

Zircon and monazite U-Pb ages, chemical and Sr-Nd-Pb-Hf isotopic compositions of these Eocene-Miocene gabbroic diorite- granodiorite- leucogranite -pegmatite complex along the southeastern side of the Hindu Kushi (<https://doi.org/10.5880/fidgeo.2025.090>)

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2. Citation

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Table of contents

1. Licence	1
2. Citation	1
3. Data Description	2
Sampling method	2
Analytical procedure and data processing:	2
4. File description	3
File inventory	3
Description of data tables	4
2025-090_ZhangChuanlin-et-al_Table1_Age-data.xlsx	4
2025-090_ZhangChuanlin-et-al_Table2-4_Geochemistry.xlsx	4
2025-090_ZhangChuanlin-et-al_Table5_Pb-Calculation.xlsx	4
2025-090_ZhangChuanlin-et-al_Table6_Lu-Hf-isotopes.xlsx	5
2025-090_ZhangChuanlin-et-al_Table7_Mineral-EPMA.xlsx	5
2025-090_ZhangChuanlin-et-al_Table8_Collected-age-data.xlsx	5
5. References	5

3. Data Description

In this contribution, we identified diverse Oligocene-Early Miocene intrusions along the southeastern margin of the Hindu Kushi between Pakistan and Afghanistan, including gabbroic diorite, diorite, granodiorite and voluminous leucogranites- pegmatites. Field observations, petrography, ages and geochemistry of these diverse intrusions are presented. Integrating this work with the previous studies on the Eocene-Miocene igneous rocks at Pamir, we aim to have a better understanding the continental uplifting and geodynamic evolution processes of the Pamir Plateau after the final closure of the Neo-Tethys. Additionally, this study sheds new lights on our understanding of the rare metal mineralization in the Hindu Kushi orogenic belt.

Sampling method

In this study, we collected six geochronological samples from gabbroic diorite, granodiorite, leucogranite and the pegmatite both from Pakistan and Afghanistan. Twenty-six geochemical samples are also collected from the diorite, granodiorite, leucogranite, and pegmatite. (The samples were not assigned with IGSNs).

Analytical procedure and data processing:

Monazite U-Pb dating was carried in Tianjin Geology Survey Center (CGS). Monazite grains and the monazite standard 44069 (Wan et al., 2004) were mounted in epoxy mounts. The mounts were subsequently polished to section the crystals almost in half. All the monazite grains were documented with BSE images to reveal their inner structures. Monazite U-Pb ages were determined using the LA-ICPMS method. Detailed analytical procedures have been reported in Cui et al. (2012).

Whole-rock major elements were determined using X-ray fluorescence (XRF) spectroscopy method at the ALS Laboratory Group, an Australian ICP-MS analytical lab in Guangzhou (China). Before analysis, samples (2 g) were fused with a Li₂B₄O₇ flux under a sample-to-flux ratio of 1:5 and temperature of 1150-1250°C to form glass fusion discs for XRF analysis. The analytical precision was better than 0.1% for all the oxides. Trace elements were analyzed using a PE Elan 600 ICP-MS at the Chinese Institute of Geochemistry of the Chinese Academy of Science, following procedures similar to those described by Li et al. (2006). In-run analytical precision for most elements was better than 2-5%.

Sr-Nd isotopic compositions were determined using a Micromass Isoprobe MC-ICPMS at the Tianjin Institute of Geology and Mineral Resources (TIGMR) China, CGS, following the procedure of Li et al. (2006). Measured ⁸⁷Sr/⁸⁶Sr and ¹⁴³Nd/¹⁴⁴Nd ratios were normalized to ⁸⁶Sr/⁸⁸Sr = 0.1194 and ¹⁴⁶Nd/¹⁴⁴Nd = 0.7219, respectively. The reported ⁸⁷Sr/⁸⁶Sr and ¹⁴³Nd/¹⁴⁴Nd ratios were adjusted to the standard NBS SRM 987 of ⁸⁷Sr/⁸⁶Sr = 0.71025 and Shin Etsu JNdi-1 of ¹⁴³Nd/¹⁴⁴Nd = 0.512115, respectively.

The ²⁰⁶Pb/²⁰⁴Pb ratio tests were normalized to results of the well-accepted Standard Reference Material NBS 981 values of ²⁰⁸Pb/²⁰⁴Pb = 36.7262 ± 31, ²⁰⁷Pb/²⁰⁴Pb = 15.5000 ± 13, ²⁰⁶Pb/²⁰⁴Pb = 16.9416 ± 13 (Baker et al., 2004). One NIST 981 standard was measured for every ten samples analyzed. Analyses of the NBS SRM 981 standard yielded external precisions of 0.03 % (2RSD) for ²⁰⁶Pb/²⁰⁴Pb ratios. In addition, the USGS reference material BCR-2 (basalt) yielded results of ²⁰⁸Pb/²⁰⁴Pb = 38.737 ± 28, ²⁰⁷Pb/²⁰⁴Pb = 15.628 ± 3, ²⁰⁶Pb/²⁰⁴Pb = 18.757 ± 22 (2σ, n=61), respectively, which is identical within error of 0.03 % to their published values (Zhang and Hu, 2020).

Zircon in situ Lu-Hf isotopes were determined using a New wave-193 nm ArF excimer laser-ablation system linked to a Neptune MC-ICPMS at TIGMR, CGS. GJ-1 zircon standard was used for external calibration. The analyses were conducted with a beam diameter of 50 μm, 8 Hz repetition rate with a

laser power of 15 J/cm². Detailed operating conditions for the laser ablation system, the MC-ICP-MS instrument, and the analytical method, were documented in Geng et al. (2011).

4. File description

One file is in .txt format and contains three supplementary figures, while the remaining six files are in .xlsx format, providing zircon and monazite U–Pb ages, as well as chemical and Sr–Nd–Pb–Hf isotopic compositions.

File inventory

ZIP folder	File name	File format	Content
	2025-090_ZhangChuanlin-et-al_data-description	.pdf	Description of data and methods
	2025-090_ZhangChuanlin-et-al_Supplementary-figures	.pdf	Supplementary Fig. 1 Specimen photos of the ore from the Kôhe-Jamânak rare metal deposit in Afghanistan Supplementary Fig. 2 Classification diagrams of the biotite from the gabbroic diorite Supplementary Fig. 3 Harker diagram of the (gabbroic) diorites, granodiorite, leucogranite and pegmatites
2025-090_ZhangChuanlin-et-al_data-excel.zip	2025-090_ZhangChuanlin-et-al_Table-1_Age-data	.xlsx	Supplementary Table 1 LA-MC-ICP-MS U-Pb zircon and monazite isotope data for the Chattian-Aquitania gabbroic diorites, granodiorite, leucogranites and pegmatites in Hindu Kushi
	2025-090_ZhangChuanlin-et-al_Table-2-4_Geochemistry	.xlsx	Supplementary Table 2 Whole-rock major element compositions of the Chattian- Aquitania gabbroic diorites, granodiorite, leucogranites and pegmatites in Hindu Kushi. Supplementary Table 3 Whole-rock trace element compositions of the Chattian- Aquitania gabbroic diorites, granodiorite, leucogranites and pegmatites in Hindu Kushi. Supplementary Table 4 Whole-rock Sr-Nd isotopic compositions of the Chattian- Aquitania gabbroic diorites, granodiorite, leucogranites and pegmatites in Hindu Kushi.
	2025-090_ZhangChuanlin-et-al_Table-5_Pb-Calculation	.xlsx	Supplementary Table 5 Whole-rock Pb isotopic compositions of the Chattian- Aquitania gabbroic diorites, granodiorite, leucogranites and pegmatites in Hindu Kushi.
	2025-090_ZhangChuanlin-et-al_Table-6_Lu-Hf-isotopes	.xlsx	Supplementary Table 6 Hornblende and biotite chemical compositions analyzed by EPMA.
	2025-090_ZhangChuanlin-et-al_Table-7_Mineral-EPMA	.xlsx	Supplementary Table 7 Zircon Lu-Hf isotopic compositions of the gabbroic diorite (23PK30-1) and the granodiorite (23PK25).
	2025-090_ZhangChuanlin-et-al_Table-8_Collected-age-data	.xlsx	Supplementary Table 8 Age data of the three main phases of igneous activities at Pamir after the closure of the Neo-Tethys.
2025-090_ZhangChuanlin-et-al_data-csv.zip			All data tables in csv format (UTF-8)

Description of data tables

2025-090_ZhangChuanlin-et-al_Table-1_Age-data.xlsx

Column header	unit	Description
Sample		Sample number
Location	Decimal degree	Latitude and longitude in WGS84
Contents	10 ⁻⁶ /ppm	The concentrations of lead and uranium in zircon
Isotope ratios	1σ; err%	Isotope ratios and an absolute error of one unit and its corresponding percentage error
Age	Ma; 1σ	Zircon/Monazite U–Pb isotopic dating results and their associated age uncertainties

2025-090_ZhangChuanlin-et-al_Table2-4_Geochemistry.xlsx

Column header	unit	Description
No.		Sample number
Rock Type		Rock's name
Contents	10 ⁻⁶ /ppm	The concentrations of lead and uranium in zircon
SiO ₂ ;TiO ₂ ; TFe ₂ O ₃ ; MnO; MgO...	Wt.%	Determination of the major element composition in rock samples
Age	Ma; 1σ	Zircon/Monazite U–Pb isotopic dating results and their associated age uncertainties
Analytical Number		Analytical sample number
Sample No.		Sample number
Anotation		Sample types
Li; Be; Sc; V...	10 ⁻⁶ /ppm	Determination of the trace element composition in rock samples
Sample		Sample number
⁸⁷ Sr/ ⁸⁶ Sr; ¹⁴³ Nd/ ¹⁴⁴ Nd		Analysed isotopic ratio
age	Ga	Formation age of the sample
Rb/Sr/Sm/Nd	10 ⁻⁶ /ppm	Trace element composition of the sample
(⁸⁷ Sr/ ⁸⁶ Sr) _i ; (⁸⁷ Sr/ ⁸⁶ Sr) _{CHUR} ; (¹⁴³ Nd/ ¹⁴⁴ Nd) _i ; (¹⁴³ Nd/ ¹⁴⁴ Nd) _{CHUR} ; ^ε Nd		Calculated isotopic ratio

2025-090_ZhangChuanlin-et-al_Table5_Pb-Calculation.xlsx

Column header	unit	Description
Sample		Sample number
²⁰⁸ Pb/ ²⁰⁴ Pb; ²⁰⁷ Pb/ ²⁰⁴ Pb; ²⁰⁶ Pb/ ²⁰⁴ Pb		Analysed isotopic ratio
Pb; Th; U	10 ⁻⁶ /ppm	Trace element composition of the sample
Age	Ma	Formation age of the sample
²⁰⁸ Pb/ ²⁰⁴ Pb; ²⁰⁷ Pb/ ²⁰⁴ Pb; ²⁰⁶ Pb/ ²⁰⁴ Pb		Calculated isotopic ratio

2025-090_ZhangChuanlin-et-al_Table6_Lu-Hf-isotopes.xlsx

Column header	unit	Description
Age	Ma	Formation age of the sample
Sample Name		Sample number
^{178}Hf ; ^{172}Yb ; ^{175}Lu ; $^{176}\text{Yb}/^{177}\text{Yb}$; $^{176}\text{Lu}/^{177}\text{Lu}$; $^{176}\text{Hf}/^{177}\text{Hf}$; $^{178}\text{Hf}/^{177}\text{Hf}$; $^{180}\text{Hf}/^{177}\text{Hf}$; 1SE		Isotopic abundances, isotopic ratios, and their one-sigma standard errors
Measurements	s	Duration of testing and valid signal acquisition
$e_{\text{Hf}}(0)$; $e_{\text{Hf}}(t)$;		Calculated initial isotope values
$T_{\text{DM}}(\text{Ma})$; $T_{\text{DM}}^{\text{C}}(\text{Ma})$	Ma	Calculated model ages
$f_{\text{Lu/Hf}}$		Slope of Hf isotope deviation from CHUR over time

2025-090_ZhangChuanlin-et-al_Table7_Mineral-EPMA.xlsx

Column header	unit	Description
structural site groupings		T: Tetrahedral, with a coordination number of 4, representing the silicon-oxygen tetrahedron; C: Octahedral (for hornblende)/ O: Octahedral (for biotite), with a coordination number of 6, constituting the octahedral layer; B: Large M-site, with a coordination number of 8-12
Comment		Sample number
Na_2O ; NiO ; K_2O ; F...	wt. %	Determination of the major element composition of the minerals (biotite and hornblende)
Si; P; Be; Al; Ti...	apfu	Unit atomic number calculated from the major elemental composition of minerals

2025-090_ZhangChuanlin-et-al_Table8_Collected-age-data.xlsx

Column header	unit	Description
Tectonic Unit		From which tectonic unit was the sample collected?
Sample Number		Sample number
Rock type		Rock types
Method		Analytical and testing methodology
Age	Ma	Formation age of the sample
References		Literature referenced for data collection

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