Extra-Terrestrial Impacts in the Geological Past:
Some Reflections

Visitors from the Heavens

The passage of Venus across the disc of the Sun, a new event, made big news on the 8th of June this year, the previous transit having been observed 112 years ago. Eclipses of the sun and the moon are comparatively more frequent and cause less sensation. With modern cities growing skyward and structures overlapping one another, there is very little opportunity for the city dweller to get a glimpse of the sky. The glory of watching sunrise and sunsets are aesthetic pleasures denied to him. But not so to the villager living far away from the crowded cities, for the starry sky is his nightly companion. I remember my young days, as a field geologist camping in remote places, far even from villages, watching the star-lit sky – ‘the majestic roof fretted with golden fire’ – was an unforgettable experience. The November sky particularly with stars shooting across the firmament was spectacular!

Asteroids and comets are probably two celestial bodies which come close to the earth in crossing its path. Fragments of such asteroids, which burn themselves out crossing the earth’s atmosphere, fall as meteorites and India has a rich collection of them which are exhibited at the Indian Museum, Kolkata. A publication brought out by the Geological Survey of India in 1999 (Catalogue Series, No.3, 308p.) lists the morphological features of one hundred of these Indian meteorites. Details furnished include location with coordinates, date and time of fall, weight and dimension of individual fragments, specific gravity, degree of weathering and fracturing followed by brief morphology. Although almost all the meteorites are stated to be eye witnessed falls, descriptive account of the nature of the falls is unfortunately lacking.

A picturesque description of a meteorite fall in 1662 by a local priest in a town in Russia (Chronology and Catastrophic Review, 2002-2, p.5) shows how impressive and sensational such observations can be.

"In the year 1662 after sunset, in our village of Novye Ergi and on the neighbouring farms, many people saw in the clouds a terrible apparition, the sun had barely set, when from the place where it had set there suddenly arose a great star which looked like lightning in the sky. The sky was cleaved into two parts with the speed of lightning and remained thus for about one-half hour, and there was indescribable light, like fire, and many saw darkly outlined in this light a huge image of a man. The head and eyes and outstretched arms and legs were all fiery. And the cold at this time was great and the air was clear and quiet. Afterwards a small cloud appeared where the image had been. The sky seemed to close and fire fell upon the earth into many courtyards, upon roads and houses, like flaming bundles of flax, and when people ran from it, it rolled after them but did not burn anyone. Then it rose into the cloud and from this cloud there poured forth noise and smoke, like thunder or like a great terrible storm. For a long time the earth and houses shook and many people fell to the ground in terror. All the animals crowded together, choking on their fodder, raised their heads toward the sky and bellowed. Then stones started falling, shining bright, large and small ones, all hot. And some of them burst from the heat scattering fire over people and beasts"
The only fragmentary notice of a meteorite fall in India is of a very recent record by Mohanti and Sahoo, who were eyewitnesses of the meteoritic shower in Orissa which occurred on 27 September, 2003, at 6.30 pm. The phenomenon seems to have been witnessed throughout the coastal tract of Orissa for just 50 seconds. What appeared as a bright incandescence in the evening sky grew into a fireball splitting intermittently in its aerial flight, in its NNW-SSE direction, its burning flares ignited a thatched house at Surusuria Village, in Mayurbhanj district, before its final fragmentation about 120 km away from Sunti village in Kendrapada district, just 500 m away from the Bay of Bengal (Jour. Geol. Soc. India, Feb.2004, p.231).

Episodes of Meteorite Activity in Ancient Classics

We are indebted to Prof. R.N. Iyengar, of the Department of Civil Engineering, Indian Institute of Science, who in his search for information on major natural disasters has come across references to what undoubtedly were meteorite falls at Prabhasa, in Gujarat (Indian Jour. History of Science, v.39, 2004, pp.11-49). He describes the ‘burning’ of the river Saraswati, obviously referring to the drying up of the ancient river. What is praiseworthy is the effort of Iyengar in wading through many Sanskrit texts (Rig Veda, Purāṇa, and ancient classics like Rāmāyaṇa and Mahābhārata), disentangling from these texts what appears to be real description of major natural events. The descriptions in the Skanda Purāṇa of ‘Kālagni-rudra, Agnimidha and Agni-īṣāṇa’ are particularly interesting as the linga is the sacred symbol of Shiva worshipped all over India and the occurrence of a 200-bow diameter circular opening round the linga is worthy of note. (Dhanuṣāṁ ca śatadvayam samantam anālākāram karnikāsānamapriyā). Iyengar comments ‘the fiery origin of the linga is indicated by the name given to it as jyotirlinga.

The linga had pierced through the earth (Sapta-pāṭāla bhedhakam). It was resplendent as thousand million suns put together and was burning like fire causing total dissolution of the world (kotisīryasya pralayanāla sannibham).

Another graphic description is that of a meteorite enveloped in smoke: tumbled down to earth like planets devoid of merit (nipetūḥ ambara-bhraṣṭāḥ kṣina punyāḥ iva graham); enveloped by smoke (vestīto dhumrāḥ); fell down like stones carried by wind breaking the ground and entering the earth (Tato vāyu vaśāḥ bhrasṭāḥ bhītvā bhumim rasātalām). The largest opening being at Arkasthala around which there were innumerable holes in the ground. Most of these are not visible now except at Srimukha. There are references to famine, recession of the sea, the appearance of fire (vadavāgni) which dried up Saraswati. The disaster was so cataclysmic that it lead to a long discontinuity and end of a previously flourishing culture.

Two other celestial events to which attention should be drawn are to the birth of Kārtikeya (Skanda) in Krithika (Pleiades) and the Aswin twins. The birth of Skanda, is ascribed to a strange fire (Adbhūtāgni) which, Iyengar believes to be the description of a
Nova which ended with disastrous consequences on earth. The sky and stars burnt and the universe was paralysed. Timing of the event is placed around 2500-3000 BC. A twelve year drought occurred. Lakes, rivers, wells and springs dried up and empty cities and burnt down villages were filled with the cry of goblins.

There is a reference in Viṣṇu Purāṇa (pt. II, ch. 37, pp. 29-30) to Lord Krishna observing earth and heavenly events indicative of portending disasters (उपपत्तिः दिव्य भौमंतरिक्षाधृतं दादरसा द्वारकापायाम विनाशयं दिवनिशाम). Seeing them Krishna asked the Yadavas, to leave Dwaraka and go to Prabhāsa kshetra as ‘the Dwaraka which I am leaving will get submerged under the sea’ (द्वारकानंत मयात्याक्तम समुद्रां प्रपायिष्यति).

Expressions like नाभाः प्राज्वलयां युग्गंतातैव (heavens glowing with fire as at the end of a yuga); क्वेलिताभोट निनादाइसुवेद वसुंदराः (the explosion caused the earth to shake); संक्राहेन्द्रु नक्षत्रां वितारेशः नभास्थालाम (sky full of planets and stars shook). Earth shook, her foundations tumbled, the sun darkened, lightning flashed and thunder pealed. All these indicate that the poet who composed the verses had witnessed the heavenly drama at least once.

Other examples from the Rāmāyana and Mahābhārata can be given illustrating fiery objects from the heavens striking the earth. It is enough if this brief description kindles in the minds of our readers a spark which makes them take to the study of old classics. A study of natural disasters in the past and their periodicity will indicate what may be expected in the future.

The region of Gujarat, Kutch and partly Western Rajasthan which are the sites of natural disasters even now, deserve a very careful ground survey for evidence of extraterrestrial impacts which may prove to have good mineral potential for copper, nickel, PGE, diamonds, mercury, oil and gas.

Although an appreciation of the significance of the facts brought to light by Iyengar through his patient studies of ancient classics, has been lukewarm in India and lacking in real interest, astronomers from outside specially those interested in the study of cosmic activity and associated natural disasters have been generous in their praise. The identification of an explosion in the region of Krithika (Pleiades) has been hailed as another evidence of a world wide event which resulted in the termination of many ancient civilizations including that of the Indus valley. The course of human history appears to be intercepted by catastrophic events with site destruction, major cultural discontinuities and migration of people lending support to such an inference. If this is true, impact of meteorites could be the cause for major natural disasters on earth in future as has happened in the past. The subject therefore is one requiring serious study.

Our ancient classics should not be dismissed as a miscellany of myths. Much useful information of value can be distilled from them by scholars who are well versed in Sanskrit and also well informed about modern developments in astronomical and space sciences. As
one of Iyengar’s foreign correspondents has said, the Prabhāsa khaṇḍa descriptions are ‘our ancestors warnings to their descendents about the potential calamity from the sky.’

Isotopic composition of carbon dioxide, nitrogen and noble gas in some meteorites are stated to be indistinguishable from the Martian atmosphere. Such studies have provided convincing evidence of linkage of some meteorites found on earth to Mars. Shergotty meteorite which fell in Bihar in 1865 has been identified as having such links on the basis of cosmic chemistry. It is interesting to note that the chemistry of this meteorite has shown the presence of water.

Some Suspected Impact Craters on Earth

The terrestrial planets are believed to have passed through a phase of heavy bombardment, traces of which are recognised on the moon’s surface. The Sudbury structure in Ontario, Canada, the Vredefort dome of South Africa, of Precambrian age, may prove to be impact structures. The circular outline of the Cuddapah basin with its associated system of radial dykes may represent an impact structure of Precambrian age.

Presently there are probably more than 200 definite impact structures, most of them of comparatively younger age, the largest known being about 170 km in diameter, the majority of the craters known being of smaller diameter are comparatively recent, less than 300 m.y. in age. The Chicxulub crater in Mexico is the largest crater, 170 km across and 48 km deep, located at the Cretaceous-Tertiary boundary.

The only recognised impact crater in India is that of Lonar, in Maharashtra, emplaced in Deccan basalt. It is a young crater (50,000 years) whose true character was very much in doubt, most observers believing it to be the effect of volcanic eruption. The finding of glass fragments, the result of shock melting, of maskelynite (a shocked plagioclase) has definitely proved Lonar to be meteoritic in origin. Being comparatively young it is only slightly modified by weathering and is also a rare instance of a crater in basalt penetrating 200 m of lava made up of different flows. The study of the Lonar crater and its surroundings should prove to be of interest in understanding the effects of impact and indicating similarities with Lunar craters.

Large-scale Impact Structures and Mass Extinction

The Cretaceous-Tertiary boundary is believed to have been caused by a major impact marked by terrestrial volcanism on a large scale (Deccan Volcanism), with serious impact on the biosphere and leading to mass extinction, particularly of dinosaurs. A new polymorph of carbon discovered in the year 1985 and known under the name of fullerene was first detected in extra-terrestrial materials. Known also as "buckyballs" because of its dome-like crystal structure (after the American architect R. Buckminster Fuller and designer of domal structures), fullerenes have now been reported from terrestrial impact environments (K/T boundary ejecta, impact breccia at Sudbury in Canada and in shungites of Karelia in
Russia and in the intertrappean beds at Anjar, Kutch (Parthasarathy 2004, Indo-US Workshop, Bangalore, Proc.). Rocks showing similarities with the shungites of Russia have been recently reported by Rao and others (Jour. Geol. Soc. India, v.63, 2004, pp.522-532) from the carbonaceous metaexhalites (?) from Aravalli Supergroup, Rajasthan. Carbon chemistry in an impact environment has a vital bearing on the larger and wider issues of origin and history of life on earth. Thus, it becomes necessary that we reexamine some of our ancient carbonaceous rocks keeping in view that new perspectives that have emerged in tracing evidences of past catastrophic events that seemed to have visited the earth often and at almost regular intervals than hitherto understood.

Geologists in their two hundred years of exploration of the earth surface have patiently built up a history of past events extending to more than 3000 million years. They have clearly recognized, on sedimentological, structural and palaeontological grounds, major breaks in the record. How far these breaks can be accounted for by large scale impact from outer space and whether a periodicity can be recognised in their incidence lies in the future course of astronomical studies in space science and the study of earth as a planet. Major destroyers of life may prove to be comets and their debris. The impact of supernova could generate dust which might take a long time to settle. An analysis of carbonaceous tuffaceous material in Archaean and Precambrian sedimentary sequences as also at the suspected major boundaries should be subjected to detailed mineralogical and geochemical examination and the resulting evidence evaluated. A specific search is to be made for tektites, spherules and dust particles of extra-terrestrial origin.

*The Significance of 'Pralaya' in Hindu Mythology*

Michael Paine (2001; www4.tpg.com.au/users/tps-seti/crater.html) has provided a graph showing impact craters on earth by age and diameter. Main geological boundaries involving mass extinctions and the approximate timing of flood basalt eruptions are also shown. He believes the Triassic/Jurassic and Jurassic/Cretaceous boundaries were caused by multiple impacts resulting in global climatic disruption and that mass extinctions are likely to be caused by asteroid/comet 10 km or larger in diameter which may happen once in 50 to 100 m.y.

Hindu mythology again and again refers to catastrophic events marked by fire (agni), floods (pralaya) and extermination of plant and animal world which appear to be the after-effects of extra-terrestrial impact. The cyclicity of such events postulated in ancient texts are indications of the awareness of this lurking danger from across the heavens at periodic intervals.

*740,000 years of Record Preserved in Ice*

A recent issue of ‘Nature’ (June, 2004) carries an account of a major drilling project undertaken in Antarctica with a view to build a record of past climatic change. Ice cores
recovered which preserve the record of past 740,000 years are invaluable archives of past conditions on earth. The record shows that Antarctica had witnessed as many as eight ice ages with recurring warm and cold phases at intervals of 100,000 years. We are at present in an interglacial period which began 10,000 years ago. An interesting result of this study is that a million years ago ice ages recurred at intervals of 40,000 years, but have now reverted to their earlier pattern of 100,000 year intervals. Why should this change takes place? Is it due to orbital changes or due to lower levels of carbon dioxide or due to any other cause? Further details of this research is awaited with interest.

We in India must also plan drilling through glaciers in higher Himalaya and Tibet which are sure to reveal changing pattern of climate during the last 100,000 years.

Geochemistry of kimberlite pipe rocks, mineralogical studies aimed at identifying high pressure minerals is sure to be a rewarding study in clearly understanding whether diamond and other carbonaceous materials are the result of impact generated magmatism. The studies carried out by Parthasarathy and his group at NGRI (see abstracts of papers presented at India-US conference on Space Science, held at Bangalore, June 21-25, 2004) are of special interest. Comprehensive programme of study of impact cratering is needed.

Raman, the great visionary and man of science said: 'Astronomy is a heaven born river of knowledge which flows to the earth and fertilises the fields of learning and culture.' Study of the geochemistry of these heaven-born visitors may lead to a better understanding of the history of earth and to the vexed problem of the origin of life itself. May it not be that life is a cosmic rather than a simple terrestrial phenomenon.

There is therefore a pressing need for organisations like the Geological Survey of India to take the lead in impact cratering studies in a comprehensive multi-disciplinary and systematic fashion not only because of the great excitement and challenge it offers but also because of the implications of mass extinctions. All these new ideas require a reexamination in the field of many rock-types that preserve impact signatures and ably supported by supplementary laboratory work demanded by the field occurrences.

Youth in our country is losing interest in geology with university geology departments particularly getting denuded of young talent. Unless their interest is aroused by directing their attention to new channels, the future of geological studies appears bleak. It is time to draw up multi-disciplinary and multi-institutional programmes aimed at gaining a better understanding of the infinite variety presented by planet earth.

B. P. RADHAKRISHNA

JOUR GEOL SOC INDIA, VOL 64, AUG 2004