Conodonts: The Backbone of the Paleozoic Timescale

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Conodont Paleontology

Conodonts are the microscopic remains of the feeding apparatus for a clade of marine organisms that existed from the middle Cambrian through Middle Triassic. The only part of the animal that was mineralized were its teeth (Fig. 1) as the rest of the organism was soft bodied. The teeth are usually the only part of the animal that can be recovered in the fossil record. Therefore, the term "conodont" technically refers to just the teeth, and "conodont animal" is used to refer to the organism that the teeth came from. A few exceptionally well-preserved impressions of the entire conodont animal have been found, so we now know that they were eel-shaped organisms (Fig. 2). The feeding apparatus of each conodont animal contained conodonts of several different shapes, just like humans have variously shaped teeth. Well-preserved assemblages of conodonts on shale bedding planes allow the reconstruction of the position of each type of conodont within the organism (Fig. 3). The evolutionary relationship of conodonts to other clades was a major paleontological controversy until the discovery of the soft-body impressions. The impressions preserve eyes, myomere muscle structures, and a notochord. These are key characteristics of Phylum Chordata (bilaterally symmetrical animals with a centralized nervous system). Some conodont researchers argue that conodonts should be included within the vertebrate clade (Fig. 4) because the mineralization of the conodont is similar to the way the vertebrates mineralize teeth or bones.

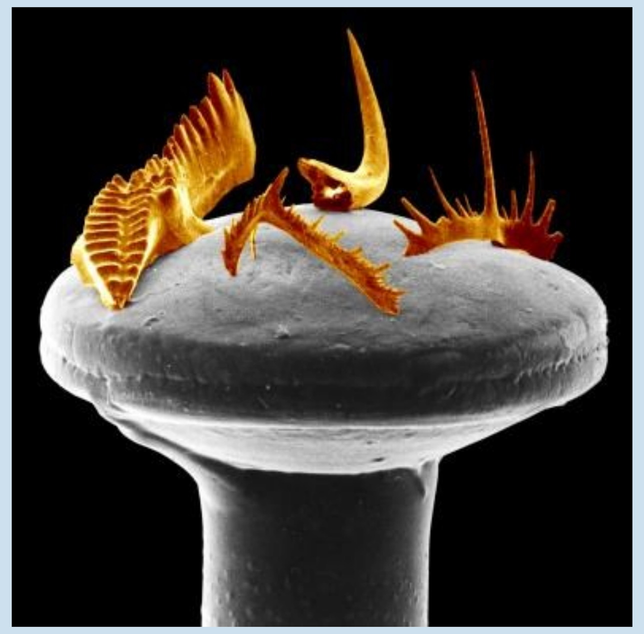


Figure 1: Conodont specimens on the head of a pin. Photo taken with a scanning electron microscope (Purnell et al., 1995).

Figure 2: An interpretation of what the conodont animal may have looked like. The tail fins, large, forward-facing eyes, and hydrodynamic shape of the organisms indicates that they had a nektic (swimming) lifestyle, and may have been predators. Drawing from paleoartist Nikolay Zverkov.

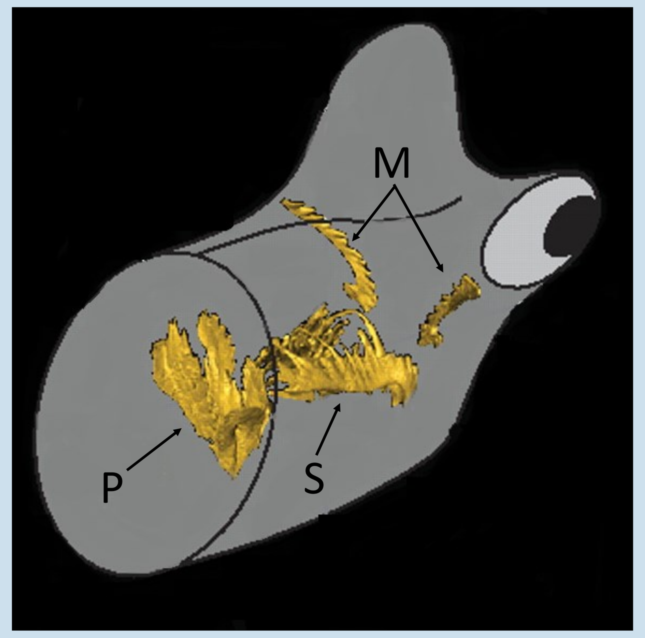


Figure 3: Illustration showing the position of each type of conodont within the organism. M and S elements were used for grasping food. P elements were used for grinding and crushing food. Modified from Goudemand et al., 2011.

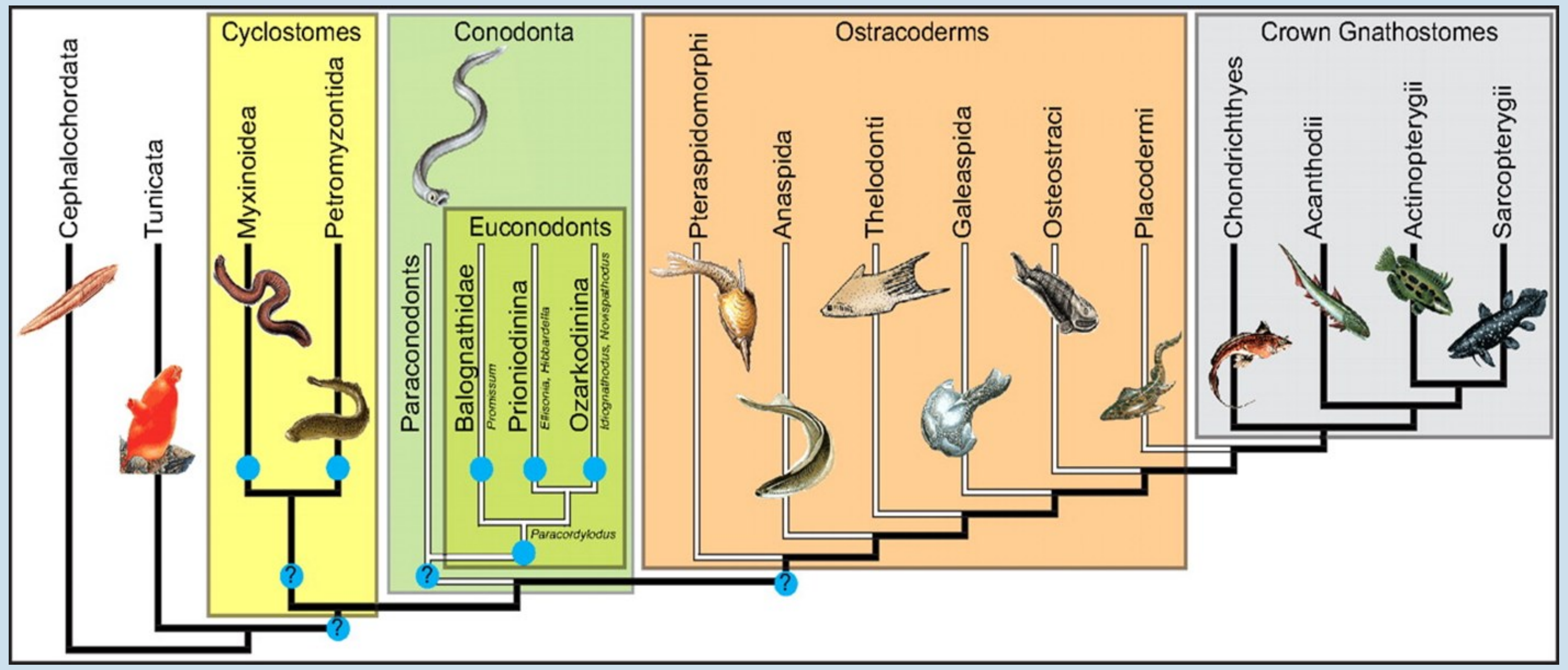
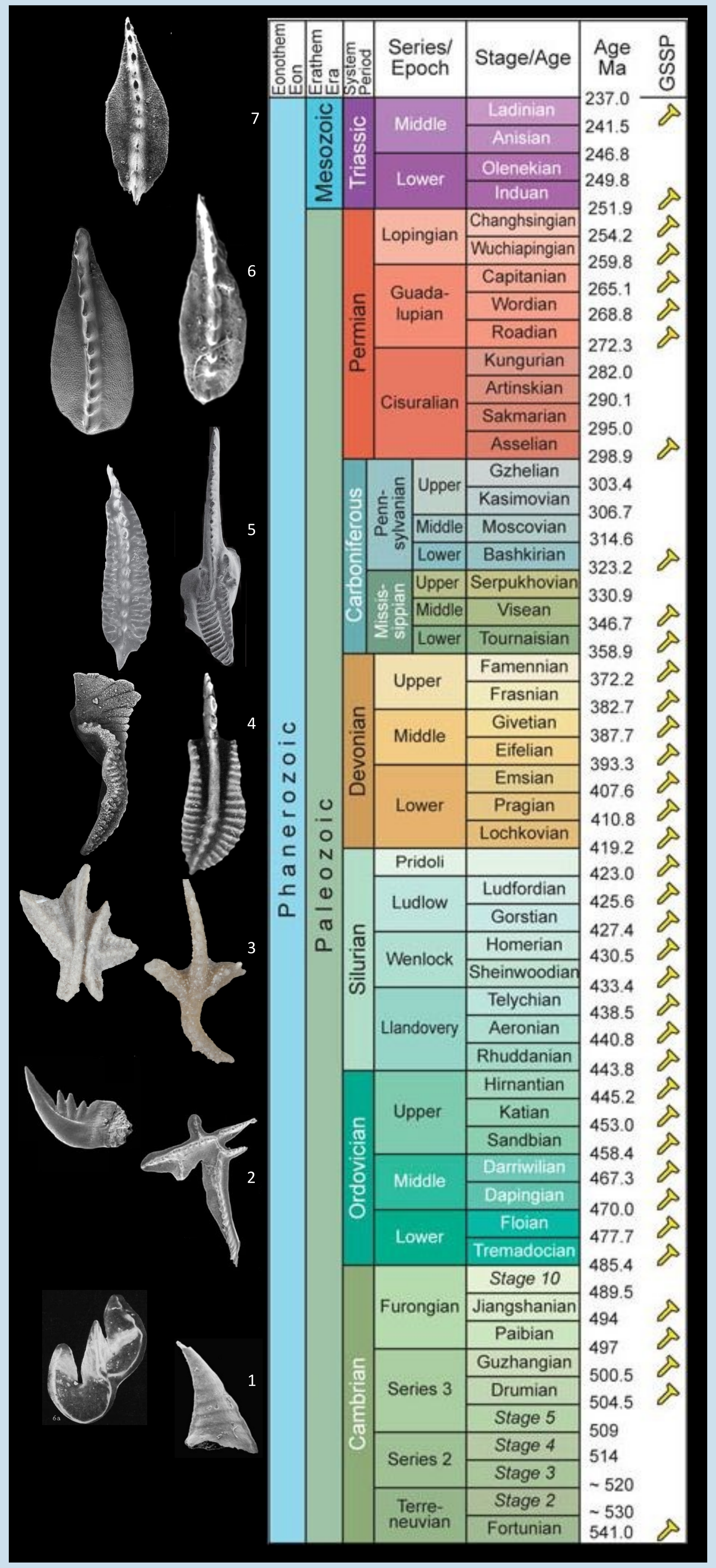


Figure 4: Phylogenetic tree showing conodonts within the vertebrate clade. Black lines indicate extant clades, white lines indicate extinct clades. From Goudemand et al., 2011.

Conodonts in Earth-History Research

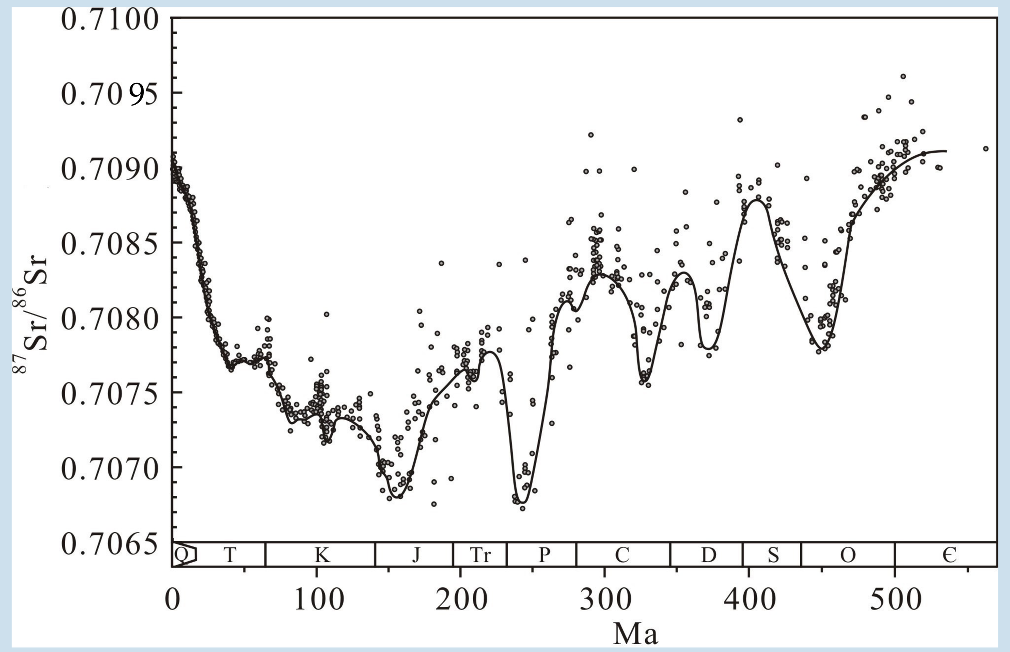
Biostratigraphy



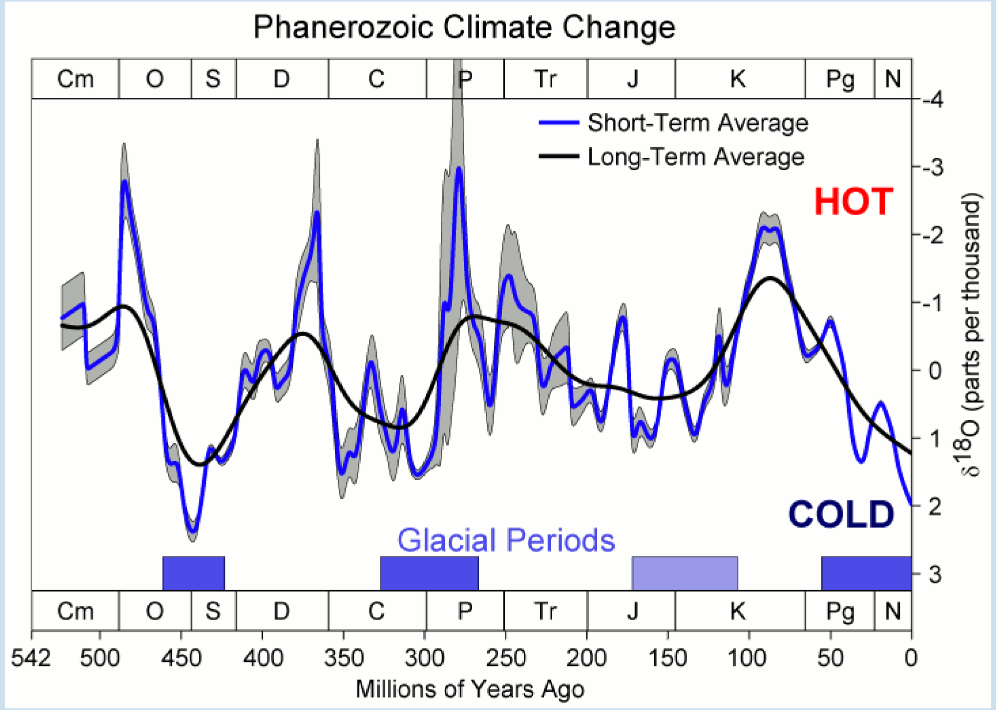
Conodonts are one of the primary fossils used for the construction of the geological time scale from the Ordovician through Triassic systems. The relative durability, high abundance, and fast evolutionary rates of conodonts allow for very precise biozonation schemes, some with an estimated precision of < 1 Myr. The integration of conodont and chemostratigraphic data allows highly precise correlations of numerical age data onto the relative timescale, thereby increasing the accuracy of the numerical timescale. The figure above shows examples of conodonts from each geologic period. Timescale: ICS, version 2014.

Ocean Paleochemistry

Conodonts are also used for studying the geochemistry of past ocean water. They are made of biogenic apatite – the same mineral as vertebrate bones and teeth. During life, conodonts grew by laminar deposition of hydroxylapatite ($Ca_{10}(PO_4)_6(OH)_2$), which re-crystalized to fluorapatite ($Ca_{10}(PO_4)_6(F)_2$) shortly after death. Most of the crystal structure is not affected by remineralization, allowing conodonts to record the chemical composition of past oceans. The chemical composition of oceans is linked to atmospheric and tectonic processes, so the chemical make up of ocean water can help researchers reconstruct tectonic events and the climate of the past.

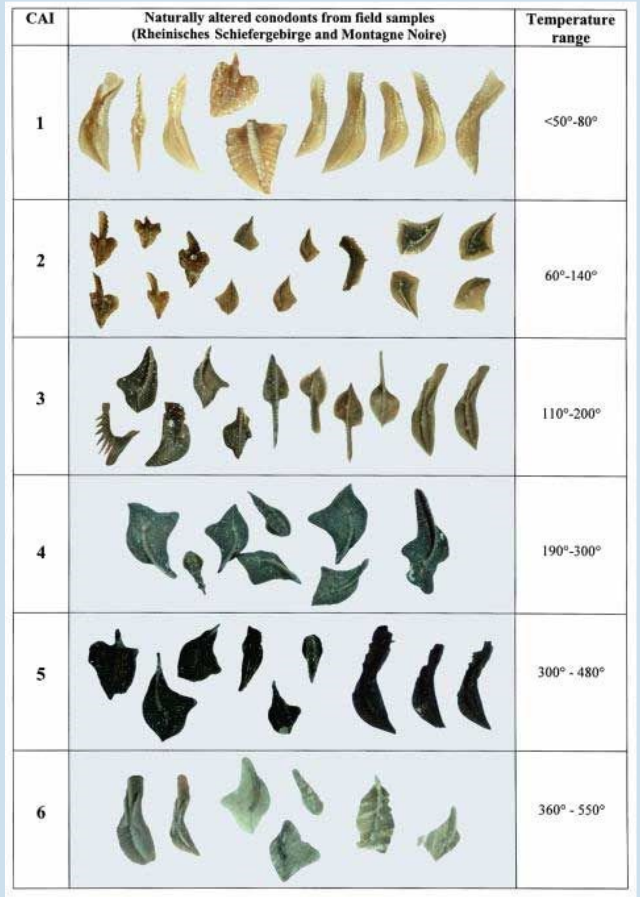


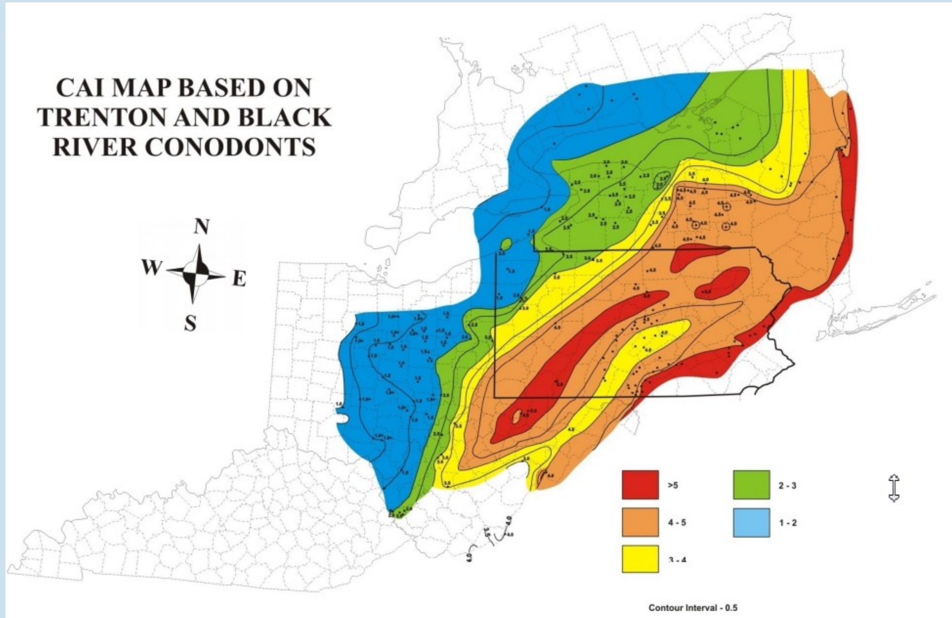
Strontium is present in low concentrations in sea water, and occasionally replaces the calcium ion in apatite. The ratio of ^{87}Sr to ^{86}Sr in the oceans is heavily dependent on the rate of continental weathering and sea-floor-spreading. This relationship can help researchers determine the timing of continental collisions. For example, after the initial formation of Pangea during the Carboniferous, the ratio decreased as continental weathering rates decreased (see above; from Hu et al., 2015).



The ratio of ^{18}O to ^{16}O of past sea-water be measured from the PO_4 ion in the fluorapatite of conodonts. This ratio is dependent on the temperature of the oceans and the volume of ice present on the Earth. During cold times, the oxygen isotopic value of the ocean gets heavier, and vice-versa during warm times. This relationship is used to determine the timing of icehouse and greenhouse climate conditions (see above; from Veizer et al., 1999).

Basin Analysis





Conodonts permanently change color when subjected to increased temperatures. Laboratory experiments have correlated the color changes with temperature changes (see top image, from Königshof, 2003), which allows for the creation of basin thermal maturity maps (see bottom image, Patchen et al., 2006). Thermal maturity information is important in the oil and gas industry, because it aids in predicting where conditions were right for oil or gas creation from source rocks.

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