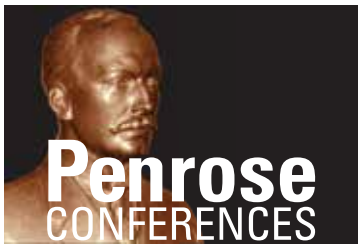

THE GEOLOGICAL SOCIETY OF AMERICA

Penrose Conference Report

Layered Mafic Intrusions and Associated Economic Deposits

Red Lodge, Montana, USA, 8–12 August 2016

CONVENERS

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INTRODUCTION

Layered mafic intrusions (LMI) play a central role in our understanding of magmatic systems. They also represent one of the fundamental modes of magma transfer from the upper mantle to the crust. These magmatic systems formed throughout geologic time from the Archean (e.g., Stillwater Complex) to the Paleogene (e.g., Skaergaard Complex) on all five continents. As many of the best-studied layered intrusions are associated with Large Igneous Provinces, they are largely independent from tectonic processes at plate boundaries. Layered intrusions have generated significant historic interest from the igneous petrology and geochemistry communities because they lie at the heart of some of the most fundamental petrologic precepts, such as fractional crystallization and Bowen's reaction series. These intrusions also host first-class economic deposits of platinum group elements (PGE), chrome, nickel titanium, and vanadium around the world. As an illustration of how unique and important these environments are, it is worth highlighting that the Bushveld Complex (South Africa) hosts >75% of the world's exploited platinum. The Stillwater Complex also hosts significant economic quantities of these precious metals, at even higher grades (i.e., 18 ppm Pt+Pd) than the Bushveld, so it is an important location for understanding ore-forming processes. In general, it is the combination of the industrial and scientific relevance of layered intrusions that has ensured support for research on these intrusions for the past six decades. Despite the large volume of literature dedicated to layered intrusions, advances in various subdisciplines are somewhat scattered, and there is a need for synthesis of the past 20 years of research as well as an urgent need to define the new scientific challenges that the broad community and graduate students should focus on. The Stillwater Complex is an ideal setting in which to consider these challenges, as it combines a rich tradition of petrological research with active economic interests in a relatively easily accessible location. More simply, it is one of the most important layered intrusions on Earth, in terms of historical study and quality of exposure.

The Geological Society of America Foundation, the National Science Foundation Petrology and Geochemistry Program, the U.S. Geological Survey Mineral Resources Program, the Rocky Mountain Association of Geologists Foundation, and the Stillwater Mining Company Foundation jointly sponsored this Penrose Conference.

The conference, held at the Rock Creek Resort in Red Lodge, Montana, USA, from 8 August through 12 August 2016, gathered an impressive array of 58 experts and six industry delegates from Taiwan, Germany, the UK, Canada, South Africa, and the U.S.

PRESENTATIONS AND FIELD TRIP

Participants met in session, exchanged new results, discussed critical scientific questions, and engaged with one another on the outcrops of the Stillwater Complex during two days of geological excursions led by Alan Boudreau and Mike Zientek on the Stillwater Complex.

The major aims of the conference were to define the critical scientific questions that the community will need to address in the next decade, to foster collaboration with industrial partners, and to promote exchange between the generation of senior scientists and younger academics. Thirteen graduate students (nine of whom were women) and seven early-career scientists (four of whom were women) were supported through the generous donations of our sponsors. The format of the discussions actively promoted the intellectual contribution of younger scientists.

The scientific party collectively defined the following key questions:

- What are the timescales of emplacement and cooling of LMI?
- What is the physical nature of a magma chamber?
- Have large volume mafic magma chambers ever existed?
- How do monomineralic layers form in LMI?
- How much crustal contamination occurs in LMI magmatism?
- In what tectonic settings are LMI likely to form?

- What can we learn from the material sciences about the cooling and solidification of layered cumulates?

The participants also agreed on a number of collaborative initiatives, including a Facebook page (https://www.facebook.com/layeredmaficintrusions/photos?ref=page_internal); an International LMI working group, including several national correspondents; a forthcoming Wager Symposium in 2018; and a large-scale collaborative research proposal focusing on graduate research to be submitted to the National Science Foundation in 2017.

The abstracts of presentations are available at **www.geosociety.org/penrose/16montana.htm.**

Participants: Raquel Alonso-Perez, Lew Ashwal, Jean Bédard, Alan Boudreau, John Boyd, Kevin Butak, Jeff Chaumba, Mike Cheadle, Gilbert Ching, June Cho, Konrad Chrzastowski, Tiffany Cummings, Jim Dahy, James Day, Mat Dunlop, Sabastien Dyer, Eric Ferré, Caroll Finn, Anais Fourny, Jeff Gee, Ennis Geragthy, Allen Glazner, Alex Hammerstrom, Adriana Heimann Rios, Luke Hepworth, Paul Holick, Marian Holness, Victoria Honour, Jeff Hughes, Emma Hunt, Chris Jenkins, Kate Jillings, Felix Kaufmann, Mike Koski, Rais Latypov, Nivea Magalhaes, Rick Marquard, Nichole Moerhuis, Ria Mukherjee, James Mungall, Brian O'Driscoll, Amy Parker, Heather Parks, Mike Pasecznyk, Steven Prevec, Ed Ripley, Jake Setera, Greg Shellnutt, Josh Smith, LeeAnn Srogi, Ilya Veksler, Tom Ver Hoeve, Zoja Vukmanovic, Corey Wall, Laurene-Marie Wavrant, Sue Webb, Ben Wermette, Lauretta Yantis, and Mike Zientek.