PROCEEDINGS OF THE TWENTY-EIGHTH ANNUAL KECK RESEARCH SYMPOSIUM IN GEOLOGY

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KECK GEOLOGY CONSORTIUM
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Keck Geology Consortium: Projects 2014-2015
Short Contributions— Paleoclimate Change from Peruvian Lake Deposits Project

HOLOCENE CLIMATIC CHANGE AND ACTIVE TECTONICS IN THE PERUVIAN ANDES: IMPACTS ON GLACIERS AND LAKES
DON RODBELL, Union College
DAVID GILLIKIN, Union College

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Research Advisor: Nathan Stansell

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HOLOCENE CLIMATIC CHANGE AND ACTIVE TECTONICS IN THE PERUVIAN ANDES: IMPACTS ON GLACIERS AND LAKES

DONALD T. RODBELL, Union College
DAVID P. GILLIKIN, Union College

INTRODUCTION

Mountain glaciers are one of the best recorders of atmospheric change over the continents, and numerous workers have highlighted the importance of glacial deposits in tropical paleoclimate studies (Porter, 2001; Mark and Seltzer, 2005; Polissar *et al*., 2006a; Rodbell *et al*., 2009; Hastenrath, 2009; Licciardi *et al*., 2009). Glaciers are also an important water resource in the tropics, and documenting the timing and causes of past variability is needed to predict future runoff changes. Studies of ice volume change in the tropics, the heat engine of Earth, provide useful information about past shifts in atmospheric water vapor content (Broecker, 1997), and such studies are important for understanding the role of the low latitude hydrologic cycle in modulating global temperature and moisture-balance fluctuations (Seager *et al*., 2000). However, these studies are currently confounded by a discontinuous record of Holocene glacial variability, one that is only broadly defined: restricted ice cover early in the Holocene, followed by a regionally complicated glacial history during the middle and late Holocene (e.g., Rodbell *et al*., 2009). While there are no current studies on modern sediment yields in glaciated catchments in the tropical Andes, climate and topographic conditions suggest that rates could be relatively high and closely related to climate-mediated glacier mass balances changes. Given a homogeneous temperature regime, tropical glaciers are highly sensitive to moisture related fluxes and variables such as accumulation, albedo, cloudiness, atmospheric long wave emission, and sublimation (Kaser *et al*., 2003; Vuille *et al*., 2008). Tropical Andean glaciers are warm-based, have strong vertical mass balance gradients, and are marked by year-round ablation (Kaser, 2001). Seasonally, maximum rates of ablation are coincident with maximum accumulation, as melt rates increase 30% in the wet season (Kaser *et al*., 1990). With high annual precipitation, mass turnover is sizeable and glaciers have short response times to changes in net balance, as demonstrated by the synchrony of hydrologically-derived mass balance with observations of terminus positions (Kaser *et al*., 2003). Variations in glacial flour flux should, therefore, closely correspond to variations in ice extent with a lag time of less than a few years.

Recent studies focusing on Holocene glaciation in the Southern Hemisphere have illustrated both the exciting potential for better moraine chronologies to elucidate global climate dynamics (Licciardi *et al*., 2009; Schaefer *et al*., 2009), and also the limitations of inherently discontinuous moraine records for discerning the relative scale ("footprint") of local and global forcing on glacier changes. There remains uncertainty about the relative timing of glacier advances across the globe during the Holocene, and whether these events are globally synchronous or if significant leads and lags took place (Balco, 2009; Schaefer *et al*., 2009). Our research advances the scientific understanding of climate change in the tropical Andes by investigating several temporal and spatial scales of how these changes are recorded in lake sediments.

PROJECT OVERVIEW

A prime goal of this year's project is to test proxies of glacial extent by studying various temporal and spatial scales of sedimentological records. Our main focus is a paternoster system of lakes in the glaciated Queshque Valley on the western side of the Cordillera Blanca in the western Andes of central Peru (Fig 1). There, we investigated several climate proxies from the ice-contact lake at the toe of the modern glacier downvalley 8 km though three other moraine-dammed lakes and their connecting streams. We also investigate short cores in these same lakes to determine how

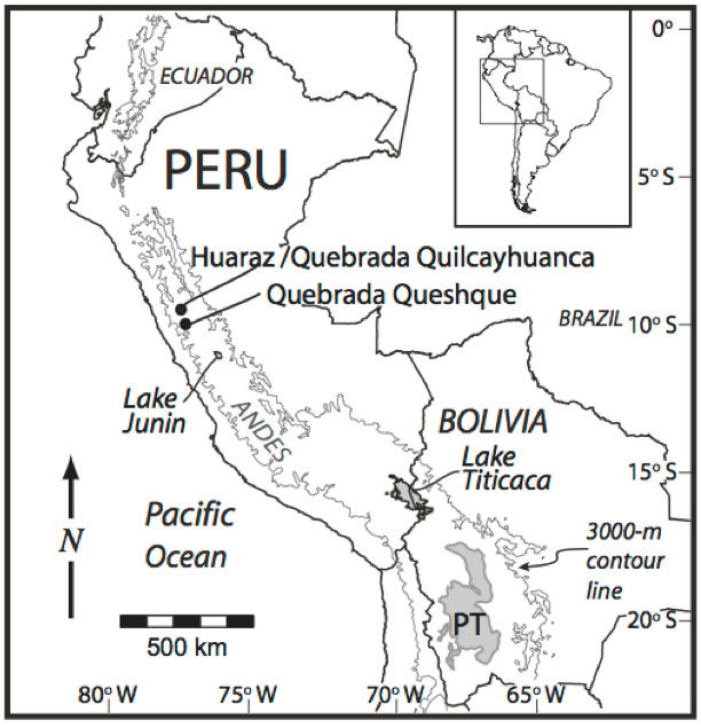

Figure 1. Location map of the two valleys studied in the Cordillera Blanca, Peru.

these proxies correlate though time within the same valley. Our final objective is to document the spatial variability of the sedimentologic and geochemical records by examining sediment cores from the glaciated Quilcayhunaca Valley, 40 km to the north.

The Peru Keck group spent three weeks in Peru, using the city of Huaraz as our base (~3000 meters above sea level (masl)). We camped for 10 nights in Queshque Valley sampling the lakes, which range from 4685 masl to 4250 masl over a nearly 8 km distance. We then spent an additional 5 nights in Quilcayhuanca Valley, where we hiked up to the lake Perolcocha at 4720 masl from our camp at 4150 masl.

Nick Weidhaas (Union College) has been investigating the modern sediment supply in the Queshque Valley. The aim is to determine how proxies (e.g., clastics, elemental signature, stable isotopes, etc.) vary with distance from the glacier. Nick sampled surface sediments from the lakes as well as water chemistry in lakes and intervening streams. His work revealed that as new lakes form they act as sediment traps and can alter the amount of glacially derived sediments delivered to lakes downvalley. Nick also documented the diurnal cycle of proglacial sediment yield to the paternoster lake sequence.

Alia Payne (Macalester College) has been studying short cores from the ice contact lake downvalley to the lowest lake in the paternoster sequence. Her results reveal that over the last centurion, the upvalley lakes have captured more of magnetic signal derived from glacial erosion than have downvalley lakes. Likewise, total organic carbon is lowest in upvalley lakes and highest in downvalley lakes, reflecting increased biologic productivity in the more distal settings. All lakes in distal settings show a pronounced increase in organic productivity over the past several centuries, which records the progressive diminution of suspended clastic input into these lakes in response to recent ice retreat.

Julie Daniels (Northern Illinois University) expanded the study into another valley by studying sediment cores from Laguna Perolcocha, in Quebrada Quilcayhunaca. The Perlococha record reveals pronounced intervals of enhanced glacial sediment flux during the early Holocene, between 5 and 2 ka, and during the last several centuries, which is broadly consistent with the record from the Queshque Valley.

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