(Ager, 1981)

3 More Gaps than Record

The late unlamented Field Marshal Goering once said that when he heard the word 'Culture', he reached for his gun; I feel rather the same about the phrase 'continuous sedimentation'. What do we mean by 'continuous sedimentation'? Do we mean something like one sand grain every square metre of sea-floor per minute, per day, per year? Even the least of these would give us vastly more sediment than we normally seem to find preserved for us in our stratigraphical record. When attempts have been made to calculate rates of sedimentation in what look like continuously deposited sediments, the results look ridiculous. Thus the *Globigerina* ooze on the floor of the Indian Ocean seems to be accumulating at between a ¼ and 1 centimetre per thousand years. A very conservative estimate for the Upper Cretaceous Chalk in northern Europe would give a figure of something like 30 000 feet as an absolute maximum, before consolidation, and about 30 million years for its deposition. That works out as around a thousandth of a foot per year, or 200 years to bury an ammonite! And that is for the most rapidly accumulating chalk.

Recent estimates of the rate of deposition of deep-sea ooze show quite considerable variation, but still very little sediment. Thus for calcareous ooze, the rate seems to vary from 0.1 to 1 gramme per square centimetre per thousand years in the less productive zones and from 10 to 30 grammes in the more productive areas. The rate for siliceous oozes ranges from as little as 0.05 grammes per square centimetre per thousand years in the tropics, to as high as 50 grammes in the Gulf of California.

In shallow-water areas, of course, the rates are higher. Carbonate

deposition on the Great Bahama Bank is said to have averaged half a metre per thousand years, even though most of the sediment is continuously swept into deeper water. The average rate of accumulation of the 6000 metres of limestone under the Bahamas is only four or five centimetres per thousand years. From this disparity in rates, Professor Norman Newell deduced that these Cretaceous and Tertiary limestones represent no more than a tenth of Cretaceous and Caenozoic times.

These sediments are only slightly compactible, but with others (particularly muds) it must be realised that the thickness of new sediment is not the same thing as the thickness of the rock that results from it. Nevertheless we are always faced with a contradiction between rates of deposition and the known thickness of rock for a particular period of geological time.

When challenged with this sort of argument, most practitioners of the doctrine of continuous sedimentation then change their ground and say: "Oh no, we just mean without significant breaks". But what is significant? Obviously there are plenty of unconformities where the break is obvious, such as the splendid unconformity between the Upper Cretaceous and the Precambrian of the Bohemian Massif shown in plate 3.1. But as our studies continue, more and more concealed breaks become apparent, such as the remarkable situation in the Jurassic limestones of western Sicily, where several stages are packed away into thin solution pipes in what otherwise look like unbroken limestone sequences (figure 3.1).

But suppose we look at some of these areas of thick 'continuous' sedimentation. Look at the spectacular cliffs of the Lower Jurassic sediment of the Dauphinois trough above Bourg d'Oisans in the French Alps (plate 3.2). Thousands of feet of shales and mudstones represent one small part (and I suspect one small part of that small part) of the Jurassic. Here, if anywhere, one would think we must have had continuous sedimentation. But what are all those bedding planes? What is any bedding plane if it is not a mini-unconformity? If we really had continuous sedimentation then there would surely be no bedding planes at all.

In fact the only time we see unbedded sediments, apart from comparatively small thicknesses of *in situ* reef development, we can almost always find evidence of the destruction of the bedding planes by recrystallisation or by the burrowing activity of organisms. Professor Gilbert Kelling has pointed out to me that, in certain

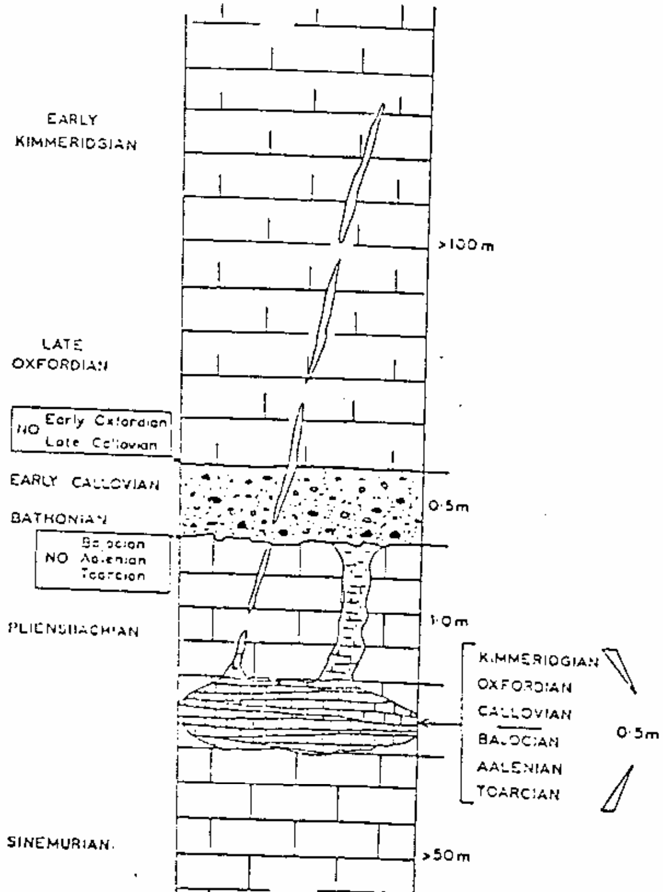

figure 3.1. Idealised diagram of the condensed sequences preserved in solution hollows in Jurassic limestones of west Sicily (from information in Wendt, 1965 and 1971)

circumstances, bedding planes can be produced by textural and diagenetic differences within 'continuous sedimentation'. But I still maintain that most bedding planes show evidence of a pause in sedimentation, if not actual erosion.

Ideally, I suppose, we should look around for the thickest available development of a particular unit if we are to find anything

approaching continuous sedimentation. Even then it has been calculated, taking systems as a whole, that the maximum rate of sedimentation would have been something like one foot in a thousand years.

In fact we have a paradox here in that the areas most commonly cited as those of continuous sedimentation without breaks, such as the late Ordovician—early Silurian of the Southern Uplands of Scotland and the Jurassic to early Oligocene of the Italian Apennines, are also those of thinnest sedimentation. Clearly in such developments there may be few, if any, erosional breaks, but there must be immense non-depositional breaks. And even in deposits such as the flysch of northern Spain or the Polish Carpathians, there is a great deal of evidence of erosion by the turbidity currents that laid down the sediment.

Having a sentimental attachment for them, I cannot resist mentioning the Cotswold Hills of western England where the formation still quaintly known by William Smith's original name of the 'Inferior Oolite', reaches what is for us the tremendous thickness of about 100 feet. This constitutes the Bajocian Stage of the Middle Jurassic and compares favourably with its equivalent on the Dorset coast of southern England, where the limestones of this age are condensed into a mere 11 feet with two obvious breaks (plate 3.3). But it has long been known from careful palaeontological studies that even in the thick development in the Cotswolds, there is evidence of two major breaks and a period of folding in what otherwise was a very peaceful period in British geological history. What is more, if we look farther afield, our magnificent 100 feet dwindles into insignificance. In Alaska we read that the Middle Bajocian alone amounts to some 4000 feet.

Again, the childlike wonder appears when we read for example of nearly 7000 feet of Kimmeridgian (Upper Jurassic) in New Zealand or 10 000 feet of Frasnian (Lower Upper Devonian) in Arctic Canada, or 17 000 feet of Arenigian (Lower Ordovician) in western Ireland. What I think of as a few steps along the beach in the Isle of Wight suffices to pass the Middle Oligocene, but I find this amounts to untold thousands of feet of sediment in New Guinea.

For any tiny part of the stratigraphical column of which we are particularly fond in our own backyard, we can almost always find somewhere else in the world where that same division is a hundred

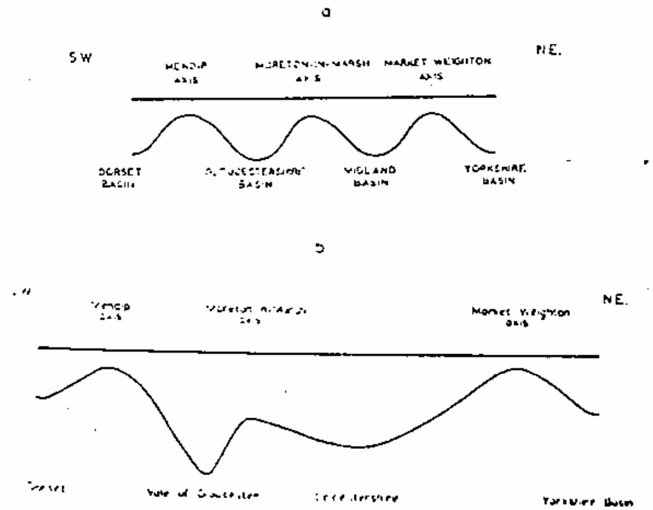

Figure 3.2. Contrasted versions of the variation in thickness of the lowermost Jurassic deposits in England.
(a) idealised text-book type variation along the outcrop showing 'axes' and intervening 'basins'.
(b) the same variation expressed in actual total thicknesses

or a thousand times thicker. We are only kidding ourselves if we think that we have anything like a complete succession for any part of the stratigraphical column in any one place.

Even within a short distance we can see remarkable changes of thickness. The so-called 'Purbeckian' Stage at the top of the Jurassic reaches a maximum of 562 feet under the Weald south of London. Yet only 30 miles or so away the 'Purbeckian' is down to a mere 3 feet, with no obvious breaks, on the French cliffs near Boulogne. Very often it is not as simple as that. What looks like thinning in a major unit may turn out to be something much more complicated in the smaller constituent units.

The textbook picture of the lower part of the Lower Jurassic in England, looked at in the usual two-dimensional textbook way, along the outcrop, is of thinning over three axes with thicker basins of sedimentation in between (figure 3.2*a*). If we put in actual thicknesses, the 'axes' are not so obvious, but they are still there (figure 3.2*b*). But if we look at just one part of that story in detail, we find

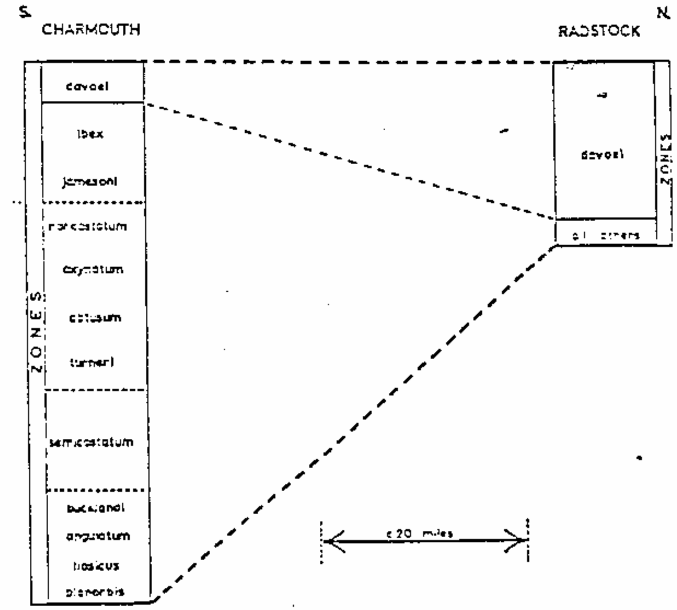

figure 3.3. Actual variation within constituent zones between the Dorset coast and the Mendip 'axis'.

complications. Thus if we trace the zones of the Lower Lias (as it is called) from the Dorset 'basin' to the Mendip 'axis', we find that 11 of the 12 zones thin as they ought (figure 3.3) with no signs of any breaks in the succession, but the twelfth actually thickens markedly!

Such misbehaviour of strata in their most classic sections leads me to have serious doubts (in fact, positive hatred) of the concept of the 'stratotype' so much favoured by many continental workers. This idea of type section for a particular stratigraphical division will be discussed in a later chapter; all I must say here is that no type section known to me can possibly pretend to be representative of a whole unit of the stratigraphical column, however small. Keeping, naturally enough, to the Jurassic (since it was the birthplace of stratigraphy), let us take as an example the Volgian Stage. Currently this competes with the Tithonian (discussed in Chapter One) for a place at the top of the Jurassic. A lesser rival is the

Portlandian (cum 'Purbeckian') of England, to say nothing of the quaintly named Bononian and Bolonian of France.

The 'stratotype' of the Volgian Stage is at Gorodishchi, along the river from the birth-place of Lenin (Ulyanovsk, formerly Simbirsk). It is an excellent section, packed with fossils, but with very obvious breaks marked by prominent bands of phosphatic nodules, and borings (plate 3.4). Clearly any break is a disadvantage in a section that sets out to typify a whole division of geological time, but here it is worse, for one of those breaks is now thought (at least by one eminent British palaeontologist) to conceal the whole of the British Portlandian.

All this leads me to the conclusion that the greater part of the passage of geological time has left over most of the earth no more than Shakespeare's 'gap in nature'. If you study textbooks or

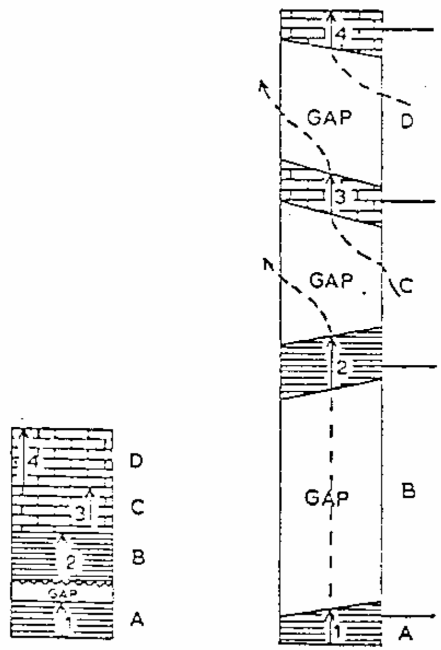

figure 3.4. Comparison of the conventional picture of a particular part of the stratigraphical record (left) with what is probably the true picture (right). See text for explanation

correlation charts, such as those produced by the Geological Society of America and the Geological Society of London, you come inevitably to the conclusion that the stratigraphical column in any one place is a long record of sedimentation with occasional gaps. Even though he may pay lip service to the idea that there are probably many breaks not yet discovered, nevertheless almost every geologist seems to accept the above doctrine, albeit subconsciously.

But I maintain that a far more accurate picture of the stratigraphical record is of one long gap with only very occasional sedimentation. This doctrine is illustrated in figure 3.4. On the left you see the conventional picture of part of the stratigraphical column, with varied sediments, a single small break and fossil records that start from nothing and end as nothing. On the right you see what I think is a far more likely explanation of the same facts. The gaps predominate (and probably should be far longer than they are shown here), the lithologies are all diachronous and the fossils migrate into the area from elsewhere and then migrate out again.

Perhaps the best way to convey this attitude is to remember a child's definition of a net as a lot of holes tied together with string. The stratigraphical record is a lot of holes tied together with sediment. It is as though one has a newspaper delivered only for the football results on Saturdays and assumes that nothing at all happened on the other days of the week. To change my metaphor yet again, I would compare the stratigraphical record with music. Just as the intervals between the notes in music are every bit as important as the notes themselves, so the bedding planes are as important as the beds.

No doubt my prejudices are coloured by having looked at too much epicontinental sediment and not enough oceanic, but I must plead in my defence that this is the nature of the stratigraphical record on the continents anyway. What is more, we now know from the Deep Sea Drilling Project that there are vast gaps in the record of the oceans, too.

So we may come to the third proposition of this book: THE SEDIMENTARY PILE AT ANY ONE PLACE ON THE EARTH'S SURFACE IS NOTHING MORE THAN A TINY AND FRAGMENTARY RECORD OF VAST PERIODS OF EARTH HISTORY. This may be called the *Phenomenon of the Gap Being More Important than the Record.*