A Level Geology – Topic T3: Quaternary geology – evidence of climate change (KI 2b, 2d, 2e, 3a, 3b & 3c)

Oxygen isotope evidence

The more common and lighter of two isotopes of oxygen, ^{16}O, is preferentially evaporated from seawater compared to the less common, heavier type, ^{18}O. During interglacials the isotopic ratio of oxygen in seawater is in equilibrium. During glacial periods seawater becomes enriched with ^{18}O as continental ice stores the evaporated ^{16}O. This changing isotopic ratio is recorded in the carbonate shells of marine microfossils in a continuous sedimentary record.

The isotopic balance between ^{16}O and ^{18}O can also be measured in water recovered from ice cores. Those with a long record of accumulation (in Antarctica & Greenland) can show evidence of glacial and interglacial stages as well as shorter term climatic cycles. This evidence is used to support Milankovitch Cycles as a cause of Quaternary climate change.

Ice cores also contain samples of past atmospheric composition, trapped in bubbles in the ice. This can be correlated with the climatic changes indicated by the variations in the oxygen isotope ratio.

Fossil evidence

Fossils show that the climate changed quickly and frequently throughout the Quaternary. The evidence can be seen in the adaptations to different climates shown by some organisms and the changing biogeographic distributions of individuals and communities in response to variations in climate.

Due to problems with their preservation, **vertebrate** fossils can be rare. However, some animals found as fossils in Britain clearly show that past climates must have been different from the present climates. For instance, woolly mammoths indicate colder climates.

Invertebrate fossils can show sequences of climatic change through the changing distribution of **beetle** communities. Their present-day range can define their climatic tolerances and can be compared to fossil assemblages. The changing nature of vegetation communities in response to climate changes can be seen in **pollen diagrams** that show the variation in the proportion of plant types in an area over time.

Human evolution

Hominins evolved about 6–7 Ma in eastern Africa as the first bipedal apes. The evolutionary trends towards limbs for an upright, ground-dwelling mode of life are shown in the feet, limbs, and hands of some of the early species. This gives good fossil evidence of living and walking on the ground, rather than climbing trees.

The evolutionary development of hominin skulls over time shows that brain volume increased in absolute volume and as a proportion of body size. This, with trace fossils indicating increasingly sophisticated human activity, suggests greater intelligence and problem-solving abilities.

These changes are interpreted as the result of a climate that became cooler and more variable.

Dating

Accurately dating the short timescales and largely sedimentary record of the Quaternary period is a challenge. Organic material can be dated using radiocarbon (^{14}C) techniques, though its short half-life (5,730 years) restricts its use to the last 60 ka. Isochronous marker beds of volcanic ash, deposited at the same time over a wide area by a single event, can be radiometrically dated to give a time control for a point in a sequence of sediment. Annual cycles of change in varves or tree rings can be counted to quantify the duration of events; tree rings can give an absolute date for the last 10 ka by comparison with a reference pattern of rings.