MICROBIAL HABITAT ON KILIMANJARO'S GLACIERS. A. Ponce, S. M. Beaty, C. Lee, A. C. Noell, C. N. Stam, and S. A. Connon. Jet Propulsion Laboratory, Pasadena, CA 91109. Adrian.Ponce@jpl.nasa.gov

Introduction: The glaciers atop Kilimanjaro in equatorial East Africa are icons for global warming [1], because they are believed to be nearly 12,000 years old and are now vanishing at an accelerating pace [2-3]. Indeed, that magical contrast of alpine ice in a tropical climate, described by Hemingway as "unbelievably white in the sun", is predicted to disappear within 10-40 years [2-3]. Beyond intrinsic beauty, the layers of ice contain climate history information of equatorial East Africa recorded via temperature and precipitation proxies. In a race against time, ice cores from equatorial glaciers have been obtained and analyzed, aiming to provide vital clues about the dynamic range of natural climate fluctuations in an ongoing effort to delineate the magnitude of anthropogenic impacts on current global warming [3].

Glacial Record of Microflora: Glaciers also contain a record of microflora, which are released by global glacier melting at an estimated rate of 10^{17}-10^{21} viable microbes per year [4]. Since the recovery of viable microbes from several hundred meter deep ice beneath surface of East Antarctic Ice Sheet in 1993 [5-6], the microbial abundance in glaciers have been positively correlated with dust concentrations and microbial diversity patterns have been discussed in terms of climate history [7-8]. As water availability during melt periods is increasing, research has expanded to characterize glacier systems as microbial habitats where active microbial growth is occurring on, within and beneath glaciers [6]. To date, there are no investigations published on the microbiology of Kilimanjaro glaciers, and the anticipated loss of that record imparts a sense of urgency for unlocking the information embedded within the ice.

Supraglacial Microbial Habitats: The Kilimanjaro glaciers, in particular, provide a glimpse into microbial ecology of the glaciers during past East African droughts via embedded microflora associated with dust-rich layers. We aseptically collected near basal ice from a vertical glacial cliff of the Northern Ice Field, and filtered particulate matter from eight ice layers, including two layers that contained visible accumulations of dust. Microbial diversity data show that at the time of dust layer formation, the glacier surface likely hosted an active microbial, cold-water ecosystem. We found that a majority of bacterial clones, as determined by bacterial 16S rRNA gene sequencing, are most closely related to those isolated from cold water environments. This is further supported by the observation of a large mud-rich pond on the surface of NIF in 2008, which likely represents conditions present during the previous droughts when the dust layers formed. We anticipate that future investigations of this tropical-alpine, supraglacial, cold-water ecosystem will yield insights into microbial activity at the temperature and nutrient availability limits for life on Earth, and serve as an analogue for putative cold water habitats on Mars and Europa.

Kilimanjaro and glacier

Dating Kilimanjaro's Northern Ice Field: The layers of ice contain climate history information recorded via temperature and precipitation proxies [3], and provide a glimpse into microbial ecology during past droughts via embedded microflora associated with dust-rich layers. Accurate age assignments of Kilimanjaro's ice layers are essential for the correct interpretation of Kilimanjaro's ice core record. However, the 11,700 year age assignment [3] of Kilimanjaro's glacier has remained controversial [9]. Here we show that Kilimanjaro's Northern Ice Field (NIF) glacier formed around 1200AD, based on radiocarbon dating of two near basal dust layers. The relatively recent formation of Kilimanjaro's NIF glacier is supported by modeling studies and favorable comparisons of the dust layer radiocarbon dates to those of extreme droughts in the region as documented by Lake Naivasha salinity/depth [10], Nile river depth [11], and oral history of regional tribes [11]. A 12th century formation of NIF glacier implies that natural climate variations have caused glacial cycling on the multi-century time scale, and that Kilimanjaro ice core record should be reevaluated.

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