Cold springs of the Barren Island, Andaman Sea, Indian Ocean

The Barren Island is the only active volcano in India. It is located 135 km east of Port Blair in the Andaman Sea, and is a part of the Andaman and Nicobar chain of islands in the Indian Ocean. It lies on the Neogene Inner Volcanic Arc – also known as SE Asian Volcanic Rim or Volcanic Line of SE Asia[1], extending between Sumatra and Myanmar. Feral goats, the largest animals on the island, can be seen grazing around. It has been reported that the feral goats, in the absence of freshwater source, drink sea water[2–4] or eat the leaves of particular trees to substitute their freshwater requirement[5]. During their recent expedition, we camped in the island for four days between 3 and 6 February 2003 to carry out detailed geological, volcanological and geothermal investigations. We located two freshwater springs in the island at about 2–300 m south of the landing site. About six feral goats were seen grazing in the island. This correspondence gives the location and composition of these springs and removes misconceptions about the life of feral goats.

'What do these feral goats drink?' This question bothers many agricultural scientists in India. Two different opinions exist in the earlier reports[3–5]. One opinion is that they drink sea water for survival. This opinion led the scientists at the Central Agricultural Research Institute (CARI), Port Blair, India to suggest rearing these animals for meat where freshwater is scarce, as a solution for the dwindling livestock problem in drought-affected regions[3,4]. As an experiment, goats were made to drink salt water and goat kidney became a subject of research[4]. The second opinion is that these animals eat leaves of trees like the *Bukheri pathi*, *Jungli Jamun*, etc. to meet their water requirement[5].

Both these opinions were based on a presumption that there is no freshwater source in the island. Ravi Shanker *et al.*[5] reported that the island is devoid of any source of freshwater.

The Barren Island (Figure 1) is a small, uninhabited volcanic island with a diameter of about 3 km. It has a 2 km-wide caldera, formed due to explosive eruption during prehistoric time, with walls reaching a height of about 350 m. The caldera wall is continuous except towards the western part, where it is open to the sea. The morphology of the central cinder cone and recent flows around it which occupy the central and northwestern part of the island within the caldera has varied through time because of historical eruptions.

There is no vegetation near the crater, but fresh green foliage can be seen at places. On the far side of the crater near the old caldera wall some vegetation is seen in the form of sparse foliage that has survived the volcanic eruption. However, the old caldera wall has good vegetation cover which is denser on the seaward side, thus making the island look green from a distance. A few trees,

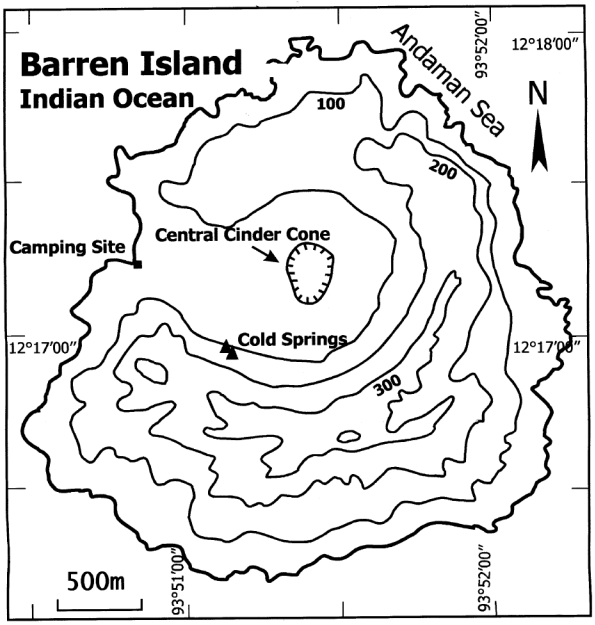

Figure 1. Barren Island topographic map showing location of the cold springs.

Table 1. Chemical parameters of the waters from the cold springs, Barren Island

Parameter	Cold spring 1		Cold spring 2		Desirable limit (ref. 6)
	a	*b*	*a*	*b*	
pH	7.7	7.2	7.8	7.4	7.0–8.5
TDS	325.6	–	296.8	–	500
Conductivity (ms)	0.49	–	0.44	–	–
$CaCO_3$ hardness	79.2	84.6	79.2	65.6	100
Ca^{2+}	23.8	23.0	23.8	19.0	75
Mg^{2+}	4.8	6.6	4.8	4.4	150, if $SO_4 < 250$
Na^+	70.5	71.0	63.3	63.0	–
K^+	4.0	2.7	3.25	4.0	–
Total alkalinity	174.8	190.0	128.7	148.0	–
SO_4^{2-}	51.2	16.0	45.2	24.0	200
Cl^-	48.0	43.0	39.5	34.0	200
Error (%)	0.90	1.85	0.78	2.37	–

Concentration in mg/l; *a*, Wet chemical method[7]; *b*, Ion chromatography for anions and atomic absorption for cations.

which are quite old, remained unaffected even after two recent eruptions (1991 and 1995). This suggests that part of the island remained largely unaffected.

During the recent expedition, two $NaHCO_3$-type cold-water springs were recorded in the southeastern part of the island (Figure 1). These springs are located in a dry 'nala' (N 12°16′55.3″, E 93°51′05.5″) at a distance of 100 m from each other on the old caldera wall at an elevation of 65 m from the sea level. Waters from these cold springs were sampled and analysed and the data are given in Table 1. For comparison, drinking water standards recommended by the World Health Organization[6] are also given in Table 1. Although the name suggests that the Barren Island is devoid of inhabitation, life does exist on this island. The largest animals found here are the feral goats. Besides feral goats, rats, bats, crabs and birds also live on this island. Under what circumstances did the feral goats make their way to Barren Island is an unanswered question. However, it is believed that they were left by a steamer way back in 1891 (ref. 2). Morphologically, feral goats are like their counterparts in other places. They are medium-sized, short-legged, black to grey coloured with thick, coarse, dry and lustreless hair coat. What makes them significant is their adaptation to the harsh and inhospitable conditions and instinct for survival in this island.

The old caldera wall that has good vegetation cover is the source of sustenance for the feral goats. These goats were found grazing around these springs, which are probably the only freshwater source on this island. Further, these goats made a small animal track from the spring source to the crest of the caldera. With the discovery of these cold springs in the Barren Island, myths about the life of feral goats have been resolved.

The freshwater reservoir is possibly entrained in the pyroclastic (cinder) formations. The flow rate when the field work was carried out was ~1 l/min. The lower permeability of the pyroclastics (cinder) with respect to that of the lava formations allows a low discharge rate of the entrapped meteoric waters. There is a possibility of locating several such cold springs towards the steep slopes (seaward side) of the old caldera. Detailed work on the isotopic signatures of the water samples is underway and the results will be published elsewhere.

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D. CHANDRASEKHARAM[†,*]
O. VASELLI[#]
B. CAPACCIONI[‡]
P. MANETTI[**]
M. A. ALAM[†]

[†]*Department of Earth Sciences, Indian Institute of Technology, Powai, Mumbai 400 076, India*
[#]*Department of Earth Sciences, University of Florence, Florence, Italy*
[‡]*Institute of Volcanology and Geochemistry, University of Urbino, Urbino, Italy*
[**]*CNR-Institute of Geosciences and Earth Resources, Pisa, Italy*
**For correspondence.*
e-mail: dchandra@geos.iitb.ac.in

Aerospora over Southern Ocean and Schirmacher oasis, East Antarctica

Geographical distribution of air-borne organisms over long distances by Sirocco and trade winds was demonstrated as early as 1846. During 1873, a study of dust samples collected near the Cape Verde Island resulted in the recording of sixty-seven different kinds of microorganisms[1,2]. A study was conducted during 1937 over the Atlantic Ocean and a number of pollen and spores were recorded from the atmosphere[3]. However, little information is available on the aerial transport of microbes into the Antarctic environment, including their viability, duration of suspension and gravitational settlement. In view of this, the Scientific Committee for Antarctic Research (SCAR) and BIOTAS have promoted aerobiology as a component of the ongoing international research programme. As a result of the review work undertaken during 1967, the principles governing long-distance transport of pollen grains and other microbiota were seriously considered[4].

As of now, no aeropalynological data from polar atmosphere are available in the context of the Indian expedition to Antarctica since 1981. However, few sticky slides were exposed during the third Indian expedition to Antarctica over the Southern Ocean, which registered a fair range but sparse population of bioaero-