USING THE EARTH TO MEASURE TIME

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Summary

The natural layering of sedimentary rocks in the Earth's crust offers a simple method for measuring time. This understanding was crucial to first realizing the great age of the Earth and so to providing a realistic framework in which to accommodate Darwin's theory of evolution. The story of how rock layering laid the foundation for modern ideas of planetary development also provides a cautionary tale against reaching premature conclusions on "big issues" in geology.

> "If you can look into the seeds of time
> And say which grain will grow and which will not…"
>
> *Macbeth*, I/iii, 58

1. Introduction

It is a fact evident to non-geologists as much as to geologists that the rock of the Earth's crust is disposed in layers. Rock unit lies upon rock unit in such a way that they pile up like paving slabs waiting to be laid. The image is an apt one, making the word "strata," which we use as the collective term for rock layers, one that is familiar to most people. When the strata are crumpled or overfolded, the understanding is clear that for some reason or another, the layers have been stressed and their horizontal attitude disturbed. The logical conclusion has to be that the Earth is at times subject to "dynamic" processes and is in no way "passive" or "dead."

Both the layering and the crumpling have influenced the thinking of scholars and artists to such an extent that we can identify the beginnings of geological thought as far back in time as the writings of the Greek philosophers and the Roman natural historians. The same logic and reasoning impressed itself upon Leonardo da Vinci, so that we can

justifiably add geology to the sciences for which he contributed seminal thought. Take his sketch of crumpled strata in the hills above Florence, now used as the logo of Rome's La Sapienza University on the cover of their journal, *Geologica Romana* (Figure 1). This has to be as valid an observation of the folding of the Apennine foothills as his conclusions drawn from the discovery of fossil marine shells on some of the same hill ridges. Ancient seabed layers elevated and transformed into fold mountains was part of the understanding of the late sixteenth century in Italy.

Figure 1. Leonardo da Vinci's sketch of deformed rock strata

If we move forward two centuries to when Cézanne was painting his 65 different versions of Mont Sainte Victoire in the rugged regions of Provence, we find that he faithfully recorded the broken curving fold in the massive Upper Jurassic–Lower Cretaceous limestones more recently described in detail by Chorowicz and Ruiz in 1984. Being a faithful recorder of what he saw in the open air rather than the studio, he could have done it in no other way. Cézanne had the eye and the understanding of a field geologist, as is confirmed by his painting companion, Antoine Fortune Marion, later the curator of the Geological Museum in Marseille. To Marion, Cézanne was the better geologist, well able to read the story of the strata. For us, it is sufficient to agree that artist and geologist alike weigh up the same landscape and come to an understanding which is a chapter in Earth's history.

2. Strata and Time

It is but a short mental step from an appreciation of stratification in rocks in the crust to seeing this as a measure of "time." In normal circumstances, the bottom layer in a pile will be the oldest—the first formed—and anything above, younger. The uppermost layers may be soft and unconsolidated and so record their very recent deposition, not yet compressed by the loading of later deposits to start the process of rock formation. Those layers may have formed within historic time, almost within living memory. At this point, we need to add the dynamic concept of the Greek philosophers that, in the system of the Earth, no material is lost; but is simply transferred to another place to become the

substance of new and younger rocks (Figure 2). Strata elevated into mountains are attacked by all the agencies of erosion. Thus quartz is released to become the sand grains of new sandstones, whereas other minerals, such as feldspars, release clay minerals and others to become the basis of shales and limestones. Appreciation of this neat and self-contained cycle predates by over 2500 years our credit to James Hutton for his comprehensive 1788 book *Theory of the Earth*. Geology has deep roots in time, let us all agree, but how do we measure actual time in these stratal sequences? How do we measure time when rocks are later folded? What is the age of a mountain chain, and is it the same as we trace it across continents? Can we trust those who say that strata exposed in one area are actually of the same age as cliffs or crags some 100 kilometers distant?

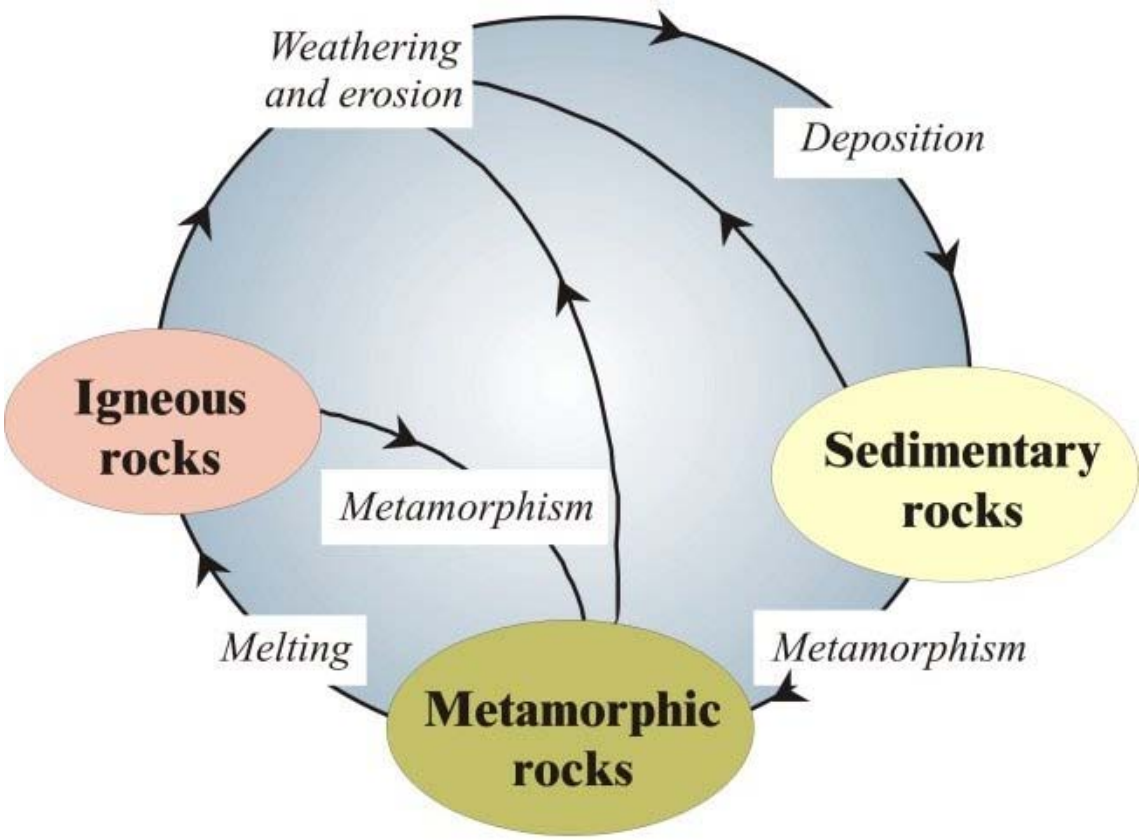

Figure 2. The rock cycle, showing how Earth's material is transformed from one rock type to another

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Biographical Sketch

Eric Robinson is a retired lecturer in paleontology and stratigraphy at the Department of Geological Sciences, University College London. His more recent interests have been the history of geology and the geology of building stones. He received the 1993 Worth Prize from the Geological Society of London for raising public interest in geology, and is a permanent Vice President of the UK Royal Archaeological Institute.