Geochronological constraints on the evolution of Meghalaya massif, northeastern India: An ion microprobe study

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^{207}Pb–^{206}Pb isotope systematic of zircons from quartzofeldspathic gneisses and metasediments belonging to the basement gneiss and Shillong group of the Meghalaya massif has been investigated using an ion microprobe. The zircon age of the gneissic samples revealed the existence of multiple protolith components ranging in antiquity between ~1.5 and 2.6 Ga. The age distribution of the detrital metasedimentary zircons is similar to the range of the gneissic protoliths. Zircons from a charnockite sample yielded ages of 1.0–1.3 Ga, presumably recording the global Grenvillian orogeny. Our data suggest that crust formation in the Meghalaya massif started during the Archaean and experienced a protracted and episodic evolution that has some similarity with the Eastern Ghats Province.

Keywords: Basement gneiss, ion microprobe, Meghalaya massif, Shillong group, zircon.

THE Indian shield is one of the oldest and best-preserved Archaean continental fragments on earth. A good deal of work has already been done in the cases of prominent cratons from various regions of the Indian shield (viz. Singbhum in the east[1], Aravalli in the west[2,3], Dharwar in the south[4–6]) although little attention had been given to Precambrian lithounits in the northeastern part of India. The Meghalaya massif forms the basement of northeastern India. It is considered to be the extension of the Eastern Ghats granulitic terrain[7]. The age of the rock types of the area ranges from Proterozoic to Tertiary. The area comprises mainly of Precambrian basement gneisses, overlain unconformably by metasediments of the Shillong group. Metamorphosed mafic intrusives locally known as 'Khasi Greenstone' are confined within the Shillong group. Several Pan-African affinity porphyritic granitoid plutons and Early Cretaceous ultramafic–alkaline–carbonatite complexes intrude the gneissic basement and the Shillong group. The southern part of the massif is covered by the Sylhet trap and Tertiary sedimentary sequences. Reconstructing the tectonic history of Precambrian terrains is often difficult due to the relative scarcity of exposure and the imprint of later geological processes that obscure the primary information. Geochronological data have the potential to provide useful inputs to infer plausible evolutionary processes affecting the Archaean/Precambrian terrains. In the case of the Meghalaya massif, scarcity of basement outcrops, weathering of the exposed samples, metamorphic history and deformation affecting the samples and paucity of geochronological data are factors hindering our understanding of the Precambrian geology of the area. The aim of this communication is to obtain further insights into the evolution of the Meghalaya massif based on the determination of Pb–Pb age of zircons from the basement gneisses and Shillong group metasedimentary rocks.

Three gneisses, two quartzites and one charnockite from the Meghalaya massif were studied. Among the three gneisses, one was collected from the village Umling (GPS coordinate 25°57′25.8″N, 91°51′32.9″E) about 2 km from Nongpoh, Ri-Bhoi district on the Shillong–Guwahati highway, another sample from Riangdo, West Khasi Hills and the third from a spot about 2 km from Rhesu village (GPS coordinate 25°54′34.7″N, 90°35′50.5″E) on the Medipathar–Tura road, Garo Hills. The two quartzite samples are from Ri-Bhoi district, one from a quarry about 1.5 km from the Umrai Cantonment (GPS coordinate 25°42′25.3″N, 91°56′42.7″E) and another from a spot on the Shillong–Jowai Highway (GPS coordinate 25°32′06″N, 91°58′19.9″E). The charnockite sample was collected from a spot about 30 km on the Nongstoin–Riangdo road. The analysed gneissic samples have the assemblage quartz, K-feldspar, plagioclase, amphibole and biotite; zircon and opaques are present as the accessory phases. The metasedimentary samples are pure quartzite with no ferromagnesian phase. Petrographically the charnockite sample consists of K-feldspar, plagioclase, quartz and orthopyroxene.

The samples were processed using standard technique[2] to obtain zircon grains. Each sample was crushed into centimetre-sized chips and was thoroughly washed after eliminating the weathered portions. The clean chips from each sample were then pulverized to <250 μm in a clean environment using a stainless steel piston and cylinder. Non-magnetic, high-density mineral grains were concentrated by density separation using aqueous Na–polytungstate solution (density = 3 g per cubic cm) followed by magnetic separation using a Frenz isodynamic separator. Zircon grains were handpicked from this fraction using a binocular microscope. Individual, clear, unfractured and least intensely coloured zircons were selected and mounted on a double-sided tape, cast in epoxy and sectioned by polishing. Transparent zircons with simple internal structure were documented in detail. Zircons from the gneissic samples are transparent, colourless to pale brown, mostly inclusion-free, typically elongate to subrounded, with consistently rounded termination. The detrital zircons of the metasediment are subhedral, transparent and colourless to brownish. The rounding of the gneissic zircons might be due to dissolution and recrystallization[8], caused by high-temperature metamorphism, a feature found in

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zircons from high-grade terrains[9]. Some of the zircons show fine zoning, while a few others have distinct overgrowths. The zircon mounts were thoroughly cleaned in ethanol using an ultrasonic bath and coated with a 100 nm thick, high-purity gold film for isotopic measurement using an ion microprobe.

A Cameca ims-4f ion microprobe was used for measuring $^{207}Pb/^{206}Pb$ isotopic ratios in the zircons. Analytical procedures used in this study were similar to those reported in Wiedenback and Goswami[10]. The instrument was operated at a mass resolution ($M/\Delta M$) of ~4600, sufficient to resolve all the significant isobaric molecular interferences in the Pb isotope mass spectrum. A 7 nA focused $^{16}O^-$ primary beam was used to sputter ~20 μm domain of individual zircon grains. Secondary sputtered ions were accelerated through a potential difference of 4.5 kV, energy sorted using an electrostatic analyzer and mass analysed using an electromagnet. Each analysis consisted of 15 blocks of data and each block comprised of five scans through the mass sequence $^{204}(Zr_2O)$, ^{204}Pb, ^{206}Pb, ^{207}Pb, $^{208}(HfO_2)$ and ^{208}Pb in peak jumping mode. The age for a given analysis was inferred from the weighted mean $^{207}Pb/^{206}Pb$ ratio obtained from the data of the 15 quasi-independent blocks that were corrected for common Pb, following the method of Cumming and Richards[11]. Exclusion of uranium isotopes in our measurement routine rules out the possibility of having specific information on Pb-loss as well as the presence of multiple age components within our dataset. Several objective criteria[2,10] were used for identifying analyses belonging to the magmatic component and the age of a sample was derived from the mean radiogenic $^{207}Pb/^{206}Pb$ ratio obtained by pooling the data (at block level) for all such analyses. The inferred age may be considered as the ‘minimum’ age of the sample. However, for samples that show a sharp cut-off in higher radiogenic $^{207}Pb/^{206}Pb$ ratios, the minimum age closely approximates the true age of the sample. Details of the procedure adopted for data acquisition and assessment are reported in the literature[2,10].

Ten analyses were conducted on seven zircons from the Umling gneissic sample and the results are presented in Table 1. The obtained zircon ages reflect imprints of isotopic mobilization during the Archaean and Proterozoic period. One grain with a distinct core–rim morphology yielded an Archaean age of 2637 ± 55 Ma (#7B) for the core, while the rim material yielded a younger age of 2230 ± 13 Ma (#7D). Four analyses in two zircons (#1A, B, 2A, B) yielded comparable ages and the combined data provide a weighted mean radiogenic $^{207}Pb/^{206}Pb$ value of 0.09766 ± 0.00079 corresponding to an age of 1580 ± 15 Ma. The zircon ages ranging from 1.67 to 1.98 Ga (#3, 4, 5, 6) for the other grains may represent zircon growth or modification during secondary events, although it is not possible to uniquely identify such events. We note that metamorphic age of ~1.7 Ga for granitoid gneiss was reported by Ghosh *et al.*[12] for the Patharkhang area.

Only two out of six analyses conducted in five zircons from the Riangdo gneissic sample (#7a) could be considered (Table 1), as the common lead component is rather high (>10%) in the other zircons; most of the zircons from this sample also have high uranium content. The results obtained in the two homogenous grains yielded ages of 1451 ± 129 and 1415 ± 48 Ma, that are similar to the whole rock Rb–Sr isochron age of the South Khasi pluton noritic enclaves[12]. Nine analyses were conducted on five zircons for the Rhesu area (Garo Hills) gneissic sample; three analyses with low common lead component ranging between 1.54 and 1.84 Ga are presented in Table 1. This age cluster falls within the age range of the Umling gneiss indicating the contemporaneous nature of the two gneisses. Six analyses in five zircons were conducted in the charnockite sample from the Nongstoin–Riangdo road, two of these analyses having low common lead component are presented in Table 1. They yielded ages of 1284 ± 60 and 1077 ± 81 Ma respectively. Although it is not possible to ascertain the significance of these ages, it can be noted that they are similar to the Grenvillian Orogeny documented in the Eastern Ghats Province. The ages obtained by us for samples from the Meghalaya massif reflect several episodes of isotopic mobilization affecting the zircons in this region.

The lack of considerable rounding of zircon extracted from the quartzite indicates that it may have experienced only limited transport and had a proximal source. Sixteen analyses were conducted on sixteen zircons from the Shillong–Jowai highway quartzite sample. However, most of them are characterized by high common Pb component, and data from analysis with low common lead are presented in Table 1. The detrital zircons yielded ages in the range of 1.62–1.98 Ga, which are much older than the reported 1.53–1.55 Ga zircons of the Shillong group[13]. Two homogenous zircons yielded nearly identical ages of 1673 ± 58 and 1617 ± 74 Ma respectively. Analyses performed in the core regions of two grains showing core-overgrowth morphology yielded distinctly older ages of 1825 ± 53 and 1979 ± 65 Ma respectively. No meaningful analysis of the overgrowth could be done due to their high common lead content. Quartzite sample from the Umrai area displays an irregular distribution of age (Table 1). Two zircons yield ages of 1.48 and 1.75 Ga, respectively because of high common Pb component, a third grain yielding an age of 2.72 Ga is not considered. The upper limit of the deposition of the Shillong group was constrained by the 1.48 Ga age of the youngest detrital zircon. The age distribution of detrital zircons (Table 1) suggests that the sediment was derived from Mesoproterozoic to Paleoproterozoic terrain, along with a probable minor Archaean component.

It is difficult to ascertain if the lower ages reflect Pb-loss associated with younger events. The younger ages of the charnockite and gneisses are in conformity with the reported Rb–Sr isochron ages for migmatization

Table 1. ^{207}Pb–^{206}Pb zircon age data of Meghalaya

Analysis no.[a]	Measured		Total	^{206}Pb[b]				
	^{204}Pb/^{206}Pb	^{207}Pb/^{206}Pb	^{206}Pb (counts)	(ppm)	U[c] (ppm)	^{207}Pb/^{206}Pb[b]	Obs./Exp.[d]	Age[e] (Ma)
Gneiss from the Umling area (5J), GPS coordinate 25°57′25.8″N, 91°51′32.9″E								
1A	n.d.	0.0989	175,280	569	2344	0.0989 ± 15	2.42	1604 ± 29
1B	n.d.	0.0979	40,100	174	728	0.0979 ± 28	1.43	1584 ± 53
2A	0.00033	0.1027	186,845	1146	4760	0.0983 ± 18	1.83	1592 ± 33
2B	n.d.	0.0967	106,685	258	1096	0.0967 ± 32	3.59	1560 ± 61
3	n.d.	0.1217	62,280	428	1386	0.1217 ± 24	1.7	1981 ± 34
4	0.00057	0.1134	106,970	186	704	0.1057 ± 25	1.59	1727 ± 43
5	0.00016	0.1049	103,125	594	2329	0.1028 ± 18	1.23	1675 ± 32
6	0.00038	0.1164	124,220	643	2290	0.1114 ± 34	2.75	1822 ± 55
7B (core)	0.00154	0.1974	64,915	851	1959	0.1783 ± 59	1.96	2637 ± 55
7D (rim)	0.00026	0.1436	170,725	470	1325	0.1402 ± 11	1.08	2230 ± 13
Gneiss from the Riangdo area (7a)								
2B	0.00088	0.1034	24,395	112	517	0.0912 ± 61	1.05	1451 ± 129
6	0.00066	0.0987	79,215	898	4257	0.0895 ± 22	1.17	1415 ± 48
Gneiss from Rhesu area on the Medipathar–Tura Road, GPS coordinate 25°54′34.7″N, 90°35′50.5″E								
2	0.0003	0.1033	39,505	39505	3259	0.0992 ± 37	1	1609 ± 69
3A	n.d.	0.0953	18,570	18570	2107	0.0953 ± 55	1.38	1535 ± 110
5B	n.d.	0.1138	19,755	19755	3184	0.1138 ± 40	1.05	1862 ± 63
Charnockite sample from the Nongstoin–Riangdo Road (7g)								
3A	0.00011	0.0945	131,025	584	3084	0.0836 ± 26	1.58	1284 ± 60
4	0.00009	0.0834	152,295	579	3707	0.0753 ± 31	2.31	1077 ± 81
Quartzite about 1.5 km from the Umrai Cantonment (5d), GPS coordinate 25°42′25.3″N, 91°56′42.7″E								
2	0.0004	0.1126	35,370	179	669	0.1071 ± 41	1.01	1751 ± 70
3	0.00074	0.103	25,480	68	306	0.0927 ± 57	1	1481 ± 116
Quartzite from the Shillong–Jowai Highway (4b), GPS coordinate 25°32′06″N, 91°58′19.9″E								
6	0.00008	0.1038	29,210	54	213	0.1027 ± 32	1.02	1673 ± 58
10 (core)	0.00042	0.1173	45,010	67	240	0.1116 ± 33	1.02	1825 ± 53
11	0.00026	0.1033	35,865	56	230	0.0996 ± 39	1.01	1617 ± 74
16 (core)	n.d.	0.1216	19,435	40	130	0.1216 ± 45	1.16	1979 ± 65

[a] The letters refer to multiple analyses of single zircons.

[b] Radiogenic value corrected using model common Pb following Cumming and Richards[11]. ^{206}Pb content based on instrument sensitivity (counts/s/ppm ^{206}Pb) determined using a standard (91500) of known composition[10].

[c] Calculated value based on the assumption that the sample has remained a closed system.

[d] This is the ratio between the observed and expected (ion counting based) precision estimates.

[e] Errors are 1σ.

n.d.: No ^{204}Pb counts were detected.

(1150 ± 26 Ma) near the Nongpoh and the noritic enclave age of the South Khasi plutons (1462 ± Ma)[12]. It has long been considered that the Meghalaya massif forms a part of the Gondwanaland, but so far no reliable Archaean age has been found in the area. The oldest reported age from the area is ~1.7 Ga, obtained using Rb–Sr isochron and EPMA monazite dating methods[12,14,15]. Our study provides evidence for the presence of >2.6 Ga-old gneissic zircon in this area and constrains the time of emplacement of the magma that formed the igneous precursor of the granitic gneiss. This also substantiates the presence of Archaean basement in northeastern India, linking it to the crustal components of Gondwanaland of similar ages. The similarity in the ages of detrital and basement gneiss zircons and evidence for limited transport of the sedimentary protoliths suggest that the detrital metasedimentary zircons might have been derived from the basement gneisses. The zircon ages from the present study indicate that the Meghalaya massif represents an Archaean to Neoproterozoic tectonostratigraphic sequence. Further, a comparison of the zircon ages from the Meghalaya massif and geochronological data for the Eastern Ghats Belt[16] suggests that the Precambrian basement rocks in northeastern India and the Eastern Ghats Belt have imprints of similar geological episodes, and these discrete terrains may have experienced a common petrogenetic process.

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Ethnobotanical studies of Shompens – A critically endangered and degenerating ethnic community in Great Nicobar Island

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Shompens, a dwindling and critically endangered Mongoloid aboriginal tribe inhabiting the Great Nicobar Island, indicate poor prospects of population growth in the near future. Ethnobotanical studies conducted among the Shompens inhabiting Jhaunala, Laful, Shompenhut and Kopenheat areas have revealed some interesting plants used for food, medicine, hut construction, canoe making and honey collection. Botanical name, family, Shompen name and plant parts used are recorded along with their unique usage.

Keywords: Ethnobotanical studies, Great Nicobar Island, medicinal plants, Shompens.

SHOMPENS are one of the most primitive tribes of the Andaman & Nicobar (A&N) Islands and constitute one-sixth of its total population[1]. The Shompen tribe is one of the dwindling Mongoloid aborigines and presently it is an ethnic oddity. It is a forest-dwelling tribe inhabiting the Great Nicobar Island (Figure 1) which constitute 'the home of Shompens'. However, the island does not provide much clue about the origin of the Shompens. Probably, they might have migrated several years back from the nearby Malaysian regions and made the Great Nicobar Island their home. However, legends place them at the time of great epic – *the Ramayana* – which states that they were sent by Lord Rama in search of Sita. Having failed in their mission, they decided not to go back, as they dreaded the wrath of Lord Rama.

Shompens are semi-nomadic food-gatherers and hunters with stone-age civilization. They live in small groups in the dense interior forests of the island. Being suspicious and shy, they have rejected all contacts with the outside world; however, they are not hostile. They are well-built and taller than the Nicobarese (Figure 2 *a*). They have slightly dark complexion and their features, especially their noses and jaws are quite prominent. The term Shompen might be the outcome of the British pronunciation of the Nicobari term 'Shamhap' meaning 'one who lives in forests'. The Nicobarese call them 'Shompehan' and 'Champion'. Perhaps Shompens are the last remnants of the Malay race who maintain a separate existence in

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