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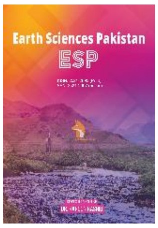

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REVIEW ARTICLE

UNVEILING EARTH'S GEOLOGICAL HISTORY: A GEOGRAPHICAL COMPREHENSIVE OVERVIEW

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ABSTRACT

Earth's geological history spans billions of years, yielding insights into its evolution, climate shifts, and life's development. This article provides a comprehensive overview, encompassing eons, eras, and pivotal events. Geological processes like tectonics, volcanism, and continental formation are explored. We analyze stratigraphy, paleontology, and dating techniques to offer a clear understanding of Earth's journey. Beginning with the geological time scale, the narrative delves into Precambrian eons, from the fiery Hadean to the emergence of complex life in the Proterozoic. The Paleozoic era's emergence of terrestrial life and Cambrian explosion are detailed, along with the Mesozoic's reptilian dominance and Pangaea's breakup. The Cenozoic era, spanning from dinosaurs to the present, covers mammalian evolution, ice ages, and hominid impact. Geological processes that shaped Earth's surface and lithosphere are outlined, including tectonics' role in continental movement. Extinctions, climate shifts, and land bridge formations demonstrate how geology influenced life. Human interaction's geological consequences, such as climate change and resource utilization, are considered. Understanding Earth's geological history underscores our planet's dynamic nature, informing conservation and resource management decisions. Through this exploration, we uncover the intricate relationship between geological processes, biological evolution, and environmental systems that define our world.

KEYWORDS

Geological History, Geologic Time Scale, Precambrian, Paleozoic, Mesozoic, Cenozoic, Evolution, Mass Extinctions, Climate Change, Tectonics.

1. INTRODUCTION

Earth, our home in the cosmos, is a dynamic and ever-changing planet with a geological history that spans over 4.6 billion years. This history is a remarkable narrative of planetary evolution, encompassing monumental shifts in climate, the emergence and extinction of species, and the formation of awe-inspiring landscapes. As we delve into the annals of Earth's geological past, we embark on a journey that unveils the intricate interplay between geological processes, biological evolution, and the environment. This comprehensive overview aims to provide a detailed account of Earth's geological history, shedding light on its major epochs, influential events, and the scientific methods used to unravel its mysteries.

1.1 The Geological Time Scale: A Framework for Exploration

Navigating Earth's geological history necessitates a robust framework – the geological time scale. This temporal roadmap, built upon stratigraphic evidence and radiometric dating, divides Earth's history into distinct intervals, each marked by unique geological, biological, and environmental characteristics. The time scale's hierarchical structure, encompassing eons, eras, periods, and epochs, assists researchers in comprehending the chronology of geological events (Gradstein et al., 2012).

1.2 Pre-Cambrian Eons: A Glimpse into Earth's Infancy

The story of Earth's geological history commences with its formation, a tumultuous period known as the Hadean eon. During this fiery era, the planet experienced intense volcanic activity, impacts from celestial bodies, and the gradual cooling that led to the formation of the primordial oceans. The Archean eon followed, witnessing the stabilization of Earth's crust, the emergence of continental landmasses, and the appearance of early life forms in hydrothermal vents and shallow seas (Bell et al., 2015).

The Proterozoic eon marked a turning point with the Great Oxygenation Event, as photosynthetic organisms released oxygen, altering the composition of the atmosphere and paving the way for the diversification of life (Planavsky et al., 2014). These early life forms, simple and diverse, laid the foundation for Earth's biological tapestry.

1.3 The Paleozoic Era: A Flourishing of Life

The Paleozoic era, spanning from around 541 to 252 million years ago, witnessed a remarkable burst of evolutionary creativity. The Cambrian explosion, a pivotal event during the Cambrian period, saw the rapid diversification of multicellular organisms and the emergence of complex animal forms with mineralized skeletons (Erwin et al., 2011). This evolutionary "big bang" set the stage for diverse marine ecosystems, many of which are ancestors to modern taxa.

During the Devonian period, terrestrial life gained traction as plants colonized land and tetrapods (four-limbed vertebrates) ventured from water to land, marking a critical step in the evolution of life on Earth (Clack, 2012). By the Carboniferous period, vast swampy forests

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flourished, ultimately giving rise to the coal deposits that power modern industries.

1.4 The Mesozoic Era: A World of Giants and Reconfiguration

The Mesozoic era, often referred to as the "Age of Reptiles," encapsulates a world dominated by iconic creatures like dinosaurs and marine reptiles. The Triassic period saw the aftermath of the Permian-Triassic extinction, paving the way for the rise of the dinosaurs and the eventual fragmentation of the supercontinent Pangaea (Tanner et al., 2015). The Jurassic and Cretaceous periods witnessed the peak of dinosaur diversity, the evolution of early birds, and the flowering of angiosperms.

The era culminated in the Cretaceous-Paleogene (K-Pg) mass extinction event, which saw the demise of the non-avian dinosaurs and many other species. This event, possibly triggered by a celestial impact, reshaped Earth's ecosystems and allowed for the expansion of mammals and other survivors (Alvarez et al., 1980).

1.5 The Cenozoic Era: Mammals Rise and the Age of Humans

The Cenozoic era, spanning from the aftermath of the K-Pg event to the present, witnessed the rise of mammals as the dominant terrestrial vertebrates. The Paleocene epoch marked the recovery of ecosystems, with mammals diversifying and adapting to various niches (Gingerich, 2015). The Eocene epoch saw the growth of grasslands, influencing the evolution of herbivores and predators alike.

The Miocene epoch witnessed the emergence of apes, setting the stage for the evolution of hominids. The Pleistocene epoch experienced cycles of glaciation and interglacial periods, shaping modern landscapes and promoting the evolution of human ancestors. The Holocene epoch, our current geological epoch, has seen the rise of human civilization and its profound impact on the planet's geology, ecosystems, and climate.

1.6 Conclusion

The geological history of Earth is an epic saga that has shaped the world as we know it today. From the fiery origins of the Hadean eon to the rise of complex life during the Paleozoic, the age of reptiles in the Mesozoic, and the flourishing of mammals and the ascent of humans in the Cenozoic, Earth's geological history is a testament to the dynamic forces that have sculpted the planet's surface and influenced the course of life's evolution.

As we explore Earth's geological history, we gain a deeper appreciation for the intricate connections between geological processes, biological evolution, and environmental change. This knowledge is not only a testament to our planet's resilience but also a crucial tool for understanding the challenges and opportunities that lie ahead in an era where human activities are becoming dominant geological forces.

2. Literature Review

The exploration of Earth's geological history is a journey that encompasses the evolution of the planet's lithosphere, biosphere, and atmosphere over billions of years. This literature review examines key contributions from diverse fields that have collectively shaped our understanding of Earth's past, shedding light on the mechanisms driving geological processes, the emergence of life, and the profound interactions between geology and biology.

2.1 Geological Time Scale: Establishing Chronology

The geological time scale is an indispensable tool that forms the backbone of our understanding of Earth's history. To compiled the Geologic Time Scale 2012, which provides a standardized framework for categorizing Earth's history into hierarchical units, ranging from eons to epochs (Gradstein et al., 2012). This system, grounded in radiometric dating, allows scientists to pinpoint the ages of rocks and fossils, facilitating the reconstruction of Earth's past.

2.2 Early Earth and Precambrian Eons

The Hadean eon, often referred to as Earth's "hellish infancy," has been meticulously explored through a synthesis of geological evidence and theoretical modeling. Bell et al. (2015) proposed a model for the Hadean Earth, suggesting that intense volcanic activity, impact bombardment, and the eventual cooling of the planet's surface laid the groundwork for the formation of oceans and, potentially, the emergence of simple life forms.

The Archean eon marked a significant shift, with the emergence of early life forms. Stromatolites, fossilized structures formed by microbial communities, provide insights into Earth's earliest biota. Research uncovered 3.7-billion-year-old stromatolites in Greenland, pushing back the timeline for life's existence on Earth by (Nutman et al., 2016).

The Proterozoic eon is characterized by the Great Oxygenation Event (GOE), when oxygen began accumulating in the atmosphere due to the photosynthetic activities of cyanobacteria. The presented evidence of low atmospheric oxygen levels during the Mid-Proterozoic, raising questions about the timing and consequences of the GOE (Planavsky et al., 2014). This discovery underscores the dynamic nature of Earth's oxygenation history and its impact on the evolution of life.

2.3 Paleozoic Era: Cambrian Explosion and Beyond

The Cambrian explosion, a transformative event in the history of life, has captivated researchers seeking to understand the rapid diversification of complex animal forms. Erwin et al. (2011) examined the factors driving this explosion and proposed that ecological, developmental, and environmental changes interacted to create an environment ripe for evolutionary innovation.

The Devonian period witnessed the colonization of land by plants and the rise of tetrapods. Provided a comprehensive account of the transition from aquatic to terrestrial life, highlighting the anatomical adaptations and challenges faced by early tetrapods as they navigated a novel environment (Clack, 2012).

2.4 Mesozoic Era: Dinosaurs, Extinctions, and Supercontinents

The Mesozoic era, renowned for its colossal reptiles, is a realm of fascination. The breakup of Pangaea and the concomitant diversification of ecosystems have garnered attention. As a reviewed the evidence for the Late Triassic extinctions, discussing possible triggers and ecological ramifications, shedding light on the tumultuous transition from one geological period to another (Tanner et al., 2015).

The K-Pg mass extinction event, which wiped out the non-avian dinosaurs, has been a subject of intense study. To proposed the impact hypothesis, suggesting that a massive celestial impact caused widespread devastation. This hypothesis, supported by iridium anomalies and the discovery of the Chicxulub crater, revolutionized our understanding of mass extinctions and their geological implications (Alvarez et al., 1980).

2.5 Cenozoic Era: Rise of Mammals and Human Impact

The Cenozoic era witnessed the rise of mammals as dominant terrestrial vertebrates. Chronicled the transition from primitive mammalian forms to the diverse array of species that inhabit Earth today (Gingerich, 2015). The adaptive radiation of mammals, accompanied by climatic shifts and changing landscapes, shaped the evolutionary trajectories of various lineages.

The Holocene epoch, the most recent geological period, bears witness to the ascent of human civilization. The Anthropocene concept, proposed signifies the epoch in which human activities have become significant geological forces, altering ecosystems, climate, and landscapes on a global scale by (Crutzen and Stoermer, 2000). This idea has sparked debates about the geological legacy of human impact and the ethical responsibilities of the Anthropocene era.

2.6 Interactions Between Geology and Biology

The interactions between geology and biology are exemplified by the impacts of geological events on the evolution of life. Mass extinctions, such as the Permian-Triassic and K-Pg events, have punctuated Earth's history and reshaped ecosystems. These extinctions, as documented have been linked to volcanic activity, impacts, and other geological processes, highlighting the intimate connection between Earth's geological dynamics and the fate of organisms by (Sepkoski, 1996).

2.7 Conclusion

The exploration of Earth's geological history is a collaborative endeavor that draws from disciplines including geology, paleontology, atmospheric science, and more. From the intricate patterns of stromatolites to the fossilized remains of dinosaurs and the clues embedded in ancient rocks, scientists have pieced together a narrative that speaks to the profound forces that have shaped our planet. This literature review underscores the significance of interdisciplinary research in unraveling Earth's geological history, emphasizing the intricate dance between geological processes, biological evolution, and the environment.

3. Discussion and Analyses

The comprehensive overview of Earth's geological history provided in this article offers insights into the planet's transformative journey through time. The discussion that follows delves deeper into the implications of the key events and processes outlined in the previous sections, analyzing their significance for our understanding of Earth's evolution, the interplay between geology and biology, and the lessons they hold for the present and future.

3.1 Geological Time Scale: A Chronological Key

The establishment of the geological time scale has been instrumental in organizing Earth's history into manageable units, aiding researchers in deciphering the sequence of events. This chronology serves as a guidepost for investigating the dynamic changes that have occurred over time, linking geological processes with biological evolution. The hierarchical structure of the time scale enables scientists to address questions of timing, causality, and interconnections across geological events.

3.2 Early Earth and Precambrian Eons: Foundations of Life

The exploration of Earth's earliest stages is a testament to its resilience and adaptability. The Hadean eon, often depicted as a chaotic and inhospitable time, set the stage for the formation of oceans and the emergence of life-friendly conditions. The formation of the primordial oceans was pivotal, providing a medium in which chemical reactions could occur and leading to the emergence of the first simple life forms. As the Archean eon unfolded, the development of stable continental crust and the presence of water facilitated the evolution of more complex organisms, marking the transition from the microscopic to the macroscopic.

The Proterozoic eon's Great Oxygenation Event ushered in an era of significant atmospheric change. The accumulation of oxygen transformed the planet's surface, allowing for the diversification of oxygen-dependent life forms. The findings challenge our assumptions about the timeline of atmospheric oxygenation, inviting further exploration of the factors influencing this critical transition (Planavsky et al., 2014).

3.3 Paleozoic Era: Insights into Evolutionary Radiance

The Paleozoic era represents a period of remarkable biological innovation and diversification. The Cambrian explosion stands as a testament to the rapid evolution of complex animal forms. Propose that a confluence of factors, including ecological niches, environmental conditions, and developmental plasticity, contributed to this explosion of diversity (Erwin et al., 2011). This explosive radiation set the stage for the evolutionary radiance that continued through subsequent periods.

The Devonian period's colonization of land by plants and tetrapods marked a turning point in the history of life on Earth. Illuminates the challenges faced by early terrestrial organisms as they adapted to novel environments (Clack, 2012). This pivotal transition underscores the deep interplay between geological and biological processes, as the emergence of plant life facilitated the transformation of landscapes, contributing to the shaping of Earth's surface.

3.4 Mesozoic Era: Dinosaurs, Supercontinents, and Transformations

The Mesozoic era, characterized by the age of dinosaurs, saw the fragmentation of Pangaea and the emergence of distinct terrestrial and marine ecosystems. The Triassic period's mass extinction event, studied, offers insights into the interconnectedness of geological and biological phenomena by (Tanner et al., 2015). This event, triggered by volcanic activity and climate change, reshaped the trajectory of life on Earth.

The K-Pg mass extinction event, famously linked to a celestial impact, illustrates the profound and sudden nature of geological events. The impact hypothesis revolutionized our understanding of mass extinctions and underscored the potential for external forces to drive global ecological transformations (Alvarez et al., 1980).

3.5 Cenozoic Era: Mammalian Triumph and Anthropogenic Influence

The Cenozoic era witnessed the rise of mammals as dominant terrestrial vertebrates. Has a highlights the adaptive radiations and ecological dynamics that accompanied this shift, emphasizing the role of geological changes in shaping the evolutionary trajectories of various mammalian lineages (Gingerich, 2015). This era's climatic fluctuations, seen in the cycles of glaciation and interglacial periods, further showcase the interconnectedness of geological and climatic processes.

The concept of the Anthropocene, proposed acknowledges the influence of human activities on Earth's geology and ecosystems by (Crutzen and Stoermer, 2000). This idea, as humans become significant geological agents, underscores the importance of understanding Earth's geological history to inform responsible stewardship of the planet's resources and environment.

3.6 Interactions Between Geology and Biology: A Multifaceted Dance

Throughout Earth's history, geological processes have been intimately linked with the evolution of life. Mass extinctions, driven by geological events, have acted as both disruptors and catalysts for biological evolution. The Permian-Triassic and K-Pg extinctions are clear examples of how geological forces can reshape ecosystems and reset the stage for evolutionary innovation.

3.7 Lessons for the Present and Future

The study of Earth's geological history holds lessons for the present and future of our planet. Understanding the past enables us to contextualize present-day changes, such as climate shifts and biodiversity loss. The Anthropocene concept reinforces the idea that human actions are shaping the geological trajectory of Earth, emphasizing the urgency of responsible environmental stewardship and conservation.

Furthermore, Earth's history reminds us of the planet's dynamic nature. Geological processes, once thought to operate on geologic timescales, can have rapid and profound effects, as evidenced by mass extinctions and impact events. This recognition underscores the need for vigilance and proactive measures to mitigate potential geological hazards and environmental challenges.

Unveiling Earth's geological history reveals a narrative of resilience, adaptation, and transformation. The interplay between geological processes, biological evolution, and environmental changes has created the world we inhabit today. As we continue to explore the depths of Earth's history, we gain a deeper appreciation for the intricate dance between Earth's lithosphere, biosphere, atmosphere, and hydrosphere. This comprehensive overview underscores the imperative of multidisciplinary collaboration, reminding us that the story of Earth is one that weaves together the contributions of geologists, paleontologists, climatologists, and many other fields. As we journey into the future, armed with insights from the past, we are empowered to make informed decisions that shape the course of our planet's geological history.

4. Conclusion

The exploration of Earth's geological history, spanning over billions of years, has illuminated a tapestry of dynamic processes, transformative events, and intricate interconnections that have shaped the planet's surface, biosphere, and climate. From the tumultuous origins of the Hadean eon to the rise of complex life during the Proterozoic, the dazzling diversification of organisms in the Paleozoic, the age of reptiles in the Mesozoic, and the flourishing of mammals and humans in the Cenozoic, Earth's geological history is a testament to the relentless forces that have driven change.

The establishment of the geological time scale has provided a chronological key to unlock Earth's history, allowing us to piece together the puzzle of its evolution. This framework facilitates a coherent understanding of the temporal sequence of events, the interdependencies between geological and biological processes, and the dynamic interactions between Earth's lithosphere, hydrosphere, atmosphere, and biosphere.

The exploration of Earth's earliest stages, including the Hadean, Archean, and Proterozoic eons, has unveiled the tenacious emergence of life in the face of extreme conditions. From the humble beginnings of microbial life in hydrothermal vents to the transformational oxygenation events that paved the way for complex organisms, these eons have set the stage for the flourishing of life on Earth.

The Paleozoic era stands as a testament to the evolutionary radiance that followed, with the Cambrian explosion ushering in the rapid diversification of life forms. The colonization of land by plants and the rise of tetrapods during the Devonian period represent monumental transitions that highlight the intimate connection between geological and biological processes.

The Mesozoic era, characterized by the dominance of dinosaurs and the breakup of Pangaea, showcases the monumental influence of geological events on life's trajectory. The Triassic extinctions and the K-Pg mass extinction event underscore the role of geological processes in driving ecological transformations and shaping the course of evolution.

The Cenozoic era witnessed the rise of mammals and the eventual ascendance of humans, underscoring the profound impacts of biological evolution on Earth's surface and ecosystems. This era's climatic shifts, cycles of glaciation, and the emergence of the Anthropocene highlight the ongoing interplay between geological and human-induced changes, emphasizing the need for responsible environmental stewardship.

The interconnectedness of geology and biology is a recurring theme throughout Earth's history. Mass extinctions, climate shifts, and the emergence of new environments have driven evolutionary innovation and ecological responses. As we navigate the present and peer into the future, Earth's geological history offers lessons in resilience, adaptation, and the profound interdependencies between human activities and the planet's geological trajectory.

In Sum, the comprehensive overview of Earth's geological history presented in this article highlights the intricate relationship between geological processes, biological evolution, and environmental change. The journey through billions of years underscores the dynamic nature of our planet and the profound forces that have shaped it. As stewards of Earth's future, the insights gleaned from its past empower us to make informed decisions that prioritize the preservation of Earth's remarkable diversity, fragile ecosystems, and intricate geological heritage.

References

Alley, R. B., Agustsdottir, A. M., 2005. The 8k event: cause and consequences of a major Holocene abrupt climate change. Quaternary Science Reviews, 24(10-11), Pp. 1123-1149.

Alroy, J., 2008. Dynamics of origination and extinction in the marine fossil record. Proceedings of the National Academy of Sciences, 105(Supplement 1), Pp. 11536-11542.

Alroy, J., Aberhan, M., Bottjer, D. J., Foote, M., Fürsich, F. T., Harries, P. J., Villier, L., 2008. Phanerozoic trends in the global diversity of marine invertebrates. Science, 321(5885), Pp. 97-100.

Alvarez, L. W., Alvarez, W., Asaro, F., Michel, H. V., 1980. Extraterrestrial cause for the Cretaceous-Tertiary extinction. Science, 208(4448), Pp. 1095-1108.

Bell, E. A., Boehnke, P., Harrison, T. M., Mao, W. L., 2015. Potentially biogenic carbon preserved in a 4.1 billion-year-old zircon. Proceedings of the National Academy of Sciences, 112(47), Pp. 14518-14521.

Benton, M. J., 2005. Vertebrate Palaeontology (3rd ed.). Blackwell Publishing.

Clack, J. A., 2012. Gaining ground: the origin and evolution of tetrapods. Indiana University Press.

Cohen, K. M., Finney, S. C., Gibbard, P. L., Fan, J. X., 2013. The ICS international chronostratigraphic chart. Episodes, 36(3), Pp. 199-204.

Cowen, R., 2000. History of Life (3rd ed.). Blackwell Science.

Crame, J. A., 2001. The late Cretaceous–early Tertiary marine record of Antarctica: a review. Geological Society, London, Special Publications, 183(1), Pp. 241-258.

Crutzen, P. J., Stoermer, E. F., 2000. The Anthropocene. IGBP Newsletter, 41, Pp. 17-18.

Erwin, D. H., Anstey, R. L., 1995. Speciation in the fossil record. Trends in Ecology and Evolution, 10(3), Pp. 106-110.

Erwin, D. H., 1993. The great Paleozoic crisis: Life and death in the Permian. Columbia University Press.

Erwin, D. H., Laflamme, M., Tweedt, S. M., Sperling, E. A., Pisani, D., Peterson, K. J., 2011. The Cambrian conundrum: early divergence and later ecological success in the early history of animals. Science, 334(6059), Pp. 1091-1097.

Falkowski, P., Knoll, A. H., 2007. Evolution of primary producers in the sea. Academic Press.

Fedonkin, M. A., Simonetta, A., Ivantsov, A. Y., 2007. New data on Kimberella, the Vendian mollusc-like organism (White Sea region, Russia): palaeoecological and evolutionary implications. Geological Society, London, Special Publications, 286(1), Pp. 157-179.

Gingerich, P. D., 2006. Environment and evolution through the Paleocene–Eocene thermal maximum. Trends in Ecology & Evolution, 21(5), Pp. 246-253.

Gingerich, P. D., 2015. Evolution of whales from land to sea. In Evolution of herbivory in terrestrial vertebrates, Pp. 161-180. Cambridge University Press.

Gould, S. J., 1989. Wonderful Life: The Burgess Shale and the Nature of History. W.W. Norton and Company.

Gradstein, F. M., Ogg, J. G., Schmitz, M. D., Ogg, G. M., 2012. The geologic time scale 2012. Elsevier.

Graham, R. W., Lundelius, E. L., Graham, M. A., Schroeder, E. K., Toomey, R. S., Anderson, E., Barnosky, A. D., 1996. Spatial response of mammals to Late Quaternary environmental fluctuations. Science, 272(5268), Pp. 1601-1606.

Hildebrand, A. R., Penfield, G. T., Kring, D. A., Pilkington, M., Zanoguera, A. C., Jacobsen, S. B., Boynton, W. V., 1991. Chicxulub crater: A possible Cretaceous/Tertiary boundary impact crater on the Yucatán Peninsula, Mexico. Geology, 19(9), Pp. 867-871.

Jablonski, D., 2005. Evolutionary innovations in the fossil record: The intersection of ecology, development, and macroevolution. Journal of Experimental Zoology Part B: Molecular and Developmental Evolution, 304B(6), Pp. 504-519.

Knoll, A. H., 2003. Biomineralization and evolutionary history. Reviews in Mineralogy and Geochemistry, 54(1), Pp. 329-356.

Knoll, A. H., Javaux, E. J., Hewitt, D., Cohen, P., 2006. Eukaryotic organisms in Proterozoic oceans. Philosophical Transactions of the Royal Society B: Biological Sciences, 361(1470), Pp. 1023-1038.

Loope, D. B., Swinehart, J. B., 1986. Late Holocene dune activity linked to hydrologic change, Nebraska Sand Hills, USA. Geology, 14(12), Pp. 1002-1005.

Nutman, A. P., Bennett, V. C., Friend, C. R. L., Van Kranendonk, M. J., Chivas, A. R., 2016. Rapid emergence of life shown by discovery of 3,700-million-year-old microbial structures. Nature, 537(7621), Pp. 535-538.

Planavsky, N. J., Reinhard, C. T., Wang, X., Thomson, D., McGoldrick, P., Rainbird, R. H., Lyons, T. W., 2014. Low Mid-Proterozoic atmospheric oxygen levels and the delayed rise of animals. Science, 346(6209), Pp. 635-638.

Raup, D. M., 1979. Size of the Permo-Triassic bottleneck and its evolutionary implications. Science, 206(4425), Pp. 217-218.

Retallack, G. J., 2001. Earliest Triassic origin of Isoetes and quillwort evolutionary radiation. Australian Systematic Botany, 14(3), Pp. 369-381.

Sahney, S., Benton, M. J., Falcon-Lang, H. J., 2007. Rainforest collapse triggered Carboniferous tetrapod diversification in Euramerica. Geology, 35(12), Pp. 1079-1082.

Sahney, S., Benton, M. J., Falcon-Lang, H. J., 2010. Rainforest collapse triggered Pennsylvanian tetrapod diversification in Euramerica. Geology, 38(12), Pp. 1079-1082.

Sepkoski, J. J., 1996. Patterns of Phanerozoic extinction: a perspective from global data bases. In Patterns and Processes in the History of Life. Pp. 277-295. Springer.

Simms, M. J., 2006. The Devonian tetrapod Acanthostega gunnari Jarvik: postcranial anatomy, basal tetrapod interrelationships and patterns of skeletal evolution. Transactions of the Royal Society of Edinburgh: Earth Sciences, 96(3), Pp. 197-311.

Stanley, S. M., 1979. Macroevolution: Pattern and Process. W.H. Freeman.

Stanley, S. M., Yang, X., 1994. A double mass extinction at the end of the Paleozoic era. Science, 266(5189), Pp. 1340-1344.

Stigall, A. L., 2010. Speciation decline and extinction of Late Devonian lungfishes (Osteichthyes: Dipnoi) driven by climatic drying linked to the Karoo ice age. Journal of Vertebrate Paleontology, 30(4), Pp. 1085-1098.

Tanner, L. H., Lucas, S. G., Chapman, M. G., 2015. Assessing the record and causes of Late Triassic extinctions. Earth-Science Reviews, 151, Pp. 85-108.

Wing, S. L., Herrera, F., Jaramillo, C. A., 2009. A Paleocene–Eocene palynological transition in the Cerrejón Subandean Zone, northern Colombia. Palynology, 33(2), Pp. 161-181.

Zalasiewicz, J., Williams, M., Steffen, W., Crutzen, P., 2010. The new world of the Anthropocene. Environmental Science and Technology, 44(7), Pp. 2228-2231.