Barren Island Volcano: recent field findings

Barren Island Volcano (BIV), the only active stratovolcano in South Asia, is part of the Neogene Inner Volcanic Arc (NIVA) situated in the Indian territory at ~135 km to the northeast of Port Blair, the capital of Andaman & Nicobar (A&N) Islands. BIV is an uninhabited stratovolcano with an elevation of ~350 m amsl and is located on seismically active subduction zones wherein the Indian Plate subducts beneath the Burmese Plate along the Andaman Trench. The currently exposed BIV cone with multiple ridges is just the upper part of the volcano, whereas almost 90% of it is submerged in water, as revealed by recent bathymetry. Interestingly, BIV has a broken caldera ridge on the west that is filled with various phases of lava flows[1,2] and an active polygenetic cone at the centre, which emits pyroclastic materials. Being dormant for ~200 years, BIV has become active since 1991, sporadically erupting lava and pyroclastic materials, including large amounts of gases[1,2].

In recent decades, significant research has been carried out on BIV, providing significant findings[1–6]. Especially, remote sensing has played a crucial role in understanding the behaviour of eruption patterns through morphological features and associated regional seismicity[3–5]. The frequency of regional seismicity and volcano eruption has increased post-2005 (ref. 4). While our knowledge of BIV has improved markedly over the past decades through geological studies with sample collection and remote sensing, geophysical investigations and morphological studies on the volcano are lacking due to its remote and relatively inaccessible location[4,5]. The initial subsurface studies were carried out around BIV by the Geological Survey of India and the Indian Institute of Geomagnetism[7]. However, no geophysical survey was carried out on the volcano due to its inaccessibility and various other reasons. However, a few studies concentrated either near the shore or at the broken ridge.

In continuation with our first BIV expedition in April 2019, we conducted the geophysical investigations on the Volcano in our second expedition on 7 November 2021 to delineate and understand its subsurface features with assistance from the crew of *ICGS Durgabai Deshmukh*, the Indian Coast Guard and the A&N Islands Administration, Port Blair. To our knowledge, no magnetic and electromagnetic studies have been conducted on BIV. During our second expedition, we conducted a detailed survey close to the centre cone and collected samples of recent flows. Geologically, BIV forms a part of NIVA[8,9] and is roughly ring-shaped with ~3 m diameter. It consists of different volcanic features which have developed over time. The caldera of BIV occurs as a ridge which had breached on the west during historical eruptions and

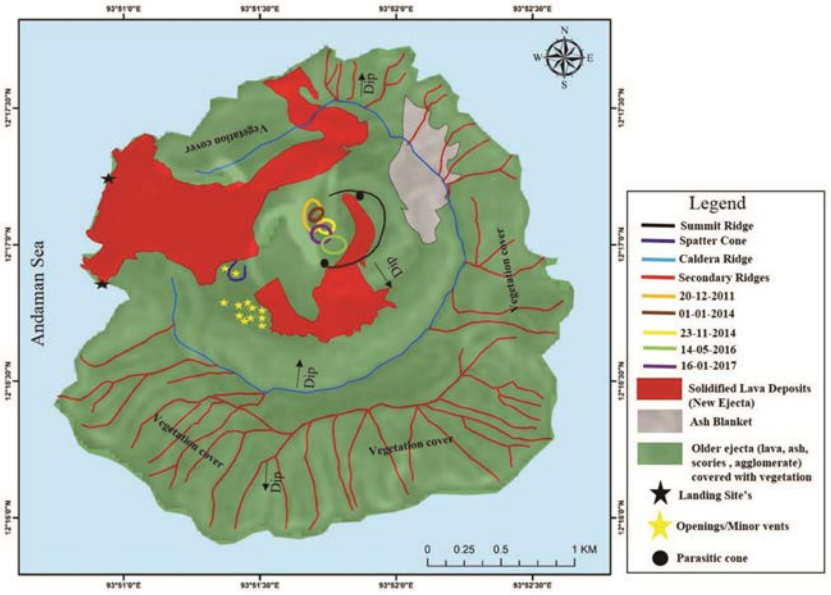

Figure 1. Geological map of Barren Island Volcano based on field observations in 2019 and 2021 showing various volcanic features and structures (modified after Bandopadhyay and Carter[10]).

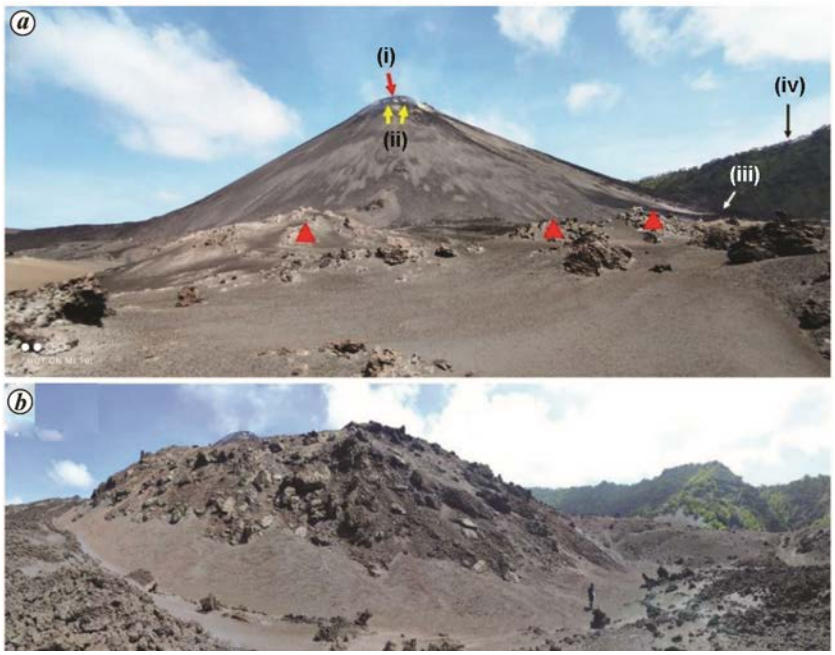

Figure 2. ***a***, Close view of Barren Island Volcano: (i) main vent, (ii) small openings/secondary vents, (iii) recent lava flow deposited site (2018), (iv) east side ridge. Red triangle represents the small developing cone with numerous openings that emit continuous hot gases. ***b***, Large developing cone with numerous openings on all sides releasing the heat gases continuously.

Figure 3. ***a***, Large opening on the developing cone emitting continuous hot gases. ***b***, Panoramic view from north to south showing the main cone along with small scatter cone from which flows active lava (solidified) and open vent.

is filled with various lava flows and volcanic deposits[2]. It also contains a polygenetic cinder cone of ~332 m in height at its centre that emits basalt and basaltic–andesite tephra and lava flows in sporadic eruption phases, i.e. pr e-historic (unknown years), historical eruptions (1787–1832) and recent (1991–till date)[10]. Currently, BIV is characterized by strombolian-type activity and has become more active compared to the 2005 eruption episode. In a recent field expedition in 2021, we observed new volcanic features near the centre cinder cone, i.e. Spatter cones, small mounts with minor openings and a few with vents emitting hot gases at high pressure and solidified lava (Figure 1). We also demarcated various volcanic features, i.e. vents of various eruption years, caldera ridges, crater rim, minor openings/vents, spatter cones, parasitic cones, new and old ejecta using field data and available remote sensing datasets (Figure 1). We observed that the elevation of the polygenetic cone at the centre had increased and developed multiple openings on top from west to south from which the gases and lava were emitted continuously, compared to the first expedition. Interestingly, we also witnessed numerous new volcanic mounts near the main cone, considered to be linked with the main magma reservoir through fractures or fissures. These small mounts had several openings and continuously released hot gases, mainly sulphur dioxide (Figure 2). These openings may have been connected with shallow magma chambers through dykes and a few may be considered laccolith features due to their dome shape with flat bottom. Additionally, we encountered a small active cone, i.e. a 'spatter cone', a volcanic-type of landform produced by low-intensity molten lava eruptions and associated with a relatively small volume of lava flow. This dome-shaped cone is several metres high and has minor openings that emit hot gases (Figure 3). In an earlier study, we had demarcated the recent lava deposition using remote sensing, with the flow towards the southern side due to the slight tilt of the main vent; these flows have been validated through the present field work conducted during our second expedition. BIV volcano is currently active and associated with local regional seismicity. The geophysical survey may reveal interesting facts about unknown subsurface features of BIV and will be communicated soon.

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