Chapter: One

Chapter 1
Introduction

1.1 Modern Geodynamics

Based on the physical properties of the Earth, it has been realized that there are two important layers which govern most of the activities on and inside the Earth; the lithosphere and the asthenosphere. The lithosphere is the top 100 km or so of the Earth's interior, which is made up of the rocky crust and outermost rocky layer of the mantle, also known as plate. The asthenosphere is part of the upper mantle below the lithosphere, comprising the low velocity layer and more viscous mantle rocks beneath, down to about 700 km. Two types of lithospheric plates have been recognized: I) the oceanic lithosphere: that encompassed the oceanic crust and II) the continental lithosphere: that encompassed the continental crust.

The interior of the Earth is hot, owing to the heat originally accumulated in the Earth during the time of formation and heat produced by ongoing radioactive decay. The present rate of radioactive heat production in the mantle is ~ 2.5×10^{13} W according to the two-layer model and ~ 2.1×10^{13} W according to the whole-mantle convection model (Spohn and Schubert, 1982). This internal energy causes instability in the Earth's interior and its surface plates leading to plate tectonics.

Earth is made up of seven major and several minor lithospheric plates, which are continuously moving with respect to each other (Fig. 1.1). The science and study of cause of, and relative motions of, the Earth's lithospheric plates form the study of plate tectonics. The motion of these plates is extremely slow due to the incredible amount of mass being moved, friction, and the high viscosity of the asthenosphere. The driving

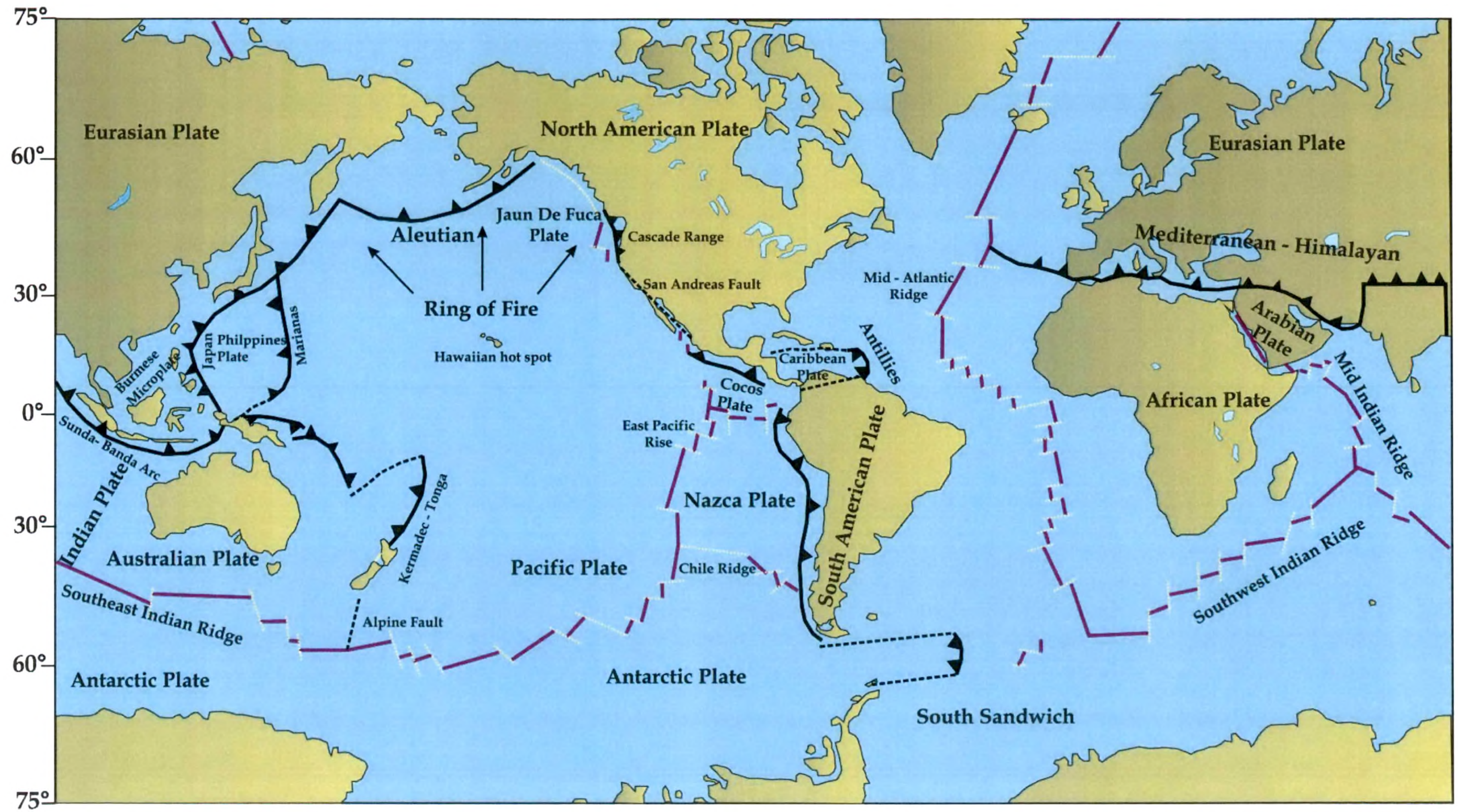

Fig. 1.1 Global tectonic map showing various plates, plate boundaries and different tectonic features (modified after Wilson, 1989)

force behind these movements is mainly the mantle convection. Based on relative motion of these plates three types of plate boundaries are developed; I) Transform II) Divergent and III) Convergent.

At a transform plate boundary, the plates horizontally slide past one another without production or destruction of the lithosphere. The motion can be in the same direction or in the opposite direction. If the motion is in the same direction but at different speeds earthquakes are created. In 1965, a Canadian Geologist, Tuzo Wilson, was the first to observe the true nature of the transform fault. Wilson suggested that these large faults connect the global active belts into a continuous network that divides Earth's outer shell into several rigid plates (Tarbuck and Lutgens, 2006). Most transform faults are located within ocean basins, but a few cut through continental crust, e.g., the San Andreas Fault of California, USA.

At a divergent plate boundary, two plates move apart resulting in upwelling of mantle that melts to create new oceanic crust. These plate boundaries, located along mid oceanic ridges (MOR), are known as constructive plate boundaries. The interconnected oceanic ridge system is the longest topographic feature on the Earth's surface, exceeding 70,000 km in length, which represent 20 % of Earth's surface (Fig. 1.1).

Farther away from MOR, driven by the mantle convection when an older and denser lithospheric plate collide with another lithospheric plate, relatively younger and lighter, it becomes negatively buoyant and sinks into the mantle. These places represent the zones of convergent plate boundaries and are also known as subduction zones, which are tectonically most active regions on our planet. Subduction of an older plate beneath a younger plate results in the formation of several tectonomorphic features such as trench, accretionary prism, volcanic arc and back arc spreading ridge. New continental crust also gets generated along these zones as a result of magmatism on the leading margin of the overriding plate (Hawkesworth et al., 1993).

Both volcanic and earthquake activities are indicators of, and a consequence of, the movements of the lithospheric plates. The world-wide distribution of earthquakes and volcanoes are observed along zones of higher than average heat flow from the Earth's interior (Fig.1.1). This information has been used to define the tectonically active regions of the world and thereby the margins of the lithospheric plates. Spreading oceanic ridges and transform faults are characterized by shallow earthquakes limited to axial rift zones. These earthquakes are generally small in magnitude, commonly occur in swarms and appear to be associated with intrusion and extrusion of the basaltic magmas. The most destructive earthquakes are found along subduction and collision zones. The subduction zones are defined by earthquake hypocentres that lie in an approximate plane and dip beneath the arc systems. This plane, known as the seismic zone or Benioff zone, dips at moderate to steep angles and extends in some instances to the 660 km seismic discontinuity (Condie, 1997). The seismic zone is interpreted as a brittle region in the upper 10-20 km of descending lithospheric slabs. Although collision zones such as the Himalayas, are seismically very active, earthquake foci tend to be shallow, probably because there is no longer a subducting plate beneath the mountains.

Volcanisms are found along subduction zones, spreading ridges, continental rift vallies and at isolated locations inside the plate boundaries, where 'hot spots' are created by rising plumes of the materials within the mantle. The source and type of magma are different in different tectonic environment. The magma involved in spreading, rift valley and hot spot volcanoes is a result of decompression melting of the mantle and is basaltic in nature which reflect chemistry of the mantle; whereas the magma found in subduction zones whether in island arc or in orogenic belt, has its origin in the partial melting of heavily metasomatized mantle wedge in presence of fluids derived from subducting oceanic crusts. The compositions of these lavas are complex, but are mainly andesitic.

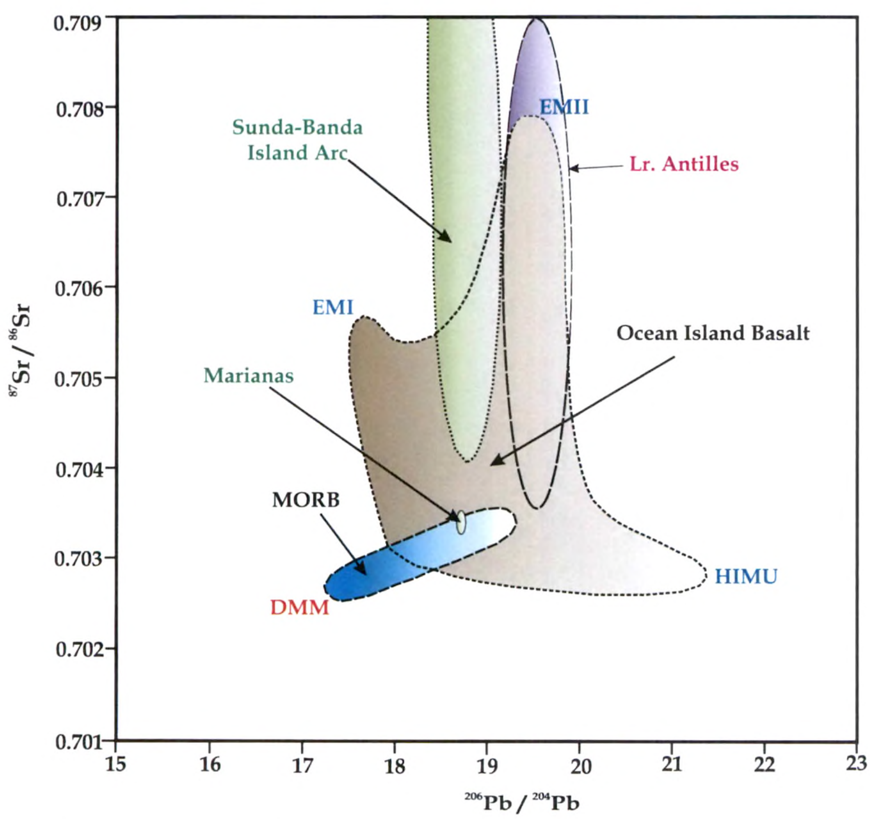

Fig.1.2 $^{87}Sr/^{86}Sr$ vs. $^{206}Pb/^{204}Pb$ for various mantle components as sampled by magma MORBs and OIBs. Also shown are fields for different oceanic island volcanics for comparison, MORB – Mid-ocean-ridge basalt; DMM – Depleted MORB mantle; EMI – Enriches mantle I, EMII – Enriches mantle II, HIMU-High μ. Fields are drawn base on databases given in GERM website: (http://earthref.org/GERM/)

Based on isotopic compositions of mantle derived magma at mid-ocean ridges and ocean islands, several major mantle components have been identified (Fig. 1.2 and 1.3). These include depleted MORB mantle (DMM), enriched mantle-I (EM-I), enriched mantle-II (EM-II), high-μ mantle (HIMU) and prevalent mantle (PREMA) [e.g. Zindler and Hart, 1986, Stracke et al., 2005]. It is believed that the changes in the primordial mantle compositions are caused by subduction; as for example the evolution of EMI and EMII type of mantle sources is due to addition of mafic lower crustal materials and oceanic sediments to the pristine mantle sources respectively, which have high $^{87}Sr/^{86}Sr$ and relatively low $^{143}Nd/^{144}Nd$. The HIMU, or high-μ ($\mu = {}^{238}U/^{204}Pb$), source is characterized by higher $^{206}Pb/^{204}Pb$, but depleted (MORB-like) in $^{87}Sr/^{86}Sr$ and $^{143}Nd/^{144}Nd$ compared to other end member components (EMI, EMII etc.). The composition of HIMU mantle source is the product of the mixing of subducted oceanic crust and pristine mantle source, because the subducted oceanic crust contains high concentration of U and Th. The PREMA mantle, also known as FOZO (Stracke et al., 2005) is the most

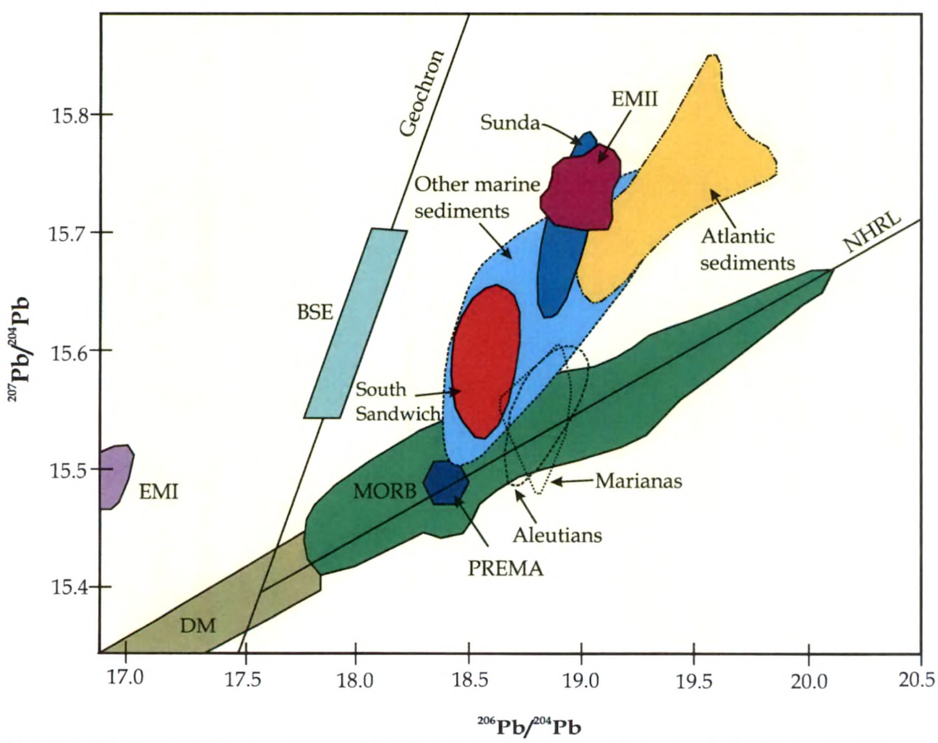

Fig.1.3 $^{207}Pb/^{204}Pb$ vs. $^{206}Pb/^{204}Pb$ plot showing chemical difference of magma at various tectonic setting with different oceanic island arc volcanics and sediments (modified after Wilson 1989) MORB – Mid-ocean-ridge basalt; NHRL – Northern Hemisphere reference line; DM – Depleted mantle; EM – Enriches mantle, PREMA- Primitive mantle, BSE- Bulk Silicate Earth.

common or prevalent mantle components, inferred from isotopic compositions of OIBs and possibly represents the most pristine mantle composition.

1.2 Subduction Zone

Subduction zones are extremely dynamic regions of the Earth's surface. They are the collision sites between Earth's tectonic plates, where a subducting plate is carried deep into the Earth's mantle beneath an overriding plate. These zones are also known as our planet's largest recycling system, where oceanic lithosphere, sediments (pelagic and terrigenous) and seawater return to and reequilibrate with Earth's mantle. Arc magmas are produced along these zones that ultimately contribute to the generation of young continental crusts.

There are two types of subduction zones defined on the basis of nature of convergence of two lithospheric plates: I) ocean-ocean subduction and II) ocean-continental subduction. When an oceanic plate subducts beneath an oceanic plate, a deep trench, such as the Marianas, is created at the boundary between the two. The arc volcanism products at this type of setting is usually basaltic and basaltic andesitic. In the second case where an oceanic plate subducts beneath a continental plate, a shallow trench, Chilean type, is created. The arc volcanism at this type of setting is mainly calc- alkaline andesitic.

Subduction of lithospheric plates plays an important role in plate tectonics because it is considered that the gravitational pull of subducted slabs drives the motions of the plates, but the coupling between slabs and plates is not well established (Conrad and Bertelloni, 2002). It is also believed that mantle convection, which is responsible for the plate motions, may be driven primarily by the descent of dense slabs of the subducted oceanic lithosphere (Hager, 1984). The initiation of subduction is always debated. How a subduction zone begins remains poorly understood (Niu et al., 2003) but a recent study by Michael et al. (2004) proposes two principal views on the physical mechanism leading to the initiation of subduction. The first and most common view is that as the oceanic lithosphere ages and cools, its density increases so that an instability arises and the plate sinks spontaneously in the mantle under its own weight and the second view proposes that the externally applied compressive stresses and moderate convergence are necessary to form a new subduction zone. The most likely mechanism would be through a transfer of stress induced by a collision, leading to 'forced' subduction initiation elsewhere. Silver and Behn, (2008) proposed that the subduction has operated continuously on Earth without interruption, and are routinely terminated by ocean closure and supercontinent assembly. These authors also agree with Niu et al. (2003) is view that subduction initiation is probably the least well-understood aspect of plate tectonic theory. Hansen (2007) presented a hypothesis that mantle upwelling and similar thermal processes, combined with an impact from an extraterrestrial source, might have given the early Earth the discontinuities in the crust for the subduction of the denser material underneath lighter material. In a recent work, Lowman (2011) proposed that the difference of densities between two adjacent lithospheric slabs is sufficient to lead to the initiation of subduction.

1.2.1 Structure of a subduction zone

The structure of a typical ocean - ocean subduction zone with its various components is presented in Fig. 1.4. When a lithospheric plate begins to descend beneath another plate along a subduction zone, the point of contact where the bending of the subducting slab from a horizontal to a dipping position occurs is known as a trench (Fig. 1.4).

During the process of subduction, the surface of the downgoing plate shears against the edge of the overriding plate. The shearing leads to scrapping off materials from the downgoing slab onto the overriding plate producing an accretionary prism or wedge. The angle of subduction varies significantly, as inferred from seismic data on Benioff zone earthquakes (Hamilton, 1998).

The Benioff Zone is a planar trend of earthquakes along the upper boundary of subducted slab, which can extend up to 700 km into the mantle. The wedge shaped mantle that lies in-between the slab and the overriding plate is called the mantle wedge (Fig. 1.4). When the cold subducting slab comes in contact with hot mantle wedge, dehydration takes place and fluids are released into the wedge leading to melting – which generates the volcanic arcs (Fig. 1.4).

An island arc a volcanic arc in the sea, set up begins on the overriding plate with the development of a forearc (the portion of the arc between the volcanic front and the trench is called the 'forearc'), which contains both volcanic rocks and sedimentary rocks derived by weathering of the arc. Behind the forearc is the main volcanic arc, which runs parallel to the trench at a distance that correlates with the dip angle of the subducting slab (Pluijm and Marshak, 2004). The basin behind the volcanic arc is called a backarc basin, which is underlain by basaltic oceanic crust and may contain a spreading ridge (Fig.1.4). Extensional tectonic features are common in backarc environments. The trench and forearc realms are characterized by low heat flow because the downgoing slab of cold oceanic lithosphere acts as a heat sink (Pluijm and Marshak, 2004). The volcanic arc and the adjacent backarc basin are the areas of unusually high heat flow, partly because of localized magmatic activity, but principally because of mantle convection (Hamilton, 1998).

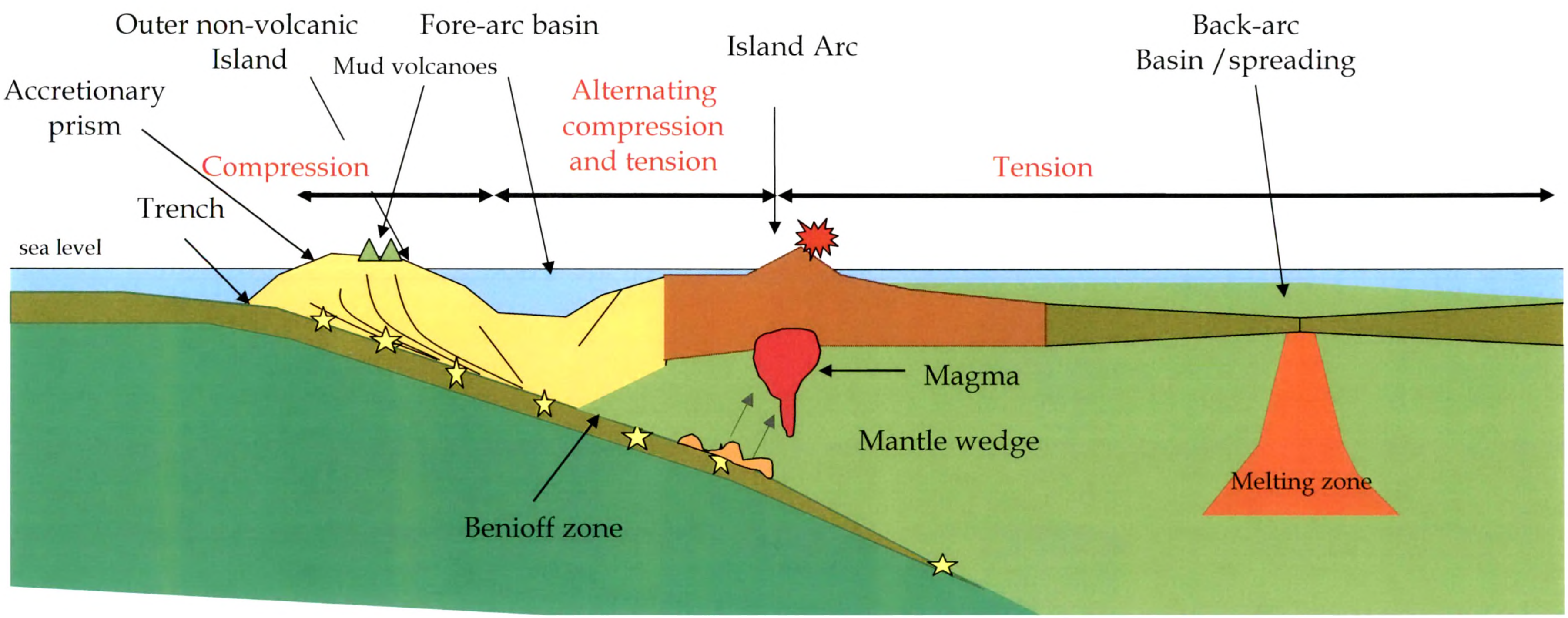

Fig.1.4 A schematic diagram showing various components of an ocean-ocean subduction zone, stars indicate hypocentres of earthquakes, solid curve lines in accretionary prism indicate the direction of off scraped materials which resist to go inside with lithospheric plate and the straight solid line indicate fault lines.

1.2.2 Accretionary Prism

The accretionary prism or wedge consists of ophiolites, deformed pelagic sediments, and of the deformed trench deposited turbidities. It also contains a special type of sedimentary feature, known as mud volcanoes. The details of all the components of a typical accretionary prism are described in the following paragraphs.

Ophiolites

Ophiolites represent obducted uppermost portions of oceanic lithospheres (Dewey and Bird, 1971; Coleman, 1977; Nicolas, 1989) that were incorporated into continental margins during continent-continent and arc-continent collisions (Dilek and Flower, 2003), ridge-trench interactions (Cloos, 1993; Lagabrielle et al., 2000), and/or subduction-accretion events (Cawood et al., 2009). However, in recent times it has been realized that a great majority of ophiolites form at the subduction zones. Dilek and Furnes (2011), categorized ophiolites into two types; subduction-related and subduction-unrelated types. Subduction-related ophiolites include suprasubduction zone varieties, whose geochemistry is similar to island arc magma. They further divided subduction-unrelated ophiolites into three types; continental- margin, mid-ocean ridge, and plume-type, compositionally similar to MORB or OIB. Pearce et al. (1984) suggested that the suprasubduction zone ophiolites develop during the initial stages of subduction prior to the development of any volcanic arc and that the more common mechanism for formation of suprasubduction zone ophiolites have been pre-arc rather than back-arc spreading, whereas subduction-unrelated types evolve during rift-drift and seafloor spreading. Fig. 1.5 depicts a generalized model for the generation of suprasubduction zone ophiolites.

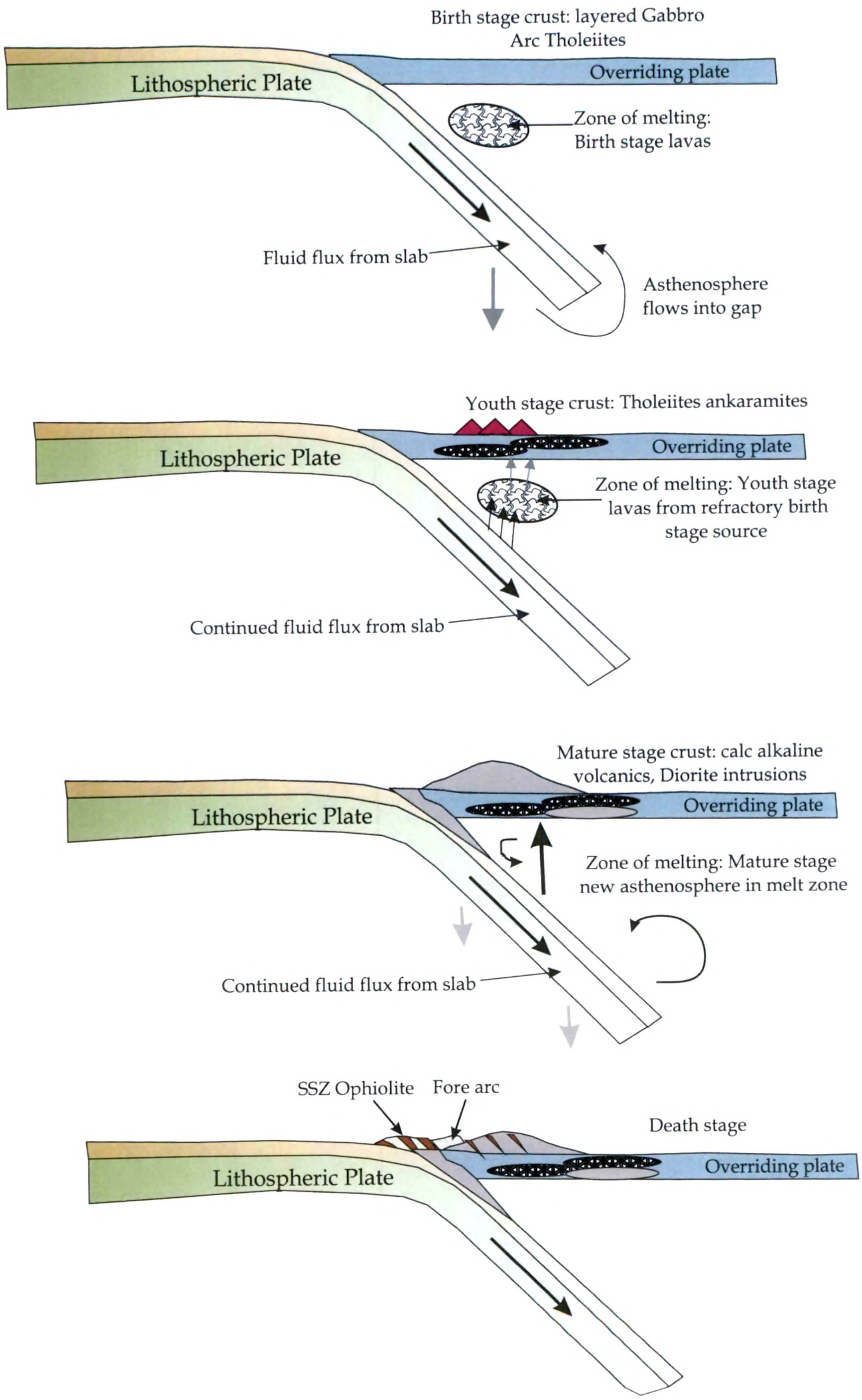

Fig. 1.5 Model for formation of suprasubduction zone (SSZ) ophiolite (modified after Shervais et al., 2004)

Sediments

Sediments are an important constituent in subduction environment. It is the water holding capacity of the sediments that makes them crucial for magmatic activity in a subduction zone. The dewatering process of sediments along the interface of slab and mantle wedge contributes significantly to the melting processes in the wedge leading to volcanism on the overriding plate. Jarrard (2003) suggested that addition of less then 1 % of water can lower the melting point by several hundred degrees of mantle wedge. Apart from this the sediments are the ultimate sources of many of the unusual enrichments and chemical signatures found in arc lavas (Stern, 2002).

Mud volcanoes and fluid activity

Mud volcanoes are common features in forearc region. Apart from the main fault of the subduction zone, i.e. the decollement fault along which the two plates come into contact, there exist numerous faults along the convergent margin that are loci of earthquakes. Some of these faults play an important role in the formation of mud volcanoes. These faults help release of high pressurized fluids and solid materials from the subduction zone through deep conduits and serve as windows to the subducting slab.

Moore and Vrolijk (1992) proposed that in accretionary prisms, fluid rock interactions occur in most dynamic structural environment on Earth. The prism materials loose fluids both through tectonically induced consolidation and thermally induced dehydration processes. Peacock (1990) argued that the expulsion of large volume of pore waters and CH_4-H_2O fluids produced by digenetic and low grade metamorphic reactions at shallow depth affect the thermal and rheological evolution of the accretionary prism and at greater depth it alters the bulk composition of mantle wedge after CO_2 and H_2O are released by metamorphic reactions in the subducting altered crust and trigger partial melting reactions which are responsible for magma generation.

1.2.3 Island Arc

In a convergent margin, where two oceanic lithospheres are involved, it is the descending oceanic lithosphere that contributes to melting process in the mantle wedge. These melts rise from the point of melting through the overriding plate to form volcanoes just behind the leading plate edge. The resulted volcanoes on the overriding plate occur in a series of volcanoes and make a chain of volcanic islands forming an arc shaped chain, popularly known as 'Island Arc'. On the globe many such boundaries have been recognized: e.g., the islands of Japan, Aleutian, Mariana, and Lesser Antilles. Island arcs are generally 200 to 300 km wide and can be several thousand kilometers long.

1.3 Chemistry of subduction related ophiolites, slab and mantle wedge

1.3.1 Suprasubduction Ophiolite

Subduction related ophiolites are known as supra-subduction zone (SSZ) ophiolites. Their geochemical characteristics are akin to island arc lavas but they are thought to have formed by sea-floor spreading directly above subducted oceanic lithosphere (Pearce et al., 1984). They differ from 'MORB' ophiolites not only in their geochemistry but also in the more depleted nature of their mantle sequences. These types of ophiolites are mostly best-preserved in orogenic belts (Pearce et al., 1984).

Pearce et al. (1984) also suggested that these ophiolites are the first magma to form in response to intra-oceanic subduction and are boninitic in composition, derived by partial melting of hydrated oceanic lithosphere in the 'mantle wedge'. As subduction proceeds, the magma composition changes to island-arc tholeiite, probably because the hydrated asthenosphere of the 'mantle wedge' eventually becomes the dominant mantle source. Other SSZ ophiolites formed in the early stages of back-arc spreading following splitting of a pre-existing arc. The characteristic of suprasubduction zone basaltic magma compositions is the elevated concentrations of large ion lithophile elements (LILE: Cs, Rb, Ba, Th, K, Sr and Pb) relative to high field strength elements (HFSE: Nb, Ta, Hf, Zr and Ti) (Fig. 1.6). Isotopic compositions of these ophiolites overlap with those of MORB and Island Arc lavas (Fig. 1.7).

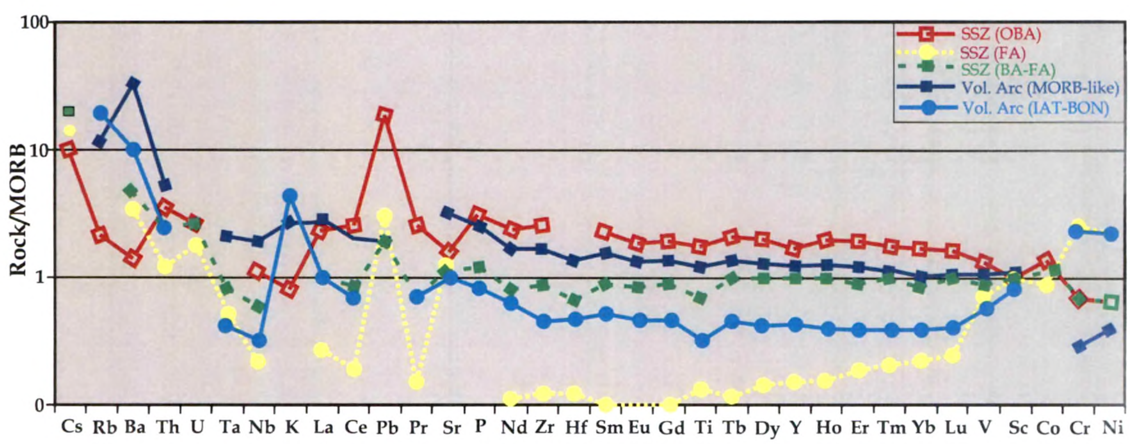

Fig. 1.6 Mid-ocean-ridge-basȧlt (MORB)–normalized multi-elements diagram, showing average compositions of subduction-related ophiolites and Island arc type ophiolites. IAT – island - arc tholeiite; Bon – boninite. Suprasubduction - zone (SSZ), backarc to forearc (BA-FA), forearc (FA) and oceanic backarc (OBA). (Data sources and normalizing values: Dilek and Furnes, 2011)

1.3.2 Chemistry of Mantle wedge and Slab

The asthenospheric mantle that lies between the slab and the overriding plate is called the mantle wedge. It is called so because of its shape. The prime importance of the mantle wedge lies in its role in the generation of new continental crust at the volcanic/magmatic arc region. The chemistry of mantle wedge, although is similar to a depleted MORB mantle at the initiation of subduction, gets continuously modified through metasomatism by material derived from the slab.

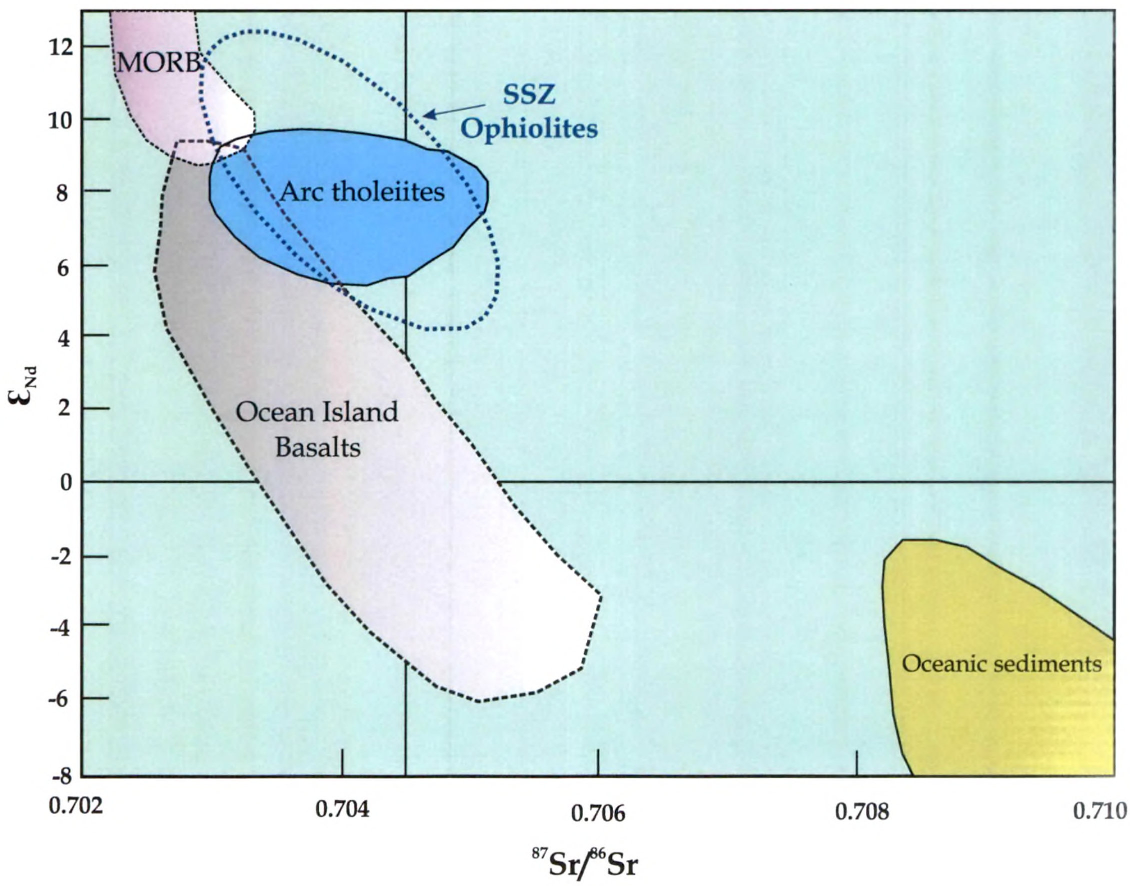

Fig. 1.7 Comparative ε_{Nd} *vs* $^{87}Sr/^{86}Sr$ *plot for MORB, OIB, SSZ, island arc tholeiites and oceanic sediments (Data sources: Rollinson, 1993 and Wakabayashi et al., 2010)*

The slab introduces chemically different materials to the mantle. It contains apart from older oceanic lithospheric mantle, altered oceanic crust, pelagic and terrigenous sediments. It is believed that the mantle in close contact with the slab gets chemically modified by subduction processes, such as dehydration and melting, creating a delaminated mafic lower arc crust. This mafic arc crust when gets subducted to much deeper mantle plays a significant role in the evolution of mantle in generating heterogeneity (Tatsumi, 2005). Therefore, it is necessary to understand the chemistry of the mantle wedge through the island arc lavas. Compositions of arc magmas, if not contaminated by the crust through which they pass, are mainly controlled by three sources: the slab, subducted sediments and the mantle wedge overlying the slab. In general, arc magmas are fractionated, porphyritic and wet compared to mid-ocean ridge or hot spot magmas (Tatsumi and Eggins, 1995). Their petrology also depends on crustal thickness through which they pass.

In general, the chemistry of island arc lavas has the following major characteristics that reflect the nature of the mantle wedge from which they are derived.

I) Enrichments in fluid mobile trace elements (K, Rb, Cs, Ba, Pb, Sr, and LREE) as compared with MORB (Fig. 1.8).

II) Be and Th are relatively enriched in arc basalts, but believed to be relatively insoluble in H_2O-rich fluids that suggest sediment melting.

III) Depleted in high field strength elements (Ta, Nb, Zr, Ti) (Fig. 1.8).

IV) Mostly basaltic to basaltic andesite in composition.

V) Sr and Nd isotopic ratios are highly variable ranging from MORB to highly enriched compositions (Fig. 1.9).

The slab chemistry plays an important role in the evolution of arc magmas and the mantle as a whole. Age of the slab is a crucial factor that controls its chemistry. Older slabs carry lots of fluids and sediments and subducts to greater depths affecting the depth and degree of partial melting in the mantle wedge. Initially, when a cold subducting slab comes in contact with hot mantle wedge, dehydration takes place and fluids from slab migrate to the mantle. In second stage, sediments also move with fluids to mantle wedge and lastly when the slab reaches greater depths it melts. On the basis of fluid transport, Johnson et al. (1994) proposed that the arc magmas contain up to 6% water, much higher compared to MORB and hot spot tholeiites, which contain 0.4 % and 1% of water respectively.

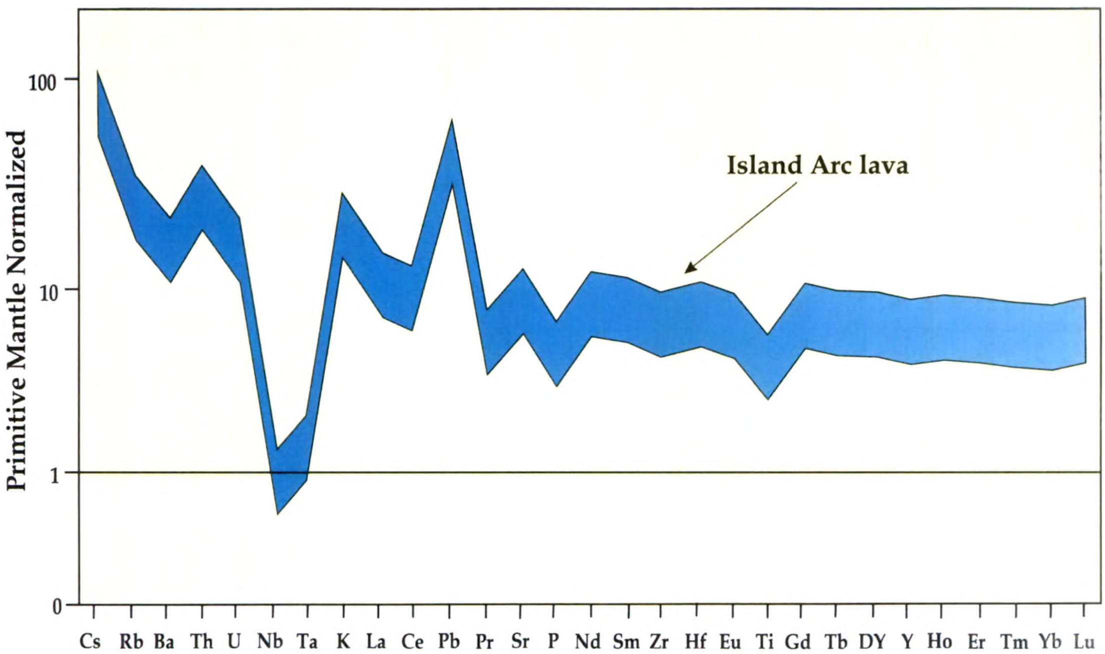

Fig. 1.8 Primitive mantle normalized trace element patterns for arc lavas

As stated earlier, the lithospheric slab is central to the modifications in the mantle chemistry. In spite of their importance, the chemical characterization of slab materials (sediments and rocks) remains mostly speculative. Interestingly, the mud volcanoes that occur in forearc area appear to serve as a window to the subducting slab, at the slab-wedge interface. Therefore, chemical characterization of materials emitted through these unique vents can help to answer some of questions pertaining to the chemistry of the slab.

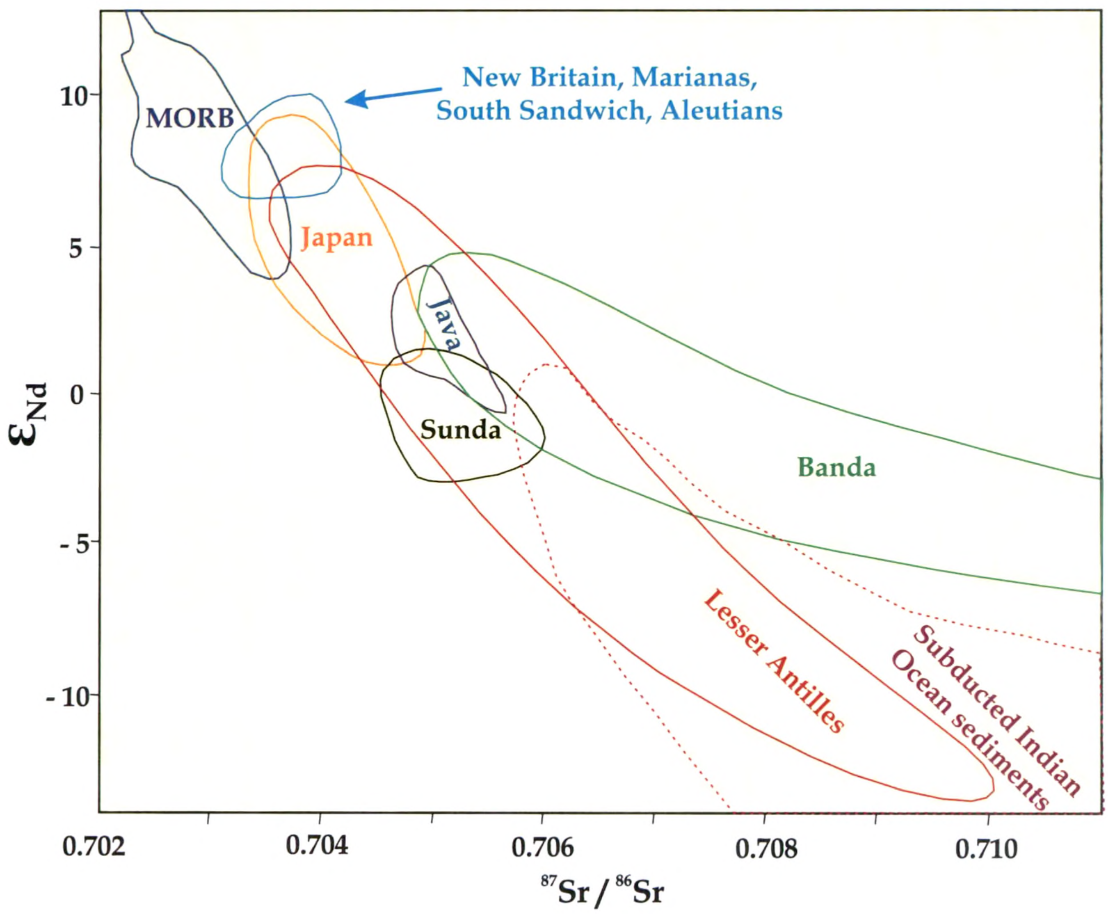

Fig. 1.9 Sr and Nd isotopic variations plot for various arc magmatism and Indian Ocean subducted sediments (modified after Wilson 1989)

In spite of numerous studies on subduction zone processes several important questions pertaining to the chemistry of various components of these zones remain unanswered. Some of these, as listed below, form the basis of this thesis work:

I) What is the chemistry of subducting materials and how does it influence the volcanism near the trench (suprasubduction ophiolites) and the volcanic arc?

II) Where is the exact location of the source of the primary magmas for the arc lavas and how much of melting is required to generate these?

1.4 The Andaman Subduction Zone

The Andaman subduction zone (Fig. 1.10) is one of the most seismically active and young subduction zones of the globe. The Andaman arc - trench system in north-east Indian Ocean extends from Myanmar in the north to Indonesia in the south. It is the result of subduction of NE-moving Indian Plate beneath the Burmese Plate. This subduction process gave rise to the Indonesian Arc system that also includes the Andaman and Nicobar Islands and contains more than 100 volcanoes. The Barren Island Volcano (12.29°N; 93.85°E) is located in the Andaman Sea is the northernmost active center of this arc system and is the only active volcano of India.

The timing and mode of initiation of the Andaman Subduction Zone is still being debated. About the timing of initiation, two schools of thoughts exist. The first school (Acharyya et al., 1990; Sengupta et al., 1990) argues that the present subduction, all around the western Sunda arc, began during Miocene times and onland emplacement of ophiolites took place during terminal collision in Oligocene. In their model, a second trench further east of the present trench with a protocontinent was assumed. Also, Cretaceous ophiolites and Eocene sediments were considered as part of this accretionary prism related to second subduction margin and believed to have subsequently emplaced as east to west propagating allochthonous nappe sheets on present subduction margin. The second school of thought is based on the presence of melange and the highly deformed sediments. These authors suggest that the onset of subduction took place during Late Cretaceous times, after the early Cretaceous break-up of the Gondwanaland (Curray and Moore, 1974; Karig et al., 1979) or from Late Palaeozoic (Hamilton, 1979; McCourt et al., 1996). The detailed descriptions of these models are given in chapter 2.

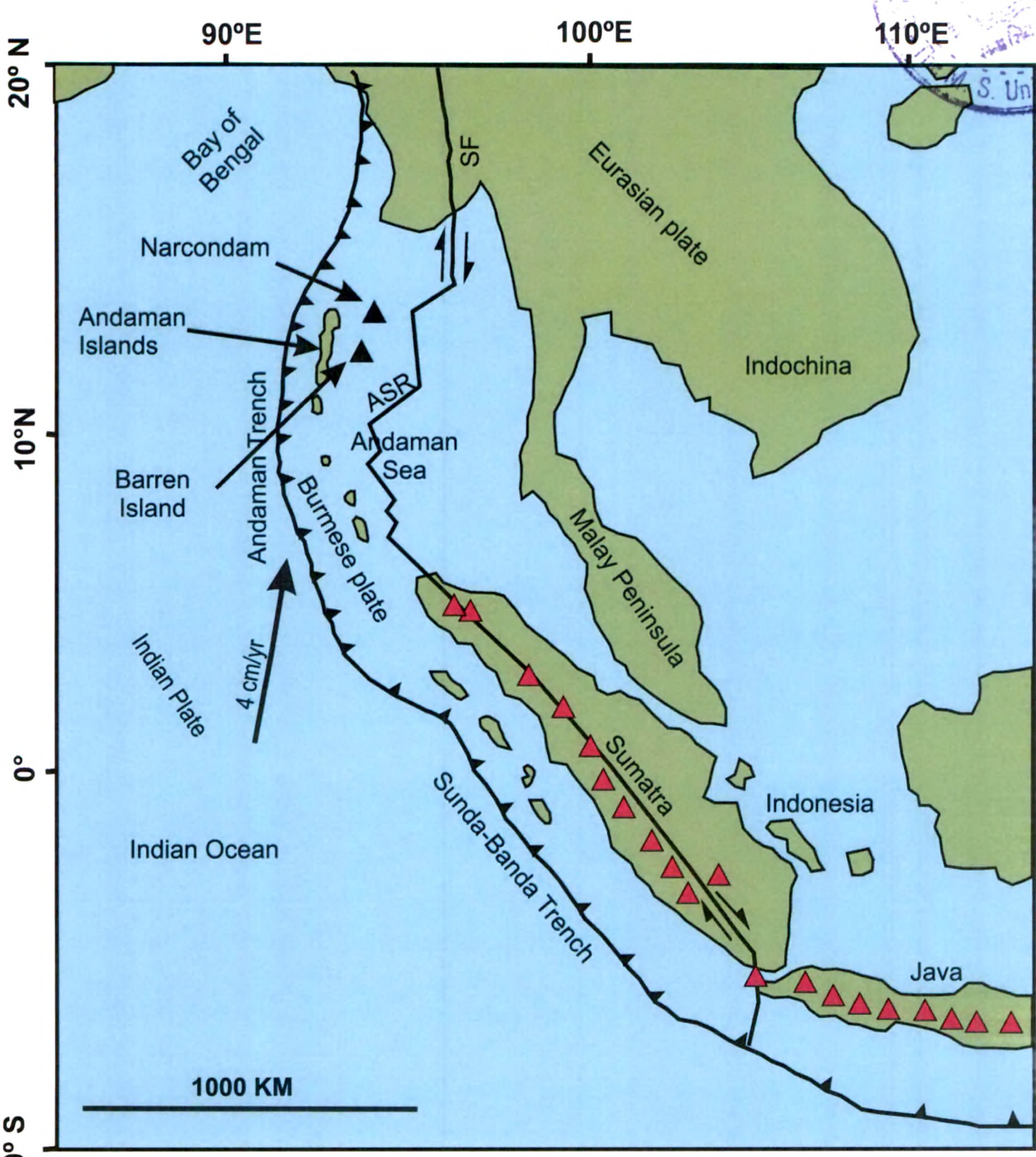

Fig. 1.10 Map of Southeast Asia and northeastern Indian Ocean showing major geological and tectonic features. ASR: Andaman Sea ridge; SF: Saigang Fault.

Srivastava et al. (2004) suggested that the Andaman ophiolites are geochemically similar to N-MORB. Pal et al. (2003) and Pal (2011) gave models for the geodynamic evolution of the Andaman Islands and for the petrogenesis of the Andaman ophiolites. Apart from these there have been several other important studies on these rocks (Jafari et al. 1990, Shastry et al., 2001, Ray, 1987, Acharyya, 2007, Pal and Bhattacharya, 2010 etc.), however, no isotopic study has been carried out so far.

Unlike the ophiolites the mineralogical, petrological, geochronological and geochemical aspects of the arc lavas of the Andaman subduction zone have been studied by several workers [Alam et al., (2004), Luhr and Halder (2006), Chandrashekaram et al., (2009), Sheth et al., (2009, 2010 and 2011), Pal et al., (2010), Banerjee (2010), Streck et al., (2011) Awasthi et al., (2010), Ray et al., (2011)]. However, these studies with their limited datasets (very little isotopic data) have not been able to answer many of the most important questions pertaining to the origin and evolution of the volcanic arc (Barren Island and Narcondam) and magmatism in it. In particular, they fail to address the role of the Andaman slab in the generation of arc magmas (type and amount of contribution?), depth and degree of melting of the mantle wedge and geochemical and isotopic evolution of the magma through time.

1.5 Objectives and significance

The Andaman subduction zone is one of the few accretionary convergent margins where all the important components of a convergent margin are exposed and are available for scientific scrutiny. These include a trench, an outer arc accretionary prism, a forearc, a volcanic arc, a back arc basin etc. (Fig 1.11).

In an effort to understand the subduction zone processes, crust – mantle interaction and origin and evolution of arc magmas in the Andaman Subduction Zone a comprehensive geochemical study was undertaken in this thesis. The specific objectives of this study are:

I) to understand the origin and evolution of the subducting fluids through their chemistry;

II) to characterized subducting solid materials and understand their impact on the chemical evolution of the mantle wedge;

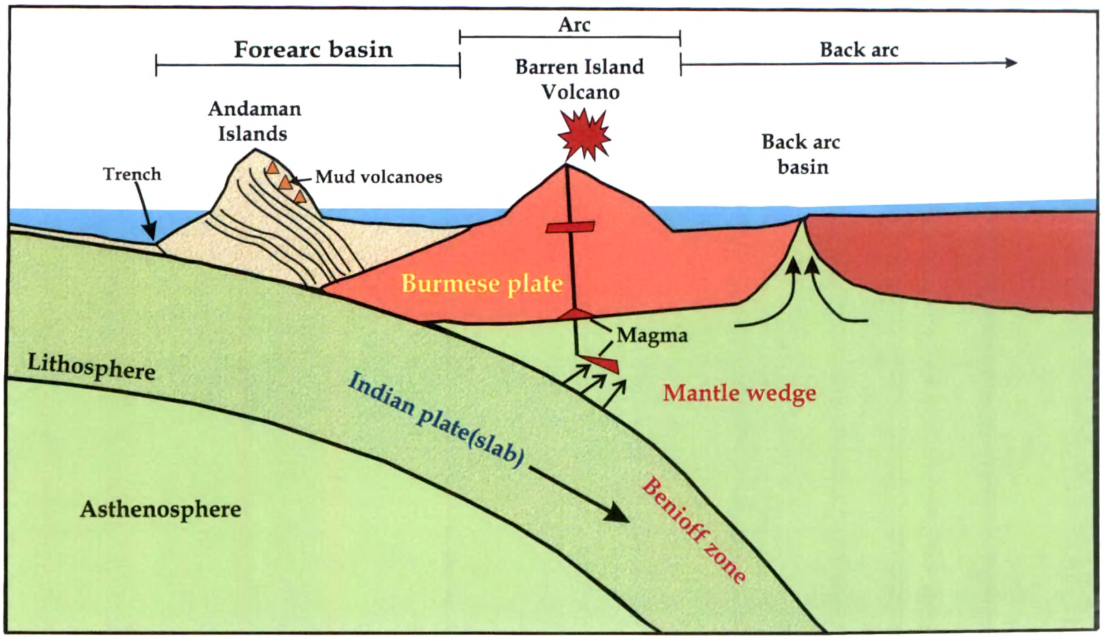

Fig. 1.11 A schematic diagram showing various components of the Andaman subduction zone (Based on author's interpretation)

III) to characterize the chemistry and nature of subduction zone ophiolites and understand their evolution in the context of initiation of subduction at the Andamans;

IV) to characterize the type and history of arc volcanism (on Barren Island);

V) to decipher the nature and composition of the lava flows and magmatic differention processes (for the Barren Island lavas);

VI) to determine the degree of partial melting and the depth of magma generation and

VII) to understand the chemical evolution of the mantle source for Barren Island magmas.

To answer the questions pertaining to the slab chemistry efficiently, focus has been given in this work on the study of fluids and solid materials emitted from the mud volcanoes located on the accretionary prism. To understand the evolution of the arc and mantle melting in the mantle wedge, we focussed our study on the Barren Island volcano. This volcano is young, mafic and is believed to lie on a young lithosphere, and therefore the lavas from this volcano can be considered to represent a source in the Andaman mantle wedge that is at very initial stages of chemical modifications resulting from the mixing with crustal material derived for the slab. Hence, geochemical and isotopic studies of these lavas can reveal a great deal about the nature of interactions of the mantle wedge and slab derived materials. This work is one of the few studies where the chemical evolution of the mantle is studied at the subduction zone with a focus on the chemical characterization of subducting material at depth. This is also the first study on the Barren Island Volcano where an extensive sampling has been done to understand the evolution of the volcano since its emergence for the sea surface.