The Geological record of environmental change

Utah: Cliffs near Helper

Steve Flint

These are Helper engines, it takes at least six of them to push the mile-long trains of Book Cliffs coal up this valley and over the Wassach Mountains. John and I are standing on this ridge overlooking the town of Helper, behind which is this fantastic exposure of Book Cliff stratigraphy.

John Howell

The lower part of the Helper Face is comprised of a series of blue-grey weathered green shales. We'll take a look at those in more detail later. The upper part includes a whole series of sandstone benches. Each one of these benches represents a phase of either delta or shoreface progradation. I'm going to take a look at one of these in detail now and it's the one that's about the level of that balanced rock.

Voice Over

The stratigraphy at the level with the balanced rock is most easily seen at Gentile Wash, a few miles north of Helper.

Caption: Dr. John Howell, Earth Sciences, University of Liverpool

This is Gentile Wash, a small canyon near to the Helper Face. The succession we'll see as we walk up this canyon will give us the opportunity to take a closer look at the facies which comprise the rock bands that we see towards the top of the Face. The lower part of the succession here is comprised of a series of blue-grey silty mudstones which contain an abundance of trace fossils and bioturbation and lack any really clear good stratification within them. The other key observation about these mudstones is that they don't actually contain, or they're not inter-bedded with any sandstones. This lack of sandstone tells us that the mudstones were deposited out of suspension in relatively deep waters where storms and waves couldn't affect the sea bed. This means we're in the offshore environment. The abundance of the bioturbation tells us that we're in an open marine environment that was fairly favourable for organisms to live in. As we pass upwards we see the first appearance of the sandstone. This sandstone here is about 10-20 centimetres thick, fine-grained and includes low angle, sweeping, hummocky laminations. These hummocky laminations are hummocky cross-stratification and this is developed through storms. The fact that we actually have storm deposits tells us that storm waves were affecting the sea bed. This point here we define as storm wave base. The interval above it, which includes a whole series of these hummocky beds, is the interval that we call the offshore transition zone, and it comprises a series of inter-bedded sandstones and siltstones.

As we move up the succession, the individual hummocky beds become thicker and start to become more amalgamated, the proportion of silt stones we see decreases. This carries on until we get to a point where individual hummocky beds are in the order of about 60 centimetres to a metre, and we have no siltstone. We can see the big, broad sweep of the low-angle laminations which comprise the hummock, and we can see if we look across in the third dimension on this right-angled face over here, that the bed-fall also has a hummocky shape to it. This tells us of its overall domal nature. The laminations are cross-cut by burrows and by turbation, and the key observation here is the absence of siltstone. The beds themselves are still deposited by the storms, but the fair weather wave action is actually removing any of the siltstone that would be deposited in between the storm events. The base of the lower shoreface is defined as fair weather wave base which, in a system like this, is typically at 20.25 metres.

Overlying the hummocky cross-stratification beds of the lower part of the shoreface we pass upwards into a series of white, well-sorted cross-bedded sandstones. The cross-stratification

we see in these sandstones is slightly different to the low-angle laminations we saw in the hummocks. Here we see a series of steeper dipping faucet, typically all migrating in the same direction. This is trough cross-stratification and this represents the migration of dunes in the upper part of the shoreface. Shoaling waves which are coming onshore pick up sediment, build dune bed forms and then ultimately deposit it in this trough cross-stratification.
Above the cross-stratified sands we pass upwards into a series of low-angle laminated sandstones, which are also white; these dip gently at about one or two degrees towards the east, and this cross-stratification represents the deposits of the beach. This is where the waves are actually breaking and the shoaling waters are creating this plainer cross-stratification. The beach interval itself is relatively thin, it's in the order of about two and a half metres and this tells us something about the tidal range. This tells us that the tidal range is in the upper part of microtidal to the lower part of mesotidal. The deposits which over-lie the beach can be seen slightly further up the canyon. So the question is: what might we expect to find?
So in this case, overlying our beach we see a black bituminous coal. The coal is about 30-40 centimetres thick and represents a deposit that was laid down in a peat swamp. The peat swamp was sitting immediately behind the beach and tells us some significant factors about the climate: that it was warm, tropical, and that there was frequent rainfall. We know this coal grew in situ because if we look at the underlying beach deposits, we can see these pitted pockmarks. These represent the rootlets of the plants that were growing in the peat swamp as they passed down into the sediment of the upper part of the beach.

Voice Over
Much of the strata in the Book Cliffs was deposited in shallow marine systems similar to the ones we've just seen. Sediment supplied to the coast by rivers was reworked by fair weather and storm waves into long, thin beaches, backed by luxuriant forests. The shallowing out succession at Gentile Wash that John walked through resulted from the progradation of this coastal depositional system. He started here at the boundary between offshore shales, and sandstones and shales of the offshore transition. As the system progrades successively shallow water facies are preserved at a given point so that eventually all the marine accommodation space is filled.
The succession John walked through represents a single phase of progradation called a parasequence. The boundary between parasequences is marked by a flooding surface. In the Book Cliffs and similar systems, the boundaries are always very sharp and plainer, but they have different expressions in basinal and proximal settings.