The Unitary Association Method: introduction and applications to radiolarian biochronology

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The Unitary Associations (UAs) method is a deterministic mathematical model designed to construct concurrent range zones. The basic idea of the method is to construct a discrete sequence of coexistence intervals of species. Each interval consists of a maximal set of intersecting ranges (= intervals of minimal duration or UAs). Each of these units is characterized by a set of species or species pairs allowing us to identify it in the stratigraphic sections.

The basic steps of the method are summarized as follows. We start by establishing the neighborhood of each species, based on biostratigraphic observations from several sections. For example, species "1" may be present or absent in the sections, and may co-occur or not with species "2", "3", "4" etc. The observed inter-species coexistences are compiled in a species-species matrix. This matrix can be organized by a permutation of its rows and columns to allow the appearance of sets of mutually coexisting species. From this reorganized matrix we can extract maximal sets of intersecting species' ranges and represent them in a table called a UA range chart. This chart is used to go back to the data and assign relative ages to the fossiliferous beds of the differents sections.

Biostratigraphic data are usually complicated by the fact that species' ranges are highly conflicting from place to place. As an example, consider two pairs of coexisting species (1, 4) and (2, 3). We say that their ranges are conflicting if species "1" occurs below species "3" and if species "2" occurs below species "4" in some localities. Such stratigraphic relationships mean that either the range of "1" virtually overlaps that of "3" or that the range of "2" virtually overlaps that of "4".

The computer program UA-Graph (http://folk.uio.no/ohammer/uagraph/) optimizes the constructions of such virtual coexistences and produces range charts where the conflicting stratigraphic relationships are expressed as virtual co-occurrences. This method is especially advantageous in establishing global zonations because it compiles co-occurrences of all taxa in all samples and produces range charts with the maximum range of each species. In this way UA successfully integrates a large number of different localities among which the observed FADs and LADs are highly diachronous.

The UA method has been efficiently applied to radiolarian biochronological correlation for nearly 30 years and has become the standard method to construct reliable radiolarian zonations. In the Mesozoic, a continuous interval from the Rhaetian to the Turonian has now been covered by UA radiolarian zonations. These are largely employed by radiolarian paleontologists worldwide because, in comparison with other zonations, the number of included taxa is generally higher and the stratigraphic ranges are less truncated.

A recently established global Pliensbachian to Aalenian radiolarian range chart will be used as an example to demonstrate the application of the UA-Graph computer program. This biochronological scale integrates radiolarian-occurrence data of 197 species in 220 samples from measured sections in Queen Charlotte Islands, B.C., Williston Lake, B.C., east-central Oregon, Baja California Sur, southern Spain, Austria, Slovenia, Turkey, Oman, Japan and Argentina.