c23 Stratigraphic units and time

< index fossils, stage; biofacies, sequence stratigraphy; inversion history >

> [Lyell in 1828] confirmed to his own satisfaction that the huge volcano Etna had been built up gradually by the eruption of successive lava-flows and ash-falls, no different in magnitude from those recorded in history, on a time-scale that must have been immensely long by human standards. Yet he found that Etna stood on strata that were, by his reckoning, extremely recent by geological standards, since they contained a fauna composed almost exclusively of [mollusk] species still living in the Mediterranean.
>
> — Rudwick.[1]

> We have lost the ante-diluvial measure of Time, about which Usher has led us into so many lamentable follies, ...
>
> The present is so absolutely little when compared with the dread Past, that these Reliquiae derive an Attribute from that circumstance to our Faculties as absolutely infinite. ...
>
> The [ichthyosaur] skeleton before us is altogether unique: he is the longest ever found in Somerset, and lacks not one the least joint: His color remains unchanged by the lapse of many Ages; his Animus [a feeling of ill will arousing active hostility] survives in his attitude, discoursing most eloquent things. The Profound, the Solitary Seas he haunted, the appetites he accomplished, the brassy Skies he saw, the Soulless World he ruled, the unjoyous Times, the unchecked lusts this dragon knew, crowd their Memories in his ribbed boat, which, tracking the wide Oceans of years, lands them at last on our Modern Shores.
>
> —Thomas Hawkins (1810–1889) fossil collector and popularizer (in 1840) of geology.[2]

> When we see a species first appearing in the middle of any formation, it would be rash in the extreme to infer that it had not elsewhere previously existed. So again when we find a species disappearing before the uppermost layers had been deposited, it would be equally rash to suppose that it then became wholly extinct. We forget how small the area of Europe is compared to the rest of the world: nor have the several stages of the same formation throughout Europe been correlated with perfect accuracy.
>
> —Charles Darwin, 1859.[3]

> Throughout most of geologic time, individual species and their immediate descendants lived an average of about 1 million years. They disappeared naturally at the rate of about one species per million per year, and newly evolved species replaced them at the same rate, maintaining a rough equilibrium.
>
> —Edward O. Wilson, 2000.[4]

***Table c23.1* Stratigraphic units** [5]

Names under the headings are arranged in decreasing rank from the top down:

Rock-stratigraphic Lithostratigraphic	*Time-stratigraphic Chronostratigraphic*	*Time Geochronologic*	*Biostratigraphic*
(*time transgressive*)	Eonothem	Eon	
Supergroup	Erathem	Era	
Group	**System**	**Period**	
Subgroup	Series	Epoch	biozones
	Stage	Age	
	Chronozone	Chron	

Note: Biozones are different from Chronozones. Biozones are based on the objective occurrence of fossils without regard to their time ranges. Chronozones are time-stratigraphic (chronostratigraphic) units assumed to be pinpointed by the overlapping time ranges of fossil species.

The suffix -*them* means *deposit* (from Gk. *thema*).

A stage, as defined in the *Glossary of Geology*, is “a time-stratigraphic unit next in rank below series and above substage, commonly based on a succession of biostratigraphic zones that are considered to approximate closely time-equivalent deposits; the rocks formed during an age of geologic time. Stages are the basic working units of local time-stratigraphic correlation [for the reality that each spans a species' average time-range of 5 to 10 million years],[6] and are often used to relate the various kinds of minor stratigraphic units in one geologic section or area to those in another with respect to time of origin. Most stage names are based on rock-stratigraphic units, although preferably a stage should have a geographic name not previously used in stratigraphic nomenclature; the adjectival ending for the geographic name is most commonly '-an' or '-ian', although it is permissible to use the geographic name without any special ending, such as 'Claiborne Stage'."[7]

Fossils useful for stratigraphic correlations occur in diverse groups but are not equally useful through the range of a group (***Figure c23.1***). The most useful fossils for regional stratigraphic correlations are called *index fossils* each of which is a genus, or more rarely a species, that can be easily and reliably distinguished from others and which, as evidenced by its preservation, achieved for a short geological duration an abundant worldwide presence. Macrofossils useful for correlations are clams and gastropods (Cenozoic), ammonoids (Mesozoic, Late Paleozoic), graptolites (Devonian, Silurian, Ordovician), and trilobites (Cambrian). Microfossils are particularly useful for correlations as they are never rare when present and many forms are distinctive and have evolved rapidly.

Quantitative stratigraphy, pioneered by Lyell in his subdivision of the Cenozoic, makes much use of biozones which are fossil-delineated finescale temporal subdivisions that embody geologically-frequent, momentarily disruptive, "catastrophic" episodes of wide-area effecting storms, earthquakes, and volcanic eruptions. Using the most "responsive" fossils, biozones as short as 0.5-1.0 million years have been established, as is so for the 416-444 million years ago Silurian Period using graptolites. As communicated in 1998 to Keith Olin Mann, Amoco geologists have used graphical correlations of last and first occurrences of fossil species in numerous drilled sections to successfully subdivide the Phanerozoic into 23,000 increments!

The Geologic Names Unit (GNU) offices of the United States Geological Survey (USGS) are compiling data on nomenclature applied to stratigraphic units used in the USA, its territories and possessions, into a computer-based system—acronym GNULEX (Geologic Names Unit Lexicon).[8]

Stratigraphic definitions and concepts are in debate for a variety of practical and immediate reasons while the North American Commission on Stratigraphic Nomenclature (NACSN), and the International Subcommission on Stratigraphic Classification (ISSC) of the International Union of Geological Sciences (IUGS) Commission on Stratigraphy, work toward consensus.

How the work is done

Note: Drill bits go down and the core is logged that way. And keeping pace is "on the job" interpretation and planning. Because of the way core is laid out in coretrays, tape measured "thicknesses" of sedimentary beds from the top down are logged as "widths." Microfossils (index and assemblage species of say forams or chonodonts) are particularly useful (***Figure c23.2***) as they can be recovered from drill-hole rock chips and cores, and where they occur they are always abundant in numbers and so not rare.

For each locality, a column of existing layers (beds, strata, formations) is described, and stratigraphic units are named for distinctive of these in them. Correlation between localities is the next step. For this the geologist prepares a correlation chart.

In advanced studies, biofacies and sequence stratigraphy that analyses derive from "refindable" field data, are summarized in correlation charts. This information is then used to set up, and improve as more information comes in, chronostratigraphic and biostratigraphic divisions ("frameworks") for regional correlations.

Inversion history in sediments shed from an area undergoing uplift

Recognition of an inversion history is aided when:

1) the succession of the formations in the source area are not everywhere lost to erosion so that clasts and reworked fossils in the inverted sequence can be correlated with it. Otherwise, if the source area has been completely unroofed, reliance must be from the known fossil succession.

2) the distance from source to place of accumulation is not great. This allows reworked delicate-fossils to exist. Possibly helpful is paleocurrent information that points back to the source. ❏

Figure c23.1 **The utility of fossil groups** *After* Curt Teichert (1905-1996), 1958.[9]

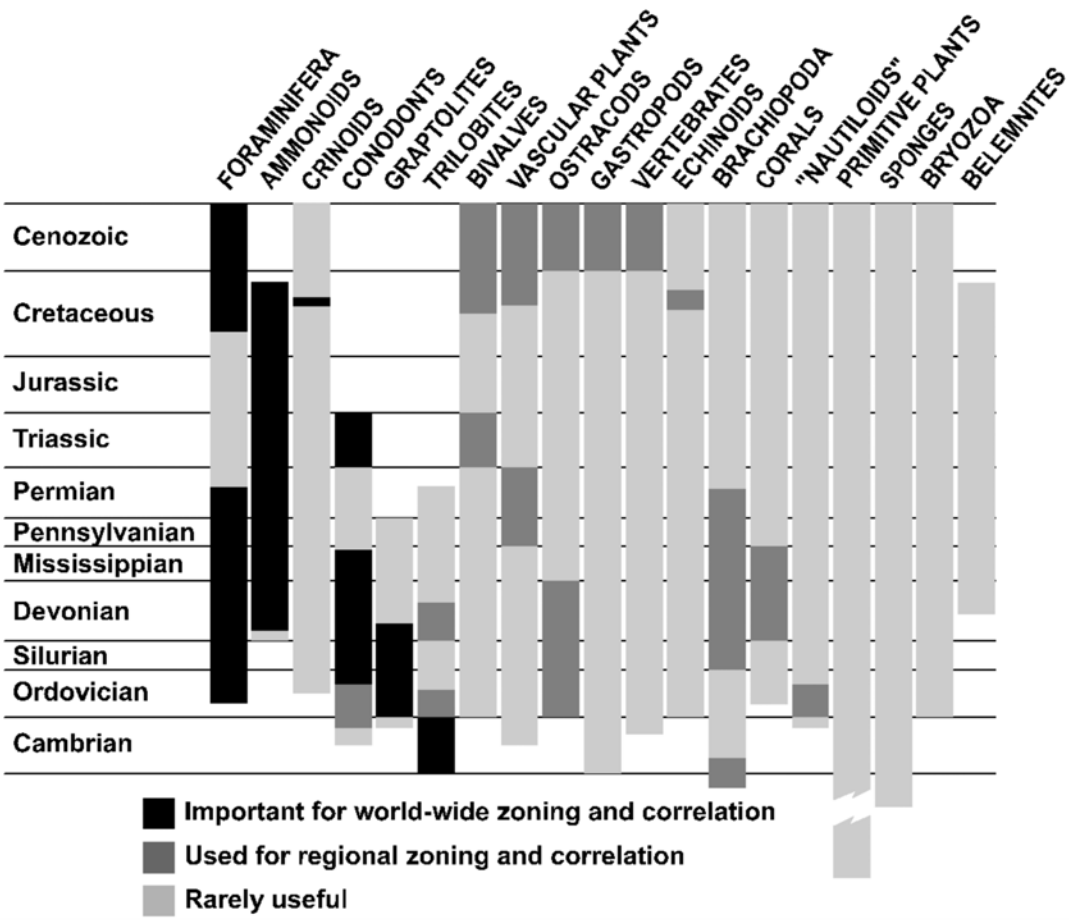

Figure c23.2 [10]
The rarity of phytoplankton during the Jurassic and earlier Triassic periods of the Mesozoic Era could account for the slow recovery of many filter feeding marine invertebrate survivors of the end-Paleozoic extinction crisis. Also, major acritarch groups had gone extinct. However, the apparent 120 million years paucity of phytoplankton need not be actual. It could be just a rarity of phytoplankton fossils. Arguably, the decline to few phytoplankton at the beginning of the Mississippian Period of the Paleozoic Era records when major acritarch groups continued in abundance but had evolved to eliminate an encysted stage.[11]