019.

[45] Joffe and Garfunkel, "Plate Kinematics of the Circum Red Sea—a Re-Evaluation."

[46] N. Bellahsen et al., "Why Did Arabia Separate from Africa? Insights from 3-D Laboratory Experiments," *Earth and Planetary Science Letters* 216, no. 3 (November 2003): 365–81, https://doi.org/10.1016/S0012-821X(03)00516-8.

[47] J Dercourt et al., *Atlas Peri-Tethys, Paleogeographical Maps.* (Paris: Commission for the Geologic Map of the World, 2000).

[48] ArRajehi et al., "Geodetic Constraints on Present-Day Motion of the Arabian Plate: Implications for Red Sea and Gulf of Aden Rifting."

[49] Bellahsen et al., "Why Did Arabia Separate from Africa?"

[50] Reilinger and McClusky, "Nubia-Arabia-Eurasia Plate Motions and the Dynamics of Mediterranean and Middle East Tectonics."

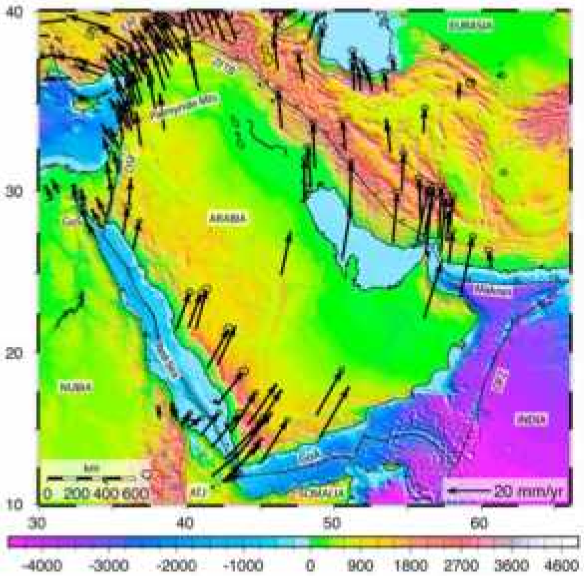

Figure 5. Relative motion of Arabian Plate using a GPS velocity vector data.[51] Abbreviation: EAF, East Anatolian fault; GoS, Gulf of Suez; ATJ, Afar Triple Junction; ZFTB, Zagros fold-thrust belt; GoA, Gulf of Aden; OFZ, Owens fracture zone.

According to absolute motion of Arabian Plate, which widening up the Red Sea and narrowing Gulf of Persia, in a matter of time, the climate region will definitely change. Such as the Csa climate classification on the Palestine, Lebanon, and Syiria which affected by Mediterranean Sea. The sea is 2.5 million meter square bisects Europe and Africa but connects to western of Asia. The matter of area is having moderately wide and long sides, to optimize evaporation and water vapor content of convergence air. Tropical, mild, and moist climate regions are located near thousands of kilometer air-free above oceans. For instance, Mediterranean Sea has more than 3,700 km long and 620 km of its wide and West Indian landmass tropical region which located near the latitude of arid southern Arabian peninsulas, facing toward 2,500 km away of open Indian Ocean. It is as tropical as Yucatan Peninsula and its adjacent area likely Greater and Lesser Antilles which located at same northern latitude of Sahara and Arabian Desert. The area is amidst profoundly 5,100 km Atlantic Ocean and more than halfway of earth's circle Pacific Ocean. In contrary, the broadest distance of Red Sea separating Africa and Arabia Landmasses is 357 km near the city of Jazan while the narrowest strait is only 28 km long in Bab al Mandab with an average about 260 km away. This gap is inadequate to make the Arabia Peninsula green, except the gap is much wider like the length of Mediterannean Sea which will take millions or even hundreds millions years to go.

[51] ArRajehi et al., "Geodetic Constraints on Present-Day Motion of the Arabian Plate: Implications for Red Sea and Gulf of Aden Rifting."

3. Meteorological Approach

This approach in detail recaps paleo-climate and paleo-environment constraint. Begin with ancient Fertile Crescent, a throw-back over 6000 years ago domestication. Mesopotamia considered as the oldest farming-culture blessed by crescent shape of fertile soil. The shape is made of Tigris, Eufrat, Jordan and Nile Rivers sediment. The sediment deposited from Anatolian Highland to the north of Tigris and Eufrat, where Jordans' upstream located on the highland of Jordan and Israel, so on with the Nile which eroded from Ethiopian Highland far to the south. River stream is an agent to picked top soil up then rushes down from the mountain and floods land. Fertile Crescent and Arabian Desert located side-by-side. In the other hand, Fertile Crescent is excluding Nile downstream of Egypt[52] resulting the western border of crescent halted approximately in Palestinian Landform.

The presence of Fertile Crescent grew Sumerian as the earliest civilization, and this fertile land exist towards nowadays. It is neither matter of paleo-climate nor paleo-environment but river deposition of rich-organic-matter topsoil. Also the Nile watershed which has greenery landform and many cultivations, are obviously related to its alluvial deposit containing numerous minerals eroded from highland. In the same way, Arabian Desert also has its own rivers with majority of non-perennial watercourse. Nevertheless, group of water catchments in peninsula were made by Rausch et al.[53] of Wadi Ar-Rimah and Wadi Ad-Dawasir excluding Tigris and Eufrat. These two rivers are considered as paleo-river within last thousand years, and might be full of water once hit by significant rainfalls.

Edgell[54]revealed as much as 24 paleo-lakes across dry environment in the peninsula, some of captivating and famous are: Rub al Khali or called the Empty, An Nafud, and Umm as Samim paleo-lakes (fig 6). These three of paleo-lakes are containing abundant of freshwater mollusks, which formed in wetter condition than present day. Wet, humid and semi-arid conditions accommodated formation of lakes during last period. Different climate conditions of Arabian Peninsula have been majorly affected by rainfall precipitation amounts annually then extended to humidity.

[52] Albert T. Clay, "The So-Called Fertile Crescent and Desert Bay," *Journal of the American Oriental Society* 44 (1924): 186, https://doi.org/10.2307/593554.
[53] Randolf Rausch et al., "The Scarp Lands of Saudi Arabia," *Arabian Journal of Geosciences*, March 26, 2013, https://doi.org/10.1007/s12517-013-0918-1.
[54] Edgell, *Arabian Deserts*, 2006.

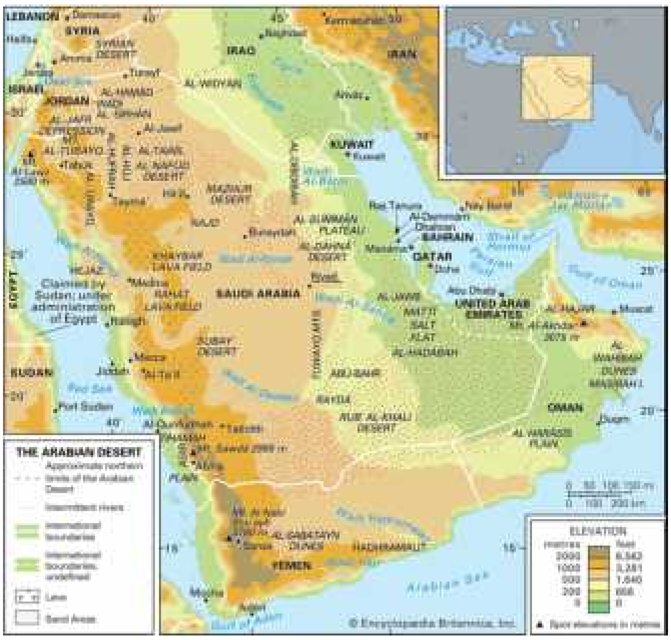

Figure 6. Arabian desert map, showing the Rub al-Khali desert[55] located in the southern part of peninsula which elvated among 500 to 1640 m above sea level.

In this paper, we will discuss deeper about Rub Al Khali which considered as the largest sand desert in the world, covers up to 560,000 km sq.[56] The annual rate of precipitation in Rub al Khali merely not excesses than 40 mm reckoned data from 1960 to 2014.[57] In addition, the hottest place in peninsula also located over the Rub al Khali with more than 30 degree celcius extend northward and westward within the country.[58] Following research from Matter et al.[59] resulting extend the spatial coverage of evidence and show that most of the lake deposits correlate to Marine Isotope Stage (MIS) 5 circa 130,000-70,000 years ago and the Early/Mid Holocene circa 11,000-5,500 years ago. MIS is a warm-cool period of earth's paleo-climate. The evidence of past temperature, fossils of fish is supported rich and diverse[60] as well as mollusks, bivalves and grasses developed within vast intra-dunes lakes. The existence of ancient lakes in the peninsula once triggered us to review what were happened last couple thousands of years.

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[55] L Owen, William L. Ochsenwald, and Donald August Holm, *Arabian Desert Map* (Encyclopedia Britannica, n.d.), https://www.britannica.com/place/Arabian-Desert.

[56] Arun Kumar and Mahmoud M Abdullah, "An Overview of Origin, Morphology and Distribution of Desert Forms, Sabkhas and Playas of the Rub' al Khali Desert of the Southern Arabian Peninsula" 4 (n.d.).

[57] Hassan Basahel and Hani Mitri, "Application of Rock Mass Classification Systems to Rock Slope Stability Assessment: A Case Study," *Journal of Rock Mechanics and Geotechnical Engineering* 9, no. 6 (December 2017): 993–1009, https://doi.org/10.1016/j.jrmge.2017.07.007.

[58] Mansour Almazroui et al., "Future Changes in Climate over the Arabian Peninsula Based on CMIP6 Multimodel Simulations," *Earth Systems and Environment* 4, no. 4 (December 2020): 611–30, https://doi.org/10.1007/s41748-020-00183-5.

[59] Albert Matter et al., "Palaeo-Environmental Implications Derived from Lake and Sabkha Deposits of the Southern Rub' al-Khali, Saudi Arabia and Oman," *Quaternary International* 382 (September 2015): 120–31, https://doi.org/10.1016/j.quaint.2014.12.029.

[60] Matter et al.

A time-lined chronology of Quaternary climate and events in Arabia have been unveiled by Edgell[61] (Table. 1). Turning back into Middle Pliocene, approximately 5.3 million age (Ma) to 3.6 Ma when well-developed drainage systems were found, as well as erosion and deposition of coarse gravels in valley fills. Followed by warm and temperate semi-arid weather until the end of Late Pliocene or 2.58 Ma marked by savannah and woodland condition. The climate fluctuations continuously happen to present day, it ranged from thousands of years to hundreds thousands of years.

Back to thousands hundreds years, the Rub al Khali provided some evidences of the living freshwater animals. Previous studies[62] encountered widespread lacustrine mollusks over one of the driest part in the peninsula. Latter researcher used Optically Stimulated Luminescence (OSL), Thermally-transferred OSL (TT-OSL), Infrared Stimulated Luminescence (ISL), and post-IR Infrared Stimulated Luminescence (pIR-IRSL) to date back the age of its samples. The samples dug from vary thicknesses of deposits between a few decimeters and up to several meters contained *Unio tigridis, Corbicula fluminalis, Melanoides tuberculatus, Biomphalaria sp.* and *Pirenella conica* whom indicated freshwater environment[63] (fig. 7).

[61] Edgell, *Arabian Deserts*, 2006.
[62] Matter et al., "Palaeo-Environmental Implications Derived from Lake and Sabkha Deposits of the Southern Rub' al-Khali, Saudi Arabia and Oman."
[63] Matter et al.

Table 1. A chronology of Quaternary climate and events in Arabia (Revised from Edgell 1989a, 2004).

GEOLOGICAL EPOCH	CHRONOLOGY IN YEARS BP	YEAR RANGE	CLIMATIC PHASE	CLIMATIC EVENTS IN ARABIA
HOLOCENE	0 -700	700	HYPERARID	CONTINUOUS MOVEMENT OF HIGH CRESTED DUNES
	700 - 1300	600	SLIGHTLY MOIST	HOFUF RIVER NOTED BY YAQUT AND OTHER GEOGRAPHERS
	1300 - 1400	100	ARID	DUNE MOVEMENT
	1400 - 2100	700	SLIGHTLY MOIST	SABEAN KINGDOM FLOURISHED AND KINGDOM OF KINDA AT QARYAT AL FAU (ANSARY 1982)
	2100 - 5000	2900	HYPERARID	DUNE MOVEMENT ACTIVE
	5000 - 5400	400	SLIGHTLY MOIST	"NEOLITHIC" CAMP RUB' AL KHALI
	5400 - 5500	100	HYPERARID	HIGH CRESTED DUNES, 'IROS
	5500 - 11000	5500	SEMI-ARID	NEOLITHIC WET PHASE, LAKES IN SW RUB' AL KHALI, FASAD POINTS
LATE PLEISTOCENE	11000 - 22000	11000	HYPERARID (G)	PERSIAN GULF DRY SL -130 M
	22000 - 34000	12000	SEMI-ARID	RUB' AL KHALI, AN NAFUD LAKES
	34000 - 64000	30000	HYPERARID	RUB AL KHALI & WAHIBA DUNES, OSL
	64000 - 99000	35000	SEMI-ARID	SINTER FORMATION SUMMAN CAVES
	99000 - 115000	16000	HYPERARID	RUB AL KHALI & WAHIBA DUNES, OSL
	120000 - 135000	15000	SEMI-ARID	GROWTH OMAN CAVES STALGMITES
MIDDLE PLEISTOCENE	135000 - 180000	45000	ARIDITY (G)	WAHIBA DUNES ACTIVE, GLACIAL
	180000 - 200000	20000	SEMI-ARID	GROWTH OMAN CAVES STALGMITES
	200000 - 210000	10000	ARIDITY	MINOR COLD DRY INTERVAL
	218000 - 240000	22000	SEMI-ARID	WAHIBA AEOLIANITES, SW MONSOON
	240000 - 280000	40000	ARIDITY	ARID, COLD; SL -80M RED SEA
	280000 - 295000	15000	SEMI-ARID	U/Th DATES SPELEOTHEMS OMAN
	295000 - 300000	5000	ARIDITY (G)	MINOR COLD DDRY INTERVAL
	300000 - 335000	35000	SEMI-ARID	U/Th DATES, OMAN SPELEOTHEMS
	335000 - 370000	35000	ARIDITY (G)	ARID, COLD INTERVAL
	370000 - 420000	50000	WET, SEMI-ARID	LARGE ALLUVIAL FANS; SPELEOTHEMS
	420000 - 460000	40000	ARIDITY (G)	ARID COLD INTERVAL SL -80M RED SEA
	460000 - 660000	200000	WET, SEMI-ARID	WARM, WET U/Th DATES SPELEOTHEMS
	660000 - 680000	20000	ARIDITY (G)	DRY INTERVAL LOW DUNES
	680000 - 710000	30000	SEMI-ARID	EARLY ACHEULIAN
	710000 - 790000	80000	ARIDITY (G)	EARLY DUNES, COLD DRY INTERVAL
EARLY PLEISTOCENE	790000 - 868000	78000	SEMI-ARID	OXYGEN ISOTOPE EVIDENCE, WARMER
	868000 - 880000	12000	ARIDITY	EARLIEST COLD PHASE; DUNES
	880000 - 920000	40000	WARM (G)	WARM DEGLACIATION ANTARCTICA
	920000 - 1800000	880000	HUMID SEMI-ARID	OLDUWAN TOOLS, 1Ma TO 1,4 Ma EARLY QUATERNARY DRAINAGE LARGE ALLUVIAL FANS FORMED
LATE PLIOCENE	1800000 - 3600000	1800000	WARM TEMPERATE SEMI-ARID	SAVANNAH WOODLAND CONDITIONS
MIDDLE PLIOCENE	3600000 - 5333000	1733000	WETTER, HUMID	WELL DEVELOPED DRAINAGE SYSTEMS EROSION AND DEPOSITION OF COARSE GRAVELS IN VALLEY FILLS

Figure 7. Mollusk fossils are discovered in the Rub al Khali. 1: Unio tigridis (l = 67 mm); 2. Corbicula fluminalis (l = 17 mm); 3. Melanoides tuberculatus (h = 22 mm); 4. Pirenella conica (h = 14 mm), Biomphalaria sp. (d = 13 mm).[64] Abbreviation: l = length, h = height, d = diameter

[64] Matter et al.

Lacustrine deposit of the Rub al Khali can be divided into three different facies –a body of rock with has specific environment deposition- with the most abundant facies is limestone facies that consists of 60 cm to 270 cm beige micrites, while the others are marl and sandy facies.[65] In addition, presence of the low quartz content signals that the dunes were stabilized by vegetation whereas the non-fossiliferous sandy facies records alternating wet-dry conditions, characterized by insect burrows.[66] The limestone facies indicate broad sediments containing calcium carbonate and somehow dolomite were deposited then lithified during specified period. Calcium carbonate and dolomite primarily can be founded within shelly organism. While marl facies is levelly equal amount of mixed clay and calcium carbonate, sandy facies is a vast sedimentary deposition of sand without any marks of other grain size and non-calcareous. Limestone and marl facies illustrate the development of water remnants abundantly, which demanded enough water table to living in.

The Rub al Khali had two wet conditions as early as 20 kilo age (ka) before present (b.p). This condition accommodated all fossils (a preserved organism within a rock), lake beds (rock layer formed from lake sediment), speleothem (cave features made from dissolve water), and pollen (ancient preserved seed plant) dating that had been collected from different paleo-lakes of inner area from the Mundafan basin and other six smaller lakes. Dating is a method to define ages of samples based on natural raadioactive decays. These fossils and beds then dated back using radiometric dating in order to get the absolute ages of the samples. It revealed that two main periods of high water table occurred in the area between 36 ka – 17 ka b.p with concentration dates between 21 ka and 30 ka b.p as an older phase, and the younger one between 6 ka and 9 ka b.p which all of the phases are including late Quaternary[67]. In fact, radiocarbon dates for the Late Holocene lakes, given by McClure[68] on 14 samples, range from 8,800 ± 100 to 6,100 ± 70 years, except for two older dates of 11,465 ± 115 and 14,965 ± 195 years b.p. The Early Holocene lakes were temporary lakes of the playa-type, which probably received rainfall in several months of the year. They were largely restricted to inter-dune areas, bordered by vegetation of *Typha* and *Phragmites,* and remains of oryx, gazelle and *Bos primigenius* are present. Another latest absolute OSL dating[69] in the same Rub al Khali, that as young as 5.4 ka massive gypsum bed have deposited. It is indicating that the evaporation of

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[65] Matter et al.

[66] Matter et al.

[67] H. A. McClure, "Radiocarbon Chronology of Late Quaternary Lakes in the Arabian Desert," *Nature* 263, no. 5580 (October 1976): 755–56, https://doi.org/10.1038/263755a0.

[68] McClure.

[69] Matter et al., "Palaeo-Environmental Implications Derived from Lake and Sabkha Deposits of the Southern Rub' al-Khali, Saudi Arabia and Oman."

the area extremely high during that year. From 6 ka to the present, the area has been hyper-arid, and the site of some of the world's longest sand dunes.[70]

This wet condition during Quaternary happened for several times. A comprehensive graph compares between ages in several approaches to climate condition during periods. The ages comprise absolute radiometric dating lasting to 200 ka and from MIS 6, other axe is responsible for Monsoon index, OSL of lake deposits, and global ice volume using oxygen isotope.[71] From the graph we can summarize that lake deposits and shells have a group of age that indicating the presence of water body within subjected peninsula. The groups of ages fitted the pattern of oxygen isotopes when global ice were soaring, giving characteristics of colder condition. In coincident, insolation difference of Monsoonal index was getting higher when the oxygen isotopes were diving deeper to minus. The colder condition decreased temperature globally whereas the monsoonal index has positive correlation to precipitation numbers. Where monsoonal index hit its peak of defined period, the global ices volume was used to follow the pattern to increase. Thus, the number of water being rainfall due to cooling temperature was increasing, made up higher water table of the Rub al Khali in particular area, which covered the entire peninsula (fig. 8).

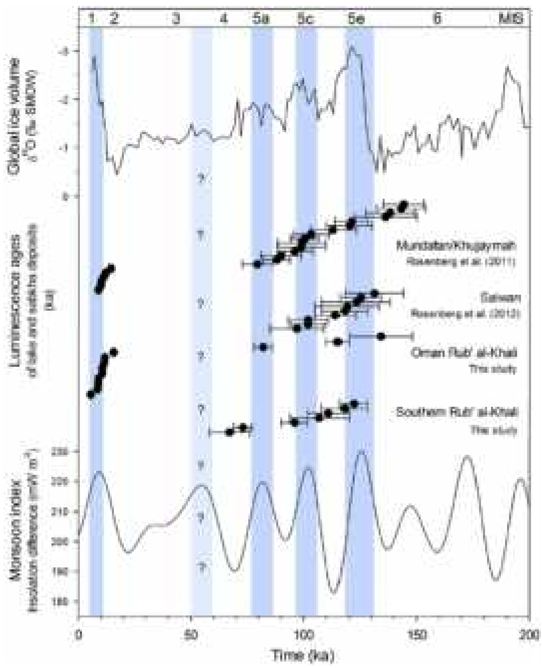

Figure 8. Past global climate condition using comparation between global ice volume from oxygen isotopes, absolute luminescence (OSL) ages of lakes samples, and monsoon insolation difference indices[72].

[70] Edgell, *Arabian Deserts*, 2006.
[71] Matter et al., "Palaeo-Environmental Implications Derived from Lake and Sabkha Deposits of the Southern Rub' al-Khali, Saudi Arabia and Oman."
[72] Matter et al.

The blue areas indicate all events that strongly correlate to each other. Groups of absolute dating from lake beds and fossils spotted in area of blue, in coincident with events of increasing global ices volume and monsoonal index. The latest wetter condition last for approximately 5 to 10 ka b.p and it was confirmed from 6 ka to 9 ka b.p in the Mundafan Basin within Rub al Khali researched by McClure[73]. However, on the graph is not showing an interval of 21 ka and 30 ka b.p which previously mentioned by McClure[74] instead of inferred wetter condition with no evidence of fossil and lake bed records for earlier year at 50 ka to 60 ka b.p. By that means, using chronological Quaternary issued by Edgell[75] is a must to summary and predict what will happen in the future from a simple approach.

The first scenario begin with how long it takes when the Red Sea Spreading reaches minimum wide of the Sea to feed up surrounding region. Precipitation will rocket when the water amount is high, thus vast open water space is needed to accomplish this demand to thrive plants and stream rivers altogether. At least 620 km length open-sea is demanded as wide as Mediterannean Sea north-south section to construct at least mild climate. With the gap rate of the Arabian and Nubian Plate by 14 mm annually, and subtracting value in between Mediterannean and Red Sea distances is 360 km, geological measurement can be conducted simply quiet.

Dividing gap distance of 360 km and 14 mm per annum, we will have ~25 million years to go. This value is as ancient as Late Oligocene Warming Events at the southern North Sea Basin was taken during Upper Oligocene[76] on the reverse time. That fascinating time sounds impossible about human being existence to carry on since the first of human appearance at mere 11,000 years ago, though that number is sound minuscule relative to 4.54 billion years or 176.58 back-to-back times. Indeed, it is too long to assure 2,337.67 of the same Holocene including existence of us. Almost nothing to worry about but earthquakes that will hit some regions along the border plates. And note that we simply measure a chord instead of the arc vector of peninsula, resulting a less plummeted number of years.

Other abrupt change of Arabian Plate also can swipe the whole of peninsula, as if the occurrence of Arabian Shield which cover west region of peninsula. Somehow it will definitely make up the microclimate of Arab with unspecific change but it is obviously

[73] McClure, “Radiocarbon Chronology of Late Quaternary Lakes in the Arabian Desert.”
[74] McClure.
[75] Edgell, *Arabian Deserts*, 2006.
[76] E. De Man and S. Van Simaeys, “Late Oligocene Warming Event in the Southern North Sea Basin: Benthic Foraminifera as Paleotemperature Proxies,” *Netherlands Journal of Geosciences - Geologie En Mijnbouw* 83, no. 3 (September 2004): 227–39, https://doi.org/10.1017/S0016774600020291.

unprecedented situation to all of researchers.

The second scenario that we are trying to approach is the fluctuate climate of Arabian Peninsula. A list of recent epoch show that the climate of peninsula has been fluctuating to present day, proven by widespread of fossils and paleo-beds which segregated from the calm brine water. Last two episodes of 5 to 10 ka and 21 to 30 ka b.p[77] classified as semi-arid climate phase with minor deviation years[78], reveal that it is unambiguous situation once Arabian Peninsula was greenery for couple of millennia. We try to look back further as early as 5.3 Ma in the Middle Pliocene, where 18 cycles of climate-warming-freezing run based on Edgell[79]. The cycles are consisting 17 wet conditions classified as humid semi-arid, semi-arid, slightly moist, wet-semi-arid, wetter-humid, and wet-semi-arid while 18 arid conditions comprise hyper-arid and hyper-arid (G), warm (G), warm temperate semi-arid, arid, aridity, aridity (G) are constructing the whole series climate since Middle Pliocene (Tabel. 2 and Fig. 9).

Table 2. Climatic phase cycles of warm and cold climate with orange and light green colors respectively..

CLIMATIC PHASE	Count of CHRONOLOGY IN YEARS BP	Cycle for each climate group
HYPERARID	5	
HYPERARID (G)	1	
WARM (G)	1	
WARM TEMPERATE SEMI-ARID	1	18
ARID	1	
ARIDITY	3	
ARIDITY (G)	6	
HUMID SEMI-ARID	1	
SEMI-ARID	10	
SLIGHTLY MOIST	3	17
WET, SEMI-ARID	2	
WETTER, HUMID	1	

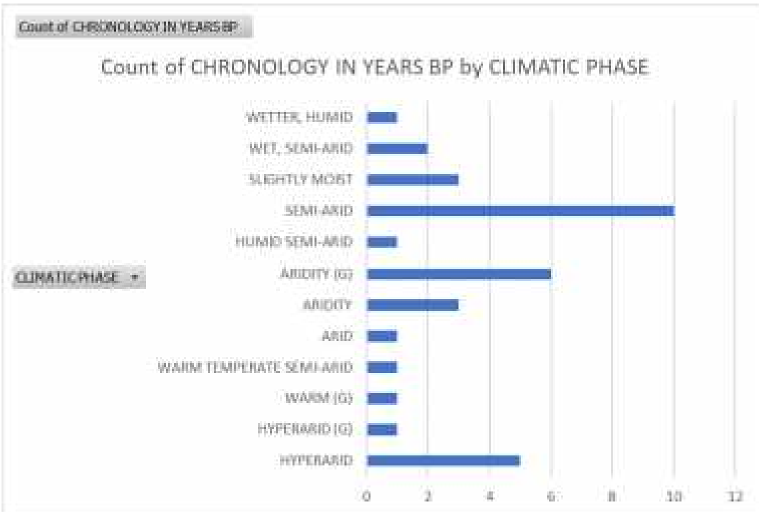

Figure 9. Total count of climatic phases since the Middle Pliocene.[80] We group and separate hot and wet condition of the climatic phase and reveal the climate cycles.

[77] Edgell, *Arabian Deserts*, 2006.
[78] McClure, "Radiocarbon Chronology of Late Quaternary Lakes in the Arabian Desert."
[79] Edgell, *Arabian Deserts*, 2006.
[80] H. Stewart Edgell, *Arabian Deserts: Nature, Origin and Evolution* (Dordrecht: Springer, 2006).

Even though the future climate prediction that exceeding couple of millennia are delicate, and no current researches study about that, near future forecast research are done. Kotwicki & Al Sulaimani[81] predict as far as 2100 AD that the Arabian Peninsula will have both extreme temperature and precipitation are likely to occur more often, leading to both more floods and droughts. Also it can be projected that the Arabian Peninsula, will face more violent floods, and more severe and long-lasting dry conditions. However, the latest research[82]stated that at the near (2030-2059) and far (2070-2099) future peninsula's temperature will increase at the rate of 0.63 C per decade and spread between 1.2-4.8 C at 66% likely range for near and far future respectively. In contrary, precipitation amount of Southern Arabian Peninsula (SAP) which the Rub al Khali located will increase both for near and far future while the Northern Arabian Peninsula (NAP) will face a decrease prediction. The annual-averaged precipitation of peninsula is projected to change by 3.76–31.83% by the end of the twenty-first century[83].

We keep an eye on the increasing precipitation number of the peninsula that may affect to the local climate and environment, even merely small change at the end of the century. For far future, the role of climate change is extremely tending to show off which is being proved by CO^2 concentrations exceed any recorded data since last 650 ka years at level of 140-263 percent relative to 2,000 levels by 2100 anno domini (AD)[84].

Precession of earth will change the regional climate for every 26,000 years long due to tropical precipitation. The earth's rotation on its axis and obliquity certainly result variation in season periods both in northern and southern hemisphere. When the northern hemisphere is closer to the sun, it will get higher radiation amount of solar radiation and so do the southern hemisphere when the cycle is hitting the opposite tilting away angles. At present, summer in the southern hemisphere occurs near perihelion and winter near aphelion give the southern get more extreme season than the northern one. Located in the northern hemisphere, Arabian Peninsula will make the opposite position roughly for next 13 ka apart from other Milankovitch cycles hypothesis of axis tilting and eccentricity. The Middle Holocene climate which mainly driven by precession[85], may be the biggest possibility to responsible for the last

[81] Vincent Kotwicki and Zaher Al Sulaimani, "Climates of the Arabian Peninsula – Past, Present, Future," *International Journal of Climate Change Strategies and Management* 1, no. 3 (July 31, 2009): 297–310, https://doi.org/10.1108/17568690910977500.

[82] Almazroui et al., "Future Changes in Climate over the Arabian Peninsula Based on CMIP6 Multimodel Simulations."

[83] Almazroui et al.

[84] Kotwicki and Al Sulaimani, "Climates of the Arabian Peninsula – Past, Present, Future."

[85] Jalihal et al., "The Response of Tropical Precipitation to Earth's Precession."

period of paleo-lakes in the Rub al Khali. This earth's precession not independently stand up but also sided by axis tilting and eccentricity within Milankovitch cycle hypothesis. It means that the earth precession strongly correlates to ITCZ periodically movement[86].

Change of climate due to ITCZ monsoonal pattern that affected regions which is passed. As we can see in Sahel, a southern part of the Saharan Desert is greening and recovered from dry period of the 1970s and 1980s.[87] The Sahel belt has certainly same latitude of Rub al Khali and other southern Arabian Peninsula. The shifting northward of ITCZ was proven by model and zero sum of Middle East and North Africa (MENA), make up July convergence and precipitation are increase as minimum as 20^0N and soaring to the south of Yemen[88]. In the future, we expect the ITCZ to move north in response to warming. Such movement is undetectable at present, it seems likely that a change will happen in a booming precipitation in dry regions in MENA, and may be possible this will be affected by drying in the tropical rain belt.[89] However, reason beyond the warming can be consider as GHG effect in near future and for further long future it could be rely on the earth precision.

C. CONCLUSION

As short as 6 ka b.p to last wetter climate in the peninsula, and roughly next 13 ka to culminate the opposite precession of earth, the land of Arabia might become even greenery than today. This short periodic meteorological effect from earth precession will shape the green peninsula relatively faster than latitude-longitude climate which need ~25 million years later. Nevertheless, the puzzles of next hundreds or thousands of years Arabian Peninsula's greenery remain veiled, but we can conclude that the greenery of Arabia will come much shorter due to the climate change domains rather than waiting for tectonic setting to fit. These geology and meteorological approach as insight from sciences are inline with hadith sahiih Muslim that the Arabia will definitely return to be green which being our guidences as Moslems.

AKNOWLEGMENTS

This research would not have been possible without the deep discussions with our partners, Fida' Azzam Madania and Abdullah Azzam Bishri from the Islamic University of

[86] Jalihal et al.

[87] Francesco S.R. Pausata et al., "The Greening of the Sahara: Past Changes and Future Implications," *One Earth* 2, no. 3 (March 2020): 235–50, https://doi.org/10.1016/j.oneear.2020.03.002.

[88] Anna Ailene Scott, "The Intertropical Convergence Zone over the Middle East and North Africa: Detection and Trends" (n.d.).

[89] Scott.

Madinah, as well as the literature support provided by Irfans Maulana Firdaus from the Bandung Institute of Technology. The authors declare that there are no conflicts of interest in relation to the writing of this article.

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