Technical Box IX: The Anthropocene

Have we entered a new geological epoch? Paul Crutzen and Gene Stoermer (2001) proposed that we have now moved out of the Holocene into a new period they labelled the **Anthropocene** based on its distinguishing hallmark, namely human impact on the Earth system. There is no doubt that the dramatic increase in population and in our use of resources have had major consequences for the Earth’s environment in recent centuries (Oldfield, 2005; Chapters 8–10; Steffen et al., 2011). But will human impacts of the kind shown in Figure 7.1 leave a record that is clearly detectable to a geologist living millions of years in the future? For this to be the case, these would need to create Anthropocene strata distinct from the underlying and overlying layers of rock (Zalasiewicz et al., 2011). This will almost certainly be true in places such as cities, where concrete and tarmac will form a characteristic lithostratigraphic unit, and in some river valleys, where large dams are creating new fluvial beds behind them. If – as seems likely – rising greenhouse gas concentrations lead to significant warming of the climate, then this may eventually cause some of the world’s land-based ice sheets, such as Greenland, to melt away. The result would be a sea level rise of 5 m or more, sufficient for deposition of transgressive marine sediments that would be recognisable world-wide. On the other hand, it seems premature to accept a new geological epoch based on something that has not yet happened!

The ‘classic’ means of defining geological epoch is by using fossils contained in sedimentary rocks, and this approach may be of help in deciding if the Anthropocene should be separated from the Holocene. No new species have appeared in recent centuries, but many have decreased in abundance or changed their distribution as a result of alien introductions. Around 500 species went extinct during the twentieth-century (McNeill, 2000), although most of them will not be preserved in the fossil record. Should this rate of species loss continue through the twenty-first century and beyond, then a future palaeontologist is likely to look back at an Anthropocene Mass Extinction event comparable to that at the end of the Cretaceous when dinosaurs died out. However, if we were to look for one distinguishing feature of the human epoch that occurs world-wide and is likely to be preserved in the geological record, then it is probably plastics, even if they end up being broken into tiny fragments. Perhaps this new geological epoch should be called the Plasticene, not the Anthropocene!

It is not easy to agree a date for when the Anthropocene began, if indeed it has done so. Paul Crutzen proposed using the start of the Industrial Era around 1800 AD, when our use of fossil fuels became globally significant. For others, a sharp augmentation in global human impacts is more easily recognizable during the middle of the twentieth century (Figure 7.1). At the other end of the timescale, researchers such as Bill Ruddiman have argued that, as
judged from greenhouse gas emissions, the anthropogenic era began 5000 years ago (see Technical Box VIII). Still further back in time, the mass extinction of large mammals around the end of the Pleistocene would probably not have occurred without human involvement (see Chapter 3). Hindsight is a great thing, and current geological trends of human causation will doubtless be much clearer in the future than they are now…

*Figure 7.1* Increasing rates of global human impact since the beginning of the Industrial Revolution (adapted from Steffen et al., 2011; Gehrels and Woodworth, 2013).
Technical Box X: Climate from tree rings

Tree ring growth is influenced by environmental conditions, especially near the edges of a species’ geographic distribution. Favourable environmental conditions lead to the formation of a broad growth ring, while adverse conditions have the opposite effect. The result is a unique sequence of wide and narrow rings not unlike the bar-codes used for in-store price tags (Plate 7.1). The main environmental factors which cause ring-width variations are climatic ones, but the critical stress factor will not be the same everywhere. In the Alps, a narrow tree-ring is usually the product of a cold summer while in the American Southwest low rainfall is more likely to be responsible for stunted growth. Tree-rings therefore provide information not only about age (Stokes and Smiley, 1996; see Chapter 2) but also about past climate, via measurements of ring widths and properties such as wood density and chemical isotope composition, the study of which is known as dendro-climatology (Schweingruber, 1988; Fritz, 1991).

Tree-ring records offer a number of advantages for climate reconstruction, including wide geographic availability in temperate or sub-tropical regions of the world, annual to seasonal resolution, and in-built, high-precision dating (Briffa, 2000). Dendro-climatology places great emphasis on replication (Cook

![Year-to-year variations in tree-ring widths, shown in the graph, reflect growing conditions and hence past climate. Reproduced with permission of Fritz Schweingruber and Inst. WSL, Birmensdorf, Switzerland.](Plate 7.1)
and Kairiukstis, 1990), with at least 10 trees from each species being sampled at a site. Tree-ring science is more challenging in the humid tropics, because a clear growth season is often lacking, and trees such as the baobab (*Adonsonia*) do not possess easily identifiable rings.

Identifying year-to-year (high-frequency) variations in tree ring records is relatively straightforward, but longer (decadal to century scale) climate signals require de-trending of the data to remove the effects of tree growth on ring width, which become narrower as the tree gets older and bigger. The problem is that de-trending also removes any low-frequency climate signal, in what Ed Cook and colleagues (1995) have called ‘the segment length curse’. Methods such as Regional Curve Standardization (or RCS) have been developed in an attempt to minimize this problem (Briffa et al., 2004), but it remains the case that tree rings are better suited to identifying short-term (year-to-year) variations in weather than they are for long-term (e.g. centennial) trends in climate.