

The Himalayan Question



The collision of India into Asia has produced the highest mountain belt on the planet, the Himalayas, which is often held to be the classic example of mountain building. Despite this, much about the mountain belt is not understood, including the unexpectedly vital role it plays in shaping our climate. **Rowan Vernon** explains more.

The Himalaya is the youngest and most spectacular continent-continent collision belt on Earth. It stretches for 2500 kilometres along the north of India and Pakistan, with its highest peaks towering over 8000 metres above sea level. Great glaciers have carved deep valleys into the belt, creating some of the most dramatic topography on earth.

The mountain belt is made of a complex mix of rocks. Ocean sediments, intrusive volcanics, and compressed and heated fragments of oceanic crust all help build the mountains. Mount Everest itself is composed of limestone that was laid down at the bottom of an ocean more than 60 million years ago. So how did something once at sea level end up over eight kilometres higher at the top of the world's highest mountain?

“The Himalaya is but one consequence of the Indo-Asian collision”

Plate tectonics, of course, is the answer. After the break-up of the supercontinent Pangaea 250 million years ago, the Indian continent had been moving northwards, while the Tethys Ocean, formerly separating it from Asia, was subducted below Tibet. Finally, 50 million years ago, no more oceanic crust was left between the two

continents, and India slammed into Asia. Sediments and oceanic crust fragments trapped between the two continents were squeezed and thrust upwards over the Indian crust, creating the Himalaya.

In fact, the Himalaya is just one part of an enormous mountain belt system, stretching from the European Alps in the west to the Sumatra Arc in the east. They were all uplifted in the same event: the closure of the Tethys Ocean.

Even more than that, this is but one consequence of the Indo-Asian collision. Over the past 50 million years, India has continued ploughing over 2000 kilometres northwards into Asia, creating a large area of high and smooth elevation clearly visible on topographic maps of the region – the Tibetan Plateau. It is the largest plateau on Earth, having an area of over 2,500,000 square kilometres and an average elevation in excess of 5000 metres. The crust is twice as thick as normal continental crust, and up to three times as thick in some places, having absorbed an enormous amount of shortening.

Bizarrely, India is largely unaffected by the continuing collision. India is like an anvil smashing into jelly. So why is it that the Asian crust is deforming, while India remains intact?

The answer actually underpins the geology of the whole of Asia. The Indian crust is a cold, solid and ancient continental mass,



World colliding: A diagram showing the collision of the Indian subcontinent into Asia, highlighting the Himalayas and the Altn Tagh fault

while Tibet is composed of many different blocks of crust that were welded onto the south margin of the Asian continent between 500 and 200 million years ago. This creates a crust that contains many weak zones, making it easier to deform.

As the rock-solid India continued to plough into Asia, the stresses became too high, pushing up mountains. The Asian lithosphere tore along pre-existing weak zones in the crust, and Tibet escaped eastwards. However, compression of the crustal blocks south of these weak zones caused mountains to be thrust upwards.

Initially, basins separated these mountain ranges. Eventually, however, these basins were plugged with sediment and the mountain tops smoothed off. This created the Tibetan plateau.

Current research at Leicester aims to find out whether Tibet is actually still growing. We are doing this by making direct comparisons between two regions of Asian crust that have very different deformation regimes.

The first is the northeast of the Tibetan Plateau. This is the youngest and lowest part of the plateau, and provides an analogue for the formation of the higher plateau. Here, crust is made from island arc blocks, separated by oceanic sediments, stuck to the south margin of the Asian continent between 550 and 200 million years ago. This mixed crust is being obliquely compressed as it is forced over the Tarim block. As slip continues and the fault moves northeastwards, new mountains are growing at its termination and river catchments are being damned, causing the basins to start filling.

In contrast, the Beishan region just to the north has a very low elevation and little topography. The crust here is composed of old, highly deformed, and metamorphosed rocks. Deformation here is limited to small thrust faults, which uplift low ridges of basement rock.

“The Indo-Asian collision dominates Asia”

The structures and rocks found in these regions are inherited from the collisional history of the Asian continent. They control the location of the current north margin of Tibet and the style of deformation in the northeast. So, by making this comparison, we can understand how the continuing collision is affecting the region today, and determine whether Tibet is really still growing.

Regardless of whether Tibet is still growing or not, however, across northwest China, Mongolia and southern Siberia there are large mountain belts, such as the Qilian Mountains, Tien Shan and Altai, that are well known to be actively growing. Mountain belts normally form where two tectonic plates collide. Surprisingly, these belts are developing in the middle of one of the largest continents on earth. How and why is this happening?

Similar to Tibet, these ranges are all forming in areas where there are pre-existing joins in the crust. They are also all separated by rigid, undeformed blocks of crust, the largest of these being the Tarim block. As India continues to plough northwards, the Tarim block is being forced beneath the Tibetan Plateau in the south ►



and the Tien Shan mountains in the north. As Asia continues to be compressed by India, weak sutures are reactivated, forming new mountain ranges in the middle of the Asian continent.

Finally, the Indo-Asian collision dominates Asia in one more respect: the climate. As the Himalaya and Tibetan Plateau are so high and so extensive, they dominate weather systems. The Himalayan Mountains push moist air up high into the atmosphere where it forms clouds, and causes rain to be focused on the south side of the mountains. This creates a huge rain shadow, and is responsible for creating the Gobi desert in north China. This effect is also believed to be critical in driving the Indian monsoon.

Consequently, the growth of the Himalaya and the Tibetan Plateau is thought to have had a major control over global weather patterns and climate change over past 50 million years. These changes, in turn, may have altered the erosion rate and pattern within the

orogen, altering the dynamics of growth of the mountains. Indeed, our work on the solid geology may potentially be able to identify where the continuing northwards deformation may occur next. In this way, we can predict how the collision will continue to affect climate change well into the future.

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With a large percentage of the world's population concentrated in Asia, climate change in the region affects the lives of billions of people. It is therefore vital to understand both the historic and the present day evolution of the Indo-Asian collision, not just to understand the climate of Asia, but in fact, the whole world. ■

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