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Franklin & Marshall College

Kelly Erb
Keck Consortium Administrative Assistant

Diane Kadyk
Academic Department Coordinator
Department of Earth & Environment
Franklin & Marshall College

Keck Geology Consortium
Franklin & Marshall College
PO Box 3003, Lancaster PA 17604-3003
717 291-4132  keckgeology.org

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GEOLOGY OF THE HÖH SERH RANGE, MONGOLIAN ALTAI
Faculty: NICHOLAS E. BADER and ROBERT J. CARSON: Whitman College; A. BAYASGALAN: Mongolian University of Science and Technology; KURT L. FRANKEL: Georgia Institute of Technology; KARL W. WEGMANN: North Carolina State University

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Students: ALANA BARTOLAI: Macalester College; EMMA KRAVET and CONOR VEENMAN: Wesleyan University; RACHEL NEURATH: Smith College; JESSICA SCHECK: Bryn Mawr College; DAVID JAKIM: SUNY.

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NICHOLAS E. BADER and ROBERT J. CARSON: Whitman College
A. BAYASGALAN: Mongolian University of Science and Technology
KURT L. FRANKEL: Georgia Institute of Technology
KARL W. WEGMANN: North Carolina State University

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GANBAYAR RAGCHAASUREN: Mongolia University of Science and Technology

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Research Advisor: Sarah Titus
TSOLMON ADIYA: Mongolia University of Science and Technology

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**ANDREA SEYMOUR**: Whitman College
Research Advisors: Bob Carson and Nick Bader

**GALBADRAKH SUKHBAATAR**: Mongolia University of Science and Technology

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**KATHRYN LADIG**: Gustavus Adolphus College
Research Advisor: Laura Triplett

**ENKHBEI GANBOLD**: Mongolia University of Science and Technology

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**KELLY DUNDON**: Whitman College
Research Advisors: Bob Carson and Nick Bader

**ESUKHEI GANBOLD**: Mongolia University of Science and Technology

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**GIA MATZINGER**: Whitman College
Research Advisors: Bob Carson and Nick Bader

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**RYAN J. LEARY**: Whitman College
Research Advisor: Robert J. Carson

**TAMIR BATTOGTOKH**: Mongolia University of Science and Technology

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**GREG MORTKA**: Lehigh University
Research Advisor: David J. Anastasio

**NARANCHIMEG MERGEN**: Mongolia University of Science and Technology

RECONSTRUCTING LATE HOLOCENE CLIMATE THROUGH TREE-RING ANALYSIS OF SIBERIAN LARCH: ALTAI MOUNTAINS, WESTERN MONGOLIA

**BRITTANY GAUDETTE**: Mount Holyoke College
Research Advisors: Al Werner

**DELGERTSEGTSEG BURENDELGER**: Mongolia Univ. of Science and Technology

Visitors:
- Tsolman Amgaa: Mongolia University of Science and Technology
- Steven Boettcher: University of Bayreuth
- Laura Gregory: Oxford University
- Richard Walker: Oxford University

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Keck Geology Consortium
Franklin & Marshall College
PO Box 3003, Lancaster Pa, 17603
Keckgeology.org
INTRODUCTION

Right-lateral slip along northwest-trending ranges in western Mongolia is 10 mm/y due to the collision of India and Eurasia and extension from the Baikal rift system; this activity has resulted in 4 historic M>8 earthquakes in western Mongolia (Baljinnyam et al., 1993). The northwest-trending, right-lateral, oblique Höh Serh Fault (HSF), which accommodates a portion of this right-lateral slip, is exposed along the western edge of the Höh Serh range. We conducted a detailed survey on the Praying Mountain Fault Segment (PMFS), the 10-km segment of the HSF between Naran Khondii Valley in the north and Debris Flow Valley in the south (Fig. 1). We described and measured visible offsets along the PMFS in order to better understand its slip rate and mechanism of deformation and to quantify offset distances.

METHODS

After examining satellite imagery and conducting reconnaissance drives, we walked along the PMFS looking for signs of deformation, including breaks in slope on the mountain front, variation in vegetation, offset channels and alluvial fans, shutter ridges, changes in lithology, and fault fabrics. We measured offset in 23 locations. To measure vertical offset, we surveyed profiles perpendicular to the fault with a tape and clinometer (Fig. 2B). Lateral displacement, which we identified by offset drainages and shutter ridges, was measured along the strike of the PMFS with a tape and Brunton compass (Fig. 2D). We surveyed offset and fault features with a differential GPS in 27 locations. GIS was used to compile vertical and lateral displacement at various locations along the fault.

To estimate the timing of the last rupture along the PMFS, we compared the geomorphic expression of the fault exposures to other fault segments of known age in the Mongolian Altai (Walker et al., 2006). We combined this estimate with our measurements of horizontal and vertical offsets to calculate slip rate along the PMFS.

FAULT EXPRESSION

The average strike and dip of the PMFS is N 15-20° W, 80° E and its mean elevation is 2470 m (Fig. 1). Mean right-lateral offset of late Quaternary landforms is 31 +/- 26 m. Mean vertical offset is 3 +/- 3 m, with the segment's maximum vertical offset of 12 m between Naran Khondii Valley and Rhyolite Valley (Table 1).

Measured lateral offsets vary along the PMFS (Table 1). This variability is unsurprising for four reasons. First, not all offset features are the same age; an old stream that experienced more fault ruptures should be offset more than a younger stream. Second, differential stress along the fault generates local differences in thrust or slip amounts. Third, a thrust fault does not always continuously intercept the surface; variation in the extent that it intercepts the surface causes variation in its geomorphic expression. Fourth, soils vary in their ability to preserve fault scarps, and in some places scree has covered the rupture site; thus post-movement erosive processes have dulled the fault's geomorphic expression and made offset impossible to observe in many places.

Shallow, discontinuous normal faults are found at a number of localities, such as 25 m above the thrust...
fault at point 1 on Figure 1. Two thrust faults, 113 m apart, extend from point C to just after point D (Fig. 1). South of Rhyolite Valley, burrows and a break in slope indicate the lower fault. Three generations of terraces in Rhyolite valley and distinct notches in the south wall of Rhyolite Valley (Fig. 2A) indicate the HSF's reverse component. A ridge, point E and F (Fig. 1), 10° off strike is approximately 120 meters long. At the south end of the ridge is a 34 m by 32 m depression, at point G. This anomalous morphology may be related to a step in the fault.

En echelon tension gashes cross the Yamaat Valley terminal moraine (Fig. 2C). Here, the fault strikes N

<table>
<thead>
<tr>
<th>Reference Points</th>
<th>Approximate Fault Elevation</th>
<th>Description of movement and/or feature</th>
<th>Lateral offset (m)</th>
<th>Vertical offset (m)</th>
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Table 1: Measured offsets along the PMFS. Points correspond with points in Figure 1.

15°. The orientation of the tension gashes indicates right-lateral motion. Dextral and reverse movement from Yamaat Valley to Debris Flow Valley is apparent in the satellite images. Baljinnyam et al. (1993) suggested that tension gashes are a common rupture style in the Altai and that their presence is preserved and further expanded by freeze-thaw conditions. As the tension gashes at Yamaat valley are at between 2420 m and 2480 m elevation, less than 2 km below the extant ice cap, freeze-thaw mechanisms are plausible.

Flat benches, parallel to the PMFS, are prominent immediately north of Debris Flow valley, at approximately 2500 m elevation. Here, vague fault scarps, dipping nearly vertical are discernable.
TIMING OF MOTION

Slow erosion rates in the Altai enable rupture scarps to be preserved for thousands of years (Walker et al., 2006). Cosmogenic dates indicate that the Deluun Debris Flow is around 13 ka; since the debris flow crosscuts the PMFS, the last rupture occurred >13 ka. Lake Valley Offset, a segment of the HSF to the north, last ruptured around 15 ka (Sprajcar, this volume). In comparison with the Lake Valley Offset, the PMFS rupture is poorly preserved; we thus estimate that the last movement occurred more than 15 ka.

Three strath terraces in Naran Khondii Valley indicate three separate fault ruptures. The uplift of the mountains during each rupture caused the river to downcut at the mountain front, resulting in the formation of strath terraces downstream that project into nickpoints upstream.
CONCLUSIONS

Steep mountain fronts along the PMFS make vertical offset apparent. The dextral component of the PMFS was confirmed by multiple offset drainages. Average strike along the PMFS is N 20° W, which is roughly perpendicular to the direction of convergence between India and Eurasia. Our principal results are consistent with Baljinnyam et al. (1993) and Cunningham et al. (2003), who concluded that the HSF is a right-lateral fault with a strong reverse component.

The consistent vertical offset throughout the segment (Table 1) is in agreement with previous assessments of western Mongolia’s oblique faults: the reverse component of the HSF uplifted the Höh Serh Range and tilted it eastward.

Baljinnyam et al. (1993) calculated that lateral offset for the for the Western Altai is (6-10 mm y-1). Our estimation of lateral slip along the HSF (1 and 2 mm y-1 and vertical slip is about 0.5 mm y-1) is consistent this Baljinnyam calculation because the HSF accommodates only a portion of the total Altai strain.

REFERENCES

