Chapter 1

Introduction and history of mapping and research

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Abstract: This chapter examines the history of reconnaissance and geological mapping work on the Andaman and Nicobar islands. To understand early exploration it is necessary to review the driving forces for colonization, including the development of the Andaman Islands as a penal colony for political prisoners. Geological mapping conducted in the colonial era continued after India gained independence in 1947 and expanded in the 1980s to include hydrocarbon and mineral resources. More recent work has placed greater emphasis on supporting field observation data with geochronological, geochemical and petrological analyses.

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Floating in splendid isolation in the NE Indian Ocean, a curved chain of islands, islets and rocks constitute the Andaman and Nicobar archipelago, the central part of the Western Sunda Arc that extends from the outer-arc islands of Sumatra in the Nicobar archipelago, the central part of the Western Sunda chain of islands, islets and rocks constitute the Andaman and Nicobar Islands.

The Andaman–Nicobar chain stretches for over 700 km with a maximum width of c. 58 km and has a total land area of 8249 km². The islands are an exposed segment of the accretionary wedge (outer arc) of the Sunda subduction system, where the Indian Plate subducts beneath the Sunda Plate. Ongoing uplift of the sediment-dominated accretionary wedge has exposed, over a relatively small area, a diverse range of rock types associated with the subduction complex (dismembered ophiolites, volcanic-arc rocks, trench-slope deposits, submarine fan turbidites, pelagic sediments and the sediments of shelf and reef environments), making it an ideal area for investigating subduction processes.

The region remains tectonically active and experiences frequent arc volcanism and earthquakes. The most recent event, the 26 December 2004 earthquake and tsunami, triggered mud eruptions from mud volcanoes on Baratang Island, lava eruptions from Barren Island volcano (Fig. 1.2) and metre-scale subsidence and uplift across the island chain (Fig. 1.3). Searle (2006) documented uplift of the coral reefs along the coast of the Interview Island off the west coast of Middle Andaman, and his book Colliding Continents (Searle 2012) contains a useful summary of the December 2004 Indian Ocean tsunami with particular reference to the Andaman Islands.

Books written on the geology of the Andaman and Nicobar islands tend to be limited in their scope, coverage and depth. Sharma & Srinivasan (2007) published a book on the geology of Andaman and Nicobar but only dealt with the Neogene sequences. The Pictorial Monograph of the Barren Island Volcano by Shanker et al. (2001) is mainly a photographic documentation of recent and past volcanic eruptions, with a limited and inadequate description and discussion of the petrology and origin of the volcano. The Geology and Mineral Resources of Andaman-Nicobar Islands published by the Geological Survey of India in 2012 (Miscellaneous Publication No 30, part XX) contains 40 pages of text that only outline the geology, although it does include a geological map at the 1:1 000 000 scale. The aim of this memoir is to provide a more complete, integrated and comprehensive treatment of the geology, stratigraphy and tectonics and a first systematic attempt to understand the geomorphology. This first chapter outlines the history of the islands and the early exploration and mapping.

History of colonization

The tortuous history of the Andaman–Nicobar islands includes a period of European colonization, serving as a penal colony, and a short-lived brutal Japanese occupation (1942–45) (Dasgupta 2002; Singh 2006). The first recorded European settlers were from the Danish East India Company who arrived on the Nicobar Islands on 12 December 1755. On 1 January 1756 the Nicobar islands were made a Danish colony, first named New Denmark (‘The Last Island of the Savages’) and later (December 1756) Frederick’s Islands (Frederikskøerne). Between 1754 and 1756 the islands were administered from Tranquebar, the former Danish colony in what is now a district of the Indian state of Tamil Nadu. The British were not far behind; in the early 1780s captains Ritchie and Thomas Forrest, a navigator who worked for the British East India Company, surveyed the Andaman islands since they were located along the trade routes of India, Burma and SE Asia and seen as strategically important. At around this time the British began to establish small settlements on the Andaman islands rather than on the Danish Nicobars. Although Britain became the dominant colonial power in the region, Denmark did not formally cede its Nicobar territory until 1868.

One of the earliest and most important British surveys was instigated by the Governor General of India, Lord Cornwallis, who in 1788 dispatched Lieutenant Archibald Blair of the Bombay Marines to survey the Andaman Islands, instructing him to raise the Union Flag and to set up a harbour where merchant and navy ships might be refreshed and refitted (Blair 1793). Most of the surveying took place between 1789 and 1790. The detailed instructions provided by Lord Cornwallis included mention of visiting the volcano on Barren Island to determine if significant depositions of sulphur (an essential ingredient of gunpowder) was present (Phillimore 1945). In 1789 formal possession was taken by the Indian Government (Mout 1862) and a small squadron of His Majesty’s ships under Commodore Cornwallis, brother to the Governor General, visited the islands to extend the survey work, including the...
Fig. 1.1. Location maps of Andaman–Nicobar archipelago and names of individual islands and key places.
harbour at Nanconwry on Nicobar; this led to the Danish Governor at Tranquebar making a formal protest to the British. Blair held charge of the settlement for three years, first with the establishment of Port Cornwallis on Chatham Island, part of South Andaman. In 1792 it was relocated to North Andaman while keeping the same name, but was abandoned in 1796. Between 1786 and 1796 the first attempts were made to establish a penal colony, but the high death rate led to closure and transfer of the penal role to Malaysia. Over the next 40 years the British improved the settlement and harbour facilities, and strengthened its hold on the territory.

The strategic importance of Port Cornwallis was made clear in 1824 when it became the rendezvous point for the Bengal and Madras troops on their way to Rangoon to join the First Burmese War between the British and Burmese for control of NE India (and to deny the French access to Burmese harbours). In the 1830s and 1840s, shipwrecked crews who landed on the Andaman were often attacked and killed by the natives and the islands had a reputation for cannibalism. One headline event took place in 1839 when Johann Wilhelm Helfer, a German doctor and explorer who collected animals and plants for the Indian government, was attacked and killed. Native attacks were commonplace as experienced by the survivors of the troopships Runnymede and the Briton that were shipwrecked on 12 November 1844 by the same storm among the islands that form Ritchie’s Archipelago (Fig. 1.1). Survivors (numbering in excess of 630) suffered spear and arrow attacks by the natives, although none were reported killed by these actions.
imperative. The Sepoy Mutiny, delayed construction but also gave it an imperative. In 1857, the Indian Rebellion of 1857, including a convict colony. The Indian Rebellion of 1857, the Sepoy Mutiny, delayed construction but also gave it an imperative.

After the Indian Rebellion of 1857 was quelled, the large numbers of prisoners were seen as a political threat to the British establishment; it was therefore considered desirable that prisoners be removed from the Indian subcontinent. In November 1857 Lord Canning sent a commission headed by Dr F. Mouat (Inspector General of Jails in Bengal) to the Andamans to find a suitable site for a new penal colony. The recommendations of the committee for the establishment of a penal settlement in the ‘old harbour’, to be renamed Port Blair, were accepted in January 1858. Under the direction of James Pattison Walker, the penal colony was first and foremost a repository for political prisoners. Building started in 1896 and was mainly completed by 1906. It used the latest panopticon design, allowing the independence activists to be closely watched. There were 698 cells designed for solitary confinement; each cell measured 4.5 by 2.7 m with a single ventilation window 3 m above the floor. A notable prisoner from 1910 to 1920 was Vinayak Damodar Savarkar, a famous Indian patriot and philosopher, after whom the Port Blair international airport is named. The Indians imprisoned here referred to the island and its prison as Kala Pani (black water) (Dasgupta 2002). The Viper Chain Gang Jail on Viper Island was reserved for troublemakers, and was also the site of hangings.

The headquarters of the Indian Penal Settlement was based on Ross Island. The site was badly damaged by an earthquake in 1942 and all that is left today are the overgrown ruins of the British establishment (a ballroom, swimming pool, Chief Commissioner’s house, church, cemetery, hospital, bakery and barracks). The penal colony closed on 15 August 1947 when India gained independence, and since then the Cellular Jail has served as a museum to the independence movement. In 1969 the jail was declared a national memorial. Another memorial, found in the Andaman water sports complex, commemorates a local uprising that took place on 17 May 1859 when local indigenous people from the Great Andamanese Tribe armed with bows and arrows attacked Port Blair. The event became known as the ‘Battle of Aberdeen’. Stirred by an escaped convict from the Cellular Jail, the Great Andamanese tribe stormed the British post but was easily crushed as the British had been forewarned. It emerged later that the escaped convict, Dodo Nath, had changed sides and informed the British of the tribal plans.

The Andaman Islands were later occupied by Japan during World War II between 1942 and 1945 and were nominally put under the authority of the Arzi Hukumate Azad Hind, an Indian provisional government established in Singapore in 1943 supported by Japan. Head of State Netaji Subhash Chandra Bose visited the islands during the war, and renamed them as Shaheed (Martyr) and Swaraj (Self-rule). As a member of the around-the-world Danish scientific cruise, Rink (1847) was the first to examine the geology of the Nicobar Islands. He divided the rocks into the Brown Coal Islands into three groups: the Brown Coal Formation, Igneous Rocks and Older Alluvium in ascending order of age. Between 1850 and 1864, Quigley, Kurz, Stoliczka, St John and Mallet produced various reports on the lithology and petrography of rocks from some of the Andaman Islands (Oldham 1885). The first record of microfossils was also likely made during this period. As a member of an Austrian scientific cruise on board the Novara, Hochstetter visited many islands of the Nicobar group and noted that the Brown Coal Formation and Older Alluvium proposed by Rink (1847) are variants of the term ‘marl’ as a substitute for Older Alluvium.

Oldham (1885) classified rocks of the Andaman islands into the older Port Blair Series and younger Archipelago Series, separated by a period of igneous activity. Oldham correlated the Brown Coal formation of Rink with the Port Blair series and the Nicobar clays of Ball with the Archipelago Series. Tipper (1911) dealt with the geology of the (mainly north) Andaman islands and correlated the rocks with those of Nicobar. Work by Gee (1927) covered a larger area including Middle Andaman, Ritchie’s Archipelago, Rutland and Little Andaman as well as many islands of the Nicobar group, and proposed a stratigraphic classification scheme. These studies provided the foundation for the later more systematic geological studies. The volcanic islands of Barren and Narcondam were first studied by Ball (1879, 1888) who also produced notes on the geology and faunal content of rocks in the vicinity of Port Blair, South Andaman and the Nancowry islands of the Nicobar group (Ball 1870a, b). Barren and Narcondam islands were first mapped by Hobday & Mallet (1885) who also provided an impressive account of field attributes, petrology and eruptive history. Their formative work continues to provide the framework for many recent studies. Washington (1924) published the first compositional data of volcanic rocks from the Barren and Narcondam volcanoes.

The beginning of systematic mapping programs

Detailed and systematic geological investigations of the Andaman Islands gained momentum after World War II.
The Geological Survey of India (GSI) and the Oil and Natural Gas Commission (ONGC) of India played a key role and initiated detailed geoscientific surveys in 1959, mainly through geological mapping coupled with structural, lithological and palaeontological studies. Most of the reports were not published, however, with the exception of Chatterjee (1964), Karunakaran et al. (1964a, b, 1968, 1975), Pawde & Ray (1964), Guha & Mohan (1965), Chatterjee (1967), Gururaja & Rao (1976), Ray (1982), Roy (1983) and Haldar (1985). The first publically accessible geological map of the Andaman Islands was confined to South Andaman and published in 1964 at the 22nd International Geological Congress (IGC) held in New Delhi (Karunakaran et al. 1964a). A generalized geological map of the entire Andaman Island chain at a scale of 1:1 000 000 was published in 1967 (Chatterjee 1967). Entrusted with finding oil and gas, the ONGC mapped large areas of North and Middle Andaman (Pandey et al. 1992). During the late 1990s Pal and co-workers conducted detailed mapping of parts of South and North Andaman; the structural attitudes of the ophiolites in their geological maps (Pal et al. 2003) have, however, been questioned by Acharya (2007) (see Chapter 7). The most recent publication of GSI (Bandyopadhyay & Moulik 2012) includes a 1:1 000 000 scale geological map of the Andaman–Nicobar Islands. More detailed GSI geological maps exist for some areas, but these are not yet in the public domain. To date, 6749 km² out of a total area of 8249 km² has been systematically mapped by the GSI.

Thematic work and resource characterization

Thematic mapping by GSI was underway by the early 1990s. This includes large-scale mapping in key areas to understand the stratigraphic and structural relationships between ophiolite basement and the overlying sedimentary cover. Coastal environmental studies were included in the geomorphological mapping of Andaman beaches, including the study of wave dynamics and beach processes in relation to accretion and erosion. ONGC conducted seismic studies across the Andaman Islands and offshore areas (Roy 1983) during the late 1970s to early 1980s, including ground-truthing by onshore and offshore drilling in and around Middle and North Andaman (Roy 1983; Pandey et al. 1992; Roy & Das Sharma 1993). Mineral investigation started with large-scale mapping and exploratory drilling on Long Island, Middle Andaman during the late 1980s led by the GSI, followed by a wider search for potential deposits of sulphide minerals, coal, gold and platinum group minerals. Ghosh et al. (2009) studied chromite occurrences in ultramafic rocks as well as beach sands across the Andaman Islands.

Since the middle–late 1990s, there has been a significant change in the nature of investigations to couple field-based observations with more sophisticated petrological, geochemical and isotopic techniques. Advanced petrological research has included: the study of major, trace and rare Earth elements (REE) concentrations; Sm–Nd isotope chemistry; geochemistry including U–Pb, 40Ar/39Ar and 14C methods and fission track thermochronology; and identification of mineral phases by electron probe micro-analysis (EPMA). These studies have provided the first isotopic age constraints on depositional and uplift history of the Palaeogene sedimentary formations of the evolving Andaman–Nicobar accretionary arc (Allen et al. 2008). REE geochemistry and the U–Pb dating of zircon from plagiogranite of the ophiolite suite have placed robust age constraints on the formation and emplacement of ophiolite (Pedersen et al. 2010; Sarma et al. 2010; Pal 2011). Results from the study of light framework and opaque and non-opaque heavy minerals of the modern sands using highly sophisticated petrographic techniques by Garzanti and co-workers at the University of Milano-Bicocca, Italy (Garzanti et al. 2013) have altered earlier concepts and approaches to the study of sediment provenance in subduction zone sediments.

The National Geophysical Research Institute (NGRI) in Hyderabad, India has also been involved in the study of the geochemistry of igneous and sedimentary rocks of the Andaman Ophiolite suite (Jafri et al. 1990, 1993, 1995; Jafri & Sheikh 2013). Awasthi et al. (2010) provided radiometric dates of ash layers interbedded with marine sediments from a drill core obtained from 32 km SE of Barren Island, and were able to infer the timing and frequency of eruptions over the past 72 ka.

Following the eruptions of May 1991, GSI conducted a rolling program of research on the Barren Island and Narcondam volcanoes, later joined by academicians from the Indian Institute of Technology (IIT), Mumbai (see Chapter 12 for details). Haldar et al. (1992) provided a chronology of historical and recent volcanic eruptions for Barren Island. This initial study, coupled with field documentation of volcanic features and petrographic, mineralogical and geochemical analysis of the fragmental ejecta (lava and coarser pyroclastic debris), led to the publication of a pictorial monograph on Barren Island volcano (Shanker et al. 2001). Sheth et al. (2009) provided a praiseworthy description and documentation of features of the pre-historic volcanoes on Barren Island and established the pre-historic eruptive history. While petrological and geochemical studies of past and current eruptions (Alam et al. 2004; Pal et al. 2007a, 2010) have helped to constrain the origin and evolution of subsurface magma; however, poor documentation and incorrect interpretations of the active lava flows and identification of lavas of particular eruptions during the last two decades have left plenty of scope for re-examination and further work (see Chapter 12 for details), partly provided by Bandyopadhyay et al. (2014). Narcondam has seen much less study (Haldar et al. 2007; Pal et al. 2007b; Pal & Bhattacharya 2011; Streck et al. 2011) after the pioneering work of Hobday & Mallet (1885) and Ball (1888).

 Likewise, the Nicobar Islands has seen less study compared to the main Andaman Islands. Distinct location and accessibility is one reason for this; the other is that many of the islands are protected areas and reserved for indigenous tribal communities. The geology, geography and faunal content of the rocks of Nicobar Islands were however studied during British rule, sometimes in remarkable detail (Rink 1847; Hochstetter 1869; Ball 1870a; Tipper 1911; Gee 1927), although these early studies do not appear to have produced any geological maps. Mapping programmes led by GSI started in the late 1950s and early 1960s, and continue to the present day. These have produced some geological maps now in the public domain, such as GSI Misc Publication no. 30, part XX, 2012. The Joint Scientific Expedition to Great Nicobar Island in 1966 provided an improved and comprehensive picture of the geology of these islands, and linked the main rock units with those on the Andaman Islands (Karunakaran et al. 1975). The formations of Great Nicobar and Little Nicobar follow the same stratigraphic scheme as the Andaman islands.

Conclusions

Much has been achieved since the earliest mapping in the late nineteenth century but, given the complexity of Andaman geology, much disturbed by tectonics, there remains much to do, especially with regard to defining the ages of the mapped units, a common theme in subsequent chapters.
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