Age of Allanite from Kabbaldurga Quarry, Karnataka

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Abstract

Allanite from a pegmatitic veinlet cutting an amphibolite lens in Peninsular gneiss at Kabbaldurga Quarry yields the following ages (in million of years): $^{207}Pb/^{235}U$ – 2507, $^{206}Pb/^{238}U$ – 2520, and $^{208}Pb/Th$ – 2887. The U-Pb ages date the high-grade metamorphism and emplacement of the Closepet granite at Kabbaldurga at close to 2500 million years ago.

Kabbaldurga is the classic exposure of the transition between the charnockitic and noncharnockitic rocks in the Precambrian shield of South India. Pichamuthu (1960) was the first to propose that the dark colored patches of orthopyroxene-bearing gneiss had formed by charnockitization of migmatitic Peninsular gneiss, while other investigators (e.g., Ray, 1972) have suggested that the Peninsular gneiss developed by retrogression of charnockite. Janardhan *et al* (1982) have studied the charnockitization process at Kabbaldurga in detail and related it to large scale CO_2 metasomatism.

Kabbaldurga Quarry, which is located about 50 km south-southwest of Bangalore, is an exposure of migmatitic Peninsular gneiss that has been extensively intruded by granite and pegmatite belonging to the Closepet granite (Pichamuthu, 1960; Friend, 1981; Janardhan *et al* 1982). The gneiss and granite have been locally converted to a charnockitic rock, dark in color, that appears as diffuse, nebulitic masses and stringers on the outcrop surface. This quarry has been the site for several geochronological investigations, including Rb-Sr studies (Venkatasubramanian and coworkers) and a detailed survey of zircon U-Pb ages now in progress, of which a preliminary account has been published (Buhl *et al* 1983). Venkatasubramanian *et al* (1971) report a Rb-Sr age of 1350 million years (m.y.) on biotite from gneiss associated with charnockite and a 1840 m.y. age on biotite from granite porphyry from the Closepet suite. Venkatasubramanian (1975) and Venkatasubramanian and Narayanaswamy (1974) obtained an isochron age of 2670 ± 60 m.y. on a suite of five charnockitic, granitic, and gneissic rocks, including three samples from Kabbaldurga, and Rb-Sr ages of 1320 and 1880 m.y. on biotite separated from two of the Kabbaldurga samples. These biotite separates appear to be the same as those reported in the 1971 paper, but reanalysed for ^{87}Rb. Buhl *et al* (1983) report three U-Pb ages based on the upper intercept with concordia of chords defined by zircon fractions: charnockite – 2844 m.y., gneiss – 2515 m.y., and pink granite – 2535 m.y. Two zircon fractions from the granite lie on the chord defined by the charnockitic fractions.

In January, 1981, the first author was guided to the Kabbaldurga Quarry by S. M. Naqvi and A. S. Janardhan, at which time he collected the allanite analysed in the present study. The sampled allanite occurs in a discordant pegmatitic veinlet a few centimeters thick cutting a lens of amphibolite in the gneiss. Maximum grain size in the veinlet is about 1 cm. The veinlet which has a diffuse contact with the host amphibolite, consists of quartz, plagioclase, magnetite, subordinate perthitic

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K-feldspar, and biotite, and traces of hornblende, zircon, allanite, tourmaline and pyrite. Allanite is metamict, largely isotropic and brown in thin section; identification was confirmed with an element scan on the electron microprobe. The amphibolite consists of hornblende (pleochroic in olive and brownish green), plagioclase, and subordinate biotite, quartz, and K-feldspar, accessory apatite, opaque and an optically active brown mineral tentatively identified as non-metamict allanite. Secondary calcite is present sparingly in the amphibolite and plagioclase in both rocks has been slightly sericitized. Some of the biotite in the amphibolite appears to be replacing hornblende. Mild cataclastic deformation of the veinlet is indicated by suturing of quartz grain boundaries and bending of some plagioclase twin lamellae and biotite flakes. The mineralogy and contact relations of the veinlet suggest it was most likely derived from the host amphibolite during metamorphism, possibly as a result of local remobilization.

The veinlet allanite was analysed for isotopes of U, Th, and Pb (Table I). The calculated $^{207}Pb/^{235}U$, $^{206}Pb/^{238}U$, and $^{208}Pb/Th$ ages are 2507, 2520, and 2887 m.y., respectively. The concordance of the U-Pb ages suggests that the U-Pb system was not affected by the event that reset Rb-Sr ages in biotite to the 1320 and 1880 m.y. values reported by Venkatasubramanian and his coworkers. The discordant Th-Pb age may be due to thorium loss during this event. We do not believe the higher thorium age dates an event prior to 2500 m.y., such as that recorded by Buhl *et al*'s (1983) charnockite zircons.

TABLE I. Uranium, thorium, and lead contents and isotopic ratios of lead of allanite (#3033A) from Kabbaldurga Quarry.

U	Th	Pb	$^{206}Pb/^{204}Pb$	$^{208}Pb/^{207}Pb$	$^{208}Pb/^{206}Pb$	$^{207}Pb^*/^{235}U$	$^{206}Pb^*/^{238}U$	$^{208}Pb^*/Th$
Parts per million								
135.7	11982	1720	549.5	5.354	28.60	10 81	0.4783	0.1535

* Common Pb assumed 2500 m.y.

Our allanite U-Pb data are in excellent agreement with the U-Pb ages near 2500 m.y. on zircon fractions from pink granite and amphibolite-bearing gneiss obtained by Buhl *et al* (1983). These authors suggested that a thermal event reset the U-Pb isotopic system in the granite and gneiss zircons 2500 m.y. ago and that some zircons may have grown at this time. As our allanite data contain no firm evidence for an event prior to 2500 m.y., we suggest that the allanite 2500 m.y. age dates the crystallization of the allanite, and thus emplacement of the veinlet and recrystallization of the amphibolite. Moreover, the 2500 m.y. age may also date the development of the Closepet granite at Kabbaldurga by partial melting of Peninsular gneiss. In the gneiss and granite sampled by Buhl *et al* (1983), the preponderant zircon growth may have occurred during the 2500 m.y. event, for only two of the ten zircon fractions from these two rocks appear to have an older component. The 2500 m.y. age may also be the age of incipient charnockitization at Kabbaldurga, for Friend (1981) interpreted the charnockitization and partial melting as penecontemporaneous processes. Although the U-Pb data obtained from zircon fractions from a charnockite show no evidence of the 2500 m.y. event, Buhl *et al* (1983) suggested that the CO_2-rich, H_2O-poor fluid present in the charnockite may have protected these

zircons from lead loss. Moreover, the 2500 m.y. event apparently did not completely redistribute Rb and Sr isotopes over the scale of whole rock samples, for Rb-Sr isochrons record older events (*Venkatasubramanian, 1975; Venkatasubramanian* and Narayanaswamy, 1974).

The 2500 m.y. event at Kabbaldurga is of particular interest in understanding the evolution of Precambrian crystalline terrains in Gondwanaland. A 2500 m.y. old episide, which involved high-grade metamorphism, deformation and charnockitic pegmatitic activity has also been recognised in the Archean Napier complex of Enderby Land, Antarctica (Grew and Manton, 1979; De Paolo *et al* 1982). Enderby Land is interpreted by most workers (*e.g.* Barron *et al* 1978) to have been contiguous to South India prior to Gondwanaland break up.

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