

To my arrow...

Jake Ross  
*New Mexico Institute of Mining and Technology*  
*April, 2014*

**Geochronology of Southern McMurdo Sound and development  
of a micro laser furnace**

by

Jake Ross

Submitted in Partial Fulfillment  
of the Requirements for the Degree of  
Doctor of Philosophy

New Mexico Institute of Mining and Technology  
Socorro, New Mexico

April, 2014

## **ABSTRACT**

Minna Bluff has been a significant topographic barrier to the flow of the Ross Ice Shelf since the mid-Miocene. Detailed Ar-Ar analyses of kaersutite and sanidine phenocrysts, and groundmass concentrates from volcanic units indicate an overall west to east progression of volcanic activity. Eruptions of basaltic to intermediate lavas, domes, and scoria cones started at 12 Ma in at what is now the eastern most point of Minna Bluff, Minna Hook. Activity was centered in this area for 4 Ma, constructing a pre-Minna Bluff island. Multiple glacial unconformities found at Minna Hook suggest repeated interaction with large warm-based, erosive ice sheets. Activity migrated westward from Minna Bluff Island at 7-8 Ma closing the gap created by the island and the mainland. Significant edifice construction continued until 4-5 Ma with sporadic and parasitic scoria cone eruptions, possibly associated with Mt. Discovery activity, continuing until 2 Ma.

The orientations of Minna Bluffs two major axes are strongly controlled by regional tectonic features. Minna Bluffs E-W axis, McIntosh Cliffs, is sub-parallel to the Radial Lineament and the N-S axis, Minna Hook, appears as extension of faulting bounding the Terror Rift. The constructional evolution of the 70km long volcanic complex has an important role in interpreting the climate signals recovered by the ANDRILL Project. Minna Bluff influenced the material delivered to the AND-1B drill site (ANDRILL MIS 2006-2007) in three critical ways: 1) Minna Bluff diverted upstream material, 2) provided

a pinning and stabilizing point for the Ross Ice Shelf, possible controlling the calving line prior to the emergence of Ross Island, and 3) was a significant source of fresh volcanic material throughout much of the period recovered by ANDRILL MIS. For example, a kaersutite-bearing clast recovered from 822.78 mbsf in AND-1B yielded an age of 8.530.51 Ma, and was likely derived from Minna Bluff. The results from this study can be incorporated into detailed glacier and ice-sheet models of the McMurdo Sound region, a critical area in the Ross Ice Sheet and global climate system. Jourdan et al. (2007)

**Keywords:** A; B; C

## ACKNOWLEDGMENTS

Foo

This dissertation was typeset with  $\text{\LaTeX}$ <sup>1</sup> by the author.

---

<sup>1</sup>The  $\text{\LaTeX}$  document preparation system was developed by Leslie Lamport as a special version of Donald Knuth's  $\text{\TeX}$  program for computer typesetting.  $\text{\TeX}$  is a trademark of the American Mathematical Society. The  $\text{\LaTeX}$  macro package for the New Mexico Institute of Mining and Technology dissertation format was written for the Tech Computer Center by John W. Shipman.

# CONTENTS

<b>LIST OF TABLES</b>	<b>v</b>
<b>LIST OF FIGURES</b>	<b>vi</b>
<b>PREFACE</b>	<b>vii</b>
<b>1. ANDRILL</b>	<b>1</b>
<b>2. GEOCHRONOLOGY OF MINNA BLUFF, SOUTHERN MCMURDO SOUND, ANTARTICA</b>	<b>2</b>
2.1 Introduction . . . . .	2
2.2 Geology . . . . .	2
2.2.1 Volcanic . . . . .	2
2.2.2 Glacial . . . . .	2
2.3 Methods . . . . .	3
2.3.1 Ar-Ar . . . . .	3
2.4 Results . . . . .	3
2.4.1 Ar-Ar Laser Fusion . . . . .	3
2.4.2 Ar-Ar Step Heating . . . . .	3
2.5 Discussion . . . . .	3

<b>3. DEVELOPMENT AND TESTING OF A LASER MICRO FURNACE FOR AR-AR ANALYSIS</b>	<b>4</b>
3.1 Design . . . . .	4
3.2 Testing . . . . .	4
3.3 Preliminary Results . . . . .	4
<b>4. PYCHRON: NOBLE GAS DATA ACQUISITION AND PROCESSING FRAMEWORK</b>	<b>5</b>
<b>A. AR-AR DATA</b>	<b>6</b>
<b>B. ELECTRON MICROPROBE DATA</b>	<b>7</b>
<b>REFERENCES</b>	<b>8</b>

## LIST OF TABLES



## LIST OF FIGURES

This dissertation is accepted on behalf of the faculty of the Institute by the following committee:

---

William C. McIntosh, Advisor

---

---

---

---

---

I release this document to the New Mexico Institute of Mining and Technology.

---

Jake Ross

Date

## **PREFACE**

Foo

## **CHAPTER 1**

### **ANDRILL**

## **CHAPTER 2**

# **GEOCHRONOLOGY OF MINNA BLUFF, SOUTHERN MCMURDO SOUND, ANTARTICA**

### **2.1 Introduction**

Minna Bluff is a large volcanic peninsula 70km south of Ross Island, Antarctica

### **2.2 Geology**

#### **2.2.1 Volcanic**

This section describes the glacial geology of Minna Bluff. Here is the text wrapping around and a displaying a the outer indentation

#### **2.2.2 Glacial**

This section describes the volcanic geology of Minna Bluff. Here is the text wrapping around and a displaying a the outer indentation

## **2.3 Methods**

### **2.3.1 Ar-Ar**

## **2.4 Results**

### **2.4.1 Ar-Ar Laser Fusion**

### **2.4.2 Ar-Ar Step Heating**

## **2.5 Discussion**

## **CHAPTER 3**

### **DEVELOPMENT AND TESTING OF A LASER MICRO FURNACE FOR AR-AR ANALYSIS**

#### **3.1 Design**

#### **3.2 Testing**

#### **3.3 Preliminary Results**

## **CHAPTER 4**

### **PYCHRON: NOBLE GAS DATA ACQUISITION AND PROCESSING FRAMEWORK**



## **APPENDIX A**

### **AR-AR DATA**

**APPENDIX B**

**ELECTRON MICROPROBE DATA**

## REFERENCES

- Bachmann, O. and Dungan, M. A. (2002). Temperature-induced Al-zoning in hornblendes of the Fish Canyon magma, Colorado. *American Mineralogist*, 87(8-9):1062–1076.
- Bachmann, O., Dungan, M. A., and Bussy, F. (2005). Insights into shallow magmatic processes in large silicic magma bodies: the trace element record in the Fish Canyon magma body, Colorado. *Contributions to Mineralogy and Petrology*, 149(3):338–349.
- Bachmann, O., Dungan, M. A., and Lipman, P. W. (2002). The Fish Canyon magma body, San Juan volcanic field, Colorado: rejuvenation and eruption of an upper-crustal batholith. *Journal of Petrology*, 43(8):1469–1503.
- Bachmann, O., OBERLI, F., DUNGAN, M., MEIER, M., Mundil, R., and FISCHER, H. (2007).  $^{40}\text{Ar}/^{39}\text{Ar}$  and U–Pb dating of the Fish Canyon magmatic system, San Juan Volcanic field, Colorado: Evidence for an extended crystallization history. *Chemical Geology*, 236(1-2):134–166.
- Charlier, B. L. A., Bachmann, O., Davidson, J. P., Dungan, M. A., and Morgan, D. J. (2007). The Upper Crustal Evolution of a Large Silicic Magma Body: Evidence from Crystal-scale Rb Sr Isotopic Heterogeneities in the Fish Canyon Magmatic System, Colorado. *Journal of Petrology*, 48(10):1875–1894.
- Jourdan, F., Matzel, J., and Renne, P. R. (2007).  $^{39}\text{Ar}$  and  $^{37}\text{Ar}$  recoil loss during neutron irradiation of sanidine and plagioclase. *Geochimica et Cosmochimica Acta*, 71(11):2791–2808.
- Jourdan, F. and Renne, P. R. (2007). Age calibration of the Fish Canyon sanidine  $^{40}\text{Ar}/^{39}\text{Ar}$  dating standard using primary K–Ar standards. *Geochimica et Cosmochimica Acta*, 71(2):387–402.
- Lipman, P., Dungan, M., and Bachmann, O. (1997). Comagmatic granophyric granite in the Fish Canyon Tuff, Colorado: implications for magma-chamber processes during a large ash-flow eruption. *Geology*, 25(10):915.
- Lipman, P. W. and McIntosh, W. C. (2008). Eruptive and noneruptive calderas, northeastern San Juan Mountains, Colorado: Where did the ignimbrites come from? *Geological Society of America Bulletin*, 120(7-8):771–795.

Min, K., Mundil, R., Renne, P. R., and Ludwig, K. R. (2000). A test for systematic errors in  $^{40}\text{Ar}/^{39}\text{Ar}$  geochronology through comparison with U/Pb analysis of a 1.1-Ga rhyolite. *Geochimica et Cosmochimica Acta*, 64(1):73–98.

Renne, P. R., Mundil, R., Balco, G., Min, K., and Ludwig, K. R. (2010). Joint determination of  $^{40}\text{K}$  decay constants and  $^{40}\text{Ar}^*/^{40}\text{K}$  for the Fish Canyon sanidine standard, and improved accuracy for  $^{40}\text{Ar}/^{39}\text{Ar}$  geochronology. *Geochimica et Cosmochimica Acta*, 74(18):5349–5367.

Schmitz, M. D. and Bowring, S. A. (2001). U-Pb zircon and titanite systematics of the Fish Canyon Tuff: an assessment of high-precision U-Pb geochronology and its application to young volcanic rocks. *Geochimica et Cosmochimica Acta*, 65(15):2571–2587.

Geochronology of Southern McMurdo Sound and development of a micro laser  
furnace

by

Jake Ross

Permission to make digital or hard copies of all or part of this work for personal or classroom use is granted without fee provided that copies are not made or distributed for profit or commercial advantage and that copies bear this notice and the full citation on the last page. To copy otherwise, to republish, to post on servers or to redistribute to lists, requires prior specific permission and may require a fee.