THE GEOLOGICAL SOCIETY OF AMERICA
Thompson FIELD FORUMS
REPORT

Catastrophic Mega-Scale Landslide Failure of Large Volcanic Fields

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Cedar City and Bryce Canyon City, Utah, USA

CONVENERS

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FIELD TRIPS AND ANALYSIS

This six-day Thompson Field Forum investigated the concept of exceptionally large catastrophic collapse of volcanic fields using the distinguishing features of the newly discovered Markagunt (MGS) and Sevier (SGS) gravity slides, Marysvale volcanic field, southwest Utah, USA. Large landslides are known from hundreds of volcanoes and increasing numbers of laccoliths around the world, yet the mega-scale failure of volcanic fields themselves, producing gravity slide structures so large that they blur the boundary between gravitational and tectonic processes, has not received widespread attention. This was a transformative week of (1) redefining the physical limits of what is possible; (2) investigating evidence—on the outcrop—to identify unique characteristics of structures and deposits indicative of mega-slide deformation and of fast versus slow processes; and (3) planning for future collaborative studies.

First, some background. The MGS and SGS exhibit the full range of structural features commonly seen in modern landslides, but on a gigantic scale; they are among Earth's largest terrestrial landslides. The MGS remained undiscovered for so long precisely because of its gigantic size (>5000 km^2, >95 km long, >35 km runout, estimated volume 3000 km^3 [dimensions revised from D.B. Hacker et al., 2014, *Geology*, v. 42, no. 11, p. 943–946]) and its initially confusing mix of extensional, translational, and compressional structures overprinted by post-MGS basin-range tectonism. In comparison, the 1980 Mount St. Helens debris avalanche was only about 3 km^3. Preliminary mapping of the SGS, discovered in 2015, shows it to be smaller (likely at least 1500 km^2 in size) and slightly older than the MGS. Both slides are composed of large contiguous sheets of andesitic lava flows, volcaniclastic rocks, and intertonguing ash-flow tuffs that record southward catastrophic transport of the southern flank of the Oligocene to Miocene Marysvale volcanic field, preceded by gravitational spreading on the Paunsaugunt thrust fault system. MGS emplacement is currently constrained between 22 to 21 Ma, whereas SGS emplacement is between 25 to 23 Ma. That features as large as the MGS and SGS can remain undetected despite decades of geologic mapping and research in a well-exposed area suggests to us that other volcanic fields around the world may hold evidence of as-yet-undiscovered exceptionally large gravity slides.

This field forum brought together 27 participants, including nine students, who represented disciplines including rock mechanics, landslides, volcanology, petrography, paleomagnetism, sedimentology, isotope geochemistry, structure, and tectonics. We began the forum with a half-day meeting to introduce the MGS and SGS and hear participant research presentations on their relevant interests, then spent five days viewing and discussing exceptionally instructive outcrops. The meeting concluded with a session that summarized the group's findings and planned for collaborative research, student involvement, and funding opportunities. In early 2018, the conveners will submit a field guide and participant abstracts for publication in the GSA Field Guide series.

Using the MGS and SGS as examples, the conference emphasized the following:

- Different lines of evidence diagnostic of large to small catastrophic gravity slides;
- Cross-disciplinary assessment of extreme deformation recorded by basal layers and associated injectites (clastic dikes), ultracataclasite shear zones, pseudotachylyte, fragmented clasts, and main and sidewall breakaways;
- Fabrics and rock types developed by rheomorphic versus tectonic versus debris-avalanche modes of emplacement;
- Factors contributing to volcanic landslide initiation and transport—why and how did these slides happen?;
- The role of magmatic intrusions in inflation of volcanic fields and slope destabilization;
- Gravitational basement spreading of volcanic fields prior to catastrophic failure;

- Relationship to other large landslides and volcanic provinces throughout the world and on other planets;
- Understanding paleoclimate and its relationship to deeply weathered volcaniclastic strata at the base of the volcanic field; and
- Public education opportunities highlighting unique features of the slides and evolution of the Marysvale volcanic field, which are adjacent to several of Utah's national and state parks and monuments.

Importantly, there was significant debate about structures and features diagnostic of catastrophic failure versus those produced by (1) slow, episodic tectonic processes such as low-angle, non-rooted or rooted normal faults; or (2) volcanic processes, such as those that produce autobreccia—distinctions that are critical in identifying mega-scale landslides in volcanic fields elsewhere. The MGS and SGS provide significant research opportunities on these and other questions. Already, several student theses are under way, as is preliminary lab work to support future funding proposals.

Participants gathered at the base of the 22-Ma Harmony Hills Tuff, one of the regionally extensive ash-flow tuffs that constrain emplacement parameters and timing of the MGS and SGS. From left to right: Shannon Hunter, Bill Lund, Chris Rowan, Julia Morgan, Grant Willis, Nic Barth, Lee Siebert, Jay Melosh, Eric Ferré, Bob Biek, Kevin Rafferty, Sam Thiele, Mike Hozik, Mark Anders, Zach Smith, Ashley Griffith, Scott Giorgis, Majie Fan, Troy Barber, Melanie Ray, Jeff Keith, Dave Malone, Pete Rowley, Mike Braunagel, David Hacker, and Collin Jensen (Amy Hughes is not pictured). Photo courtesy Lance Weaver, Utah Geological Survey.

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