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Thorium-rich zircons in granitoids of the Ladakh Batholith, Indus–Tsangpo Suture Zone, Ladakh, India

In northern India, the Ladakh batholith is an important geologic entity, located between two major tectonic suture zones – the Shyok to the north and the Indus–Tsangpo to the south. These sutures mark the closing of different branches of the Tethys Ocean and finally the collision of India with Asia at 60–50 Ma. The former represents a collisional boundary between the Karakoram block and the Kohistan–Ladakh–Gangdese island arc, and the latter represents the main boundary zone between the Indian and Asian plates. The Ladakh batholith is part of the Andean-type Trans Himalayan Plutonic Belt that extends for 2500 km from Afghanistan in the west, to east of Lhasa in Tibet[1]. It is composed of multiple calc-alkaline intrusions that vary in composition from olivine–norite and gabbro to granite[1]. The batholith trends roughly WNW–ESE and is approximately 600 km long and 30–50 km wide. The crystallization ages of the batholith[2,3] range from 102 to 65–49 Ma, suggesting that magmatism was contemporaneous with the Gandese batholith (southern Tibet) and that magmatic activity ceased with the collision of India and Asia[1,2]. The geological structure of the Indus and Shyok suture zones has been discussed elsewhere[4,5].

Recently, Ladakh granitoid samples were collected from several localities in the Ladakh area, including Chang La, Daah-Hanu and Hunder, and were processed to obtain U–Pb geochoronological data on zircons separated from them. Preliminary studies reveal that the granitoids at Chang La, Daah-Hanu and Hunder contain abun-

Table 1. U and Th contents (in ppm) of zircons in granitoids of the Ladakh batholith. Samples were analysed by TIMS at Isotope Laboratory of the University of Tuebingen, Germany under the aegis of the Alexander von Humboldt Fellowship

Sample no.	Location	Sample weight (separated zircon in mg)	Uranium (ppm)	Thorium (ppm)
1(i)	Daah-Hanu granitoid	0.024	993	6115
(ii)	Daah-Hanu granitoid	0.0339	1182	4329
(iii)	Daah-Hanu granitoid	0.0354	889.2	4146
(iv)	Daah-Hanu granitoid	0.0159	1346.2	9231
2(i)	Daah-Hanu granitoid	0.241	64	6090
(ii)	Daah-Hanu granitoid	0.0158	262	9289
(iii)	Daah-Hanu granitoid	0.0269	139	5456
(iv)	Daah-Hanu granitoid	0.244	152	6015
3(i)	Hunder granitoid	0.0293	738	5009
(ii)	Hunder granitoid	0.0122	706	12,030
(iii)	Hunder granitoid	0.0079	393	18,900
(iv)	Hunder granitoid	0.016	544	9173
4(i)	Chang La granitoid	0.017	313	8634
(ii)	Chang La granitoid	0.012	380	12,230
(iii)	Chang La granitoid	0.0254	309	5778
(iv)	Chang La granitoid	0.0282	368	5205

Table 2. Major oxides (in wt%) and trace element (in ppm) analysis of Ladakh batholith. RG-6, Hunder; RG-16, Chang La and RG-20, Daah-Hanu

Sample	RG-6	RG-16	RG-20
SiO_2	75.2	68.68	66.75
TiO_2	0.208	0.454	0.554
Al_2O_3	13.08	14.88	15.18
Fe_2O_3	1.886	3.758	3.841
MnO	0.073	0.093	0.073
MgO	0.415	1.281	1.596
CaO	1.293	3.563	3.88
Na_2O	3.816	4.271	4.412
K_2O	3.976	2.179	3.226
P_2O_5	0.057	0.125	0.269
CO_2	0.13	0.21	0.35
Ba	389.3	425.3	1378
Co	2	6.9	8.5
Cr	126.1	111.7	14.8
Rb	133	67.1	131.6
Sr	113.1	321.5	840.8
V	12.7	59.1	71.9
Y	18	18.5	13.8
Zn	8.8	36.9	45.9
Zr	119.2	141.9	227.6
Ce	37.8	27.1	136.6
Eu	0.3	1.1	2.3
La	59.7	50.4	105.1
Nd	21.4	19.9	51.7
Pb	13.7	3.4	62.8
Sm	2.2	4.4	7.9
Th	15.9	6.6	56.4
U	0	0	3.5
Yb	1.6	1.5	0.9
Sc	0	9.7	6
Cu	23.3	29.5	29.7
Ga	0	0	17.5
Hf	0.1	7.5	5
Pr	0	0	10.1
Gd	4	0	4.9
Tb	0.5	0.6	0.7
Sum (%)	100.2	99.63	100.4

0, Not determined.

dant small–medium to large-grained, euhedral, light rose, smoky to colourless zircons. Geochemical analysis of these separated zircons (unbroken and inclusion-free) shows exceptionally high thorium concentration of 0.4–1.9%, with relatively low uranium concentration of 64–1346 ppm (Table 1). Furthermore, the heavy mineral separation of the Daah-Hanu porphyritic granite indicates the presence of exceptionally high concentration (transparent to translucent pale yellow grains) of monazite (>50%) that can be utilized for dating as well as for economic purpose.

Zircons normally contain higher content of U and lower content of Th, which contrasts with the recorded pattern of lower content of U and higher content of Th in this study. Such a pattern may be indicative of the presence of sub-microscopic inclusions of Th-bearing minerals like monazite within zircon. As the Daah-Hanu granitoid samples are rich in monazite, it is quite likely that the higher Th content in zircon is inherited due to higher monazite concentration in whole-rock heavy mineral assemblage as well as the presence of monazite-rich micro-inclusions in zircon. In order to rule out such a possibility and to support factually the anomalous pattern of high Th and less U in the studied zircons, further electron probe microanalysis studies are required.

The major and trace element geochemical data of the granitoids are presented in Table 2. Detailed geochemical and geochronological data have been discussed elsewhere[3]. This report indicates the presence of highly radioactive minerals within the Ladakh block of the India–Asia collision zone. However, further detailed work is required to verify the economic viability of these important minerals.

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