Geological structures exposed.
Kinematic indicators

Narrator:
We will examine evidence for the sense and direction of movement of rocks during deformation. We start with the Glencoul Thrust, a typical structure from the Outer Zone. Below the thrust are Cambrian quartzites overlying Lewisian basement. In the hanging wall lie Lewisian gneisses brought up from deeper levels. The upper part of the footwall has been deformed by a network of minor faults forming imbricate slices that have been stacked into a duplex. From this perspective the geometry of the imbricate slices give a sense of the direction of movement along the thrust. However, when viewed along the same direction of movement as the thrust, or even from above, the geometry of the imbricate slices does not seem to give any direction information about the direction of movement.

John:
We're here on the shores of Loch Eribol. We've got a foreshore with a series of rock types exposed. At our feet we've got a siliciclastic rock unit, and then down in the gully where by the side of us we've got a carbonate.

Nigel:
Yep.

John:
And in both we can see that the bedding is just about vertical, and you see the trace of the bedding underneath us here, and the boundary between the units follows the edge of the crag. But if you follow it along, that should have its parallel to bedding, but down below me here it starts to curve and there is a plane that then cuts across bedding both in the siliciclastic rock unit that we're stood on, and in the carbonate rock unit. And you can follow that curving plane all the way across for about three metres before it then curves back and becomes bedding parallel again.

Nigel:
So that in the fact that it cuts out these beds means that it has to be a tectonic contact.

John:
It's got to be a tectonic contact, but remember that we're dealing with slices of rock that are vertical, so looking down in a horizontal plane like this we're seeing what we call a lateral cut-out for one of our imbricate slices.

Narrator:
Seen from above the most important observation is that vertical beds are truncated by small curving faults. Such cut-offs confirm that we are viewing imbricate slices, but seen from a plan view. If we remove one of the slices, the fault plane is seen to be a complex curving surface in three dimensions. To obtain the movement direction we must change our perspective to view a section parallel to thrusting direction, as we saw in Glencoul; that is why it is essential to establish the three-dimensional geometry of the imbricate slices. Only then can we use these structures as kinematic indicators. Imbricate structures provide only one kind of kinematic indicator. We can now look for other indicators of movement, in this case associated with the Moine Thrust.

John:
Well walking this close to a major thrust in its footwall we might expect to find some sort of kinematic indicator as we're walking along here.

Nigel:
Ah, there's a modest little fold here. Can you make anything of this one, John?

John:
Well, let's have a look. Well, we can see that it is asymmetric certainly, can demonstrate that because we have a long limb alternating with a short limb, and then back to a long limb again. And we can see because we've got a three-dimensional aspect to it, we can see that its fold axis is trending into the face about that orientation so that's a profile section. And if we have got a profile section, then we can assess the vergence of the fold, and we'll do that by taking our long limb and assessing what the sense of rotation is that we need to apply to it, to bring it round into the orientation of a short limb. So, in this case, we can rotate round clockwise to get the long limb into the short limb orientation, and we then have to consider the upper arrow of that rotational pair, and we would then say that that upper arrow is pointing in that direction.

Nigel:
Well I guess that's quite a good example of how a small scale observation might have major implications for movement directions in Orogenic Belts.

John:
And it does show how carefully you've got to look at these rocks if you're going to pick out all the relevant information.