Geological structures exposed.
Using dikes as kinematic indicators

Narrator:
Kinematic indicators are not restricted to thrust zones. We now digress from the Caledonian Orogeny to illustrate ductile deformation in the Lewisian gneisses – in this case the Orogeny took place during the Early Proterozoic, long before these gneisses provided the basement for the Caledonian Foreland.

John:
This area of Lewisian happens to be classic for finding evidence for kinematic indicators within shear zones, so while we're here let's make use of it. The story is largely that the late Archaean Lewisian gneisses were deformed in the early Proterozoic, that's about 2000 million years ago, by a series of shear zones. And those shear zones are readily found by tracing out basic dikes and we can look at the effects of these shear zones where these dikes enter the zones and see what happens to them as they become deformed. So, shall we go find a dike? OK. Well, this is fairly pale, well-foliated so we're still on the Lewisian gneiss there.

Nigel:
Yes, that's pretty, pretty characteristic. Okay, well this looks much darker than the Lewisian material and I have a suspicion that it could well be a suitable dike.

John:
I think you're right.

Nigel:
Let me just take a sample. Think it's fairly coarse-grained.

John:
It's fairly coarse-grained; it's got some nice little phenocrysts in it though. I think there's no doubt we'd call that a Dolorite.

Nigel:
Good, so it's a Dolorite dike, cutting the Lewisian, a possible marker for us.

John:
A possible marker.

Nigel:
Let's follow it along.

John:
Right, well this is still dike here, and it does seem to be forming this low ridge.

Nigel:
Yes, yes.

John:
By going up the hillside.

Nigel:
Exactly, it's weathered proud and should be able to get a strike off that.

John:
Well that would give us trend of about 140, like it's pretty much heading up towards the summit cairns.

Nigel:
Well, it's very distinctive rock type and it's been looking at the width on the way up and I think it's a good twenty, possibly even thirty metres wide, so it must be one of the larger dikes in this area.

John:
Yes, it's not easy to miss, is it? We've been walking on a bearing of 1-4-0 and we're still on the dike so it's got a pretty consistent trend, 1-4-0 up towards the crest of the hill.

Nigel:
Okay, let's get up to the top then. Well, we've been following the line of the dike along quite a way up to the top.

John:
Up to the top.

Nigel:
And stay with us. Now unless I'm mistaken this rock over here looks a little bit paler.

John:
Well I don't think this is dike, is it?

Nigel:
No, it has a very strong fabric; it's much paler than the dike, certainly Lewisian.

John:
Yeah, it's our Lewisian gneiss, but with now a ex a a fabric that is almost vertical.

Nigel:
Ah now that's interesting 'cos everywhere else I've seen the Lewisian it's been very, very flat-lying fabric.

John:
Yep, it has, and I think we can see that grain shape is rather more extreme than we've seen in the Lewisian before.

Nigel:
Right.

John:
So we have hit a deformation zone. Okay. And the dike has gone so it's either been deflected or it's just stopped dead when it entered the shear zone.

John:
Yep.

Nigel:
What's your bet?

John:
I think we look for the dike.

Nigel:
And yeah, there's a line of pretty dark rocks, dike-looking rocks, down there so it's quite possible that the dike has been deflected in that direction.

John:
Well that would give a direction of around about 1-0-0, so that would imply at least a forty degree change in orientation of the dike.

Nigel:
Okay, well let's follow it along to see if that's what's actually happening.

John:
Well we've come down quite a way now, about two hundred metres from the Cairns.

Nigel:
Yep, about that.

John:
And on a bearing of about 1-0-0.

Nigel:
And we picked up the dike continuously so it certainly didn't disappear, it was deflected.

John:
Indeed it was.

Nigel:
And there appear to be some fabrics in this dike which we didn't see before – before it was fairly massive. And now, this rock here, the feldspar, the pale parts are extremely strongly streaked out and the orientation seems to be parallel to the direction of the dike at this point and I also, I noticed coming down that the dike has thinned considerably, I mean it can't be more than about five metres thick by this point. Would you expect those sorts of changes in a shear zone?

John:
Well you would because if you're going to stretch it out in one direction, increase its length in one direction, then you're going to have to thin it in the opposite, the direction at ninety degrees or else change its volume very dramatically so, yes, I would expect to see it much thinner within the shear zone.

Nigel:
I find it amazing that a dike which is not large geologically-speaking can retain its integrity while undergoing such strong shearing.

John:
Once you start to get ductile deformation where the individual grains of the rock can change their shape and accommodate the deformation then you do, you don't have to rupture, you don't have to fracture, you can just simply stretch and change the shape in that way. And that's what's happening here. We have a dike that comes in and is deflected hundreds of metres over to the east.

Nigel:
And in terms of kinematics, what does all this tell us?

John:
We're being told then by the dike that this shear zone had a sinistral to the left sense of movement on it.

Nigel:
So the dike's proved to be a pretty powerful kinematic indicator.

John:
It's about as good as they get, yes.

Narrator:
By tracing out the dike, observing its changing width and the changing orientation of the fabrics within the gneisses, the resulting map clearly shows a sinistral shear zone, about 100 metres wide, within the Lewisian basement.