Stratigraphy and Geological Events Student Worksheet

Principles of Stratigraphy

Nicolaus Steno defined the first principles of stratigraphy in 1669. He stated that sedimentary rocks are laid down horizontally (*original horizontality*) and that younger rock units are deposited on top of older rock units (*superposition*). The idea that geological processes have been roughly the same through time (*uniformitarianism*) was added by James Hutton in 1795.

These principles allowed workers to recognise local rock sequences. Fossils proved the key to matching rock sequences in different locations. William Smith formalised the idea that fossils are found in a definite order in rocks (*faunal succession*). He used this principle to create a geologic map of England in 1815 and faunal succession was used to define time periods on a geological time scale (Figure 1).

Developing the Geological Time Scale

The early geological time scales were developed in Europe and names of time intervals are based on the sites used to define those times. For example, the Jurassic Period is named after the Jura Mountains in Switzerland. As geological knowledge has grown, more time periods have been added. One example is the Ediacaran Period, named after the Ediacara Hills in South Australia.

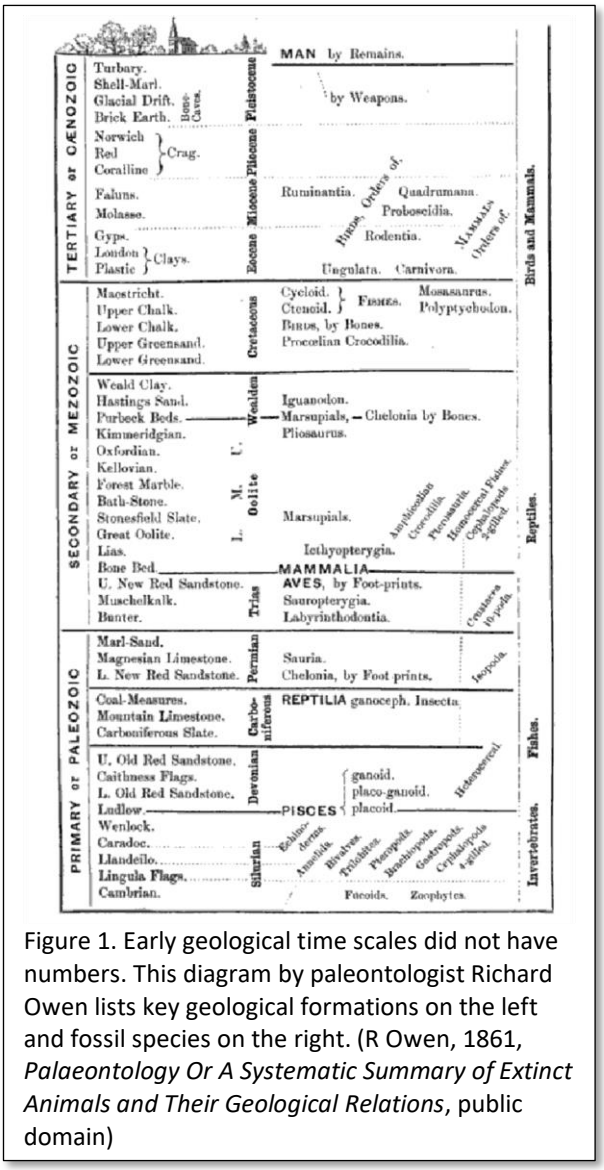

Figure 1. Early geological time scales did not have numbers. This diagram by paleontologist Richard Owen lists key geological formations on the left and fossil species on the right. (R Owen, 1861, *Palaeontology Or A Systematic Summary of Extinct Animals and Their Geological Relations*, public domain)

Faunal succession and relative dating allowed scientists to construct a geological time scale. There were no numbers on that scale until techniques for radiometric dating were developed in the early 1900s. Radiometric dating of igneous rocks allowed scientists to begin putting dates onto the time scale. However, the geological time scale is based upon sedimentary rocks. Fossil-bearing layers can only receive an absolute date if they contain volcanic ash, which is a rare occurrence. Radiometric dating of rocks above or below fossil-bearing layers allowed scientists to gradually refine the dates of major events.

The modern geological time scale is coordinated by the International Commission on Stratigraphy. Each geological division has a standard colour code and these are used in geological maps (Figure 2). The commission meets regularly to decide whether the current system requires refinement based upon research. The Ediacaran Period was formally named in 2005 and was the first period-level interval created for over 100 years.

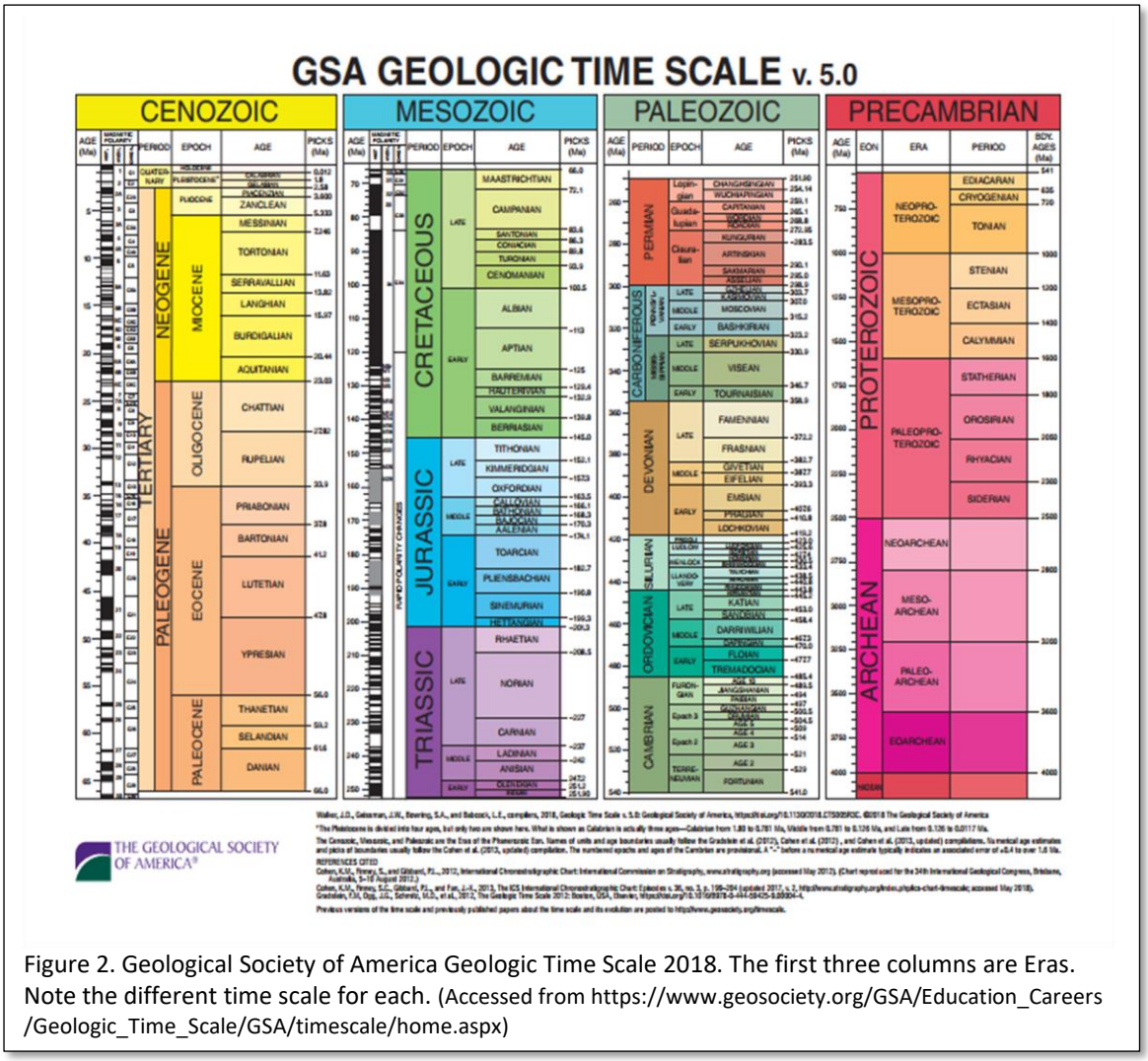

Figure 2. Geological Society of America Geologic Time Scale 2018. The first three columns are Eras. Note the different time scale for each. (Accessed from https://www.geosociety.org/GSA/Education_Careers/Geologic_Time_Scale/GSA/timescale/home.aspx)

Divided by Disaster

Geological intervals reflect significant events in Earth history. Periods and smaller intervals of the Phanerozoic generally end with extinction. Mass extinctions affect both aquatic and terrestrial environments globally, so evidence must be gathered from many locations. There are more subdivisions in more recent Periods because there is more evidence of these times. Older rocks are deeply buried, destroyed and distorted, therefore, evidence of the distant geological past is rare.

Because the time intervals are governed by natural events, the intervals of the geological time scale are irregular, and it is difficult to present them all to scale. In Figure 2, you will notice that each column has a different time scale. The Cenozoic, Mesozoic and Paleozoic are Eras. The Precambrian is not a formal time interval but represents billions of years before the evolution of hard parts and more likely fossilisation.

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Questions

1. Explain the stratigraphic principles geologists use to determine the order of past events without radiometric dating. _____

2. Why is it challenging to add numbers to the time scale? _____

3. Identify two special things about the Ediacaran Period. _____

4. Why are there more subdivisions of the recent Cenozoic Period than of the Ediacaran? _____

5. How many millions of years are represented by the following?
   a. Cenozoic _____
   b. Mesozoic _____
   c. Paleozoic _____
   d. Precambrian _____

6. Figure 3 presents the known occurrence (thick black lines) of a variety of ancestral reptiles.

   a. What evidence in Figure 3 suggests a mass extinction and at what time? _____

   _____

   _____

   b. What other evidence would you look for in the fossil record to confirm your hypothesis in part a? _____

   _____

   _____

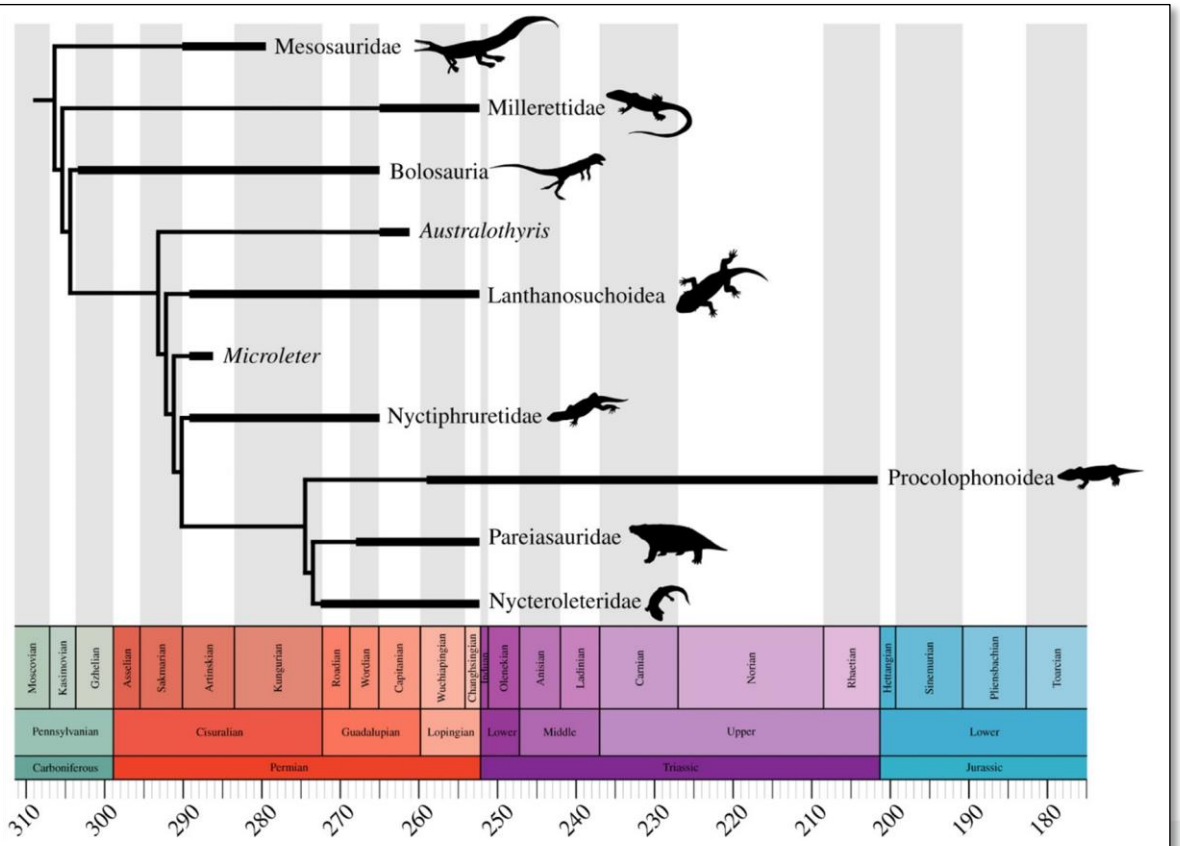

Figure 3. Stratigraphic ancestral tree of parareptiles. From MacDougall MJ, Brocklehurst N, Fröbisch J (2019). Species richness and disparity of parareptiles across the end-Permian mass extinction. *Proc Royal Soc B* **286** https://doi.org/10.1098/rspb.2018.2572

7. The Central Atlantic Magmatic Province (CAMP) is a large igneous province formed during the initial rifting event that split Pangea (Figure 4). Scientists propose that carbon dioxide released by the CAMP may be responsible for the end Triassic mass extinction.

   a. What sort of geological evidence would indicate a large rifting event?_____

   _____

   b. How can the date of this event be determined?

   _____

   _____

Figure 4. The Central Atlantic Magmatic Province erupted in the late Triassic and is implicated in the end-Triassic mass extinction. (Williamborg 2013, Creative Commons 3.0)

   c. What geological evidence would indicate a mass extinction occurred at the end of the Triassic? _____

   _____

   _____

8. How are both igneous and sedimentary rocks used to reconstruct the history of Earth?_____

   _____

   _____

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References:

Grey K, Laurie J, Gehling J (2005). The 'New' Ediacaran Period. *AusGeo news* **80**. Accessed from http://www.ga.gov.au/webtemp/image_cache/GA7517.pdf

University of California Museum of Paleontology (n.d.). The geologic time scale in historical perspective. Accessed from https://ucmp.berkeley.edu/exhibit/histgeoscale.html