Relative Time

Part 1 -- James Hutton and "Deep Time"

Part of a portrait of Hutton by Sir Henry Raeburn

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What to Look For:

• James Hutton first interpreted the meaning of an angular unconformity in Scotland, pointing out that there must be enormous amounts of time involved in forming one.

• At Siccar Point we can see two sequential ones, but other places in the world may have even more.

• For most educated people this put to rest a prevailing idea that the Earth is about 6000 years old. This was a major change in how humans view the world, the enormity of which we can barely get our heads around today.

• Hutton’s wording of his discovery was “…no vestige of a beginning, no prospect of an end”. His friend John Playfair called it “…the abyss of time.”
In his search for evidence of past episodes of uplift of Earth’s surface Hutton “discovered” what has become a very famous angular unconformity, called, rightfully, the Hutton Unconformity – one of the very few geologic features not named for the place they occur. The diagram below is a sketch of it from his book, done near the Scottish village of Jedburgh (the 2000 population of which was ~4000 people).
We discussed angular unconformities earlier in the course. Hutton was the first to interpret one, and to recognize their temporal importance – what they tell us about time. At Jedburgh the Old Red Sandstone appears flat, but this is actually not the case.
A portion of the Berwickshire coast between Dunbar and Eyemouth, Scotland. This is the area of the far more famous exposures of the Hutton Unconformity.
This more famous outcrop of the unconformity is about 140km (90 miles) to the north-northeast of Jedburgh, at Siccar Point. This is part of Figure 17.9 in your textbook, which is very similar to, if not identical with, an image you can find on Google Earth. Image taken facing east.

Angular unconformity at Siccar Point, Scotland. James Hutton first realized the significance of unconformities at this site in 1788.
Older editions of your textbook had a slightly different picture to illustrate Hutton’s unconformity. The dip on the Old Red Sandstone is not so obvious.
Both versions miss one important thing. Siccar Point is a headland on an erosional coast, so the seacliff in the background plunges right to the North Sea.

“Old Red Sandstone”

“Schistus” (NOT a schist)

However, these same rocks occur all along the nearby coast, including in the coves between headlands, where there are pocket beaches. The dips of the beds and the differences in elevation of the erosional surface means that in some coves the Recent sands are being deposited on the Old Red Sandstone but in most coves it lies on the “Schistus”.

Photo by Marli Bryant Miller
A fairly accurate schematic cross section might attempt to show the present topography of the area along with the bedrock and sediment relationships, ...

The uncertainty about what is beneath the “Schistus” was part of Hutton’s fascination with this unconformity!
... but this very simple one contains the same information. The order of events is:

7) Deposition of Recent sand (Holocene)
6) Erosion
5) Tilting (folding)
4) Deposition of Old Red SS (Devonian)
3) Erosion
2) Tilting (folding)
1) Deposition of “Schistus” (Silurian)

Just for the record, the two episodes of folding obvious in this diagram record two separate mountain-building events: one in the late Silurian and the other in the Carboniferous. The latter was accomplished by the same collision that built the northern Appalachians on the continent Europe “ran into” -- us.)
When he looked at this outcrop Hutton realized that *some of* the sand accumulating on the nearby beaches was eroding off his farm, as he had already surmised that it did. But some of it was also weathering out of the rocks at Jedburgh closer to the coast, and some of it was also weathering out of these very seacliffs!

In other words, the Old Red Sandstone and the sands in the “Schistus” were the *source* for the sand, whether right here or farther inland. But this begged the question: what was the source of the sand for the Old Red Sandstone? An obvious possibility was that the sands in the “Schistus” had provided at least part of those grains.

I hope you see where this is going. The next begged question was where did the sand for the “Schistus” sandstones come from? Here Hutton ran into the end of his data. The question marks at the base of the diagram accentuate this observation. *There must have been an even older source that we cannot see!*

What if that was another sandstone? That takes it yet one step farther back! Could this be an example of infinite regress? Could the Earth cycle endlessly between uplift/tilting and erosional flattening? Could the present beach sands ultimately be lithified and uplifted and start the cycle again?
Hutton asked himself at least three important questions about this unconformity:

1) If the Recent sand came from the “Schistus” and Old Red, at least in part, and the sand in the Old Red came, at least in part, from the “Schistus”, and if that sand came (hypothetically at least) from an older sand, how many cycles back could we follow this line of reasoning? **Could the Earth be infinitely old?**

2) Never mind “infinite”. How long would it have taken, **at the rate I see sand and mud leaving my farm**, to accumulate 1000’s of meters of flat-lying beds of “Schistus”, tilt it up into a vertical position, then weather it down to a flat surface so the Old Red could be deposited upon it? **Surely more than 6000.**

AND

3) Will the Recent sands eventually pile up to great thickness, become lithified, be tilted, and then be weathered and eroded back down to a flat surface as the Schistus was? **There’s no reason why not!**

(Notice that all these ideas – hypotheses, really, are based upon the evidence of his senses. He did not read any of this in a book. He came, he saw, he reasoned.)
"The result, therefore, of our present enquiry is, that we find no vestige of a beginning,—no prospect of an end." Hutton, 1788 – “Theory of the Earth ...”.

We now refer to Hutton’s idea as “deep time”.
Incidentally, here are our current answers to Hutton’s questions:

1) **Could the Earth be infinitely old?** – No. Plate tectonics causes the uplift and this is a linear process with a clear beginning and end point. The “Schistus” probably did come from an older sandstone, but that sand almost certainly came from igneous rock in a volcanic arc created by subduction at a trench.

2) How long would it have taken to do all the depositing, tilting, and eroding that we actually see evidence for at Siccar Point? **Surely more than 6000 years.** – Absolutely. From the Silurian uplift that tilted the “Schistus” to the Carboniferous uplift that tilted the Old Red Sandstone was over 150,000,000 years. From then until the Recent sands began being deposited was over a quarter of a billion years.

AND

3) **Will the Recent sands have the same fate?** – Yes, most likely. Eventually the lithosphere and asthenosphere will cool to the point that the tectonic system will shut down and then the cycling will end – the former will be too thick and the latter not plastic enough to continue. Anything above base level will be eroded to base level and then waves will plane it down farther to wave base. Mass wasting off the “continental” slopes and so on will eventually create a virtually flat outer surface to the Earth, covered by a consistently deep ocean. This, however, is so far into the future that there’s time for at least a few more cycles to run. If western Europe bumps into another continent in the future then the cycle will repeat.
James Hutton was an awful writer who took a particular joy, apparently, in saying the same thing over and over and over. Very few people have ever actually read his monstrous book (with an equally monstrous title: “Theory of the Earth; or an Investigation of the Laws observable in the Composition, Dissolution, and Restoration of Land upon the Globe” from 1788 – I’ve gotten to about page 10 several times). However, his friend John Playfair guaranteed Hutton’s fame by writing his own book: “Illustrations of the Huttonian Theory of the Earth”. Playfair was a wonderful writer, and his book is a joy to read. I’ve done it twice.

One line has been quoted many times. It records his impression when Hutton took him to Siccar Point and showed him how to interpret it:

“... the mind seemed to grow giddy by looking so far into the abyss of time.“

Mine did too in 1974, when I first saw a picture of Siccar Point, learned to reason my way to an ancient Earth, and to realize that it has a long and comprehensible history stretching from then until now!
Short Version:

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