

## MAJOR FEATURES OF ORDOVICIAN GRAPTOLITE RADIATIONS AND EXTINCTIONS

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Study of paleoceanographic setting of Ordovician graptolite-bearing sequences indicates that the richest, most diverse faunas occur in shelf-marginal rock sequences. These graptolite-bearing strata form a band that broadened as sea level rose and seas transgressed across shelves. It became constricted as sea level fell and seas regressed. Sea level changes during the Ordovician led to graptolite radiations and extinctions, which are most prominently developed in tropical platform marginal strata. Peri-Gondwanan sequences differ somewhat from those in the tropics.

The earliest Tremadoc is characterized by wide transgression across shelves and development of the classic "*Dictyonema* Shales." These shales bear the first holoplanktic, nematophorous graptolites. Modest mid-Tremadoc regression is accompanied by extinctions of most early Tremadoc species. Subsequent late Tremadoc sea level rise is followed by radiations among multi-branched graptoloids with bithecae. Adelograptids, bryograptids and clonograptids are common. Major latest Tremadoc regression, the Ceratopyge of Erdtmann, was followed by extinction of graptoloids with bithecae.

The earliest Arenig *Tetragraptus approximatus* Zone is typified by the name-bearer and few other taxa. Subsequent early Arenig sea level rise was accompanied by major radiation among dichograptids. Middle Arenig stratigraphic sequences on Laurentia record a dramatic sea level drop and pronounced lowstand that may have been global. In contrast to the general pattern, this lowstand coincided with the isograptid radiation that increased graptolite diversity substantially. Diversity increase continued into the latest Arenig, which was a time of transgression in Laurentia. Species turnover continued in the dichograptid and isograptid faunas in the Late Arenig when the biserial scandent forms appeared and radiated. Continued transgression in the Llanvirn was accompanied by further radiation among biserial scandents in the tropics and modest radiation of pendent didymograptids in peri-Gondwanan sequences. The latest Llanvirn-Llandeilo regression was followed by extinctions of almost all species. The few that remained were early biserials and glossograptids and cryptograptids. Species diversity dropped to its lowest level since the earliest Arenig.

Sea level began to rise again in the late Llandeilo and continued well into the Caradoc. It was accompanied by the appearance and major radiation of dicellograptids, dicranograptids, nemagraptids, leptograptids and diverse climacograptids. The radiation lasted two zones and produced the highest levels of diversity since the late Arenig. Extinctions in most lineages accompanied a modest sea level fall in the mid-Caradoc. Subsequent sea level rise was followed by appearances of new species of dicellograptids, dicranograptids, leptograptids, and spinose climacograptids. The radiation was modest and lasted until the early Ashgill when diversity increased dramatically with the proliferation of small spinose climacograptids, small orthograptids, and dicellograptids. This radiation coincided with one of the highest stands of sea level in the Ordovician. However, the radiation was short lived and was terminated abruptly by global climatic and oceanographic changes related to Hirnantian glaciation, including a rapid sea level drop. Nearly all graptolites except three normalograptid species became extinct, and little speciation took place until well into a later transgression in the early Silurian.