# MESOZOIC GEOLOGY

## *g15* Mesozoic Erathem and Era subdivisions < ammonoid extinctions >

> Giordano Bruno wrote that when he learned that the earth was just a small part of the universe, he felt that he could breathe more freely. On the other hand, some of the old magic has gone out of our view of the role of humanity in the universe, its place being taken by what Matthew Arnold called the 'note of sadness.' —Steven Weinberg, *Facing Up*, 2001.[1]

A vision of three worlds in time, each with greatly different life, was formalized in 1840 when John Phillips named the era in which we live the *Cænozoic* (recent life) after *Kainozoic*, a spelling long in use [2] (*Cenozoic* is an alternative spelling after 1841); the era before recorded by extinct marine ammonoid ammonites, and large, terrestrial, marine, and flying reptiles, the *Mesozoic* (middle life);[3] and the era before that, characterized by coals in its upper part and extinct marine invertebrates throughout, the *Palæozoic* (*Paleozoic*, ancient life).[4]

### systems (sequences of rock strata) and periods (durations of time recorded by systems)

The Mesozoic Erathem is comprised (top-down) of Cretaceous, Jurassic, and Triassic systems (***Figure g15.1***). The erathem and systems lend their names to the era and periods respectively.

The end of the Mesozoic Era, which is the also the end of the Cretaceous Period, is marked by the total, and abrupt, worldwide extinction of the ammonoid cephalopods. At the same time, the last of the dinosaurs became extinct worldwide.

The Cretaceous System type area is the Paris Basin, northern France. Here, "Tertiaire" (Tertiary) strata in pockets eroded into chalk (L. *creta*) are unconformable on what d'Omalius d'Halloy (1707-1789) in 1822 called the "Terrain Cretace." This "Chalk" is top stratum of gently inclined strata of fossiliferous continental-shelf sediments that received the name "Cretaceous." In outcrop in the margins of the Paris basin, Cretaceous strata can be seen to unconformably bury an angular unconformity that truncates Variscan-orogeny folded strata. These record an earlier shelf-environment and can be identified as "Jurassic" as they can be followed all along the southern margin of Europe to the Jurassic System type area, which is the Jura Mountains where there are good exposures. As a gross generalization, the presence of fossil ammonite ammonoids allow the Cretaceous and the Jurassic to be recognized. The radiation of these *ammonites* (in which the suture line is complexly frilled) had been mostly accomplished soon after the beginning of the Jurassic from a few deep-ocean stocks that were survivors of the profound, worldwide, wave of ammonoid extinctions that marks the end of the Triassic.

The Triassic Period was a time of continentality (emergent continents and narrow continental shelves). Dinosaurs appeared in the late Triassic. The Triassic System in its type area in central Germany is a molasse shed from the once Hercynian fold mountains. These terrestrial red-beds are not particularly fossiliferous but minor marine end-Triassic and Middle Triassic (Munchelkalk sea incursion) sequences within them contain distinctive ammonoid fossils. As a gross generalization, fossil ammonoids typical of the Triassic are *ceratites* (in which only part of the suture line is frilled).

Immediately preceding the Mesozoic was an event of great extinctions among marine invertebrates of all types. The Mesozoic-Paleozoic boundary is marked by the abrupt diminution in abundance and diversity of *goniatites* (in which the suture line is straight or is a simple curve).

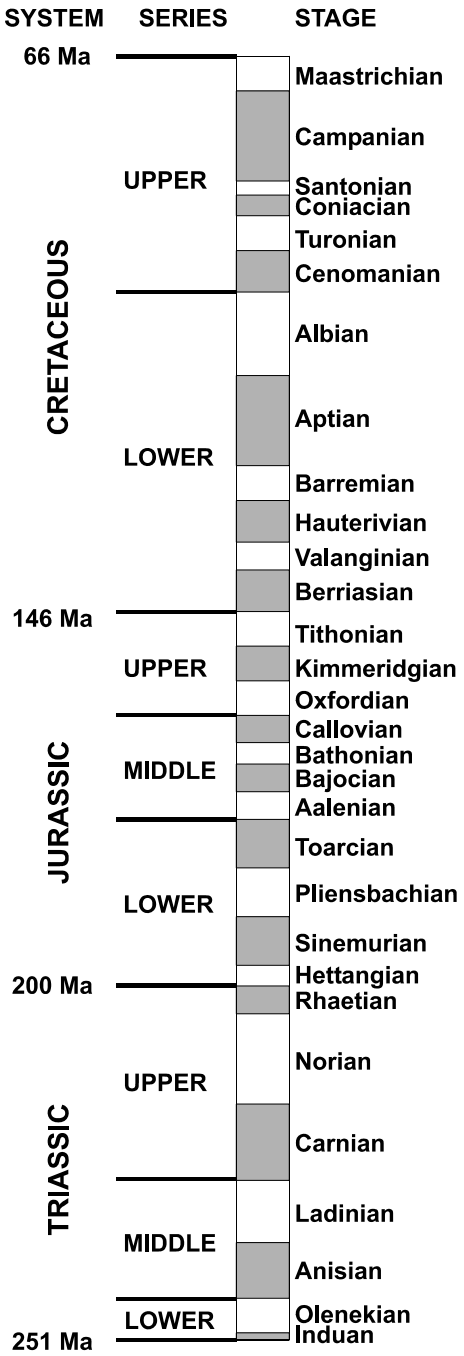
### series and epochs (subdivisions of systems and periods respectively)

The subdivision of the Cretaceous System is into two series: Upper and Lower. The subdivisions of the Jurassic and Triassic systems are both into three series: Upper, Middle, and Lower. The durations of time that each of the series records are epochs and these are respectively: Late, Middle (or Medial), and Early.

### stages and ages (subdivisions of series and epochs respectively)

In Europe, the Mesozoic series have been subdivided into stages. These are used as time-stratigraphic units for worldwide correlations. The same names are used for the durations of time (ages) that the rocks of each record. To make such reliable at this level of fineness—as has been remarkably achieved for the subdivision of the North American Cenozoic continental strata into 23 stages (the "provincial land-mammal ages" first formalized by H. E. Wood II *et al.* in 1941, each about 1 to 2 million years duration)—much still needs to be done.[5] ❑

*Figure g15.1* The stage names are for those defined in Europe. North American stages of the Mesozoic are given the same name when correlatives are identified.




### Cretaceous

During the Cretaceous. The continents became flooded to 40% of their areas with sealevel rising to 200 meters higher than now. Consistent with this, continental drift (so also sea-floor spreading) proceeded at about three times as fast as now. India, as an island continent then, traveled north. In North America, the Cretaceous Inland sea transgressed north through the Midwest.

A Cretaceous "greenhouse" (when characteristically the deep ocean is poorly mixed and anoxic, and nutrients are recycled on continental shelves) is evidenced by the geologic and the isotopic record of an unusually high rate of mid-oceanic ridge basalt outpourings and exhalations of anaerobic making CO and $H_2$, and acidifying $H_2S$ and $Cl_2$. This time of oceanwide anoxia that led to mass extinctions was triggered by the rapid eruption about 93 million years ago of the stack of lava flows that forms the Caribbean tectonic plate (a large igneous province).[6]

The Alps began its rise as the Tethys Ocean closed. The Cretaceous arrangement of ocean and continents enabled circulation of equatorial warm waters towards the poles. Hottest was during the Turonian. Dinosaurs' range was then into Antarctic fern forests. Paradoxically, some "large rapid sealevel changes" in New Jersey cored coastal-plain sediments are best explained, says Kenneth Miller, by Late Cretaceous high-latitude ice sheet expansions.[7]

In central and western Europe, the Chalk records the Cenomanian marine transgression over Wealden continental (freshwater) sediments in which fossil plants record warm humid conditions. Angiosperms appeared.

### Jurassic

Laurasia and Gondwanaland were the two continents into which supercontinent had Pangea split, ending its existence, during the Late Jurassic.

Jurassic climate was a greenhouse. Flora in existence were sphenophytes, ferns, pteridosperms, cycadophytes, ginkgophytes, and conifers.

### Triassic

The Triassic, saw the beginning of the rifting that presaged the breakup of Pangea. Continentality and interior aridity of Pangea characterize the period. The final coalescence of Pangea occurred in the Early Triassic when former North Paleochina joined.