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Bedrock uplift of the San Gabriel Mountains: Linking long-term rates to modern observations

Principal Investigator: _

Martha A. House
Division of Geological & Planetary Sciences
California Institute of Technology
Pasadena, CA 91125

Objective: Obtain low-temperature thermochronologic limits on the recent uplift and exhumation history of the eastern San Gabriel Mountains in order to compare long-term bedrock uplift rates to modern estimates of vertical offset along the Cucamonga and Sierra Madre faults.

Introduction: The goal of this project is to provide a comprehensive record of the long-term exhumation and uplift history of Transverse Ranges using (U-Th)/He ages in the mineral apatite. This thermochronometric technique records the time at which rocks pass through shallow levels in the earth's crust (depths corresponding to temperatures of approx. 45-75 C; Wolf et al., 1996), and so provides a means to link long term exhumation and bedrock uplift histories to more recent limits on deformation provided by paleoseismology and cosmogenic dating. By illustrating how the Late Cenozoic uplift history of the Transverse Ranges relates to recent (<1 m.y.) deformation, we may hope to better understand the modern distribution of active tectonism that is vital in assessing potential seismic hazards in southern California.

Summary of results: Table 1 outlines the status of samples collected for helium analyses during 1999. Sample transects are shown on Figure 1 and helium ages are plotted relative to elevation on Figure 2. Eleven samples were collected from transects leading from Icehouse Canyon to Cucamonga Peak (A), Baldy Ski area to Thunder Mountain (B), and from Stockton Flat to the Baldy saddle (C). The samples were collected in order to identify differential movement along the Icehouse Canyon fault (A and B), and from north to south across the Baldy region.

Cucamonga Peak (Transect A) Four samples were collected over 400 meters of elevation. Three samples, ranging over 120 m of elevation, are all 5.2 Ma. This young age suggests rapid exhumation and cooling of summit samples since ~5.2 Ma. The lowest elevation sample along this transect has not yet been dated; its age will yield more insight into the exhumation history of this block by expanding the elevation range. Apatite fission track analyses of these samples will be completed this year (by A. Blythe), as will the completion of the last two helium ages.

Thunder Peak (Transect B) Four samples were collected over 230 m elevation. Three samples yield ages of 4.7-10.9 Ma. To first order, these results imply exhumation rates of approx. 0.05 km/my between ~6.8 and 10.9 Ma. Apatite fission track analyses of these

samples will be completed this year (by A. Blythe), as will the completion of the last helium ages.

Table 1. Status of San Gabriel Helium samples.

Transect	Sample	elevation (m)	Helium age (Ma)
<u>Cucamonga Pk. (A)</u>	99MHCP1a	2694	5.5(0.1)
	99MHCP1b	2694	5.2(0.1)
	99MHCP2a	2694	Not yet analyzed
	99MHCP3a	2573	5.2(0.1)
	99MHCP4a	2292	Not yet analyzed
<u>Thunder Peak (B)</u>	MH99TP1a	2597	10.9(1.3)
	MH99TP2b-a	2469	4.7(0.8)
	MH99TP2a	2469	Not yet analyzed
	MH99TP3a	2365	6.8(0.7)
<u>Stockton Flat (C)</u>	SG40a	2378	6.0(0.2)
	SG41a	2195	Not yet analyzed
	SG42a	2073	1.8(0.2)

Stockton Flat (Transect C) Three samples were collected along the fire road leading from Stockton Flat to Baldy Saddle. The helium ages for these samples are 1.8 – 6 Ma, spanning 300 m elevation.

Discussion: Helium ages obtained during 1999 are similar in range to those reported by Blythe et al. (in press) for the eastern Mt. Baldy and Sierra Madre Blocks. These thermotectonic blocks are among four that were defined on the basis of regional patterns in apatite fission track cooling ages (Tujunga, Western San Gabriel, Baldy and Sierra Madre). In general, cooling ages in the Tujunga, Western San Gabriel and western parts of the Sierra Madre blocks are much older than ages in the Baldy and eastern Sierra Madre blocks, reflecting the more recent distribution of bedrock uplift. However, the eastern limits of the Mt. Baldy and Sierra Madre blocks do not correspond to any internal faults, and cannot be well-determined from the thermochronometric data of Blythe et al. (in press).

The preliminary helium ages suggest that the Baldy and Sierra Madre blocks may terminate with the San Antonio Canyon fault. To the east of this fault, helium age-elevation relationships are significantly different than those observed to the west, suggesting the possibility of at least one additional thermotectonic block (called here the Cucamonga block). For example, helium ages of ~5 Ma are observed at the summits of Cucamonga Pk (2694 m) and Baldy (3070 m). The Baldy block has experienced approx. 400 m more uplift than that Cucamonga block since this time. Combining the new helium results along transect C (Stockton Flat) with those of Blythe et al., suggests that the north slopes of the San Gabriel Mountains were exhumed at a rate of approx. 0.3 mm/yr since 5 Ma, consistent with estimates reported by Blythe et al. (in press). The suggested Cucamonga block may, in turn be broken into two pieces via the Icehouse Canyon fault, across which different cooling age-elevation trends are observed (Figure 2).

Ongoing work: In order to better resolve the morphology of the Cucamonga block, samples will be collected along two additional transects (D & E, shown on Figure 1).

Transect D will extend down the San Antonio Canyon, to the suggested southern limit of the Baldy Block in order to extend the range of elevation available. Transect E will extend to the east of Icehouse Canyon saddle, along Lytle creek in order to obtain a third dimension in cooling ages. Apatite fission track ages will be obtained for all of the samples collected by A. Blythe.

Publications

Blythe, A.E., House, M.A., Spotila, J.A., Farley, K.A., Burbank, D.W., Strain partitioning and topographic response of fault blocks along the San Andreas fault, southern California, from apatite fission track, (U-Th)/He and DEM analyses, 9th Int. Conf. On Fission track Dating and Thermochronology, Geol. Soc. Of Australia Abstr. Series #58, p. 37, 2000.

References

Blythe, A.E., Burbank, D.W., Farley, K.A., Fielding, E.J., Structural and topographic evolution of the central Transverse Ranges, California, from apatite fission-track, U-Th/He and DEM analyses, Basin Research, in press.

Spotila, J.A., Farley, K.A., Sieh, K., Uplift and erosion of the San Bernadino Mountains associated with transpression along the San Andreas fault, California, as constrained by radiogenic helium thermochronometry, *Tectonics* 17, 360-378, 1998.

Wolf, R.A., Farley, K.A., Silver, L.T., Helium diffusion and low temperature thermochronometry of apatite, *Geochim. Cosmochim. Acta* 60, 4231-4240, 1996.

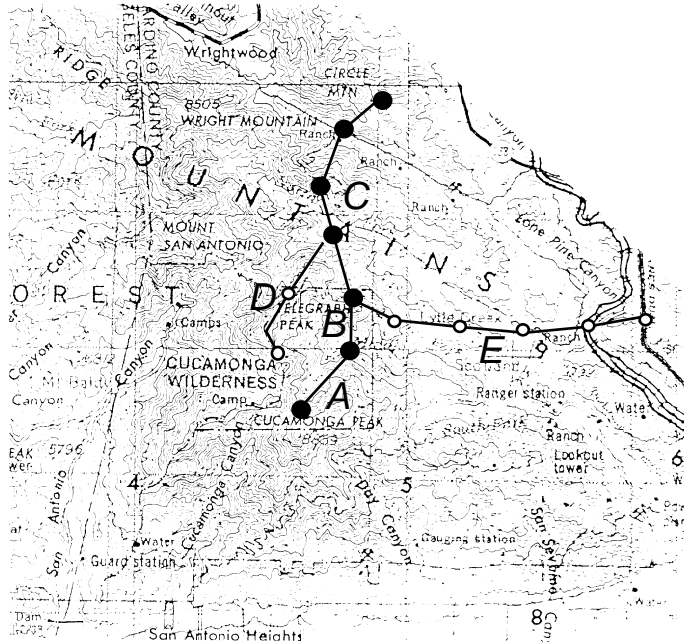


Figure 1. Sample transects in eastern San Gabriel Mountains. Transects follow trails in Cucamonga Pk. area. Filled circles indicate completed samples transects; open circles indicate future sites, subject to accessibility.

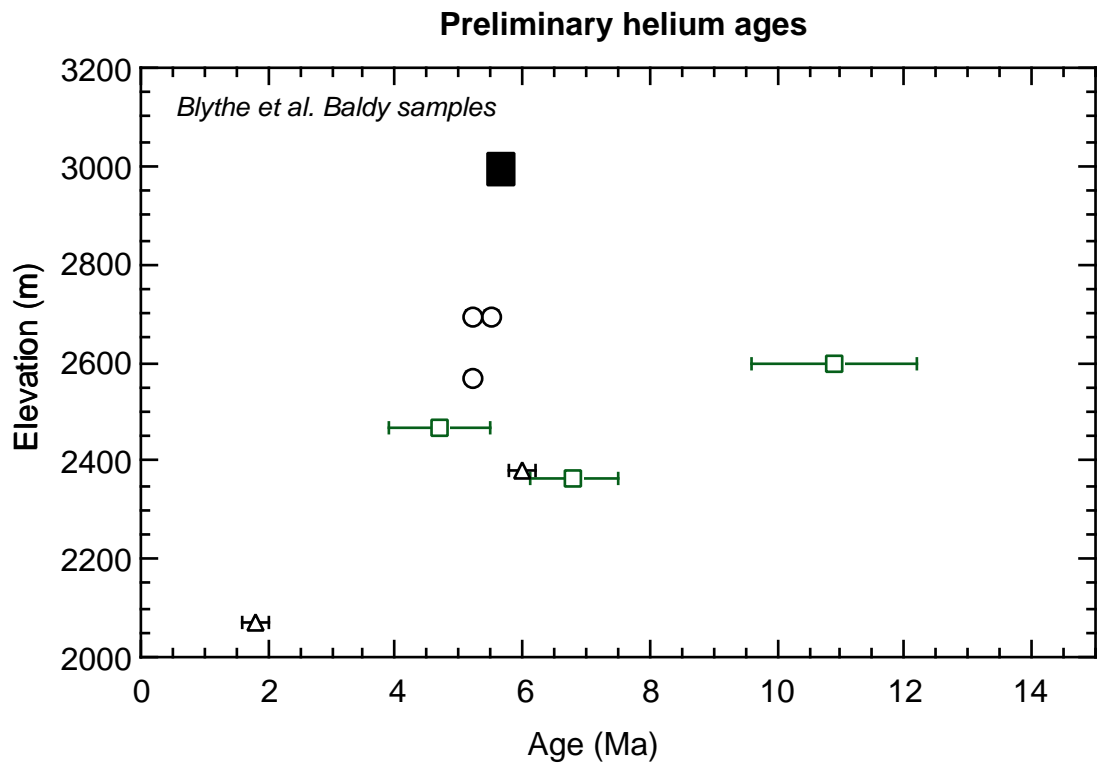


Figure 2. Preliminary helium ages from eastern San Gabriel Mtns. Ages are plotted vs elevation. Cucamonga Pk transect A shown by circles; Thunder Pk transect B shown by squares; Stockton flat transect C shown by triangles. Helium age for Baldy summit shown by filled square (Blythe et al., in press).

