When asked why he wished to conquer Mount Everest, George Mallory enigmatically replied, ‘Because it is there’. The question of *why* it is there cannot be dismissed so pithily but, as **Randall Parrish** explains, isotopes are providing some of the answers.

Cool rocks and hot flow

The collision of India with southern Asia in the past 50 million years has produced a mountain system of great diversity and immense size, with the Himalaya, Karakoram and the Tibetan plateau being the direct result. All of the world’s 8000-metre peaks lie in the Himalaya–Tibet–Karakoram mountain system, and the structure, relative timescale, and dimensions of this great range have strongly influenced our ideas of how such systems have evolved. It is now reasonably well established that the rise of the range caused significant changes in the Earth’s climate in the past 40 million years, culminating in extensive glaciation in the northern hemisphere and Antarctica.

The BGS, and especially the isotopic geochronology and geochemistry facilities at the NERC Isotope Geosciences Laboratory, has collaborated with more than 15 Ph.D. students at about 10 UK and overseas universities in recent years to help unravel the complex tectonic history of the Himalayas. These studies span the system from north-west Pakistan near the Afghan border to remote regions of eastern Bhutan; and from the Indo-Gangetic plain of northern India to the 5000-metre plateau of southern Tibet near the Indus Suture. Our work has focused on determining the timing of events, the age and provenance of stratigraphical units within the core of the range, and on helping to quantify the phases of erosion of the mountains and their effect on the changing chemistry of the oceans. Isotopic analysis of rocks and minerals that contain uranium, thorium, lead, hafnium, neodymium, or strontium are helping to unlock the secrets of continental collision processes.

Remarkable insights into the geology of the belt were made in the 1930s by Professors Augusto Gansser, Lawrence Wager and others who outlined the basic elements of the Himalaya. However, various enigmatic features took several more decades to be explained.

An early idea, that even today is regarded as fact by many geologists, was that a 35 kilometre thick slab of cratonic crust of continental India underwent wholesale duplication, creating the more than 70 kilometre thick crust that supports the high Himalayan mountains. The boundary between the two slabs was named the Main Central Thrust, a profound feature that separates high-grade metamorphic rocks above from mainly Precambrian and Palaeozoic sedimentary rocks scraped off the Indian craton below. This notion was based upon the somewhat misplaced assumption that the high-grade rocks represented older continental crust. However, due in large part to isotope studies, this is now known to be untrue. In fact the high-grade metamorphic rocks include little if any ‘Indian basement’. Instead they comprise a Late Precambrian metasedimentary

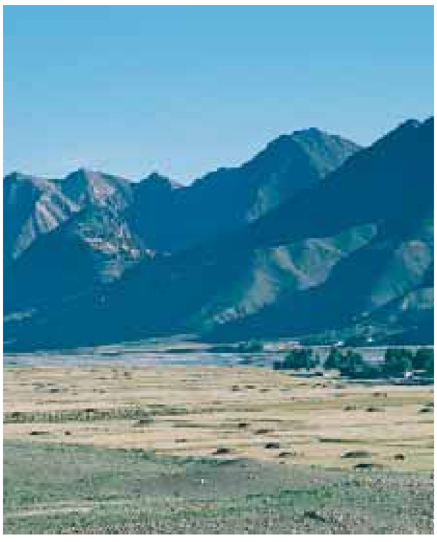
Distribution of the Himalaya–Tibet–Karakoram mountain system.

Sample collection from the 27.5 million year old leucogranite forming a prominent intrusion within the north Himalayan gneiss domes of southern Tibet.

succession affected mainly by metamorphic events less than 35 million years old. The movement along the principal fault, the Main Central Thrust, displaced these high-grade rocks on to the Indian foreland. Through isotope dating we now know that this movement mainly took place from about 24 to 16 million years ago, and even later in the far east in Bhutan.

" the structure, relative timescale, and dimensions of the Himalaya have strongly influenced our ideas of how such systems have evolved "

A second profound feature of the range, understood only recently, is exemplified by the world's highest mountain: Mount Everest or Quomolongma. Much has been made of the unmetamorphosed Ordovician fossils in limestone at the summit of Everest. But these sedimentary rocks overlie a profound north-dipping contact with tourmaline leucogranites and deformed high-grade metamorphic rocks beneath. The geometry of this contact was recognised very early by the Oxford geologist Lawrence Wager during one of the early climbing expeditions to Everest from the Tibetan north side. This enigmatic feature has now been mapped from Ladahk in the west to northern Bhutan in the east, almost without a break. Everywhere it represents a profound metamorphic omission and it is no wonder that early workers believed it to be an unconformity. In the mid 1980s it was first recognised to be a low-angle fault with normal displacement, that is, the northern low-grade rocks had moved northwards relative to the high-grade rocks beneath. Subsequent work in many other places has confirmed this arrangement, and the feature has been called the South Tibetan Detachment system. Isotope geochronology undertaken at the BGS in association with UK and North American scientists and their army of students over the past 10 years has shown that in most places this fault was moving from about 22 to 17 million years ago before it ground, more or less, to a halt. Though in some places, like Bhutan in the east, movement may have only ended about 12 million years ago.



The landscape of the southern Tibetan plateau, south-west of Lhasa.

These two faults have opposite senses of movement and their geometry, along with the 22 to 17 million year synchroneity of movement on them, suggests that the high-grade metamorphic rocks of the Himalaya have been pushed southward — as if through a channel — and rapidly eroded by the heavy rainfall of the Indian monsoon. A recent conference held at the Geological Society of London on this topic arrived at a general consensus that this 'channel flow' has taken place due to southward flow of hot and weak metamorphic rocks, lubricated by partially molten layers, from beneath the 75 kilometre thick Tibetan Plateau to the north of the Himalaya. Evidently, the geophysicists who have created elaborate and comprehensive computer models of the process not only believe it is possible but can even predict the geometry of the channel!

These strides in knowledge of the mountain system — the recognition of the lack of duplicated Indian crust, the discovery and dating of the South Tibetan Detachment system, the dating of the Main Central Thrust movement, and the recognition of the age of major lithological units of the Himalaya have partly been made possible by the Ph.D. student research done in collaboration with the BGS and its isotope laboratories. The collaboration continues with more projects on the agenda and a queue of rocks to date!

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