2008-09 AAPG Distinguished Lecture

Abstract

CARMALA N. GARZIONE

Department of Earth and Environmental Sciences,
University of Rochester, Rochester, New York

Funded by the AAPG Foundation

Rise of the Andes & the Geodynamics of Orogenic Plateaus

Paleoelevation and incision histories provide important constraints on the timing and magnitude of regional surface uplift of mountain belts that point to specific processes that led to surface uplift. Multiple elevation proxies including paleoleaf physiognomy, d18O paleoaltimetry, and ?47 paleothermometry, indicate that the Altiplano basin had attained no more than ~2 km of elevation by ~10 Ma. Both d18O paleoaltimetry and ?47 paleothermometry show that the northern Altiplano was raised to its current elevation by ~6.4 Ma, suggesting that surface rise on the order of ~2 km or more took place between ~10 and 6 Ma. Geomorphic constraints on the incision history of widespread, low-relief paleosurfaces on both the eastern and western flanks of the Andes also suggest that deep incision began between ~10 and ~6 Ma over the entire width of the mountain belt and over at least 5° latitude, associated with ~1 to 2 km of surface uplift of the eastern and western margins of the plateau. Also coincident with regional surface uplift is the cessation of shortening across the plateau, a decrease in sedimentation rates within the Altiplano basin, the widespread eruption of ignimbrites, and eruption of asthenosphere-derived lavas in the southern Altiplano and Puna. Regional surface uplift of the Andean plateau in the late Miocene predicts a decrease in the horizontal deviatoric stress in the plateau that is consistent with the observed histories of shortening, sedimentation, and volcanism. The combination of geodynamic processes that appear to have occurred in the Andes during the Cenozoic, including Eocene to middle Miocene upper crustal shortening, late Miocene removal of high density lower lithosphere, and redistribution of crustal material by lower crustal flow and erosion/sedimentation are likely mechanisms for building broad, flat, high elevation plateaus in convergent tectonic settings.

Modern Rainfall and Paleoclimate across NE Tibet: Climate Consequences of the Growth of the Tibetan Plateau

The NE Tibetan plateau consists of sedimentary basins at elevations between ~2 to 3 km and intervening mountain ranges that reach elevations 1 to 2 km higher than the basin floors. The stable isotopic composition of modern rainfall across NE Tibet shows patterns associated with the topography across the region. The patterns in precipitation amount and isotopic composition across NE Tibet are compared with paleoprecipitation composition derived from sedimentary carbonates to understand the development of late Cenozoic topography across the region. Based on paleoflow patterns and the Sr and stable isotopic compositions of lacustrine carbonates, individual sub-basins in NE Tibet appear to have been segmented early in their history (by ~20 to 10 Ma). Similar to modern isotopic patterns since ~8 Ma across the region suggest that individual ranges formed significant topographic barriers by that time. These data, as well as (U-Th)/He cooling histories from basin-bounding ranges, indicate that NE Tibet experienced a long term growth history that established the major topographic features that bound individual basins between ~45 and 8 Ma. Since ~10 to 8 Ma, outward growth of the Tibetan plateau has accommodated deformation on the distal margins, including the northern Qilian Shan along the northern margin and the Liupan Shan along the northeastern margin.

American Association of Petroleum Geologists
An International Geological Organization
P.O. Box 979 • Tulsa, Oklahoma 74101-0979 USA
(918) 560-2621 • Fax; (918) 560-2678 • email: kdotts@aapg.org

Carmala N. Garzione

Education

2000 Ph.D. in Geoscience, University of Arizona, Tucson, AZ
1996 M.S. in Geoscience, University of Arizona, Tucson, AZ
1994 B.S. in Geology, University of Maryland, College Park, MD

Appointments

2006 - present Associate Professor, Department of Earth and Environmental Sciences, University of Rochester
2000 - 06 Assistant Professor, Department of Earth and Environmental Sciences, University of Rochester
2003 - 04 Visiting Research Associate, CIRES, University of Colorado, Boulder
1999 Chevron Internship, Asian Business Unit, Chevron Overseas Petroleum Inc., San Ramón, CA
Chevron Internship, South Texas Production Team, Houston, TX

Awards

2007 Donath Medal, Geological Society of America Young Scientist Award
2007 University of Maryland Geology Alumni Award
2007 University of Arizona Geosciences Alumni Achievement Award

Selected Publications

Hoke G.D., and Garzione, C.N., 2008, Paleoelevation and Geomorphic Constraints on the Late Miocene Rise of the Andes: Earth and Planetary Science Letters, v.271, p. 192-201.

Garzione, C.N., Hoke, G.D., Libarkin, J.C., Withers, S., MacFadden, B.J., Eiler, J.M., Ghosh, P., Mulch, A., 2008, Rise of the Andes: Science, v. 320, p. 1304-1307.

Rowley, D.B. and Garzione, C.N., 2007, Stable isotope-based paleoaltimetry: Annual Review of Earth and Planetary Sciences, v. 35, p. 463-508.

Garzione, C.N., Molnar, P., Libarkin, J.C., MacFadden, B., 2006, Rapid late Miocene rise of the Andean plateau: evidence for removal of mantle lithosphere: Earth and Planetary Science Letters, v. 241, p. 543-556.

Ghosh, P., Garzione, C.N., and Eiler, J., 2006, Paleothermometry of Altiplano paleosols: Implications for Late Miocene surface uplift of the Andean plateau: Science, v. 311, p. 511-515.

Garzione, C.N., Ikari, M., and Basu, A., 2005, Source of Oligocene to Pliocene sedimentary rocks in the Linxia Basin in NE Tibet from Nd Isotopes: Implications for tectonic forcing of climate: Geological Society of America Bulletin, v. 117, p. 1156-1166.

Dettman, D.L., Fang Xiaomin, Garzione, C.N., Li Jijun, 2003, Uplift-driven climate change at 12 Ma: a long ? 18O record from the NE margin of the Tibetan plateau: Earth and Planetary Science Letters, v. 214, p. 267-277.

Fang Xiaomin, Garzione, C.N., Van der Voo, R., Li Jijun, Fan Majie, 2003, Flexural subsidence by 29 Ma on the NE edge of Tibet: magnetostratigraphy of Linxia Basin, China: Earth and Planetary Science Letters, v. 210, p. 545-560.

Garzione, C.N., DeCelles, P.G., Hodkinson, D.G., Ojha, T.P., and Upreti, B.N., 2003, East-west extension and Miocene environmental change in the southern Tibetan plateau: Thakkhola graben, central Nepal: Geological Society of America Bulletin, v. 115, p. 3-20.

Garzione, C.N., Quade, J., DeCelles, P.G., English N.B., 2000, Predicting paleoelevation of Tibet and the Himalaya from ? 18O vs. altitude gradients of meteoric water across the Nepal Himalaya: Earth and Planetary Science Letters, v. 183, p. 215-229.

Garzione, C.N., Dettman, D.L., Quade, J., DeCelles, P.G., and Butler, R.F., 2000, High times on the Tibetan Plateau: Paleoelevation of the Thakkhola Graben, Nepal: Geology, v. 28, p. 339-342.