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NEWSINDIA

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Craters change the landscape for India's volcanic origins

Mumbai Geologists looking for clues to the dynamics of the Earth's interior and the Indian subcontinent are drawn to the Deccan Traps, a thick layer of old lava flows covering most of western and central India. This volcanic landscape has now revealed its latest secret, known as 'rootless cones'.

Also (mistakenly) called 'pseudocraters', rootless cones are formed by the explosions that occur when hot lava rises up to the surface and enters a body of water, or wet or icy ground.

The Deccan Traps (Fig. 1) were created about 60 million years ago by India's largest ever volcanic episode. They are about a kilometre thick on average, and are spread over an area of 500,000 km^2. But where are the volcanic vents through which these gigantic lava flows poured out on to the surface, and what do they look like?

Hetu Sheth, an assistant professor at the Indian Institute of Technology in Bombay who has been studying the Deccan Traps for more than a decade, thinks he has the answer. Several areas of the Deccan province contain swarms of magma-filled fractures called dykes, and Sheth believes these are the fissures through which the lava poured out. Dykes are blade-shaped features, much longer than their thickness and width, and range in size from a mere 2 metres in length to more than 40 kilometres.

"There is no doubt that the Deccan Traps represent an excellent example of fissure eruption," Sheth told *NewsIndia*. "The lavas poured out from long fissures in the ground," he explains, not from conical volcanoes with a central conduit and a summit crater, such as Mount Fuji in Japan or Mount St Helens in the United States.

Figure 1 A clearer view. The Deccan Traps were created by lava flows 60 million years ago. The geological features associated with their formation are now being identified.

Many approaches have been used to shed light on the origins of the Deccan Traps, including geochemistry, petrogenesis (the study of the processes involved in the generation of lava from solid rock), palaeomagnetism (the record of the Earth's ancient magnetic field held by the iron oxide minerals in the lavas) and stratigraphy (the order of superposition of the lavas in different areas and the connections between them).

"Physical volcanology has been subordinate to these subjects and is probably under-appreciated," says Sheth. This is partly because India has only one active volcano, on Barren Island in the Andaman Sea.

Circular, crater-like features have been found in a few areas in the Deccan Traps, and are usually thought to be central-conduit volcanic vents. But Sheth and his colleagues George Mathew, Kanchan Pande, Soumen Mallick and Balram Jena have proposed[1] a very different explanation for similar features they discovered on top of Mount Pavagadh — one of the holiest Hindu shrines in the state of Gujarat.

Sheth *et al.*[1] propose that these roughly circular craters nestled within very gentle cones are probably rootless cones — not true eruptive vents connected by vertical conduits to the lava source, but more superficial structures produced when the lava was flowing and interacted explosively with water on the surface.

Rootless cones have also been identified in Iceland, a land of many volcanoes where rootless cones were first identified. Sheth has done fieldwork in southern and

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south-central Iceland, and visited a site containing several hundred rootless cones near Thjorsardalur.

"Because the cones at Pavagadh are relatively steep-sided and have small or no summit craters, I thought at first that they were something very different," Sheth says. But a literature survey revealed that rootless cones have a great variety of size and shape; indeed, the rootless-cone field at Myvatn in northeastern Iceland is morphologically very similar to the Pavagadh features[2]. The area occupied by the Pavagadh features is much smaller, but this is because the Deccan Traps is much older and so has suffered more erosion.

Volcanic cones found on Mars are morphologically similar to those in Iceland, and have also been proposed to be rootless cones[3]. Because the martian cones are geologically younger, they would suggest the presence of liquid water or water ice on the martian equator not long ago — an inference of fundamental importance in planetary research.

When visiting Pavagadh, Sheth *et al.* were aware of a previous report[4] of circular, crater-like features near Jabalpur in Madhya Pradesh state. These craters had been suggested to be eruptive vents, and Sheth *et al.* at first thought that the Pavagadh features were too. But true volcanic craters known as 'maars', which are shallow and wide, resembling the Pavagadh and Jabalpur craters, are rarely less than a kilometre in diameter. The Pavagadh and Jabalpur craters are at most 100 metres in diameter.

"The morphological similarities of both the Pavagadh and Jabalpur features with the Myvatn rootless cones in Iceland is so striking that we thought rootless cones to be a much better explanation for them," says Sheth.

"This is apparently the first report of rootless cones not only in the Deccan province, but all Indian geology," the authors claim.

As their paper was accepted for publication, their explanation received some unexpected support from a study of the Jabalpur craters by a group of geophysicists[5] who imaged the site using gravity and magnetic methods. They found no deep-going conduits under these craters of the sort that would be expected for central-conduit volcanoes.

Sheth is hoping that more occurrences from different areas will come to light. "Further detailed physical volcanological studies of the Deccan province are warranted, and should provide exciting insights into our planet's development," he says.

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Heat shock for malaria parasite

Bangalore Biochemists in Bangalore have identified a possible drug target in *Plasmodium falciparum*, the deadly parasite that causes cerebral malaria[1].

The drug target is a heat-shock protein (HSP) known as HSP-90. The scientists, from the Indian Institute of Science, claim that this protein controls the development of the parasite after it enters the erythrocytes (red blood cells). The protein is so named because it is produced by the parasite in response to the high temperatures it experiences during the fever that is characteristic of human malaria.

The researchers have shown that the HSP-90 protein protects the parasite during the fever and controls its development during the part of its life cycle inside the erythrocytes. They hope that a drug that disrupts this protein function could be a potential cure for malaria.

The clinical symptoms of malaria occur when the parasite enters the erythrocytes and starts to progress from the early 'ring' stage of its life cycle to a biosynthetically active stage called the trophozoite. Trophozoites in turn become schizonts and then undergo nuclear division to form merozoites.

Body temperatures ranging from 38 to 41 °C are often encountered during fever in malaria patients. "The influence of such repeated exposures to high temperatures on parasite growth has not been studied systematically," the scientists report[1].

The Bangalore team has examined this for the first time by studying the growth of the malarial parasite in culture under conditions that mimic malaria. The team used conventional staining methods for counting and a technique called flow cytometry to examine the transitions between parasite stages after subjecting the culture to two heat shocks separated by an interval of 10 hours.

One important finding was that parasites exposed to a prior heat shock were not only protected but also developed efficiently from the ring stage to the trophozoite stage in response to the second heat shock. This implies that the appearance of several episodes of fever in patients actually hastens the development of the parasite in the erythrocytes, the researchers say. "This is the first demonstration that increased temperature can promote intra-erythrocytic stage maturation in the malarial parasite."

The team then investigated whether HSP-90 was responsible for protecting the parasites by adding geldanamycin — a known inhibitor of HSP-90 function — to the parasite culture. They found that the geldanamycin arrested a significant proportion of parasites at the ring stage, suggesting a role for HSP-90.

"Our observations suggest that recurrent fever, which is a characteristic of clinical malaria, contributes to the pathogenesis by promoting parasite development and increasing parasite counts in circulation," the scientists report[1]. "Such growth-stimulating effects of febrile temperatures on parasite growth are mediated through HSP-90."

A drug that disrupts the function of HSP-90 could therefore be a potential cure for malaria, they conclude.

The work was funded by the Indo-French Centre for the Promotion of Advanced Research and the Department of Biotechnology in New Delhi.

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