

Volcanic  
Fields on  
Earth & Mars

Jacob  
Richardson

Introduction

Overview

Sills

Lava Flows

Vent Density

Mars Clusters

Arsia Mons  
Volcanic Field

Methods

Results

Implications

Conclusions

# Modeling the Construction and Evolution of Distributed Volcanic Fields on Earth and Mars

Jacob A. Richardson

School of Geosciences  
University of South Florida

19 February 2016

# Team

Volcanic  
Fields on  
Earth & Mars

Jacob  
Richardson

Introduction

Overview

Sills  
Lava Flows  
Vent Density  
Mars Clusters

Arsia Mons  
Volcanic Field

Methods  
Results  
Implications

Conclusions

# Introduction

Volcanic  
Fields on  
Earth & Mars

Jacob  
Richardson

## Introduction

Overview

Sills

Lava Flows

Vent Density

Mars Clusters

## Arsia Mons Volcanic Field

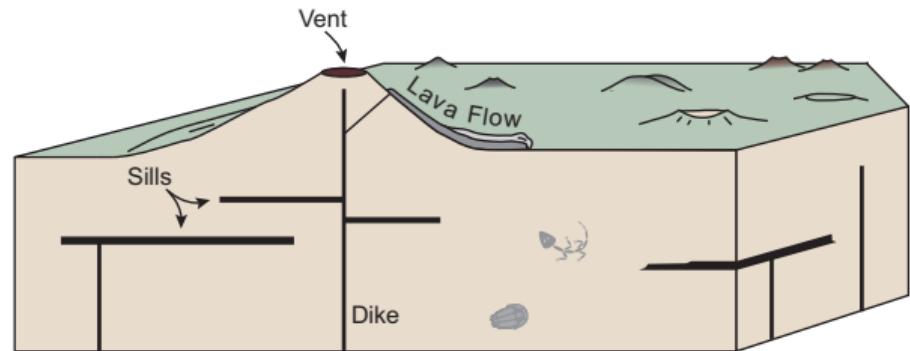
Methods

Results

Implications

## Conclusions

- Distributed Volcanism  
Definition
- Vertical Subregions can be  
detailed in volcanic systems



# Outline of Talk

Volcanic  
Fields on  
Earth & Mars

Jacob  
Richardson

## Introduction

Overview

Sills

Lava Flows

Vent Density

Mars Clusters

## Arsia Mons Volcanic Field

Methods

Results

Implications

## Conclusions

- Overview of Dissertation
- Arsia Mons
- Conclusions

# Sills in the San Rafael Swell

Volcanic  
Fields on  
Earth & Mars

Jacob  
Richardson

Introduction

Overview

Sills

Lava Flows

Vent Density

Mars Clusters

Arsia Mons  
Volcanic Field

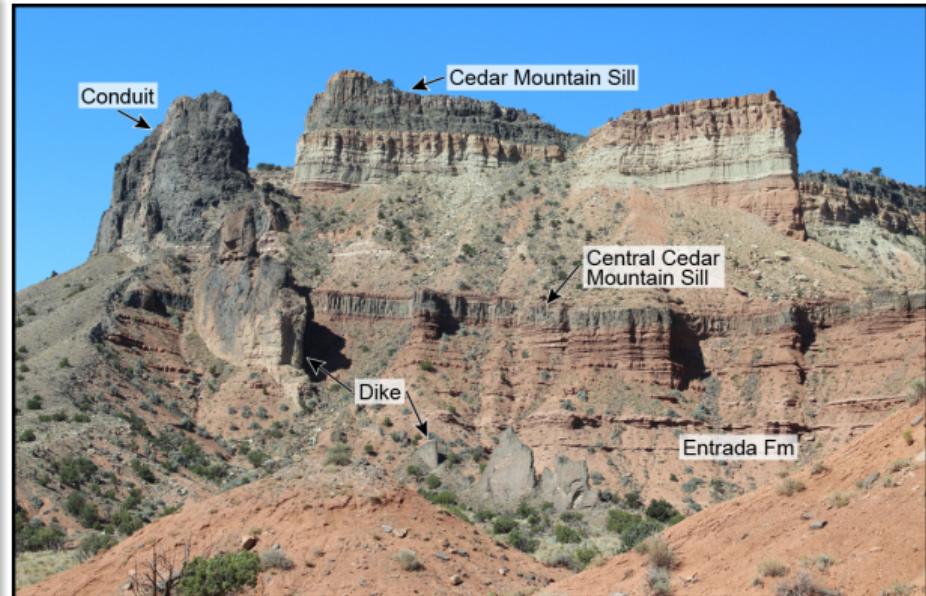
Methods

Results

Implications

Conclusions

- Lidar
- Sills
- Total volume, geometry
- Modulation of eruption style



# Sills in the San Rafael Swell

Volcanic  
Fields on  
Earth & Mars

Jacob  
Richardson

Introduction

Overview

Sills

Lava Flows

Vent Density

Mars Clusters

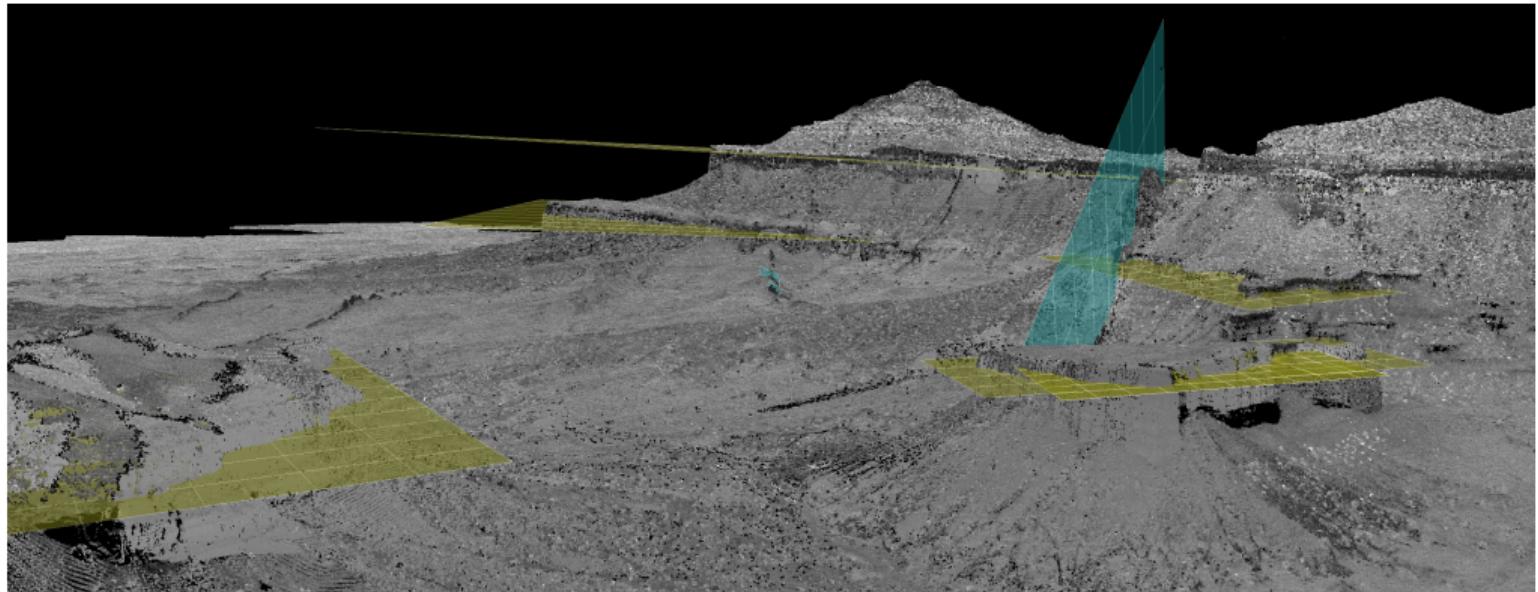
Arsia Mons  
Volcanic Field

Methods

Results

Implications

Conclusions



# Sills in the San Rafael Swell

Volcanic  
Fields on  
Earth & Mars

Jacob  
Richardson

Introduction

Overview

Sills

Lava Flows

Vent Density

Mars Clusters

Arsia Mons  
Volcanic Field

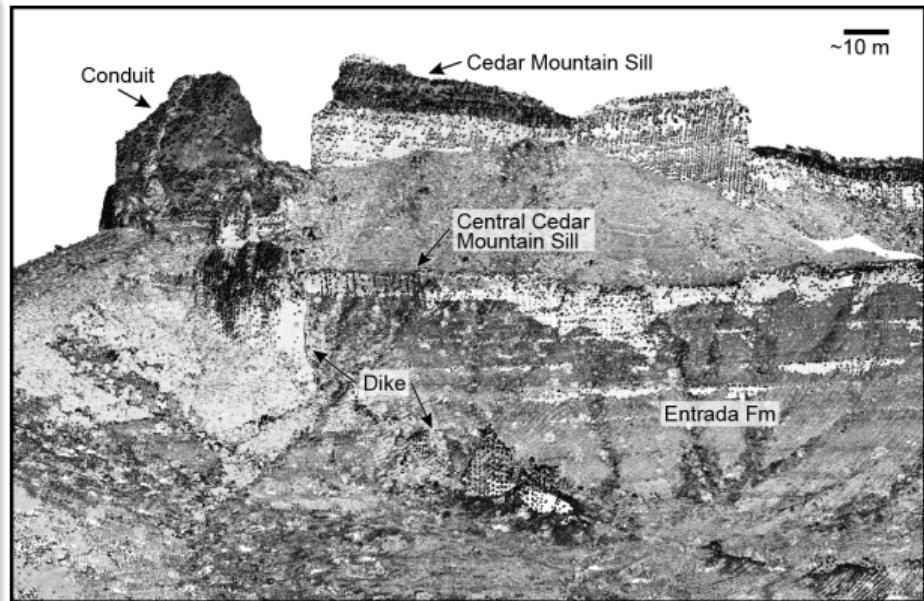
Methods

Results

Implications

Conclusions

- Lidar
- Sills
- Total volume, geometry
- Modulation of eruption style



# Lava Flows/Simulators

Volcanic  
Fields on  
Earth & Mars

Jacob  
Richardson

Introduction

Overview

Sills

Lava Flows

Vent Density

Mars Clusters

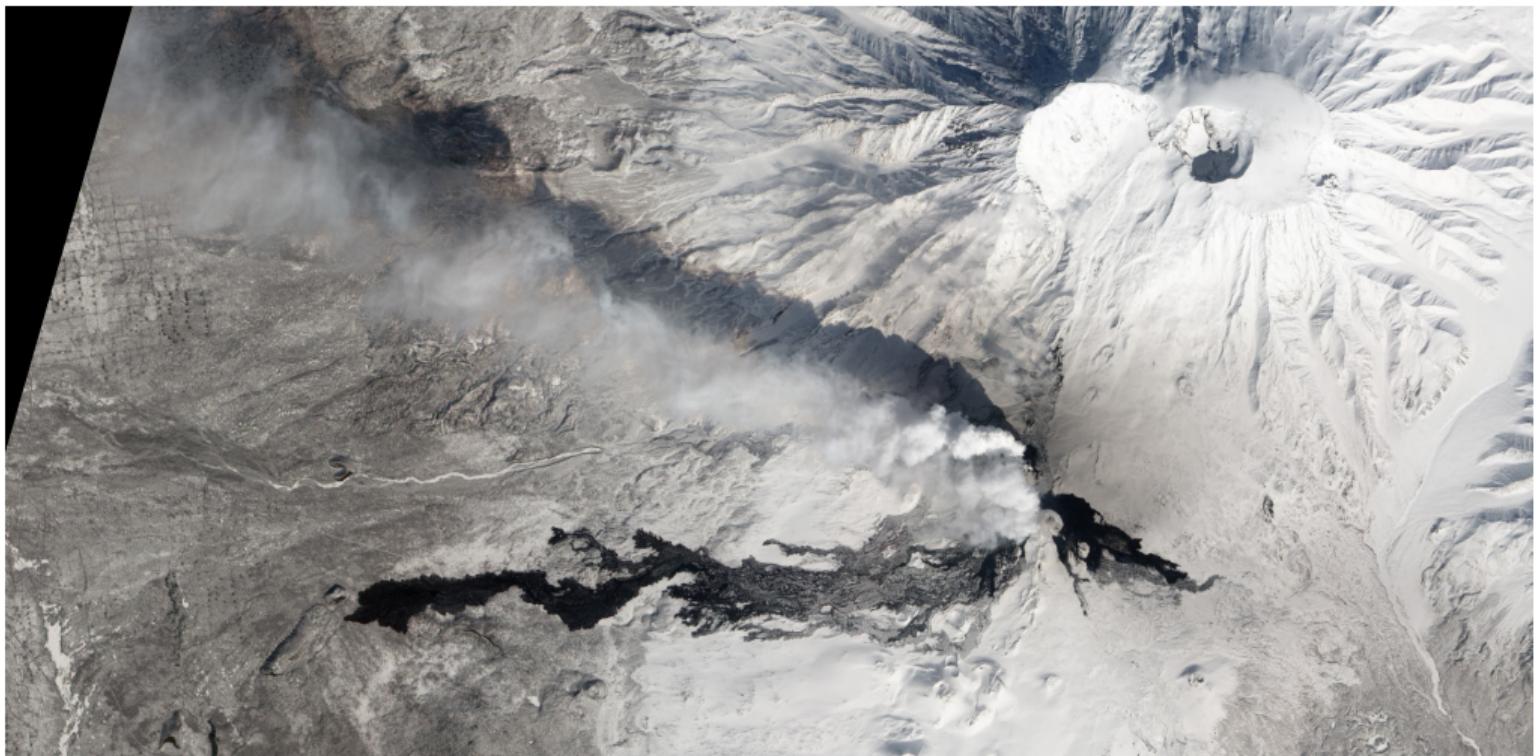
Arsia Mons  
Volcanic Field

Methods

Results

Implications

Conclusions



# Lava Flows/Simulators

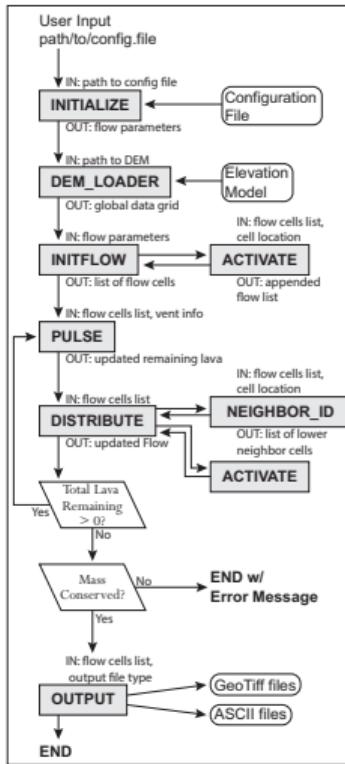
Volcanic  
Fields on  
Earth & Mars

Jacob  
Richardson

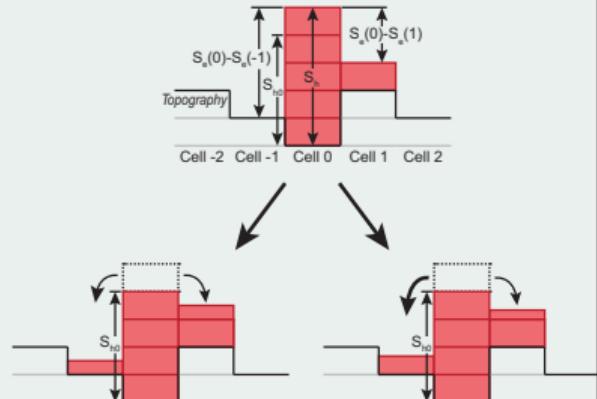
Introduction  
Overview

Sills  
Lava Flows  
Vent Density  
Mars Clusters

Arsia Mons  
Volcanic Field  
Methods  
Results  
Implications  
Conclusions



## MOLASSES — Modular Lava Simulation Software



- MOLASSES
- CA Code

# Lava Flows/Simulators

Volcanic  
Fields on  
Earth & Mars

Jacob  
Richardson

Introduction

Overview

Sills

Lava Flows

Vent Density

Mars Clusters

Arsia Mons

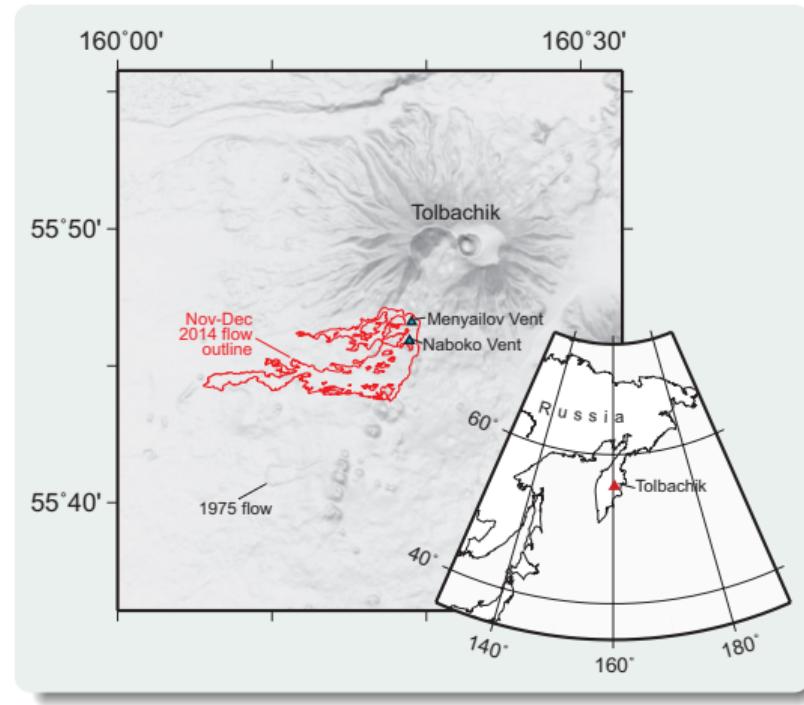
Volcanic Field

Methods

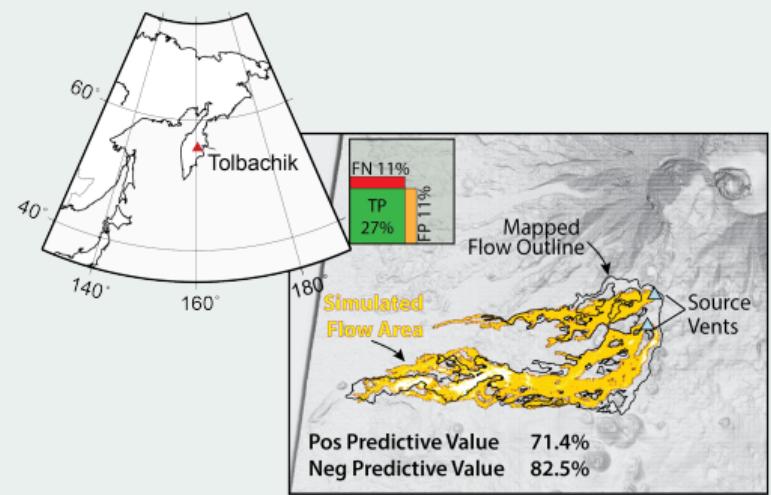
Results

Implications

Conclusions



## Validation



# Spatial Density of Clusters

Volcanic  
Fields on  
Earth & Mars

Jacob  
Richardson

Introduction

Overview

Sills

Lava Flows

Vent Density

Mars Clusters

**Arsia Mons**  
**Volcanic Field**

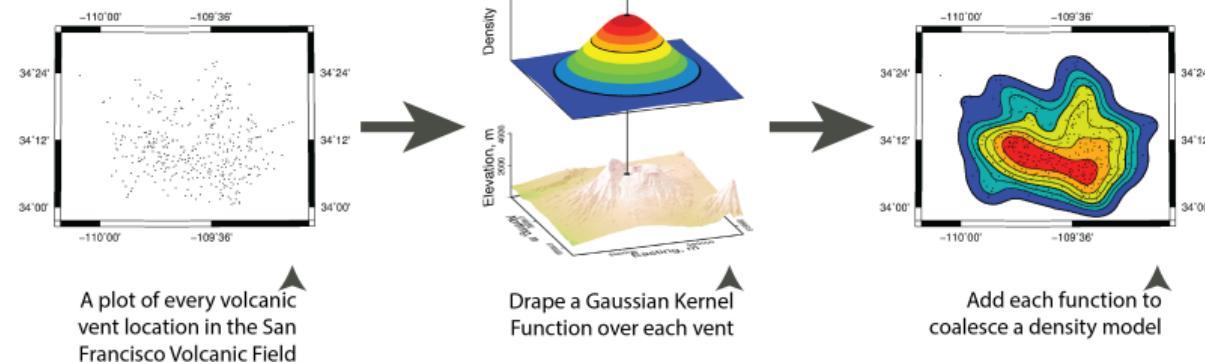
Methods

Results

Implications

Conclusions

## Spatial Density is modeled with KDE



# Spatial Density of Clusters

Volcanic  
Fields on  
Earth & Mars

Jacob  
Richardson

Introduction

Overview

Sills

Lava Flows

Vent Density

Mars Clusters

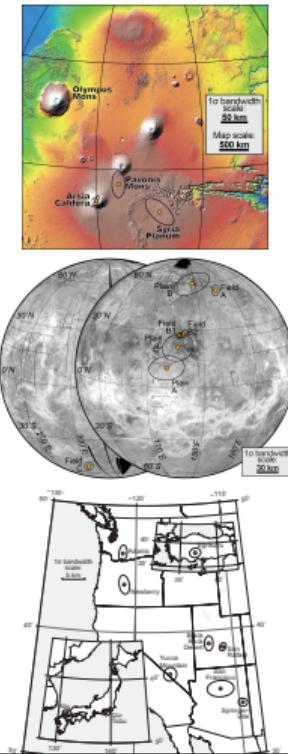
**Arsia Mons**  
Volcanic Field

Methods

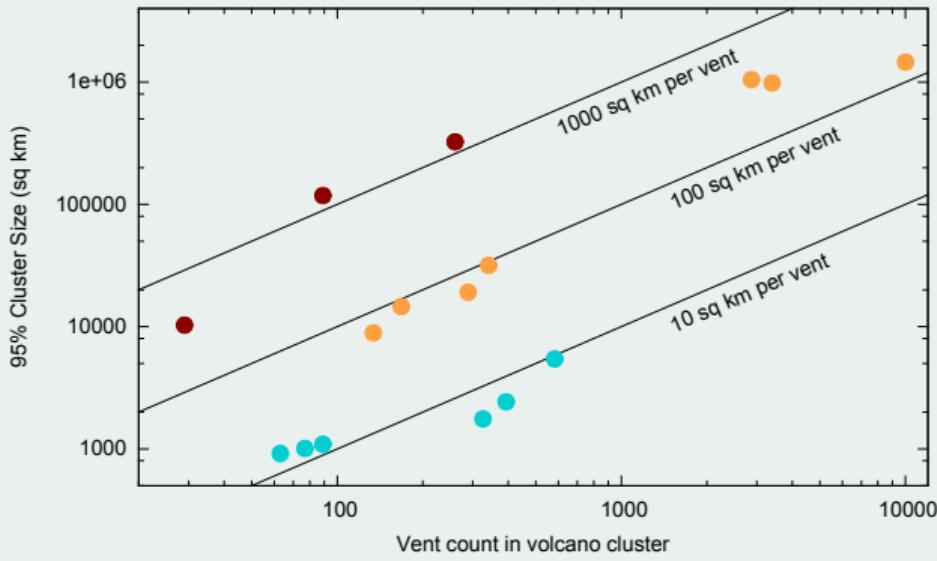
Results

Implications

Conclusions



## Average Vent Intensity



# Syria Planum

Volcanic  
Fields on  
Earth & Mars

Jacob  
Richardson

Introduction

Overview

Sills

Lava Flows

Vent Density

Mars Clusters

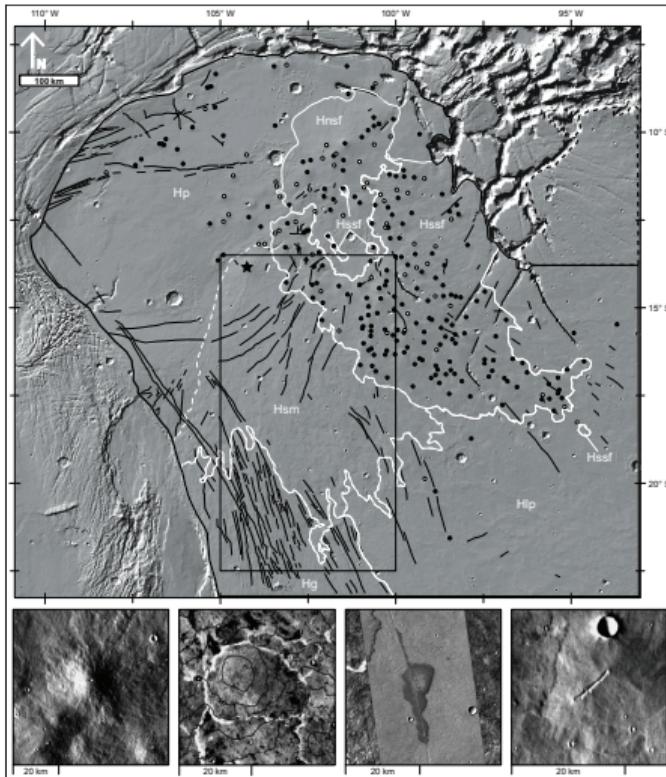
**Arsia Mons**  
Volcanic Field

Methods

Results

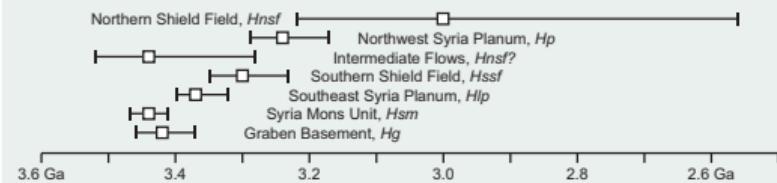
Implications

Conclusions

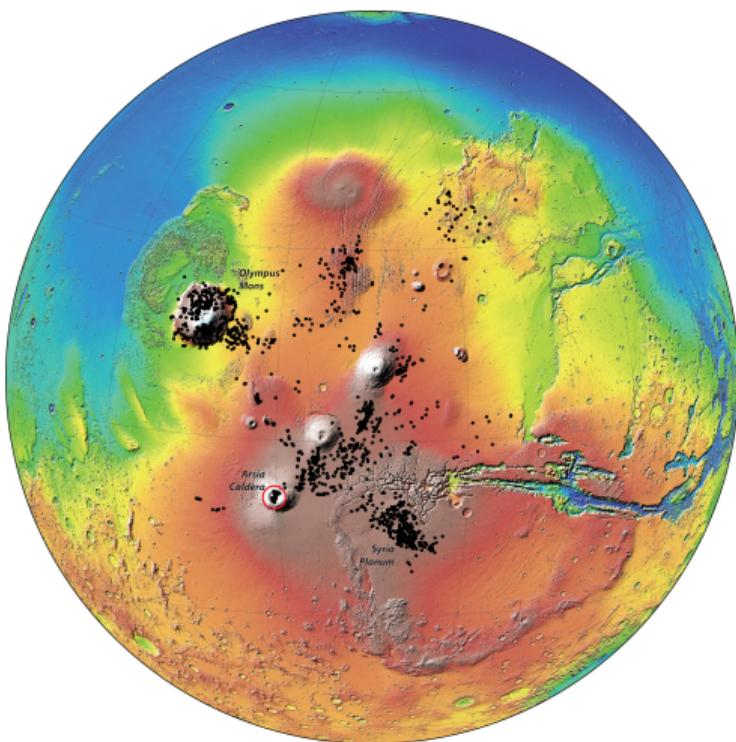


## Evolution of a volcano cluster

- Here's the rub...
- Another idea...



# Distributed Volcanism of the Tharsis Volcanic Province



## Tharsis Vent Catalog

Catalog created by J. Bleacher et al.

# Arsia Mons Overview

Volcanic  
Fields on  
Earth & Mars

Jacob  
Richardson

Introduction

Overview

Sills

Lava Flows

Vent Density

Mars Clusters

**Arsia Mons  
Volcanic Field**

Methods

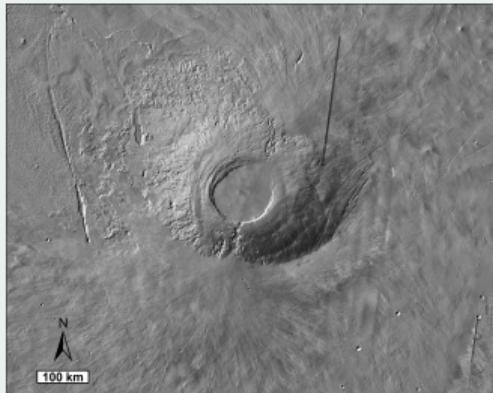
Results

Implications

Conclusions

## Arsia Mons

Arsia Mons is here:



# Mapping

Volcanic  
Fields on  
Earth & Mars

Jacob  
Richardson

Introduction

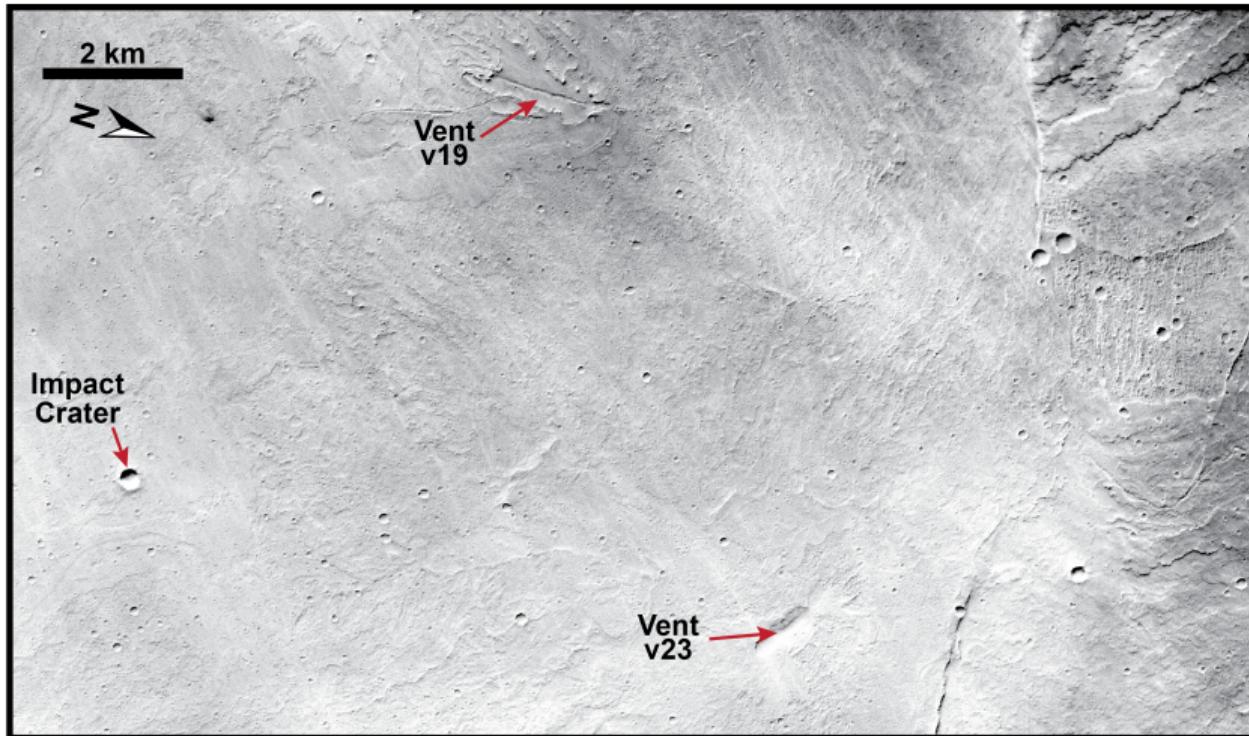
Overview

Sills  
Lava Flows  
Vent Density  
Mars Clusters

Arsia Mons  
Volcanic Field

Methods  
Results  
Implications

Conclusions



CTX Image: G10\_022160\_1710\_XN\_09S120W (NASA/JPL-Caltech/MSSS)

# Mapping

Volcanic  
Fields on  
Earth & Mars

Jacob  
Richardson

Introduction

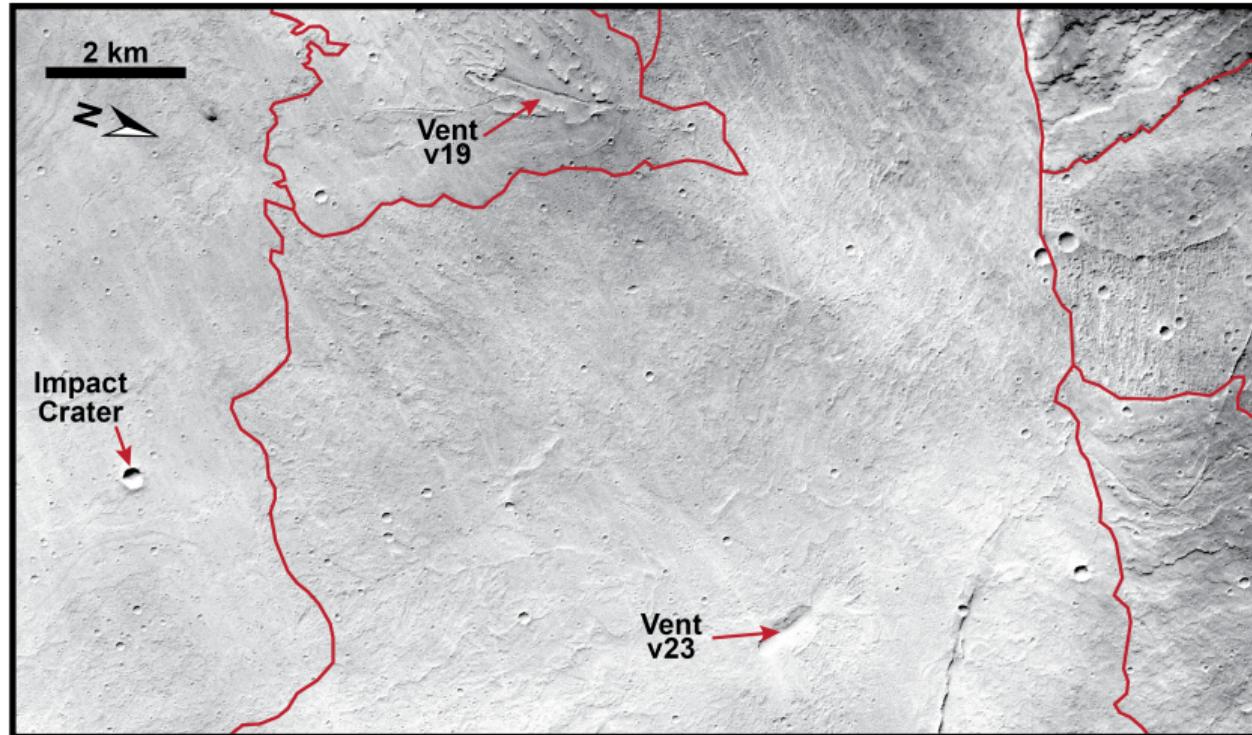
Overview

Sills  
Lava Flows  
Vent Density  
Mars Clusters

Arsia Mons  
Volcanic Field

Methods  
Results  
Implications

Conclusions



CTX Image: G10\_022160\_1710\_XN\_09S120W (NASA/JPL-Caltech/MSSS)



# Mapping

Volcanic  
Fields on  
Earth & Mars

Jacob  
Richardson

Introduction

Overview

Sills

Lava Flows

Vent Density

Mars Clusters

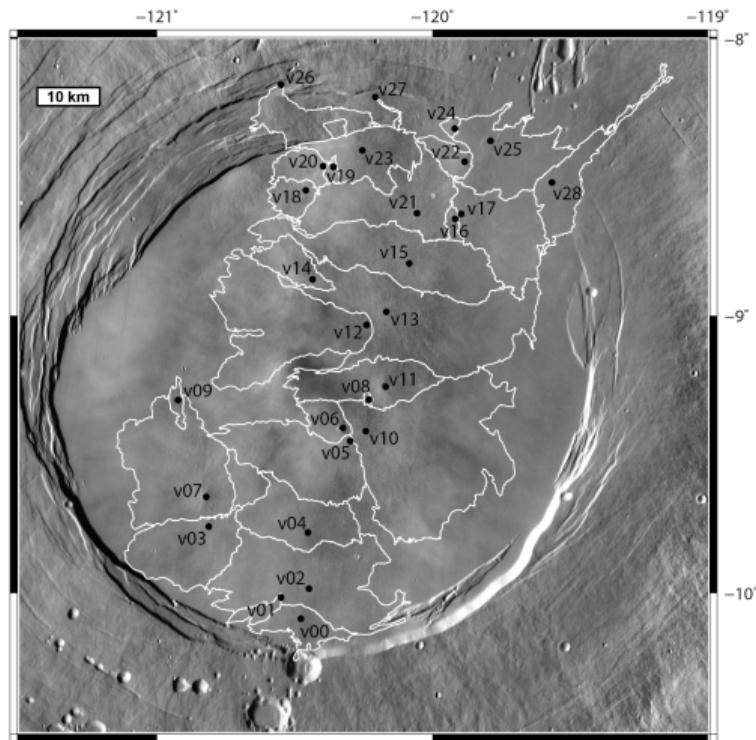
Arsia Mons  
Volcanic Field

Methods

Results

Implications

Conclusions



29 vents are mapped

# Ages: Crater Counting

Volcanic  
Fields on  
Earth & Mars

Jacob  
Richardson

Introduction

Overview

Sills

Lava Flows

Vent Density

Mars Clusters

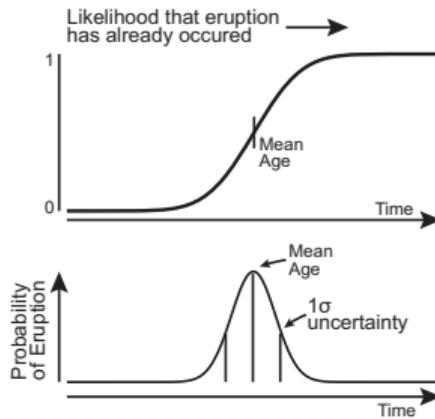
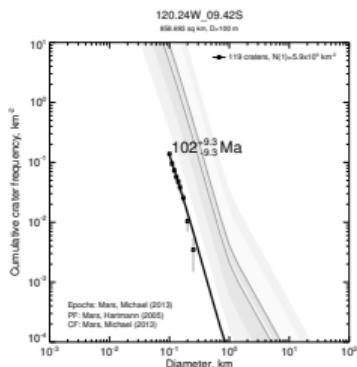
**Arsia Mons**  
Volcanic Field

Methods

Results

Implications

Conclusions



# Ages: Crater Counting

Volcanic  
Fields on  
Earth & Mars

Jacob  
Richardson

Introduction

Overview

Sills  
Lava Flows  
Vent Density  
Mars Clusters

Arsia Mons  
Volcanic Field

Methods

Results  
Implications

Conclusions

# Ages: Stratigraphy

Volcanic  
Fields on  
Earth & Mars

Jacob  
Richardson

Introduction

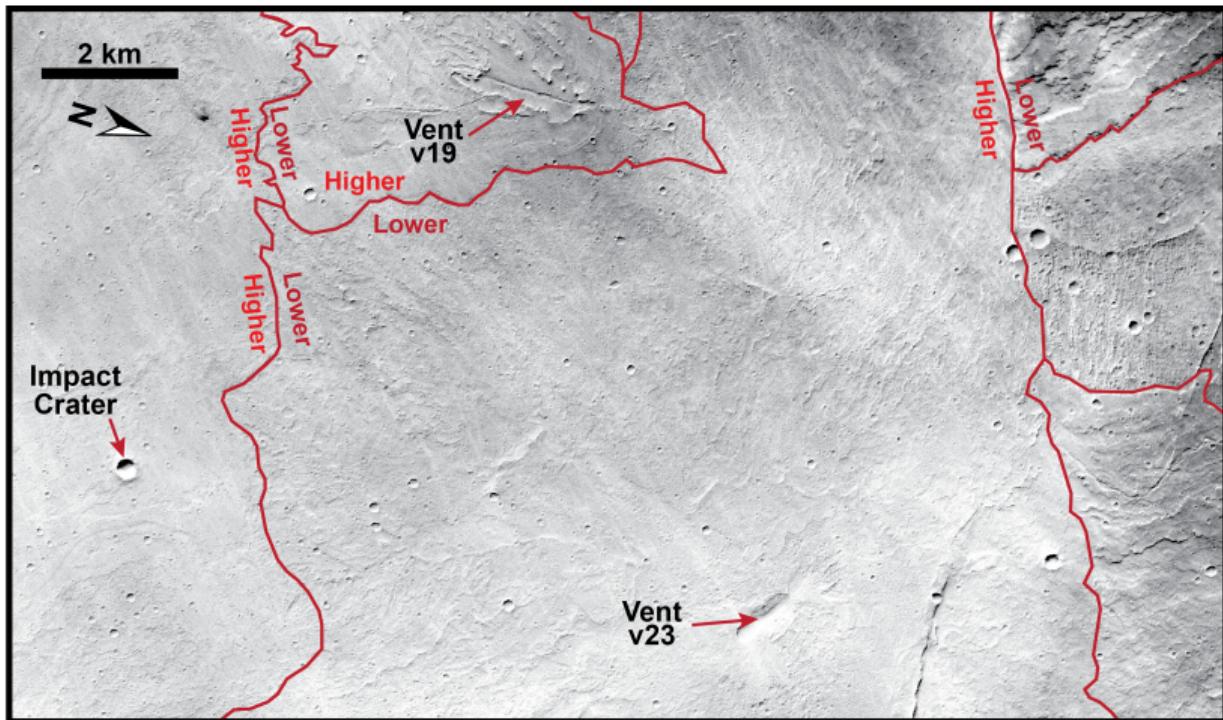
Overview

Sills  
Lava Flows  
Vent Density  
Mars Clusters

Arsia Mons  
Volcanic Field

Methods  
Results  
Implications

Conclusions



CTX Image: G10\_022160\_1710\_XN\_09S120W (NASA/JPL-Caltech/MSSS)

# Ages: Stratigraphy

Volcanic  
Fields on  
Earth & Mars

Jacob  
Richardson

Introduction

Overview

Sills

Lava Flows

Vent Density

Mars Clusters

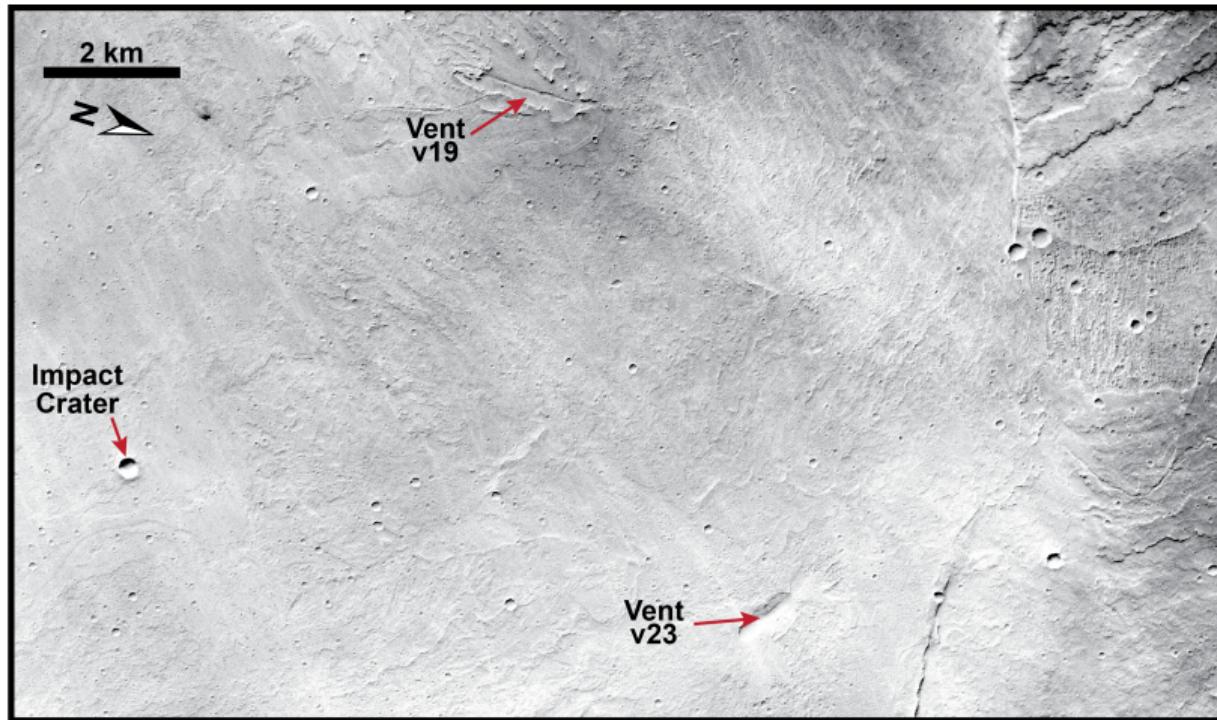
Arsia Mons  
Volcanic Field

Methods

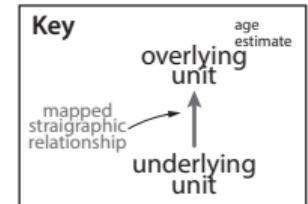
Results

Implications

Conclusions



CTX Image: G10\_022160\_1710\_XN\_09S120W (NASA/JPL-Caltech/MSSS)



Volcanic  
Fields on  
Earth & Mars

Jacob  
Richardson

Introduction

Overview

Sills

Lava Flows

Vent Density

Mars Clusters

Arsia Mons  
Volcanic Field

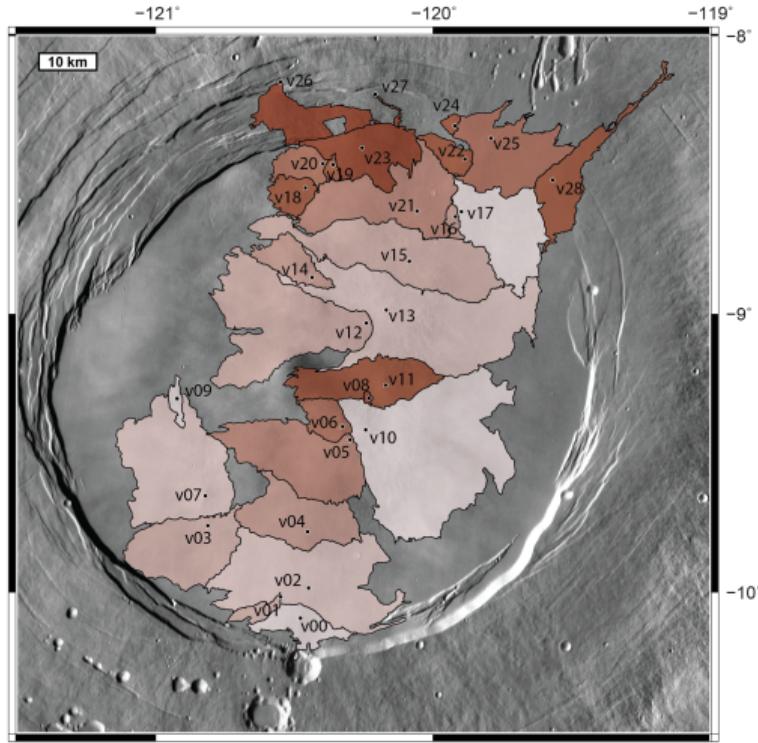
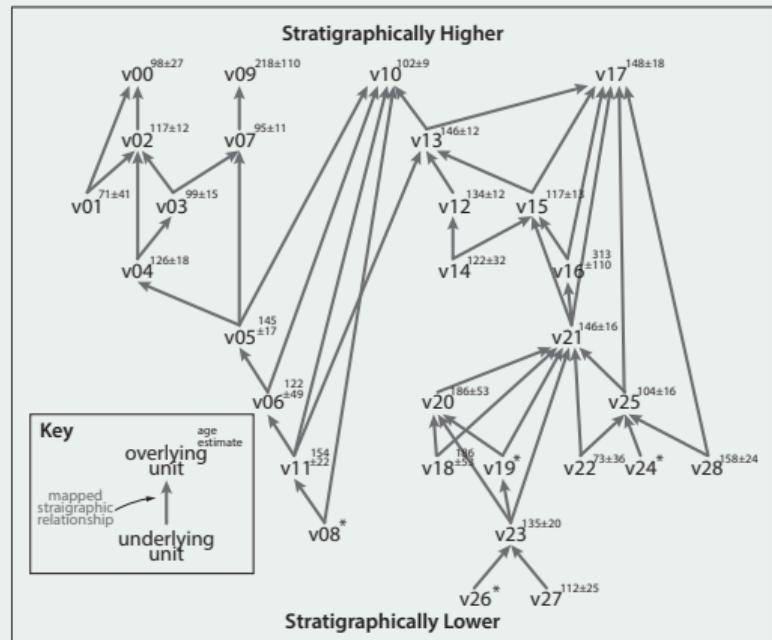
Methods

Results

Implications

Conclusions

## Stratigraphy “Web”



# Ages: Information Conflicts

Volcanic  
Fields on  
Earth & Mars

Jacob  
Richardson

Introduction

Overview

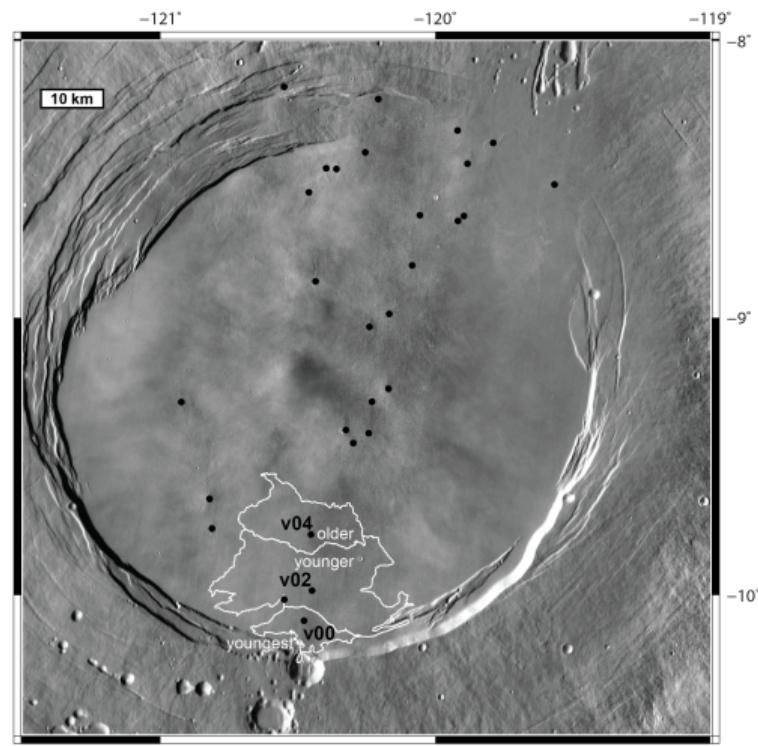
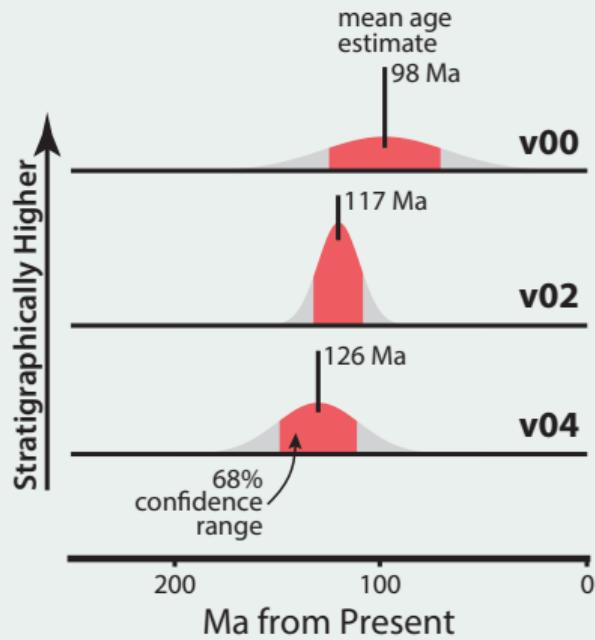
Sills  
Lava Flows  
Vent Density  
Mars Clusters

Arisia Mons  
Volcanic Field

Methods  
Results  
Implications

Conclusions

Mean crater ages can agree stratigraphy...



# Ages: Information Conflicts

Volcanic  
Fields on  
Earth & Mars

Jacob  
Richardson

Introduction

Overview

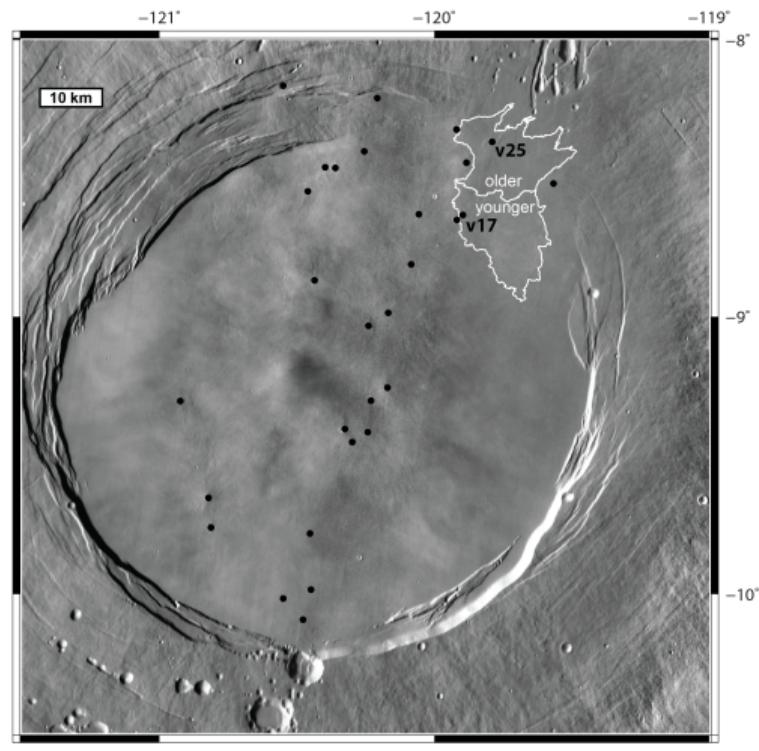
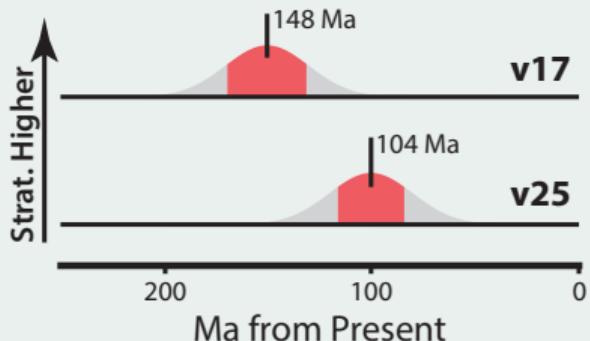
Sills  
Lava Flows  
Vent Density  
Mars Clusters

Arsia Mons  
Volcanic Field

Methods  
Results  
Implications

Conclusions

... or they can disagree



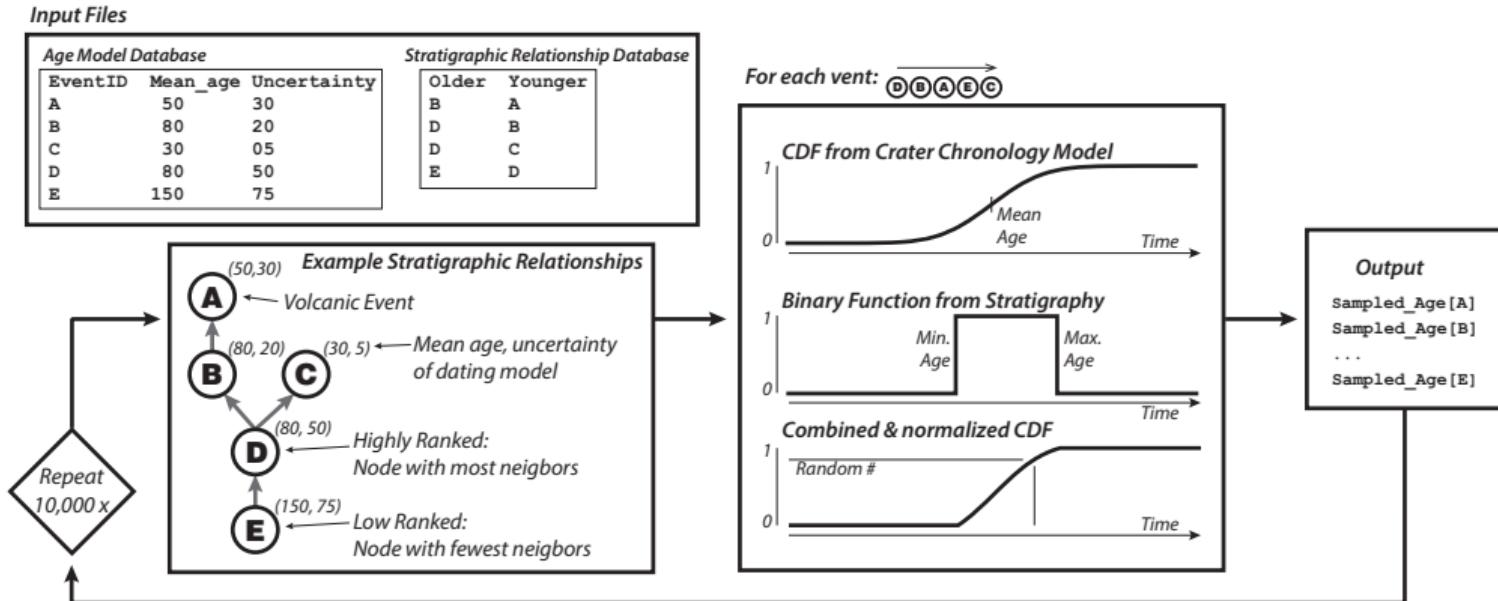
Volcanic  
Fields on  
Earth & Mars

Jacob  
Richardson

Introduction  
Overview

Sills  
Lava Flows  
Vent Density  
Mars Clusters

Arsia Mons  
Volcanic Field  
Methods  
Results  
Implications  
Conclusions



# Results

Volcanic  
Fields on  
Earth & Mars

Jacob  
Richardson

Introduction

Overview

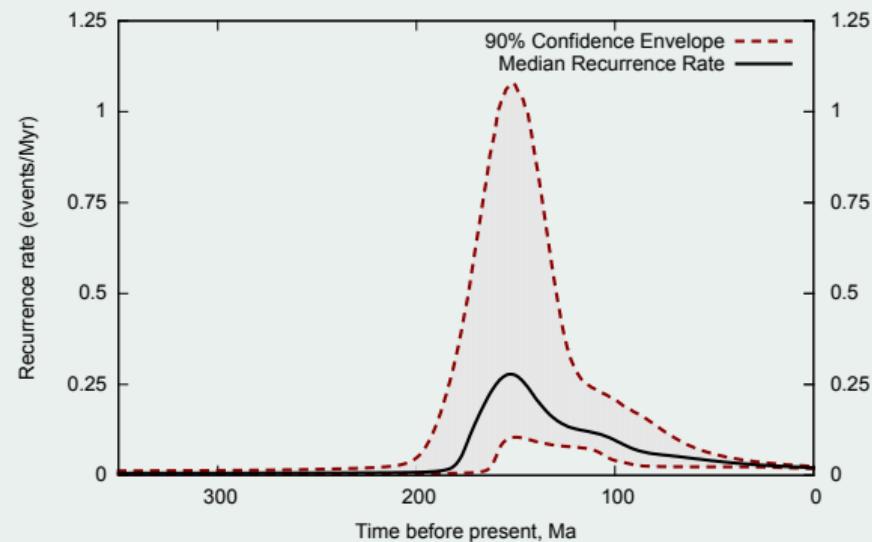
Sills  
Lava Flows  
Vent Density  
Mars Clusters

Arsia Mons  
Volcanic Field

Methods  
Results  
Implications

Conclusions

## Recurrence Rate



# Volume Flux

Volcanic  
Fields on  
Earth & Mars

Jacob  
Richardson

Introduction

Overview

Sills

Lava Flows

Vent Density

Mars Clusters

Arsia Mons  
Volcanic Field

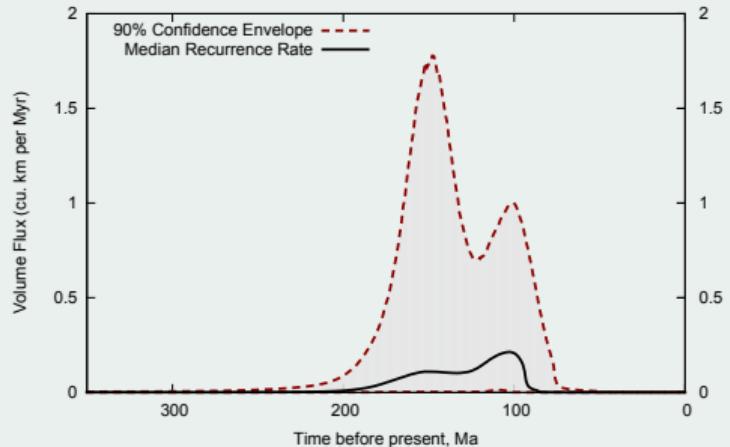
Methods

Results

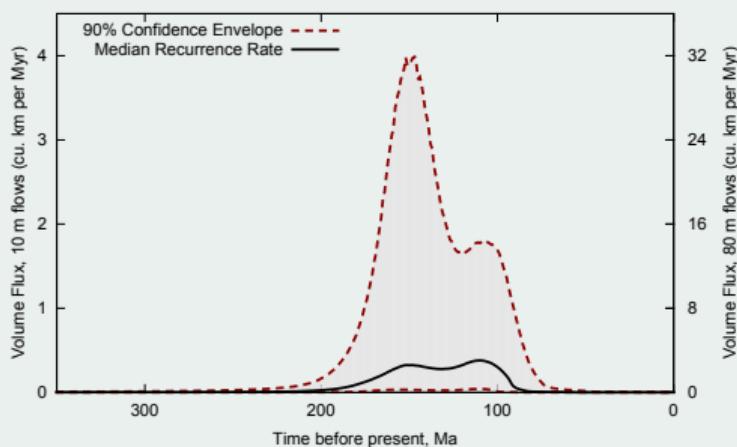
Implications

Conclusions

## Sub-surface mesh model



## Thickness model



# Tie in with Ashes and glaciers?

Volcanic  
Fields on  
Earth & Mars

Jacob  
Richardson

Introduction

Overview

Sills  
Lava Flows  
Vent Density  
Mars Clusters

Arsia Mons  
Volcanic Field

Methods  
Results  
Implications

Conclusions

# Model of waning volcanism of Arsia

Volcanic  
Fields on  
Earth & Mars

Jacob  
Richardson

Introduction

Overview

Sills  
Lava Flows  
Vent Density  
Mars Clusters

Arsia Mons  
Volcanic Field

Methods  
Results  
Implications

Conclusions

# Arsia Specific Conclusions

Volcanic  
Fields on  
Earth & Mars

Jacob  
Richardson

Introduction

Overview

Sills  
Lava Flows  
Vent Density  
Mars Clusters

Arsia Mons  
Volcanic Field

Methods  
Results  
Implications

Conclusions

# Other Conclusions

Volcanic  
Fields on  
Earth & Mars

Jacob  
Richardson

Introduction

Overview

Sills  
Lava Flows  
Vent Density  
Mars Clusters

Arsia Mons  
Volcanic Field

Methods  
Results  
Implications

Conclusions

# Additional Thanks

Volcanic  
Fields on  
Earth & Mars

Jacob  
Richardson

Introduction

Overview

Sills  
Lava Flows  
Vent Density  
Mars Clusters

Arsia Mons  
Volcanic Field

Methods  
Results  
Implications

Conclusions

# Questions?

Volcanic  
Fields on  
Earth & Mars

Jacob  
Richardson

Introduction

Overview

Sills  
Lava Flows  
Vent Density  
Mars Clusters

Arsia Mons  
Volcanic Field

Methods  
Results  
Implications

Conclusions