Geol. Mag. **124** *(5) 1987, pp. 485–486. Printed in Great Britain*

CORRESPONDENCE AND NOTES

The Solway Line is not the Iapetus suture

SIRS – Dr Soper referred to me quite correctly as having mapped a cleavage in the Eskdale Granite in the Lake District, but I do not agree with some of the arguments he developed after acknowledging the Ordovician age of intrusion for the granite.

The cleavage is well developed south of the River Esk in the area between Garner Bank and Brantrake Crags. All rock types in the polyphase Eskdale intrusion are affected, but the cleavage pre-dates lamprophyre, dolerite and feldspar porphyry dykes. The fabric is characteristically a fracture cleavage confined to ENE-trending zones a few metres to 300 m wide, and of variable intensity within them. Zones of crushed rock have the same trend, though the only mylonite in the area trends north-north-east.

In various publications Dr Soper, sometimes with co-authors, has supported the hypothesis that the Solway Line marks the Iapetus suture and, in conjunction with D. H. W. Hutton (Soper & Hutton, 1984), he invoked three-plate collision and transpression to explain the attitudes of the main cleaveages north and south of the line. The assumption was that there was synchronous development of the main cleavage on both sides of the Solway Line and, on evidence from the Lake District, the cleavage-forming event was dated as post-Pridoli.

I am not convinced that the main cleavage in the Southern Uplands is post-Pridoli in age; nor am I sure that the cleavage in the Eskdale Granite and the one recognized in high-strain zones within the Borrowdale Volcanic Group can be equated temporally with the widespread post-Pridoli cleavage found in Silurian rocks in the Lake District.

Insufficient work has been done in the Lake District to demonstrate two main cleavage events. Proof, however, might come from a study of the lamprophyre dykes. The Eskdale Granite cleavage pre-dates a lamprophyre dyke of unknown affinity, whereas in the Cross Fell Inlier, Arthurton & Wadge (1981) reported mica-lamprophyres showing an ENE-trending foliation, which they presumed to be the end-Silurian cleavage. According to Macdonald *et al.* (1985), the lamprophyres in northern England probably represent a single intrusive episode, which would suggest that there may be two main cleavage events in the Lake District.

There is evidence, presented by Barnes, Rock & Gaskarth (1986), that the main cleavage in the Southern Uplands is earlier than the lamprophyre dykes dated by Rock, Gaskarth & Rundle (1986) at *c.* 418–398 Ma. Using any of the recently published time-scales this cleavage event must, therefore, be late Wenlock or early Ludlow in age. Thus the main cleavage in the Southern Uplands, which possibly even correlates with the earlier of the two cleavage events in the Lake District, is pre-Pridoli.

Arguments in favour of siting the Iapetus suture along the Solway Line tend to flounder when magmatic events are considered, as Thirlwall (1981) and Rock, Gaskarth & Rundle (1986) have pointed out. Subduction-related volcanism in the Lake District ended in Ashgill time. In the Southern Uplands, direct evidence of subduction-related volcanism is weak, but it is also confined to the upper Ordovician succession. If the Southern Uplands greywacke sequence is an accretionary prism, closure of Iapetus across the Solway Line could not have happened before Wenlock time, when the youngest sediments in the Southern Uplands sequence were deposited. The alternative interpretation, put forward by Stone *et al.* (in press), that the sequence is a back-arc/foreland basin complex, requires closure in mid-Llandovery times. Thus neither of the Ordovician magmatic events coincided with collision. As Dr Soper suggests, they may signify a 'close encounter', but not, I suggest, between the Souther Uplands and Lake District terrains in their present juxtaposition.

In relation to any of the younger magmatic events, the Solway Line has no significance as a boundary between magmatic provinces: the probably early Devonian Cheviot volcanics either sit on the Solway Line or lie just north of it, and batholithic granites with early Devonian ages occur from Shap to Loch Doon. Moreover, the Silurian lamprophyre dyke suite appears to span the two areas. Rock, Gaskarth & Rundle (1986) commented that the lamprophyres throughout northern England and Scotland show similar chemistry, and they are able to demonstrate (J. W. Gaskarth, pers. comm.) that chemical variations within the suite do not relate to an Iapetus suture positioned at the Solway Line. It would appear, therefore, that the Southern Uplands and Lake District terrains could have had separate identities prior to magmatic events that began in late Silurian time, but from then onwards the terrains were unified. Whether or not they had to have been separated by an Ordovician ocean, rather than by latitude along a common continental margin, is a matter on which palaeontologists may wish to comment.

There is no evidence to support the hypothesis of late Wenlock or early Ludlow subduction-driven continental collision. It seems far more likely to me that juxtaposition of the Southern Uplands and Lake District terrains came about at that time by strike-slip movement alone. Phillips, Stillman & Murphy (1976) postulated dextral strike-slip, whereas others, including Johnson, Sanderson & Soper (1979), postulated sinistral strike-slip along the Solway Line, though always in conjunction with plate collision. Watson (1984) argued that NE–SW strike-slip became important in the Caledonides at about 420 Ma. Soper & Hutton (1984) showed that there is a sinistral shear component in the main deformation in the Southern Uplands and Barnes, Rock & Gaskarth (1986) argued that it could be recognized in the minor succeeding extensional and compressional events. There is, therefore, sufficient evidence for late Silurian strike-slip movement along the Solway Line and I would suggest that the postulated early cleavage in the Lake District is related to the same event.

During the late Silurian-early Devonian calc-alkaline magmatic event that gave rise to the Cheviot volcanics and the main granites of northern England and southern Scotland, the two terrains were already annealed. Thirlwall (1981) clearly made this point when he argued for early Devonian subduction westwards under a Scottish plate. He was imprecise in his placing of the plate margin, but it has to be south of the Lake District if the young granites of

northern England were subduction-related. A plate margin south of the Lake District is also implicit in the arguments based on the geochemistry of the lamprophyre dykes presented by Rock, Gaskarth & Rundle (1986).

I suggest that the identification of the Solway Line as the Iapetus suture is a red herring. The line is probably a major strike-slip fault along which the Lake District terrain moved into position during the second half of the Silurian Period, becoming the fifth or sixth, thin, accreted slice that went into the construction of northern Britain. The early Devonian plate margin and the Iapetus ocean lay much farther to the south. Whether or not continent-to-continent collision took place at that margin has yet to be established.

Beamish & Smythe (1986) interpreted a northward-dipping high conductivity zone, the high point of which crosses the Lake District about 5 km beneath the outcrop of the Skiddaw Group, as the Iapetus suture. If this is the early Devonian plate boundary, considerable northward crustal under-thrusting would have had to have taken place during early Devonian time. Deformation in the Lake District Silurian rocks is intense enough to produce locally inverted strata associated with reversed faults showing translation to the northwest. I wonder if this is commensurate with northward under-thrusting of a slab of crust at least 100 km wide?

The alternative explanation, which I am beginning to favour, is that ocean closure and continent-to-continent collision south of the Lake District might not have taken place before the Variscan event, and the whole of pre-Carboniferous Britain north of the Variscan Front may have been constructed by a combination of subduction accretion and strike-slip accretion at a convergent plate boundary.

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2 March 1987