7.4: Correlation

Correlation is the process of establishing which sedimentary strata are of the same age but geographically separated. Correlation can be determined by using magnetic polarity reversals (Chapter 2), rock types, unique rock sequences, or index fossils. There are four main types of correlation: stratigraphic, lithostratigraphic, chronostratigraphic, and biostratigraphic.

Figure: Image showing fossils that connect the continents of Gondwana (the southern continents of Pangea). Wegener used correlation to help develop the idea of continental drift.
7.4.1: Stratigraphic Correlation

Stratigraphic correlation is the process of establishing which sedimentary strata are the same age at distant geographical areas by means of their stratigraphic relationship. Geologists construct geologic histories of areas by mapping and making stratigraphic columns—a detailed description of the strata from bottom to top. An example of stratigraphic relationships and correlation between Canyonlands National Park and Zion National Park in Utah. At Canyonlands, the Navajo Sandstone overlies the Kayenta Formation which overlies the cliff-forming Wingate Formation. In Zion, the Navajo Sandstone overlies the Kayenta formation which overlies the cliff-forming Moenave Formation. Based on the stratigraphic relationship, the Wingate and Moenave Formations correlate. These two formations have unique names because their composition and outcrop pattern is slightly different. Other strata in the Colorado Plateau and their sequence can be recognized and correlated over thousands of square miles.

Figure: Correlation of Paleozoic and Mesozoic strata along the Grand Staircase from the Grand Canyon to Zion Canyon, Bryce Canyon, and Cedar Breaks. (Source: National Park Service)

7.4.2: Lithostratigraphic Correlation

Lithostratigraphic correlation establishes a similar age of strata based on lithology, which is the composition and physical properties of that strata. Lithos is Greek for stone and -logy comes from the Greek word for doctrine or science. Lithostratigraphic correlation can be used to correlate whole formations long distances or can be used to correlate smaller strata within formations to trace their extent and regional depositional environments.

Figure: View of Navajo Sandstone from Angel’s Landing in Zion National Park
For example, the Navajo Sandstone, which makes up the prominent walls of Zion National Park, is the same Navajo Sandstone in Canyonlands because the lithology of the two are identical even though they are hundreds of miles apart. Extensions of the same Navajo Sandstone formation are found miles away in other parts of southern Utah, including Capitol Reef and Arches National Parks. Further, this same formation is called the Aztec Sandstone in Nevada and Nugget Sandstone near Salt Lake City because they are lithologically distinct enough to warrant new names.

7.4.3: Chronostratigraphic Correlation

Chronostratigraphic correlation matches rocks of the same age, even though they are made of different lithologies. Different lithologies of sedimentary rocks can form at the same time at different geographic locations because depositional environments vary geographically. For example, at any one time in a marine setting, there could be this sequence of depositional environments from the beach to deep marine: beach, nearshore area, shallow marine lagoon, reef, slope, and deep marine. Each depositional environment will have a unique sedimentary rock formation. On the figure of the Permian Capitan Reef at Guadalupe National Monument in West Texas, the red line shows a chronostratigraphic timeline that represents a snapshot in time. Shallow-water marine lagoon/back reef area is light blue, the main Capitan reef is dark blue, and deep-water marine siltstone is yellow. All three of these unique lithologies were forming at the same time in Permian along this red timeline.

Figure: Cross-section of the Permian El Capitan Reef at Guadalupe National Monument, Texas. The red line shows a chronostratigraphic timeline that represents a snapshot in time in which the shallow marine lagoon/back reef area (light
blue), main Capitan reef (dark blue), and deep marine siltstones (yellow) were all being deposited at the same time.

Figure: The rising sea levels of transgressions create onlapping sediments, regressions create off-lapping. Ocean water is shown in blue so the timeline is on the surface below the water. At the same time sandstone (buff color), limestone (gray), and shale (mustard color) are all forming at different depths of water.

### 7.4.4: Biostratigraphic Correlation

*Figure: Conodonts*

**Biostratigraphic correlation** uses index fossils to determine strata ages. Index fossils represent assemblages or groups of organisms that were uniquely present during specific intervals of geologic time. Assemblages refer a group of fossils. Fossils allow geologists to assign a formation to an absolute date range, such as the Jurassic Period (199 to 145 million years ago), rather than a relative time scale. In fact, most of the geologic time ranges are mapped to fossil assemblages. The most useful index fossils come from lifeforms that were geographically widespread and had a species lifespan that was limited to a narrow time interval. In other words, index fossils can be found in many places around the world, but only during a narrow time frame. Some of the best fossils for biostratigraphic correlation are microfossils, most of which came from single-celled organisms. As with microscopic organisms today, they were widely distributed across many environments throughout the
world. Some of these microscopic organisms had hard parts, such as exoskeletons or outer shells, making them better candidates for preservation. Foraminifera, single-celled organisms with calcareous shells, are an example of an especially useful index fossil for the Cretaceous Period and Cenozoic Era [37].

Conodonts are another example of microfossils useful for biostratigraphic correlation of the Cambrian through Triassic Periods. Conodonts are tooth-like phosphatic structures of an eel-like multi-celled organism that had no other preservable hard parts. The conodont-bearing creatures lived in shallow marine environments all over the world. Upon death, the phosphatic hard parts were scattered into the rest of the marine sediments. These distinctive tooth-like structures are easily collected and separated from limestone in the laboratory.
Because the conodont creatures were so widely abundant, rapidly evolving, and readily preserved in sediments, their fossils are especially useful for correlating strata, even though knowledge of the actual animal possessing them is sparse. Scientists in the 1960s carried out a fundamental biostratigraphic correlation that tied Triassic conodont zonation into ammonoids, which are extinct ancient cousins of the pearly nautilus. Up to that point, ammonoids were the only standard for Triassic correlation, so cross-referencing micro- and macro-index fossils enhanced the reliability of biostratigraphic correlation for either type [38]. That conodont study went on to establish the use of conodonts to internationally correlate Triassic strata located in Europe, Western North America, and the Arctic Islands of Canada [39].

7.4.5: Geologic Time Scale

Geologic time has been subdivided into a series of divisions by geologists. Eon is the largest division of time, followed by era,
period, epoch, and age. The partitions of the geologic time scale are the same everywhere on Earth; however, rocks may or may not be present at a given location depending on the geologic activity going on during a particular period of time. Thus, we have the concept of time vs. rock, in which time is an unbroken continuum but rocks may be missing and/or unavailable for study. The figure of the geologic time scale represents time flowing continuously from the beginning of the Earth, with the time units presented in an unbroken sequence. But that does not mean there are rocks available for study for all of these time units.

Figure: Geologic Time Scale with ages shown in millions of years ago (Ma).
The geologic time scale was developed during the 19th century using the principles of stratigraphy. The relative order of the time units was determined before geologists had the tools to assign numerical ages to periods and events. Biostratigraphic correlation using fossils to assign era and period names to sedimentary rocks on a worldwide scale [40]. With the expansion of science and technology, some geologists think the influence of humanity on natural processes has become so great they are suggesting a new geologic time period, known as the Anthropocene. [39; 41].

References


