The Geological record of environmental change

Glaciation: Snowball Earth?

Voice Over
The sandstone dyke is equally controversial but can be explained as an ice wedge. Examples of both features in the upper carbonates imply that climatic cooling, if any, was not sudden. Carbonates extract carbon dioxide from the atmosphere; however for global cooling to occur that extraction has to exceed volcanic supply. The Dalradian shows no geochemical evidence for such an imbalance in the carbon cycle.

M.E. Andrews Deller
This is the first of the thirty-eight diamictites on this little island and they're all inter-bedded with sandstones. Whatever conditions they represent, they've been repeated again and again.

Steve Drury
Yeah the thirty-eight repetitions built up almost a kilometre of sediment and those critical of these mythologies are the diamictites, and it's to them we have to look for some indication of general environment conditions.

M.E. Andrews Deller
And what were the alternatives?

Steve Drury
Well, the most ridiculous suggestion that's been put forward is that the boulders might have fallen out of floating tree roots but you know 600 million years ago there weren't any trees so we can rule that one out.

M.E. Andrews Deller
And then of course there's the impacts?

Steve Drury
Yeah I've heard of that one, sounds great, but there would have to be a lot of evidence for shattering, but we've seen nothing like that.

M.E. Andrews Deller
So the glaciagenic model seems the best?

Steve Drury
Yeah that's the way the evidence is looking, but remember the bedding and the dropstones rules out a tillite. I feel we've got debris falling from floating ice into, onto the sea bed, being reworked by currents, and then an ice-free tidal environment.

M.E. Andrews Deller
And warmer marine conditions?

Steve Drury
Possibly warmer marine conditions, yeah, but there are always surprises in thick piles of sediments like these, and perhaps one last outcrop could throw a spanner in the works.

M.E. Andrews Deller
This is another diamictite with a huge range of grain sizes and some of the clasts are very angular.

Steve Drury

They look familiar, this yellowy colour, I think they're carbonate, yes, they're soft, yep right, let's see which one. No, it's not fizzing, these are dolomite clasts in here. You might think there's a pretty big range of grain sizes here but this particular unit has got some of the biggest clasts in it you're ever likely to see. Some of them go up to almost 200-300 metres across.

Voice Over

This great breccia of the Gravellachs is unlike the other diamictites. It's a formless mass of angular clasts, some the size of bungalows. One dwarfs them all. It's a block of the lower limestone unit and almost 100 metres thick; its bedding is distorted as if a soft mass had rolled along the sea bed. The great breccia is a mass flow deposit formed by collapse of the continental shelf. It extends as far as Western Ireland, more than 200 kilometres away. Its trigger was probably a massive seismic event. Reconstruction of the overall environment for deposition of the Dalradian super-group illustrates how tectonics may have had a major influence on sedimentary facies. The Rodinia super-continent began to break up along continental rift systems. Major extensional faults caused the continental crust to thin and the thinned crust then gradually subsided below sea level to form a series of fault-bounded basins, which progressively filled with Dalradian sediments until extension and faulting stopped 250 million years later. Earthquakes occurred continually on the basin bounding faults, and if the slope on the sea bed became high enough to be unstable, seismicity may have triggered collapse and mass flow deposits, like that of the great breccia. Tectonic influences, as well as those resulting from environmental change, complicate what geologists can deduce from fieldwork in sedimentary sequences. Excellent as rock textures and structures on several scales are, interpreting them often presents several alternatives for the processes that produce them. As a result, new hypotheses about major environmental change, such as that of the late Precambrian Snowball Earth conditions, generate much controversy. Field evidence may give rise to these hypotheses but cannot fully confirm them. Geochemical data relating to the carbon cycle can help resolve ambiguities about climatic influences on the sedimentary record. Careful sampling through an entire sequence, such as that on the Gravellachs, and precise carbon isotope analysis, perhaps offer a better way of confirming or refuting the Snowball Earth hypothesis.