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The Carboniferous World: Assembly of Pangaea and Onset of late Paleozoic Glaciations

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The Carboniferous (358.9 - 298.9 Ma), comprising the Mississippian (Tournaisian, Viséan and Serpukhovian) and Pennsylvanian (Bashkirian, Moscovian, Kasimovian and Gzhelian) [5], was a period of profound change. Pangaea was assembled by continent-continent collisions and subduction causing magmatism, volcanism and emplacement of base-metal orebodies. From earliest Mississippian into the late Viséan (Middle Mississippian), marine environments with limestone deposition prevailed over vast regions on continental shelves, but from the latest Viséan to Permian, continental environments with siliciclastic deposition became progressively more extensive. Increasing continentality resulted largely from orogenic and epeirogenic uplift associated with assembly of Pangaea but oscillatory, low sea levels resulting from waxing and waning of alpine and continental ice sheets were a major factor. Devonian greenhouse conditions terminated with latest Famennian to Tournaisian glaciations [2,1,3,6] but the Viséan was largely ice-free. The latest Viséan and Serpukhovian record the onset of major high-frequency glaciations (icehouse conditions) and interglacials on southern Gondwana that continued into the Permian [1,3,6]. In south China slope limestone $\delta^{13}C$ values increase from 3‰ (V-PDB) in the Viséan to >5.50‰ in the Gzhelian and Asselian suggesting maximum ice development near Carboniferous-Permian boundary [1]. Carbonates formed on ramps and less commonly platforms with shelf-margin reefs. Shallow-marine, deltaic and coastal-plain successions are conspicuously cyclic. "Aragonite seas" in which aragonite was the dominant non-skeletal carbonate mineral precipitated characterized the Middle Mississippian into the Permian [7]. Pre-late Viséan low- to mid-latitude sequences were largely controlled by tectonism. They are frequently carbonate dominant, autocyclic, lack high-frequency regionally developed subaerial unconformities, and include extensive carbonate tidal-flat facies. Post-middle Viséan, low- to mid-latitude sequences typically resulted from glacially controlled sea-level changes (fluctuations >120 m) superimposed on tectonic cycles. The latter sequences are allocyclic, high frequency, show regionally developed high-frequency subaerial unconformities on supratidal to neritic lithofacies, and comprise either mixed-carbonate-siliciclastic facies or coal-bearing siliciclastics. Bedded chert formed in basin to slope settings at subtropical to mid-latitudes, whereas glacial and related siliciclastics were deposited at high-latitudes on Gondwana. Establishment of anoxic bottom-waters during major transgressions produced black hydrocarbon source rocks.

After Late Devonian extinctions, invertebrate groups recovered substantially and crinoid abundance peaked, contributing voluminous debris. Stromatoporoids never recovered but new reef builders evolved and, along with submarine cements, constructed mounds and shallow-water reefs [8]. Fusulinids appeared and became major components of Pennsylvanian carbonates. Components of many phyla became fully terrestrialized as recorded by extensive coal swamps dominated by seedless vascular plants and upland gymnosperm forests, appearance of reptiles, and evolution of diverse assemblages of amphibians and nonmarine invertebrates [4].

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