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AGE OF THE BOULDER BATHOLITH AND OTHER BATHOLITHS OF WESTERN MONTANA*

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By Randolph W. Chapman, David Gottfried,

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ABSTRACT

New data are presented on the age of the Boulder, Philipsburg, and Idaho batholiths of western Montana. These were obtained by measuring the lead-alpha activity ratios of zircon and monazite from selected rocks. The Boulder batholith has been found to be about 68 million years old, and it is thought that it was probably emplaced near the close of the Cretaceous. From the data obtained, the Philipsburg batholith has an age of about 50 million years, and the gneissoid quartz monzonite from the eastern border zone of the Idaho batholith has an average age of 52.5 million years. Judging from this evidence, the Philipsburg batholith and the gneissoid quartz monzonite from the Idaho batholith are younger than the Boulder batholith. As an age of 100 million years has been obtained for several other rocks from the Idaho batholith, this great pluton seems to contain intrusions of different ages.

INTRODUCTION

It is the purpose of this paper to present some new age data which have recently been obtained on rocks from the batholithic bodies in western Montana. The Boulder batholith, a large composite intrusion composed mainly of quartz monzonite, is on the Continental Divide and covers an area of about 1,200 square miles. The Philipsburg batholith is a much smaller and simpler intrusion of quartz monzonite about 50 miles west of the center of the Boulder batholith. The Idaho batholith is a huge composite body of granitic rocks, the eastern edge of which is about 100 miles west of the center of the Boulder batholith. Most of the age data presented here were obtained from rocks of the Boulder batholith and the age of this body is now clearly evident. The data from the Philipsburg and Idaho batholiths suggest certain time relationships between these bodies and the Boulder batholith, but more information is needed before positive conclusions can be drawn.

This study is part of a program undertaken by the U. S. Geological Survey on behalf of the Division of Research of the Atomic Energy Commission.

The writers are indebted to several individuals for their assistance. Montis R. Klepper supplied much of the geologic information used in dating the Boulder batholith. George H. Hayfield helped to separate the minerals of the rocks and to concentrate and purify the radioactive zircon and monazite. Esper S. Larsen, Jr., Howard W. Jaffe, Lorin R. Stieff, and Thomas W. Stern offered valuable assistance and advice.

NATURE AND HISTORY OF THE BOULDER BATHOLITH

The Boulder batholith is a composite pluton consisting of numerous intrusions of different composition and texture, such as quartz diorite, granodiorite, quartz monzonite, granite, alaskite, aplite, and pegmatite; quartz monzonite is by far the most abundant rock type. The relative ages of all these types have not been determined, but it is known that the alaskite, aplite, and pegmatite are younger than the others because they occur as dikes in them.

The role of the Boulder batholith in the geologic history of western Montana is fairly clear. In Late Cretaceous time a thick series of andesitic pyroclastics and flows was extruded over a wide area. Plant remains of probable Judith River age (Roland Brown, personal communication), that is just slightly older than middle Upper Cretaceous, have been found in pyroclastic beds high in this thick series. Near the close of the Cretaceous the pyroclastics and flows were folded and faulted by the deformation (Laramide) which affected the Rocky Mountains area. Following this, either in very Late Cretaceous (Knopf, 1913, p. 34) or very early Tertiary time, the plutonic rocks of the Boulder batholith moved into place by one or more processes of unknown nature. These plutonic rocks intruded volcanics and older rocks which were extensively contact metamorphosed. Considerable time then elapsed after which a variety of fairly siliceous volcanics were extruded. The oldest of these are basal tuffs with early Oligocene fossils which rest with marked unconformity on the eroded plutonic rocks of the batholith. In part contemporaneous with these tuffs and in part somewhat later, perhaps in Oligocene or Miocene time, flows and tuffs of trachyte, rhyolite, and dacite were extruded onto a topography that had been cut on the batholith, most probably during Eocene time.

From the above stratigraphic and structural relations, it can be concluded that the Boulder batholith is later than middle Upper Cretaceous and earlier than Oligocene.

METHOD OF AGE DETERMINATION

The method described by Larsen et al. (1952) was used to determine the age of the rocks from the three batholiths considered here. This method is based on lead-alpha activity ratios in suitably radioactive accessory minerals, principally zircon and monazite. In both zircon and monazite the lead present is believed to be essentially radiogenic. This has been convincingly borne out by geologic evidence and, where possible, by comparison with isotopically determined ages (unpublished data).

The alpha activity was first determined for each radioactive accessory by a thick-source alpha-counting technique, and the lead content was then measured by a spectrographic method developed by Waring and Worthing (1953). The accuracy of the alpha activity measurements is believed to be $\pm$ 5 percent and the accuracy of the lead analyses ranges from 6 to 10 percent.

PREPARATION AND PROCESSING OF SAMPLES

The several rock types used in this study were collected in the field by Randolph W. Chapman and processed as follows: 50-lb samples of each were crushed and sized, and the radioactive accessories were concentrated and purified by heavy liquids, the Frantz isodynamic magnetic separator, and by hand-picking. David Gottfried then made an alpha count of each purified concentrate, and Claude L. Waring determined the amount of lead in each concentrate by means of the spectrograph. The age of each mineral was then calculated from the lead-alpha activity ratio. The results are shown in table 1.

Table 1.--Age determinations on minerals from Boulder, Philipsburg, and Idaho batholiths, Mont.

Number 1/	Rock	Mineral	Counts in α/mg/hr	Lead (ppm)	Age (MY)
		Boulder batholith			
52-C-45-Z	Quartz monzonite	Zircon	227	8	69
52-C-60-Z	Quartz monzonite	Zircon	203	6	71
52-C-10a-Z	Quartz monzonite	Zircon	160	4.6	69
52-C-8-Z	Alaskite	Zircon	4990	127	61
52-C-8-M	Alaskite	Monazite	6545	231	72
		Philipsburg batholith			
53-C-198-Z	Quartz monzonite	Zircon	858	18	50
		Idaho batholith			
53-C-210-Z	Quartz monzonite	Zircon	275	6.2	54
53-C-210-M	Quartz monzonite	Monazite	3123	79	51

1/ Below are the rocks from which the minerals were separated:

52-C-45 Medium-grained, porphyritic, hornblende-biotite quartz monzonite with large phenocrysts of pink potash feldspar, from the quarry 1 1/2 miles west of Boulder, Mont.

52-C-60 Medium- to fine-grained hornblende-biotite quartz monzonite with more ferromagnesian minerals than in 52-C-45, from a road cut about 3 miles northeast of Elk Park, Mont.

52-C-10a Medium-grained quartz monzonite with about 30 percent biotite and hornblende, from near the border of the batholith about 7 miles southeast of Helena, Mont.

52-C-8 Medium-grained alaskite from half a mile southwest of the summit of Elkhorn Peak, Mont.

53-C-198 Medium-grained biotite-hornblende quartz monzonite from the Philipsburg batholith, 1 mile east of Philipsburg, Mont.

53-C-210 Medium-grained white, gneissoid quartz monzonite from the border zone of the Idaho batholith in Lost Horse Creek, Bitterroot Mountains, Mont.

AGE RELATIONSHIPS OF THE BATHOLITHS

The five age results obtained for the Boulder batholith give an average age of 68 million years and suggest that it was emplaced at or near the close of the Cretaceous. All five determinations fall within $\pm$ 10 percent of the average, a very close conformance for rocks so young. However, as the results are all within the limit of error of the lead-alpha activity method, no conclusions can be drawn as to the relative ages of the five rock types studied here.

The age of 50 million years determined for the Philipsburg batholith suggests that this pluton is somewhat younger than the Boulder batholith. However, final conclusions cannot be drawn without more data.

The rock from the Idaho batholith yielded both zircon and monazite which gave ages of 54 and 51 million years, respectively, a remarkably close agreement for two minerals with such different lead contents. The average of these is 52.5 million years. Another determination, previously made by Howard W. Jaffe, on a monazite from the same rock type from farther west along Lost Horse Creek, gave a value of 72 million years, which when averaged with those shown above, gives an average age of 59 million years for the white, gneissoid quartz monzonite of the Idaho batholith. This rock, therefore, seems to be at least as young as, if not somewhat younger, than those of the Boulder batholith.

Age determinations previously made on certain other rocks from the Idaho batholith give an average age of 100 million years (unpublished data by Larsen, Gottfried, and Jaffe), so that the bulk of this enormous body is probably Middle Cretaceous. However, the relatively young age of the gneissoid quartz monzonite from Lost Horse Creek indicates that a part of the rocks of the batholith is very Late Cretaceous or even early Tertiary in age.

SIGNIFICANCE OF THE DATA

It is significant that the age of the zircon containing 4.6 ppm lead (52-C-10a-Z) is in close agreement with that of the zircon containing 127 ppm lead (52-C-8-Z). The introduction of only 1 ppm of foreign lead into the concentrate containing the smaller quantity of total lead would give an age of 84 million years, or an error of approximately 22 percent. This indicates that the presence of original lead in the sample is negligible; otherwise a considerably older age would have been obtained. Monazite is known to contain small amounts of original lead, approximately 1 to 3 percent of the total lead. In the monazite sample containing 231 ppm of lead (52-C-8-M), the effect of original lead is negligible. The very close agreement of the monazite and zircon ages in one case and the rather close agreement in the other serve to indicate the reliability of age determinations of monazite by this method. Monazite determinations seem particularly suitable for rocks containing zircon which has less than 10 ppm lead and has an alpha activity of less than 100 α/mg/hr.

A worth while analogy can be drawn between the Boulder batholith and the pitchblende deposits of the Colorado Front Range. The pitchblende deposits are believed to have formed during the Laramide orogeny. Although generally assigned to the end of the Cretaceous, many geologists believe that these deposits may be late Paleocene in age (Holmes, 1947, p. 140). On the basis of isotopically corrected lead and uranium ratios, Holmes (1947) has assigned an age of 58 million years to these deposits. The results obtained by the lead-alpha activity method on zircon and monazite from these batholiths show close agreement with age determinations by the lead-uranium method on bodies of about the same geologic age.

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