

# Dinosaurs on an Expanding Earth

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*“Plate Tectonic reconstructions and proposed movements of continents do not correspond to the known or necessary migration routes and directions of biogeographical boundaries.” Meyerhoff et al., 1996*

## Abstract

**O**n an Earth increasing in surface area and radius over time the development of ancient continental seas and supercontinents, along with the modern continents and oceans is shown to be the prime cause of evolution of all life forms on Earth. The distribution, migration, and eventual demise of the dinosaurs on an Expanding Earth can be visualised in conjunction with a very involved period of crustal break-up, new ocean development, and changes in surface gravity. While the prolonged period of time involved during this crustal break-up allowed dinosaur species to migrate to more equitable locations, it also presented new physical and environmental barriers. The draining of ancient continental seas, for instance, influenced distribution of the modern seas and oceans and hence adversely affected available dinosaur habitats, migration routes, and escape avenues. Migration away from these physical barriers may have then encouraged the dinosaurs to evolve into new species. In contrast, failing to evolve, migrate, or being land-locked may have also caused their localised demise. The unique provincial distribution of the earlier Permian ancestral reptiles and Mesozoic dinosaurs on an increasing radius Earth demonstrates consistent evolutionary links between Permian, Triassic, Jurassic, and Cretaceous species. Many of these links were permanently disrupted during the Triassic and Cretaceous Periods as a result of crustal breakup and continental dispersal, draining of the ancient seas, variable sea-levels, and disruption to existing climate zones. On an increasing radius Earth it is also considered that breaching between Australia and Antarctica during initiation and opening of the Southern Ocean resulted in a period of disruptive sea-level change. This continental breaching and sea-level change coincided precisely with the end-Cretaceous extinction event. These observations support the conclusions of others where the extinction event was more gradual, resulting from drastic sea-level changes already occurring during the late-Cretaceous, extending over a period of approximately 8 million years.

**Key Words:** Dinosaurs, Expanding Earth, Expansion Tectonics.

## Introduction

**T**he quality and quantity of faunal and floral data available for biogeographical studies is now extensive. The selection of reptile and dinosaur species data presented in this paper are used as examples only in order to emphasise their distributions and inter-relationships on increasing radius small Earth models. Modelled data are based on the published Paleobiology Database (PaleoBioDB, 2015). The navigator used to access this data can be opened from: <https://paleobiodb.org/navigator/>. The reader is encouraged to visit this navigator in order to compare and contrast data plotted on increasing radius small Earth models with the same data plotted on conventional Plate Tectonic assemblages.

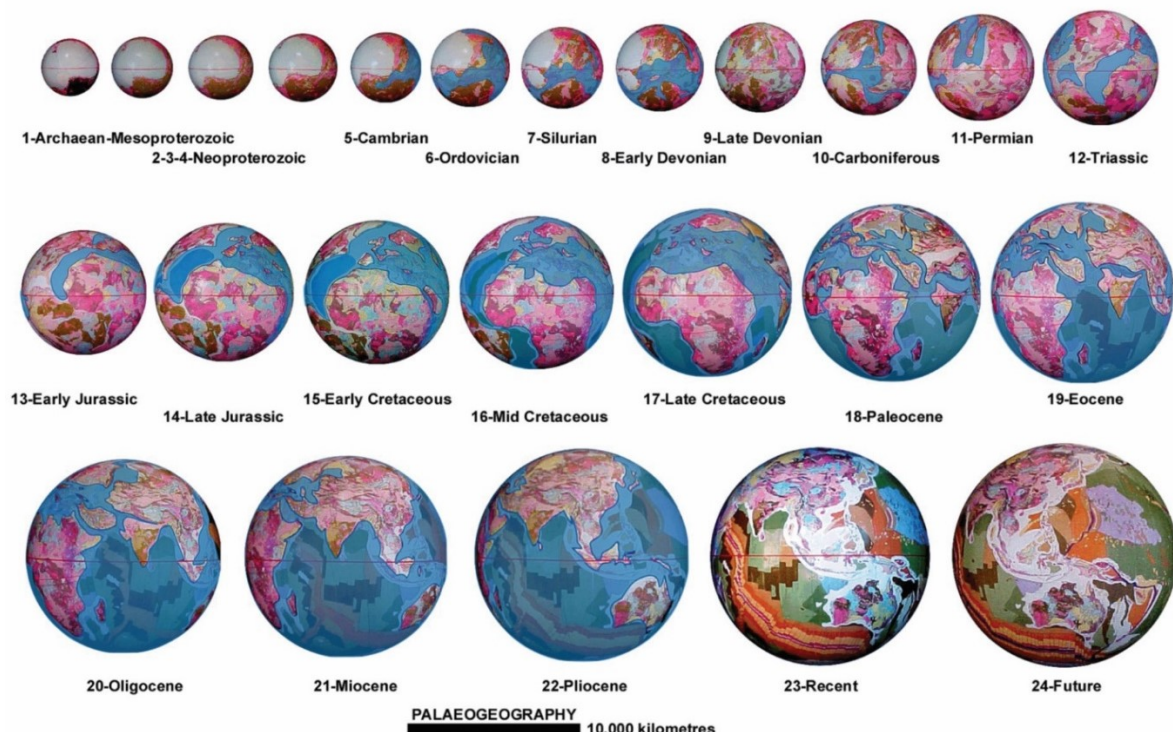
The reader is also encouraged to visit my website at: [www.expansiontectonics.com](http://www.expansiontectonics.com) to become familiar with the extensive amount of research now available in support of the Expanding Earth theory. An extensive range of modern geological and geographical data now available for study is located under “Data Modelling” on the home page which includes additional faunal and floral data plotted on small Earth models. This display is interactive and shows the distribution of various species plotted over time.

The following introduction is summarised from Maxlow, 2014. Dinosaur fossils have been known for millennia, although their true nature was not recognized at the time of their original discovery. The Chinese, whose modern word for dinosaur is *konglong*, or *terrible dragon*, considered them to be dragon bones. Villagers in central China have long since unearthed these fossilized dragon bones for use in traditional medicines, a practice that continues today. In Europe, dinosaur fossils were originally believed to be the remains of *giant lizards* or other creatures killed during the *Great Biblical Flood* (Maxlow, 2014).

Descriptions of dinosaur bones first appeared in the late 17th century in England. Part of a bone, now known to have been the femur of a *Megalosaurus*, was discovered in 1676 in a limestone quarry at Cornwell, England. Between 1815 and 1824 the Rev. William Buckland, a professor of geology at Oxford University, collected more fossilized bones of *Megalosaurus* and became the first person to scientifically describe the fossils. The study of these so called *great fossil lizards* soon became of great interest to European and American scientists and in 1842 the English palaeontologist Richard Owen conceived the term “*dinosaur*”, meaning terrible lizard. Owen went on to establish the Natural History Museum of London in order to display the national collection of dinosaur fossils and other biological and geological exhibits (Maxlow, 2005, 2014).

## Brief Introduction to Ancient Life on Earth

On an Earth increasing in surface area and radius over time the development of ancient continental seas and supercontinents, along with the modern continents and oceans (Figure 1), is shown to be the prime cause of evolution of all life forms on Earth. For an informative introduction to this research and list of publications available see: [www.expansiontectonics.com](http://www.expansiontectonics.com). (Maxlow, 1995, 2001, 2005, 2012, 2014)



**Figure 1** Shoreline palaeogeography on Archaean to present-day small Earth models (after Scotese, 1994, and Smith et al., 1994). The ancient shorelines are shown as blue lines and the ancient seas and modern oceans are shaded blue. Each image advances 15 degrees longitude throughout the sequence to show a broad coverage of palaeogeographic development. Note: there are no published data available for the late-Devonian model or models prior to the Cambrian Period.

On an increasing radius Earth the ancient continental seas, in particular, provided an ideal setting for the primitive Precambrian microbe's effectiveness as nurseries of evolution and to markedly drive evolutionary change in all life forms. Similarly, extinction of species is shown to be a

by-product of sea-level changes, disruption to the distribution of established seas, and the inability of species to keep pace with these environmental changes. It is further considered that evolution of species during these early times was subsequently driven by the need to survive amongst these ever increasing changes to the Earth and environment.

With the evolution of oxygenic photosynthesis during the early- to mid-Proterozoic times the stable platform sedimentary basins and shallow seas existing during the Precambrian provided ideal settings and conditions for chemical precipitation of iron, calcium carbonates, and silicates. This environment was also reflected in the development of carbonate mats and early reefs by primitive life forms, along with carbonate-based shells and skeletons of the higher life forms during the late-Proterozoic and beginning of the Cambrian.

On an increasing radius Earth, warm sea waters during the early-Palaeozoic extended from equatorial regions through to the North Polar Region allowing newly evolved species to readily colonise and populate throughout much of the interconnected ancient Tethys, Iapetus, and Panthalassa seaways. The warm seas enabled stable carbonate shelf environments to develop adjacent to the ancient lands, along with deeper anoxic basins further away from the coastlines. The extensive algal mats and early reefal mounds present throughout much of the Precambrian eventually gave way to predation and bioturbation, and planktonic life forms were able to readily spread throughout the deeper seas.

Mid-Palaeozoic life forms also show that the ongoing network of relatively shallow continental seas provided an ideal environment for early reef development and an environment for marine creatures to continue to thrive and proliferate. Warm sea waters during the mid-Palaeozoic continued to extend from equatorial regions through to the North Polar Region allowing evolved species to readily colonise and populate throughout much of the ancient seas. Changing Earth surface curvature during increase in radius was, however, becoming increasingly prevalent, in particular later in the Palaeozoic. These changes fragmented and disrupted the distribution of ancient seas, including changes to surficial areas, sea levels, and warm water circulation patterns. All of these changes adversely affected species development, in particular during a number of devastating mass extinction events. Changes to the environment also provided the impetus to drive colonisation of the lands, sparking new adaptive terrestrial radiations never before seen.

During the late-Palaeozoic, increasing geosynclinal activity and orogenesis severely disrupted the distribution of continental seas forming isolated, often relatively deep seaways. Warm sea waters during these times were mainly confined to the equatorial and northern hemisphere regions. A well-developed South Polar ice-cap was present and possible seasonal icing may have occurred within the Northern Polar Region. Disruptions to the continental seas, along with elevated topography further increased erosion, with extensive coal-bearing swamps confined to low-lying regions.

The late-Palaeozoic is well noted for the colonisation and proliferation of plant and insect species, along with early vertebrates such as the reptiles. On an increasing radius Earth this colonisation was severely disrupted during the late-Permian with onset of breakup of Pangaea to form the modern continents and opening to form the modern oceans, coincident with the end-Permian extinction event. The post-extinction resurgence of life-forms, including the dinosaurs, then enabled previously subdued species to rapidly diversify and again repopulate the entire Earth.

While the prolonged period of time involved during this post-Permian crustal breakup allowed dinosaur species to evolve and migrate to more equitable locations, it also presented new physical and environmental barriers. Draining of the ancient continental seas, for instance, influenced distribution of the modern seas and oceans and hence adversely affected available dinosaur habitats, migration routes, and escape avenues. Migration away from these physical barriers then encouraged the dinosaurs to further evolve into new species. In contrast, failing to evolve, migrate, or being land-locked may have also caused their localised demise.

During the Mesozoic times, continental crustal breakup during increasing Earth radius continued unabated as each of the modern continents became well established. By then all of the intervening modern oceans, except for the Southern Ocean, had opened. Breaching of a North American and Australian land connection had occurred during the Triassic Period, giving rise to merging of the north and South Pacific Oceans, which resulted in the end-Triassic extinction event. During this end-Triassic extinction event most of the non-dinosaurian archosaurs, as well as most of the terrestrial vertebrates, the ancestors of mammals, and most of the large amphibians became

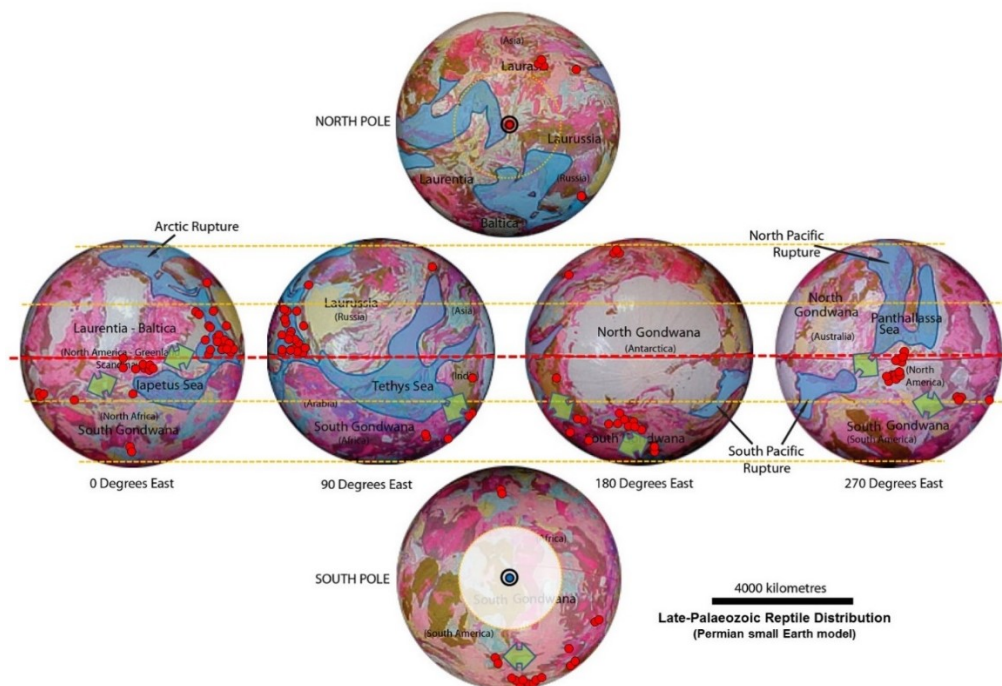
extinct. The unique provincial distribution of the earlier Permian ancestral reptiles and Mesozoic dinosaurs on an increasing radius Earth demonstrates consistent evolutionary links between Permian, Triassic, Jurassic, and Cretaceous species. Many of these links were permanently disrupted during the Triassic and Cretaceous Periods as a result of crustal breakup and continental dispersal, draining of the ancient seas, variable sea-levels, and disruption to existing climate zones.

The Cenozoic Era has seen the modern continents and oceans continue to migrate and open to their current configurations, and studies (Maxlow, 2014) show that this will continue unabated into the near future. The era was dominated by species development being increasingly isolated within island continents, with many species now endemic to specific continents or islands. In recent times this isolation has, of course, been severely disrupted by the colonisation activities of mankind, with all its attendant implications for renewed species diversification and secondary extinctions.

## Late-Palaeozoic Ancestral Reptilian Life

The late-Palaeozoic interval of time includes the Carboniferous and Permian Periods. On an increasing radius Earth the late-Palaeozoic was a time when the ability of continental crusts to continue extending within established sedimentary basins was reaching its limit, eventually leading to onset of crustal rupture and breakup during the late-Permian. Breakup of continental crusts during the late-Permian initiated opening and formation of the modern continents as well as rifting to form the modern, relatively deep, oceans. All of which gave rise to the major end-Permian extinction event and the demise of many plant and animal species on both the lands and in the seas. Draining of the ancient continental seas into the newly formed oceans then led to contraction of established coal swamps, plus exposure and drying of the lands along with the accumulation of evaporites.

The earliest known reptiles originated around 315 million years ago during the Carboniferous Period, having evolved from advanced reptile-like amphibians that had become increasingly adapted to life on dry land. The distribution of known reptile sites is shown on the Permian small Earth model in Figure 2. Also highlighted on this figure are suggested migration links between the various ancient continents. These links, highlighted by green arrows, represent possible migration routes for both the reptiles and succeeding dinosaur life forms prior to breakup of the Pangaeian supercontinent during the late-Permian. Some of these links remained into the early-Triassic allowing the early dinosaurs to migrate and populate many of the modern continents prior to isolation during the late-Triassic. Important provincial centres for the reptiles include western North America, western and central Europe, and South Africa.



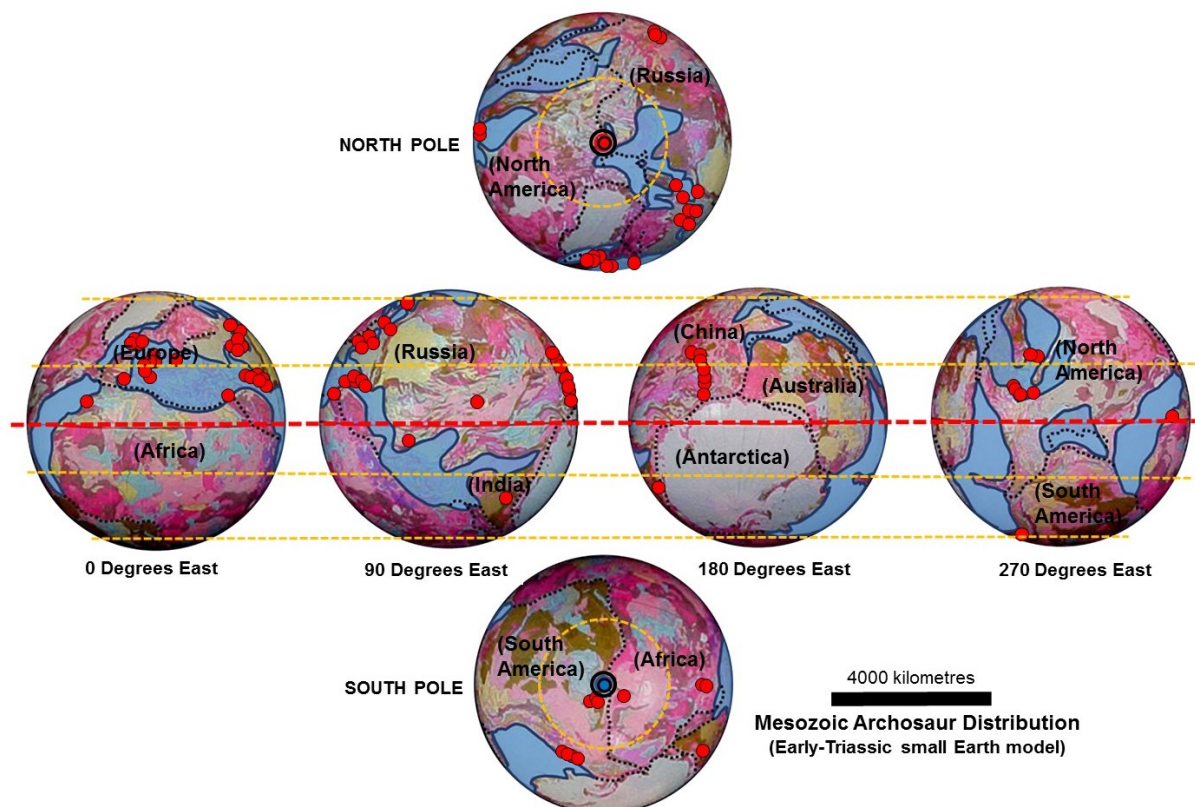


**Figure 2** Distribution of late-Palaeozoic reptiles plotted on a Permian small Earth model. Reptile data are shown as red dots (data after PaleoBioDB, 2015), in relation to climate zones, a late-Palaeozoic South Polar ice-sheet, shaded white, and distribution of ancient continental seas. Suggested migration routes are highlighted by green arrows.

## Mesozoic Dinosaurian Life

The Mesozoic Era comprises the Triassic, Jurassic, and Cretaceous Periods and is renowned as the age of the dinosaurs. On an increasing radius Earth this era coincides with breakup of the ancient Pangaean supercontinent to form the modern continents and opening of the modern oceans. This era also coincides with apparent migration of the South Pole across the opening South Atlantic Ocean, migrating from South Africa as it moved north, across to Antarctica as it moved into the South Polar Region. During that time both the north and south poles were centred over oceans and there were no polar ice caps. The era was also punctuated by the end-Triassic extinction event during merging of the North and South Pacific Oceans and the era terminated with the end-Cretaceous extinction event approximately 65 million years ago.

The fossil dinosaurs found today are now known to form a well-defined group of extinct reptiles. These reptiles first evolved from the ancient Archosauria group, characterised by limbs held erect beneath their bodies. The oldest known archosaur is called *Archosaurus*, which is known from fragmentary remains found in late-Permian rocks from Russia. From their earliest beginnings, archosaurs then evolved and radiated extensively during the following Triassic Period (Figure 3). After the end-Triassic extinction event, survivors of the dinosaurs became the dominant terrestrial vertebrates throughout the remaining Mesozoic Era. Other groups of animals existing at the same time were more restricted in size and habitat. Survivors of the end-Triassic and similarly the end-Cretaceous extinction events are now considered to be closely linked to the birds and reptiles of today.



**Figure 3** Distribution of Mesozoic archosaurs plotted on an early-Triassic small Earth model. Archosaur data are shown as red dots (after PaleoBioDB, 2015) in relation to climate zones and distribution of ancient continental seas and modern oceans.

Dinosaurs are a diverse group of animals belonging to the group Dinosauria. They first appeared during the Triassic period, approximately 230 million years ago, and became the dominant terrestrial vertebrates for 135 million years. The dinosaurs lasted until the end of the Cretaceous Period—approximately 65 million years ago—where the end-Cretaceous extinction event led to the extinction of most, if not all, dinosaur groups. It is interesting to note that Paleocene—the epoch following the Cretaceous—fossil dinosaur remains have since been found from above the Cretaceous/Paleocene extinction boundary in both New Mexico and China. These fossils provide evidence to support the suggestion that some dinosaur populations, in fact, survived the end-Cretaceous extinction and lasted at least a further half million years into the Paleocene Epoch.

Current knowledge suggests that dinosaur evolution after the Triassic Period followed changes in vegetation, along with changes in the physical locations of the continents. Gymnosperms, a group of seed-producing plants represented mainly by the conifers, became well-established during the late-Triassic. The dominance of gymnosperms continued into middle- and late-Jurassic times and these plants provided an important food source for the dinosaurs. By the early-Cretaceous, as a result of ongoing break-up of the Pangaea landmass, evolution of the dinosaurs was then becoming increasingly diversified. A major change in the early-Cretaceous was also marked by the evolution of flowering plants, along with the first grasses, which continued into the late-Cretaceous. This change in vegetation enabled several groups of herbivorous dinosaurs to evolve more sophisticated ways to process food.

The end-Cretaceous extinction event has been extensively studied by others and has been shown to have resulted in the extinction of all but a few remaining dinosaur groups, including ancestors to the modern birds. Other groups, such as the crocodiles, turtles, lizards, snakes, and various related but now extinct species, also survived the extinction, as did a number of Paleocene dinosaurs. Though the consensus in conventional studies is that an impact event was the primary cause of dinosaur extinction, other scientists cite other possible causes or support the idea that a confluence of several factors was responsible for the disappearance of dinosaurs from the fossil record.

It should be noted from the fossil record that misguided confusion surrounds the real meaning of extinction of the dinosaurs. Dinosaurs have always been an extremely varied group of animals. According to a 2006 study, over 500 dinosaur genera have been identified with certainty so far and the total number of genera preserved in the fossil record has been estimated at around 1850, nearly 75 percent of which are said to still remain to be discovered. On average, throughout the reign of the dinosaurs, each dinosaur genus existed for only about five to six million years. As well as this, individual dinosaur species existed for only two to three million years prior to becoming extinct through natural background rates of extinction. This typical rate of dinosaur species turnover suggests that, rather than a single or even multiple catastrophic extinction events, natural species turnover and dying out was a common phenomenon throughout their entire 135 million years of existence.

In addition to climate and crustal changes during that time, it is significant to note that on an increasing radius Earth (Maxlow, 2005, 2012, 2014), the 135 million year Permian to late-Cretaceous interval of time when the dinosaurs prevailed represents an increase in Earth radius from 50 percent of the present radius to approximately 80 percent. Prevailing surface gravity calculated from the radius data shows that, during that time, gravity then increased from around 50 percent of the present surface gravity during the Permian to approximately 75 percent during the late-Cretaceous. Considering the large size of many dinosaur species, the dinosaurs existing during these times would well have benefited from the much lower surface gravity prevailing during the early part of the Mesozoic Era.

Hurrell, (2011, 2012, 2014) provided independent evidence for a reduced gravity during these times after analysing the mechanical aspects of dinosaur bones. He concluded that it would have been impossible for the larger dinosaurs to exist in environments of high surface gravity—such as exists now. From his mechanical studies of dinosaur bones Hurrell also independently calculated a surface gravity during the Permian of 50 percent of the present surface gravity. The subsequent increase in surface gravity during the remaining Mesozoic Era may then offer an additional explanation for the large turnover of dinosaur genera throughout the history of the dinosaurs, as noted by Dodson and Tatarinov (1990).

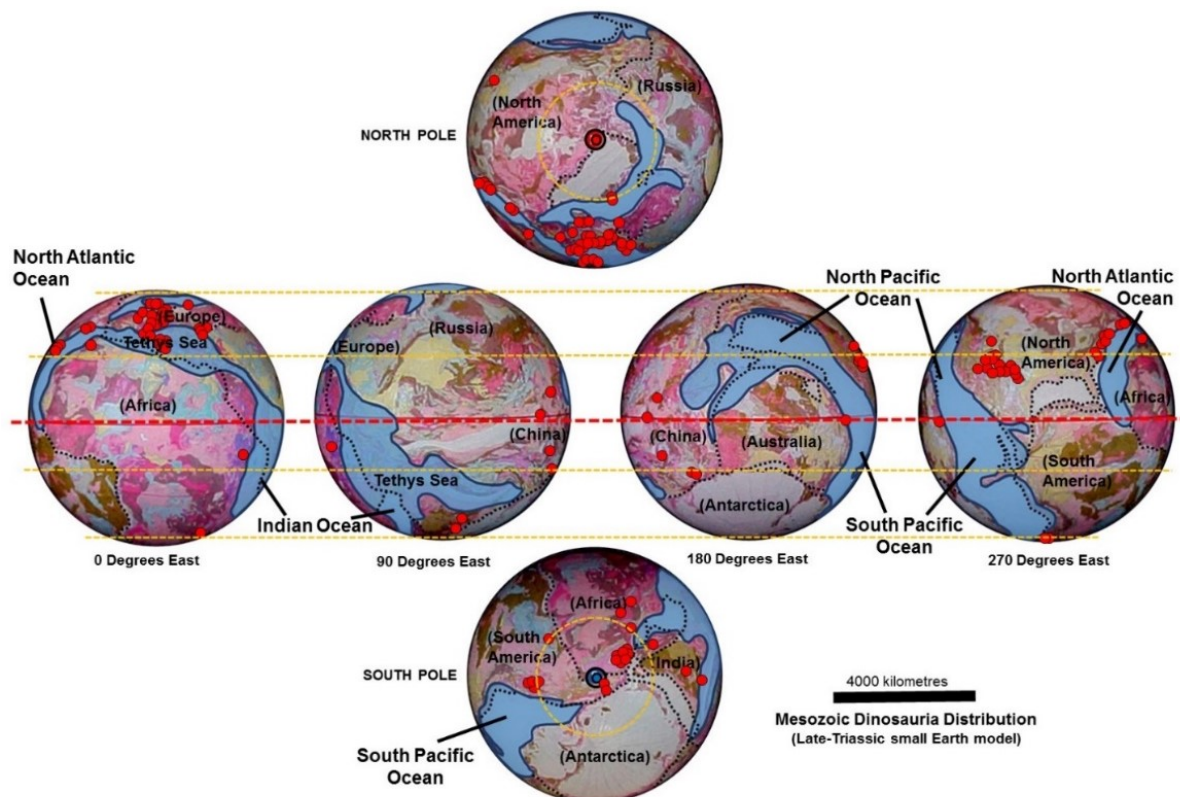
The distribution, migration, and eventual demise of the dinosaurs on an increasing radius Earth should then be visualised in conjunction with this very involved period of crustal break-up, new

ocean development, and change in surface gravity. While the prolonged period of time involved during this crustal break-up allowed the dinosaur species to migrate to more equitable locations, it also presented new physical and environmental barriers. The draining of the ancient continental seas, for instance, influenced the distribution of the modern seas and oceans and hence adversely affected available dinosaur habitats, migration routes, and escape avenues. Migration away from these physical barriers may have then encouraged the dinosaurs to evolve into new species. In contrast, failing to evolve, migrate, or being land-locked may have also caused their localised demise.

The following figures focus on the various dinosaur-related lineages to highlight their global distributions in context with opening of the modern oceans and dispersal of the modern continents during the Mesozoic Era. During the slow recovery from the end-Permian extinction event, the previously obscure group of archosaurs—a group that includes the extinct dinosaurs and whose living representatives consist of birds and crocodiles—became the most abundant and diverse terrestrial vertebrates during the Triassic.

The dinosaurs were a diverse group of animals that first appeared during the Triassic period. They were the dominant terrestrial vertebrates until the end of the Cretaceous. The Dinosaurs are divided into two orders, the Ornithischia and Saurischia. This division is based on the evolution of the pelvis into more bird-hip and lizard-hip like structures, details in the vertebrae, the development of armour, and the possession of a predentary bone in the front of the lower jaw used to clip off plant material.

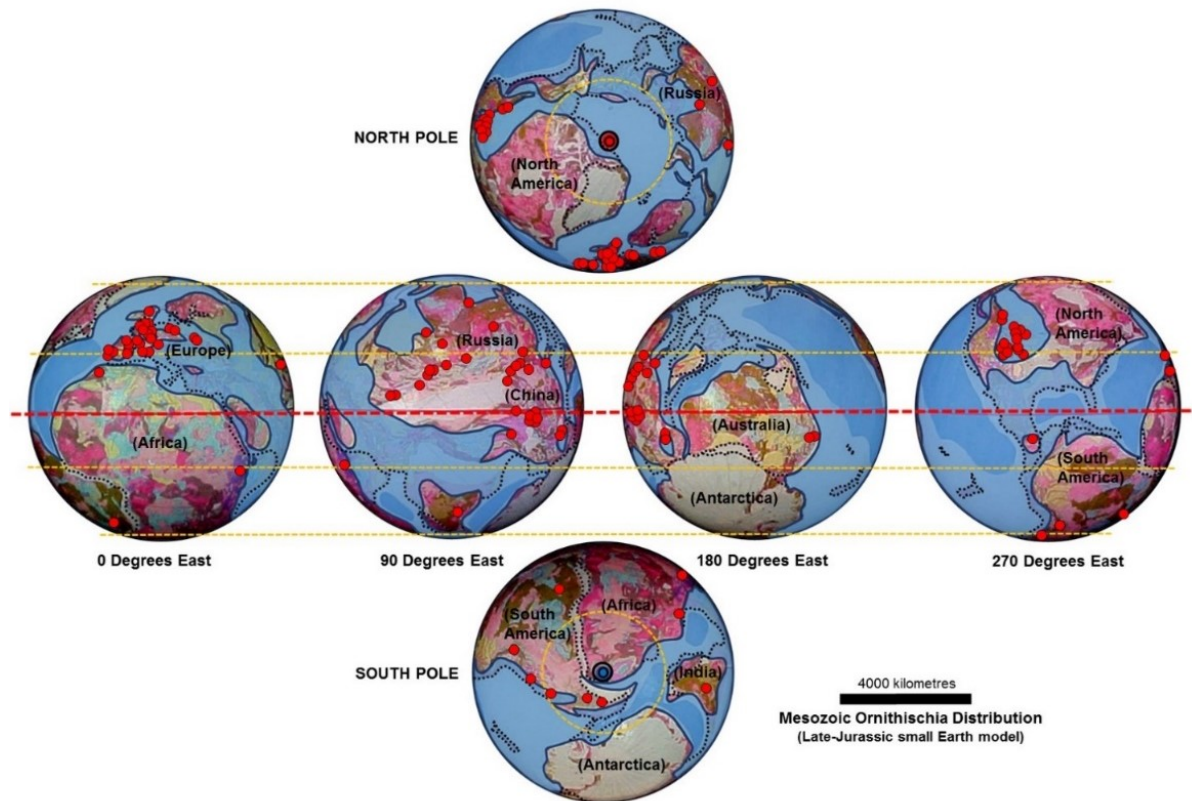
The early distribution of the dinosaurs is shown on the late-Triassic small Earth model in Figure 4. Important provincial centres coincide with their ancestral reptile centres and include locations in Europe—located in the northern Temperate Zone, North America—located in the Equatorial Zone, and South Africa—located in the South Polar Region.



**Figure 4** Distribution of Mesozoic dinosauria plotted on a late-Triassic small Earth model. Dinosauria data are shown as red dots (data after PaleoBioDB, 2015) in relation to climate zones and distribution of ancient continental seas and modern oceans.

The Ornithischia are a group of medium to large, beaked, herbivorous dinosaurs. The distribution of ornithischia is shown on the late-Jurassic small Earth model in Figure 5. In this figure, as with the dinosauria in Figure 4, there is still an element of provincial distribution centred on

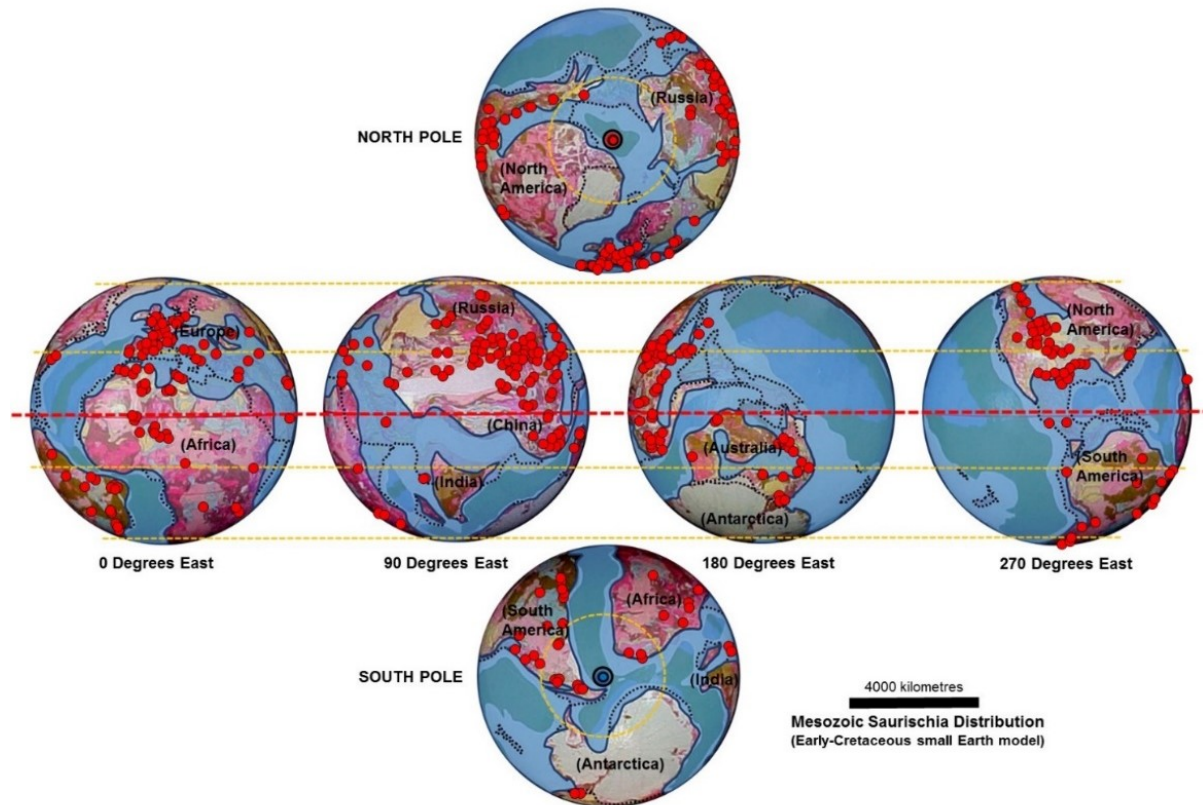
locations in North America and Europe, plus a new centre in China. By the late-Jurassic, indications are that the South African ornithischia had either died out or had migrated to adjoining southern South America. During that time the South Pole had migrated into South Africa and breaching between Africa and South America and opening of the Atlantic and Indian Oceans had commenced. This opening effectively isolated South Africa from adjoining southern South America, India, and Antarctica. Elsewhere, other dinosaur species were becoming increasingly isolated in Australia, India, and the Asian-Russian continents.



**Figure 5** Distribution of Mesozoic ornithischia plotted on a late-Jurassic small Earth model. Ornithischia data are shown as red dots (data after PaleoBioDB, 2015) in relation to climate zones and distribution of ancient continental seas and modern oceans.

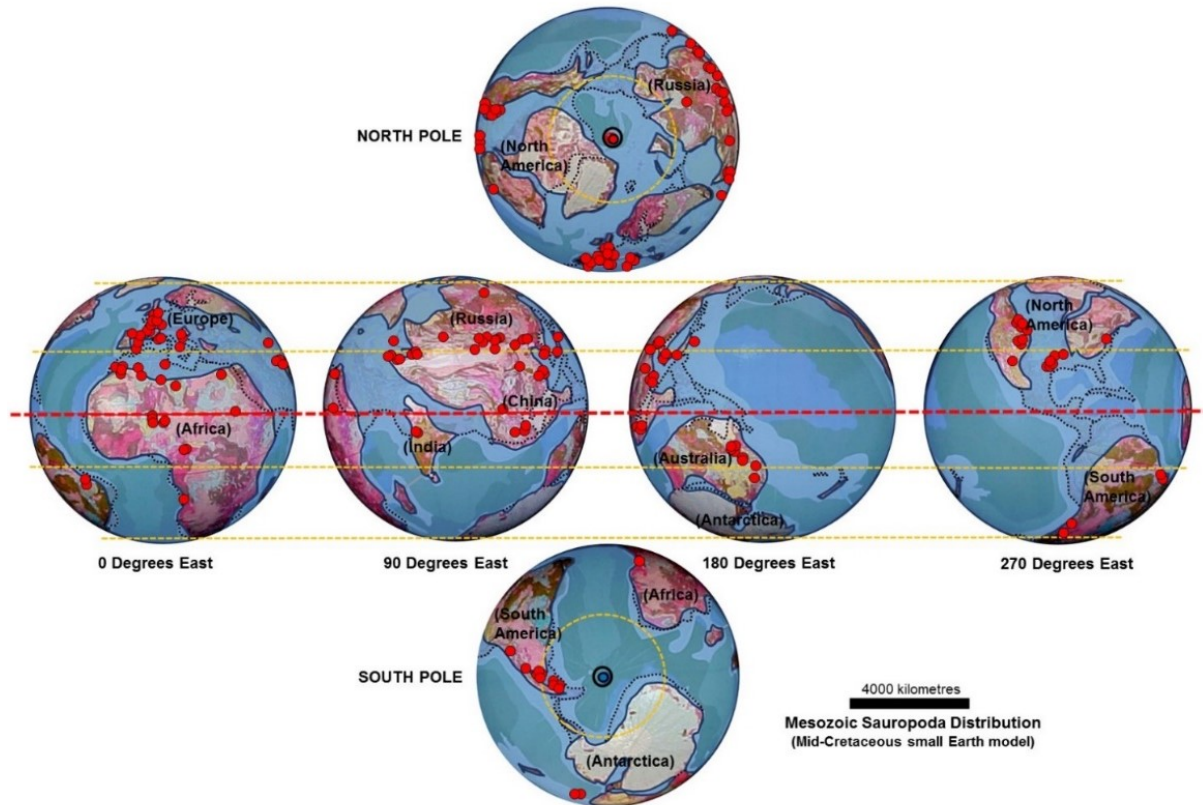
The saurischian dinosaurs are traditionally distinguished from ornithischian dinosaurs by their three-pronged pelvic structure, with the pubis pointing forward. The distribution of saurischian dinosaurs is shown on the early-Cretaceous small Earth model in Figure 6. By the early-Cretaceous these dinosaurs were rapidly diversifying and populating most continents on Earth. From small provincial centres the saurischians were also evolving independently as continental breakup and changing sea levels formed a number of isolated island continents.





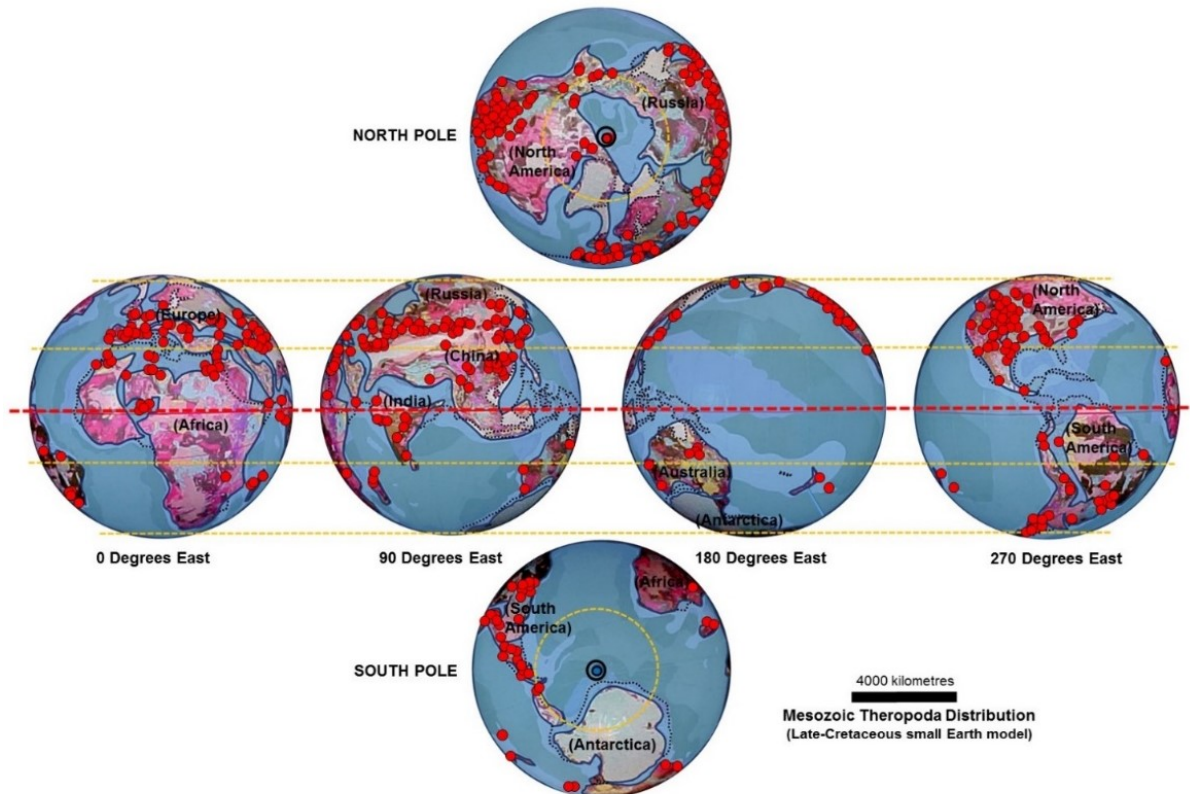
**Figure 6** Distribution of Mesozoic saurischia plotted on an early-Cretaceous small Earth model. Saurischia data are shown as red dots (data after PaleoBioDB, 2015) in relation to climate zones and distribution of ancient continental seas and modern oceans.

Sauropods were a group of four-legged, herbivorous animals with a relatively simple body plan that varied only slightly throughout the group. The distribution of sauropod dinosaurs is shown on the mid-Cretaceous small Earth model in Figure 7. From the mid-Cretaceous through to the late-Cretaceous their distributions remained much the same and fossil evidence shows they were more prolific during the late-Cretaceous.



**Figure 7** Distribution of Mesozoic sauropoda plotted on a mid-Cretaceous small Earth model. Sauropoda data are shown as red dots (data after PaleoBioDB, 2015) in relation to climate zones and distribution of ancient continental seas and modern oceans.

The theropod dinosaurs are a diverse sub-group of the bipedal saurischian dinosaurs. The distribution of theropod dinosaurs is shown on the late-Cretaceous small Earth model in Figure 8. In this figure, by the late-Cretaceous the theropods had become widely dispersed, populating all continents and extending from the high northern to the high southern latitudes. This distribution also included theropods in remote islands such as New Zealand and Madagascar. Theropods in remote islands may represent a holdover of species from early beginnings during the late-Triassic times when New Zealand, for instance, was connected to Central America and Madagascar was connected to India and South Africa.



**Figure 8** Distribution of Mesozoic theropoda plotted on a late-Cretaceous small Earth model. Theropoda data are shown as red dots (data after PaleBioDB, 2015) in relation to climate zones and distribution of ancient continental seas and modern oceans.

## What Really Happened to the Dinosaurs?

The end-Cretaceous extinction event—commonly referred to as the K-T event—is the most publicised and well known of all the extinction events, occurring around 65.5 million years ago at the Cretaceous to Paleogene transition. This extinction event was a large-scale mass extinction of animal and plant species, most notably the dinosaurs, in a geologically short period of time. During that time about 17 percent of all families, 50 percent of all genera, and 75 percent of all species became extinct. In the oceans the number of marine species was also reduced to about 33 percent.

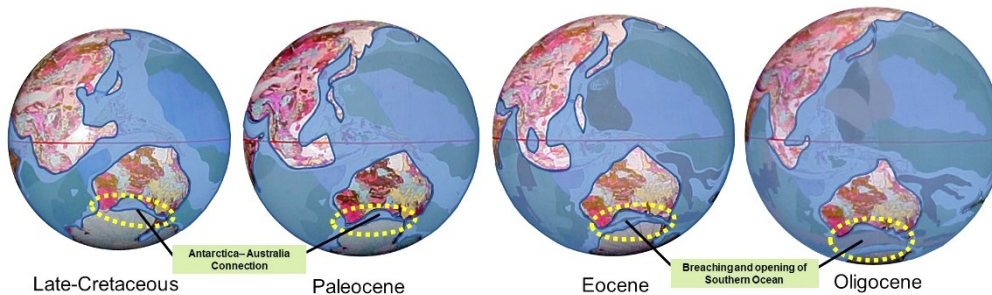
It is currently hypothesized that the end-Cretaceous extinction event was caused by one or more catastrophic events, including either an asteroid impact or an increase in terrestrial volcanic activity. In 1980, a team of researchers lead by Luis Alvarez recognised that concentrations of the element iridium, located at the Cretaceous–Paleogene time boundary, were higher than in surrounding sedimentary layers. This gave support for consideration of a collision of the Earth by a large celestial object—similar to the Shoemaker-Levy impact observed on Jupiter in 1994. This potential celestial object was later identified to be the Chicxulub crater located in Central America.

Other researchers though consider the extinction event was more gradual, resulting instead from sea-level and climate changes already occurring during the late-Cretaceous, which may or may not have been aggravated by impact events or increased volcanic activity. Based on fossil evidence, the end-Cretaceous extinction of the dinosaurs, for instance, was considered by Dodson and Tatarinov (1990) to have been a highly selective world-wide phenomenon, which lasted for approximately 8 million years. They went further to consider that although disappearance of the dinosaurs was a spectacular aspect of the Cretaceous extinction, it actually represented the loss of rather few species and was only a small percentage of the entire extinction of species.

On increasing radius small Earth models the end-Cretaceous extinction event coincided with breaching and opening of the Southern Ocean, located between Australia and Antarctica (Figure 9).

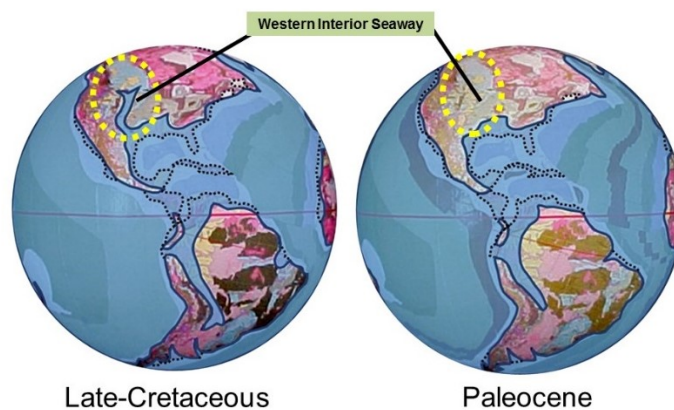


During the late-Cretaceous the Australia to Antarctica assemblage had exposed land connections adjacent to Western and Eastern Australia with an isolated shallow sea located adjacent to Southern Australia—known as the Eucla Basin. These land connections were then partly breached along the Western Australian coastline, causing flooding of the Eucla Basin, prior to complete breaching and opening of the Southern Ocean during Paleocene to Eocene times—around 65 million years ago.



**Figure 9** Late Cretaceous to Oligocene small Earth models showing land connections between Australia and Antarctica, prior to breaching during the Paleocene to form the Southern Ocean (coastlines after Scotese, 1994, and Smith *et al.*, 1994).

The significance of this breaching event is highlighted in Figure 10 showing the continued decline in surficial area of the Western Interior Seaway of North America during the late-Cretaceous and Palaeocene times. The Western Interior Seaway is an important area for dinosaur study and has provided a large amount of data for interpretation of the end-Cretaceous extinction event. It is significant to note that the considerable regression of the Western Interior Seaway into the Gulf of Mexico coincides with the extended duration of the end-Cretaceous extinction event, as noted by Dodson and Tatarinov.



**Figure 10** Late Cretaceous and Palaeocene small Earth models showing regression of seas within the Western Interior Seaway of North America (coastlines after Scotese, 1994, and Smith *et al.*, 1994).

On an increasing radius Earth it is considered that breaching between Australia and Antarctica during initiation and opening of the Southern Ocean resulted in a period of disruptive sea-level change. This continental breaching and sea-level change coincided precisely with the end-Cretaceous extinction event. These observations support the conclusions of others where the extinction event was more gradual, resulting from drastic sea-level changes already occurring during the late-Cretaceous, extending over a period of approximately 8 million years.

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**Maxlow, J. (2016). Dinosaurs on an Expanding Earth. [dinox.org](http://dinox.org)**