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Recent Advances in Ideas on the Origin of the Igneous Rocks of the Tertiary Igneous Province—Introduction

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THE first five papers of this issue of the *Mineralogical Magazine* have as a common theme Tertiary Igneous Geology. In May 1983 the Society held a thematic meeting on the igneous rocks of the Tertiary Province and from this has followed a collection of papers, grouped here together for convenience. The range of topics covered is broadly based and the papers demonstrate the extent of current research activity in the area.

All readers of the Magazine will be aware of the extent of the contribution made to igneous petrology and geochemistry by work done on the Tertiary Igneous Province. The Tertiary age of the igneous rocks had been recognized from work during the last century by Sir Archibald Geike and Professor J. W. Judd. The international reputation of the igneous rocks was, however, established by the series of classic memoirs published by the Geological Survey. These included Skye (Harker, 1904), small Isles and Rhum (Harker, 1908), Mull (Bailey *et al.*, 1924), Arran (Tyrrell, 1928), and Ardnamurchan (Richey and Thomas, 1930). This 'early' phase of research and publication provided detailed accounts and unravelled the immense complexity of the rocks of the Hebridean igneous centres. Moreover, the interpretations made by the authors of these memoirs provided new concepts on magma genesis and emplacement. Many refinements and developments to the early concepts can be seen in present-day research in the area. The Tertiary Igneous Province has been, and still is, a rich source of new and frequently controversial ideas.

The concept of magma series and magmatic evolution owes much to the work published by

Bailey *et al.*, 1924. The original concepts of Plateau basalts and Non-Porphyrific Central type basalts have been substantially modified. Nevertheless, the alkali and tholeiitic basalt terms (Tilley and Muir, 1962) and the more recent work on the Skye Lava series (Thompson *et al.*, 1972) followed from the earlier work.

The work by Thompson and co-workers has done much to develop and refine ideas on the concept of magma series and 'parental magmas'. The reader is referred particularly to the excellent review of this fundamental aspect of work in the province by Thompson (1982). The data on the basaltic lavas may provide important information on the composition of the upper mantle beneath the igneous centres. However, this will only be true if the critical problem of the extent of crustal contamination of the lavas can be resolved. In recent years this has become one of the more exciting (and controversial) aspects of the research work in the province. Different authors hold entirely opposed points of view and a consensus has yet to emerge. The comment made by Thompson (1982) on the subject, 'a crustal isotopic component was introduced to some but not all, of the magmas', would perhaps best summarize most workers' views. Indeed few authors totally exclude contamination of the basaltic lavas by crustal contamination. Even the most hopeful (i.e. Beckinsale *et al.*, 1978) consider that for the Mull lavas it occurred, but on a sufficiently small scale to enable primary mantle characteristics to be identified. The work by Beckinsale *et al.* suggests major divisions of the Mull lavas into groups I and II, indicating separate mantle-derived chemical characteristics. The

persistence of these groups through the Mull lava pile has been confirmed by more recent unpublished work.

The controversial nature of the province has been seen nowhere more clearly than in the development of new ideas on the origin of the acid rocks. The relative poverty of acid and especially intermediate rocks in the province appears to have only encouraged speculation on the possible mode of formation of evolved rocks. The arguments propounded are well known and have been the subject of reviews, i.e. Open University, 1976. However, the active nature of studies on the granitic rocks is demonstrated by recent changes in our ideas on the origin of the evolved rocks. A few years ago there was a widespread consensus that melting of older crustal material was the predominant mechanism for the formation of the acid magmas in the province. This concept is by no means rejected but the role of magmatic fractionation as an associated and complimentary process is now widely accepted (Moorbath and Welke, 1969, Walsh *et al.*, 1979, and Thompson, 1983).

The role of contamination and of hydrothermal fluids has attracted much attention in recent years. Important papers on zeolite formation (Walker, 1971) and on oxygen isotope studies of igneous rocks (Taylor and Forester, 1971) have used the Tertiary Province for 'case studies'. The complexities of the Mull hydrothermal system in particular are noted by Morrison (1983). The role of meteoric-water hydrothermal systems in modifying the chemistry of the igneous rocks in the province, including isotopic compositions, has been the subject of detailed investigation. In this aspect of research there is now a surprising degree of unanimity of opinion. There is little doubt that migration of hydrothermal fluids can and does have an effect on rock chemistry. However, these effects are often localized, and with careful selection of samples need not place serious restrictions on the interpretation of the analytical data.

The constraints that hydrothermal alteration may, in certain circumstances, place on the interpretation of radiogenic isotopes is demonstrated in the paper by Dickin *et al.* in this volume. Crystal settling and accumulation in igneous masses has also provided a theme for research activity. Many spectacular examples are known worldwide. The chrome-spinel layers in Rhum (described in detail by Brown, 1956) are the subject of one paper in this volume (by I. Young) and work is in progress on other examples in the province (Bevan, 1983).

It is encouraging to see the other perhaps less well known examples of the province receive attention. The published studies have often concentrated on Skye, Mull, etc. but other areas have provided interesting examples of igneous activity. Thus work on the Northern Ireland rocks has now been published, and this volume includes new work on the granites of this area (Meighan *et al.*).

The 'British' Tertiary Igneous Province is in reality a part of the much wider Thulean or North Atlantic Province. The paper by Upton *et al.* on the Mygupta and Kap Broer Rhys complexes in the volume is a welcome reminder of the extent of the Tertiary Igneous Province.

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