Gaps in deep time

The granite and Malmesbury shale together constitute the regional basement rock of the Saldania Belt on the West Coast. The Saldania Belt along with the Gariep and Damara belts to the north are part of the Pan African event that welded the continents together, forming the supercontinent Gondwana by around 530 million years ago (Fig. 24).[12] The much higher temperatures and pressures recorded in the Damara belt suggest that its mountains were significantly larger than those of the Saldania Belt to the south. Over time, uplift and erosion levelled the mountains of the Saldania Belt into a flat to gently undulating peneplain. Tectonic forces, which had been pushing upward for so long reversed, and the land started to sink – a reversal that may relate to subduction of oceanic crust along the southern margin of Gondwana. Subduction is associated with volcanic arcs, and the upwelling of mantle rock further inland can result in stretching, rifting and sinking in the interior of the continent, forming a back-arc basin. The sand and gravel deposits of the Klipheuwel Group, which occur today in narrow bands along the Colenso and Piketberg-Wellington fault zones (Fig. 8), record the early phases of back-arc rifting. Continued stretching and thinning led to opening of a major rift basin, the Agulhas Sea – a side arm of the ocean fringing the southern Kalahari Craton.

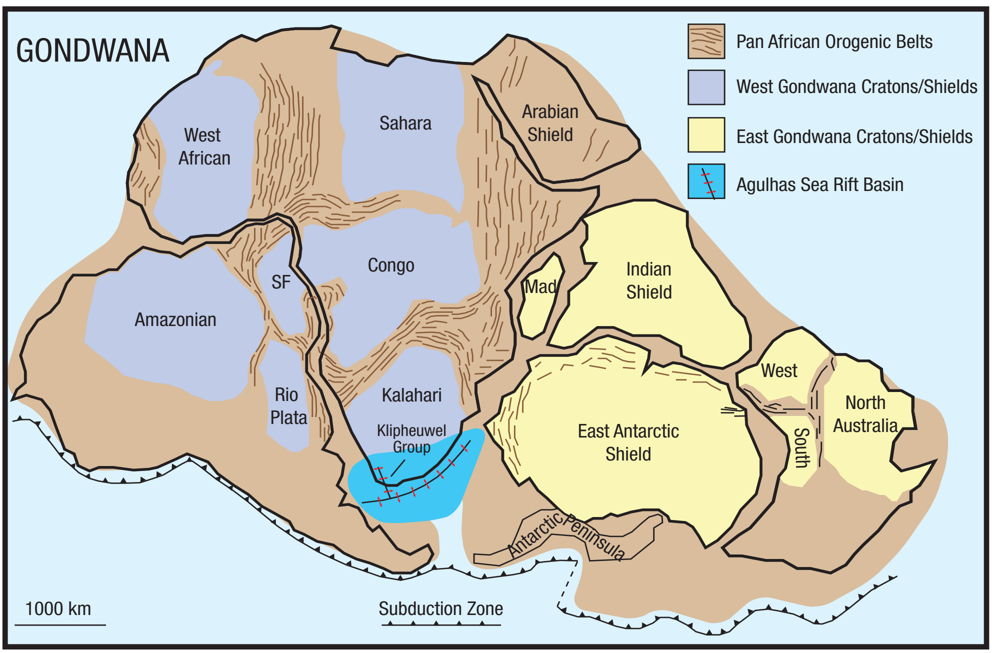

Figure 24. The Gondwana supercontinent was welded by Pan African orogenic belts. The Agulhas Sea developed through rifting at the southern end of the Kalahari Craton.

Figure 25. The contact between granite and overlying sandstone and mudstone largely coincides with Chapman's Peak Drive (left). Close-up of the 'cold' erosional contact is on the right.

The radical reversal in tectonic forces driving the land's surface up and then down is seen where the overlying sandstone is in contact with the underlying Malmesbury shale and granite. The granite/sandstone contact is noncomformable because, unlike the 'hot' magma contact at Sea Point, the sand and mud were deposited on an eroded, weathered granite surface that had long since cooled (Fig. 25). The contact with the shale is an angular unconformity because the layers of rock intersect at right angles to one another, as in the letter T (Fig. 26). It is unconformable because sediment layers are originally laid down flat – such that the shale layers below must have been deformed into their near-vertical position and eroded before the sand was deposited on top of them. Both contacts represent a major hiatus, with a long time gap separating the rocks below from those above. Similar contacts are not uncommon elsewhere in the world, but it took a long time before anyone understood what they meant. James Hutton was a gentleman farmer and the first person, in the English-speaking world at least, who fully grasped and articulated the significance of angular unconformities, such as the one exposed at Siccar Point in Scotland at the end of the 18th century.

Hutton realised that the tilted beds below were originally deposited as flat layers of soft sediment and through deep burial were transformed into rocks that at some stage were pushed by forces into a near-vertical position. These tilted rocks were then uplifted and eroded, capped by an erosional gravel layer (puddingstone) containing fragments of the underlying rock, as well as rounded pebbles and cobbles arriving from more distant sources. At some stage, uplift and erosion stopped and the eroded surface sank rather than rose, and flat-lying layers were deposited on top of the puddingstone. The overlying layers were then buried deeply enough to transform them into hard rock and eventually the whole ensemble was uplifted and eroded for us to see at the surface.

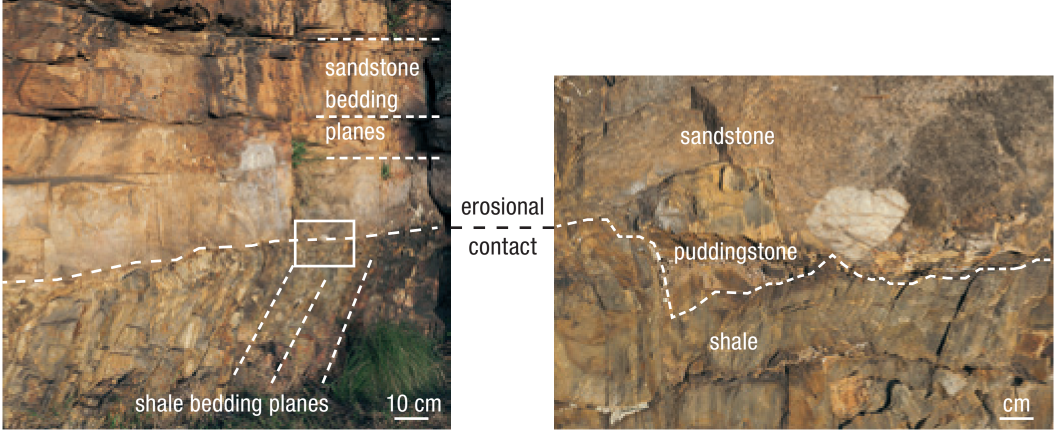

Figure 26. Tafelberg Road angular unconformity: nearly vertical beds of Malmesbury shale are overlain by horizontal beds of Table Mountain Group sandstone (left). Close-up of the erosional contact (box on left) containing dark shale and white quartz cobbles (puddingstone) is on right.

Hutton had no way of knowing how long the unfolding of this sequence of events took, only that it must represent an almost unimaginably long time if he considered how slowly the rivers washed away the soil on his farm. He famously phrased the concept of geological deep time when he wrote in 1788: 'we find no vestige of a beginning, no prospect of an end'.[13] Or as John Playfair, Hutton's companion along with James Hall to the angular unconformity at Siccar Point in 1788, wrote in 1802: 'The mind seemed to grow giddy by looking so far back into the abyss of time ...'[14]

In addition to being ancient beyond his comprehension, Hutton also came to realise that Earth is dynamic. Upheavals sometimes pushed the surface upward, crumpling up and eroding rocks in the process, while at other times the same place sank and allowed the piling up of sediment. These up and down movements occurred at rates generally too slow for us to appreciate in our lifetimes, but cumulatively, operating over deep time, they could completely reconfigure landscapes. Believing the age of Earth not to exceed 6000 years, Hutton's contemporaries had assumed the major landforms were always as we see them now. The only exception was the biblical Great Flood, with spurious reports of seashells and a large iron anchor on top of Table Mountain attributed to the Great Flood. Hutton saw that rather than representing an unchanged tableau, landscapes are constantly being transformed throughout deep time.

Hutton's other significant insight was the concept of uniformitarianism, in which observations of the present day – erosion of soil from his farm, for example – could be used to make inferences about the deep past because many of the processes we observe have operated uniformly through time. For these and other insights expressed in his book *Theory of the Earth*, many consider Hutton to be the 'father' of geology – concepts that Charles Lyell carried forward and expanded upon in his book *Principles of Geology*.