Illuminating Northern California's Active Faults

PAGE 55

Newly acquired light detection and ranging (lidar) topographic data provide a powerful community resource for the study of landforms associated with the plate boundary faults of northern California (Figure 1). In the spring of 2007, GeoEarthScope, a component of the EarthScope Facility construction project funded by the U.S. National Science Foundation, acquired approximately 2000 square kilometers of airborne lidar topographic data along major active fault zones of northern California. These data are now freely available in point cloud (*x*, *y*, *z* coordinate data for every laser return), digital elevation model (DEM), and KMZ (zipped Keyhole Markup Language, for use in Google Earth™ and other similar software) formats through the GEON OpenTopography Portal (http://www.OpenTopography.org/data). Importantly, vegetation can be digitally removed from lidar data, producing high-resolution images (0.5- or 1.0-meter DEMs) of the ground surface beneath forested regions that reveal landforms typically obscured by vegetation canopy (Figure 2).

The GeoEarthScope northern California lidar acquisition presents an extraordinary opportunity to advance our understanding of the major active faults of the region. These data provide an unobstructed view of active faults that make up the plate boundary, spanning the transition from Cascadia subduction approximately 150 kilometers south of the Oregon-California border to the mature San Andreas system south of the San Francisco Bay region. Previously, dense forest canopy above most of these faults hampered accurate mapping of active faults in northern California.

The newly acquired lidar data reveal the fault traces with unprecedented clarity (Figure 2), furnishing opportunities to (1) locate paleoseismic sites in forested regions where slip rate and prehistoric earthquake chronologies may be acquired, (2) quantify offsets of geomorphic features that may be used to constrain coseismic slip and geologic slip rates, and (3) compare fault slip rates over geologic time with current rates obtained using the Global Positioning System (GPS) via EarthScope's Plate Boundary Observatory. Additionally, researchers can use the new lidar data to shed light on issues such as the complexity of fault zones, the evolution of active fault zones, the extent of off-fault deformation, and the response of hillslope and fluvial systems to climate and tectonic controls.

The data are available via an interactive, map-based, user interface at the OpenTopography site, and they are organized into 1-square-kilometer tiles. Each tile is downloaded to a user as a compressed directory (typically about 30 megabytes) containing both filtered (forest and urban cover removed) and unfiltered DEMs (generally 0.5 meter; in some cases DEMs are 1.0 meter). Additionally, users can view DEM hillshades, derived from lidar data, in Google Earth™ (or other similar software) by downloading a KMZ file. Users wishing to download the original point cloud data or create custom DEMs can use OpenTopography tools to access and process the data in regions of particular interest.

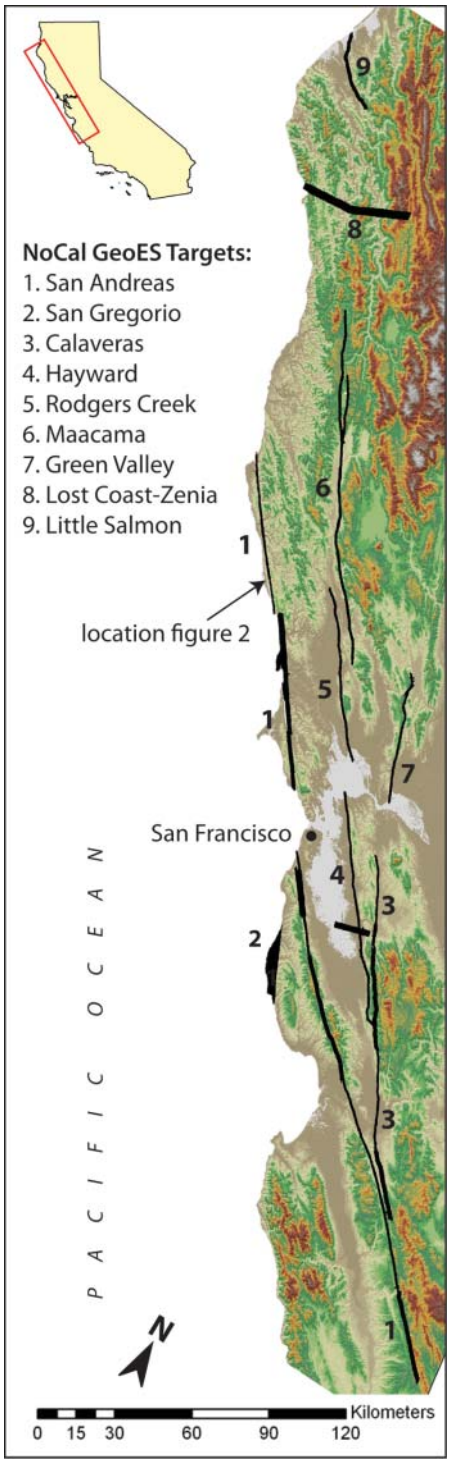

Fig. 1. Map of northern California (NoCal) showing fault zones studied using GeoEarthScope (GeoES) light detection and ranging (lidar).

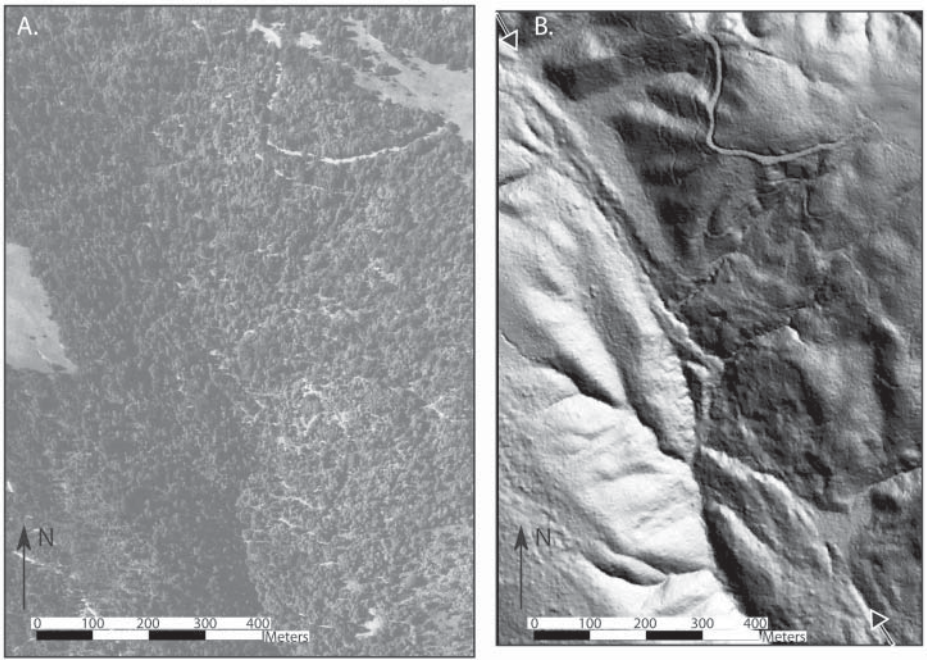

Fig. 2. San Andreas Fault under forest canopy. (a) Aerial photograph (original scale 1:12,000). (b) Hillshade image derived from filtered 1.0-meter digital elevation model constructed from lidar data of the same area, showing the ground surface below the redwood forest. The San Andreas Fault is indicated by white outlined arrows.

Future GeoEarthScope Lidar Data Releases

The northern California lidar data set is the first of the GeoEarthScope lidar acquisitions in the western United States. Other areas imaged include tectonic features in southern and eastern California, Washington, Utah, Wyoming, and Alaska (maps showing target areas are at http://www.unavco.org/geoearthscope).

These additional lidar data will become available through the OpenTopography Portal as processing is completed for each region. The complete GeoEarthScope lidar data acquisition contains 5788 square kilometers of digital elevation data suitable for producing 0.5- to 1.0-meter DEMs, the largest high-resolution data set dedicated to imaging active tectonic structures. The northern California GeoEarthScope lidar acquisition complements the B4 Project, which used lidar data to image the San Andreas Fault in southern California (http://www.earthsciences.osu.edu/b4/Site/Welcome.html), such that lidar data are now available for the entire length of the San Andreas Fault.

Acknowledgments

GeoEarthScope lidar data were provided by the UNAVCO Plate Boundary Observatory for the EarthScope Project (http://www.earthscope.org) supported by the U.S. National Science Foundation (NSF; grant EAR-0350028). UNAVCO subawards included the following: (1) Lidar data were collected and processed by the National Center for Airborne Laser Mapping; (2) GPS geodetic control was managed by Ohio State University; and (3) data handling and distribution via OpenTopography were provided by GEON (with additional support from NSF grant EAR 0225543). Additional funds were provided by the San Francisco Public Utilities Commission, the Pacific Gas and Electric Company, and the U.S. Geological Survey.

—CAROL S. PRENTICE, U.S. Geological Survey, Menlo Park, Calif.; E-mail: cprentice@usgs.gov; CHRISTOPHER J. CROSBY, San Diego Supercomputer Center, University of California, San Diego, La Jolla; CAROLINE S. WHITEHILL, Whitehill Consulting, Cupertino, Calif.; J RAMÓN ARROWSMITH, Arizona State University, Tempe; KEVIN P. FURLONG, Pennsylvania State University, University Park; and DAVID A. PHILLIPS, UNAVCO, Boulder, Colo.

MEETING

Toward a Better Understanding of Climate of the Past Million Years

Quaternary Climate: From Pole to Pole—EPICA Open Science Conference; Venice, Italy, 10–13 November 2008

PAGE 55

The European Project for Ice Coring in Antarctica (EPICA) has provided unique paleoclimatic data and is now widely recognized and cited in hundreds of scientific papers. EPICA is a multinational project that has successfully drilled and analyzed two Antarctic ice cores to bedrock. The first one, at Dome C (75°06'S, 123°21'E, 3233 meters above sea level, 3259.7-meter core length), has yielded a complete stratigraphically ordered sequence covering the past 800,000 years, almost doubling the length of previous Antarctic records (Vostok). The exceptional similarity of the Antarctic temperature and carbon dioxide (CO_2) records highlights the likely role of the Southern Ocean in the carbon cycle, while other trace gas and chemical profiles show the close coupling between different aspects of the Earth system. The second EPICA core, in Dronning Maud Land (75°00'S, 00°04'E, 2892 meters above sea level, 2774.2-meter core length), has provided a very high resolution record of a complete glacial cycle in the Atlantic sector, confirming theoretical predictions regarding the coupling of the two hemispheres during millennial-scale climate changes. In this ice core, Antarctic counterparts were found to each of the rapid Dansgaard-Oeschger climate change events prominent in Greenland and other Northern Hemisphere records of the glacial period; from Dome C data it appears that such events may have occurred in each previous glacial period.

The EPICA 2008 Open Science Conference brought together more than 150 scientists to highlight the progress made in understanding climate variability through the interglacial and glacial periods of the past million years. Participants contributed and discussed exceptional paleoclimate records from the marine, terrestrial, and cryospheric realms, and presented insights from topics such as paleoclimate modeling and glaciology. The goals of the meeting were to better integrate international research groups in the different fields that study the climate of the past million years and to bring together researchers from different backgrounds. Emphasis was placed on how precise and accurate past climate reconstructions can contribute to a better understanding of possible future scenarios. EPICA 2008 covered the following themes: climate of the last million years, forcings and feedbacks, past interglacials; thermohaline circulation, methods for paleoclimate reconstruction, ice instabilities and sea level, and causes for glacial/interglacial climate change.

A special focus concerned the reliability of the data and the dating of different archives. Attendees recognized that synchronization of records from different archives (marine cores, ice cores, speleothems) is a prerequisite to investigating processes in the climate system through the analysis of paleoclimatic data. The role of the Southern Ocean in the regulation of atmospheric CO_2 at orbital timescales over the past 1 million years was discussed from a combined marine-terrestrial perspective, highlighting the fundamental importance of a multidisciplinary approach to paleoclimate studies. The dynamics of glacial and interglacial periods, abrupt climatic changes, as well as the links between temperature proxies and sea level changes, were also duly debated at the conference, considering the forcing factors and feedbacks.

For additional information about the conference or to receive the book of abstracts, contact the authors or visit http://www.epica2008.eu. A special issue of *Quaternary Science Reviews* is planned for summer 2009.

—CARLO BARBANTE, Department of Environmental Sciences, University of Venice, Venice, Italy; E-mail: barbante@unive.it; HUBERTUS FISCHER, University of Bern, Bern, Switzerland; VALERIE MASSON-DELMOTTE, *Laboratoire des Sciences du Climat et l'Environnement*/l'Institut Pierre-Simon Laplace (LSCE/IPSL), Gif-sur-Yvette, France; THOMAS STOCKER, University of Bern; CLAIRE WAELBROECK, LSCE/IPSL; and ERIC WOLFF, British Antarctic Survey, Cambridge, UK