Voluminous Acid Volcanism in the Bushveld Complex: A Review of the Rooiberg Felsite

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ABSTRACT

The 2.1 b.y. old Rooiberg Felsite roofs and is intruded by the mafic layered rocks and granites of the Bushveld Complex. The felsite unit, which locally exceeds 5 km in thickness and may represent an originally erupted volume of more than 300,000 km³, is dominated by rhyolitic to dacitic lavas with minor pyroclastic and sedimentary rock types. Volcanic rocks of more mafic composition occur towards the base of the sequence. The Rooiberg episode essentially terminated the volcanic activity in the Transvaal basin and heralded the emplacement of the Bushveld Complex.

Despite the close spatial and temporal relationships between the Rooiberg Felsite and the Bushveld Complex, the precise nature of the petrogenetic link is obscure. Chemical analyses of felsite have been variously interpreted to suggest cyclic differentiation along a co-magmatic trend or to demonstrate anomalous enrichment in SiO₂. Several characteristics delineate the Rooiberg Felsite as a possibly unique occurrence of rhyolitic magmatism, notably the immense volume of the unit, the marked preponderance of lavas over pyroclastic types, and the unusually great thickness and lateral extent of the flows. The thesis that the Rooiberg Felsite represents a shock-produced, meteorite-impact melt cannot be supported on the available evidence.

INTRODUCTION

The term «Rooiberg Felsite» designates the thick sequence of acid volcanic rocks and minor interbedded sediments that roof granites and mafic layered rocks of the Bushveld Complex. The term was originally applied as the «Rooiberg Sedimentary Series» to a sequence of sediments and acid volcanic rocks exposed in the vicinity of the Rooiberg Tin Mine north of Pretoria (HUMPHREY, 1909, p. 117-119). In current usage, the term «Rooiberg Felsite» or «Rooiberg Group» designates only the felsic volcanic rocks in the upper part of the original sequence, whilst the lower quartzizes and shales are now considered to be the upper part of the pre-Bushveld Pretoria Group. Stemming from Humphrey's work, Rooiberg is taken as the type area for the felsites despite the fact that a more detailed characterization was earlier made by MELLOR (1905a, 1905b, 1907) in the better-exposed areas to the southeast. Additional historical and stratigraphic details are furnished by SACS (South African Committee for Stratigraphy, 1980, p. 193-196).

Interlayered volcanic formations (the Ongeluk volcanic rocks, the Machadodorp volcanic rocks, the Dullstroom volcanic rocks) in the Transvaal Sequence preserve a record of a long but discontinuous eruptive history which preceded the emplacement of the Bushveld Complex (HALL, 1932; WILLEMSE, 1964, 1969; SHARPE et al., 1982). The Rooiberg Felsite represents the youngest, most siliceous and most voluminous volcanic phase in this sequence; its extrusion was the final eruptive episode in the Transvaal basin and heralded the emplacement of the
Bushveld Complex. Although contacts are not preserved because of the intruding Bushveld magmas, it has been suggested that the Rooiberg Felsite represents the continuation of the volcanism that produced the Dullstroom Formation, a 1.6 km thick basalt-andesite sequence with felsites developed near the top, which forms the upper part of the Pretoria Group in eastern Transvaal (Sharpe et al., 1982).

Present exposures of the Rooiberg Felsite lie entirely within the limits of the Bushveld Complex (Fig. 1). In most areas, the lower boundary is an intrusive contact against the younger granites and mafic layered rocks of the complex. In two areas, at Rooiberg itself and near Marble Hall, the felsites rest with apparent conformity on older pre-Bushveld quartzites and shales of the upper Pretoria Group. The upper boundary of the Rooiberg is preserved in two areas where it is overlain, apparently conformably, by a sequence of sediments and minor interbedded volcanic rocks, the Loskop Formation in the area of Loskop Dam and the similar Glentig Formation in the Swaershoek Mountains north of Nylstroom. Elsewhere, the Rooiberg is overlain unconformably by conglomerates and quartzites of the Waterberg Group.

The Rooiberg Felsite is thus younger than the Pretoria Group and older than the Bushveld Complex itself. Available radiometric age measurements on these two units suggest an intermediate age for the Rooiberg of about 2,150 m.y. (SACS, 1980, p. 194). Age measurements attempted directly on the Rooiberg have so far given anomalously low ages of 1600-1700 m.y., which are not considered to represent the true age of the unit (F. Walraven, pers. comm.; cf. Lenthall and Hunter, 1977, p. 389).

Upper and lower stratigraphic contacts of the Rooiberg Felsite are nowhere preserved in the same vicinity and therefore thickness measurements should be treated as minima: these range from 3 to more than 5 km (see Von Grünemwaldt, 1968, 1972; Du Plessis, 1976; Clubley-Armstrong, 1977). The original extent of the Rooiberg Felsite can only be estimated: present exposures suggest that the unit covered at least 50,000 km². Moreover, mineral geobarometers in Transvaal Sequence rocks imply a much greater lithostatic pressure than could have resulted from the weight of the Bushveld Complex itself (Hulbert and Sharpe, 1981; Nell, in prep.) and, assuming only a minor component of directed pressure, this implies that the Rooiberg originally roofed the entire complex, a present area of 67,000 km² (Willemsie, 1969). Accordingly, the erupted volume of felsite may have exceeded 300,000 km³. This volume is comparable with that of the mid-Tertiary rhyolite field of western Mexico (Cameron and Hanson, 1982) and indicates that the Rooiberg Felsite is one of the largest provinces of acid volcanic rocks known.

The Rooiberg Felsite is an important unit for several reasons:

1) It represents a major, and as yet little studied, volcanic province. It is possibly the largest accumulation of acid volcanic rocks anywhere in the world.

2) Its emplacement was a major event in the Precambrian history of South Africa.

3) It is closely, but obscurely, linked with the activity that produced the Bushveld Complex (cf. Hunter, 1976; Hunter and Halmton, 1978, p. 121-123). Early workers (e.g. Daly and Molengraaff, 1924; Daly, 1928; Hall, 1932) supposed that the felsites, together with the Bushveld granites, were derived by differentiation of the magma which crystallized to produce the layered mafic suite of the Bushveld Complex. These authors realized that the felsites were the first component of the complex to be emplaced, but believed that they represented eruptions of siliceous magma from the roof of the chamber which were subsequently intruded by the mafic liquids. Willemsie (1964, 1969) regarded the Rooiberg Felsite as the «epicrustal phase» of the complex. The terminology of these earlier workers is not in accord with current lithostratigraphic nomenclature, which defines the Bushveld Complex so as to include only the plutonic rock types (i.e. the layered mafic suite, the younger