Paper 5: Palaeogeography

"Ultimately world reconstructions must be congruent not only with the data from geology and geophysics, but also with palaeobiogeography, palaeoclimatology, and palaeogeography." Shields, 1997

On increasing radius small Earth models prior to about 250 million years ago there were no modern oceans, only ancient continental seas. Similarly, before that time, ancient supercontinental crusts existed as a complete crustal shell encompassing the entire ancient Earth. The outlines and configurations of the exposed lands making up the supercontinents were then dictated by the presence of, and changes to, the ancient seas, primarily as a result of changes to the distribution and surface areas of each of the ancient continental sedimentary basins. The transition from ancient seas to modern oceans only came about when the Pangaean supercontinent first started to rupture and breakup during the late-Permian. It was this breakup of Pangaea that initially established the modern continents and intervening modern oceans, as well as initiating draining of waters from the ancient continental seas into the newly opening oceans.

The distributions of ancient shorelines on each of the Cambrian to present-day small Earth models are plotted as heavy blue outlines in Figure 1, based on the published evidence of Scotese, 1994, and Smith *et al.*, 1994. The ancient seas and modern oceans are shown as shaded blue areas and the remaining coloured areas represent exposed lands.

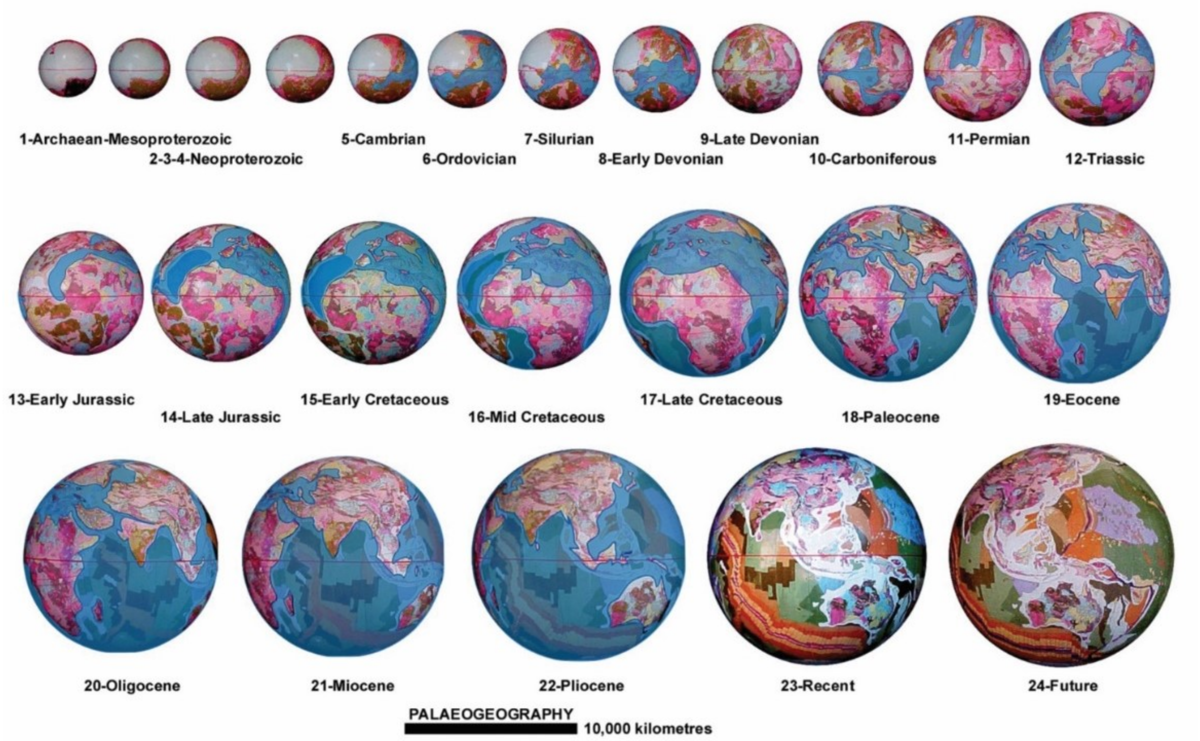

Figure 1 Shoreline palaeogeography on Archaean to present-day small Earth models (after Scotese, 1994, and Smith *et al.*, 1994). The ancient shorelines are shown as blue lines and the ancient seas and modern oceans are shaded blue. Each image advances 15 degrees longitude throughout the sequence to show a broad coverage of palaeogeographic development. Note: there are no published data available for the late-Devonian model or models prior to the Cambrian Period.

The global distributions of ancient shorelines for the Cambrian to present-day small Earth models (Figure 1) are shown to be an evolving and progressively changing process. This distribution of coastal shorelines is interpreted to be intimately related to changes in sea-levels over time. On an increasing radius Earth these changes were, in turn, related to changes in surface curvature and associated tectonism during on-going increase in Earth radius and eventual breakup of the supercontinents. As well as global-scale sea-level changes, the distribution and variation of ancient sea levels also reflects more regional-scale changes as well as the introduction of new water from within the newly opening mid-ocean-ridge spreading zones.

Precambrian small Earth models—models older than 540 million years ago—show that the distribution of progressively older sedimentary basins continued to form a global network surrounding the most ancient cratonic and orogenic crusts. Without any published coastline information to fully confirm this, these sedimentary basins are inferred to represent the distribution of ancient Precambrian continental seas. This inference is substantiated by an abundance of geological evidence from all continents showing that sedimentary basins, and hence continental seas, existed as far back as early-Archaean times.

Figure 2 shows in more detail that the exposed supercontinental land surfaces, as highlighted by the surrounding late-Jurassic shorelines and seas, generally coincide with the distribution of the ancient continental cratons and orogens—shown as areas of mainly pink and red coloured rocks. Similarly, the ancient continental seas—highlighted in blue shading—coincide with the distribution of underlying younger sedimentary basins. By definition, these sedimentary basins represent low-lying regions where transported sediments were deposited and preserved, so it is to be expected that the margins of these sedimentary basins should coincide with the shorelines of the ancient seas.

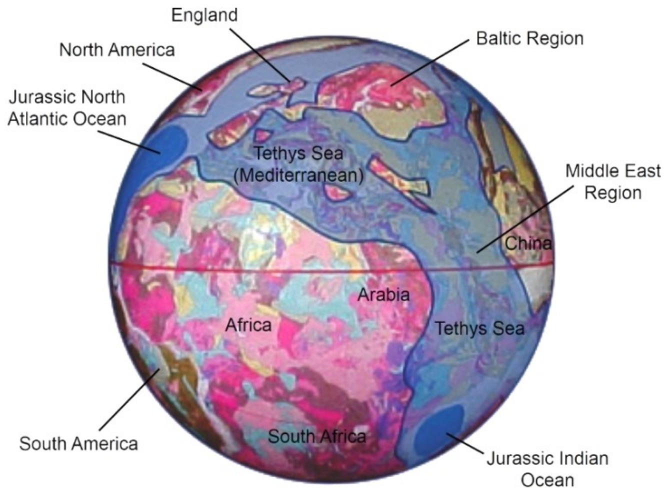

Figure 2 Late-Jurassic shorelines, highlighted as heavy blue lines, shown in relation to the shallow continental seas, shaded in blue, as well as the distribution of exposed lands and the newly opening North Atlantic and Indian Oceans—shaded in dark blue (after Scotese, 1994, and Smith *et al.*, 1994).

The distribution of coastal geography on small Earth models shows that large conventional Panthalassa, Iapetus, and Tethys Oceans are not required. Instead, these oceans are replaced by continental Panthalassa, Iapetus, and Tethys Seas which represent precursors to the modern Pacific and Atlantic Oceans, as well as precursors to ancient seas previously covering continental Europe and Asia respectively. Similarly, configuration of the Rodinia, Gondwana, and Pangaea supercontinents and smaller sub-continents on small Earth models shows that the aerial distributions and extents of these ancient supercontinents were evolutionary, with no requirement for random conventional dispersion-amalgamation assemblage or breakup cycles. On increasing radius small Earth models the ancient supercontinents are instead defined by progressive changes in the surface areas of sedimentary basins, changes to the distribution of ancient seas and shorelines, and associated changes to sea levels (e.g. Figure 3).

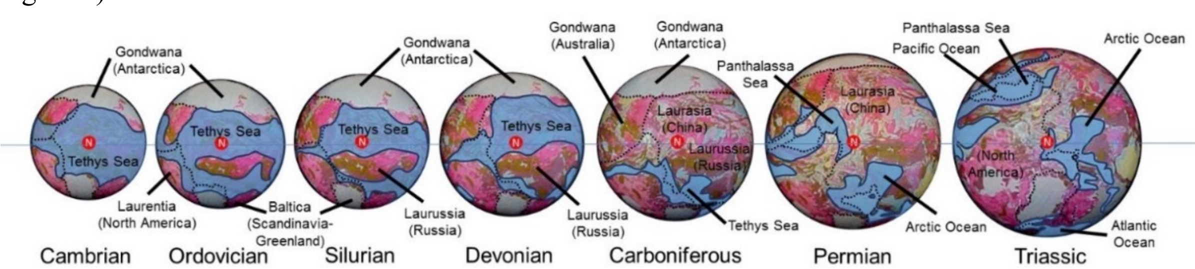

Figure 3 The Tethys Sea and Laurentia, Baltica, Laurussia, Laurasia, and Gondwana supercontinental configurations centred over the ancient North Pole, extending from the Cambrian to Triassic Periods.

The ability for supercontinental crusts to continue to increase in surface area by crustal extension localised within each of the sedimentary basins was finally exceeded during late-Permian times. This process then initiated rupturing and breakup of the supercontinental crusts to form the modern continents and oceans. During late-Permian times, draining of the ancient continental seas was also initiated, which resulted in progressive exposure of the pre-Permian, relatively shallow continental seafloors. Once exposed, these ancient seafloors were then subjected to the ravages of erosion and vegetative colonisation. Eroded seafloor sediments were, in turn, redeposited elsewhere into new low-lying regions, in particular around the newly formed continental margins and marine sedimentary basins.