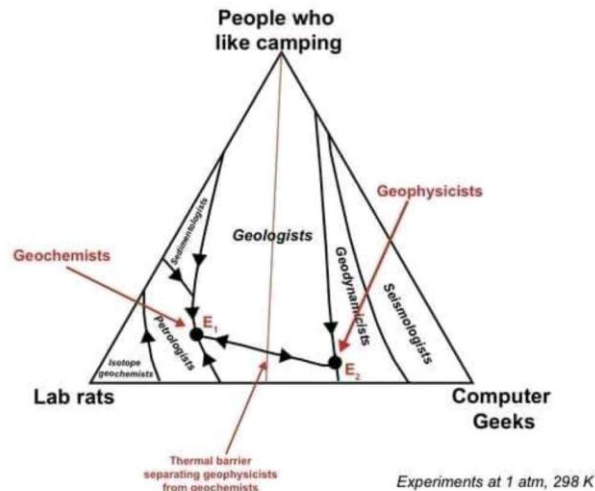


August 29, 2022

## News and notes

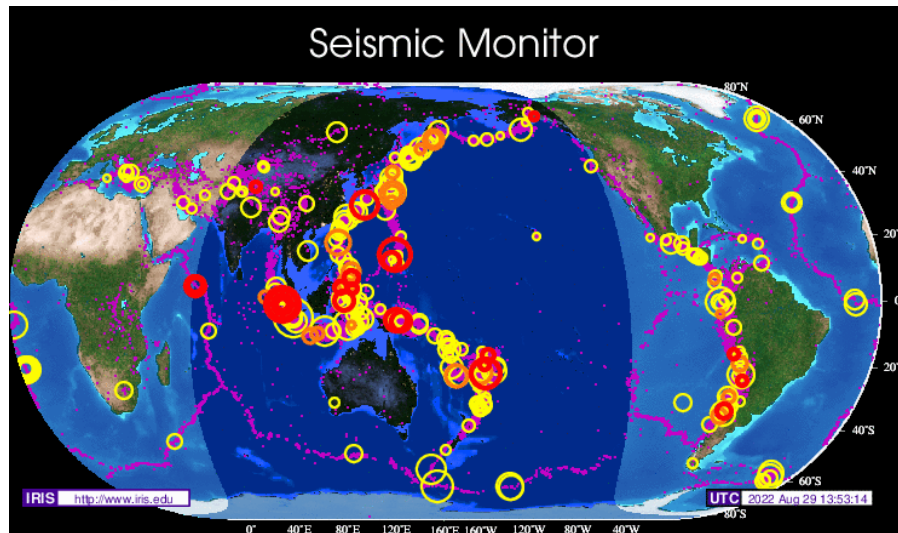
Before going onto discuss the events of the [Paleogene Period](#), here are some news items that I thought were interesting.

## Humour- Geoscientists



**Ternary Diagram of the Geology Professional System**  
**Credit: [u/h trismegistus](#), [reddit](#), [subreddit](#), [r/geology](#)**

## Volcanoes, Earthquakes and Geohazards



[Seismic Monitor Link](#)

- Anthropogenic earthquakes in the heartland: [Basement Fault Activation before Larger Earthquakes in Oklahoma and Kansas](#); Phys.org summary [here](#).
- [Worldwide Volcano News and Updates](#)

## Research

- India moving towards Asia in the Cretaceous and Paleogene: [Slab remnants beneath the Myanmar terrane evidencing double subduction of the Neo-Tethyan Ocean](#); Phys.org summary [here](#).
- More on the Himalayas: [Megathrust Heterogeneity, Crustal Accretion, and a Topographic Embayment in the Western Nepal Himalaya: Insights From the Inversion of Thermochronological Data](#); Phys.org summary [here](#).
- Interaction between minerals and microbes: [A critical review of mineral-microbe interaction and coevolution: mechanisms and applications](#); Phys.org summary [here](#).
- Irrigating plants with alcohol, does it come up already half-cut? [Ethanol-Mediated Novel Survival Strategy against Drought Stress in Plants](#); Phys.org summary [here](#).
- Early continents and plate tectonics: [Did transit through the galactic spiral arms seed crust production on the early Earth?](#) Eureka Alert summary [here](#).
- [Zircon U–Pb Dating of Tuff Layers in the Middle–Upper Triassic Strata of Successions and Sedimentation of Chang 7 Member in the Ordos Basin, China](#).
- Modern times: [Planetary-scale change to the biosphere signalled by global species translocations can be used to identify the Anthropocene](#).

## Paleontology

- [A multidisciplinary approach to reconstructing the history of early animal life on Earth](#).
- Evolution of manatees and dugongs: [Total evidence time-scaled phylogenetic and biogeographic models for the evolution of sea cows \(Sirenia, Afrotheria\)](#); Phys.org summary [here](#).
- Mosasaurs: [Thalassotitan atrox, a giant predatory mosasaurid \(Squamata\) from the Upper Maastrichtian Phosphates of Morocco](#); Eureka Alert summary [here](#).
- Cretaceous turtles: [Stratigraphic range extension of the turtle \*Boremys pulchra\* \(Testudinata, Baenidae\) through at least the uppermost Cretaceous](#).
- [Middle Miocene \(Serravallian\) rhodoliths and coralline algal debris in carbonate ramps \(Betic Cordillera, S Spain\)](#).
- From Smithsonian Magazine: [Drought Exposes Dinosaur Tracks in Texas](#).
- Behind a paywall: [Deep origin of the crossed-lamellar microstructure in early Cambrian molluscs](#).

## Environmental Geology and Hydrogeology

- [Accumulation of recalcitrant dissolved organic matter in aerobic aquatic systems](#); Phys.org summary [here](#).
- From Phys.org and the Conversation: [Dallas is only the latest flood disaster: How cities can learn from today's climate crises to prepare for tomorrow](#).

- Soil and groundwater contamination can last forever: [Per- and Polyfluoroalkyl Substances \(PFAS\) in Subsurface Environments: Occurrence, Fate, Transport, and Research Prospect](#); Phys.org summary [here](#).
- Cleaning up heavy metals in water: [Production of microalgal-based carbon encapsulated iron nanoparticles \(ME-nFe\) to remove heavy metals in wastewater](#).

## Mining and Energy

- Delaying deep sea mining: [The Invocation of the 'Two-Year Rule' at the International Seabed Authority: Legal Consequences and Implications](#); Phys.org summary [here](#).
- Won't replace boots on the ground: [Application of Machine Learning to Characterizing Magma Fertility in Porphyry Cu Deposits](#); Phys.org summary [here](#).
- Oil and gas exploration: [U.S. oil & gas rig count falls for first time in 25 months -Baker Hughes](#).
- [Natural Gas Soars in Europe, Asia as Crisis Heats Up Competition](#).
- Related: [Russia Is Flaring Natural Gas While Choking Supply To Europe](#) and [Germany Rethinks Gas Levy Following Major Outcry](#).
- From Oil Price.com: [Oil And Gas Producers To Break New Cash Flow Records](#).
- Whoops: [Oil Refinery Fire Sparks Fears Of A Fuel Shortage In Four States](#).
- From the U.S. Energy Information Administration (USEIA): [Crude oil production in Texas's Eagle Ford region has been increasing since February 2022](#).
- Also from the USEIA: [Monthly Energy Review](#) for August 2022.
- Start with good field geology: [Use of Analogue Exposures of Fractured Rock for Enhanced Geothermal Systems](#).
- Mining minerals and climate change: [Trend and priority change of climate change mitigation technology in the global mining sector](#); Mining.com summary [here](#).
- From Mining.com: [Tesla's battery metals bill balloons to \\$100 billion](#); and [Japan's nuclear policy shift marks a turning point for uranium](#).

## Upcoming Events



4<sup>th</sup> International Congress on Stratigraphy

**strati 2023**

11<sup>th</sup> -13<sup>th</sup> July 2023, Lille, France

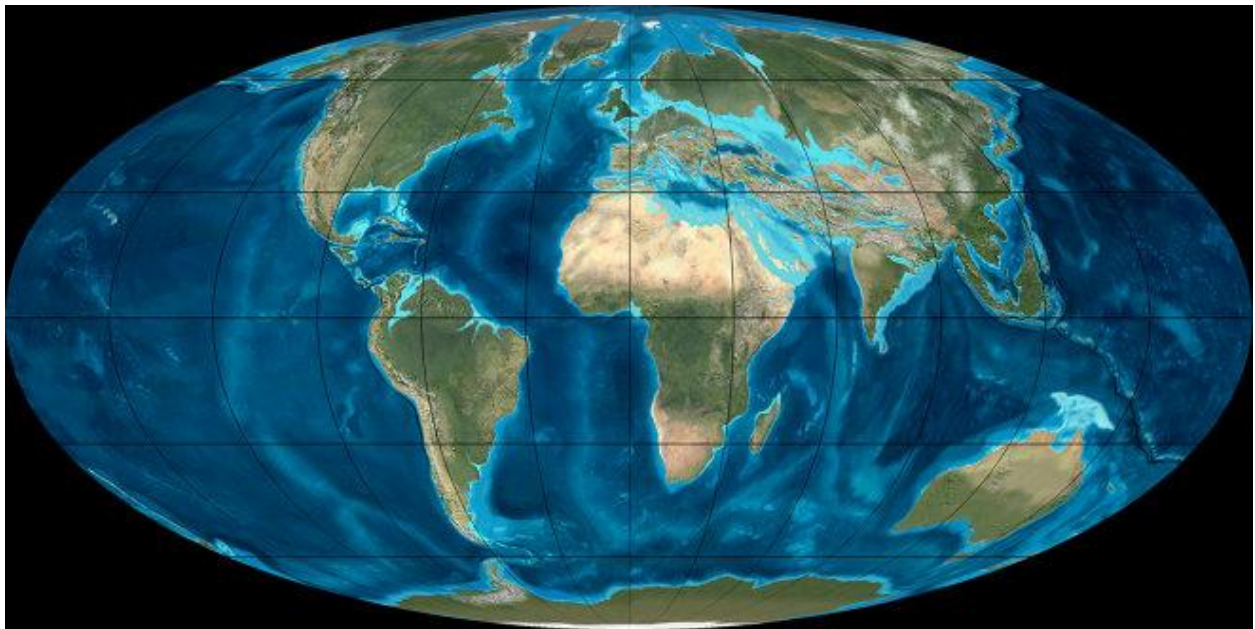
[Link](#)

*August 29, 2022*

## The World of the Paleogene Period

Lasting almost 43 million years from 66 million years ago (Mya) to 23.03 Mya, the [Paleogene](#) Period covers many important changes in the Earth's geography and biology. Following the [End Cretaceous Mass Extinction](#), the surviving life adapted to the new conditions, eventually evolving many new and amazing forms. We'll review the fossils from the Paleogene in upcoming posts, but for this week, let's look at the paleogeography, climate, mountain building events, and subdivisions of the period.

### Paleogeography and Climate



**Figure 1 - The World of the Paleogene, 35 Mya**

**Credit:** Corentin Barbu, [Creative Commons Attribution-Share Alike 4.0 International](#) license

During the Paleogene Period, the continents began to take on most of their present shape. The North Atlantic and South Atlantic Oceans continued to grow as the [Mid-Atlantic Ridge](#) continued to expand. The [Tethys Sea](#) gradually shrank as Africa and India moved north towards Eurasia with the Indian portion being completely closed off during this time. The [epicontinental seas](#) that covered central North America receded at the end of the [Cretaceous](#) Period but covered much of north central Europe and central Asia. Outside the main land masses, the [Panthalassa](#) Ocean covered much of the Earth.

During the Paleogene, the general climate of the world became warmer in the [Paleocene](#) Epoch, culminating in the [Paleocene-Eocene Thermal Maximum](#) (PETM) and the generally very warm climate of the first half of the [Eocene](#) Epoch. However, by the latter half of Eocene, things began

too cool on the Earth, to the point [that permanent glaciers first began in Antarctica](#) during the early [Oligocene](#).

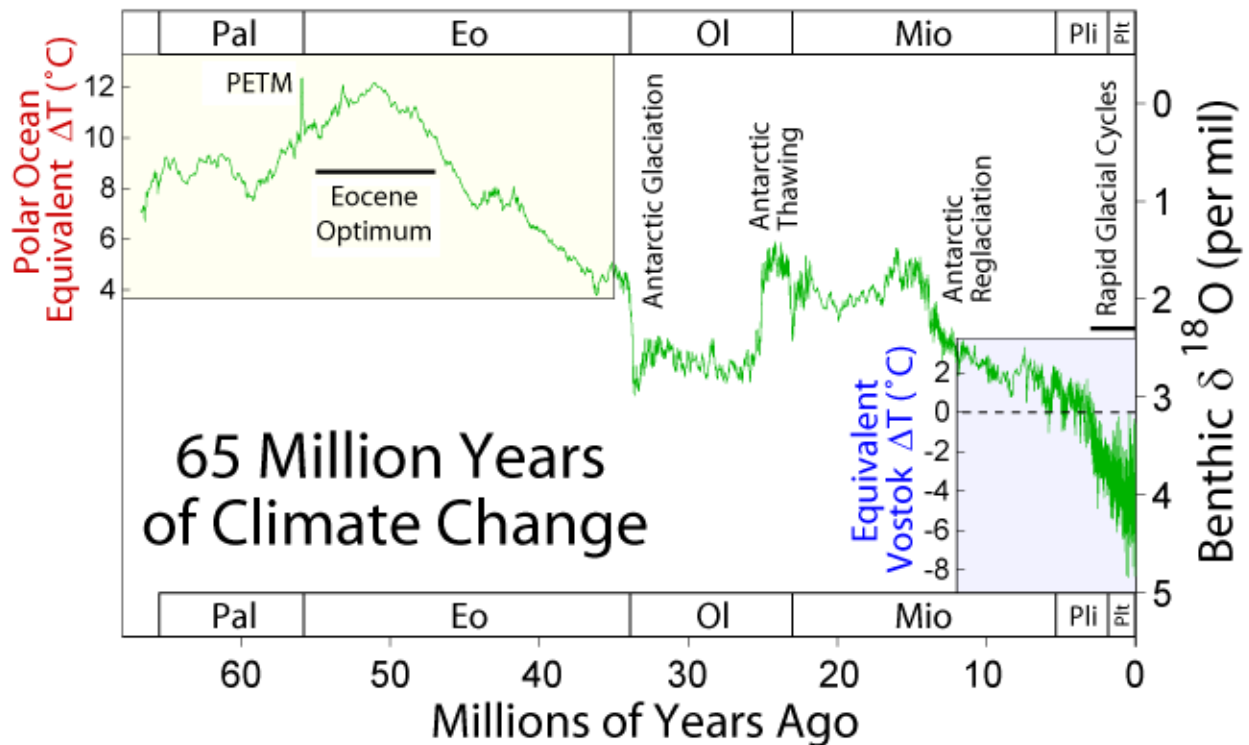


Figure 2 - 65 Million Years of Climate Change

Credit: [Robert A. Rohde](#), [Creative Commons Attribution-Share Alike 3.0 Unported license](#)

The rise of carbon dioxide (CO<sub>2</sub>) concentrations in the atmosphere probably lead to the PETM. The causes of the [Eocene Optimum](#) that followed are still under investigation. The general cooling that followed appears to have been the result of the establishment of the [Antarctic Circumpolar Current](#), which altered weather patterns, and the rise of new mountain ranges, which removed CO<sub>2</sub>.

### Mountain Building Events

Mountain building events ([orogenies](#)) during the Paleogene occurred in Asia, Europe, North America, South America, and New Zealand.

#### *Asia - Himalayan Orogeny*

During the [Late Cretaceous](#), the [Indian Subcontinent](#) began its relatively rapid [tectonic movement](#) towards the north. By the Oligocene Epoch, India began to push into Asia, closing the eastern part of the Tethys Sea and beginning the rise of the [Himalayan Mountains](#) and eventually, the [Tibetan Plateau](#). The rise of the Himalayas and Tibet increased the area of land open to erosion, thus causing more CO<sub>2</sub> to be segregated out of the atmosphere. ([See recent research on this](#)).

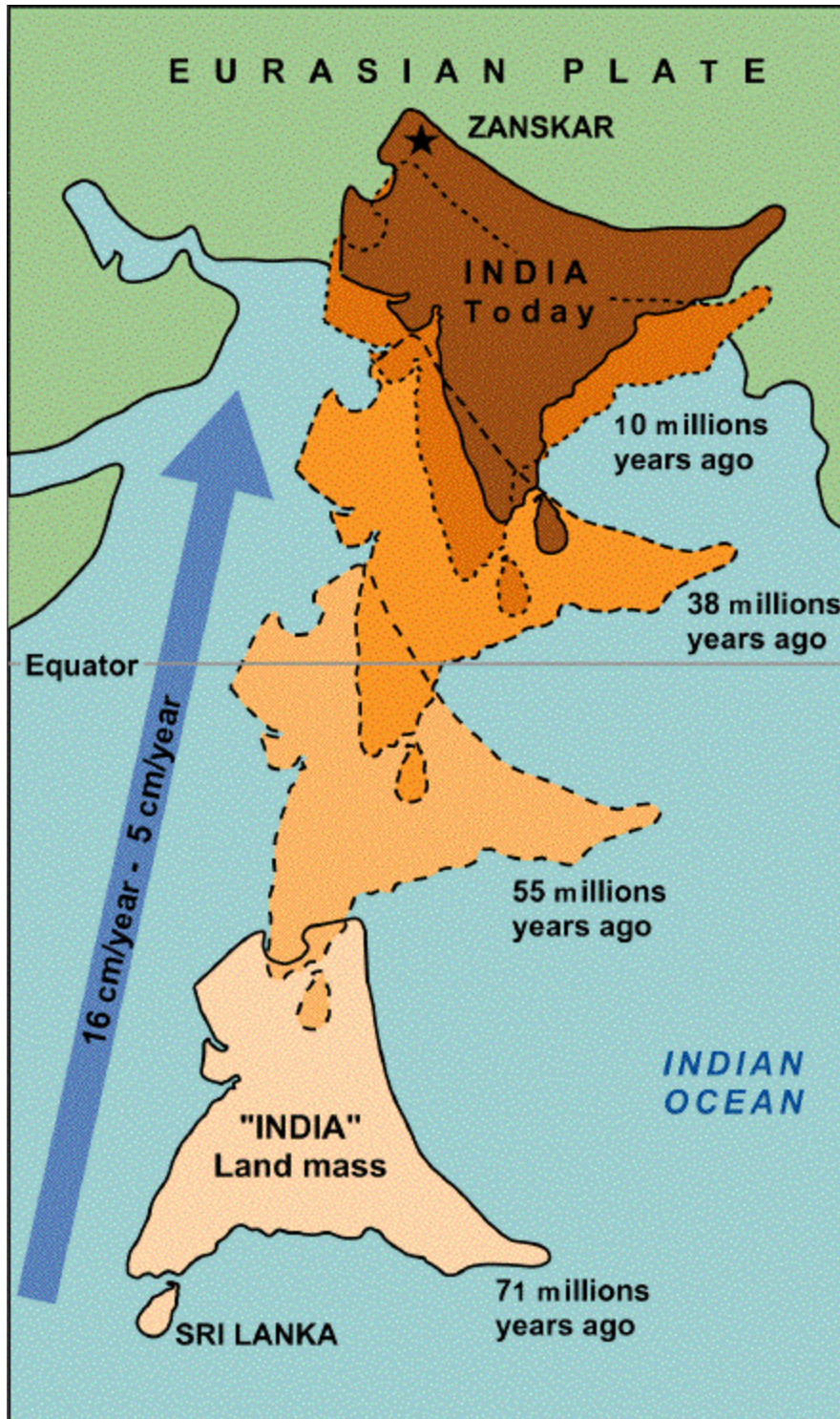


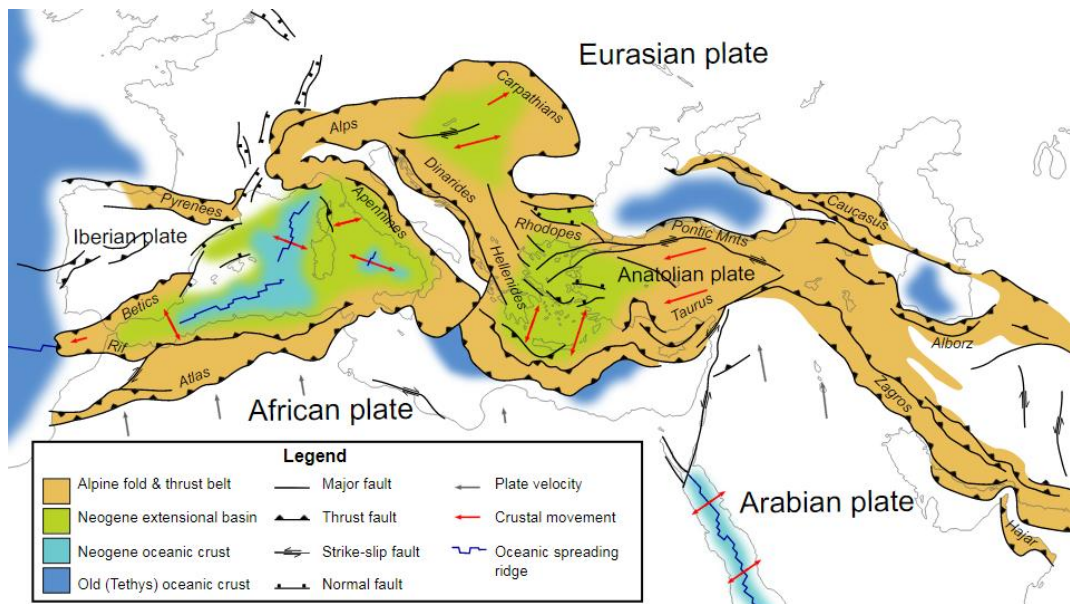
Figure 3 - Indian Subcontinent  
Credit: From Figure 2.1 in [Pierre Dèzes 1999](#)

*Europe - Alpine and Hellenic Orogenies*



**Figure 4 - Mont Blanc, Alpine Orogeny**  
**Credit: TL, Free Art License**

Most of the beautiful mountains of Europe, Northwest Africa, and Asia Minor began to form in the [Alpine Orogeny](#). The Alpine Orogeny mostly took place between the Eocene Epoch of the Paleogene and the [Miocene](#) Epoch of the [Neogene](#) Period, although some earlier mountain building in the Carpathians began during the [Jurassic](#).



**Figure 5 - Tectonic map of southern Europe, North Africa and the Middle East**  
**Credit: Woudloper, Creative Commons Attribution-Share Alike 1.0 Generic license**

The driving force behind the Alpine Orogeny was the northward tectonic movement of the [African Plate](#) closing off the Tethys Sea and driving up the mountains of Europe.

### *North America - Sevier and Laramide Orogenies*



**Figure 6 - Sun River Canyon Montana, Sevier Orogeny**

**Credit: [Qfl247 \(talk\)](#), [Creative Commons Attribution-Share Alike 3.0 Unported](#) license**

Both the [Sevier](#) and [Laramide](#) orogenies took place in western North America. The Sevier Orogeny began during the [Late Jurassic](#), 160 Mya, and continued until the Eocene Epoch, about 50 Mya. The cause of the Sevier Orogeny was the [subduction](#) of the oceanic [Farallon Plate](#) underneath the continental [North American Plate](#). The Laramide Orogeny began in the Late Cretaceous, about 70 to 80 Mya, and ended during the Eocene, 35 to 55 Mya. The Laramide Orogeny was also caused by plate subduction, in this case by both the Farallon and [Kula](#) plates.

Between them, the Sevier and Laramide orogenies are responsible for much of the topography of western North America including the [Rocky Mountains](#), the [intermontane basins](#) of Colorado, Utah and Nevada, as well as the [Black Hills of South Dakota](#).

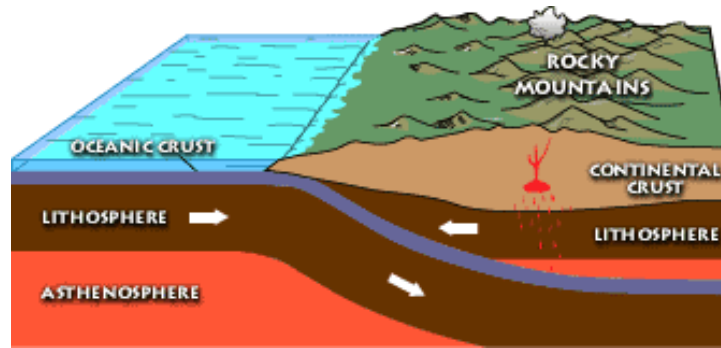


Figure 7 - Shallow Subduction of a Tectonic Plate during the Laramide Orogeny  
[Credit: Melanie Moreno, public domain](#)

### *South America - Andean Orogeny*



Figure 8 - Satellite image of the Andes Mountains  
[Credit: NASA, public domain](#)

The [Andean Orogeny](#) began during the [Early Jurassic](#) and continues to this day. As with the North American orogenies, the cause of the Andean Orogeny is the subduction of oceanic plates, in this case the [Antarctic](#), [Cocos](#) and [Nazca](#) plates, under the [South American Craton](#).

### *New Zealand - Kaikoura Orogeny*

Another orogeny that continues to this day is the [Kaikoura Orogeny](#) that began 25 Mya during the Oligocene and is responsible for the formation of the [Southern Alps](#) (made famous by the [Lord of the Rings](#) films by Peter Jackson). As with almost all mountain building, the Kaikoura Orogeny is the product of interaction between tectonic plates, in this case the [Pacific Plate](#) is colliding with the [Australian Plate](#) along the [Alpine Fault](#).



**Figure 9 - The Southern Alps of New Zealand**

**Credit:** W. Bulach, [Creative Commons Attribution-Share Alike 4.0 International](#) license

### **Subdivisions of the Paleogene**

The Paleogene Period is divided into three epochs:

- The [Oligocene](#), 33.9 to 23.03 Mya;
- The [Eocene](#), 56 to 33.9 Mya; and
- The [Paleocene](#), 66 to 56 Mya.

Table 1, below, outlines the general organization of the Paleogene.

Period	Epoch	Ages	Mya
Paleogene 66 to 23.03 Mya	Oligocene 33.9 to 23.03 Mya	Chattian 27.82 to 23.03 Mya	23.03
		Rupelian 33.9 to 27.82 Mya	27.82
	Eocene 56 to 33.9 Mya	Priabonian 37.71 to 33.9 Mya	33.9
		Bartonian 41.2 to 37.71 Mya	37.71
		Lutetian 47.8 to 41.2 Mya	41.2
		Ypresian 56 to 47.8 Mya	47.8
	Paleocene 66 to 56 Mya	Thanetian 59.2 to 56 Mya	56
		Selandian 61.6 to 59.2 Mya	59.2
		Danian 66 to 61.6 Mya	61.6

**Table 1 - Subdivisions of the Paleogene**  
Based Upon [The International Subcommission on Paleogene Stratigraphy](#)

### Oligocene Epoch

The term Oligocene was coined by German paleontologist [Heinrich Ernst Beyrich](#) in 1854. He took the name from the Greek words ὀλίγος (olígos, "few") and καινός (kainós, "new") referring to the fact that he found few new molluscs in the Oligocene deposits that he was studying. The epoch is divided into two ages: the [Chattian](#) and the [Rupelian](#).

#### *Chattian Age*

The Chattian Age lasted from 27.82 to 23.03 Mya and is the last, or topmost age of the Oligocene. The age was named in 1894 by Austrian palaeontologist [Theodor Fuchs](#) after an ancient Germanic tribe, the [Chatti](#).

The top of the Chattian age is the first appearance of foram species [Paragloborotalia kugleri](#), the extinction of calcareous nanoplankton species [Reticulofenestra bisecta](#) (which forms the base of nanoplankton biozone NN1) together with the base of [paleomagnetic zone C6Cn.2n](#). The top of the Chattian is also the base of Neogene Period.

The base of the Chattian Age is at the extinction of the foram genus [Chiloguembelina](#) (which is also the base of foram biozone P21b). An official [Global Boundary Stratotype Sections and Points](#) (GSSP) [for the Chattian Stage](#) was ratified by the International Commission on Stratigraphy (ICS) in October of 2016.

### ***Rupelian Age***

The Rupelian Age lasted from 33.9 to 27.82 Mya and is the first age in the Oligocene Epoch. In 1850, the Belgian geologist [André Hubert Dumont](#) named the age after the [Rupel River](#) in Belgium.

The base of the Rupelian is at the extinction of the foraminiferan genus [Hantkenina](#). The ICS assigned the official GSSP for the [base of the Rupelian](#) in 1992 to a site near [Massignano](#), Italy. The base of the Rupelian coincident with the first appearance of glaciers in Antarctica.

## **Eocene Epoch**

Scottish geologist [Charles Lyell](#) named the Eocene Epoch in 1833. There are four ages in the Eocene: the [Priabonian](#), the [Bartonian](#), the [Lutetian](#), and the [Ypresian](#).

### ***Priabonian Age***

The Priabonian Age lasted from 37.71 to 33.9 Mya and is the topmost age of the Eocene. [Ernest Munier-Chalmas](#) and [Albert de Lapparent](#) named the age after the hamlet of Priabona near [Monte di Malo](#) in Italy.

The first appearance of the calcareous nanoplankton [Chiasmolithus oamaruensis](#) (which forms the base of nanoplankton biozone NP18). The ICS ratified the [official GSSP](#) in 2020 and it is in [Alano di Piave, Belluno, Italy](#).

### ***Bartonian Age***

Swiss stratigrapher [Karl Mayer-Eymar](#) named the Bartonian Age in 1857 after the [Barton Group](#), a group of formations in the south English [Hampshire Basin](#).

The base of the Bartonian is at the first appearance of the calcareous nanoplankton species [Reticulofenestra reticulata](#). The ICS has not established an official GSSP for the age, their [website](#) lists the [Contessa highway section near Gubio, Central Apennines](#), Italy as a tentative GSSP.

### ***Lutetian Age***

The Lutetian Age lasted from 47.8 to 41.2 Mya. The name comes from the Latin name for Paris and was first used by French geologist [Albert de Lapparent](#) in 1883.

The base of the Lutetian Stage is at the first appearance of the nanofossil [Blackites inflatus](#). The ICS established [the GSSP for the Lutetian](#) in 2011 at the [Gorrondatxe sea-cliff section](#), northwest of Bilbao, Spain.

### ***Ypresian Age***

Lasting from the beginning of the Eocene at 56 until 47.8 Mya, the Ypresian Age was named in 1850 by the Belgian geologist André Hubert Dumont after the Belgian city of [Ypres](#), the location of the original type section.

The base of the Ypresian Age is defined geochemically by a strong negative anomaly of the stable isotopes  $C^{12}$  and  $C^{13}$  ([the  \$\delta^{13}C\$  ratio](#)) at the Paleocene-Eocene Thermal Maximum. The ICS established the [official GSSP for the Ypresian](#) at the [Dababiya Section](#), near Luxor, Egypt.

## **Paleocene Epoch**

The French paleobotanist and geologist [Wilhelm Philipp Schimper](#) first used the term Paleocene in 1874. It come from a combination of the Greek word *palaios* παλαιός meaning "old" and the name for the following epoch, the Eocene; so you can say that it means older than the Eocene. There are four ages in the Paleocene: the [Thanetian](#), the [Selandian](#) and the [Danian](#).

### ***Thanetian Age***

The Swiss geologist [Eugène Renevier](#) first named the Thanetian Age in 1873 and it lasted from 59.2 to 56 Mya. Renevier named it after the [Thanet Formation](#), the oldest Cenozoic deposit of the [London Basin](#) which in turn was named after the [Isle of Thanet](#), an area in Kent, England.

The base of the Thanetian Stage is laid at the base of magnetic [chronozone](#) C26n. The ICS [established the GSSP](#) for the base of the Thanetian at the sea-cliff along the main beach of the coastal town [Zumaia](#), Spain. The GSSP is about 78 m above the [K/Pg boundary](#).

### ***Selandian Age***

The Selandian Age lasted from 61.6 to 59.2 Mya. Danish geologist [Alfred Rosenkrantz](#) named the age in 1924 after the Danish island of Zealand.

The base of the Selandian is close to the boundary between [biozones](#) NP4 and NP5. slightly after the first appearances of many new species of the calcareous nanoplankton genus [Fasciculithus](#) and close to the first appearance of calcareous nanoplankton species [Neochiastozygus perfectus](#). The ICS established [the official GSSP](#) at the [Zumaia section](#) (43° 18'N, 2° 16'W), located at the beach of Itzurun, Spain.

## *Danian Age*



**Figure 10 - Danian / Maastrichtian Boundary, Interstate 25, Raton Pass, Colorado**  
**Credit: [Anky-man](#), [Creative Commons Attribution-Share Alike 3.0 Unported](#) license**

The lowest part of the Paleocene, the Danian Age, lasted from 66 to 61.6 Mya. French geologist [Jean Édouard Desor](#) first introduced the term Danian in 1847. He named it after the Latin name for Denmark where he found many deposits of that age.

The base of the Danian is the [Cretaceous/Paleogene Mass Extinction](#). The [ICS established the GSSP](#) for the Danian in northern Tunisia, about 7 km west of the town of El Kef.

### **Winding Up**

That's the quick introduction to the Paleogene. Follow upon the links if there is more you want or need to know. The [ICS website on the Paleogene](#) is a good place to start.

### **Standard Caveat**

The purpose of my weblog postings is to spark people's curiosity in geology. Don't entirely believe me until you've done your own research and checked the evidence. If I have sparked your curiosity in the subject of this posting, follow up with some of the links provided here. If you want to, go out into the field and examine some rocks on your own with the help of a good field guide. Follow the evidence and make up your own mind.

In science, the only authority is the evidence.

