THE FORMATION OF PITS IN VOLCANIC ENVIRONMENTS

Brent Garry (GSFC)
Jacob Bleacher (GSFC)
Christopher Hamilton (U of A)
Lynn Carter (GSFC)

Contributing SSERVI Teams: RIS4E, FINESSE, DREAM2, CLSE
INTRODUCTION

- Formation of pits within inflated lava sheet flows
  - Sheet inflation
  - Pit formation
  - Pit characteristics
- SSERVI efforts
  - RIS$^4$E, FINESSE, CLSE
  - DREAM2
- Take Home Message:
  - HEOMD-SMD should be interested in pits
  - If so, focused studies on the ground are needed to understand HOEMD-SMD relevance
**BACKGROUND**

- High resolution lunar observations identify pit craters *(Haruyama et al., 2009; Robinson et al., 2012; Ashley et al., 2012; Wagner and Robinson, 2014)*

- **Formation:**
  - Volcanic and/or Structural

- **Subsurface void space**

- **Possible environmental conditions:**
  - Radiation protection & thermal stability *(Horz, 1985)*

- **Difficult linking caves to pits** *(Halliday et al. 1998, 2008, 2012)*
PIT MORPHOLOGY

- Pits display some common characteristics (Wagner & Robinson, 2014):
  - Outer funnel
  - Layered stratigraphy
  - Inner Rim
  - Overhanging ledges
  - Associated with local high terrain

- Pits identified in mare, highlands and ejecta melt sheets

- Likely not representative of active skylights

- Recent features formed by collapse into void space
SSERVI RELEVANCE

- Remote sensing morphology often leaves many valid SMD hypotheses
- IF, HEOMD exploration might use subsurface voids as safe havens:
  - SMD responsibility to make sure all formation scenarios are on the table
- Viscous Sheet Inflation
  - Here, focus on Mare pits (Keszthelyi, 2008; Garry et al., 2012)
  - Ejecta melt inflation? (Bray et al., 2010)
LAVA FLOWS

Channels

Tubes

Sheets
**SHEETS**

- Large, flat surface areas
- Tabular units
- Common over low slopes
- Extensive terrestrial literature

(Walker, 1991, 2009; Keszthelyi Pieri, 1993; Chitwood, 1994; Hon et al., 1994; Self et al., 1998; Whitehead Stevenson, 1998; Keszthelyi et al., 2000 and many others)
SHEETS

• Development of crust enables thermal insulation of liquid core

• Morphology dependent on balance between lateral spreading and flux into sheet

• If lateral advance (hummocky toes) is inhibited and supply sustained, flow will inflate

• Inflation more likely on lower gravity objects (Keszthelyi & Self, 1998)

• Low slope, low gravity mare ideal site for inflation
SHEETS

- Observed inflating lobes at flow fronts, HI
- Enables 10s cm thick flows to attain thicknesses of meters in days to weeks
- Humans have long recognized inflation of lavas
- Invert topography
PLATEAUS

McCartys Flow, NM
CLSE field site
MARGINS

- Steeply dipping plates
- Occasionally overturned
- > 10 m in relief based on DGPS measurements
MARGINS

- Steeply dipping plates
- Occasionally overturned
- > 10 m in relief based on DGPS measurements

McCarty's Lava Flow Platform

Basal Width: 232 m
Thickness: 6.5 – 14 m
Platform Change: 0.6 m
TERRACED MARGINS

Carrizozo, NM

Pre-flow / Aeolian
INFLATED SHEETS

• Form apparently isolated plateaus with disrupted margins (hummocky flow fronts)
• Can form extensive, undisrupted surfaces
• Can contain pits
INFLATED SHEETS

Plateaus

Hummocky Margins

Pits

600 m
PITS

- Vary from flat floored to conical
- Abrupt drop with overhanging roof to gradual increase in slope
- Floors covered in rubble, younger flows, or pre-flow surface
PIT FORMATION

- Topographic obstacles locally inhibit inflation
PIT FORMATION

- Floors can flood
PIT FORMATION

• Inflation pits display a sense of collapse
• Inflation pulses produce “layering”, as can burial of roof prior to collapse
• Collapse creates overhanging ledges, funnels
• Inflation pits rarely linked to adjacent void space
Isolated pit within local topographic high
CONCLUSIONS

• Inflation rise pits common on Earth

• Produce:
  ▪ Upper funnels, layered stratigraphy, overhanging ledges and are found in local topographic highs
  ▪ No extensive subsurface void space

• Take Home Message:
  ▪ Inflation of viscous sheets should be considered among candidate formation mechanisms for pits
  ▪ Precursor pit missions are critical to identify possible link to subsurface void space
  ▪ SSERVI studies focusing on pit measurements