Overview of Data Archive, Version 1, Little Devil's Postpile Project

National Science Foundation Project *"Collaborative Research: Little Devil's Postpile Revisited: Intercalibration of Thermochronometers Kinetics in a Contact Aureole,"* 2011-2015

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Project overview

The main goal of this collaborative project was to assess the relative performance of the main thermochronometers currently used in Earth sciences to determine lower-temperature temperature-time histories. We did this by studying the response of each dating system in a well-constrained "natural laboratory" located near Tuolumne Meadows in Yosemite National Park. At the Little Devil's Postpile locality, ~8 million years ago a small basalt intrusion delivered a sharp thermal pulse to the enclosing Cathedral Peak Granodiorite. This ~89 million-year-old granite contains a rich variety of the minerals most commonly used in thermochronology. Combining our measured ages with thermal models of heat transfer and such measurements as the subsurface geometry of the basalt intrusion and its intrusion temperature, we can assess the performance of the various interpretive and diffusion models used in thermochronology.

A major project result to date is that currently used kinetic models for helium diffusion in the minerals apatite and zircon, which incorporate the impacts on diffusion of radiation-damage accumulation, do very well at explaining the degree of age resetting at Little Devil's Postpile (see **Figure 1**). This reassuring result is important not only to the thermochronology community but also the broader spectrum of Earth scientists that use such data. We also found that K-feldspar observations interpreted using the multi-diffusion domain (MDD) model (**Figure 2**) were very consistent with the U-Th/He apatite and zircon ages: thermal models tuned to best fit the helium ages do a good independent job of predicting K-feldspar age spectra that match observations using the assumptions of the MDD model (**Figure 3**).

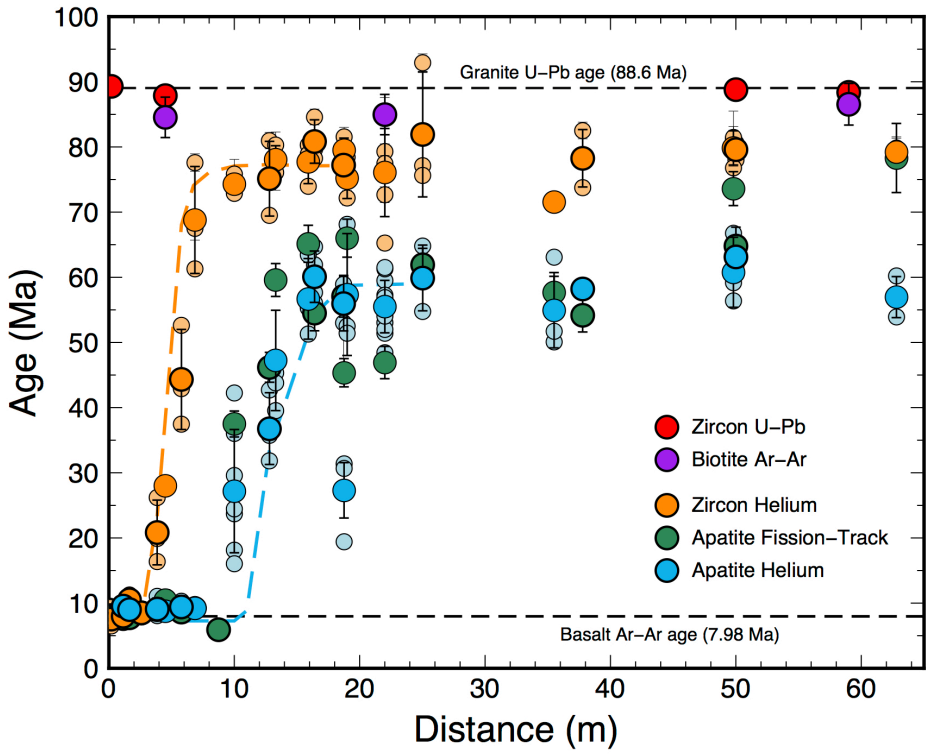

Figure 1. All mineral-age results from both transects extending away from the Little Devil's Postpile basalt intrusion. Larger symbols show mean sample ages and paler, smaller symbols show ages of individual aliquots for each sample. Orange and blue dashed lines show best-fit predictions for a simple conductive-only analytical thermal model, using radiation-damage models for the age predictions and the observed aliquot AHe and ZHe ages as the target. These thermal histories were used for prediction of K-feldspar age spectra (see **Figures 2 and 3**).

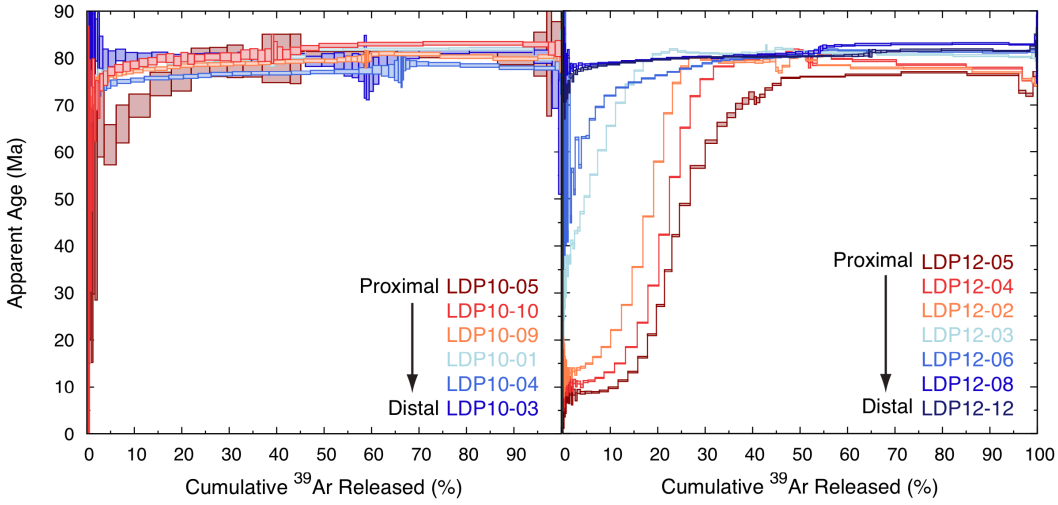

Figure 2. K-feldspar ^{40}Ar/^{39}Ar age spectra for transects LDP10 (left) and LDP12 (right).

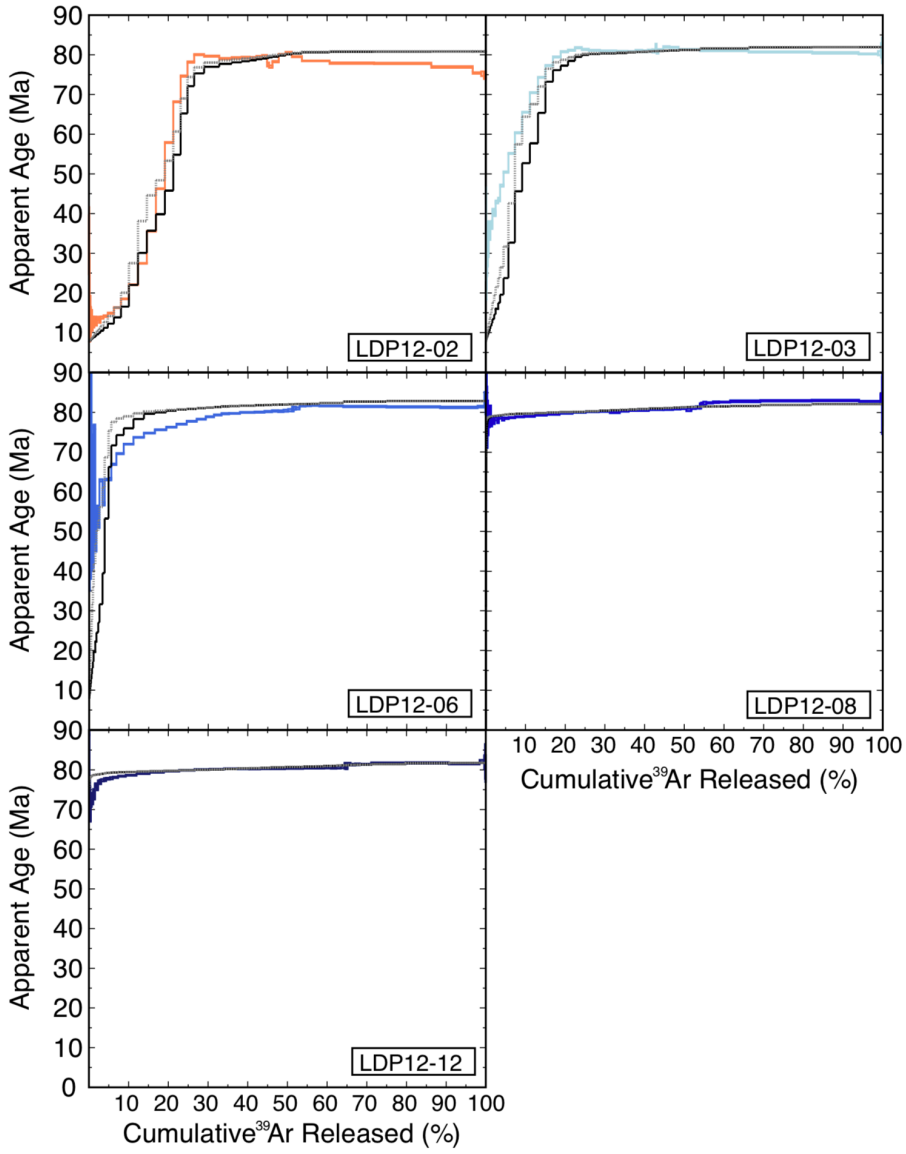

Figure 3. K-feldspar $^{40}Ar/^{39}Ar$ age spectra predicted for two thermal models. Observed spectra are colored as in **Figure 2.** Age spectra predicted from the model best fit to the zircon (U- Th)/He data are in black. Age spectra predicted from the model best fit just to the K-feldspar $^{40}Ar/^{39}Ar$ data are dashed.

Data and information for files archived at Harvard Dataverse site

Information files

LDP_project_and_file_overview.pdf – (this file) information and references relevant to the project that generated this dataset.

LDP_transect_information.pdf – information about the locations of the two sampling transects and their orientation. Images showing transect locations as well as the nature of the granodiorite-basalt contact.

LDP_analytical_methods.pdf – Summary of analytical methods used in gathering the data archived here.

Data files

LDP_basalt_geochemistry.xlsx – XRF geochemical analyses of two LDP basalt samples.

LDP_intrusion-age_summary.xlsx – Summary of LA/ICPMS U-Pb zircon, $^{40}Ar/^{39}Ar$ biotite and whole-rock, and AHe and ZHe reset ages, all relevant to determining the intrusion ages of the host Cathedral Hill Granodiorite and Little Devil's Postpile basalt.

LDP_sample-locations_2020.xlsx – samples locations along the two transects as well as information about the location of transects and their internal details.

LDP_10-and-12_AFT_summary.xlsx – abbreviated summary of apatite fission-track age results from both transects.

LDP_contact_AHe-ZHe.xlsx – Summary of reset U-Th/He apatite and zircon data from the southern contact of LDP.

LDP10_AHe-ZHe-The.xlsx – U-Th/He apatite, zircon , and titanite analytical data from the LDP10 transect.

LDP12_AHe-ZHe-The.xlsx – U-Th/He apatite, zircon , and titanite analytical data from the LDP12 transect.

Data files forthcoming in Version 2 (expected by January, 2021)

- K-feldspar $^{40}Ar/^{39}Ar$ analytical data
- Apatite $^{4}He/^{3}He$ analytical data
- Code and modeling support files for LDP thermal models

Reference and publications

Historical Context

Calk, L.C., and Naeser, C.W., 1973. Thermal effect of a basalt intrusion on fission tracks in quartz monzonite. Journal of Geology, v. 81, p. 189-198.

Publications referencing or using LDP data

Abbey, A.L., Randolph-Flagg, N.G., and Shuster, D.L., 2019. Isotopic constraints on fluid-rock interactions associated with the Little Devils Postpile magmatic intrusion, Yosemite National Park, CA. Abstract V34A-05 presented at 2019 Fall Meeting, American Geophysical Union, San Francisco, Calif., 11 December.

Schmidt, J.L., 2018. Revealing a Cenozoic history of landscape change and differential unroofing in the southeastern Lhasa block: Applications of thermochronometry along the Tibetan Plateau margin. Unpublished Ph.D. dissertation, Lehigh University, Bethlehem, PA, USA, 297 pp.

Schmidt, J., Zeitler, P.K., Ketcham, R.A., Reiners, P.W., Shuster, D.L., and Karlstrom, L., 2014. Little Devil's Postpile revisited: Behavior of multiple thermochronometers in a contact aureole. Abstract presented at the 14th International Conference on Thermochronology, Chamonix-Mont Blanc, France, 8-14 September.

David L. Shuster; Peter W. Reiners; Jennifer L. Schmidt; Peter K. Zeitler; Richard A. Ketcham; Leif Karlstrom, 2012. Intercalibration of multiple thermochonometric systems at the Little Devil's Postpile contact aureole. Abstract V23D-2867 presented at 2012 Fall Meeting, American Geophysical Union, San Francisco, Calif., 3-7 December.

Zeitler, P.K., Ketcham, R.A., Reiners, P.W., Schmidt, J.L., and Shuster, D., 2013. Thermal histories from thermochronology: where do we stand? Geological Society of America Abstracts with Programs, Vol. 45, No. 7, p. 223.