HISTORICAL DEVELOPMENT OF HIMALAYAN GEOLOGY

"Science must be tempered by humanity, and best way of doing this is to explain its organic development... We must teach reverence for past, - not simply for its own sake or because it is still full of treasures, - but because for the sake of the present which it will aid us to appreciate, and for the sake of the future in which it will help us to walk."

George Sarton (1919)

Introduction

This article aims to provide a chronological framework of significant events in the development of Himalayan geology.

The world “Himalaya” (also variously referred to as Himavat, Himavanta, Himachala and Himadri) is one of the oldest geographical terms. The earliest written reference is found in the oldest known scripture, the Rig Veda (X:121:4). The two epics, the Mahabharata and Ramayana, have their very setting in the Himalayan region. These as well as some of the Purâna, Jain and Buddhist scriptures relate numerous cosmological myths, and geographical facts and fantasies about the Himalaya. Many of their notions clearly indicate elements of observation and travel. For example, they describe a classification of India’s river systems according to their source mountains (see e.g., Law, 1968 a, b). Some of the high summits and great rivers of the Himalaya have been frequently cited in the Indian scriptures and associated with mythical legends as it was in the shadow of these high mountains and on banks of their rivers that the early agricultural civilisations in northern India developed. In the Mahabharata (II:27:3), where the journeys of the Pandavas and victories of Arjuna in the Garhwal Himalaya are described, we find, among interesting observations, the first physiographic classification of the Himalaya into “inner mountains”, “outer mountains” and “small mountains”, which correspond to the Higher, Lesser, and Sub-Himalaya as were named in the 19th century. The Himalayan mountains were deified not only because of their purity, majesty and beauty, but also because they were known to provide river and rain waters, fertile soil, precious stones and medicinal plants, and to sustain forests abundant in plant and animal life.

Ancient Myths and Travels

A significant concept held both by ancient Indo-Iranian and Graeco-Roman scholars was the existence of a linear belt of mountains stretching from west to east, of which the Himalaya formed a part (Ptolemy’s world map shows this clearly). Locally these mountains were believed by native people to have risen out of former seas (a mythological background to what is today called Tethys: see Sengör, 1985).
Persian, Greek, Chinese and Muslim travellers and geographers have also left some records of the Himalaya. The first Greek book on this region was probably written by Scylax of Caryanda, a Greek sea-captain whom the Persian King Darius I employed to explore the course of the Indus (c. 515 B.C.). Scylax’s book (filled with fabulous tales) became the main source of geographic information of India for scholars such as Herodotus and Aristotle. These early Greek writers used the terms “Caucuses” or “Paropamisus” (Hindu Kush) to designate all of the mountains in south-central Asia, including the Himalaya. The term, Imaus or Emodos (for the Himalaya), appeared in the Greek literature only after Alexander’s invasion of northwest India in 326 B.C. Even then, the Greek views of the Himalaya stopped at the river Beās (Hyphasis in Greek), beyond which Alexander’s troops did not march. More information was compiled by Megasthenes (c.350-290 B.C.), a Greek ambassador to the court of Chandragupta Maurya, in his Indica (only fragments of which are extant), who estimated the length of the northern boundary in India, i.e. the distance from the mouth of the Indus to that of the Ganga to be 16,000 stades (1838 miles)—a figure supported by Eratosthenes and Strabo in their geographies. (See Bevan, 1922, and War­mington, 1934, for the Greek geographic knowledge of the Himalaya).

With the spread of Buddhism to China by 100 A.D., the Himalayan region became a pilgrimage site for several Chinese monks and travellers (see Mirsky, 1964, for their accounts). The “prince of the pilgrims” was Hsuan-Tsang (Xuanzang) (602-664), whose arduous travels lasted sixteen years and were carefully documented in his book, “Account of Western Countries” (Xiyu Ji). During his journeys, he covered the entire length of the Himalaya and of the Ganga.

Of the several known Muslim explorers to the Himalayan region, the Persian scholar Alberuni (973-1050) holds a special rank because his approach was scientific in a modern sense. In his Tahqiq ma‘l-lil-Hind (Research on India, 1030) Alberuni not only documented the geographic knowledge of India and of Indians in a systematic manner, but also made a few important geoscientific observations, including the following on the Indo-Gangetic plains, which is probably the first reference to the concept of river grade in the foreland of high mountains (the Himalaya):

“If you have seen the soil of India with your own eyes and meditate on its nature—if you considered the rounded stones in the earth however deeply you dig, stones that are huge near the mountains and where the rivers have a violent current; stones that are of smaller size at greater distance from the mountains, and where the streams flow more slowly, stones that appear pulverised in the shape of sand where the streams begin to stagnate their mouths and near the sea—if you consider all this, you could scarcely help thinking that India has once been a sea which by degrees has been filled up by the alluvium of the streams” (Alberuni, 1030; English translation, 1910, p.198).

Since the travels of Marco Polo in the late 13th century, the exotic east has occupied European fantasy. Edward Said has analysed this phenomenon of imaginative geography in Orientalism (Said, 1979). Bishop (1980) has detailed it in the context of Tibet. Sykes (1950), Crone (1972) and Severin (1976) give interesting accounts of European adventures and “discoveries” in Asia. Wessles (1924) provides a comprehensive report of the Jesuit fathers, who journeyed the Himalaya and central Asia during the 17th and 18th centuries, in order to diffuse their religion and search for the Neostorian Christian communities (which were supposedly eking out in these mountainous regions). Gole (1976) has compiled the maps of India prepared during the 17th and 18th centuries.

It should be noted that the so-called “discoveries” of the Himalaya or Asia were rarely
true geographical discoveries such as those made in the barren continent of Antarctica; they were mainly reports of European explorations and expeditions in the old continent of Asia. These explorations (in the widest sense of the term) were conducted for various reasons—adventure, trade, Orientalism, geographic knowledge, natural history, political or religious expansion, military intelligence etc. To all these explorations many little known natives equally contributed, both in terms of geographic knowledge of their homelands and logistic support for their uninvited guests. Nevertheless, the European explorers produced geographic maps and charts, and their reports and publications became a valuable part of global knowledge, which in many cases, even helped the native peoples with their attempts of self-discovery in the modern times (see for example, Kejariwal, 1988, for the role of the Asiatic Society of Bengal in the discovery of India’s past).

Mountain Glory, Modern Geology and British Raj

Several significant events took place in the late 18th century, which directly or indirectly influenced geological studies in the Himalaya. Therefore, in order to understand that the roots of Himalayan geology these historical processes should be taken into account.

The first trend in the late 18th century was a major change in European attitude towards mountains. To borrow the terms used by John Ruskin in the fourth volume of his Modern Painters (1856), “Mountain Gloom” gave way to “Mountain Glory”. Nicolson (1959) has shown that during the first seventeen centuries, Europeans viewed mountains mainly as “Warts, Wens, Blisters, Imposthumes” upon the otherwise fair face of the Earth (in a sharp contrast to Asian views of sacred mountains). Even the poets such as Virgil, Horace, Dante, Shakespeare or Milton did not praise lofty mountains. The rapid change in European attitude towards and hence their perception of mountains can be seen both in the arts (painting and poetry, especially in the Romanticism of Wordsworth, Shelley and Byron) and sciences (natural history and geology) in the late 18th century. Mountains then came to be regarded as suppliers of fresh water and mineral resources; they fascinated human spirit and evoked awe and wonder; and they held the keys (“written in the stone”) to unravel the mysteries of the natural world. One of the leading figures in Mountain Glory was the Swiss mountaineer and geologist, Horace Benedict de Saussure (1740-1799), whose Voyages dans les Alpes (1779-1796) influenced many intellectuals, including geologists (James Hutton) and artists (John Ruskin). De Saussure’s most famous phrase, “It is above all the study of mountains which will accelerate progress in the theory of the earth”, served as the epigraph of many textbooks in the 19th century (Greene, 1982 p.146).

The second trend was the consolidation of geology as a science independent from natural philosophy or natural history. Indeed the very word, Geology, was first used in a modern sense in late 18th century. During this period, several founders of geology lived: James Hutton and William Smith in Britain, Jean de Lamarck and Georges Cuvier in France, and Abraham Werner in Germany.

The third historical process was the political and military consolidation of the British East India Company in India (see eg. Edwardes, 1968), following the formal surrender of sovereign rights (“Diwan”) of Bengal by the Indian Moghul Emperor, Shah Alam, to Captain Robert Clive in 1765. This was a major turning point in the British encroachment in the subcontinent.

The fourth trend was more ideological than political. It was the rise of Utilitarianism
and Orientalism. Clive's system of "dual government" (with the native rulers in action, but dependent on the British in the background) soon gave way to direct British rule in India with the appointment of Warren Hastings as the first Governor General of Bengal in 1772. Hastings and other Utilitarians were sympathetic to the Indian culture and social institutions, and saw no reason to anglicise India. (On the other hand, the Evangelicals, such as Hasting's successors, Charles Cornwallis and Richard C. Wellesley, had little respect for the Indian norms and cultural heritage, and favoured a radical transformation of India into the British etiquette, education and Christianity). The Utilitarians encouraged oriental studies in order to understand India; and indeed some of them were eminent orientalists, such as James Mill and John Malcolm. (Stokes, 1959, presents a scholarly analysis of the English Utilitarians in India). Also in the late 18th century, the orientalists felt the need and opportunity for systematic, scholastic studies of India rather than relying on travel tales.

While the first two were philosophical and scientific trends taking place in Europe, the last two were socio-political events that occurred in India. However, it was through the socio-political changes in India that the effects of European Enlightenment, Romanticism, Industrial Revolution and developments in science and geology were soon felt in the Himalaya in the form of systematic geographic explorations and geological mapping. Himalayan geology took shape when all these trends and processes merged. In the following sections, the development of Himalayan geology is outlined in five chronological stages: 1760s-1840s (stage I); 1850s-1890s (stage II); 1900s-1930s (stage III); 1940s-1950s (stage IV); and 1960-1990s (stage V).

**Stage I: 1760-1840**

Keay (1981) has observed that "no subject people, nor conquered land, was ever as exhaustively studied as was India during the period of British rule". The Survey of India illustrates this point remarkably. It was one of the most prolonged and meticulous scientific projects ever conducted in human history. An initial survey work was carried out by the Company along the Chittagong coasts in 1761. Then in 1765, Clive asked Major James Rennell to prepare a map of Bengal. The 24 year old Rennel performed such a good job that he was appointed as the Surveyor General of Bengal in 1767. Although Rennel left India in 1777 (after having suffered from malaria and impairing climate of Bengal), his leading role in Indian geography continued for the following decades. After returning to England, Rennell published *A Bengal Atlas* in 1777 and the Map of Hindostan in 1782 (it was reissued three years later with a Memoir).

The survey work was extended to Madras by Robert Kelly and Michael Topping, and to Mysore by Francis Buchanan and Colin Mackenzie (later Surveyor-General of India). In 1800, a year after Tippu Sultan of Mysore was defeated by the Company forces led by Arthur Wesslley, William Lambton (1756-1823) began the first trigonometric survey in southern India (initially around Bangalore, and then beginning with 1802 from coast-to-coast equipped with a huge theodolite). Lambton's vision was to cover the entire country. This programme was officially called the Great Trigonometric Survey (GTS) in 1818, when George Everest (1790-1866) succeeded Colonel Lambton as the Surveyor-General. By 1841, the GTS from Cape Comorin to the Himalayan foothills in Dehra Dun was completed, and Everest retired in 1843. For more information on the history of the Survey of India, refer to Markham (1878), Phillimore (1945-1962) and Khosla (1981).

Meanwhile, in the Himalayan region geographic expeditions were launched. In May

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1774 (the same year Clive committed suicide), the Company despatched the 28 year old George Bogle (chosen by Hastings himself) to Bhutan and Tibet. After a year, Bogle returned to Calcutta. His journey was followed by that of an army officer, Samuel Turner, whose *Account of an Embassy to the Court of the Teshoo Lama in Tibet* (1800), remained for nearly a century the standard European book on Tibet because the notes of Bogle as well as those of Thomas Manning, the first Englishman to enter Lhasa in 1811, were not published until 1876 (they were edited by Clemens R. Markham.) After Manning’s journey, Tibet closed its border to outsiders, and the British focused their attention to explore southern Tibet. Keay (1977, 1979) give accounts of explorers of western Himalayan in the 19th century.

In 1808, William Webb and Hyder H. Hearsey journeyed Garhwal. They produced the first map of the Bhagirathi valley as far north as the Batwari village, but could not reach the source of Ganga as was intended by Robert Colebrook, then the Surveyor-General of Bengal. In 1811-12, William Moorcroft and Hyder Hearsey made the first trip to Lake Manasarovar in southern Tibet. The knowledge of the Himalaya until this time was compiled by Walter Hamilton in *The East India Gazetteer containing particular description of Hindostan and the adjacent countries, India beyond the Ganges* (1815, London).

After the triumphant war with the Gurkhas in Nepal in 1814, the Company annexed the Garhwal and Kumaun regions of the Himalaya. (These regions were included in what was initially called the Ceded and Conquered Provinces, later the Northwestern Provinces in 1836, the United Provinces of Agra and Oudh in 1902 and finally Uttar Pradesh in 1950). William Webb spent five lonely years surveying Kumaun, while John Hodgson (who succeeded Colebrook as Surveyor-General in 1821) and James Herbert explored Garhwal. The English painter, John B. Fraser, was the first European to reach Gangotri in 1815; and his Journal and paintings of observation in the Sutlej and Ganga valleys were published in 1821. Meanwhile, the three brothers, James, Alexander and Patrick Gerard, made their specialty the exploration of the Sutlej Valley and Simla.

Moorcroft was probably the greatest Himalayan explorer of the 19th century. During 1819-1825, he and George Trebeck journeyed Ladakh, Kashmir, Baltistan and Afghanistan. Although both of them died mysteriously on their way back from Afghanistan, their painstaking report was preserved and published in two volumes (*Travels in the Himalayan Provinces of Hindoostan and the Punjab*) in 1841. The French botanist, Victor Jacquemont, in 1831-32 and the British spy, Godfrey Vigne, in 1834-39 explored Kashmir and Baltistan, and returned with documented observations, both of which were published in 1840. During 1831-33, Alexander Burnes, a political agent-cum-explorer travelled across Punjab and Afghanistan as far north as Bokhara. One of his companions and a sailor with Indian Navy, John Wood, reached the source of the Oxus River in 1838. Burnes in 1834 (*Travels into Bokhara*) and Wood in 1841 (*A Journey to the Source of the River Oxus*) published their observations. In 1846, Henry Strachey, and two years later his brother Richard Strachey, visited Lake Manasarovar via Kumaun. Like Moorcroft and Hearsey, Henry Strachey disguised himself as a Hindu pilgrim; his report was published in *Journal of Royal Geographical Society* in 1853 while Richard’s report was not published until 1990 in *Geographical Journal*. Henry Strachey emphasised that the watershed of the Indian rivers do not correspond with the Great Himalayan peaks as seen from India, but lie beyond the Himalaya (Strachey, 1853). Richard Strachey fixed the position of Mount Kailash and calculated its height to be 22,000 feet (only 28 feet lower than later measurements). During 1847-48, Thomas Thomson made a journey to western Himalaya and Tibet, and scaled the
Karokoram pass (its account was published as a book in 1852). From 1848 to 1852, Andrew Fleming conducted a geological survey of the Punjab and worked out the Palaeozoic stratigraphy of the Salt Range.

The Asiatic Society of Bengal was founded as a research centre by Sir William Jones (1746-1794) in Calcutta in 1784. The Society had a strong support from Hastings himself, although he declined to be its president (Kejariwal, 1988). "The intended objects of the Asiatic Society were Man and Nature—whatever is performed by the one, or produced by the other—within the geographic limits of Asia, with Hindustan as a centre" (Jones, 1788). This combination of "Man and Nature" is illustrated in many leading personalities of the 19th century Indologists. Henry T. Colebrook (1765-1837; Robert Colebrook's older brother), who succeeded Jones as a champion of Sanskrit literature and the Society's president, also carried out many topographic surveys in the Himalaya; indeed he was the first person to declare in 1816 the Himalaya as the world's highest mountain range, surpassing the Andes, which were then believed to be the highest (Colebrook, 1816). James Prinsep (1799-1840), the Society's secretary, first began working on the topography of the Bengal area, and then became an authority on Indian inscriptions. Early geological papers on India and the Himalaya were published in the Asiatic Society's periodicals: the *Asiatic Researches* (1798-1839) and *Journal of the Asiatic Society of Bengal* (1832-). The later was a continuation of *Gleanings in Science*, launched by J.D. Herbert in 1829. A sister institution, the Royal Asiatic Society of Great Britain, was founded in 1823 in London, which later incorporated the Asiatic societies (originally called "Literary Societies") of Madras and Bombay.

The two German "founders of modern geography", Alexander von Humboldt (1769-1859) and Carl Ritter (1779-1859) also contributed to Himalayan science in the context of Asian geography. Although he did not visit the Himalaya, Humboldt journeyed the Urals and Siberia in 1829 at the invitation of the Russian Tsar, Nicholas I. Humboldt's report, *Asie centrale* (3 volumes, 1843) discussed the impact of orography of Asia (especially the Himalaya) on the variations of regional climate. Later in his *Kosmos* (vol.1, 1845), Humboldt commented on the perpetual snow line in the Himalaya. Ritter's contribution was *Die Erdkunde von Asien* (1832). The Royal Geographical Society, founded in London in 1830, was also a major institution supporting exploration in the Himalaya. The Society's Gold Medals were given to many explorers of the High Asia, including J. Wood (in 1841) and H. Strachey (in 1854) (see Cameron, 1980, for details).

In the 1830s, Captain Proby Cautley (1802-1871) engineered the construction of the Ganga Canal in order to get water out of the Ganga into the Doab ("two waters"), the land between the Yamuna and the Ganga, which suffered from frequent famines. In *The Ganges Canal* (London, 1860), documented his project, which put an end to serious famines in the region. As a result of the surveys and excavations made for the Ganga Canal, the Siwalik mammalian fossils were unearthed in the Siwalik Hills (the hills between Ganga and Yamuna rivers near Haridwar, named after Lord Shiva). Cautley and the palaeontologist Hugh Falconer (1808-1865), who studied the Siwalik fossils for two decades, gave the name of "Siwaliks" to the sedimentary rocks of the hills in which the fossils were found. The Siwalik fossils captured the attention of many British geologists, including Sir Roderick I. Murchison (1792-1871), who obtained a collection of these fossils for the British Museum.

Bogle, Moorcroft, Vigne, Wood and several others who explored the Himalayan region were not geologists; their accounts were travel journals and merely geographical in...
nature. The first attempt to present a coherent geological picture of the Himalayan physiography and geology was made by James D. Herbert. In 1818, Herbert surveyed the areas between Sutlej and Kali. Herbert's paper was published in 1842, nine years after his death (his map was published in 1844). Herbert divided the Himalayan rocks into two "primary" formations (central gneiss and schists) and a "secondary" formation (sandstones). He noted that the formations dip towards the central gneiss, and that gneiss lies on top of the schist, and schist on top of the sandstones—an arrangement which was not true stratification, but produced by some process of "concretionary action" (Herbert, 1842).

Brian Hodgson (1800-1894) also published his ideas on the physiography of the Himalaya. According to Hodgson (1849), numerous streams flow from the snowy peaks at right angle to the strike of the Himalaya, but converge to from huge rivers close to the plains. He divided the Himalaya into spurs on the basis of transverse river gorges, and mistakenly argued against the continuity of the Himalaya as a mountain range.

Himalayan geology in the first half of the 19th century was subordinate to other fields of British activities in India, such as geographic exploration, archaeology, botany, or engineering. Therefore, an understanding of Himalayan geology during this period cannot be separated from these fields. Nevertheless, several important events directly concerned with the geology took place during this "Early Period", paving the way for the next stage. Geology and mineralogy were taught in the Company's colleges in India (Larwood, 1958). The Company founded an Indian Museum in London in 1801, and the rock and fossil specimens from the Himalaya and the subcontinent shipped to Britain by amateur and official collectors were shared between the Indian Museum, the British Museum and the Geological Society (Moore, 1982). Another Indian Museum was founded in Calcutta itself in 1814. The Asiatic Society of Bengal expanded its mineral and fossil collections into a full-scale Museum of Economic Geology in 1841. Of the many surveyors in India, four were officially regarded as geologists: Laidlaw (mineralogist to the Survey of Kumaon, 1817-21); Voysey (geologist to the GTS, 1818-23); Dangerfield (Geological Surveyor of the Himalaya Mountains, 1820-23) and Herbert (Geological Surveyor of the Himalayan Mountains, 1823-29) (Fermor, 1951).

**Stage II: 1850-1890**

Himalayan geology as an independent, systematic field of science (in the sense we understand today) emerged in the 1850s. The second half of the 19th century was the "Golden Age" of Himalayan geology (Gansser, 1991). Indeed during the 19th century, British geological work in India hardly lagged behind that practiced in the home islands (Stafford, 1989). This was largely due to the establishment of the Geological Survey of India (GSI) in Calcutta in 1851.

The original purpose of the GSI was limited to exploring India's coal reserves. In 1936, the Government of Bengal formed a Coal Committee to study the coal supplies for use in the steamers on the Ganges. In the early 1840s, the Coal Committee's secretary, John McColland, contacted the leading British geologists, Charles Lyell and Roderick Murchison, and the Government of Bengal to persuade them hire trained geologists and setup a proper geological survey in India in order to explore the mineral reserves as well as supportive of a survey in India in order to explore the mineral reserves as well as advance the knowledge of the earth's history, and both of them appreciated the importance the knowledge of the earth's history, and both of them appreciated the importance of geological
discoveries in the Himalayan region (Stafford, 1989). In 1843, the Government of Bengal requested Murchison to select a geologist for the survey in India. Murchison turned this selection over to De la Beche, then the head of the British Survey. Prior to that (in 1841), De la Beche had supported the foundation of Asiatic Society of Bengal's Museum of Economic Geology. At De la Beche's recommendation, David H. Williams was appointed in 1846 as Geological Surveyor to the East India Company. Williams worked nearly three years in India, exploring coal reserves. He died of fever in 1848. John McColland took his place until 1850, and finally in 1851, Thomas Oldham was appointed in Calcutta as a successor to Williams.

Thomas Oldham (1816-1878), a former professor of geology in Dublin and Director of Geological Survey of Ireland, was the real architect of the GSI, and aptly gave himself the title of Superintendent of the Geological Survey. During his 25 years of service, Oldham expanded the activities of the GSI from merely finding coal reserves to fuel the great Indian railway system, to working out the stratigraphy of India and the Himalaya. The GSI became one of the finest geological surveys; and its publications became the main reference on the geology of the Indian subcontinent and Asian highlands for eminent authors, such as Eduard Suess in his masterpiece, Das Anlitz der Erde (1885-1909; The Face of the Earth, 1904-1909). For further information on the history of the GSI, readers may refer to Fermor (1951), Anonymous (1976) and Stafford (1984).

Oldham hired several active geologists, including the two brothers John G. and Henry B. (1829-1905) Medlicott, the two brothers William T. (1832-1905) and Henry F. (1834-1893) Blanford, William Theobald, R. Bruce Foote (1834-1912), Arthur B. Wyanne (1835-1906), Ferdinand Stoliczka (1838-1874), Frederick R. Mallet (1814-1921), Otoka Feistmantel (1848-1891) and Richard Lydekker (1849-1915). The well-known publications of the GSI, Palaeontologia Indica, Memoirs and Records of the Geological Survey of India were also launched by Oldham. He also initiated the studies of earthquakes in India and prepared the first catalogue of earthquakes. These pioneer Himalayan geologists were very prolific, although the conditions to do field work then was much more difficult than these days. H.B. Medlicott, who coined the term Main Boundary Fault, worked out single-handedly the structure of the Sub-Himalaya between the Ravi and Ganga rivers in a Memoir (1864) that ran 122 pages! (Medlicott succeeded Oldham as Director of the GSI in 1878). Stoliczka’s Memoir (1865) on Himachal was 154 pages. Mallet’s 50-page Memoir (1875) still serves as the foundation of geological knowledge on Darjeeling. Wynne’s Memoir (1878) on the Salt Range was 314 pages. Lydekker’s Memoir (1833) on Kashmir and Chamba was 344 pages. Griesbach’s Memoir (1891) on the Central Himalaya was 232 pages. Middlemiss Memoir (1910) on the Kangra earthquake ran 409 pages! (probably still a record for a single-author report on an earthquake). In additions to Memoirs, these geologists also published numerous papers in the Records of the GSI.

Of the several Stracheys who served in the British India, Richard Strachey was the most talented in geoscience (although he was originally trained as an engineer in the Bombay Army). The year the GSI was established, he published two influential papers on the Himalaya: one on the physical geography and the other on the geological structure and stratigraphy of the Garhwal-Kumaun regions (Strachey, 1851 a,b). After Herbert (1842), these papers were the next major attempt to present the geological setup of the Himalaya. Strachey (1851 a) correlated the marine formations he observed in southern Tibet with those of Great Britain that had been described by Murchison in The Silurian System (1839). Strachey’s fossil collections from the Himalaya were described by J.W. Salter and H.F.
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Blanford in Calcutta; they were transmitted to the Indian Museum in London. Later in 1862, when Eduard Suess visited London, he observed these fossils and noted the stratigraphic correlations of Triassic fauna between the Himalaya and Europe. Suess, who eventually proposed the idea of Tethys Sea in 1893, was very impressed with the results of the geological studies in the Tibetan Himalaya (later called the Tethys Himalaya by John B. Auden) such as those made by Stoliczka in 1866. Indeed he supported a joint expedition in 1892 to the Himalaya by the Imperial Academy of Vienna and the GSI. Led by Carl Diener (Austria) and C.L. Griesbach (Suess former student at Vienna) and C.S. Middlemiss, this expedition contributed greatly to the Tethyan stratigraphy of the western Himalaya (see Jenkyns, 1980, Sengör, 1985, and Sorkhabi, 1995a, for historical roots of the Tethys concept).

Another group of continental Europeans who came to India to seek the help of the British Indian authorities with their exploration of the Himalaya were the three Prussian brothers, Adolf, Herman and Robert Schlagintweit. They were sent by Alexander von Humboldt, but were not well received by the Survey or the Company in Calcutta. Nevertheless, they made expeditions to Lake Manasarovar, Ladakh and the Karakoram. Whatever the Schlagintweits observed and documented drew little attention, partly because of the political climate of that time: When they had finished their work, it was the beginning of the Indian Mutiny in 1857. A year later, the power to rule India was transferred from the Company directly to the British Crown and Parliament.

Sir Joseph Dalton Hooker (1817-1911) explored Sikkim and Bengal in 1848-52 and published a fascinating account entitled, Himalayan Journals in 1854. In the same year, the first geological map of India was published by George B. Greenough (1778-1855; founder of the Geological Society of London), based on the data provided by the Englishmen working in India. Also in 1854, Alexander Cunningham (1814-1893) published his famous book, Ladak, in which he introduced the term, “trans-Himalaya”, for a range immediately beyond the Himalaya (later Cunningham became the first Archaeological Surveyor of India).

After it was known that Chimborazo of the Andes was not the highest summit, this honour went for some time to Dhaulagiri and then to Kanchenjunga. During the late 1840s, the Great Trigonometrical Survey under Andrew Waugh (who had succeeded George Everest as Surveyor-General) pushed into the foothills of the Himalaya and triangulated major peaks of the range. As a result, it was discovered in 1852 that Peak XV, then estimated to be 29,002 feet tall (26 feet less than the 1955 measurement), was the world’s highest mountain. At Waugh’s suggestion, the new peak was named Mount Everest (for Nepal being a closed country, the native name of Chomolungma was unknown to the surveyors at that time), despite George Everest’s objection to this. A very important finding of the Survey of India led by George Everest was the gravitational deficiency beneath the Himalaya to deflect the plumb lines. This led to the discovery of isostasy. Although the negative mass anomaly beneath a mountain range was first observed in the Andes in the mid-18th century by the French geodesists (when Pierre Bouguer was measuring a meridian arc in Peru), it was on the basis of the results of Everest’s survey in the Indian subcontinent (the Kaliana-Kalianpur traverse) that two different (but complementary) concepts of isostacy were given in 1855 by George Airy, Astronomer Royal of England, and John Pratt, Archdeacon of Calcutta. The principle of isostacy (a term coined by Charles Dalton in 1893) has proved to be one of the most powerful concepts to interpret the topography of the earth, including the high elevation of the Himalaya, the Andes and other orogenic belts.

(on the account of crustal roots or Airy’s isostacy) and the low elevation of oceanic floor (due to density variation or Pratt’s isostacy). (The discovery of isostacy is a fine example of de Saussure’s maxim on mountains quoted earlier in this article).

During 1855-1864, the Great Trigonometric Survey began a major work in Kashmir. In charge of the survey was Thomas G. Montgomerie (1830-1878), but also aided with two energetic colleagues, William H. Johnson and Henry H. Godwin-Austen. This team surveyed Kashmir as well as the Karakoram, and calculated the height of the world’s second highest peak, K2, to be 28,287 feet (overestimated by 37 feet). Godwin-Austen (1834-1923), a geologist-mountaineer, pioneered the mapping the Karakoram (he was awarded a gold medal by the Royal Geographical Society in 1910).

Thomas Montgomerie, who received the Royal Geographical Society’s Gold Medal in 1865, extended his work to Garhwal and Kumaun in 1867. One of his great achievements was the training and despatch of the “Pundits” to explore and fix correctly the southern part of Tibet on map. The Pundits, who journeyed in disguise as traders or pilgrims, were native Himalayan men-of-the Bhotia people who follow a blend of Hindu and Buddhist ways of life. The Pundits (especially Nain Singh, Kishen Singh and Kinthup), sometime referred to as British spies, actually advanced the geographic knowledge about the courses of great Himalayan rivers, the Trans-Himalayan Range, and Lhasa. Accounts of both their geographic work and their life, make some of the most interesting and heroic stories of Himalayan exploration during the 1860s’-1890s (see Rawat, 1973, and Walier, 1990, for the travels and contributions of the Pundits).

They covered a vast mountainous region from the River Kabul on the east to the Yangtze on the west, and from Darjeeling as far north as Kashgar. In my opinion, the exploration of the Trans-Himalaya, which is attributed to Sven Hedin, was to a large degree the work of the Pundits; indeed the very word, “Trans-Himalaya”, was explicitly used in Montgomerie’s reports of the Pundits expeditions to southern Tibet.

In 1868, the Great Trigonometric Survey began work in Assam, following the course of the Brahmaputra. The Assam triangulation was completed in 1878. In the same year, James T. Walker (1826-1896) was appointed as Surveyor General of India. He combined the Great Trigonometric Survey, and the Topographical and Revenue Surveys as the Survey of India, with headquarters in Dehra Dun.

During 1879-1887, A Manual of the Geology of India was published by the GSI bringing together a vast geologic knowledge of the India and Himalaya. It consisted of four parts: Part I. Peninsular India (by H.B. Medlicott and W.T. Blanford, 1879), Part II. Extra-Peninsular Area (H.B. Medlicott and W.T. Blandford, 1879-1881); Part III. Economic Geology (V. Ball, 1881); and Part IV. Mineralogy (F.R. Mallet, 1887). The second edition of the Manual was published in 1893, revised by Richard D. Oldham (1858-1936). Other important encyclopedic publications included: The Imperial Gazetteer of India (10 volumes, 1881-1882; and second edition in 14 volumes, 1885-1887), all edited by William W. Hunter (1840-1900) (The Imperial Gazetteer was revised and published in 1907-1909 in 26 volumes); and The Himalayan Districts of the North Western Provinces of India (3 volumes, 1882-1886), edited by Edwin F.T. Atkinson (1840-1890).

**Stage III: 1900-1930**

The beginning of this stage is marked by three important events. The first was the invasion of Tibet during 1903-4 by Colonel Francis Younghusband (1863-1942), which
opened the “forbidden city” of Lhasa and the Tibetan highland to the western world after centuries of isolation (see Holdich, 1906, MacGregor, 1970, Allen, 1982, and Hopkirk, 1982, for histories of exploration of Tibet). The second event directly related to Himalayan geology was the publication of *A Sketch of the Geography and Geology of the Himalaya Mountains and Tibet* in 1907 by Sidney G. Burrard and Henry H. Hayden. This book summarised the geological and geographical knowledge of the Himalaya gathered during the 19th century. It was revised by Burrard and Herron and published in 1934. The third event was what may be called the “Great Dying” of one generation and the “Rise of other Stars” in Himalayan geology. Within half-a-decade several outstanding figures passed away, including C.A. McMohan in 1904, W.T. Blanford and H.B. Medlicott in 1905, A.B. Wynne in 1906, C.L. Griesbach in 1907 and R. Strachey in 1908.

A new generation of GSI geologists in early 20th century continued studies of the Himalaya. Thomas H. Holland (1868-1947) succeeded C.L. Griesbach as Director of the GSI (1903-1910). H.H. Hayden published works on Spiti (1904), Tibet (1907), northern Afghanistan (1911) and Gilgit (1915). Hayden, the GSI Director from 1910 to 1921, was killed by a fall of rock in the Alps in 1923. Henry Guy E. Pilgrim (1875-1943) reconstructed the stratigraphic classification of the Siwalik Group (1910, 1913), which is used today. In a series of publications in *Palaeontologica Indica*, Carl Diener and Frederick R.C. Reed made detailed studies of Tethyan fauna in the Kashmir, Spiti and Kumaun basins.

The greatest explorer of High Asia in the early decades of this century was undoubtedly Sven Hedin (1865-1952), from Sweden, whose accounts of expeditions and observations ran into numerous volumes, including *Scientific Results of a Journey in Central Asia* (6 volumes of text and 2 volumes of maps, 1899-1902), Southern Tibet (9 volumes of text and 3 volumes of maps, 1906-1910) and *Trans-Himalaya* (3 volumes, 1909-1912). Few explorers in history have been so prolific as Hedin; however, he has been highly criticised for his support of Kaiser Wilhelm II in the First World War and Adolf Hitler in the Second.

World War I (1914-1918) and World War II (1939-1945) hampered all geological research, including those in the Himalaya. However, between the two wars, several significant contributions were made. One major development was the British expeditions to Mount Everest during the 1920s and 1930s. Although unsuccessful in reaching the summit at that time, it initiated a new wave of expeditions to the Higher Himalaya, with geological studies carried out by A.M. Heron, John B.L. Noel and Lawrence R. Wager in the Tibetan side of Mt. Everest. Mountaineering expeditions and publications, such as those contributed by the Günther O. Dyhrenfurth (a Swiss geologist-mountaineer), Herbert Tichy (an Australian geologist/explorer), Eric Shipton and Harold W. Tilman (both British climbers), promoted knowledge about the Himalaya and attracted public attention. In 1928, the Himalayan Club (on the model of the Alpine Club) was founded in Bombay by William Birdwood, then the British commander-in-chief in India, to promote and organise exploration and mountaineering in the Himalaya. *Himalayan Journal*, published by the Club, has enriched the Himalayan literature to this day.

During the 1930s, GSI geologists continued mapping: D.N. Wadia in Kashmir, Ladakh, and the Punjab, William D. West in Himachal and John B. Auden in Garhwal. Some of the foreign geologists working in the Himalaya-Karakoram-Tibetan region in the early decades of this century deserve special mention: Filippo de Filippi and Giotto Dainelli (both Italians) published numerous volumes on their expeditions to the Karakoram, Turkistan and the Himalaya; Helmut de Terra (a German-American) investigated the Pliocene-Quaternary foreland deposits in Kashmir; Peter Misch (another German-
American) studied the granites of Nanga Parbat; Erik Nori (a Swedish) explored Tibet; Arnold Heim and Augusto Gansser (both Swiss) published, *Central Himalaya* and *The Throne of the Gods* in 1939, which display some of the highly original and fascinating publications in Himalayan geology. The mapping and concept of the Main Central Thrust was the outcome of Heim and Gansser’s work in Garhwal (see Sorkhabi, 1996, for the Himalayan research of Gansser). Some general publications of this period (treating the Himalaya in the overall context of India, China or Asia) include D.N. Wadia’s *Geology of India* (1919, fourth edition in 1975), L. Dudley Stamp’s *Asia* (1929, eleventh edition in 1962), John W. Gregoroy’s *The Structure of Asia* (1929), J.S. Lee’s *Geology of China* (1932), H.L. Chibber’s *Geology of Burma* (1934), D. Mushketov’s *Modern Conception of the Tectonics of Asia* (1936) and K. Lauchs’ *Geologie von Asien* (1939).

Two important geological concepts applied to the Himalaya during this period were (i) the nappe theory, and (ii) continental collision. The Alpine nappe theory won international recognition at the International Geological Congress in Vienna in 1903. Pioneering mapping by Lajos V. Lóczy (in Sikkim), D.N. Wadia (in Kashmir and Zanskar), J.B. Auden, A. Heim and A. Gansser in Garhwal and Kumaun revealed the existence of crystalline nappes in the Himalaya. Following Alfred Wegener’s continental drift hypothesis, the Swiss geologist Emile Argand (Swiss) in his pioneering work, *Tectonique de l’Asie* (1824), argued that the Alpine-Himalaya belt was generated from the drift of Indo-Africa, closure of Tethys, the subsequent continental collision, large-scale underthrusting and plastic deformation. Among the few geologists in the world of that time who accepted Wegener and Argand’s concepts was that Indian palaeobotanist, Birbal Sahni (1891-1949), who also published several important geological papers in *Current Science* in 1936, and founded a reputed Institute of Palaeobotany in 1946 at Lucknow.

A less known tectonic concept bearing on Himalayan orogeny was the “sub-oceanic spreading” hypothesis of Baily Willis (1857-1949). In the second volume of his *Research in China* (1907), Willis proposed that Asia was a mosaic of crustal units, formerly separated by Mediterranean-type seas, which were closed by the sub-oceanic spreading, *i.e.* the underthrusting of suboceanic masses at ~100 miles deep from the direction of the Indian and Pacific Oceans, associated with the folding of subcontinental masses of Asia. The last episode of the suboceanic spreading closed Tethys, folded the Himalaya and uplifted Tibet. Despite the fact that his idea contained the germ of what was formulated later as the “sea-floor spreading” hypothesis, Willis strongly opposed the continental drift idea.

**Stage IV: 1940-1950**

After World War II, India attained independence in 1947, and simultaneously Pakistan separated from India as a new state in the subcontinent. China witnessed Mao Tse-tung’s Communist Revolution in 1949. These changes brought about the “indigenisation” of many activities, including geological work, in India and China. After the partition, Pakistan did not inherit any geological institution of the British India; Geological Survey of Pakistan was founded in 1947 (it is headquartered in Quetta with five regional offices).

The last British Director of the GSI was W.D. West, who served from 1945-47. (Dr. West later joined Saugar University in 1955, and developed a Geological Department, serving there until his death in 1994; see Radhakrishna, 1995). The first Indian Director of the GSI was M.S. Krishnan (1898-1970), author of a well-known textbook, *Geology of India and Burma* (1943, fourth edition in 1960). In 1947, a new journal, *Indian Minerals*, ...
joined the family of the GSI periodicals, which has continued to this day. Another significant event in the GSI during this period was the publication of third edition of *Manual of Geology of India and Burma* (3 volumes) revised by Edwin Pascoe, Director of the GSI from 1921-32. He worked on the new edition during his retirement but the publication was delayed until 1956 due to World War II. Other important publications during this period include G.B. Cressey's *Asia's Lands and Peoples* (1944), G.O. Dyhrenfurth's *Zum Dritten Pol* (1952; *To the Third Pole*; 1955) and O.H.K. Spate's *India and Pakistan* (1954). In 1958, the Geological Society of India was founded with headquarters in Bangalore; the Society has published a regular (initially yearly and later monthly) *Journal* as well as *Memoirs*, and has organised annual meetings in India.

In 1949 Nepal opened its borders to outsiders, and the following year, the Swiss geologist Tony Hagen went to Nepal for geological mapping. He worked there for more than a decade, publishing a pictorial book, *Nepal* (1961), and *Reports on the Geology of Nepal* (2 volumes, 1969-70). In 1954, a team of French geologists, led by Pierre Bordet, visited Nepal. Initially working in the Makalu area, the French then went on to study other parts of Nepal, especially the Manaslu area (the Manaslu is said to be the most studied granite on earth). Le Fort (1994) gives a comprehensive account of four decades of French studies in the Himalaya.

Following the successful climbing of Mount Everest (Chomolungma) from the Nepali side in 1954, unprecedented attention was drawn for mountaineering and trekking in the Higher Himalaya. This has produced a genre of folk literature about Himalayan landscape and natural history (e.g. the works of James R. Ulman, Wilfrid Noyce and William O. Douglas), thus promoting a public support for Himalayan studies. The tourist industry has led to the construction of roads and bridges, which have made geologists' job less arduous.

While India took a socialist democratic path after Independence, Chinese communists followed autocratic ways, ultimately ending up with the Cultural Revolution (1966-1969). In 1959, two seemingly unrelated events took place: Tibet was violently annexed to the People's Republic of China, and the Chinese Academy of Geological Sciences was founded in Beijing. Over the past 25 years, the Academy has carried out extensive studies of the Tibetan Plateau and its surrounding mountains, although the bulk of these studies are available only in Chinese language.

**Stage V. 1950-1990**

During the 1960s, the theory of plate tectonics emerged from several important discoveries in the dynamics and structure of the ocean floor, notably sea-floor spreading along mid-oceanic ridges, subduction along trenches and magnetic anomalies on the ocean floor. Drifted continents could be restored back to their pre-drift positions based on palaeomagnetic data; convection currents in the mantle were considered as the cause for plate motions; and resultant seismicity, volcanism, rifting and orogenesis along plate boundaries. The plate tectonic theory caused a revolution in all branches of earth sciences; Himalayan geology was no exception. Gansser (1966), Dewey and Bird (1970), Dietz and Holden (1970), Powell and Conaghan (1973), Molnar and Tapponnier (1975) and Valdiya (1984) offered influential interpretations of the Himalayan orogeny in terms of plate tectonics, although their fundamental concepts had been formulated by Argand (1924). All
these authors regarded the Himalaya as a type-example of continental collision orogenesis, and this image has been enhanced since then.

The year 1964 formed important land mark in studies on Himalayan geology. In that year, the 22nd International Geological Congress was held in New Delhi. At about the same time Augusto Gansser published his well-known book *Geology of the Himalayas* which synthesised the geological knowledge of the Himalaya gathered from 1851 onward (Strachey’s paper) until early 1960s (Gansser, 1964).

New Delhi also hosted the 21st International Geographical Congress in 1968-another important event presided by the late Professor S.P. Chatterjee. In the same year, the Institute of Himalayan Geology was established through the efforts of D.N. Wadia. Later it was re-named as the Wadia Institute of Himalayan Geology (WIHG) with its headquarters at Dehra Dun. WIHG has conducted numerous conferences since 1970, and their proceedings have been published in *Himalayan Geology* volumes. In 1990, WIHG launched the semi-annual *Journal of Himalayan Geology*. Volumes of Recent Researches in Geology (1975-1993; 17 volumes), *Current Trends in Geology* (1978-1989; 12 volumes) and *Contributions to Himalayan Geology* (1979-1989; 4 volumes), all published in Delhi, also contains numerous papers on the Himalaya, contributed mainly by Indian geologists.

Geological institutions in Pakistan and Nepal are of recent date. Institute of Geology (established in 1951-52) at Punjab University in Lahore publishes *Geological Bulletin of the Punjab University* since 1961; National Centre for Excellence in Geology (1974) at University of Peshawar publishes *Geological Bulletin of the Peshawar University* since 1966; Institute of Geology (1980) at Muzaffarabad publishes *Kashmir Journal of Geology* (since 1983); National Geological Society of Pakistan in Islamabad is a young society (established only in 1989). Punjab Geological Society of Lahore has been in existence since 1974. In Nepal, Department of Mines and Geology is the main geological survey organization. Nepal Geological Society (1980) in Kathmandu publishes a *Journal* once a year. During the 1970s, Japanese geologists from the University of Hokkaido carried out extensive work in Nepal, the results of which were documented in *Geology of the Nepal Himalayas* (edited by Y. Ohta and C. Akiba, 1973).

An important factor in the development of Himalayan geology during the 1970s was the opening of the restricted areas of the Himalayan region for geological exploration. India opened Ladakh in 1974; in the same year, Pakistan opened the Karakoram. This facilitated many studies of the Indus Suture Zone in Ladakh and Kohistan, and led to the discovery of a Northern (Shyok) Suture Zone. Plate tectonic models for the origin of the Himalaya then became geologically testable. In 1979, the construction of the Karakoram Highway was completed after twenty years of a Sino-Pakistani collaborative work. The opening of the Karakoram highway to foreigners in 1986 resulted in extension of modern geological studies to the Karakoram and western Tibet (see Searle, 1991). In 1980, the *International Karakoram Project* was organised by the Geographical Society of London in the Hunza valley of Pakistan; its results have been published in two volumes of International Karakoram Project (edited by Keith J. Miller, 1984) and a popular account, *Continents in Collision*, by K.J. Miller (1982). In 1979, the Chinese opened Tibet to outsiders. The following year, Academia Sinica organised an international meeting of Himalaya-Tibetan geologists, which resulted in two volumes of *Geological and Ecological Studies of Qinghai-Xizang Plateau* (1981). Since then, collaborative research between Chinese geologists and those from France, Britain and United States has produced several important reports on the Tibetan Plateau in the pages of *Nature*.
In 1983, The International Centre for Integrated Mountain Development (ICIMOD) was established in Kathamandu. Funded by several European and Asian governments, ICIMOD is a multidisciplinary research and information centre to promote the protection of mountain ecosystems alongside with economic development in the Himalaya-Karakoram-Hindu Kush region. ICIMOD has published numerous books, papers, conference reports and proceedings, although they are largely geographical, ecological and agronomic (an integration of various branches of geosciences towards solving socio-economic problems seems to be a long way to go, but ICIMOD's experience is a positive sign).

Since 1985, a series of annual international meetings, Himalaya-Karakoram-Tibet Workshops, have been held: at Leicester, UK (1985); Nancy, France (1986); London, U.K. (1987); Lausanne, Switzerland (1988); Milan, Italy (1990); Grenoble, France (1991); Oxford, U.K. (1992); Vienna, Austria (1993); Kathamandu, Nepal (1994); Ascona, Switzerland (1995); and Flagstaff, USA (1996). These meetings and proceedings volumes arising from them have contributed significantly to Himalayan research.

In 1992, the First South Asian Geological Congress (GEOSAS) was held in Islamabad. It was followed by GEOSAS-II in Colombo in 1995; GEOSAS-III will be held in Dhaka in 1998. The proceedings of the Islamabad congress has been published as *Geology in South Asia-I* (Islamabad, 1994). The GEOSAS provides a platform for exchange of geoscientific information between nine countries in South Asia (from Turkey to Sri Lanka). If the trend set in Islamabad continues, the GEOSAS meetings and proceedings will mark a significant development in South Asia and a contribution to the geology of the countries surrounding the Himalaya.

The most significant characteristic of Himalayan geology over the past two decades has been the applications of analytical techniques, including geochemical, geochronological, geophysical, and quantitative structural, although none of these have (nor should) replace the traditional field work (“seeing for oneself”) and masterly syntheses (“armchair geology”). Himalayan geology has become a subject of regular sessions in international meetings such as those of the International Geological Congress, American Geophysical Union, Geological Society of America, and European Geoscience Union. Not only geologists from the Himalayan countries (Afghanistan, India, Pakistan, Bangladesh, China, Nepal, Burma) but also those from various countries in Europe, USA, Canada, Australia and Japan are now involved in geoscientific studies in the Himalaya-Tibetan region. The Global Age of Himalayan geology has begun, which perhaps would not surprise the great poet Kalidasa, were he to return and listen to our modern observations and ideas of his beloved "Nagadhiraj" (King of Mountains).

**Concluding Remarks**

This essay is an attempt to go into the roots and trace the growth of Himalayan geology as a scientific discipline; my purpose was not to review the geology of the Himalaya, which is an altogether a different topic. I began with a quote from the noted historian of science, George Sarton, suggesting that chronological analyses of sciences are also helpful in revealing patterns and trends, and in learning lessons for the future pursuit of the subject. In this context, the following remarks may be relevant:

1. Although there are numerous works on the geographic knowledge recorded in the ancient Indian scriptures and travel accounts, there are very few detailed, systematic studies
of these texts from a geological perspective as a key to understanding the Holocene environmental changes in northern India and the Himalaya. Charles F. Oldham was one of the earliest geologists to point out the importance of such studies in his paper on the Sarasvati and lost rivers of the Rajasthan desert in 1893.

(2) Himalayan geology in its modern sense was the product of European Colonialism, Romanticism, Scientific and Industrial Revolutions. These trends were extended to the Himalaya with the consolidation of the British power in India. During the 19th century, exploration of the Himalaya was further stimulated by the rivalries between Britain, Russia, and China to gain control of the strategic highlands of central-south Asia (a secret war called the Great Game by Rudyard Kipling in his novel, *Kim*) (Hopkirk, 1990). Initially, Himalayan geology was a subsidiary field to topographic surveys, economic or political expansion, Orientalism or adventure. All these aspects are exemplified in the works of the East India Company, the Asiatic Society of Bengal and the Survey of India during the time of the British Raj.

(3) The Golden Age of Himalayan geology began with the establishment of the Geological Survey of India in Calcutta (the capital of British India) in 1851. Since then, geology of the Himalaya has increasingly drawn attention mainly due to its own scientific merits, which is in sharp contrast to the "Great Game" approach to the Himalaya of the early days. Over the past three decades, the tectonic theory has given a new impetus to geological and geophysical studies of the Himalaya. We are in the Plate Tectonic Age of Himalayan geology, but since plate tectonics grew largely out of the ocean floor studies, it is hoped that studies in the Himalaya and Tibet would refine the principles and mechanisms of plate tectonics as applied to continents and orogenic belts.

(4) Kumar (1991) and Worbys (1991) have aptly emphasised that the scientific investigations of the regions and resources of India and Asia in the 19th century were meant to serve the economic and political interests of the Company and the expanding British empire. However, it should not be forgotten that such activities were fruitful for two other reasons: Firstly, they provided modern India with scientific infrastructures; secondly they contributed directly to scientific knowledge. These aspects are well exemplified by development in Indian and Himalayan geology.

(5) Himalayan geology has never been free from the influences of social and political conditions. This does not mean that Himalayan geologists have not been objective in the gathering and interpretation of data, but rather the scientific activity and field logistics have been dictated largely by political constraints and social aspirations (with the exception of several pioneers and eccentrics). The Himalaya have nurtured many cultures and supported many societies; they are therefore the meeting ground for numerous states, peoples and cultures. Understandably, regional violence and political conflicts act as obstacles to Himalayan science, while peace, political stability, and freedom greatly help its growth. Considering the cultural, economic and scientific significance of the Himalaya, regional cooperation between Himalayan countries for peace, openness and stability would transform this region into a very prosperous and influential part of the world. Unfortunately these potentials have been overshadowed by the short-sighted policies of "response to crisis" and "relentless exploitation of resources", which contradict the sacred views and scientific understanding of the Himalaya.

(6) Over the past five decades, the two giant countries surrounding the Himalaya, namely India and China, have followed the policy of "indigenisation" of their scientific
activities in the Himalaya, while a pronounced trend of “globalisation” has characterised foreign works in the Himalaya. Disparity between two trends need to be resolved. Collaboration between foreign and native Himalayan scientists and institutions is a way out of this dilemma. While there are several positive signs of such collaboration (a trend which needs to be encouraged), a more challenging task for Himalayan countries is to improve ways of utilising the knowledge derived from Himalayan studies directly in their education, research and development, environmental problems and economic growth.

(7) It is increasingly realised that multidisciplinary approaches yield better scientific results. The Himalaya are not divided into various disciplines and departments as our institutions and research projects are. The processes and materials forming the Himalaya are interconnected in ways, which we are only beginning to understand their complexities (eg. relations between compressional and extensional tectonic structures, orogenic uplift and climate, effects of rapid denudation on the thermal regime of the crust, quantifying pressure-temperature-time pathways of rocks, precise dating of granite series, along-strike variations in tectonic style, etc. which have been among the ‘hot topics’ in geological literature in recent years). This calls for integrative platforms of research (field observations, laboratory analyses and physical modeling) consistent with (if not reflecting) the true nature of the Himalaya (see Sorkhabi, 1995b, for further discussion).

(8) After two centuries of scientific studies in the Himalaya, and with the increasing attention of the world’s geological community to this region, the time is ripe for the creation of an International Society for Himalayan Geoscientists as a non-governmental body to organise meetings, run publications, diffuse information and bridge the gaps between foreign and native Himalayan geologists.

Acknowledgements

This article (a result of the author’s studies of historical literature on Himalayan geology and exploration) is dedicated to a pioneer geologist of the Himalaya, Henry B. Medlicott, who wrote in 1882 (as if to justify efforts such as the one made here): “In geology, no less than in other sciences, it is desirable to be able to trace the stages of knowledge. Even in descriptive geology this information is interesting; and for the student such illustrations are almost essential”. I would like to thank Dr. V.C. Thakur, Director of the Wadia Institute of Himalayan Geology, Dr. A.K. Jain of University of Roorkee and Dr. Neptune Srima\] of the Geological Survey of India in Calcutta for their kind hospitality and stimulating discussions. I am also thankful to Dr. B.P. Radhakrishna for critically reading the article. I alone, however, am responsible for its content. A grant from the US National Science Foundation (Tectonic Program) is gratefully acknowledged. For lack of space, it was not possible to reference all the original sources in Himalayan geology and exploration; nevertheless, the secondary sources referenced below introduce the first-hand sources for further research and studies.

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