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Mineralogy of Meteorites from the North-Eastern India: A Brief Review

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Abstract

We present a brief overview of meteorites from the north-eastern India, with a focus on falls, finds, and research developments. To date, out of a total 150 numbers of meteorites fall/find in India (in Meteoritical Bulletin Database), only six meteorites from north-eastern region have received official international recognition from the Nomenclature Committee of the Meteoritical Society. Among these six meteorites, 2 finds and 4 falls, including one ureilite, two H chondrites and three L chondrites. The first meteorite from north-eastern India (Assam L5, Find) was documented in 1846. After a lack of 153 years, the first fall (Sabrum LL6 chondrite) was documented in 1999. The most recent fall is Kamargaon (L6) chondrite in 2015. Intensively researched meteorites of this region are Goalpara and Dergaon. The reported most massive meteorite of north-eastern India is Mahadevpur (H4/5) chondrite, 70.5 kg of total known weight, and the rest are <13 kg of total known weight. The researches on these meteorites from north-east India can be applied to the newly recovered meteorites to understand the astrophysical enigma.

Keywords

Meteorite, Mineralogy, North-East India

1. Introduction

Rocks of extraterrestrial origin that penetrate the atmosphere and reach the Earth's surface are called meteorites. Meteorites recovered following observed falls are called falls; those which cannot definitely be associated with observed falls are called finds [1]. The fall and find of a meteorite is quite rare. The meteorites are classified on the basis of their mineralogy, structure and chemical compositions [2] [3] [4]. The major classification of meteorites is: stony meteorites

constituting 92.8% of all meteorites, stony iron meteorites constituting nearly 1.5% and iron meteorites with abundance of 5.7%. The standard method for identifying meteorites is to compare the chemical composition of the sample with that of the meteoritic rock previously studied [5]. The explosive growth of meteorite inventory has been accompanied by a steady growth in the science of meteoritics, and associated fields of observational small body astronomy, cosmochemistry, and astrobiology. The study of meteorites has specific contributions to materials science, e.g., discovery of new minerals, a refinement of our picture of the evolution of the solar system [6] [7]. A multidisciplinary approach to the documentation and interpretation of a meteorite provides interesting opportunities to the understanding of diverse scientific fields (e.g. [8]). Meteorites provide the most substantial evidence of the chemical and physical makeup of asteroids. The broad objectives of the meteorite studies are to understand the chemical and isotopic composition of the "solar nebula" that evolved to form the solar system objects, formation of the solar system, various physicochemical processes involved to their time scales and the present state of the solar system, connection of solar system with stellar environment, evolution of terrestrial planets including Earth, and to explore the origin and evolution of life and the dynamical processes involved in the meteorite delivery to Earth.

The Meteoritical Bulletin database recorded fall/find of Indian meteorites since 1621 (**Appendix Table A1**) with two ancient impact craters at Dhala (1700 - 2100 Ma) and Lonar (52000 ± 6000 a) of Madhya Pradesh and Maharashtra respectively. Meteorite studies in India have been initiated in late 1960s. During the journey of Indian meteorite studies, some major outcomes, e.g., scrupulous studies of isotope records in early solar system solids using secondary ion and noble gas mass spectrometry techniques at Physical Research Laboratory, which led to the identification of fossil records of short-lived nuclides of stellar origin in early solar system solids; identification of the short-lived nuclide ^{26}Al as the heat source for early melting of planetesimals, etc. The fall and find of meteorite recovery rate in the north-eastern region of India is very low, yet some very special finds have been recovered (e.g. Goalpara).

2. Meteorites Fall/Find in North-East India

Here is a quick chronological survey of all meteorites from north-east India, including some of the most extensively-researched examples, with emphasis on the subjects of research in this field. **Table 1** represents the meteorites fall/find in north-east India.

The meteorite documentation era of north-eastern region of India was started with the documented meteorite Assam L5 (1846) by Silberrad [9]. It is worthwhile to mention that, out of 150 documented meteorites from India (to date), only six meteorites have been officially recognized by Nomenclature Committee of the Meteoritical Society from north-eastern region of India with various sizes and chemical classes.

Table 1. List of meteorites fall/find in north-east India during last two centuries.

Meteorite	Fall/Find	Year of Fall/Find	Weight (kg)	Fragments	Type	References
Assam	Find	1846	2.7	Three	L5	[9]
Goalpara	Find	1868	2.7	Single	Ureilite	[9]
Sabrum	Fall	30 April 1999	0.478	Single	LL6	[18]
Dergaon	Fall	2 March 2001	12.5	Multiple	H5	[19]
Mahadevpur	Fall	21 February 2007	70.5	Multiple	H4/5	[25]
Kamargaon	Fall	13 November 2015	12.1	Single	L6	[31] [32] [33]

3. Studies on these Meteorites

Assam (26˚00'N; 92˚00'E) is the first documented meteorite "find" in North-eastern India. Total known weight of this meteorite was 2.7 kg in the form of three fragments, was recovered from Meghalaya in 1846 [9]. Assam is a fine representative of one of the most abundant meteorite classes L5 chondrite.

Goalpara (26˚10'N, 90˚36'E) meteorite is "find" in 1868, a stony meteorite belong to ureilite achondrite. In last few decades it has become arguably the most-researched meteorite from north-east India. Ureilite-achondrite is a rare type of stony meteorite that has a unique mineralogical composition, which is very different from that of other stony meteorites. It has seen a level of research being described in various articles. The total known mass of this meteorite is 2.7 kg and it is the massive of all Indian ureilites. Goalpara was the most massive ureilites known before the recovery of the Kenna ureilite in 1972. Only three of this rare class has been documented from India, among them, except Goalpara, both Dyalpur (1872) and Lahrauli (1955) are fall. Ureilites contain slightly high amounts of trace elements like Cr, Mn and Zn, but the distribution of trace elements like zinc between different silicate mineral phases is not well known. Bulk zinc contents of the more heavily shocked ureilites are lower compared to the weakly shocked ureilites. The reason for the low levels of zinc in Goalpara olivines is not yet understood [10]. The Goalpara is one of the heavily shocked ureilites which contains lonsdaleite together with diamond (see [11]). Goalpura meteorite has been identified as a stony meteorite that lacks chondrules and originated on a differentiated parent body. The petrographic studies of Goodrich also indicate Goalpara experienced higher shock pressures and temperatures [12]. Presence of lonsdaleite and diamond in carbon grains of Goalpara ureilite was reported by many authors (e.g. [11] [13] [14]). Generally, lonsdaleite is not found weakly shocked ureilites. Nakamuta and Toh (2013) observed coarse-grained olivine and pigeonite with minor amounts of blade-like shaped carbon grains and mosaic texture of olivine and pyroxene crystals in Goalpara ureilite. The well crystallized graphite coexisted with olivine and pyroxene during igneous processes is converted to high-pressure diamond by impact (see [15] [16]), which suggests that the meteorite has been heavily shocked [17]. Other polymorphous of carbon (e.g. chaoite and graphite) are also found in Goalpara ureilite. The black, fine grained agglomerates, a few tenths of 1 mm in sized diamond in Goalpara and

Dyalpur are formed under shock above 160 kb. In Goalpara ureilite, diamonds are mainly cubic, with less than 10 percent hexagonal (see [11]). According to Hanneman *et al*, there is no evidence of hexagonal diamonds of terrestrial origin and also cubic diamond cannot be transformed into hexagonal under static or shocked pressure combined with temperature. Therefore, they conclude that the diamonds found in Goalpara ureilite were formed by impact shock in space from well crystallized graphite existing with the meteorite before impact [11].

Sabrum (23˚05'N; 91˚40'E) is one of the six Indian LL6 chondrites, among Segowlie (1853), Dhurmsala (1860), Manbhoom (1863), Bhawad (2002) and Sulagiri (2008) of this class. It is the first documented "fall" of this region. The total known weight of Sabrum is 478 g. The major mineral composition of Sabrum is olivine ($Fa_{31.4}$), orthopyroxene ($Fs_{25.1}$, $Wo_{2.0}$), clinopyroxene ($Wo_{45}En_{45.6}Fs_{9.4}$) and plagioclase ($An_{10.6}Ab_{83.6}Or_{5.8}$) [18]. This meteorite is belongs to S4 category with moderate shock features and the exposure age 24.8 Ma. The activities of most of the short-lived isotopes indicate the low galactic cosmic-ray fluxes over the orbital space of the meteoroid during the last few years prior to its fall. The observed cosmic-ray f1uxes of Sabrum corresponding to the solar quiet period between cycles 22 and 23 appear to be anomalously low and require further investigation (see [18]).

Dergaon (26˚42'N, 93˚51'E) is the fourth meteorite "fall" in north-east India (**Figure 1**). It is also an exhaustively studied meteorite of this region. A multiple fell of meteorite was observed on 2nd March, 2001, with a fireball accompanied by two land detonations. The largest fragment, weighing 10.3 kg, was recovered in the village of Balidua, ten km west of Dergaon town. Additional fragments were recovered in the village of Koilaghat of weighing about 1.5 kg and two fragments, each of weighing about 1 kg, were recovered in Majuli. The possibilities of other fragments fell in the Brahmaputra River channels cannot be ignored. The total known weight of this meteorite is 12.5 kg. This fall is classified and documented as Dergaon H5 chondrite [19]. The detail focussed on integrated petrology, bulk chemistry, oxygen isotopes, noble gas and cosmic ray track density of Dergaon reported by Shukla *et al.* (see [20]). A cosmic ray exposure of 9.7 Ma for Dergaon is inferred from the cosmogenic noble gas records (see [20]). Dergaon is a classic example of H chondrite with high chondrule-matrix ratio. The chondrules of Dergaon contains porphyritic olivine, porphyritic

Figure 1. Photographs of some meteorites fell in North-eastern India. (a) Dergaon H5; (b) Mahadevpur H4/5; (c) Kamargaon L6.

pyroxene, porphyritic olivine pyroxene, barred olivine, and barred pyroxene nearly 75% and about 25% non-porphyritic chondrules mainly radial pyroxene, cryptocrystalline, granular pyroxene and glassy ([21], see [22]). The lower value of K makes Dergaon notable among the H chondrites. The volatile elements such as Zn and Se are also absent in this meteorite. Besides olivine, orthopyroxene and clinopyroxene, kamacite and rare occurrences of taenite are also observed as exsolved lamellae in the metallic phases. Ray *et al.*, has presented a reasonable explanation for bulk K depletion, interpretation of chondrule formation and shock-thermal history of the Dergaon. The vesicular texture in shock-melted feldspar and concomitant loss of K were attained during the post-shock decompression stage under low pressure (see [22]). The infrared stretching features of aliphatic hydrocarbon in Dergaon were reported by Saikia *et al* [23] [24]. The weathering of the meteorite sample cannot be overlooked for presence of these features. To date, Dergaon is one of the fifteen documented Indian H5 chondrites.

Mahadevpur (27˚40'N, 95˚47'E) of total known weight 70.5 kg, is the largest documented multiple fall of north-eastern India [25] [26]. The largest fragment, weighing 60 kg (**Figure 1**), was recovered in Pangari, about 40 km away from Mahadevpur. To date, only two Indian meteorites has classified of type H4/5. (*i.e.* Mahadevpur (2007) and Kendrapara (2003) chondrite). The mineralogical phases of olivine in Mahadevpur are: olivine ($Fo_{80.8}Fa_{19.3}$), orthopyroxene ($En_{81}Fs_{17}Wo_1$), and clinopyroxene ($En_{58}Fs_8Wo_{35}$) [27], albitic plagioclase ($Ab_{87}Or_3An_{10}$), kamacite, taenite, apatite and rare chromite [25]. The matrix is a heterogeneous mixture of chondrule fragments, olivine, ortho-pyroxene and plagioclase. Chondrule sizes range from 250 to 1300 mm. The Raman and infrared spectroscopic analysis of Mahadevpur reflects a partially polymerized silicate framework [27] [28]. Red luminescence characteristic features of olivine in Mahadevpur by Laser-induced fluorescence (LIF) are also reported by Dehingia and Baruah [29]. Olivine in chondrules and matrix do not show compositional variation, suggesting that Mahadevpur is an equilibrated H-chondrite. The noble gas analyses suggest the exposure age of Mahadevpur is 6 Ma (see [30]).

Kamargaon (26˚39'01"N; 93˚46'02"E) is the most recent fall of north-eastern India (**Figure 1**). A single stone fell from clear sky at the mustard oil cultivation field of the Bali-chapari village, near Kamargaon town in Golaghat District of Assam, India, on 13th November 2015 at 12:00 hrs (Local time) with fireball and a tremendous sound [31] [32]. The stone was fully covered with fusion crust and had well rounded edges and well developed regmaglypts (thumbprint like impressions) on its surface, that are formed by ablation of material from the surface as a meteor passes through the Earth's atmosphere. The strike of the meteorite makes a crater of 1.5 ft diameter and penetrated the ground 3ft in depth. A single piece of meteorite of weight 12.095 kg is recovered and preserved under the custodian of the local police station. The fusion crust (about 1 mm of thickness) and the regmaglypths are clearly visible on the surface of Kamargaon meteorite. The olivine composition is estimated to Fo: 78.98 mol %; Fa: 20.80 mol % and

Tp: 0.88 mol %. The bulk chemical composition and mineralogical data indicates that the Kamargaon meteorite is an L6 chondrite. In Kamargaon, $^{22}Na/^{26}Al$ activities ratio is lower than expected values for an L chondrite fall during the declining stage of solar cycle 24 [33].

4. Conclusion

All meteorites from north-eastern India were belongs to ordinary chondrites except Goalpara, which is stony achondrite. The studies of meteoritic olivine of these meteorites have been reported by many authors (e.g. [18] [34] [35] [36] [37]). The carbon polymorphous hexagonal diamond is usually formed in static and shock high pressure. The presence of diamond in Goalpara reflects this phase of temperature and pressure condition under which these diamonds are formed. The crystalline graphite is the main source of the meteoritic diamonds in Goalpara. Presence of nanodiamonds in Dergaon and Mahadevpur is also reported by Saikia *et al.* (see [38]). This finding has important implications concerning the origin of meteoritic diamonds. As the meteorites from north-east India are most common type chondrites, they originate from debris of the solar nebula (e.g. [7] [39]). Due to their unique origin, these chondrites are also regarded as the sole witness for the formation of the early solar system. For example, Dergaon chondrite reports several significant observations that help to understand both nebular and asteroidal processes (e.g. [22]). Meteorites still hold many secrets about our earth and other solar system bodies that are yet to be deciphered. The researches on the meteorites from north-east India will undeniably contribute to the understanding and demystify these secrets.

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Appendix

Table A1. List of meteorites from India (https://www.lpi.usra.edu/meteor/index.php accessed on 24.04.2017).

	Year	Place of Fall/Find	Type	Mass
Jalandhar	1621	Punjab, India	Iron	1967 g
Benares (a)	1798	Uttar Pradesh, India	LL4	3.7 kg
Benares (b)	--	Uttar Pradesh, India	Iron	--
Moradabad	1808	Uttar Pradesh, India	L6	70 g
Punganaru	1811	Andhra Pradesh, India	Stone-unclassified	100 g
Chail	1814	Uttar Pradesh, India	H6	0.5 g
Gurram Konda	1814	Andhra Pradesh, India	L6	28 g
Durala	1815	Punjab, India	L6	13.2 kg
Futtehpur	1822	Uttar Pradesh, India	L6	4 kg
Kadonah	1822	Uttar Pradesh, India	H6	89 g
Umbala	1822	Punjab, India	LL5	100 g
Oriang	1825	Rajasthan, India	Doubtful meteorite	--
Mhow	1827	Uttar Pradesh, India	L6	350 g
Kandahar (India)	1833	India	Doubtful stone	--
Charwallas	1834	Haryana, India	H6	12 kg
Akbarpur	1838	Uttar Pradesh, India	H4	1800 g
Chandakapur	1838	Maharashtra, India	L5	8.8 kg
Kaee	1838	Uttar Pradesh, India	H5	230 g
Myhee Caunta	1842	Gujarat, India	OC	--
Manegaon	1843	Maharashtra, India	Diogenite	50 g
Assam**	1846	Meghalaya, India	L5	2.7 kg
Singhur	1847	Maharashtra, India	Pallasite?	14.18 kg
Dharwar	1848	Karnataka, India	OC	1800 g
Shalka	1850	West Bengal, India	Diogenite	4 kg
Bustee	1852	Uttar Pradesh, India	Aubrite	1500 g
Yatoor	1852	Andhra Pradesh, India	H5	13.6 kg
Segowlie	1853	Bihar, India	LL6	6.93 kg
Sabetmahet	1855	Uttar Pradesh, India	H5	1250 g
Parnallee	1857	Tamil Nadu, India	LL3.6	77.6 kg
Dhurmsala	1860	Himachal Pradesh, India	LL6	32 kg
Kheragur	1860	Uttar Pradesh, India	L6	450 g
Kusiali	1860	Uttar Pradesh, India	L6	5 g
Butsura	1861	Bihar, India	H6	29 kg
Meerut	1861	Uttar Pradesh, India	H5	22 g
Manbhoom	1863	West Bengal, India	LL6	1700 g

Continued

Pulsora	1863	Madhya Pradesh, India	H5	560 g
Bheenwal	1865	Rajasthan, India	Doubtful stone	1470 g
Muddoor	1865	Karnataka, India	L5	4.4 kg
Shergotty	1865	Bihar, India	Martian (shergottite)	5 kg
Supuhee	1865	Uttar Pradesh, India	H6	7.24 kg
Jamkheir	1866	Maharashtra, India	H6	22 g
Pokhra	1866	Uttar Pradesh, India	H5	350 g
Udipi	1866	Karnataka, India	H5	3.6 kg
Khetri	1867	Rajasthan, India	H6	100 g
Goalpara**	1868	Assam, India	Ureilite	2.7 kg
Moti-ka-nagla	1868	Rajasthan, India	H6	1500 g
Nedagolla	1870	Andhra Pradesh, India	Iron, ungrouped	4.5 kg
Dyalpur	1872	Uttar Pradesh, India	Ureilite	300 g
Nagaria	1875	Uttar Pradesh, India	Eucrite-cm	20 g
Sitathali	1875	Madhya Pradesh, India	H5	1600 g
Judesegeri	1876	Karnataka, India	H6	680 g
Bhagur	1877	Maharashtra, India	L6	18 g
Dandapur	1878	Uttar Pradesh, India	L6	5.65 kg
Haraiya	1878	Uttar Pradesh, India	Eucrite-mmict	1000 g
Kalumbi	1879	Maharashtra, India	L6	4.5 kg
Andhara	1880	Bihar, India	Stone-unclassified	2.7 kg
Chetrinahatti	1880	Karnataka, India	Stone- unclassified	72 g
Pirthalla	1884	Haryana, India	H6	1161 g
Chandpur	1885	Uttar Pradesh, India	L6	1100 g
Nammianthal	1886	Tamil Nadu, India	H5	4.5 kg
Lalitpur	1887	Uttar Pradesh, India	L6	372 g
Kakangari	1890	Tamil Nadu, India	K3	350 g
Nawapali	1890	Orissa, India	CM2	105 g
Bansur	1892	Rajasthan, India	L6	15 kg
Bherai	1893	Gujarat, India	L6	100 g
Bori	1894	Madhya Pradesh, India	L6	8.6 kg
Ambapur Nagla	1895	Uttar Pradesh, India	H5	6.4 kg
Bishunpur	1895	Uttar Pradesh, India	LL3.15	1039 g
Delhi	1897	Delhi, India	L5	0.8 g
Kangra Valley	1897	Himachal Pradesh, India	H5	400 g
Hyderabad	1898	Andhra Pradesh, India	Doubtful stone	--
Kodaikanal	1898	Tamil Nadu, India	Iron, IIE	15.9 kg
Donga Kohrod	1899	Madhya Pradesh, India	H6	230 g

Continued

Alwal	1901	Andhra Pradesh, India	Doubtful Iron	--
Jemlapur	1901	India	L6	450 g
Kamsagar	1902	Karnataka, India	L6	1293 g
Bholghati	1905	Orissa, India	Howardite	2.5 kg
Vishnupur	1906	West Bengal, India	LL4-6	2.44 kg
Chainpur	1907	Uttar Pradesh, India	LL3.4	8.2 kg
Baroti	1910	Himachal Pradesh, India	L6	4.5 kg
Khohar	1910	Madhya Pradesh, India	L3.6	9.7 kg
Lakangaon	1910	Madhya Pradesh, India	Eucrite-mmict	213 g
Mirzapur	1910	Uttar Pradesh, India	L5	8.51 kg
Tonk	1911	Rajasthan, India	CI1	7.7 g
Shupiyan	1912	Jammu & Kashmir, India	H6	5 kg
Banswal	1913	Uttar Pradesh, India	L5	14 g
Kuttippuram	1914	Kerala, India	L6	45 kg
Ekh Khera	1916	Uttar Pradesh, India	H6	840 g
Rampurhat	1916	West Bengal, India	LL	100 g
Sultanpur	1916	Uttar Pradesh, India	L/LL6	1711 g
Cranganore	1917	Kerala, India	L6	1460 g
Ranchapur	1917	Bihar, India	H4	290 g
Atarra	1920	Uttar Pradesh, India	L4	1280 g
Merua	1920	Uttar Pradesh, India	H5	71.4 kg
Haripura	1921	Rajasthan, India	CM2	315 g
Samelia	1921	Rajasthan, India	Iron, IIIAB	2.46 kg
Shikarpur	1921	Bihar, India	L6	3.68 kg
Lua	1926	Rajasthan, India	L5	9.24 kg
Naoki	1928	Maharashtra, India	H6	17 kg
Rewari	1929	Haryana, India	L6	3.33 kg
Khanpur	1932	Uttar Pradesh, India	LL5	3.7 kg
Bahjoi	1934	Uttar Pradesh, India	Iron, IAB-sLL	10.32 kg
Tirupati	1934	Andhra Pradesh, India	H6	230 g
Hyderabad	1936	Andhra Pradesh, India	Doubtful stone	--
Phulmari	1936	Maharashtra, India	Stone- unclassified	4.06 kg
Rangala	1937	Rajasthan, India	L6	3.22 kg
Andura	1939	Maharashtra, India	H6	17.9 kg
Erakot	1940	Madhya Pradesh, India	CM2	113 g
Ramnagar	1940	Uttar Pradesh, India	L6	3.77 kg
Semarkona	1940	Madhya Pradesh, India	LL3.00	691 g
Kamalpur	1942	Uttar Pradesh, India	L6	2.77 kg

Continued

Parsa	1942	Bihar, India	EH3	800 g
Valdavur	1944	Pondicherry, India	H6	2.8 kg
Sarratola	1948	Madhya Pradesh, India	L5	265 g
Madhipura	1950	Bihar, India	L	1000 g
Lahrauli	1955	Uttar Pradesh, India	Ureilite	900 g
Soheria	1960	Bihar, India	OC	72.9 g
Desuri	1962	Rajasthan, India	H6	25.4 kg
Muzaffarpur	1964	Bihar, India	Iron, IAB-sHL	1245 g
Seoni	1966	Maharashtra, India	H6	20 kg
Patora	1969	Madhya Pradesh, India	H6	4.38 kg
Dhajala	1976	Gujarat, India	H3.8	45 kg
Udaipur	1976	India	H3	2 kg
Nainital	1980	Uttar Pradesh, India	L	5 kg
Gujargaon	1982	Madhya Pradesh, India	H5	2.45 kg
Ankhediya Mota	1985	Gujarat, India	L4/5	20 kg
Kheri Maham	1986	Haryana, India	L5	68.5 kg
Raghunathpura	1986	Rajasthan, India	Iron, IIAB	10.2 kg
Didwana	--	Rajasthan, India	H5	1000 g
Devri-Khera	1994	Madhya Pradesh, India	L6	1140 g
Lohawat	1994	Rajasthan, India	Howardite	40 kg
Piplia Kalan	1996	Rajasthan, India	Eucrite-mmict	42 kg
Vissannapeta	1997	Andhra Pradesh, India	Eucrite-cm	1304 g
Sabrum**	1999	Tripura, India	LL6	478 g
Itawa Bhopji	--	Rajasthan, India	L3-5	1000 g
Ararki	2001	Rajasthan, India	L5	4.46 kg
Dergaon**	2001	Assam, India	H5	12.5 kg
Devgaon	2001	Madhya Pradesh, India	H3.8	12 kg
Bhawad	2002	Rajasthan, India	LL6	678 g
Kasauli	2003	Uttar Pradesh, India	H4	16.82 kg
Kendrapara	2003	Orissa, India	H4-5	6.67 kg
Kaprada	2004	Gujarat, India	L5/6	1600 g
Jodiya	2006	Gujarat, India	L5	100 g
Kavarpura	2006	Rajasthan, India	Iron, IIE-an	6.8 kg
Mahadevpur**	2007	Arunachal Pradesh, India	H4/5	70.5 kg
Sulagiri	2008	Tamil Nadu, India	LL6	110 kg
Katol	2012	Maharashtra, India	L6	13 kg
Kamargaon**	2015	Assam, India	L6	12.1 kg

**Meteorites fall/find in north-eastern India.