Planetary impacts in focus

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Large rock bodies have hit the earth and other members of the solar system throughout the geological past with variable intensity. The 174 documented impact craters on earth form the most accessible records of these events. This list also includes the Lonar crater[1] in Maharashtra, while the newly discovered Dhala crater[2] in Madhya Pradesh would be the latest addition. The process of impact cratering involves material excavation, melting and dislocation, usually forming a cavity (crater), all of it happening in a couple of moments. Impacts, especially the large ones, are still not well understood. What dwarfs the human effort in this regard is their sheer scale. Even a well orchestrated simulation of this process, at times, exceeds the current computational capabilities. A recent paper by Marinova *et al.*[3] discusses the three-dimensional simulation results obtained using 4000 processors, not enough to run the simulation to the desired resolution. It is the first such modelling effort of an impact of planetary dimensions.

The importance of understanding this fundamental process in the solar system cannot be understated. Numerous efforts are being made to assess the effects of impacts on planetary bodies using modelling and experiments, by studying evidences of devastation as well as looking out for potential asteroids that may hit the earth in the near future. Space missions like NEAR to asteroids with earth-crossing-orbits are also part of this effort. The recent windfall of research results on impact cratering have highlighted the enormous extent to which large-scale impacts can affect a planetary body, including the possible threat to life on a planet like the earth. In a set of three recent papers[3–5] supported by two commentaries[6,7], the authors propose the largest impact structure in the entire solar system. The south-pole Aitken basin on the moon, was till recently holding this position. But now it might go to Borealis basin on Mars. The structure of this basin, deciphered by a variety of geophysical datasets (gravity, topography), as also by 2D and 3D simulations, bears an elliptical shape[4], measuring 10,600 km on the longest axis and 8500 km on the shortest one.

This suggested impact structure is an effort to explain the striking observation of lowlands in the northern hemisphere and highlands in the southern hemisphere on Mars[8] with crustal thickness variation of around 30 km. The anomaly is more commonly known as the Martian dichotomy problem. Though this is not the first time that an impact origin for the observed dichotomy has been suggested, the present study has strengthened the arguments to long-standing objections and also offered some new perspectives. Explanation for elliptical character as opposed to expected circularity of the impact feature, smooth transition along the boundary of the basin as opposed to expected thicker regolith on the rim, retention of the crater with planetary dimensions in case of moderate impact angle and low impact velocity (6–10 km s^{-1}) and the possibility of a remnant outer ring, represented by the Arabia Terra region, are some of the highlights of the work done. Apart from this, inference like impact-induced local magma ocean having probably formed the northern lowlands offers fresh input towards understanding the influence of large impacts in a planetary perspective. However, further refinements in this context are still required and would surely follow in due course of time.

Another impact event that merits discussion here is the largest event of its kind documented in the entire human history with eyewitness accounts. The 30th of June 2008 marked the 100th anniversary of the Tunguska event, which probably happened in mid-air over central Siberia, wiping out vegetation spread over an area of about 2000 km^2. The event had an estimated energy of around a thousand atom bombs of Hiroshima type. It comprised of a series of blasts with a blinding flash of light and enormous heat that could be felt as far as 65 km from the blast epicentre. The explosion lit up the night skies as far as London, where people could read newspaper without additional illumination. Seismic observatories around the globe recorded this event. What remained at the impact site after the event were uprooted trees spread out in a radial pattern over a large area. Ironically, no impact crater from the event was detected and neither has anybody found a fragment of any meteorite. A good deal of international effort has gone into unravelling the details of this event. Results from some of these were presented at an International Conference '100 years since Tunguska phenomenon: Past, present and future', at Moscow in June this year. One of the recent results[9] indicates the possibility of Lake Cheko, located about 8 km from the epicentre of the event, being probably formed by an impactor fragment from the Tunguska event. Several geological investigations have been carried out at Lake Cheko using GPR, acoustic profilers, sediment corers, underwater television camera as well as GPS receivers. The data indicate a conical shape of the lake with a thick layer of chaotic sediments at the lake bottom. The investigations have further revealed a possible fragment of the impactor about 10 m below the lake bed. Though not conclusive yet, it is an important new information that adds to the earlier inferences drawn since the first expedition led by meteorite hunter Leonid Kulik in the 1920s.

It may be noted here that one of the most useful laboratories to study impact processes is located at a distance of about 400,000 km from us. The earth's moon holds records of countless impacts that have taken place on its surface ever since its formation, a few moments after the formation of the earth, on the geological timescale. Since the moon has neither undergone weathering/erosion nor is tectonically active, the impact scars on its surface are nearly intact, except obliteration caused by later impacts that may have partially or completely erased the earlier ones. Several lunar missions, including Chandrayaan-1 by ISRO[10], aim at understanding many aspects of planetary processes like impacts, volcanism, magma ocean formation and differentiation. The same will be studied by obtaining spatial, vertical and temporal variation in composition as well as several other parameters on the moon through various sensors. The objectives also include search for possible occurrence of water in permanently shadowed craters on the lunar poles.

The knowledge of these aspects might not only shed light on lunar geological evolution, but the information might be of immense importance for unravelling the history of the earth, where many of those records have been obliterated.

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MEETINGS/SYMPOSIA/SEMINARS

International Conference on 'Recent Trends in Sensor-Development for the Assessment and Management of the Environment'

Date: 8–10 January 2009
Place: Chennai, India

Areas of Focus: *Technologies* – Physical Sensors, Chemical Sensors, Biosensors, Remote Sensors, Sensor Materials and Fabrication, Nanotechnology for Sensors and Actuators. *Application Areas* – Automotive and Aerospace Industries, Commercial Development, Energy and Power, Environmental Sensing, Food and Agriculture, Marine Environment, Medical/Healthcare Sensing, Multi-sensor data fusion.

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International Conference on Biotechnology 'Innovations and Challenges in Agri, Food, Biofuel and Health care' (ICBIC – 2008)

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