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U-Pb zircon ages for the porphyritic microgranite of the Shewa-Shahbazgarhi Complex, district Mardan, North Pakistan

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Abstract

The Shewa-Shahbazgarhi complex is an isolated triangular outcrop, occurring about 12 km northeast of Mardan and resides 60 km south of the Main Mantle thrust (MMT) as part of the Indian plate. It comprises of basic and acidic alkaline rocks including microporphry, metagabbro, metadolerite, reibeckite gneiss and porphyritic microgranite. A sample from the porphyritic microgranite yields 280 $\pm$ 16 Ma year U-Pb age on zircon. Similar ages from the Swat granites (granite gneiss) and Chakdara granite gneiss including the present date show that Peshawar plain alkaline igneous province (PPAIP) rift-related igneous activity of the granitic rocks was Permian in age.

Keywords: Main Mantle Thrust; Peshawar Alkaline Igneous Province; Zircon ages

1. Introduction

The Shewa-Shahbazgarhi complex is an isolated triangular outcrop consisting of basic and acidic meta-igneous rocks and is located about 60 km south of the MMT (Main Mantle Thrust) in the Indian plate. The complex has been emplaced into a metasedimentary sequence known as the Swabi Chmala group of Martin et al. (1962) and the Jaffar Kandao Formation of Pogue et al. (1992) of Carboniferous age. The complex is located about 12 km northeast of Mardan (longitude 72˚10' E, latitude 34˚10' to 34˚30' N) and has frequently been investigated by workers since Coulson (1936) who described the petrography and chemistry of some of the rocks for the first time. He described these rocks as porphyries of Mesozoic age and correlated these with the soda granite at Warsak. Martin et al. (1962) called these rocks as albite porphyries and pointed out cataclasization in certain types. Several other workers (Siddiqui, et al., 1968; Kemp and Jan, 1970; Ahmad and Ahmed, 1974; Bakhtiar and Waleed, 1980; Kemp and Jan, 1980; Chaudhry et al., 1981; Chaudhry and Shams, 1984; Khan et al., 1990; Ahmad et al., 1990; Pogue et al., 1992) have investigated these rocks and correlated them with various complexes of the Peshawar plain alkaline igneous province, in particular with Koga alkaline complex. These workers have assigned a Carboniferous to Early Tertiary to Late Cretaceous age to the rocks of the Shewa-Shahbazgarhi complex.

The Shewa-Shahbazgarhi rocks have not been dated previously. A sample was collected from the porphyritic microgranite for zircon separation near Shahbazgarhi (Fig. 1) and U-Pb dating. Analyses were performed at the Department of Earth and Atmospheric Sciences, University of Houston, Texas, USA.

2. U-Pb Zircon analyses

2.1. Analytical methods

Zircons were separated using standard techniques of crushing, grinding, sieving and heavy liquid and magnetic separation at the University of Houston. The zircon fractions were primarily composed of clear euhedral grains ranging in morphology from elongate to stubby prisms and have occasional inclusions of quartz and biotite. Due to the relatively small size of the samples,

individual zircon grains were hand-picked under a binocular microscope and mounted with epoxy in 1" round plastic rings along with the 564 ± 4 Ma standard zircon Peixe (Dickinson and Gehrels, 2003; Chang et al., 2006). The standard was used to correct for instrumental fractionation, fragments of NIST 612 glass, and to calculate U and Th concentrations. The mounted zircons were polished to approximately half the mean grain thickness and carbon coated for CL imaging. After imaging, the carbon coat was removed by gentle polishing and the surface cleaned with ~1M HCl solution to remove any surface contaminants. Laser ablation inductively-coupled plasma mass spectrometry (LA-ICPMS) was undertaken at the University of Houston. A Cetac LSX-213 solid-state 213 nm wavelength laser ablation system coupled to a Varian 810 quadrupole ICPMS was used to collect the U-Th-Pb data which is listed in Table 1. The analyses were made with a 25 um diameter circular laser spot at a repetition rate of 15 Hz at ~2 mJ/pulse. A 15s blank was recorded prior to each 20s ablation. Baseline intensities during the blank measurements were ~1000 counts per second (cps) for 204Pb+204Hg, ~300 cps for 206Pb, ~250 cps for 207Pb, 500 cps for 208Pb, and ~ 100 cps for 238U and 232Th. Not included in the data tables are analyses that are dominated by inclusions and high common Pb that cannot be robustly corrected (i.e. 206Pb/204Pb < 200). Helium, at a flow rate of 600 ml/min, was used as a sample carrier gas. Uncertainties in U and Th contents are ~25%. Systematic errors were added quadratically after pooling of individual U-Th-Pb measurements. Data reduction techniques, including calculation of uncertainties, common Pb correction, and fractionation correction follow those outlined in Shaulis et al. (2010). All uncertainties are reported at the 2σ level and all ages, unless indicated otherwise, are reported as the 206Pb/238U age.

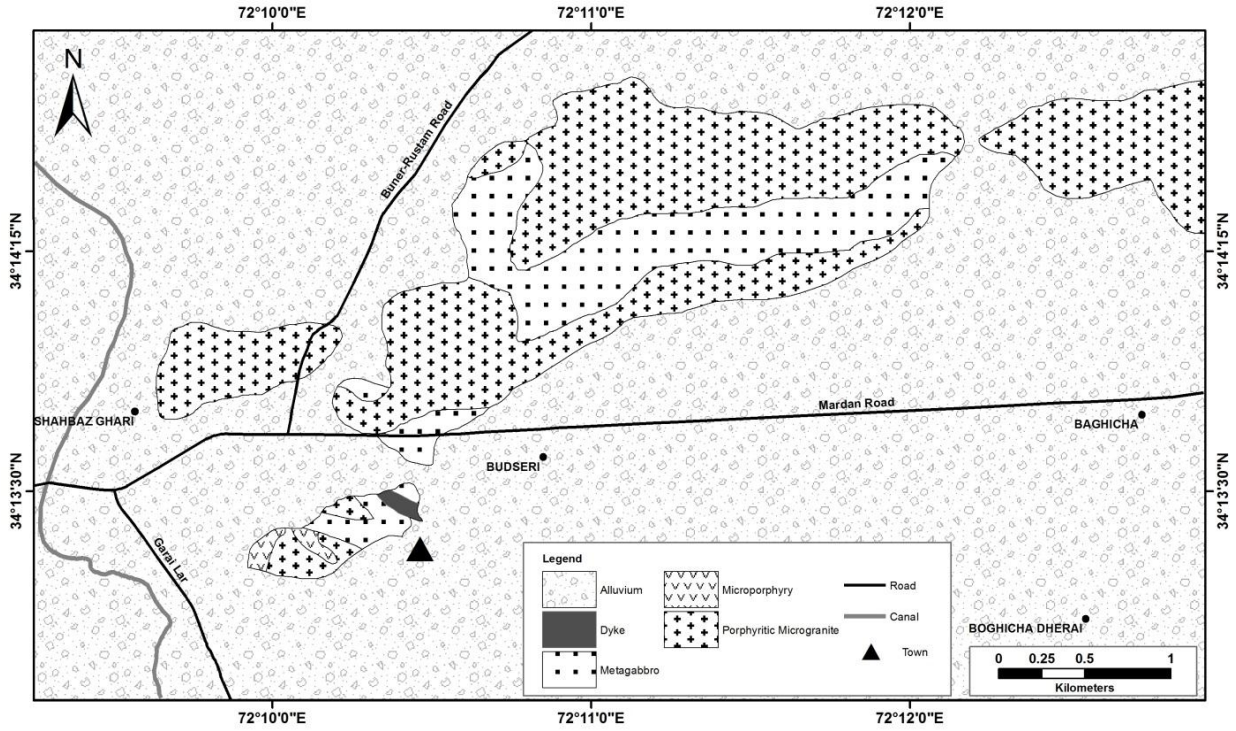

Fig. 1. Geological map of the Shahbazgarhi area, District Mardan.

Table 1. U/Pb data of the microgranite of the Shewa-Shahbazgarhi.

		Concentration (ppm)		Ratios						Ages			
Sample Shewa	**Spot**	**[U]**	**[Th]**	**U/Th**	**$^{206}Pb/^{238}U^{a}$**	**$\pm 2\sigma^{b}$**	**$^{207}Pb/^{235}U^{a}$**	**$\pm 2\sigma^{b}$**	**Rho**	**$^{206}Pb/^{238}U$**	**$\pm 2\sigma$**	**$^{207}Pb/^{235}U$**	**$\pm 2\sigma^{b}$**
	1.1	17.13	224	7.65	0.0406	0.0030	0.2584	0.0237	0.630	256.4	18.5	233.1	19.1
	1.2	944	186	4.99	0.0431	0.0033	0.2679	0.0278	0.577	272.1	20.2	240.8	22.3
	1.3	1466	246	5.97	0.0430	0.0033	0.2987	0.0236	0.765	271.7	20.3	265.2	18.4
	2.1	616	68	9.06	0.0436	0.0030	0.3113	0.0184	0.872	275.0	18.5	275.0	14.2
	2.2	524	73	7.18	0.0433	0.0029	0.3188	0.0185	0.866	273.0	18.1	280.8	14.2
	2.3	418	98	4.28	0.0444	0.0030	0.3253	0.0204	0.831	279.8	18.4	285.8	15.6
	2.4	236	160	1.48	0.0455	0.0029	0.3330	0.0208	0.799	286.8	18.0	291.6	15.8
	3.1	186	92	2.03	0.0481	0.0031	0.3457	0.0219	0.801	302.6	19.0	301.2	16.5
	3.2	137	87	1.57	0.0455	0.0031	0.1992	0.0899	0.114	286.9	19.3	184.3	76.3
	3.3	135	85	1.58	0.0455	0.0029	0.4294	0.0291	0.679	286.7	17.9	362.4	20.7
	4.1	372	207	1.79	0.0463	0.0029	0.3779	0.0319	0.558	291.6	18.2	325.2	23.5
	4.2	491	249	1.97	0.0465	0.0020	0.4164	0.0323	0.415	292.8	12.1	353.1	23.1
	4.3	457	244	1.87	0.0411	0.0020	0.2366	0.0358	0.286	259.4	12.6	215.4	29.4
	4.4	338	179	1.89	0.0407	0.0021	0.2591	0.0502	0.224	257.4	12.8	233.8	40.5
	5.1	1102	145	7.58	0.0451	0.0022	0.2757	0.0194	0.602	284.1	13.9	247.0	15.4
	5.2	1442	181	7.96	0.0452	0.0024	0.2901	0.0213	0.623	284.8	14.5	258.4	16.8
	6.1	211	187	1.13	0.0439	0.0026	0.2151	0.0981	0.116	276.7	15.8	197.7	82.2
	6.2	233	198	1.18	0.0446	0.0024	0.3691	0.0487	0.366	281.5	14.9	318.8	36.2
	6.3	174	169	1.03	0.0435	0.0026	0.3013	0.1173	0.140	274.5	16.0	267.2	91.8
	6.4	152	112	1.37	0.0480	0.0027	0.5166	0.0359	0.748	302.2	16.7	422.5	24.0
	7.1	3984	132	30.16	0.0449	0.0024	0.3215	0.0175	0.884	283.4	14.8	282.8	13.5
	7.2	3168	94	33.78	0.0450	0.0024	0.3166	0.0193	0.797	283.5	14.8	279.1	14.9
	7.3	383	211	1.81	0.0472	0.0026	0.2951	0.0351	0.438	297.3	16.2	262.3	27.5
	8.1	461	444	1.04	0.0444	0.0028	0.2004	0.0505	0.228	279.8	17.0	185.3	42.7
Average Age										280.84	16.61	273.7	29.8

Rho= Error correlation for $^{207}Pb/^{235}U^{a}$ vs $^{206}Pb/^{238}U^{a}$

[a] Corrected for Common Pb following methods outlined in Shaulis et al. (2010)

2.2. U-Pb results and description of the porphyritic microgranite

The porphyritic microgranite occurs as the dominant rock at Shahbazgarhi and Shewa and is locally present at Machai. It is fine-grained. greyish green to slaty black in color. It is well jointed and is sheared. It consists of perthite, quartz, biotite, magnetite and epidote as the major constituents while amphibole, sphene, muscovite and zircon occur as accessories. Sample S1 was collected for zircon separation from the porphyritic microgranite from near Shahbazgarhi (Fig. 1). A total of 24 analyses of 8 zircons (Table 1) yielded an average $^{206}Pb/^{238}U$ age of 280 ± 16 Ma (Fig. 2).

3. Discussion

Earlier workers (Coulson, 1936; Martin et al., 1962; Bakhtiar and Waleed, 1980; Ahmed, 1986) assigned a probable Early Tertiary to Late Cretaceous and Carboniferous age to the rocks of the Shewa Shahbazgarhi complex. Kemp (1973) and Kemp and Jan (1980) proposed that the alkaline rocks of the Peshawar plain are associated

with Tertiary rifting. Based on published data, Jan and Karim (1990) suggested that the alkaline and peralkaline magmatism in the Peshawar plain is related with Permian-Triassic rifting of the Gondwana. Khan et al., (1990) argued that there was a Carboniferous to Permian acidic magmatic activity (the magma was peraluminous but had A-type geochemical character) which was both erupted as lava flows and tuffs and emplaced as plutons (e.g., Warsak and Shewa-Shahbazgarhi sheared garnetiferous microporphyries and Ambela early phase peraluminous-metaluminous granites). They also suggested that this was followed by a phase of peralkaline granites both in Ambela and Warsak, probably in Early Triassic. Recently radiometric dates from Swat and Chakdara area fall in the Permian (Table 2).

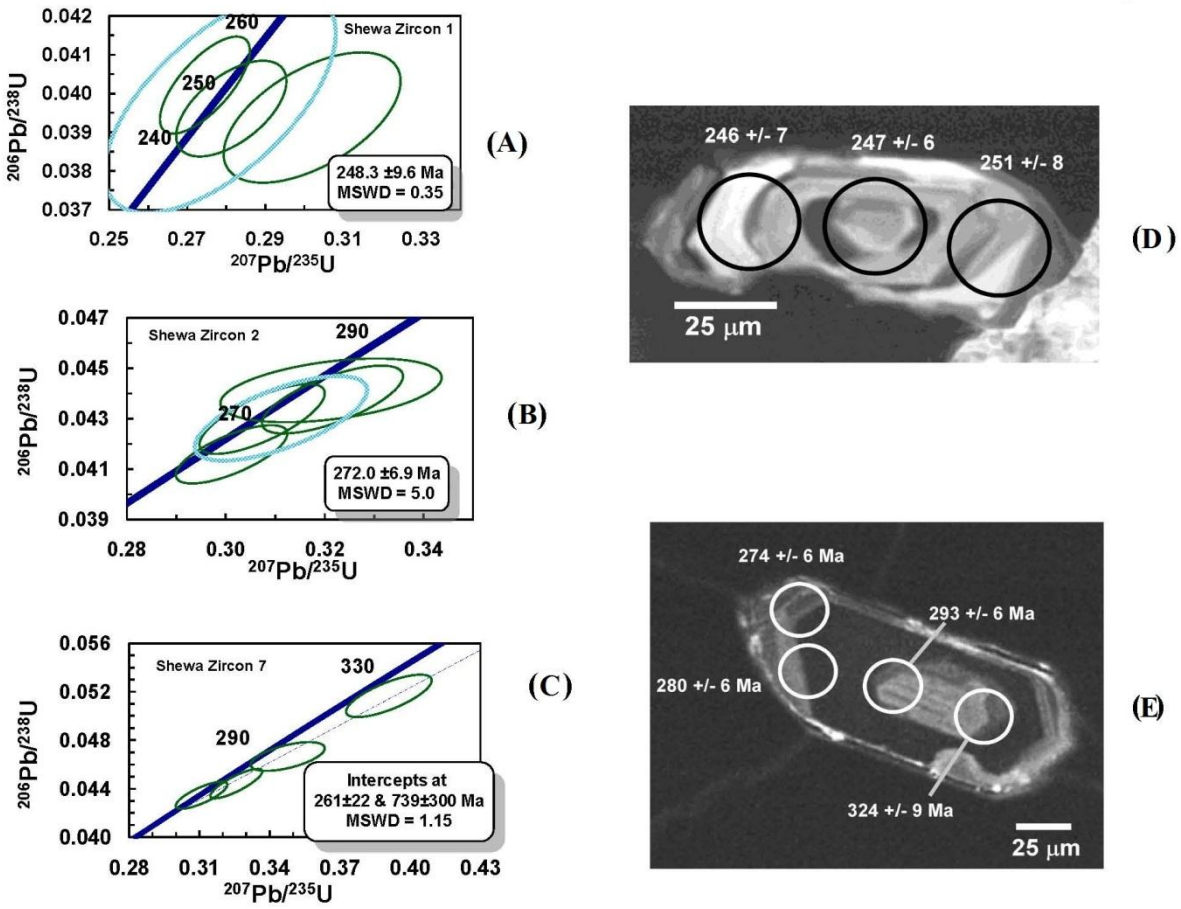

Fig. 2. Concordia diagram and the zircon of the Shewa-Shahbazgarhi porphyritic micogranite.

Table 2. Published age data of the granites from Swat and Chakdara area.

Location	Rock Type	Method	Age	Key References
Mora-Prona-Manglaur	Granite Gneiss	Rb-Sr Whole rock	285 ± 8	Ahmed et al., 1997
Malakand	Granite		271 ± 11	Smith et al., 1994
Chakdara	Granite Gneiss	U-Pb	270 ± 16	DiPietro & Isachsen, 2001
Ser (Swat)	Gneiss	Up-Pb Zircon	268 ± 7/-3	Anczkiewicsz et al., 1998
Ilam	Granite Gneiss	Up-Pb Zircon Rb-Sr ischron	260 ± 52	Ahmed et al., 1997

Our newly determined age of 280 ± 16 Ma confirms the, now increasingly well-established, conclusion that PPAIP igneous activity was Permian in age. These observations are consistent with the conclusion (e.g. Jan and Karim 1990; Khan et al. 1990) that PPAIP igneous activity was rift-related and associated with the Permian episode in which the Cimmerian ribbon continent departed from the Pangean continental margin initiating the formation of the Neotethyan ocean (Sengor, 1984). This also confirms that the acid volcanism was erupted more or less simultaneously with the basic volcanics (Panjal volcanics of Permian age) suggested earlier by Khan et al. (1990).

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