Letters to the Editors

K-Ar results from Western Ireland and their bearing on the timing and siting of Thulean magmatism: a reply

Sirs – Mussett (1978) does not appear to have appreciated the salient points of the arguments of ourselves and others. His first charge ignores the selection criteria clearly defined in our paper (Macintyre et al. 1975, p. 233) and elsewhere (Macintyre 1973). He states in 3(ii) only an elementary geographical fact acknowledged in Figs. 2 and 3. His citation in 3(i) is unfair to those who went to considerable pains to establish the presence of the Highland Boundary Fault on Arran. When considering the structural control of volcanism he should first consider these deep-seated structures which rising magma can exploit. Other comments can readily be dealt with in the order in which they were raised.

1. Ages regarded as uncertain were distinguished on Fig. 3, the defined selection criteria being no different from those usually employed. The effects of errors and analytical uncertainty were carefully considered. The major source of uncertainty is not analytical but derives from the petrography and field relationships, disregard of which, with a predilection for analytical perfection and a tendency to regard refined measurements as absolute, can be positively dangerous and misleading. Nature herself is rarely so perfect.

(i) The low Rb/Sr ratios of basic rocks limit the applicability of this method and their youthfulness further precludes accurate measurement. Some rocks yield “ages” around 300 and 2750 Ma (Pankhurst 1977; Pankhurst et al. 1978)! The suggestion that Rb-Sr is here the more accurate method is remarkable. The later IUGS revision (Steiger and Jäger 1977) reduces our Rb-Sr ages by 2-1%, but, hardly surprisingly, does not affect the conclusions.

(ii) K-Ar decay constants were those then employed in all reputable western laboratories, permitting direct comparison with both the geomagnetic polarity and the Lower Tertiary geological time-scales. In no instance was any significance attributed to ages calculated using different constants. Adoption of the IUGS constants (Steiger and Jäger 1977) increases the ages by approx. 1.5 Ma – no more than the usual analytical uncertainty.

(iii) The mineral age of the Donegal dykes (58-5 Ma) is probably accurate but the whole-rocks exhibit minor argon loss. The whole-rock ages of Ailsa Craig and Holy Island are also similar (p. 231) implying an age of 58-5 MA for these localities. The conclusion that the majority of Tertiary granites are of similar age obviously derived from the independent evidence reviewed elsewhere.
The peralkaline rocks also represent the end products of a differentiation cycle and, with this widespread penecontemporaneous outbreak of acid magmatism (Fig. 3), probably appeared at the same time. Their age will be fully discussed in a separate communication.

The lavas referred to on p. 234 are clearly those of Mull and Skye, and the Antrim basalts are considered to be of similar age because the available dates agree within their uncertainty. Magnetic polarity arguments only illustrate the general unsuitability for dating of most British Tertiary rocks collected for palaeomagnetic studies and the futility of attempting to establish a magnetic time scale for the Lower Tertiary in this way.

(iv) We are reluctant to initiate a debate as to whether a Ph.D. thesis constitutes a publication. With one exception only K-Ar ages from petrographically suitable whole-rocks were employed. No significance was attached to the only date available (51.2 Ma) for dykes cutting the Mournes (Evans et al. 1973).

(v) We re-affirm our original statement on p. 234. We did not regard the ages of the Skye granites as well-defined (p. 233, 1.33 and Fig. 3) nor did we so regard the age of the Lundy Granite (p. 233, 1.34 and Table 2). The several age measurements concordant around 53 Ma may reflect only the "later stages of activity" (Macintyre 1973), as the granite may have been completely over-printed by the intense dyke swarm. The possibility that both granites were emplaced around 52 Ma was clearly stated in our conclusions (p. 236, 1.17).

1. Known geological relationships were always closely considered. As is evident in the caption, Table 2 is obviously not a sequence of geological events at each centre as deduced in the field. Differences in detail from accurate age measurements are inevitable (through overprinting etc.).

(ii) We clearly stated (p. 236) that a number of fresh dykes appeared to confirm the validity of a later widespread period of dyke intrusion around 52 Ma which may have been immediately preceded by the emplacement of the plutonic rocks of Rockall, Lundy and Skye.

3. References to points and lines of weakness are given in our paper and our own suggestions clearly distinguished.

(i) Inasmuch as we were dealing with Lower Tertiary magmatism, pre-existing faults are clearly pre-Tertiary.

(ii) No submerged centres had been accurately dated at the time of writing. Indeed some may be pre-Tertiary (cf. Jones et al. 1974).

(iii) Line 2 (Fig. 3) is clearly interpolated. The Mull swarm and centres along the Camasunary-Skerryvore fault in no way negate our concept of a regional spacing. Some linear dyke swarms can be supracrustal in origin fed laterally from central volcanic hearths. Others linking distant centres of volcanism were interpreted by us as fracture zones which tapped reservoirs of basaltic magma in the mantle.

(iv) The N-S alignment along Line I (Fig. 3) has been noted since the time of Richey and Cloos and accepted to the present. Lines II and III are clearly tentative (p. 239,
1.10). Russell’s N-S lines illustrate the ‘grain’ of the crust. The NW-SE linear dyke swarm trend has been undisputed since Bertrand (1888). The Caledonoid grain and associated NE-SE faults are unequivocal. Rift-parallel and rift-normal fissures on plate fragmentation are a theoretically predicted ideal response. In nature it would be surprising not to find some anomalous trends. These constraints are neither “vague, variable or large in number” but serve to illustrate that basement control can readily account for the spatial distribution of igneous activity.

4. Subsequent developments necessitate only minor revision to a few of our conclusions regarding the relationship of the Province to North Atlantic evolution.

(i) The similarities of the activities in East Greenland and Britain far outweigh any differences in detail. Both are intimately associated with the rifting of Greenland from Eurasia.

(ii) The age for the activity in East Greenland was based (p. 236) on published age determinations (Beckinsale et al. 1970; Hamilton 1966). This age had also been suggested for anomaly 24 (p. 237). Two major developments have taken place since our paper was written. Firstly it has been demonstrated (Soper et al. 1976a; 1976b) that the East Greenland volcanism is younger than had previously been assumed and took place at the Palaeocene/Eocene boundary i.e. c. 53 Ma (assuming the validity of the geological time scale for the Lower Tertiary). Secondly there is increasing evidence that the geomagnetic time-scale requires minor revision with an age of c. 53 Ma now preferred for anomaly 24 (Vine 1976). Our statement that volcanism in East Greenland probably correlates with the initiation of spreading remains valid. The only modification to our conclusions is that probably both can now be correlated with the second phase of igneous activity in the British Tertiary c. 53 Ma (rather than the first, c. 59 Ma). Support for these two phases comes from the documentation of tuff bands in the North Sea with similar age (Jacqué and Thouvenin 1975). This in no way invalidates our arguments on regional stresses. Considerable time delays may occur between first adjustment to stress with graben formation and later separation by sea floor spreading. Basalt extrusion need not always correspond with separation.

In summary our review and recent studies have suggested the timing of the Lower Tertiary igneous activity was as follows:

- **c. 59 Ma**: Major phase, British Tertiary: North Sea tuffs: first adjustment to stress field.
- **c. 53 Ma**: Minor phase, British Tertiary: North Sea tuffs: East Greenland volcanism: continental separation.

Our original appraisal was based on a review of published ages and, like all hypotheses, stands or falls on the “fit” of new data. Since then the work of Brown and Mussett (1976), Mitchell et al. (1976), Mussett et al. (1976) and Fitch et al. (1976) has supported our proposed timing and sequence of events. It is not then surprising that, even with this additional knowledge and the benefit of hindsight, Mussett is unable to suggest alternative conclusions. His statement (cf. Mellor and Mussett 1975, p. 318) that our preferred age for the Antrim Basalts fits his own within one million years is
especially encouraging. In his conclusion listing the factors necessary for the critical assessment of radiometric data Mussett reiterates those which have previously been set out (Macintyre 1973, pp. K5-K6).

ADDITIONAL REFERENCES

(not cited in Mussett (1978) or Macintyre et al. (1975)


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R. M. MACINTYRE1,2
T. McMENAMIN1
J. PRESTON3
1Scottish Universities Research and Reactor Centre, East Kilbride G75 OQU.
2Dept. of Applied Geology, University of Strathclyde, Glasgow G1 1XW.
3Dept. of Geology, The Queen's University, Belfast BT7 1NN.