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Permian Conodont Biostratigraphy

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The temporal ranges of conodont species have proven to be instrumental for the definition of many Global Stratotype Sections and Points (GSSPs) and this is exemplified in the Permian where all nine stages are, or will be, defined by the First Appearance Datum (FAD) of conodont species. Therefore it is important to review how species are defined and how evolution and FADs are recognized. Permian ozarkodinid conodonts have 15 elements in their apparatus. The platform or P1-elements are discriminated at the species level because these elements have the greatest range of morphologic variability. The other 13 elements collectively can be useful to discriminate families and/or genera and therefore could be used to discriminate potential homeomorphic development of P1-elements. Samples may yield 0 to 1000 elements per kilogram and the ontogenetic and geographic morphologic variability is usually significant. As such, a sample population approach is necessary [1] to consistently discriminate Permian species. The fact that abundant conodonts may be obtained from a variety of marine lithofacies in closely spaced samples, means that evolution can be "seen" and statistical techniques designed for more disparate fossil occurrences have rarely been employed (*e.g.* unitary associations), but they could be useful to test the validity and ranges of conodont species that define the many lineage interval zones in the Permian [4]. Average interval duration is about 1.25 Myrs/zone. These include as many as seven Asselian zones based on *Streptognathodus* (ave. 0.56 Myrs/zone); at least three Sakmarian, three Artinskian, and five Kungurian zones are based on the related genera *Sweetognathus* and *Neostreptognathodus* (2.06 Myrs/zone); eight Middle Permian zones are based on *Jinogondolella* (1.65 Myrs/zone); and, twelve Upper Permian zones are based on *Clarkina* (0.60 Myrs/zone). The recognition of a standard zonation for the Permian is difficult because of profound provincialism [2] that characterizes much of the Kungurian to Changhsingian interval. In such cases, geographic clines have been employed to link geographic provinces [3]. Longer duration zones, especially for Artinskian to Wordian, partly reflect a preponderance of shallow water successions including very restricted conditions during the Kungurian. There appears to be an indirect relationship between intensity of study and duration of zones, especially for the Asselian (glaciation and cyclothems) and the Changhsingian (end-Permian extinction). These shorter duration zones presumably also reflect an evolutionary response to frequent sea-level fluctuations in the Lower Permian and climatically induced stressed conditions at the end of the Permian. Distinct lineages overlap only briefly indicating that generic turnover reflects ecologic replacement or transitions. In the Urals [5] *Streptognathodus* becomes extinct during the early Sakmarian at the same time that *Sweetognathus* diversifies. In most regions this transition coincides with the termination of high-frequency cyclothems in response to the end of primary Permian glaciation, providing a distinct, nearly global, sequence biostratigraphic signature. The apparent long overlap of *Streptognathodus* and *Sweetognathus* in cyclothems of the mid-west USA [6] and Bolivia [7] may be explained by distinguishing an early lineage of *Sweetognathus* at its centre of evolution. Reevaluation of conodont species indicates that mid-west and Bolivian cyclothems terminate in the Sakmarian rather than Late Artinskian, as predicted by the established sequence biostratigraphic signature. Geochronologic ages from Bolivia and in post-glacial Karoo deposits [8] provide additional support. *Sweetognathus* then migrated to its distributional acme during the post-glacial transgression.

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