Evidence for Late Tertiary Volcanic Activity in the Northern Black Hills, South Dakota

Abstract. *Rhyolitic volcanic rock in the northern Black Hills has a potassium-argon isotopic age of 10.5 ± 1.5 million years. This is considerably younger than any previously reported igneous activity in this or adjacent areas and indicates that the renewed uplift of the Black Hills, which occurred after the Oligocene epoch, was also accompanied by some volcanism.*

Igneous activity in the northern Black Hills has been generally considered to be intrusive in character and of early Tertiary age (*1*, *2*). An exception is a small area of volcanic rock first reported by Darton (*3*) as Mid-Tertiary in age and later described by him as "Quaternary (?)" in age (*1*). I have obtained a whole-rock potassium-argon isotopic age of 10.5 ± 1.5 million years for the volcanic rock, which is significantly younger than the ages reported for the intrusive rocks of the area (*4*). Igneous activity of this age has not been previously reported in the Black Hills or adjacent areas.

The volcanic rocks in question outcrop in an area of approximately 1 km^2 centered around the Tomahawk Lake Country Club, approximately 10 km south of Deadwood, South Dakota. The rocks consist of rhyolite flow breccia, agglomerates, bedded lithic tuffs, and obsidian. The obsidian has been previously reported to be a flow (*3*), but truncated flow lines in the obsidian and the presence of flow breccia underneath and on all sides of the obsidian indicate that it is a xenolith in the flow breccia. The obsidian block is about 8 by 9 m and is about 3 m thick.

A whole-rock potassium-argon isotopic age date was made on the obsidian xenolith because it is the only fresh or unaltered rock in the volcanic sequence. The other rocks show varying degrees of alteration, making dates on them of questionable value. The SiO_2 content of the glass (74 percent), as determined by index of refraction, is similar to that found by a chemical analysis of the enclosing flow breccia (74.6 percent), and the K_2O content of the glass (3.99 percent) is also comparable to that of the flow breccia (3.56 percent). The chemical similarity of the obsidian xenolith and the flow breccia, together with a lack of field evidence indicating more than one episode of volcanism in the area, suggests that the xenolith and the flow were formed within the same time frame; thus the age of the xenolith should reflect the age of the main episode of volcanism.

The isotopic age of the obsidian is 10.5 ± 1.5 million years, based on 3.31 percent K, 31.2 percent and 20.8 percent Ar^{40}, and 0.154×10^{-5} and 0.125×10^{-5} standard cubic centimeters of Ar^{40} per gram, as determined from duplicate analyses performed by Teledyne Isotopes' laboratory. This indicates that volcanism occurred during the Miocene epoch, which is significantly younger than the Eocene igneous activity responsible for the emplacement of the many laccoliths, stocks, and sills in the northern Black Hills area. Ages for the earlier intrusive igneous activity in the Black Hills and Devils Tower area range from 40.5 ± 1.6 to 58.9 ± 1.8 million years (*4*). Clasts from the intrusive rocks occur in Oligocene gravels, indicating that the intrusive activity was probably synchronous with the major uplift of the Black Hills dome. Further uplift occurred later in the Tertiary, after deposition of the Oligocene sediments (*1*), and now the renewed uplift appears to have been accompanied by minor igneous activity. At this time there is no evidence to indicate that other igneous rocks are genetically related to this rhyolite volcanism.

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A Compound Ovary with Open Carpels in Winteraceae (Magnoliales): Evolutionary Implications

Abstract. "Bubbia" perrieri, *a primitive angiosperm collected once in 1909 in northwestern Madagascar, differs from all other members of its genus and family (Winteraceae) in its bicarpellate, unilocular ovary. Moreover, its inflorescences are terminal, and its development is partially sympodial. It therefore represents the survivor of a previously undetected evolutionary line that should be accorded at least subfamilial status. If so, Winteraceae might, more likely than previously, be considered as allied to Canellaceae, a group of primitive angiosperms that has an ovary of* "Bubbia" perrieri *type and is specialized in some other respects.*

There are, in the Paris Herbarium, two parts of a flowering plant discovered in June 1909 by Perrier de la Bâthie on Manongarivo Mountain (northwestern Madagascar), at an altitude of about 1700 m and never recollected. The taxon *"Bubbia" perrieri* was validly described from this material by Capuron in 1963 (*1*), who noted two characteristics which, associated with the geographical distribution, might have been considered important enough to justify the creation of a new genus: (i) the kind of inflorescence, the principal axis of which is elongated and irregularly branched; and (ii) the two-lobed stigma. Notwithstanding these features, Capuron placed it in the otherwise entirely Australasian genus *Bubbia* and in the very primitive family Winteraceae, of which it is the only representative in either Africa or Madagascar.

More than half a century elapsed between the discovery of *"Bubbia" perrieri* and its formal publication. In recent years, several authors have studied this plant (*2*), but we are far from a full morphological understanding of it. Baranova, followed by Bongers, was able to affirm, from cuticular characters alone, that the placement of *"Bubbia" perrieri* in *Bubbia* is doubtful. As pointed out by Bongers, *"B." perrieri* and *Drimys* sect. *Tasmannia* occupy isolated positions in the Winteraceae. My own analysis of the herbarium material provides a more complete understanding of the nature of its inflorescence and gynoecium. In particular, it confirms the need for establishing a new genus (*3*).

Stebbins (*4*), following Parkin (*5*), Rickett (*6*), and Nast (*7*), writes of Winteraceae that "their inflorescences are always axillary, and are produced by specialized reproductive shoots." He adds, "Compared with other primitive angiosperms, the flowers of the Winteraceae show a certain amount of reduction, particularly the crowding of the stamens and the small number of carpels. . . . Consequently, one cannot exclude the possibility that the ancestors of the Winteraceae had leafy cymes" (*4*). The evidence drawn from my analysis of *"Bubbia" perrieri* does not support this view. In this species, the inflorescence is undoubtedly terminal, and consequently,