Radiogenic heat production, geochemistry and fluid inclusion studies on granulites and associated granitoids around Angul, Eastern Ghats Belt, India

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by

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Abstract

Migration of granitic melts generated during granulite facies metamorphism leaves behind a residual crust that should be depleted in incompatible elements, including the major crustal heat producing elements (HPE) K, U and Th. Accordingly, many granulite terranes have low heat production, but some, such as the Eastern Ghats Province of India, are characterized by abnormally high heat production. The lithologies, the major HPEs and the HPE-bearing mineral phases in this terrane remain unknown. In this study, a structurally and metamorphically well characterized area around Angul in the northern part of the province, containing almost all the dominant lithologies, was selected for radiometric heat production studies. The area is dominated by khondalites and quartzofeldspathic gneisses (QFG) that have been affected by five phases of deformation, with granulite metamorphism accompanying and outlasting D_1 and D_2. Felsic intrusives, including the charnockite suite of rocks and augen gneisses, intruded and crystallized through D_1 and D_2. A generation of late granitic melts including aplites, coarse biotite-bearing granitoids, graphic granites and pegmatites intruded during the D_4 deformation under amphibolite facies conditions. Gamma ray spectrometry reveals that thorium is the main HPE in these rocks, with khondalites and augen gneisses having high heat production and the QFG being uniformly low heat producing, whereas, in the charnockite suite, heat production varies from very low to very high values. Importantly, the syn-D_4 granitoids have abnormally low Th values and heat production. These results are also reflected in concentrations of other incompatible elements that are enriched in the khondalites and augen gneisses, anomalously enriched in some charnockites, and uniformly depleted in the later granitoids. Since ΣREE values show excellent correlation with Th, monazite is inferred to be the main HPE bearing phase. The presence of monazites with significant ThO_2 content is confirmed in all the analyzed high heat producing samples. While the higher monazite concentration in the khondalites is attributed either to disequilibrium melting or peritectic formation of monazite during partial melting, its presence in the charnockites and augen gneisses reflects entrainment of the peritectic or restitic monazite in the migrating melt. Petrogenetic modeling indicates that the abnormally low values of HPE, other LILE and REE, and the extremely hydrous nature of the later granitoids cannot be explained if they were derived by partial melting of the khondalites, charnockites and QFG. Fluid inclusion studies indicate that fluid exsolved from syn-D_4 hydrous melts acquired higher salinities (chloride content) at lower pressure - temperature conditions. Such fluid could have preferentially scavenged U, leading to the high Th / U ratios observed in all the rocks. A relatively hydrous crust, containing either peritectic or unmelted detrital monazite, is speculated to underlie the exposed granulites; these may be the possible source for the later hydrous granitoid suite.

Keywords:

(Eastern Ghats Belt; heat producing elements; rare earth elements; fluid inclusions; monazite)