The Roots of a Flood Basalt Province: Expedition to Antarctica

Jean H. Bédard
Natural Resources Canada, Québec

In January 2005, I participated in an Antarctic field mapping workshop with a group of researchers under the leadership of Bruce Marsh (Johns Hopkins University), who had obtained a generous grant from the National Science Foundation (Office of Polar Programs, Geology and Geophysics) covering all field and travel expenses. The focus was the plumbing system feeding the continental flood basalts that erupted when the South Atlantic Ocean opened 185 million years ago (Kirkpatrick Basalts, Ferrar Dolerites, Dufek Intrusion). Flood basalts are important features of the geological record, and their emplacement is one of the mechanisms proposed for mass extinction. The subvolcanic intrusions that feed flood basalts are also important sources of nickel and platinum-group elements (e.g. Noril'sk). However, despite their importance, many issues about the genesis of cumulate rocks remain unresolved. The origin of cumulate rocks being one of my principal interests, the trip prospectus, published in *EOS*, attracted my attention. With my employer's blessing I applied, and was very pleased to be among those selected for the workshop.

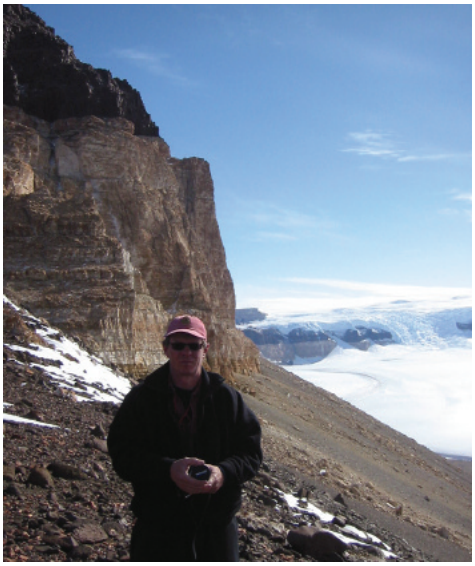
Dais intrusion, Basement sill, ~400 m thick. The pale material at the summit is Precambrian basement. Note the pale subhorizontal layers, which correspond to feldspar-enriched cumulates. In the foreground, orthopyroxenitic cumulates are sculpted by the wind.

The workshop was to target the mechanics of sill emplacement and the diversity of magma differentiation mechanisms, including crystal transport and sorting, deposition, postcumulus melt transfer, and assimilation of wall-rocks. The plumbing system of the Jurassic flood basalts is extraordinarily well preserved and exposed in the Dry Valleys of Antarctica (Marsh 2004). Lavas, dikes, and chilled margins contain microphenocrysts that can serve as points of comparison with the cumulate rocks occurring in the lowermost of three feeder sills (300–500 m thick), in which the earliest stages of cumulate formation and maturation are recorded. In contrast, the long cooling times of large layered intrusions like the Bushveld Complex allow extensive postcumulus textural and chemical reequilibration, which largely obliterates the evidence of the early processes, making it difficult to decipher how cumulate rocks and associated ore deposits form.

Group photo taken at McMurdo Station. Front row (L to R): Andrew Feustel, Dennis Geist, Tom Fleming, Alan Boudreau, Dave Elliott, Jill van Tongeren, Justin Durrell, Amanda Charrier. 2nd row: Jennifer Cooper, Ron Fodor, Scott Paterson, Ed Mathez, Jon Davidson, Sam Mukasa, Dougal Jerram, Taber Hersum. 3rd row: Karen Harpp, Jean Bédard, Michael Garcia, Dick Naslund, Adam Simon, Bruce Marsh. Not present: George Bergantz, Stu McCallum, Michael Manga, Simon Katterhorn.

Travel to Antarctica requires an intensive medical screening process, since evacuation is expensive and can be subject to long delays because of the weather. Extra-cold-weather gear is issued at the efficient US Antarctic Program's clothing distribution centre in Christchurch, New Zealand. Our first attempt to reach "The Ice" aboard a US Military Air Command C-141 Starlifter failed due to inclement weather. A frustrating week of postponements followed, with a nightly 3 a.m. knock on the door of the "Bed and Breakfast." The refrain of "24-hour delay" was greeted by curses and groans by those of us with tight schedules.

Finally, the weather cleared, and after an uncomfortable eight-hour flight, we were sitting on the Ross Ice Shelf, where McMurdo Station is situated, looking at the smoking cone of Mount Erebus, an active alkaline volcano forming the spine of Ross Island. McMurdo (or Club Mac, as some call it) is the main US base, and its population swells from about 250 in winter to over 1000 scientists and workers in the austral summer. McMurdo is situated at approximately 78°S, and in January there are 24 hours of sunshine, which is somewhat disorienting when leaving the pub at midnight. A lounge provided in each block has all the amenities of home, including satellite TV, pool tables, washing machines, etc. Food is served in a huge cafeteria-style galley. There are a gym and three bars—one for beer-drinking smokers, one for beer-drinking non-smokers, and a café–wine bar for effete intellectuals. Most importantly, the station boasts a superbly equipped laboratory. McMurdo is a veritable hive of activity in the summer as plane-loads of scientists (known as "beakers") fly in two or three times a week. Helos (helicopters) are constantly taking off and landing, and in good weather, US and NZ Hercules transports take off a dozen times a day to ferry fuel down to the Pole.



The author in front of the Beacon sandstone at the head of Taylor Glacier. The icecap is visible behind the icefalls.

The first item on the agenda upon our arrival was an intensive cold-weather survival course, which included a night out in a Quonzie/Igloo. At –5°C, the weather was mild compared to what I left behind in Canada (–30). After "graduating" we were authorized for deployment to our Dry Valleys camp. The Dry Valleys receive essentially no precipitation, and the principal geomorphic process is the wind. Wind-blown dust carves the cliffs into weird, elephant-graveyard-like ventifacts.

The environmental rules in Antarctica are very strict, and no waste of any kind is allowed to touch the ground. This means that

2006

January 5–6 Mineralogical Society Winter Meeting – Micro- and Nano-geosciences: Advances and Applications, Bath Spa University, Bath, UK. Details: e-mail: m.lee@earthsci.gla.ac.uk; web page: www.minersoc.org/pages/meetings/Bath2006.htm

January 5–6 Mineral Deposits Studies Group (MDSG) 29th Annual Winter Meeting, London, UK. Details: John Chapman, e-mail john.chapman@imperial.ac.uk; web page: www.huxley.ic.ac.uk/research/Basins/MDSG

January 11–13 Workshop on Nanoscale Processes in the Earth and Planetary Sciences (NanoPEPS), Alberquerque, NM, USA. Details: Adrian Brearley, University of New Mexico; e-mail: brearley@unm.edu; web page: http://epswww.unm.edu/nanopeps

January 23–27 Cities on Volcanoes 4, Quito, Ecuador. Details: tel.: 593-2-222-5655; fax: 593-2-256-7847; e-mail: mhall@igepn.edu.ec or citiesonvolcanoes4@igepn.edu.ec; website: www.citiesonvolcanoes4.com

March 3–6 Annual Meeting of the DGK (Deutschen Gesellschaft für Kristallographie), Freiburg/Breisgau, Germany. Website: www.dgk-2006.de

March 5–8 Earth and Space 2006, Houston, TX, USA. Web page: www.asce.org/conferences/space06/index.cfm

March 12–16 The Minerals, Metals & Materials Society Annual Meeting & Exhibition, San Antonio, TX, USA. Contact: TMS Meetings Services, 184 Thorn Hill Road, Warrendale, PA 15086, USA. Tel.: 724-776-9000, ext. 243; e-mail: mtgserv@ tms.org; web page: www.tms.org/Meetings/Annual-06/AnnMtg06Home.html

March 13–17 37th Lunar and Planetary Sciences Conference (LPSC), League City, Texas, USA. Details: Publications and Program Services Department, Lunar and Planetary Institute, 3600 Bay Area Blvd., Houston, TX 77058-1113. Tel.: 281-486-2188; fax: 281-486-2125; e-mail: cloud@lpi.usra.edu

March 26–29 18th Industrial Minerals International Congress & Exhibition, San Francisco, CA, USA. Details: Metal Bulletin Plc, 16 Lower Marsh, London, SE1 7RJ, UK. Tel.: + 44 (0) 20 7827 9977; fax: + 44 (0) 20 7827 5292; e-mail: conferences@indmin.com; web page: http://www.indmin.com/conf_details.asp?ref=C046

March 26–30 American Chemical Society 231st Annual Meeting, Atlanta, GA, USA. Details: ACS Meetings, 1155, 16th Street NW, Washington, DC 20036-4899, USA. Tel.: 202-872-4396; fax: 202-872-6128; e-mail: natlmtgs@acs.org; web page: www.chemistry.org/portal/a/c/s/1/acsdisplay.html?DOC=meetings%5catlanta2006%5chome.html

March 27–29 Society for Mining, Metallurgy and Exploration (SME) Annual Meeting & Exhibit, St. Louis, Missouri, USA. Web page: www.smenet.org/meetings/AnnualMeeting2006/index.cfm

April 1–3 Volcanic and Magmatic Studies Group: LASI II – Physical Geology of Subvolcanic Systems: Laccoliths, Sills and Dykes, Isle of Skye, UK. Details: Ken Thomson or Nick Petford; e-mail: k.thomson@bham.ac.uk or n.pet@kingston.ac.uk; web page: www.gees.bham.ac.uk/LASI_web_3.htm

April 2–7 European Geosciences Union (EGU) General Assembly, Vienna, Austria. Details: EGU Office, Max-Planck-Str. 13, 37191 Katlenburg-Lindau, Germany. Tel.: +49-5556-1440; fax: +49-5556-4709; e-mail: egu@copernicus. org; web page: www.copernicus.org/EGU/egu_info/prevga.html

April 3–7 Backbone of the Americas–Patagonia to Alaska, Mendoza, Argentina. Details: Suzanne M. Kay or Victor Ramos; e-mail: smk16@cornell.edu or andes@gl.fcen.uba.ar; web page: www.geosociety.org/meetings/06boa/index.htm

April 9–12 American Association of Petroleum Geologists and Society for Sedimentary Geology (SEPM) Joint Annual Meeting, Houston, Texas, USA. Details: AAPG Conventions Department, PO Box 979, 1444 S. Boulder Avenue, Tulsa, OK 74101-0979, USA. Tel.: 918-560-2679; fax: 918-560-2684; e-mail: convene@aapg.org; web page: http://www.aapg.org/houston/index.cfm

April 17–21 Materials Research Society 2006 Spring Meeting, San Francisco, CA, USA. Tel.: 724-779-3003; fax: 724-779-8313; e-mail: info@mrs.org; web page: www.mrs.org/meetings/future_meetings.html

May 13–14 Melt Inclusions in Plutonic Systems: Mineralogical Association of Canada Short Course, Montreal, Canada. Details: Jim Webster; e-mail: jdw@amnh.org; web page: www.mineralogicalassociation.ca/index.php?p=120

May 14–16 Society of Economic Geologists 2006 Conference, Keystone, Colorado, USA. Tel.: 720-981-7882; fax: 720-981-7874; e-mail: seg2006@seg-web.org; website: www.seg2006.org

May 14–17 Planet Earth in Montreal: Geological Association of Canada and Mineralogical Association of Canada Joint Annual Meeting, Montreal, Canada. E-mail: gacmac2006@uqam.ca, web page: www.gacmac2006.ca

May 14–18 IAVCEI 2006: Continental Basalt Volcanism, Guangzhou, China. Details: Dr. Yigang Xu, Guangzhou Institute of Geochemistry, Chinese Academy of Sciences, P.O. Box 1131, 510640 Wushan Guangzhou, PR China. E-mail: xlhuang@gig.ac.cn; website: www.iavcei2006.org

May 16–20 Geofluids V, the Fifth International Conference on Fluid Evolution, Migration and Interaction in Sedimentary Basins and Orogenic Belts, Windsor, Ontario, Canada. E-mail: geofluids5@uwindsor.ca; website: www.geofluids5.org

May 23–26 2006 AGU Joint Assembly, Baltimore, Maryland, USA. Details: AGU Meetings Department, 2000 Florida Avenue NW, Washington, DC 20009 USA. Tel.: 800-966-2481, ext. 333 or 202-777-7330; fax: 202-328-0566; e-mail: ja-help@agu.org (subject: 2006 Joint Assembly); web page: http://www.agu.org/meetings/ja06

June 3–7 Joint 43rd Annual Meeting of The Clay Minerals Society and Annual Meeting of the Groupe Français des Argiles (French Clay Group), Oléron Island, France. Details: Sabine Petit, Université de Poitiers, CNRS Hydr'ASA, 40 Av. du Recteur Pineau, 86022 Poitiers Cedex, France. Tel.: 33-(0)5-49-45-37-56; e-mail: sabine.petit@hydrasa.univ-poitiers.fr; web page: www.clays.org or www.c2s-organisation.com/gfacms06

June 12–17 Walker Memorial Meeting: Advances in Volcanology, Volcanic and Magmatic Studies Group, Mineralogical Society, Reykholt, Iceland. Details: Stephen.self@open.ac.uk; web page: www2.norvol.hi.is/page/nordvulk_walker

June 25–29 First International Congress on Ceramics, Toronto, Canada. Details: Dr. Stephen Freiman, tel.: 301-975-5658 or Mark Mecklenborg, ACerS Staff Director, Technical Publications and Meetings, tel.: 614-794-5829. E-mail: stephen.freiman@nist.gov or mmecklenborg@ceramics.org; web page: www.ceramics.org/?target=/meetings/icc/home.asp

July 2–6 Australian Earth Sciences Convention, Melbourne, Australia. Details: Australian Earth Sciences Convention, c/o The Meeting Planners, 91-97 Islington Street, Collingwood, Victoria, Australia 3066; tel.: +61 3 9417 0888; fax: +61 3 9417 0899; e-mail: earth2006@meetingplanners.com.au; website: www.earth2006.org.au

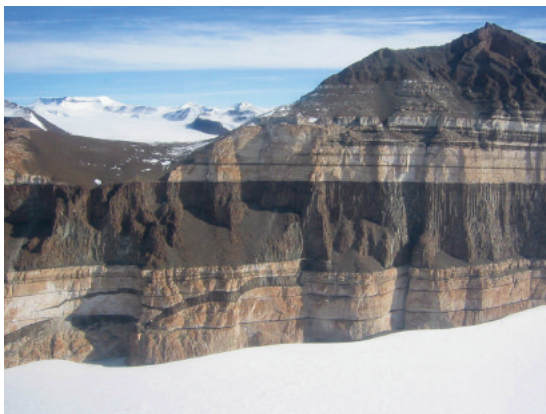
July 10–12 Granulite and Granulites 2006, University of Brasilia, Brazil. Details: Michael Brown, e-mail: mbrown@geol.umd.edu. Web page: www.geol.umd.edu/pages/meetings/granulites2006.htm

July 16–23 Zeolite '06, Socorro, New Mexico, USA. Details: Dr. Robert Bowman; e-mail: bowman@nmt.edu; web page: http://cms.lanl.gov/zeo2006.html

we had to carry around a P-bottle all day, and at the end of the day empty it into a big orange P-drum. Our camp in Bull Pass was a neat arrangement of tents clustered around a main expedition tent that served as our kitchen and lounge. Unfortunately, we had to rotate between the camp and Club Mac, since only half of our team could stay in camp at any one time in order to minimize our environmental footprint. This meant that the other half of the crew had to fly out each morning and return on a flight at night. On one occasion we had three successive days when we rose at 6 a.m. to get our helo and were picked up to return to McMurdo after 11 p.m. Returning to base after midnight resulted in 18-hour work days and a little more than four hours sleep on those nights. The nature of the schedule led me to wonder whether the two hours flying time and the multiple landings were more detrimental to the ecosystem than having three extra tents on site. Life in camp was definitely more relaxed, since we were able to rise at a slothful 7 a.m. and walk to a well-exposed section.

The research crew was a multinational herd of cats, and many lively debates took place on the outcrop. Discussion concerned mechanisms of layering development, and post-cumulus melt transfer within the orthopyroxenite zone of the Basement Sill. Several days were occupied by excursions guided by Bruce Marsh and his students. Following these, we broke up into thematic subgroups. Finally, after almost two weeks in the field, it was time to go back to the real world. All in all, the trip was a grand success and promises to be seminal with regard to the development of new concepts of magma chamber evolution. A special session is planned for the San Francisco AGU meeting (session V28: Magmatic Systems: An Antarctic Perspective).

The ESS Contribution number for this paper is: 2005390.



Ferrar dolerite sill, Finger Mountain, injected into Jurassic Beacon metasediments. Note the apophysis to sill.

Marsh BA (2004) Magmatic mush column Rosetta Stone: The McMurdo Dry Valleys of Antarctica. EOS Transactions AGU 85(47): 497