THE BIG MAN

Surveying Sir George Everest

By Brinda Gill

"I am not a compass-wala, but surveyor general and superintendent of the Great Trigonometrical Survey of India," remarked a visibly irked George Everest in 1834 when a British political agent used the appellation casually bestowed on all surveyors. Peace was restored once it was agreed that all official correspondence would refer to him as Surveyor General Sahib Bahadur, a title that truly reflected his dedication to surveying the vast and varied Indian topography.

Everest had touched Indian shores from London as a sixteen-year-old artillery cadet in 1806, during the early years of British triangulation surveys in southern India, before moving on to service in Java. He returned to the subcontinent in 1818 to take up an appointment as chief assistant to William Lambton in the newly christened Great Trigonometrical Survey (GTS), succeeded Lambton as superintendent of the GTS when the Lambton died in 1823, became surveyor general of India in 1830, and ultimately completed the measurement of the Great Meridional Arc. Before he retired in 1843, he had extended the triangles started by Lambton in the peninsula across the subcontinent and developed a "gridiron" of interlocking triangles on which the rest of a systematic survey could proceed. Moreover, despite a chronic lack of resources and skilled labor, confusing and occasionally contradictory signals from London, difficult conditions in the field, and his own poor health, Everest oversaw and greatly influenced the transformation of India surveying from rudimentary, overlapping, and inconsistent mapping efforts based on traditional methods and a wide variety of sources to a single geographic framework rooted in the principles of triangulation. By the time he set sail from India for the final time, the GTS had become what Matthew Edney has described in Mapping an Empire as a "proper institution" and had laid the foundations for what would become, thirty years later, the Survey of India.

A Survey So Far

In 1600 a group of British merchants, intent on challenging the Portuguese monopoly over the lucrative Indian spice trade, received a charter from the Crown that later led to the formation of the British East India Company (EIC). Throughout the first half of the seventeenth century, the company gained a secure foothold in important coastal towns and extended its mercantile and military activities into the subcontinent's interior. Expansion accelerated further after 1757, when British forces under Robert Clive defeated the Nawab of Bengal at Plassey.

With each territorial gain came new geographic information and additional incentive to fit that data into a recognizable cartographic image of Britain's emerging Indian empire. In 1767 the EIC appointed James Rennell as the first surveyor general of the Bengal, and over the next half-decade Rennell completed what is generally regarded as the region's first systematic survey, during which he combined topographical measurements taken by fixed chains with astronomical observations. He then drew on these results and existing cartographic materials to compile maps, which he published in The Bengal Atlas of 1779 and which he included in his 1782 Memoir of a Map of Hindoostan.

Rennell's surveys and his maps promised greater precision than previous cartographic efforts - one contemporary called Rennell's Bengal Atlas the "foundation of Indian Geography" - but the weaknesses of his methods were increasingly apparent, particularly for the construction of the large-scale maps on which effective political administration and military control rested. Astronomical observations were often inconsistent, measurements taken from route surveys even more so. In addition, even medium-scale maps required far more information than routine route surveys typically provided. Moreover, a good amount of Rennell's information came not from direct observation, but from a wide variety of European and indigenous sources, very few of which shared common standards. Triangulation, by providing a dense network of control points whose relative positions are fixed very accurately, promised a solid and accurate alternative as well as a more reliable framework for incorporating existing geographic information. The method depends on a rigorous application of trigonometry. Surveyors first establish a baseline whose length is carefully measured. They then make line-of-sight observations to "construct" a triangle - ideally at elevation to maximize the length of the triangle's sides and thus minimize the number of observations - and measure its interior angles. Once these angles have been ascertained, the length of the two other sides of the triangle can be calculated from the length of the baseline; they in turn become the baselines for additional triangles. Thus is a network of triangles built, with all points defined with respect to one another and anchored to one precise measurement.

The Great Trigonometrical Survey had its roots in William Lambton's 1799-1800 triangulation survey of the Indian peninsula south of the Krishna River. In addition to a web of triangles across the region's meridians, Lambton also intended to measure an arc of parallel by constructing triangles running north from Cape Comorin at the peninsula's southern tip, an arc later to be known as the Great Meridional Arc of India. Not only would this measurement provide a basis for calculating the length of one degree of arc along the earth's surface, it would also yield a value for the curvature of the earth, allowing all elevations to be calculated in relation to sea level.

Lambton won approval for his idea, says Edney, primarily because of the promise of a trigonometrical survey's accuracy and perhaps even more so because he would serve as the agent of such a survey. In 1802 Lambton commenced surveying the Madras presidency, measuring the baseline with 100-foot steel chains and subsequent distances based on triangulation. By 1818, when Everest joined him, the venture had been renamed the Great Trigonometrical Survey and Lambton appointed as its first superintendent. Five years later, at Lambton's death, the GTS had surveyed 165,342 square miles of territory from the peninsula to the Vindhya Mountains in Central India.

Despite these gains, however, the GTS didn't replace conventional topographical and astronomical surveying as the preferred method for compiling data about India's geography, nor did it receive a significant measure of institutional support. From the beginning the East India

Company fretted constantly about the costs of Lambton's survey and wondered publicly about his preoccupation with geodesy at the expense of topographic information. Company officers in London also did little to clarify a number of jurisdictional disputes in the field. Not only was there no agreement on the best method for surveying India, there wasn't even a consensus on the idea of a single organization to conduct such surveys.

New Horizons

Into this administrative fray stepped the newly appointed superintendent of the GTS. Less than two years after succeeding Lambton, Everest returned to England on health leave, a convalescence that stretched out for five years. He used the time wisely. He reviewed the geodetic work underway in Europe, particularly the Survey of Ireland, and made a careful study of surveying instruments whose features were was particularly well suited to conditions in India. He made no effort to conceal his disdain for earlier survey efforts on the subcontinent and took every opportunity to champion the cause of the trigonometrical survey. He proposed a series of large, or primary, triangles extending out across the subcontintent, thus creating a grid with control points in all directions. Unlike Lambton's less-systematic survey, which built out from the baseline, Everest's gridiron provided a way to check for accuracy by building back to the baseline; one side of the final triangle was the original baseline.

Ultimately, Everest convinced the East India Company's directors in London of the value of extending the Great Meridional Arc from Central India, where he had left it, to the Himalayas in the north. The plan involved continuing his gridiron of primary triangles across the vast Yamuna-Ganges plain, long regarded as insurmountable barrier to triangulation because it had no natural elevations from which to take line-of-sight measurements; without man-made structures, the control points could be no greater than about three miles apart - roughly the distance a man of average height could see before the horizon curved away. To compensate, the GTS would have to either invest in observation towers or significantly increase the number of observations.

Given the resources such an ambitious plan would require, the East India Company's endorsement was significant. When Everest returned to India in October 1830, he had been appointed the new surveyor general of India and had a commitment from London for a bigger staff and budget. He also brought with him a stock of new and improved equipment. The largest of his specially-designed theodolites, instruments for measuring horizontal and vertical angles, was thirty-six inches in diameter and weighed more than a thousand pounds. The steel chains traditionally used in baseline measurements were replaced by bi-metallic compensation bars; made of two different metals, these bars were designed to neutralize the effects of expansion due to increased temperatures and thus could maintain a fixed length. Although he continued to use the established signals - stone cairns, wooden poles, bundles of brushwood, cloth flags - Everest believed that observations for the primary triangles should be made to luminous signals. In the day he employed heliotropes, which reflected solar rays to fixed positions in the distance while controlling for the movement of the sun. At night he used blue lights, or reverberatory lamps. The lamps, according to Everest's specifications, comprised an oil-burning Argand burner with glass chimney that was placed in the focus of a parabolic reflector. Night observations minimized the refractions that occurred during the day due to variations in temperature.

The survey continued in northern India with the new instruments. Where stations were not intervisible, Everest had scaffolds constructed to mount the theodolites and high portable bamboo masts to burn the blue lights, though dismantling and transporting scaffolds and masts from one station to another required much effort and caused delays. In the plains fourteen towers were raised - two forty-feet high, eleven fifty-feet high, and one sixty-feet high. These towers allowed Everest to maintain the system of primary triangles, whose sides were usually twenty to sixty miles long. They also served as control points for secondary, or smaller and more detailed, triangulations.

Despite such meticulous organization and attention to detail, the observations were fraught with difficulty. Trees and man-made structures often obscured a clear line-of-sight. Such obstacles could be removed, but only after persuading affected villagers and compensating them for the destruction. Stormy weather or faulty signaling made it difficult to see the blue lights, which burned only for few minutes at planned intervals. At times they burned very brightly, giving the observer adequate time to fix it with the theodolite and note his findings; at other times they burnt out before a measurement could be recorded. The atmosphere during the day was often hazy due to smoke from brick and lime kilns that enveloped villages, the clouds of dust raised by cattle going out to graze, processions of travelers, and dusty winds, while the smoke from the oil lamps disrupted readings taken at night. And surveyors often had to fix their heliotropes with bits of mirrors bought in bazaars.

These technical obstacles played out against a larger backdrop of difficulties. The surveyors were often set on by bandits or villagers, who menaced them and destroyed their signals and cairn-marks, or regarded the marks as sacred and turned them into sacrificial sites. The attacks were widespread enough that the GTS eventually developed its own armed guard, separate from the military. Natives also objected for less obvious reasons. On one occasion, Zalim Singh, a landowner south of Delhi, offered to pay for shifting an observation post that he thought overlooked the zenana, or women's residence. An exasperated Everest remarked: "Persuaded that our telescopes . have magic powers, and are able to turn women upside down . they assign to us the propensity of sitting all day long, spying through the stone walls at those whom they deem so enchanting."

The far greater hardship, however, was sickness and disease. As Edney has observed, the British suffered a high mortality rate in India, but the surveyor in the field seems to have been particularly vulnerable to jungle fever. Everest fell victim on a number of occasions, beginning in 1819 when an outbreak of typhus claimed the lives of a tenth of his party and severely weakened his constitution. When he was struck down by malaria in 1835, he was confined to his bed for six months, during which he complained that the ravages of the disease and the equally ravaging treatment "produced such a degree of debility as to make it of small apparent moment whether I lived or died." In 1838, after contracting yet another serious disease, Everest told his physician, "Except in-as-far-as the work of the Great Arc is concerned, I would not stay in India on any account."

Nevertheless, Everest refused to relax his high standards. When he found a one-meter discrepancy between Lambton's baseline measurement at Sironj in 1824 and the same length as calculated through the triangles from the base at Dehra Dun, a distance of some four hundred miles, he ordered the entire series remeasured. A 2.5-meter discrepancy in Bengal resulted in another remeasurement. These and other corrections caused concern in London because they delayed the progress of the GTS and added significantly to its costs. By the same token, a chain of triangles running along the foothills of the Himalayas, executed in part to correct errors and eventually named the North-East Longitudinal Series, produced the observations from which the survey's mathematicians later concluded that Peak XV was the highest mountain in the world.

High Praise, Indeed.

During his last years on the subcontinent, Everest supervised the final surveys to complete the Great Meridional Arc. According to his calculations he had extended Lambton's earlier work to cover almost half a million square miles of surveyed ground, reaching 2,400 kilometers from Cape Comorin at the southern tip of India to Banog near Mussorie at foothills of the Himalayas in the north. Of his efforts Everest remarked, "There was no instance on record of a symmetrical series of principal triangles having been carried over a country similarly circumstanced." As to the accuracy of his work, the baseline measurement at Dehra Dun differed by only 7.2 inches from the projected value computed from the remeasured baseline at Sironj.

In September 1843 Everest left Mussorie, sailed down the Ganges River to Calcutta, and embarked for England and retirement. After his return he continued to stay in touch with geodetic work in India, and for his efforts throughout his career he was knighted in 1861, an honor he had turned down earlier.

Everest was similarly hesitant when his successor as surveyor general, Andrew Scott Waugh, proposed naming the world's highest peak after him, "in testimony of my affectionate respect for a revered chief, and to perpetuate the memory of that illustrious master of accurate geographical research." Everest objected that the Himalayan peaks should retain their local names. He also protested that "the native of India" could not pronounce his name, nor could it be written in the local Devnagari script. Nevertheless, Waugh ultimately prevailed. In 1865 the Royal Geographical Society named Peak XV after the man who had been responsible for framing the subcontinent with a gridiron of triangles and whose careful and persistent geodetic survey had established a modern foundation for measuring elevations across the Indian landscape, including the Himalayas. In so doing, he had also provided an organized model and a set of rigorous standards that would guide later efforts to survey India.

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Further Reading

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