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Zircon U-Pb Dating and Elemental Account of the Granitic Gneiss from Nagar Parkar Igneous Complex, Sindh, Pakistan

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Abstract: The NPIC is the part of north-western Indian craton and is the Pakistan ward continuity of the MIS. The granitic gneiss is found at Rannpur pluton body of the NPIC in the form of a small roof pendant structure exhibiting alternation and contortion of felsic and mafic minerals. Similar granitic gneiss exposures are reported from MIS at Erinpura granites and Sindreth region in India. The granitic gneiss sample from NPIC was processed for age dating, major, trace, and REE concentrations through LA-ICP-MS, ICP-MS, ICP-AES, and XRF. The sample yielded the zircon U-Pb age of 884±6 Ma. The Europium (Eu) negative depletion anomaly suggest decrease in feldspar during crystal fractionation or partial melting in the source. The similar character of granitic gneiss at both (NPIC and MIS) reaffirm the NPIC as the part of MIS

Keywords: Granitic Gneiss, Age Dating, Nagar Parkar Igneous Complex, Sindh, Pakistan.

1. INTRODUCTION

The Nagar Parkar Igneous Complex (NPIC) is the part of northwestern Indian craton and is the Pakistan ward continuity of one of the world's largest igneous provinces namely the Malani Igneous Suite (MIS). This Neoproterozoic igneous complex contains mosaic of reworked Archean basement, Proterozoic Aravali-Delhi foldbelt, and late Proterozoic suits of Malani, Jalore, and Siwana (Sinha-Roy *et al.,* 1997). Laghari (2004) recognized the amphibolites exposures around area of Dedhvero as the basement rock for NPIC. For the MIS Pareek (1981) suggested the Erinpura granite and Delhi sequence as the basement. MIS extends in north to Tosham (in Haryana, India), Kirana hills (in Sargodha, Pakistan), and in the southwest upto Karoonjhar hills (in Nagar Parkar, Pakistan). Butt *et al.,* (1994), Kazmi *et al.,* (1997), Jan *et al.,* (1997), and Markhand *et al.,* (2017) described NPIC as the late Proterozoic extension of post-Delhi magmatism (MIS) in southwesterly direction. The morphology of the Nagar Parkar region is chiefly controlled by the Nagar Parkar Fault (NPF); a strike slip fault formed as a result of anticlockwise movement and the resulting stress direction of Indian Plate (Biswas, 2014). NPF is the transform boundary between subducting plate on north (Indus Foreland-Karakoram Orogenic Belt) and much rifted pericraton on the south (Kutch-Cambay-Narmada-Western Offshore Rift Zone). NPF is the primordial fault that produced the Nagar Parkar uplift, infact the Indo-Pakistan region structurally from Saurashtra horst (in India) to the Indus shelf (in Pakistan) is the subsequent display of horsts and grabens; the tectonic elements behind such display are five parallel faults namely: Nagar Parkar Fault, Island Belt Fault, South Wagad Fault, Kutch Mainland Fault, and North Kathiawar Fault. Sub parallel ridges in the form of uplifts formed during the rift extension phase are the result of block tilting along these faults (Biswas, 2005). Granitoids and gneisses serve as the basement rock for the Malani magmatism. Erinpura granites comprising a variety of lithologic types i.e., massive granitoids, strongly contorted banded gneisses, and mylonitic varieties are the basement granites for MIS in Sindreth region (Sharma, 2004). Erinpura granites generally represent gneissic character with alternation of quartz-feldspar and mafic-rich bands. Granitic gneiss bearing folding contortion and transposition are reported from several places of exposures of foliated Erinpura granites (Sharma, 2004). The granitic gneiss in the NPIC is present as a roof pendant structure of around 15X40 meter size surrounded from all sides by pink granite at the Rannpur pluton body. The deformation bands of felsic and mafic minerals ranging in size from 1mm to 3cm are present in this texturally foliated rock

2. MATERIALS AND METHODS

The fieldworks were carried in NPIC exposure around Rannpur area which lies in Survey of Pakistan toposheet 40L/15 and the rock sample of granitic gneiss was collected from the location at 24° 23' 26.4" Northing, 70° 52' 03.1" Easting coordinates, and was labelled as RP1. The sample preparation, processing,

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techniques (LA-ICP-MS, XRF, ICP-MS, and ICP-AES), and measurements were performed as described in Markhand *et al.*, (2017).

3. RESULTS

The ^{235}U-^{207}Pb and ^{238}U-^{206}Pb results for the RP1 sample are summarized in **(Table 1)** while, the Concordia diagram and weighted average mean age diagram are shown as **(Fig. 1).**

Table 1. Summarized laser ablation results of the RP1 sample.

Sample No.	Analysis No.	Corrected Ratios				Corrected Ages (Ma)	
		$^{207}Pb/^{235}U$		$^{206}Pb/^{238}U$		$^{206}Pb/^{238}U$	
			1 sigma		1 sigma		1sigma
RP1	0620A141	1.21758	0.10209	0.13062	0.00343	791	20
	0620A142	1.4843	0.11588	0.15683	0.00387	939	22
	0620A143	1.30103	0.11597	0.14135	0.00372	852	21
	0620A144	1.28996	0.16701	0.15393	0.00526	923	29
	0620A146	1.45295	0.14458	0.14207	0.00421	856	24
	0620A147	1.41764	0.12065	0.14654	0.00376	882	21
	0620A148	1.40765	0.13116	0.13967	0.00414	843	23
	0620A149	1.34459	0.13248	0.15077	0.00437	905	24
	0620A151	1.22524	0.11078	0.14137	0.00382	852	22
	0620A152	1.52715	0.16022	0.14494	0.00449	873	25
	0620A153	1.42687	0.15694	0.14798	0.00516	890	29
	0620A154	1.32372	0.13304	0.15508	0.00461	929	26
	0620A156	1.31241	0.09996	0.14663	0.0035	882	20
	0620A157	1.36843	0.12439	0.14516	0.00386	874	22
	0620A159	1.45843	0.13561	0.14677	0.00409	883	23
	0620A161	1.04854	0.12334	0.13968	0.00456	843	26
	0620A162	1.20139	0.1388	0.14702	0.00512	884	29
	0620A163	1.27113	0.14115	0.14879	0.00506	894	28
	0620A164	1.2553	0.24892	0.14388	0.00718	867	40
	0620A166	1.09307	0.16223	0.14616	0.00571	879	32
	0620A167	1.35383	0.11622	0.14611	0.00384	879	22
	0620A168	1.38345	0.17204	0.14957	0.00518	899	29
	0620A169	1.31647	0.10739	0.1484	0.00373	892	21
	0620A171	1.37702	0.14281	0.14448	0.00433	870	24
	0620A172	1.35656	0.15753	0.14904	0.00505	896	28
	0620A173	1.51815	0.17986	0.16777	0.00549	1000	30
	0620A174	1.23031	0.1182	0.14461	0.00402	871	23
	0620A176	1.31219	0.1258	0.14837	0.00422	892	24
	0620A177	1.3175	0.11802	0.15603	0.00424	935	24
	0620A178	1.48557	0.15843	0.15205	0.00465	912	26
	0620A179	**1.34625**	**0.13231**	**0.14064**	**0.00394**	**848**	**22**

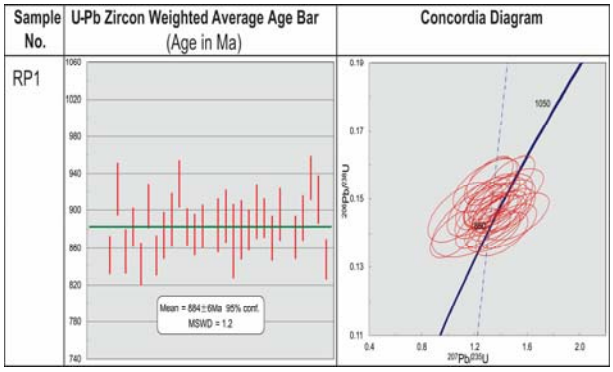

Fig. 1. Concordia diagram and weighted average mean age diagram of the RP1 sample.

The Major, Trace, and Rare Earth Elements (REE) concentrations of the sample RP1 are given in **(Table 2).** The discrimination diagrams plotted against these concentrations are Total Alkali versus Silica (TAS) diagram as **(Fig. 2),** Y versus Nb and Y+Nb versus Rb as **(Fig.3),** sample chondrite and sample primitive mantle diagram as **(Fig. 4).**

Element (wt. %)	Sample RP1	Element (ppm)	Sample RP1
SiO_2	72.63	Cs	1.02
Al_2O_3	12.18	Rb	33.4
TFe_2O_3	4.33	Ba	700
CaO	2.71	Th	5.27
MgO	1.11	U	0.9
Na_2O	3.71	Nb	5.7
K_2O	1.58	Ta	0.41
Cr_2O_3	0.01	La	21.2
TiO_2	0.67	Ce	48.4
MnO	0.10	Pr	5.93
P_2O_5	0.19	Nd	26.1
SrO	0.03	Sr	283
BaO	0.07	Sm	5.59
LOI	0.38	Hf	10.0
TOTAL	99.69	Zr	407
		Eu	1.30
		Gd	5.27
		Tb	0.83
		Dy	4.99
		Ho	1.03
		Y	42.6
		Er	3.20
		Tm	0.47
		Yb	3.23
		Lu	0.48

Table 2. Summarized elemental results of the RP1 sample.

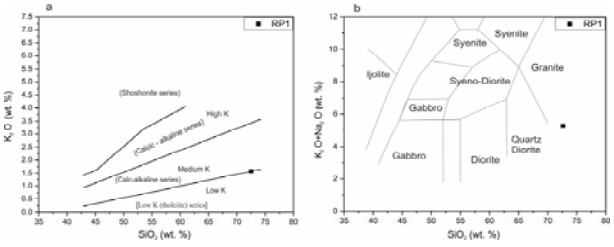

Fig. 2. TAS classification diagram (a) Chemical classification (Wilson, 1989), (b) Total alkali classification (Peccerillo and Taylor, 1976), of the RP1 sample.

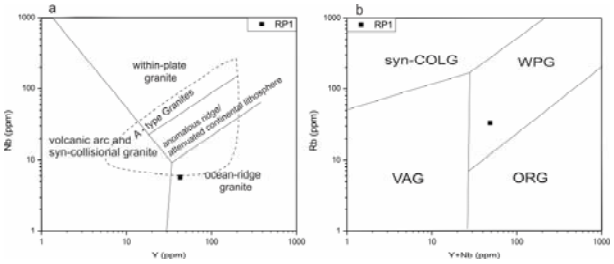

Fig. 3. Discrimination diagrams (a) Y vs Nb and (b) Y+Nb vs Rb, (Pearce, *et. al.,* 1984) for the RP1 sample.

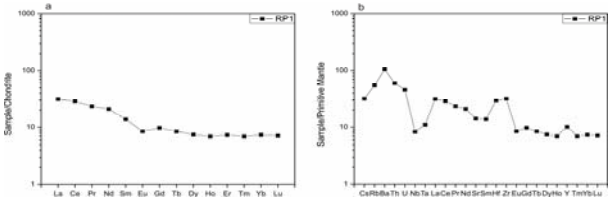

Fig. 4. (a) Chondrite normalized REE diagram (b) Primitive Mantle normalized spider diagram, for the RP1 sample. Normalization values are from Sun and McDonough (1989).

4. DISCUSSION

The granitic gneiss sample from Rannpur body of the NPIC, based on zircon crystal U-Pb ablation spot analyses (27 spots for RP1 sample) yielded 884±6 Ma age with MSWD value of 1.2 (Fig. 1). The sample elemental results for negative correlation between SiO_2 and other major oxides represent the decreased Al_2O_3, Fe_2O_3, MgO, Na_2O, CaO, and TiO_2 with respect to increased SiO_2 concentrations (Table 2). The sample data when plotted in SiO_2 versus K_2O (wt. %) diagram, it plots on the distinguishing line between medium potash calcic alkaline series and low potash tholeiite series with increased SiO_2 content. While, it plots in the region of granite in the TAS discrimination diagram (Fig. 2). The Y versus Nb (ppm) diagram categorize the sample as ocean-ridge granite whereas, Y+Nb versus Rb (all in ppm) diagram suggest WPG origin for the sample (Fig. 3). A slight Eu depletion anomaly is noticed in between decreasing trend from HREE to LREE in sample/chondrite diagram. Whereas, the Nb depletion and Ba, Hf, Zr, and Y increasing enrichment anomaly is noticed in sample/primitive mantle diagram (Fig. 4).The extracted zircon crystals are mostly of prismatic shape with a few pyramidal shape crystals, in the CL images cores appear to be darker as compared to rims, magmatic overgrowth at rims is observed in some crystals, the size range for these crystals is 90 - 100 µm. The dating results affirm with the proposal of Jan *et al.,* (2018) for the basement of NPIC being part of 900-840 Ma magmatic arc.

5. CONCLUSION

The granitic gneiss sample from Rannpur body of the NPIC, based on zircon crystal U-Pb ablation spot analyses (27 spots for RP1 sample) yielded 884±6 Ma age. The slight Eu negative depletion anomaly suggest decrease in feldspar during crystal fractionation or partial melting in the source. The similar character of granitic gneiss at both (NPIC and MIS) reaffirm the NPIC as the part of MIS.

6. ACKNOWLEDGEMENT

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