Raffaele Casnedi, Ardito Desio, Franco Forcella, Massimo Nicoletti, Claudio Petrucciani

Absolute age of some granitoid rocks between Hindu Raj and Gilgit River (Western Karakorum)

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Geologia. — *Absolute age of some granitoid rocks between Hindu Raj and Gilgit River (Western Karakorum)* (*). Nota di RAFFAELE CASNEDI, ARDITO DESIO, FRANCO FORCELLA, MASSIMO NICOLETTI e CLAUDIO PETRUCCIANI, presentata (**) dal Socio A. DESIO.

RIASSUNTO. — Alcuni campioni provenienti dai maggiori corpi granitici del Karakorum occidentale sono stati analizzati col metodo K–Ar per ottenere nuovi dati sull'età assoluta delle più importanti fasi di granitizzazione della catena. Si tratta delle prime datazioni assolute dei corpi intrusivi affioranti fra il T. Gilgit e l'Hindu Raj.

I campioni più antichi hanno un'età di 56–50 m.a. (Paleocene superiore–Eocene inferiore) e provengono dai massici di Gamugal (media valle di Yasin) e di Gindai (bassa valle di Yasin). Età intermedia, di 42–41 m.a. (Eocene superiore), hanno i graniti del versante meridionale della valle del T. Gilgit che possono pertanto essere correlati col grande affioramento granitico del Deosai già riferito in precedenza a quest'età. I campioni più recenti, con valori di 25 e 19 m.a. (sommità dell'Oligocene e Miocene inferiore) provengono dalla bassa valle del Gilgit e dal Darkot Pass sull'Hindu Raj. Si hanno perciò elementi per una correlazione fra la catena del Hindu Raj e quella del batolite assiale del Karakorum che si sviluppa ad est fra i ghiacciai Batura e Baltoro.

INTRODUCTION

This note deals with absolute ages obtained with the $^{40}Ar/^{36}Ar$ and $^{40}K/^{36}Ar$ isochron method on some samples of granitoid rocks cropping out in the Gilgit valley, upstream of Gilgit as far as Gupis, and from the Yasin River valley, as far as the Darkot pass (Western Karakorum).

On the basis of our geological field investigations it is impossible to state whether the studied granitic belts of the Karakorum and Hindu Kush ranges are parts of a single batholith, dislocated by tectonic events, or are genetically independent bodies. Chronological data on samples collected during previous Italian expeditions (Desio and Longinelli, 1961; Desio *et al.*, 1964) do not permit discrimination between these two hypotheses.

DESCRIPTION OF GRANITOID BODIES

The northern body is a batholith located between the Karakorum and Hindu Kush (fig. 1), oriented WSW–ENE; the main axis acts as the watershed of the Yarkhun and Gilgit rivers. It is known as Darkot pass or Hindu Raj

(*) Raffaele Casnedi: Istituto di Geologia, Strada Nuova 65, Pavia. Ardito Desio and Franco Forcella: Istituto di Geologia, Piazzale Gorini 15, Milano. Massimo Nicoletti and Claudio Petrucciani: Centro studio della Geocronologia e Geochimica delle formazioni recenti del C.N.R., Roma.

(**) Nella seduta dell'11 febbraio 1978.

batholith and is considered by Matsushita and Huzita (1965) as the structural continuation of the axial Karakorum batholith. South of the Darkot pass it is in contact with parametamorphic rocks of probable Paleozoic age, related to the Misgar Slates, cropping out in the Hunza valley (Desio and Martina, 1972); toward the east it seems to be overlain by sedimentary formations. Westward, it should be more continuous.

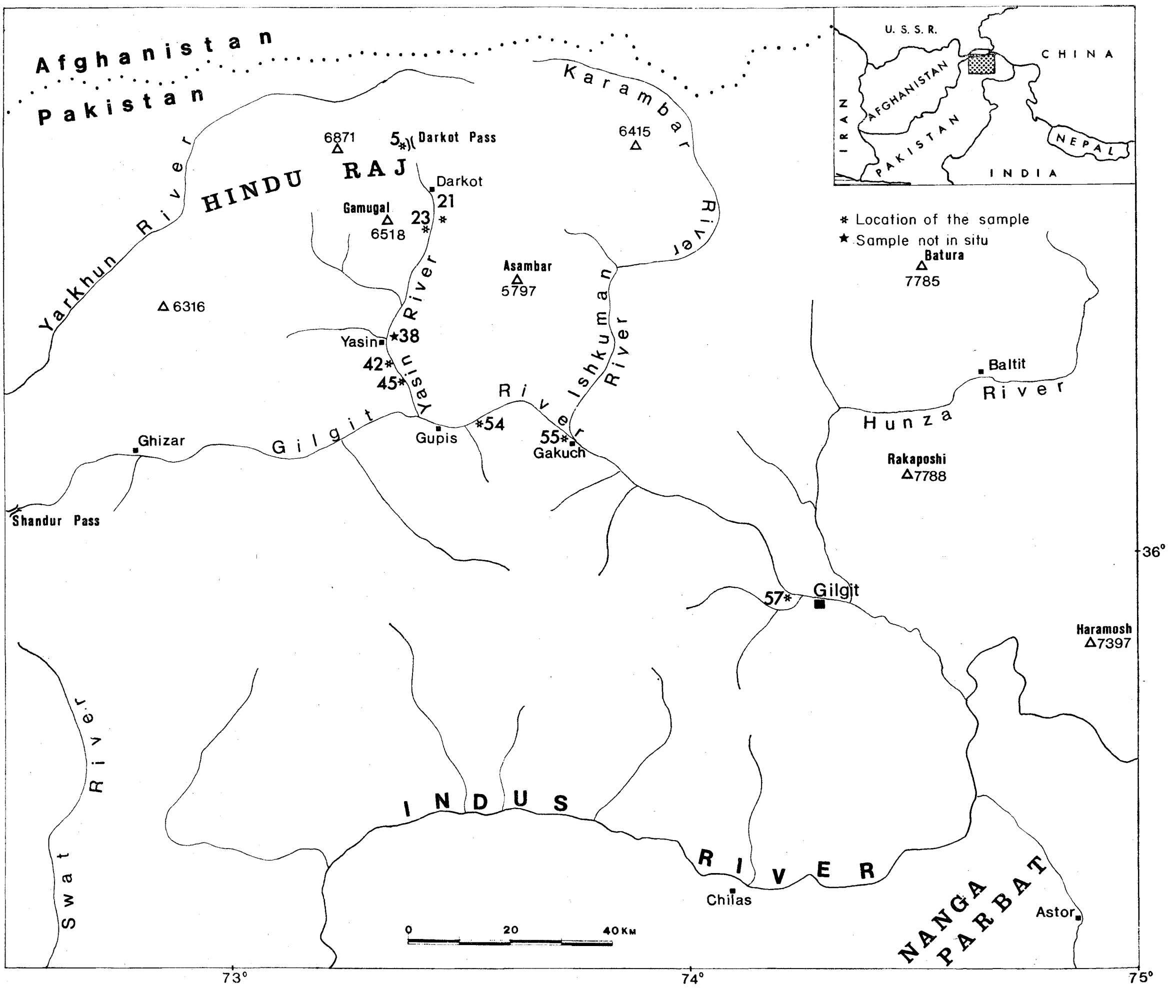

Fig. 1. – Location map of the samples.

Petrographic investigations on the CK5 sample have shown their granitic nature with mortar structure, due to the presence of big felspar porphyroclasts in a fine quartz matrix. The quartz is fine, granoblastic by cataclasis of previous larger individuals, secondarily recrystallized in part; K–felspar with undulatory extinction shows clear para- and postcrystalline deformations; plagioclase shows polysynthetic twinning, frequently incurvated, fractured and with kink bands; felspar is partially replaced by felts of small micaceous flakes.

More or less chloritized flakes of brown biotite are often strongly deformed, sometimes reaching an accordion-like folding. A small amount of green horneblende is sometimes present. Sphene, epidote, apatite, zircon, carbonate and opaque minerals are additional components.

Another granitic body incised by the Yasin River is broader and more continuous than the one previously described. It crops out in the middle Yasin valley: according to Ivanac *et al.* (1956) and to the Geological Map of Pakistan (1964) it represents the axial Karakorum batholith.

A petrographic study shows that it is made up of diorite and granodiorite rocks (CK 23) locally metamorphosed to gneiss (CK 21). Diorites and granodiorites have a granular ipidiomorphic structure. The most abundant component is plagioclase, often zoned with calcic core (about 50 %An) and a more sodic rim (about 20 % An). Quartz and perthitic microcline are present in a small amount. The femic component is represented by brown biotite, often altered to undeformed flakes of chlorite. Sphene, apatite, zircon and opaque minerals are present as minor components, and epidotes and white micas are the product of plagioclase alteration.

In the gneissic rock (CK 21) the characteristic paragenesis is: biotite + sillimanite + K-felspar + garnet which marks highly thermic metamorphism, but a dinamothermic metamorphism cannot be ruled out. The sillimanite is in randomly distributed fascicular bundles and is partly readsorbed by leucocratic phases and shows strong postcrystalline deformations. White micas, zircon, monazite and opaque minerals are minor components.

South of Yasin, near Gindai, the river crosses another granitic body, smaller than the others and intruded into basic metamorphic formations (Green Schists of Matsushita and Huzita, 1965) attributed to the Cretaceous-Eocene interval. The rocks CK42 and CK45 are coarse-grained with an ipidiomorphic texture. Felspars are represented by perthitic microcline and plagioclase (10–20 %An) slightly altered in the central part to a felt of white mica flakes with a very fine irresoluble opaque granulation; quartz is present in large allotriomorphic crystals with undulose extinction; biotite is present in variable amounts, slightly and irregularly altered to chlorite; sphene, tourmaline, zircon and opaque minerals are minor components.

Some granitic bodies crop out on the right side of the Gilgit river valley; these northern outcrops possibly belong to the larger plutonic bodies intruded into the Middle Indus Noritic Groups (= Upper Swat Hornblendic Group) between the middle Indus valley and the Gilgit valley (Chilas–Sazin). The petrographic composition varies between leucogranites with an alkaline trend and granodiorites, all with a mortar structure due to the presence of porphyroclasts of feldspar, surrounded by fine recrystallized quartz.

Plagioclase and K–felspars are variously altered and the transformation products (epidotes and white micas) show variable degrees of crystallization,

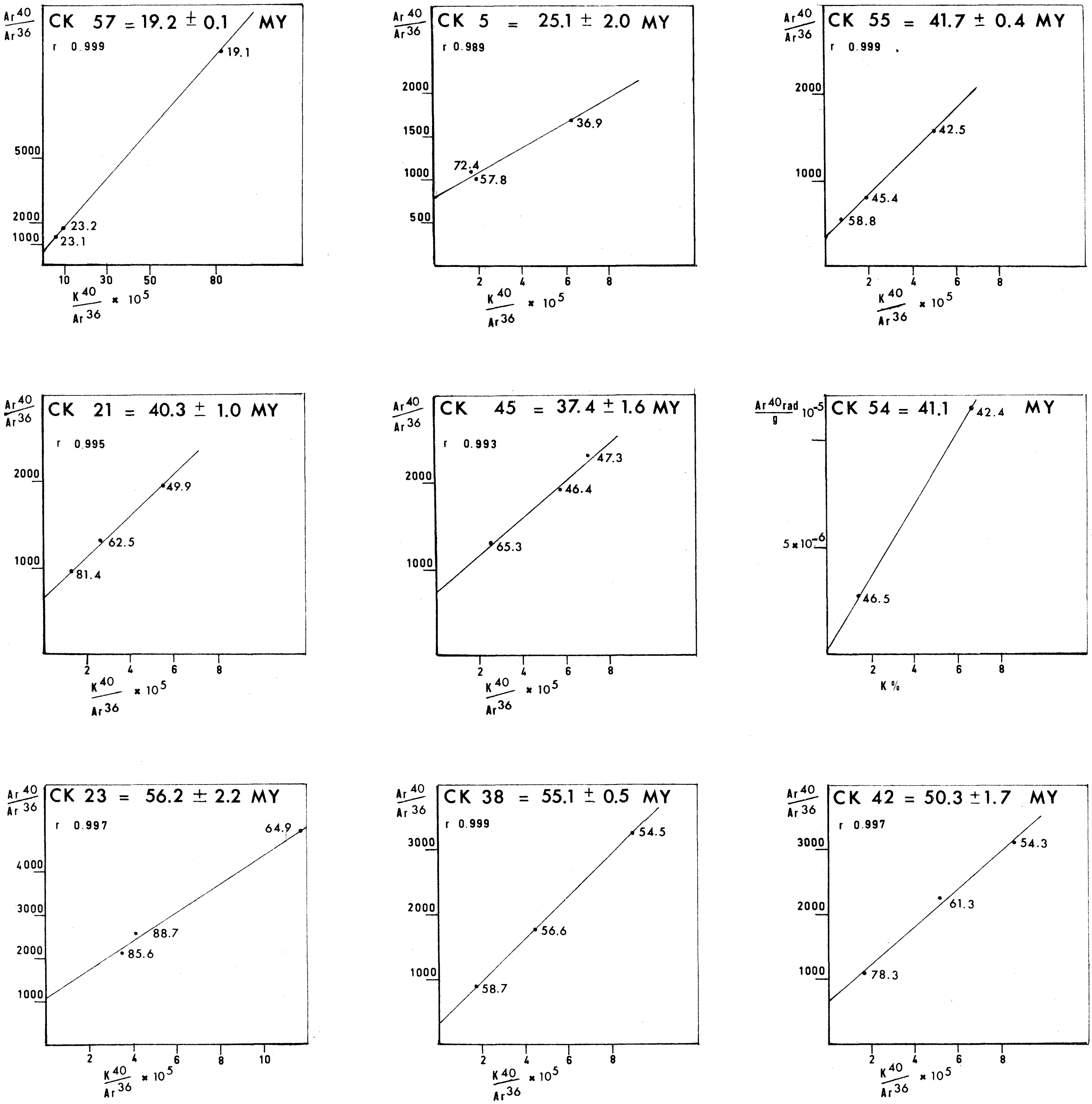

Fig. 2. – Isochron plots for samples studied; the isochron slope age is given beside the sample number, the numbers beside each point are the conventional ages; sources of data are given in Table I.

sometimes very high (CK 57). Biotite and minor amounts of amphibole are the melanocratic minerals; biotite is in various degrees decolorized and altered to chlorite; apatite, sphene, zircon, allanite, calcite and opaque minerals make up the accessory components.

ANALYTICAL METHODS

Nine samples were dated by means of the $^{40}Ar/^{36}Ar$ and $^{40}K/^{36}Ar$ isochron method. The materials analyzed were: bulk rocks, micas, K–felspars [1].

The minerals were separated from the rocks by conventional enrichment methods; argon was extracted and purified according to the method proposed by Nicoletti and Petrucciani (1977).

Argon isotopic analyses were performed with an A.E.I. MS 10 mass spectrometer; potassium was determined by flame spectrophotometry using an Optica model CF4.

Our age determinations on laboratory standards are:

muscovite P207:	80.2 ± 1 m.y. (81 ± 1 m.y.)	international standards
muscovite Berna 4M:	18.1 ± 0.8 m.y. (18.7 ± 0.5 m.y.)	
phonolite MZ:	7.5 ± 0.3 m.y. (7.4 ± 0.2 m.y.)	
biotite LP6:	12.3 ± 3 m.y. (12.5 ± 2 m.y.)	
Elba biotite:	7.3 ± 0.4 m y. (7.1 ± 0.3 m.y.)	our laboratory standards
M. Arci obsidian:	2.9 ± 0.2 m.y. (3 ± 0.2 m.y.)	

Table I shows the analytical results: " conventional " ages of all the analysed samples range from 19.1 to 88.7 m.y. (i.e. Miocene-Late Cretaceous).

From sample CK 54 we could only obtain data on bulk rock and felspars: two points falling too close on the diagram $^{40}Ar/^{36}Ar$ vs $^{40}K/^{36}Ar$ could not be distinguished; consequently, in this case the " ^{40}Ar rad vs K % isochron method " was used. Since the isochron line intersects the " 0 point " of the diagram (fig. 2) the rock seems to have a negligible initial Argon content. All the other samples contain ^{40}Ar in excess.

GENERAL REMARKS

The data here presented, compared with those known from the literature, provide a better chronological framework of igneous intrusions related to the formation of the Karakorum chain during the main Alpine orogeny, and give new elements for correlation of the different batholiths. Unfortunately the small number of samples analyzed and the metamorphism of some of

(1) Plagioclase and K–felspar in minor amount in the sample CK 54.

TABLE I.

Sample	Locality	Lithotype	Geological Pertinence	Mineral	^{40}Ar rad. CC.STP/g 10^{-6}	^{40}Ar rad. %	K %	Conventional Age (m.y.) [1]	Intercept	Isochron. Age	Stratigraphic Age [3]
CK 5	Darkot Pass	Granite with mortar structure and low recrystallization	Axial batholith	Bulk rock Biotite K–Felspar	9.106 14.693 13.802	72.6 70.5 82.4	3.04 6.06 9.22	72.4±2.2 57.8±1.7 36.9±0.7	732±46	25.1±2.0	Miocene Oligocene boundary
CK 21	Between Darkot and Umalsit	Gneiss	Gamugal batholith	Bulk rock Biotite K–Felspar	6.042 19.993 16.703	77.4 69.0 84.4	2.38 6.02 8.27	62.5±1.9 81.4±2.4 49.9±1.5	659±21	40.3±1.0	Late Eocene
CK 23	Near Umalsit	Granodiorite with ipidiomorphic structure	Gamugal batholith	Bulk Rock Biotite K–Felspar	10.043 17.447 16.770	88.5 86.2 94.0	2.77 4.99 10.15	88.7±2.7 85.6±2.6 64.9±2	1085±99	56.2±2.2	Late Paleocene
CK 38	Near Yasin (not in place)	Granodiorite with ipidiomorphic structure	?	Bukl rock Biotite K–Felspar	6.502 7.689 19.439	66.9 83.2 90.9	2.73 3.35 8.80	58.7±1.8 56.6±1.7 54.5±1.5	367±29	55.1±0.5	Late Paleocene
CK 42	Between Yasin and Gupis	Granite with ipidiomorphic structure	Gindai batholith	Bulk rock Biotite K–Felspar	6.891 15.512 17.298	86.8 72.8 90.5	2.77 4.86 7.87	61.3±1.9 78.3±2.3 54.3±1.6	638±58	50.3±1.7	Early Eocene
CK 45	Between Yasin and Gupis	Granite with ipidiomorphic structure	Gindai batholith	Bulk rock Biotite K–Felspar	6.064 19.201 14.033	87.2 77.2 84.6	3.17 7.24 7.49	47.3±1.4 65.3±1.9 46.4±1.4	725±52	37.4±1.6	Late Eocene
CK 54	Between Gupis and Gakuch	Granodiorite with mortar structure and low recrystallization	Plutons of the Gilgit valley (Gakuch granite)	Bulk rock K–Felspar (enriched)	2.650 11.427	82.21 81.83	1.41 6.68	46.5±1.4 42.4±1.3	—	41.1 [2]	Late Eocene
CK 55	Gakuch	Leucogranite with mortar structure	Plutons of the Gilgit valley (Gakuch granite)	Bulk rock Biotite K–Felspar (enriched)	5.969 7.911 11.266	81.4 46.4 63.6	3.45 3.32 6.06	42.5±1.2 58.8±2 45.4±1	371±8	41.7±0.4	Late Eocene
CK 57	5 miles west of Gilgit	Granite with mortar structure and advanced recrystallization	Plutons of the Gilgit valley	Bulk rock Biotite K–Felspar	3.589 6.178 7.582	82.7 78.5 97.0	3.84 6.65 9.88	23.2±0.7 23.1±0.7 19.1±0.6	541±24	19.2±0.1	Early Miocene

(1) Age calculated assuming all ^{36}Ar is air Argon. (2) ^{40}Ar rad vs K % isochron representation. (3) According to Berggren (1972).

them, in addition to the degree of uncertainty of the method itself, make the ensuing indication subject to further control.

On the basis of the available data the investigated samples seem to belong to groups of different age.

The oldest group has an age ranging from 56 to 50 m.y. (Late Paleocene to Early Eocene): it includes granodiorites and granites of the middle and lower Yasin valley where the most important intrusive body is the one named here Gamugal.

The radiometric data are in agreement with the aforementioned Matsushita's interpretation, rather than Ivanac's: the Gamugal batholith does not belong to the axial Karakorum batholith which is located far to the north (Hindu Raj Range). The Gamugal batholith seems to plunge eastwards under the sedimentary cover of the Darkot Group, whereas it would reach its main width westwards through Mastuj in the Bunj Zom mountain group (Gamerith and Kolmer, 1973).

A more recent age (40 m.y. = Late Eocene) was recorded from the same batholith by sample CK 21: the high degree of metamorphism of the latter sample is considered responsible for such a discrepancy.

Some doubts arose as to the age of the small intrusive body from Gindai. One of the samples, CK 42, has an Early Eocene age; the other sample, CK 45, is dated Late Eocene. The Early Tertiary age of both Gindai samples is in agreement with the fact that the granitic bodies have been intruded into the older gneissic amphibolites (= Matsushitha's Early Cretaceous Green Series).

The granitic bodies (Gakuch granite) cropping out on the southern side of the Gilgit valley belong to the same group with radiometric ages of 40–41 m.y. (Late Eocene), which could be correlated with that of the Deosai granites, referred to the Eocene because of its stratigraphic position (Wadia, 1937) and its radiometric age (Desio *et al.*, 1964). These two granitic bodies, from the Gilgit and Deosai regions respectively, are separated by the Nanga Parbat-Haramosh structure, interpreted as the northern edge of the Indian plate (Desio, 1976), which reached its present structural location during the collision of the Indian and Eurasian plates.

The last group of samples (CK 5 and CK 57) is more recent than those previously described (25–19 m.y. = Oligocene-Miocene boundary and Early Miocene). Sample CK5 collected at the Darkot pass has an age comparable to the ones obtained for the samples from the Biafo and Hispar regions (Desio *et al.*, 1964) which belong to the axial Karakorum batholith; this age similarity would suggest that the Karakorum batholith crops out further to the NW, in the Hindu Raj. It consequently forms a wide arc located north and east of the Gamugal batholith, separated from the latter by the thick Paleozoic sedimentary sequences (Hayden, 1916; Matsushita and Huzita, 1965; Casnedi, 1975). The successions from this area correspond to the Paleozoic formation cropping out in the upper Yarkhun and Hunza valleys (Desio and Martina, 1972).

Sample CK 57 belongs to a batholith cropping out on the southern side of the Gilgit valley. Its age supports the presence in the region of more than one intrusive cycle; however, the rock could actually be slightly older than radiometrically estimated because of the strong recrystallization undergone.

The samples have been collected and described by R. Casnedi and F. Forcella; absolute age determinations by M. Nicoletti and C. Petrucciani.

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