Late Quaternary glaciation in the Himalaya and Tibet

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The Tibetan Plateau is a global scale feature that has a profound influence on regional and global climate and is, in turn, itself influenced by the Asian monsoon and mid-latitude westerlies. Changes in the extent of glaciers and snow cover on the Tibetan Plateau help force climate change. Hence, understanding the nature of glacial fluctuations in Tibet is essential for successfully modeling global climate. Despite the regional and global importance of glaciation in High Asia, the dynamics, extent and timing of glaciation in this region is poorly understood, to a large extent because of the inapplicability of radiocarbon techniques in this high, arid region. Recent developments have made it possible to use cosmogenic nuclide (CN) and optically stimulated luminescence (OSL) techniques to date features that were previously inaccessible to numerical dating. To test the relative importance that different climatic systems and topographic constraints might have on glaciation and on associated hydrological changes, we have systematically examined the glacial history throughout the region by dating landforms and sediments using CN surface exposure and OSL techniques. To date, we have undertaken detailed studies in the mountains of Chitral, Swat, Nanga Parbat, Hunza Valley, Lahul, Ladakh, Zanskar, Garhwal, Nanda Devi, Langtang, Khumbu, Gonga Shan, Gangdise, Nyainqentangulha, Tangula, Kunlun, Nianbaoyeze, Anyemaqen, La Ji and Qilian Shan. This work, encompassing detailed mapping together with dating numerous moraines and associated landforms, has served to define the extent and timing of glaciation in a large portion of Tibet and the associate Himalaya. These data demonstrate a strong monsoonal influence on glaciation, synchronicity of glaciation through much of Tibet and the importance of topographic constraints on the extent of glaciation throughout Tibet and the bordering mountains. Glacial oscillations are shown to correlate with changes in the hydrological system and sediment flux that in turn largely control landscape changes.

Tracing the sources of volcanic fluids: Following Giggenbach

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"Even to this day, both the composition and proportions of volatiles, especially those of water, that are contributed to hydrothermal systems from magmatic sources are controversial" [1]. At Japanese volcanoes, Sakai and Matsubaya [2] recognized a distinct shift in fumarolic δD and $\delta^{18}O$ relative to local meteoric water – an observation confirmed for arc volcanoes worldwide. Taran [3] and Giggenbach [4] first used the term "andesitic waters" and suggested that the source of water is recycled seawater that has been transported in clay minerals to the zones of arc magma generation. In addition to water, other volatiles (CO_2 and N_2) are also derived from subducted oceanic sediments and crust [i.e. 5, 6].

Investigations of N_2-He systematics of volatile discharges along the Central American volcanic arc show considerable along strike variation in $\delta^{15}N$ (and N_2/He ratios) from Guatemala through Nicaragua to Costa Rica. Guatemala and Nicaragua volatiles have mostly positive $\delta^{15}N$ (from –0.5 to 6.3 ‰) with N_2/He ratios between 1,000 and 25,000 (typical range of arc-volcanoes). In contrast, volatiles from Costa Rica have lower N_2/He values (73- 333) and mostly negative $\delta^{15}N$ (-3.0 to 1.7 ‰). These variations are interpreted as the result of sediment off-scraping and/or underplating of N-bearing hemipelaic sediments in Costa Rica whereas in Guatemala and Nicaragua the entire sediment package is subducted and contributes to the magmatic volatiles. Mantle derived nitrogen sampled at hot spots (Kilauea and Yellowstone) has negative $\delta^{15}N$ values (-4.4‰ to -1.6‰). Volatiles from a continental rift (Rio Grande) have $\delta^{15}N$ values of -3.8‰. Therefore, N isotopes support the idea that non-air N in arc volcanoes is primarily (up to 95%) of subducted sedimentary origin. The only exception is the Costa Rica segment of the Central America arc where the mantle contribution dominates. Mass balance considerations of the volatile input via the trench versus the volatile output via arc volcanism in Central America reveals the following: 1) N is efficiently recycled from subducted sediments to the atmosphere through volcanism. 2) only ~20% of subducted C is recycled back to the atmosphere, the remainder is either released in the fore-arc or injected into the deep mantle [7]. 3) The flux of magmatic H_2O out of the arc via volcanism remains poorly constrained.

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