Reflections in the aftermath of Orissa cyclone

More than 10,000 people and lakhs of cattle perished in the last year's cyclone in Orissa. In terms of death toll of over 10,000, this was the fourth one during 20th century, the earlier ones being those of 15–16 October 1942 (Bengal), 13 November 1970 (Bangladesh) and 19 November 1977 (Andhra Pradesh). Because of the long duration of this cyclone, severity of hurricane, winds and the range of its impact over vast terrestrial region, the cyclone has come to be referred to as a supercyclone and the destruction caused has been of enormous magnitude. As soon as the Ersama block in Jagatsinghpur district became accessible, the death toll rose to more than 9,000 compared to initial estimate of less than 3,000 deaths. Not only the population density, but morphology and local structures of the affected land also determine the loss of human lives. In Ersama, though Ramtera and Ambiki villages are nearer to the sea shore compared to Kiyada, sand hills and hillocks saved many people in the former villages from the furious surge of sea water. The passage of cyclone with high speed wind and torrential rain left behind uprooted trees and poles, damaged roads and collapsed hutments, but the loss of lives was relatively low in those regions where sea water did not reach. Unfortunately we failed in rescue and relief operations during the critical period of first few days after the cyclone. Now even after the lapse of several months, the surviving people face avoidable manifold miseries in the absence of a concrete rehabilitation drive. The aim of this letter is to suggest what we as a scientific community can do in the wake of such a disaster.

Let me first point out the problems requiring urgent attention:

(1) The coming summer is likely to be very hot with substantial rise in temperature. In the vast affected areas, most of the people are living in polythene-covered shelters with practically no plants or trees around. Cost effective and simple measures to cope with this situation could be formulated by the scientists and health specialists, for implementation by the government agencies or voluntary organizations. (2) Studies on salination of soil inundated by sea water have either been not carried out or not made public. Some villagers said that they experienced salty rain during and after the cyclone, but we could see revived betel plants at Ramtera and vegetable plants here and there at Kankan and Ambiki in the first week of January 2000. Since rain water cleanses the soil, it is important to ascertain the extent of the salination of the soil. Agricultural scientists are urged to provide guidelines with regard to the variety of seeds and kind of fertilizers best suited for the present soil conditions. Further, care must be taken to prevent possible dumping of genetically engineered seeds from the MNCs.

The sight of devastation and heaps of dead bodies was a traumatic experience, but gradually overcoming it I started thinking naively if advances in science could be used to dissipate the cyclone before it matures. Perusal of some literature shows that the mechanism of cyclone formation is very complex and not well understood. To quote Holton[1]: 'The origin of tropical cyclones is still a matter of uncertainty. It is not clear under what conditions a weak tropical disturbance can be transformed into a hurricane.' In a comprehensive treatise on tropical meteorology[2], Asnani mentions the US project 'Storm-Fury' launched in 1962. This project was intended to artificially modify the cyclone, reducing its intensity and changing its direction. The basic technique was to create a cloud wall by cloud-seeding, and the scientific principle invoked for the reduction of the intensity was the angular momentum conservation. For various reasons this project was abandoned in 1983. Vortex dynamics and angular momentum balance appear to be the most significant aspects of cyclone. I think it would be profitable if meteorologists, physicists and applied mathematicians work jointly towards better understanding of the vortex dynamics in a cyclone. Design and installation of angular momentum absorbers along coastal areas could be envisaged based on such studies. Also for a better characterization of the cyclonic development, besides satellite pictures it may be possible to place a self-regulated floating probe inside the core of cyclone at the initial stage, and gather data on some of the parameters during its evolution. I hope experts may find the proposals worth serious exploration. Our science academies could take initiative to form study groups towards this aim.

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Geological lessons from nuclear tests at Pokhran, Rajasthan, India

A brief note[1] on 'Geology around Pokhran Nuclear Sites', supplemented with more information[2] deserves attention of geoscientists. Analogous to Pokhran-1 (ref. 3), when Buddha smiled on 18 May 1974, he smiled again on 11 and 13 May 1998, when five underground nuclear tests were conducted at Pokhran, District Jaisalmer, Rajasthan, India. It is realized that geological lessons can be learnt from these recent nuclear tests at the Pokhran site. This event certainly provides opportunities for geoscientific studies with a new direction for research. It involves an evaluation of the nature of shock waves, analysis of energy produced and various degrees of shock characteristics that are likely to be induced in surface and subsurface rocks due to transient ultra-high pressures and temperatures generated by these nuclear tests. According to R. Chidambaram, the yield of thermonuclear device located at a depth of 200–300 m was nearly 45 kiloton (1 kiloton = 1000 tons of TNT) with additional low yields from the other four nuclear tests[4].

The changes and transformations depend upon the nature of target rocks and shock waves generated by extremely high pressures and temperatures which produce unique effects that have been observed in nuclear explosion craters, laboratory shock wave experiments, terrestrial impact craters and meteorities. Extensive literature on this subject is now available[5–8].

Considering the lithostratigraphy of the Pokhran area, the dominant basement rocks are rhyolite and associated pyroclastics (Malani Igneous Suite) which are unconformably overlain by siltstone, shale, sandstone and carbonate rocks (Mewar Supergroup) followed by unconformable sandstone, conglomerate and grit (Lathi Formation). All these formations are overlain by 50 m of tertiary and 100 m of quaternary sediments, which consist of gravelly sand and alluvium that are exposed at the main Pokhran site. The estimated thickness of different geological formations[2] at Pokhran within a radius of about 20 km can prove very useful in comprehending various effects of shock waves involving extremely high pressure-temperature physics and chemistry of minerals and rocks, resulting in changes, transformations, melting and vaporizing the rocks of the Mewar Supergroup; they may have also affected rhyolite of the Malani Igneous Suite and Quaternary–Tertiary sediments. The Pokhran site provides the opportunity to acquire such ground-truth data for understanding the nature of shock waves, shock metamorphic characteristics and formation of the crater structure. The shock characteristics in the fallout and fallback ejecta rock masses at the Pokhran crater site and possibly at depth are expected to result in autochthonous and allochthonous monomict and polymict breccia; unique microstructures in minerals and rocks; selective phase transformations; vitreous phases (diaplectic glass) without flowage; high pressure polymorphs of silica (coesite and stishovite); shock-induced melting; impactite and possibly mixing of various categories of shock metamorphosed material of different lithologies[9–13]. Other relevant aspects such as seismicity, shock-induced metasomatism, diffusion and kinetic controls in rocks and minerals during the transient extremely high pressure-temperature environment and the amount of radioactivity, if any, entrapped in shocked, unshocked and melted rocks can be investigated. In addition, other possible aspects like changes in structure and tectonic movements of the upper crust, climatic and biological effects may occur in the course of years. All these expected features need to be searched, examined and verified at the Pokhran site. However, some problems may be difficult to be addressed with regard to the collection of ground-truth data owing to active geological environment of the earth.

It is suggested that a systematic field work and collection of shock-metamorphosed material in and around the Pokhran crater site together with drilling at some selected locations followed by detailed laboratory studies can substantiate the views envisaged here. Besides, the current knowledge of experimental ballistic, nuclear explosion craters[14–20] and terrestrial impact cratering process[8,21,22] can provide useful parameters to analyse the distribution of total energy, shock metamorphism and model the mechanics of formation of the Pokhran crater structure having dimensions of 300 m circumference and 15 m depth[23]. Detailed observations of shock metamorphism and other characteristics from nuclear explosion sites are consistent with those at the terrestrial impact craters[21]. The Pokhran crater can be broadly compared with the well-known Barringer Meteor Crater, Arizona, USA[24], and the Wabar crater, Saudi Arabia[25], in having more or less similar lithologies.

There is great scope and urgent need for developing a multi-disciplinary cooperative research programme on shock waves and shock-induced material from the Pokhran site.

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