GEOCHRONOLOGY OF THE SOUTHERN WISCONSIN RHYOLITES AND GRANITES

by

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INTRODUCTION

The rhyolitic and granitic rocks of southern Wisconsin comprise the southern-most exposures of Middle Precambrian igneous rocks in the Great Lakes area (Goldich and others, 1966). These rocks consist predominantly of rhyolitic volcanic rocks and granophyric granites (Smith, 1978) and as such are generally quite different from the volcanic and plutonic rocks of the Penokean complex in central and northern Wisconsin (Van Schmus and others, 1975). Instead, the southern Wisconsin rocks may represent the northern edge of a more extensive granite-rhyolite terrane present in the subsurface of the midcontinent region (Lidiak and others, 1966). Consequently, it is important to understand the age, tectonic setting, and petrogenesis of this key rock suite.

This report summarizes recent results obtained on the age of this suite of rocks. It is based largely on material contained in a more comprehensive study of the ages of Middle Precambrian rocks in Wisconsin (Van Schmus, in prep.). Sample numbers referred to below are from that report; detailed locations, analytical details, and analytical data on these and several related samples will be included there, and only the data for the southern Wisconsin suite proper are repeated here. All ages reported here are based on the decay constants recently recommended for international adoption (Steiger and 1977): λ (Rb-87) = 1.42×10^{-11} yr^{-1}; λ(U-235) = 9.85×10^{-10} yr^{-1}; and λ(U-238) = 1.551×10^{-10} yr^{-1}.

EARLIER RESULTS

Rb-Sr analyses on metavolcanic and granitic rocks from southern Wisconsin have been reported previously by Bass (1959), Goldich and others (1966), Dott and Dalziel (1972), and Van Schmus and others (1975). Reported ages on individual samples ranged from 1420 m.y. to 1725 m.y. This spread in ages was mainly due to two factors: (a) Goldich and others (1966) used a 47 m.y. half-life for Rb-87 while most other reports used a 50 m.y. half-life (the newly recommended value of the decay constant corresponds to a half-life of 48.8 m.y.), and (b) most of the samples have undergone variable losses of radiogenic Sr-87. Geologically, the second reason is more important. Furthermore, Van Schmus and others (1975) showed that these losses were systematic, such that results from the Fox River Valley rhyolites yielded an excellent isochron with an apparent age of 1630 ± 40 m.y. (Fig. 1).

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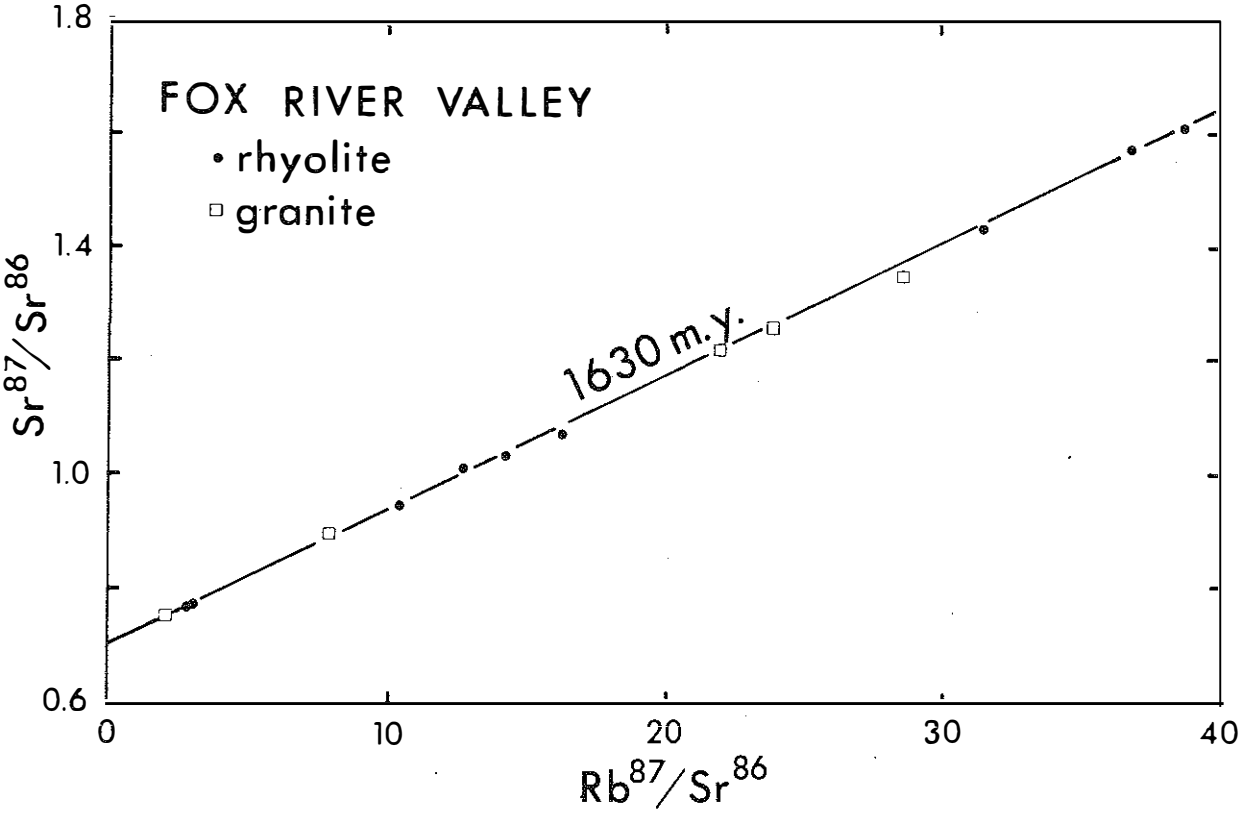

Figure 1. Rb-Sr diagram showing data obtained from granite and rhyolite of the Fox River Valley (Van Schmus and others, 1975). The isochron shown is that defined by the rhyolite alone and yields an apparent age of 1630 ± 40 m.y. with initial Sr-87/Sr-86 = 0.7046 ± 0.0043. The U-Pb age for these rocks is 1760 ± 10 m.y. (see text).

ZIRCON U-PB RESULTS

Zircons have been separated from three rhyolite samples and one granite sample: rhyolite from the Noble quarry near Marquette (sample 1, Table 1 and Figs. 2 and 3), rhyolite from the quarry at Utley (sample 2), rhyolite from Observatory Hill (sample 3), and granite from the quarry in Montello (sample 3). Details on the geology of these localities may be found in the report by Smith (1978) and references therein. All the rhyolite samples contain abundant quartz phenocrysts, a key indicator to the presence of separable zircons in rhyolite. The zircon populations from all samples consist of clear, euhedral crystals having sharp crystal face boundaries and no sign of alteration or relict cores. Ages derived from these samples will therefore represent primary crystallization ages and, hence, the virtual time of extrusion of the rhyolites or emplacement of the granite.

The U-Pb data from the individual zircon fractions (Table 1) define an excellent chord on a U-Pb diagram (Fig. 2). A least squares fit to the data yields an intersection with concordia of 1760 ± 10 m.y. (95% C.L.), which is taken as the crystallization age of the zircon suite and, thus, the true age of the rocks.

Table 1. Analytical data on separated zircon fractions

Sample No.	Zircon Frac.*	Concentrations U(ppm)	Pb(ppm)	Measured Pb Isotope Ratios# 204/206	207/206	208/206	Measured U/Pb, Pb/Pb Ratios& 206/238	207/235	207/206
1	total	847	274	0.00217	0.1360	0.1834	0.2748	4.031	0.1064
2	A	469	158	0.00215	0.1368	0.1824	0.2854	4.228	0.1075
3	A	471	137	0.00198	0.1333	0.1991	0.2445	3.583	0.1063
	B	758	199	0.00330	0.1495	0.2357	0.2081	2.996	0.1044
19	A	352	112	0.00063	0.1159	0.1258	0.2945	4.357	0.1073
	B1	386	127	0.00149	0.1271	0.1581	0.2900	4.357	0.1073
	C	484	151	0.00110	0.1223	0.1531	0.2795	4.135	0.1073

* A = least magnetic fraction; B,C = more magnetic fractions; B1 denotes 100-200 mesh sieve fraction for respective magnetic split.

Corrected for analytical blank. & Corrected for non-radiogenic Pb.

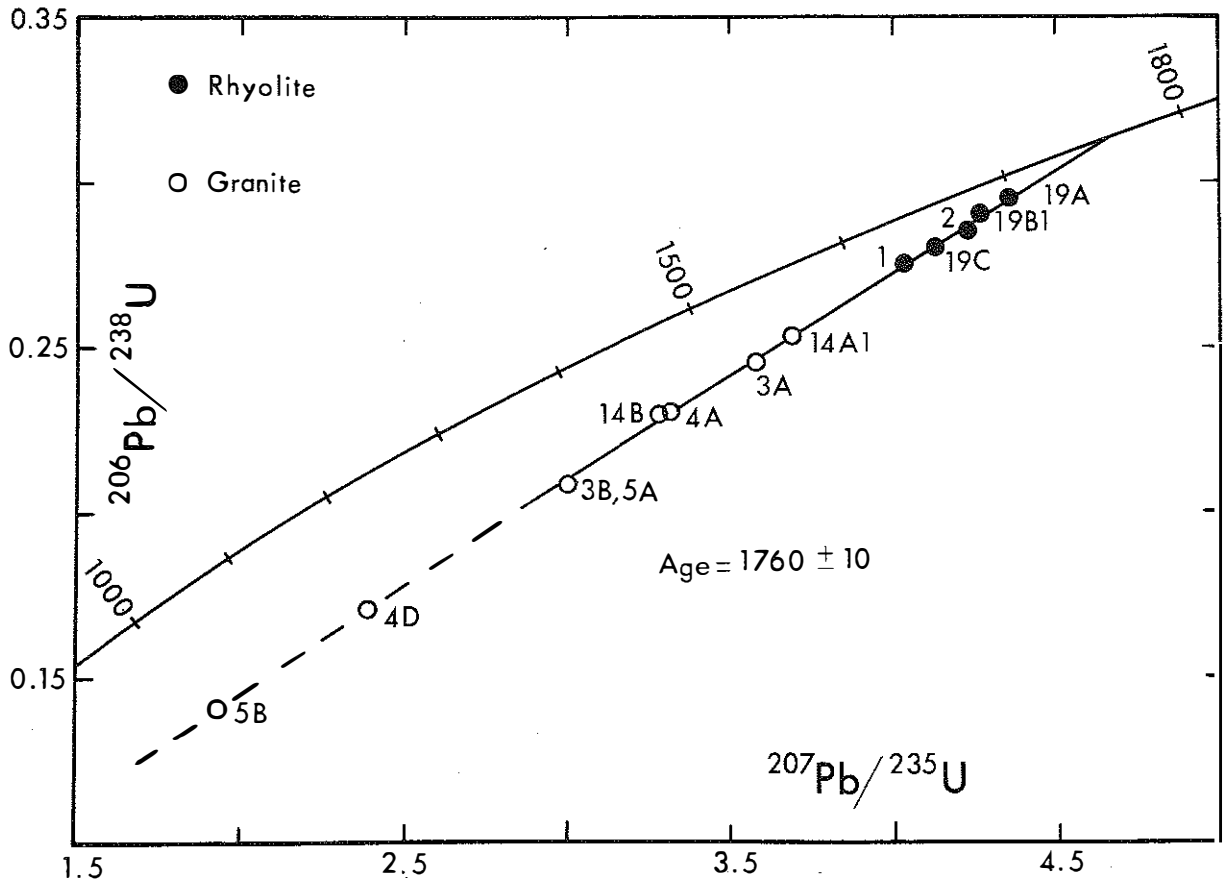

Figure 2. U-Pb plot of zircons from the rhyolite-granite suite of southern Wisconsin (samples 1, 2, 3, and 19; Table 1) and other apparently coeval plutonic rocks from northern Wisconsin (samples 4, 5, 14; Van Schmus, in prep.). The chord defined by data from the rhyolite and related granophyric granite intersects concordia at 1760 ± 10 m.y. (least squares fit at 95% C.L.).

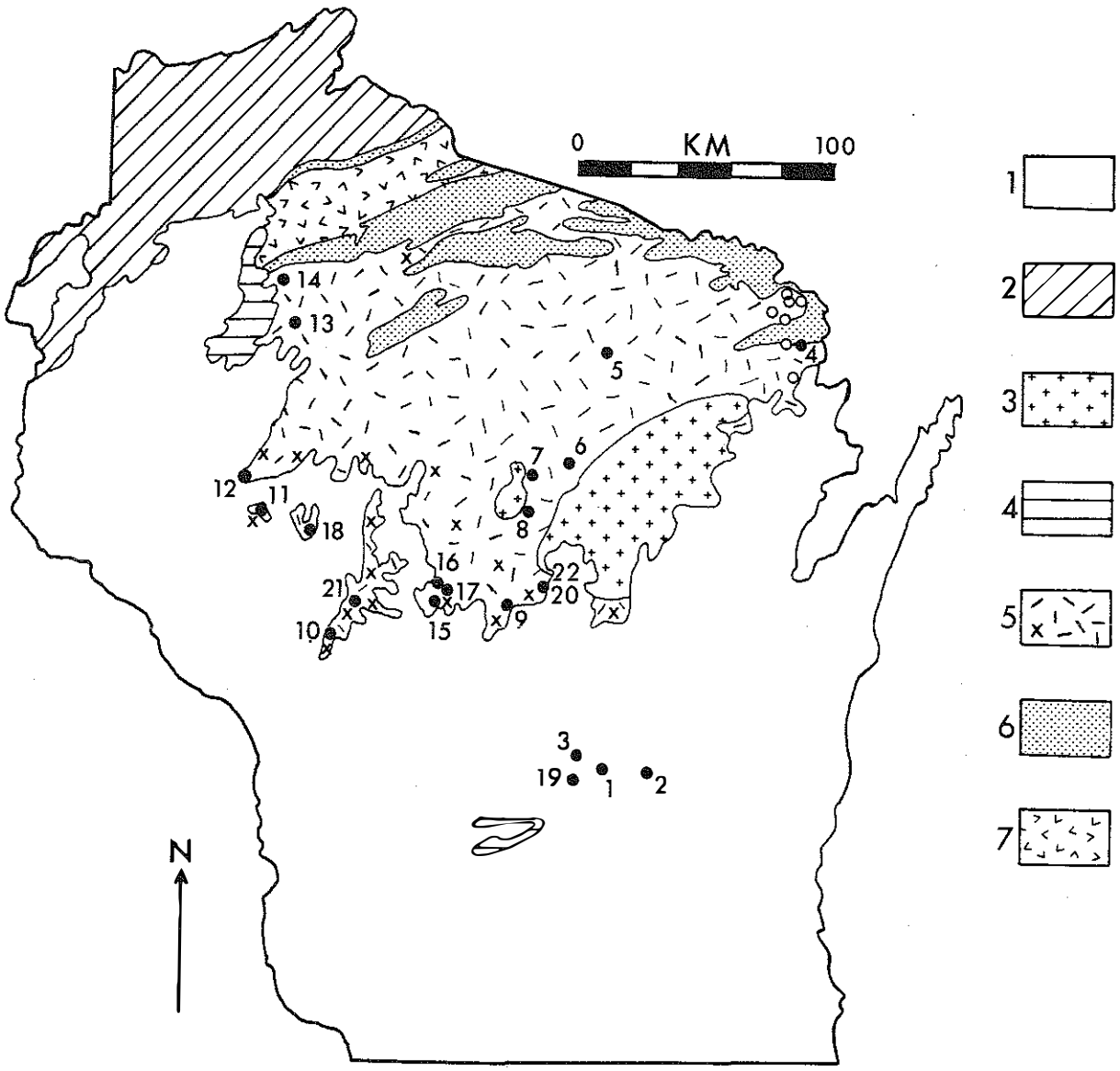

Figure 3. Generalized geologic map of Wisconsin showing major Precambrian terranes and distribution of units for which U-Pb analyses on separated zircons are available. From Van Schmus (in prep.). Unit 1, undifferentiated Paleozoic and younger rocks; Unit 2, Keweenawan igneous and sedimentary rocks; Unit 3, Wolf River Batholith; Unit 4, Baraboo and Barron Quartzites; Unit 5, undifferentiated igneous and metamorphic rocks, contains Penokean plutonic complexes, remnants of middle Precambrian metavolcanic and metasedimentary rocks, and remnants or windows of Archean gneiss and migmatite (denoted by 'x' where known); Unit 6, Middle Precambrian metavolcanic and metasedimentary rocks ca. 1850-1950 m.y. old; Unit 7, Archean basement rocks. Numbered dots are sample localities and numbers from Van Schmus (in prep.).

Several granitic plutons from northern Wisconsin contain zircons that yield U-Pb data which also fall on the chord defined by the southern Wisconsin rhyolite and granite samples (Van Schmus, in prep.; Fig. 2). These units are therefore essentially the same age, as, but petrographically distinct from the southern Wisconsin rocks. The northern Wisconsin units concerned are the Amberg Quartz Monzonite (Van Schmus and others, 1975; sample 4 on Fig. 3), granite south of Monico (Van Schmus and others, 1975; sample 5 on Fig. 3), and porphyritic granite from Radisson (sample 14 on Fig. 3). The relationship of these units to the southern Wisconsin rocks in terms of regional petrogenesis remains to be worked out, but one possible explanation is that they represent the deeper-seated counterparts of the rhyolite and granite to the south, and that the 1760 m.y. old igneous activity may have occurred throughout the Penokean complex in Wisconsin.

DISCUSSION

The problem of the Rb-Sr versus the U-Pb age in general for volcanic rocks has been discussed elsewhere (Van Schmus and others, 1975; Van Schmus, 1976; Bickford and Mose, 1975). The principal question here is whether the 1630 m.y. Rb-Sr age obtained from a large variety of rocks in the southern Lake Superior region, including the southern Wisconsin suite, has geological significance. At present there is no clear-cut answer, but my prejudice is that the age represents a definite event such as (a) a distinct post-volcanic (and post-quartzite) deformational and metamorphic event, or (b) sudden epirogenic uplift of the region. I believe it represents a distinct event because of the well defined isochron formed by the data and other well-defined 1630 m.y. systematics for Rb-Sr systems throughout the Lake Superior area (see Van Schmus, 1976) in contrast to the case in other regions where disturbed Rb-Sr systems do not yield coherent isochrons (for example Bickford and Mose, 1975). The fact that most of the rhyolites, including the overlying quartzite, are tectonically deformed (Dott and Dalziel, 1972; Smith, 1978) would tend to indicate that the 1630 m.y. age is associated with a distinct tectonic event.

At present the full regional significance of either the 1760 m.y. primary age or the 1630 m.y. metamorphic age for these rocks is unclear. There is insufficient geologic information from adjacent terranes, particularly to the south and west, to determine whether either age is related to a major crustal event (orogenic belt) or whether it is a more local phenomenon. Continued research in these areas over the next decade will hopefully clarify many of these questions.

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