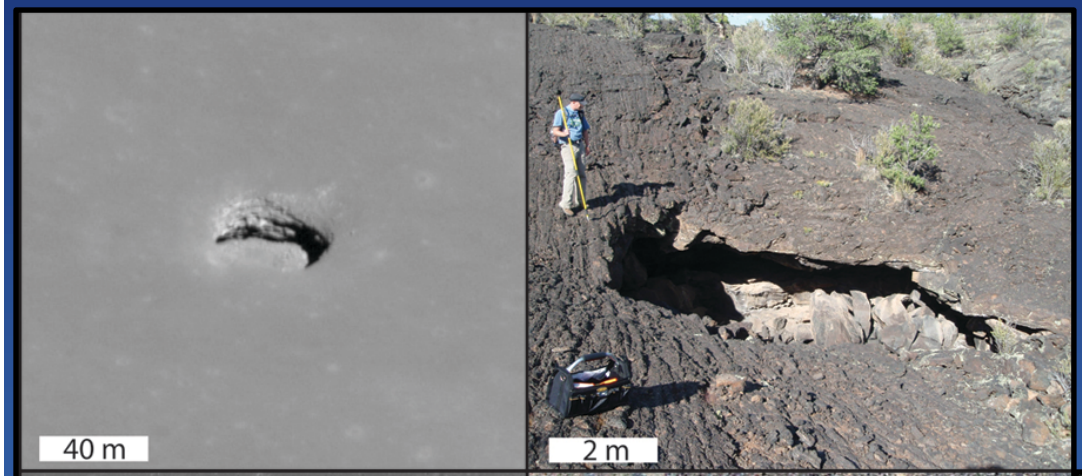
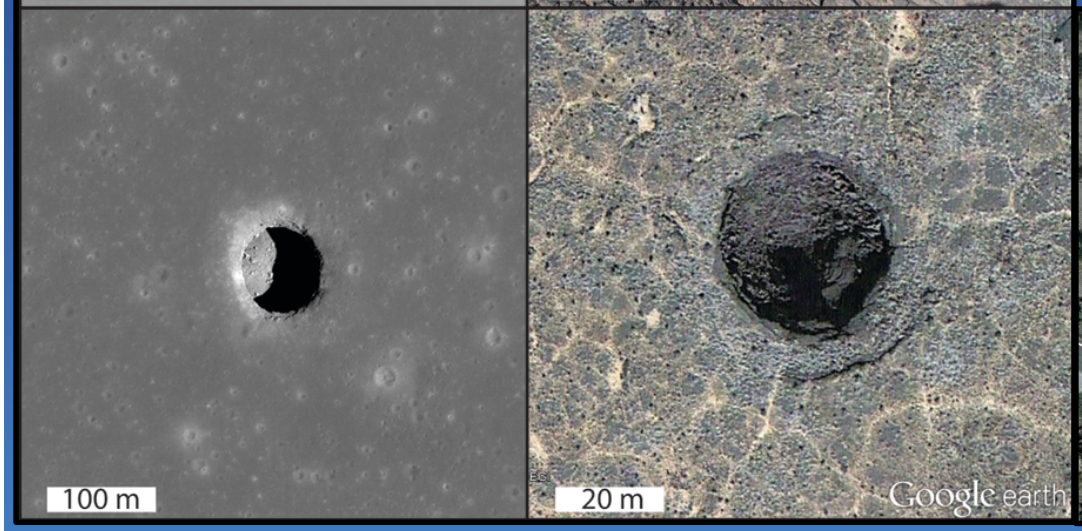
THE FORMATION OF PITS IN VOLCANIC ENVIRONMENTS





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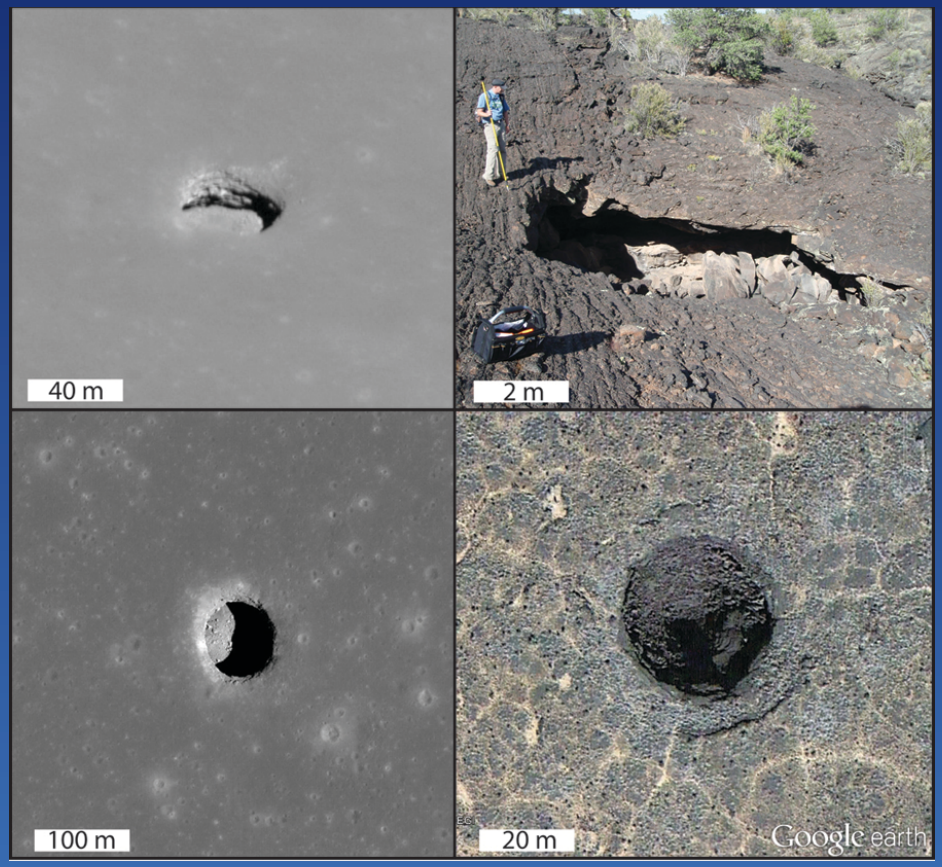
Contributing SSERVI Teams: RIS⁴E, FINESSE, DREAM2, CLSE

INTRODUCTION

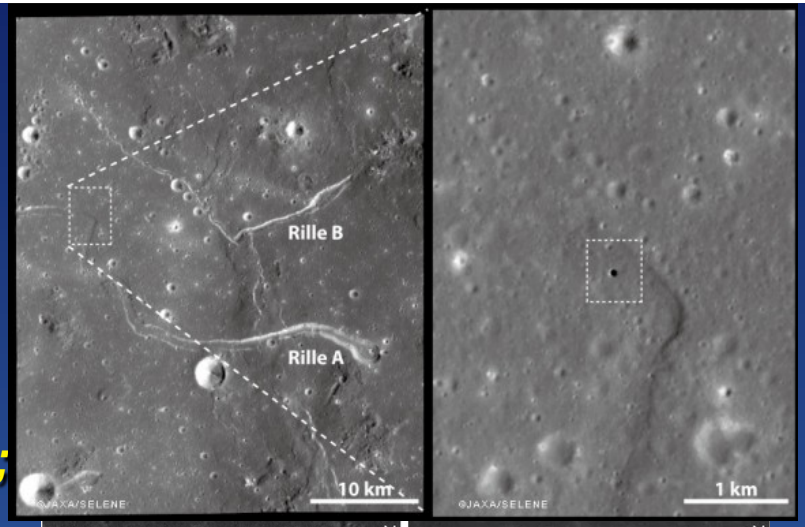
- Formation of pits within inflated lava sheet flows
  - Sheet inflation
  - Pit formation
  - Pit characteristics
- SSERVI efforts
  - RIS^{4}E, FINESSE, CLSE
  - DREAM2

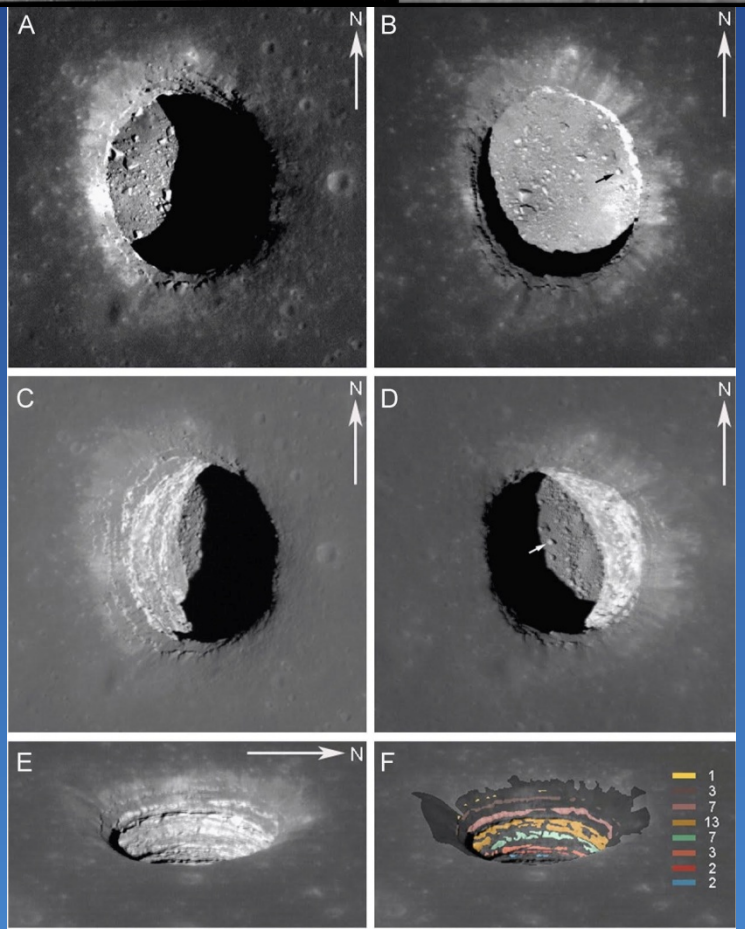


- Take Home Message:
  - HEOMD-SMD should be interested in pits
  - If so, focused studies on the ground are needed to understand HOEMD-SMD relevance

BACKGROUND

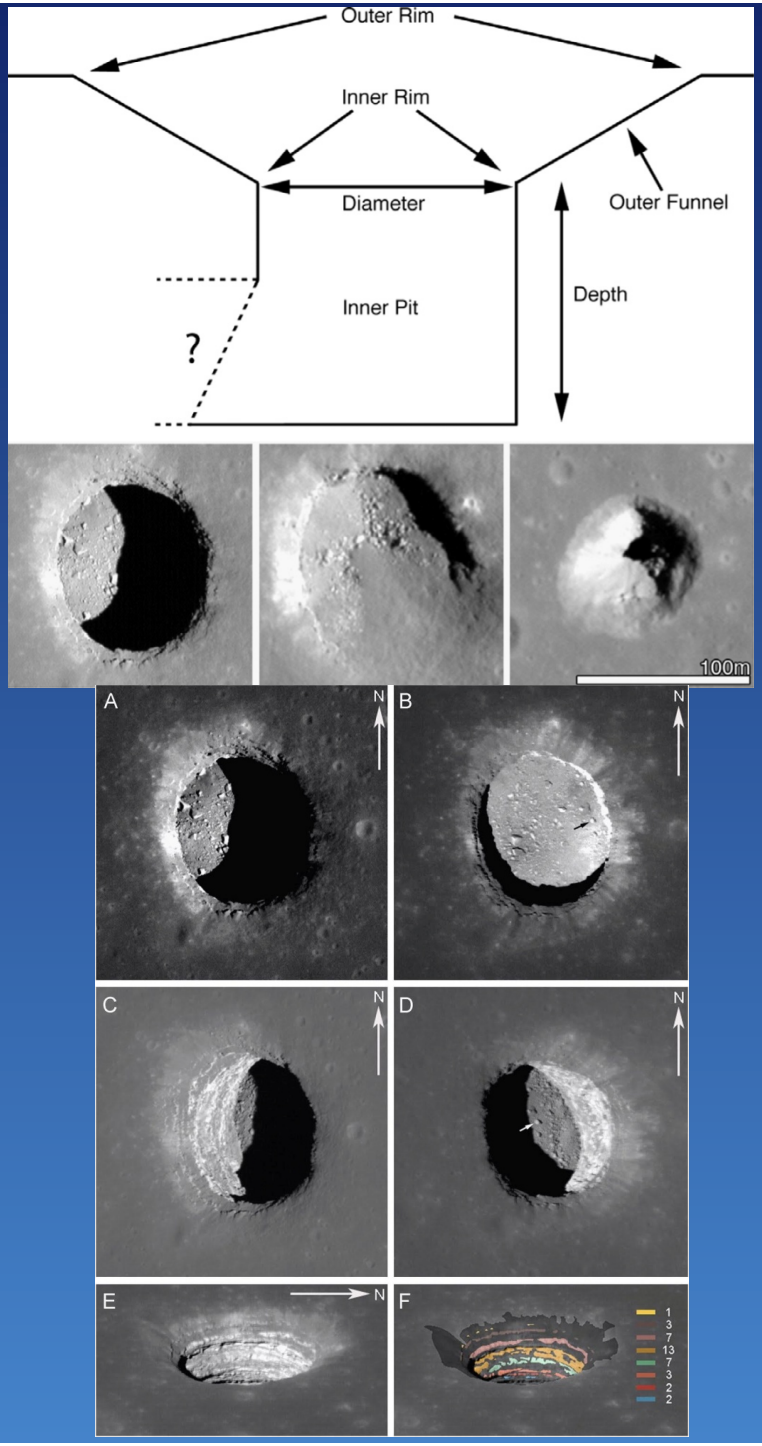
- **High resolution lunar observations identify pit craters** (*Haruyama et al., 2009; Robinson et al., 2012; Ashley et al., 2012; Wagner and Robinson, 2014*)
- **Formation:**
  - Volcanic and/or Structural
- **Subsurface void space**
- **Possible environmental conditions:**
  - Radiation protection & thermal stability *(Horz , 1985)*
- **Difficult linking caves to pits** (*Halliday (et. al) 1998, 2008, 2012*)





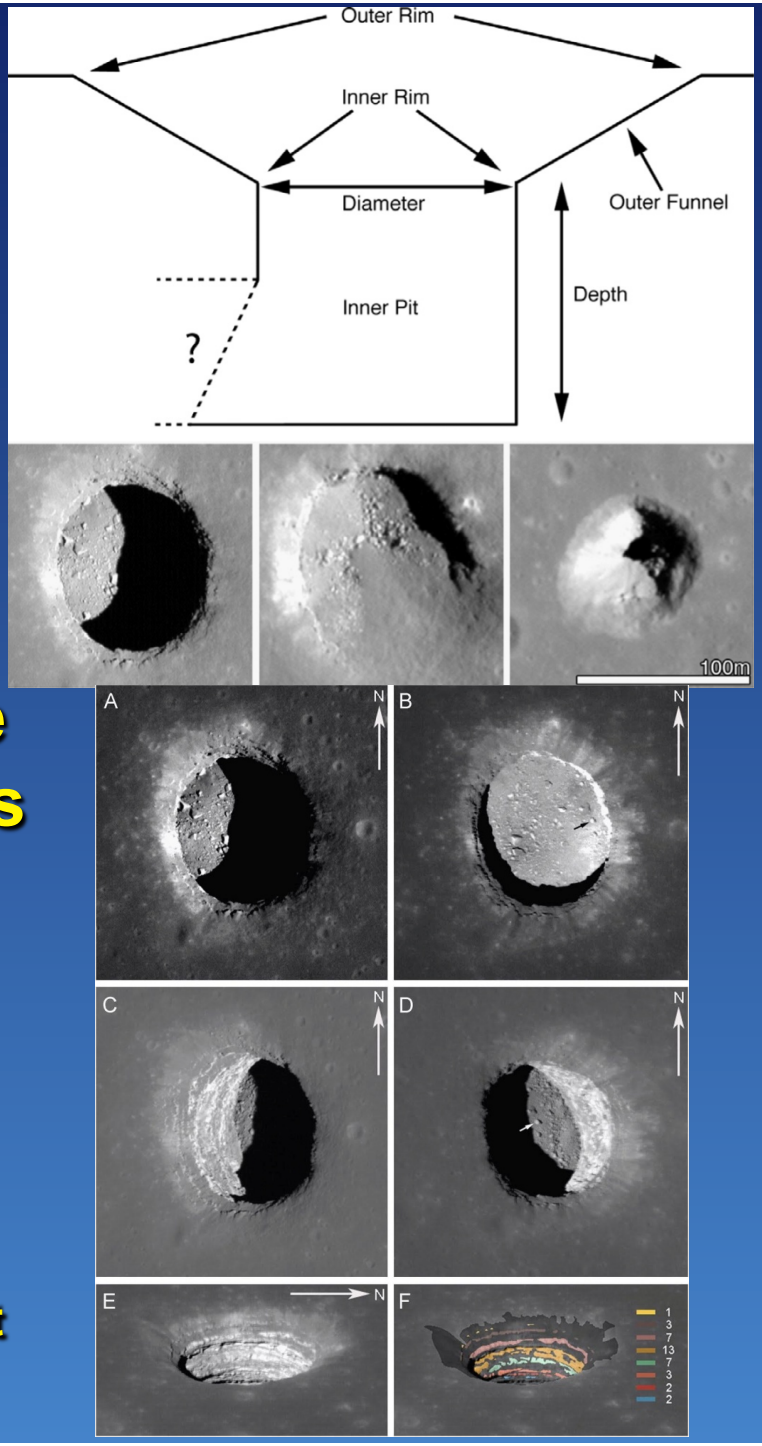
PIT MORHPOLOGY

- 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

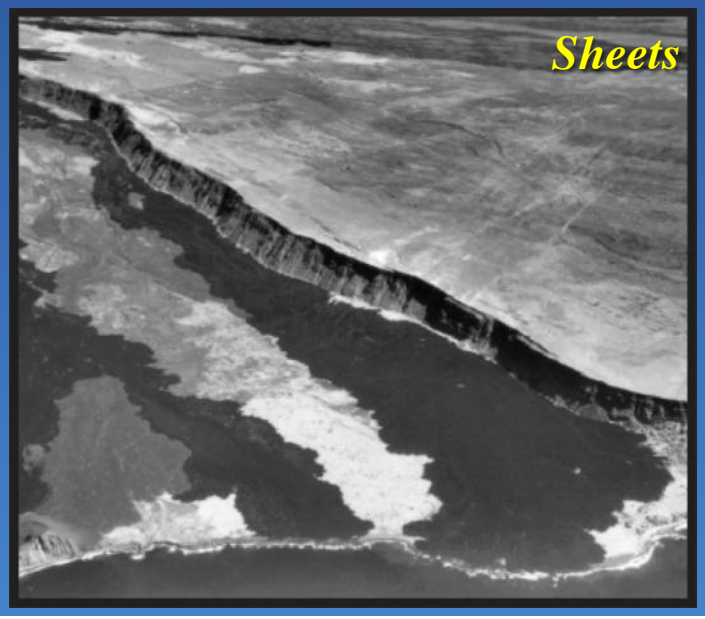


SSERVI RELEVANCE

- 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



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

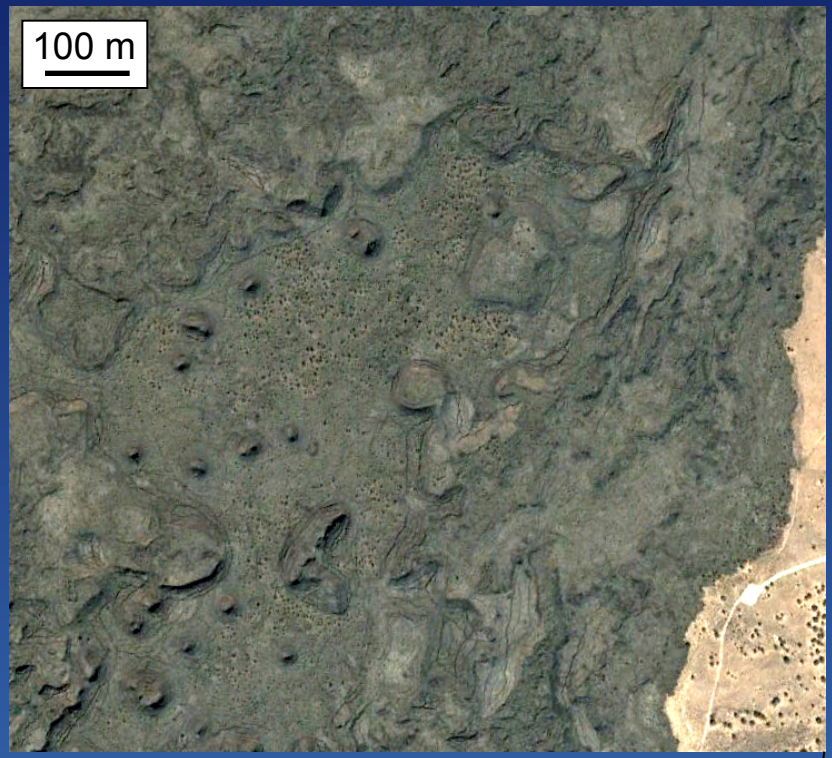
SHEETS

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

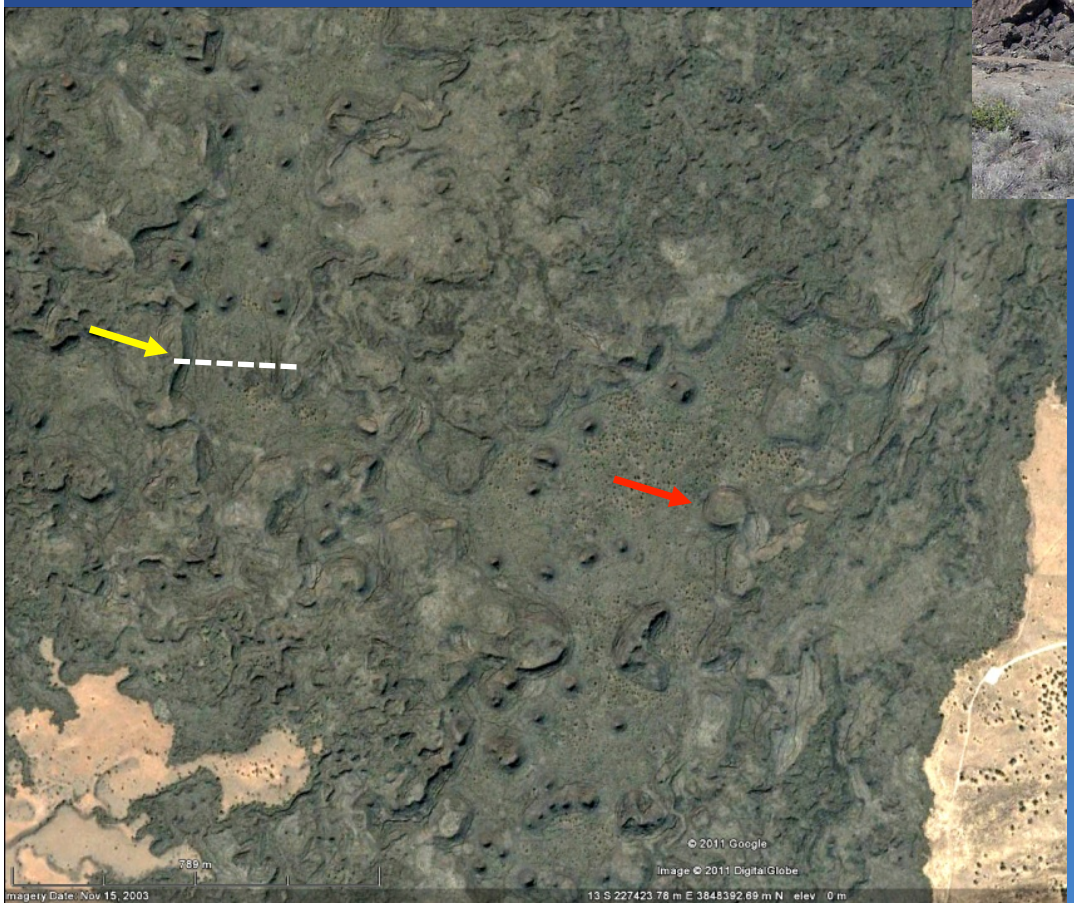
PLATEAUS


McCartys Flow, NM
CLSE field site
Route 66
Anzac
Ice Caves Rd
53
117
117
117
117


100 m

MARGINS

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



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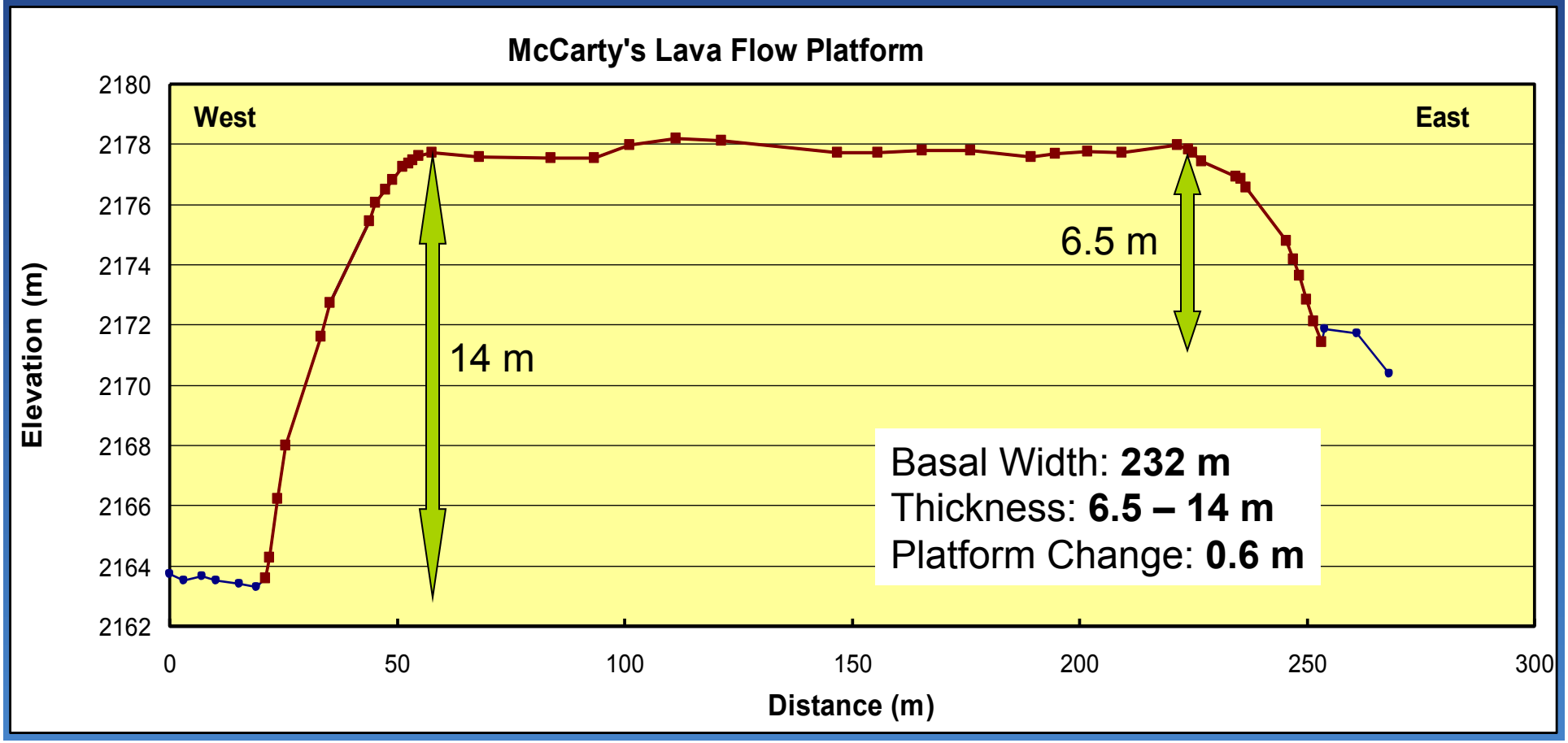
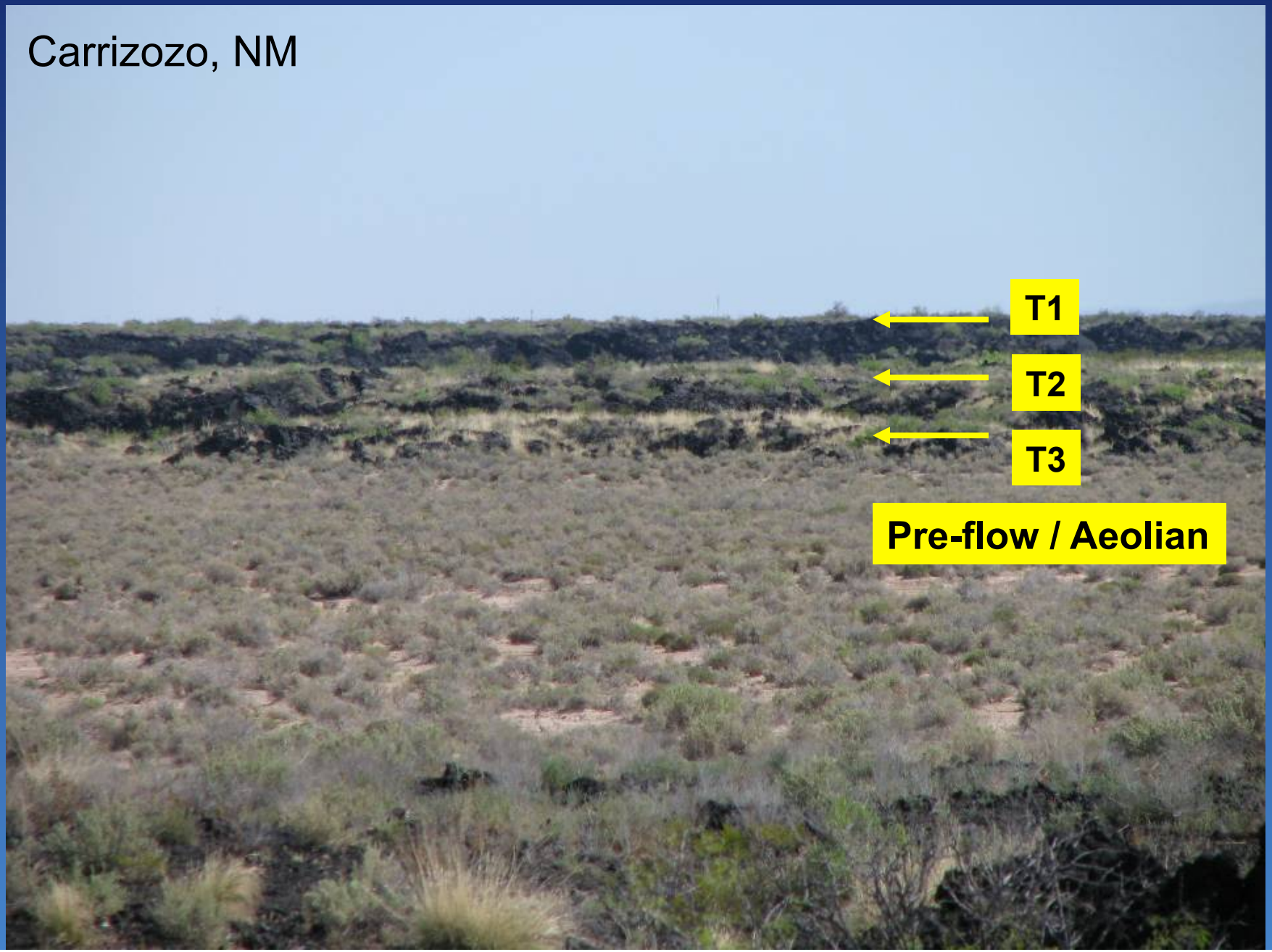


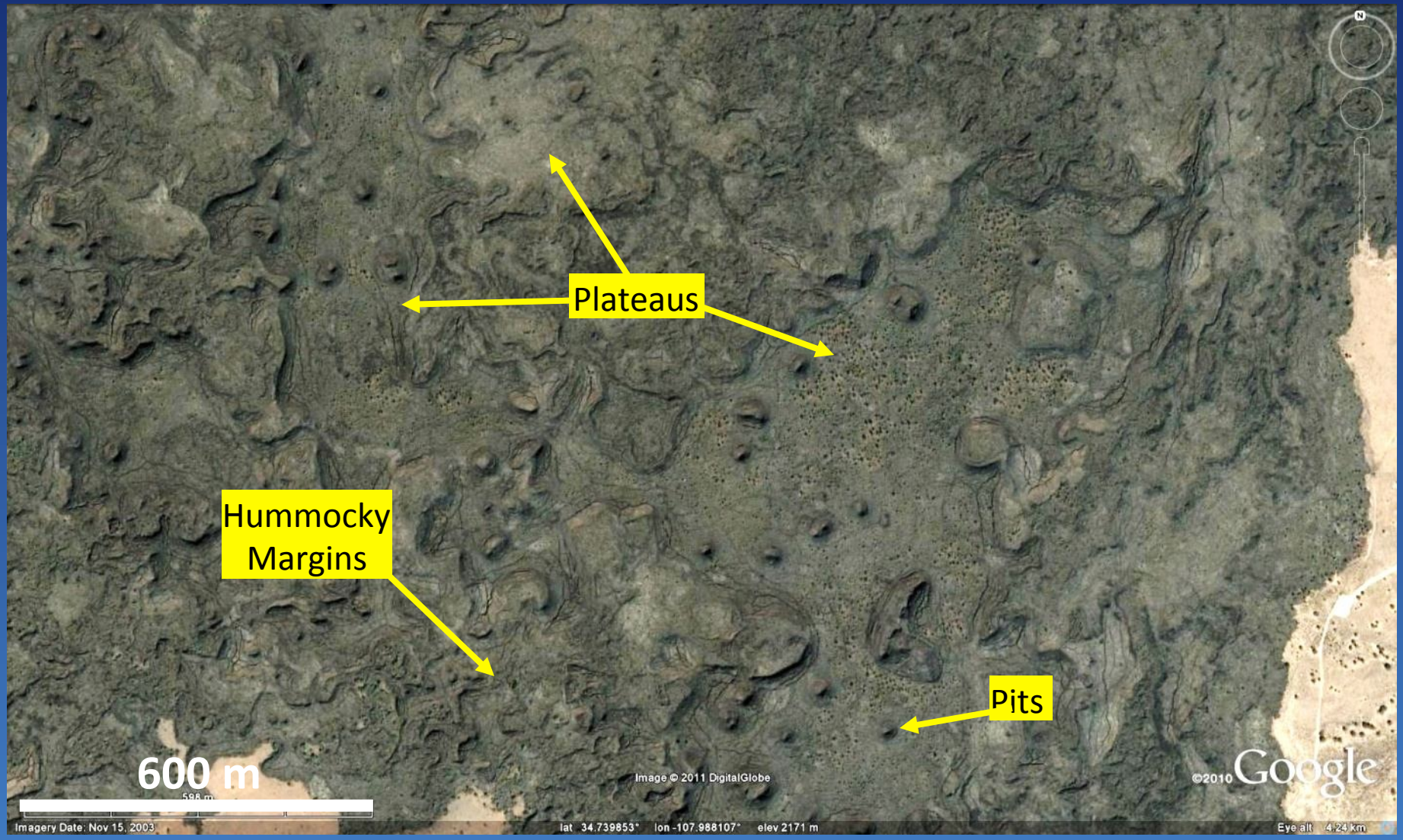
TERRACED MARGINS



INFLATED SHEETS

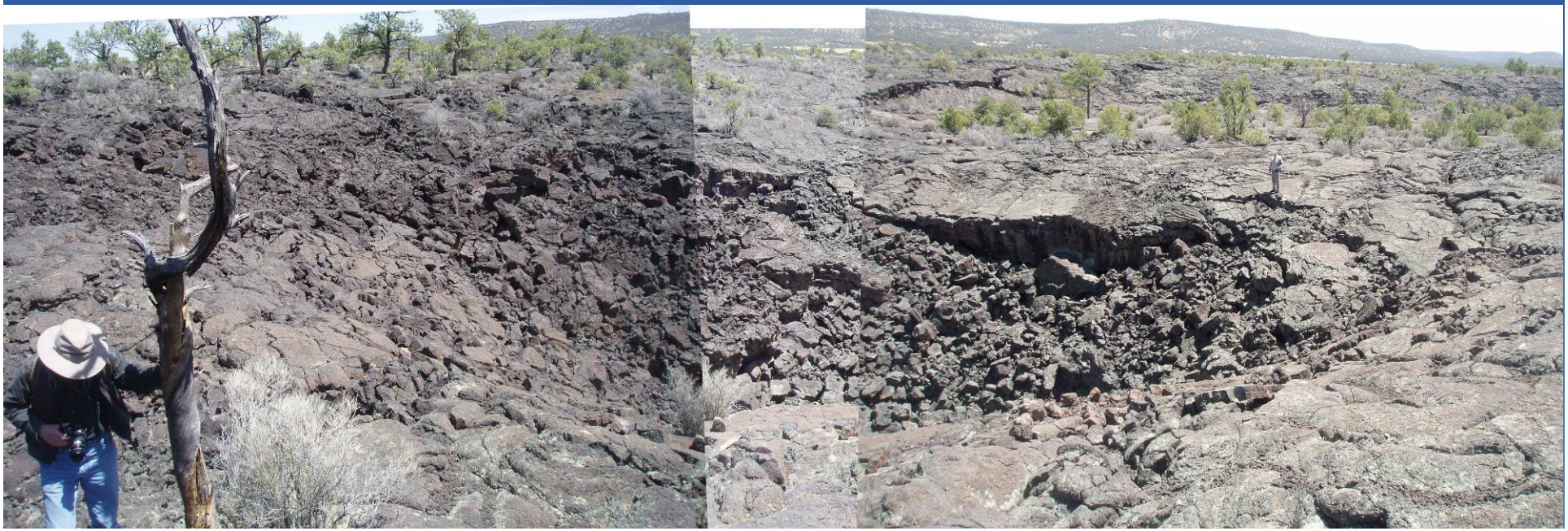
- Form apparently isolated plateaus with disrupted margins (hummocky flow fronts)
- Can form extensive, undisrupted surfaces
- Can contain pits

INFLATED SHEETS



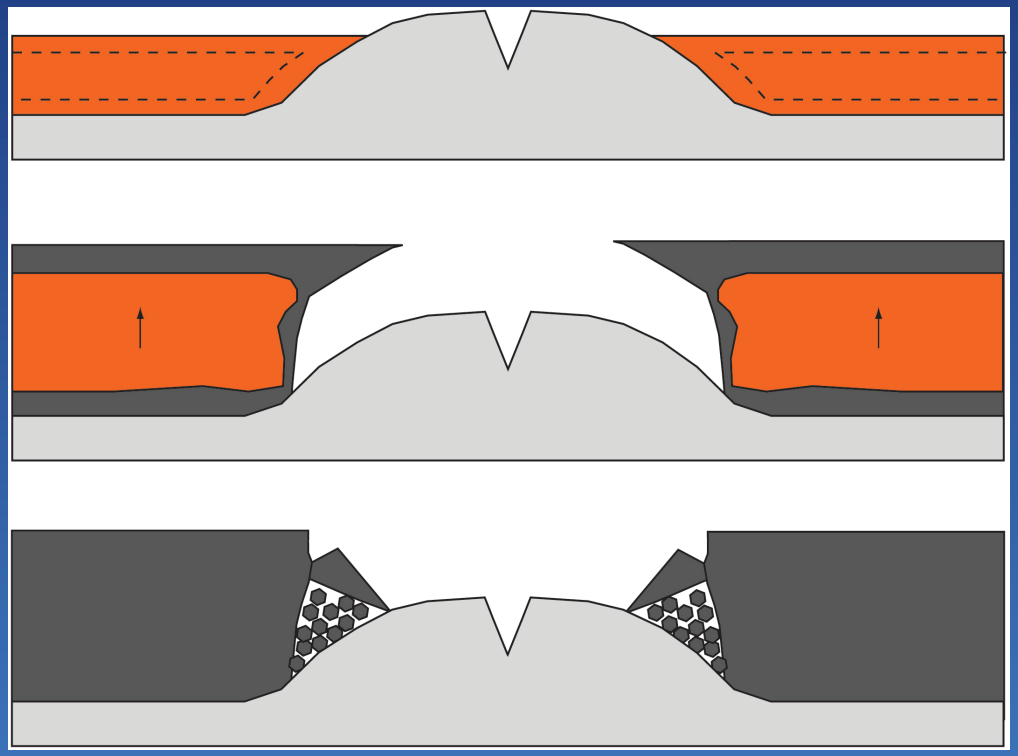
PITS

- 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



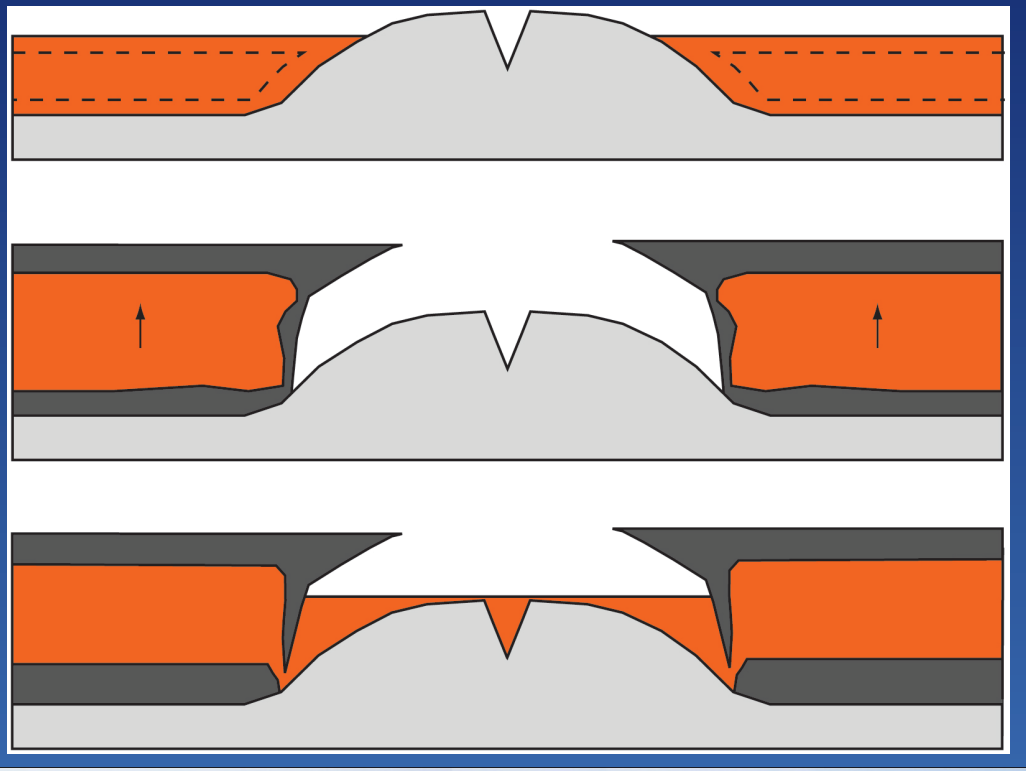
PIT FORMATION

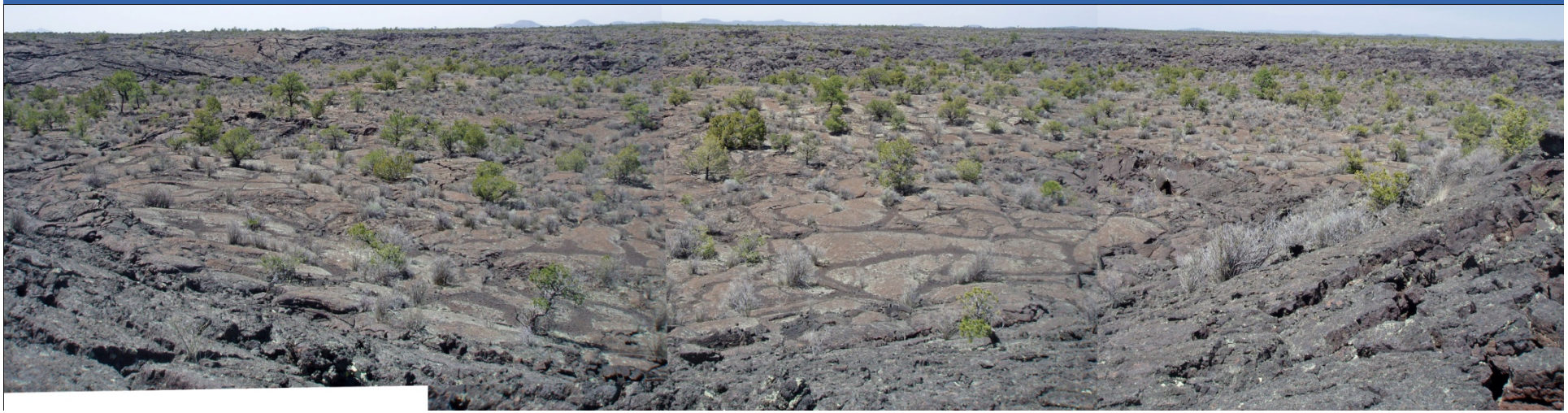
- Topographic obstacles locally inhibit inflation



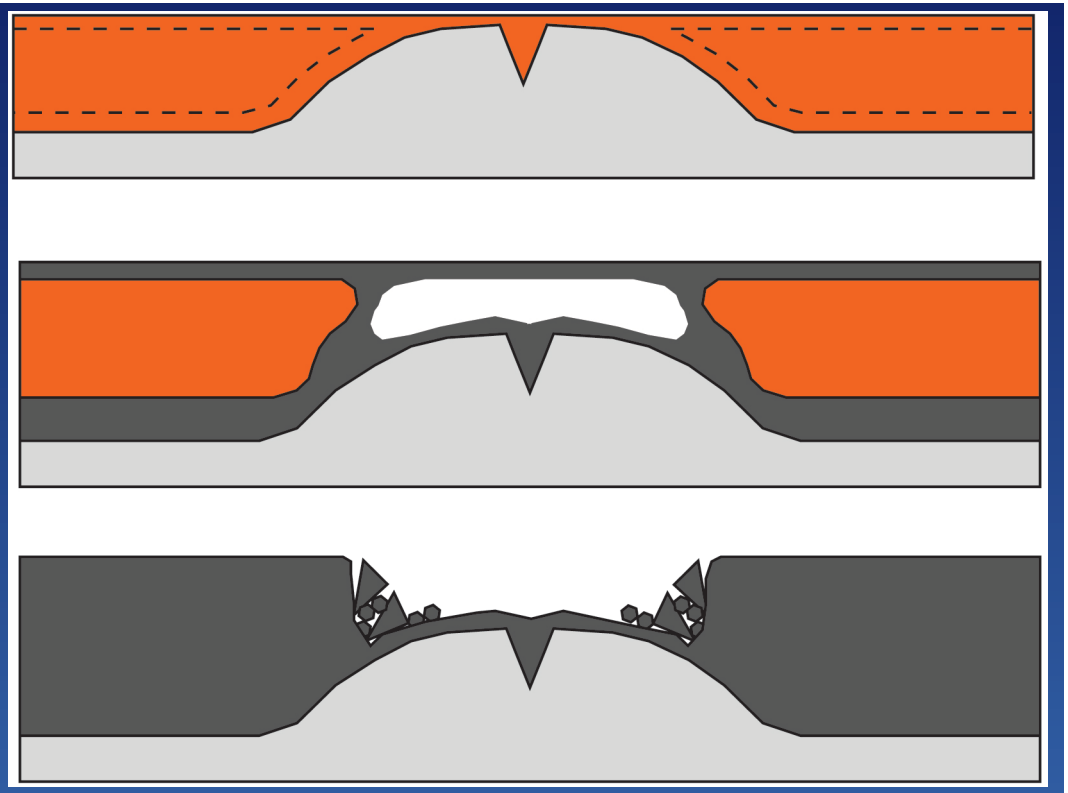
PIT FORMATION

- Floors can flood



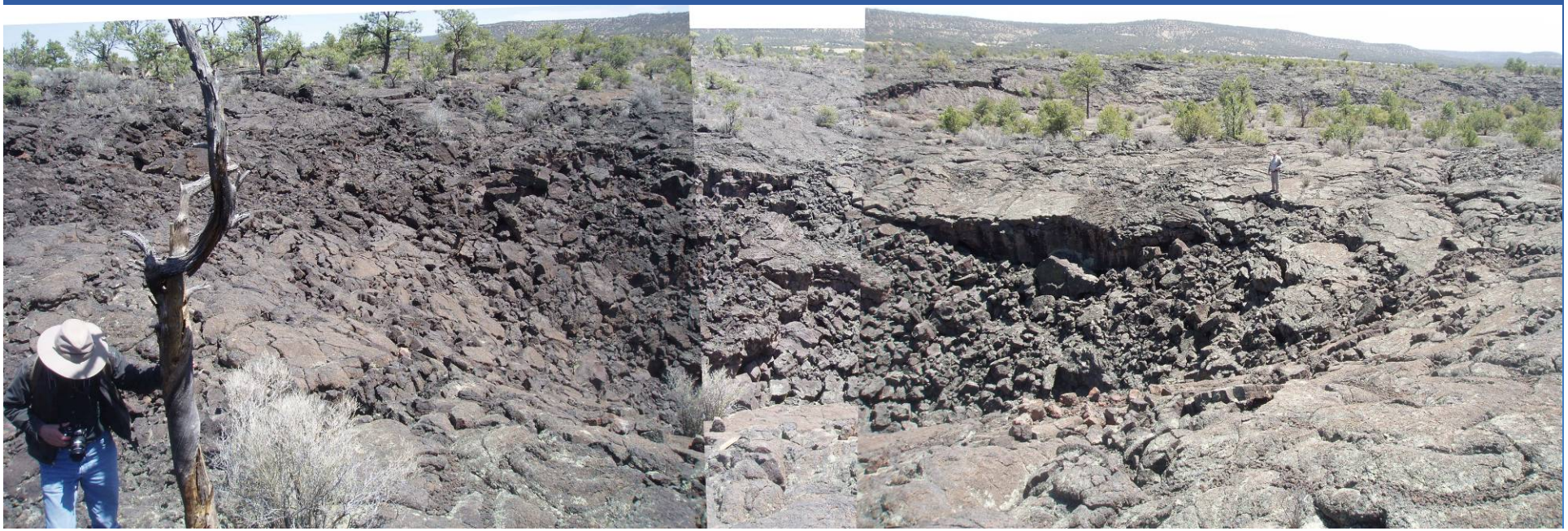


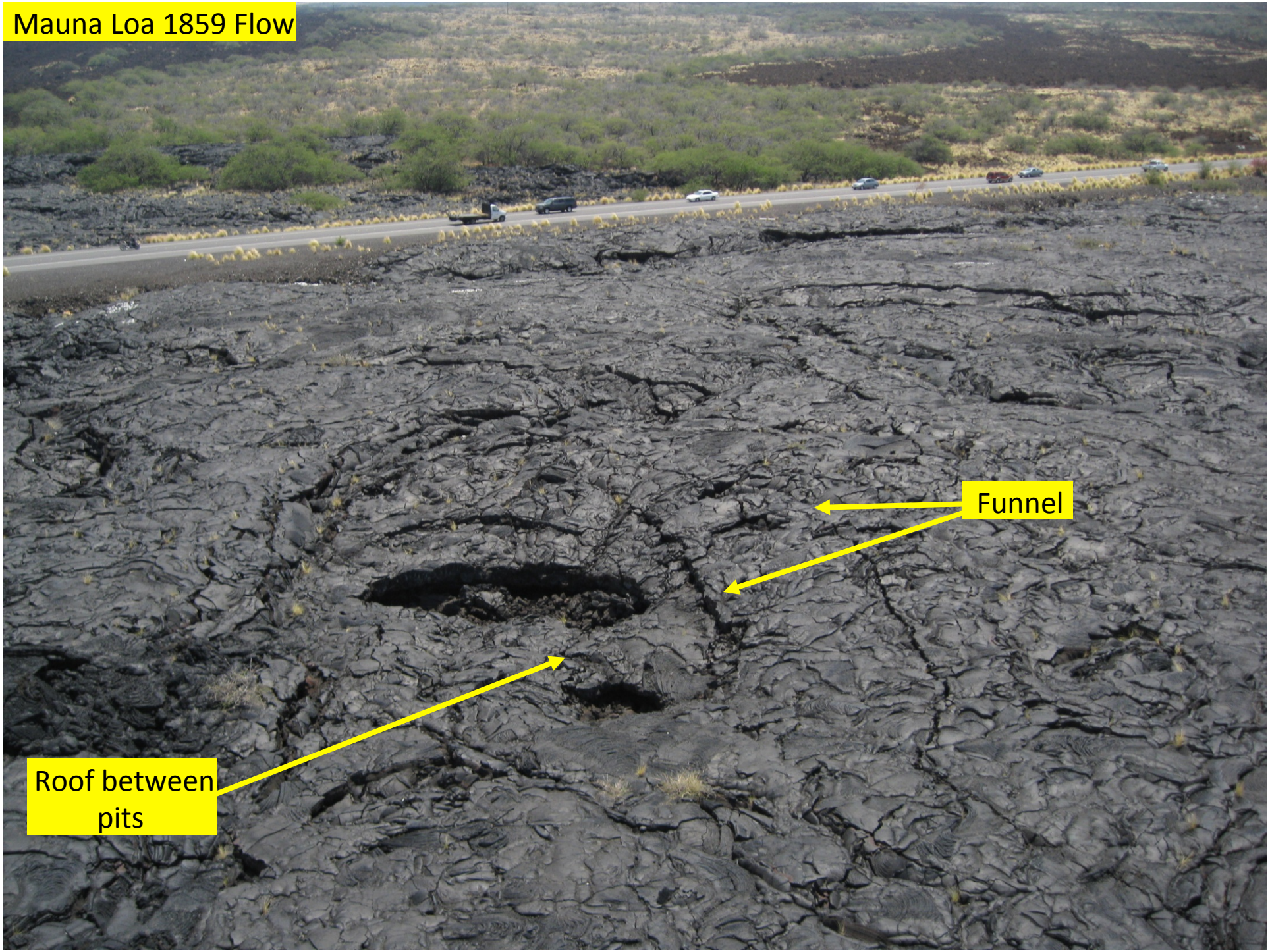
PIT FORMATION

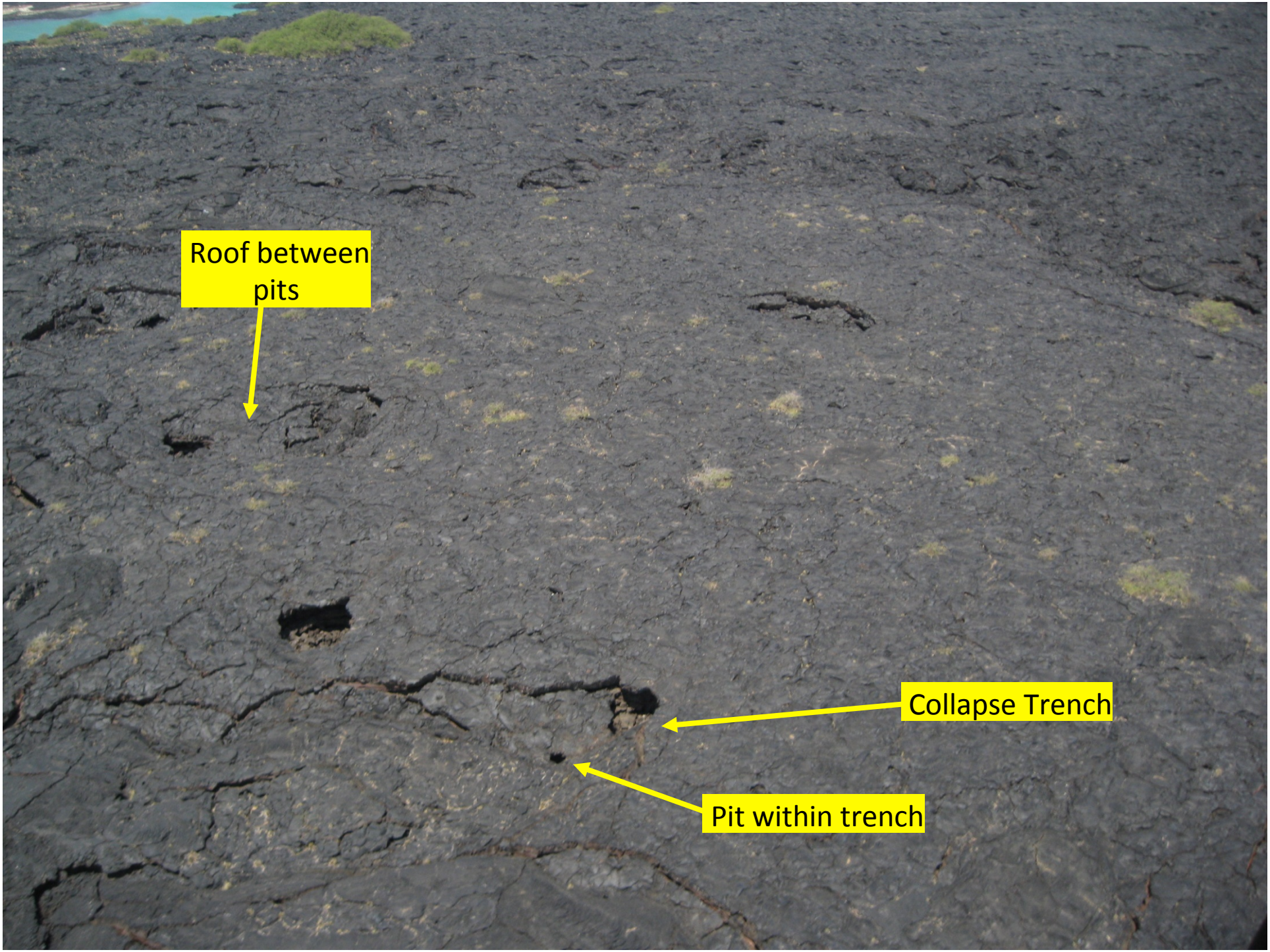


PIT FORMATION

- 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




Mauna Loa 1859 Flow
Funnel
Roof between pits

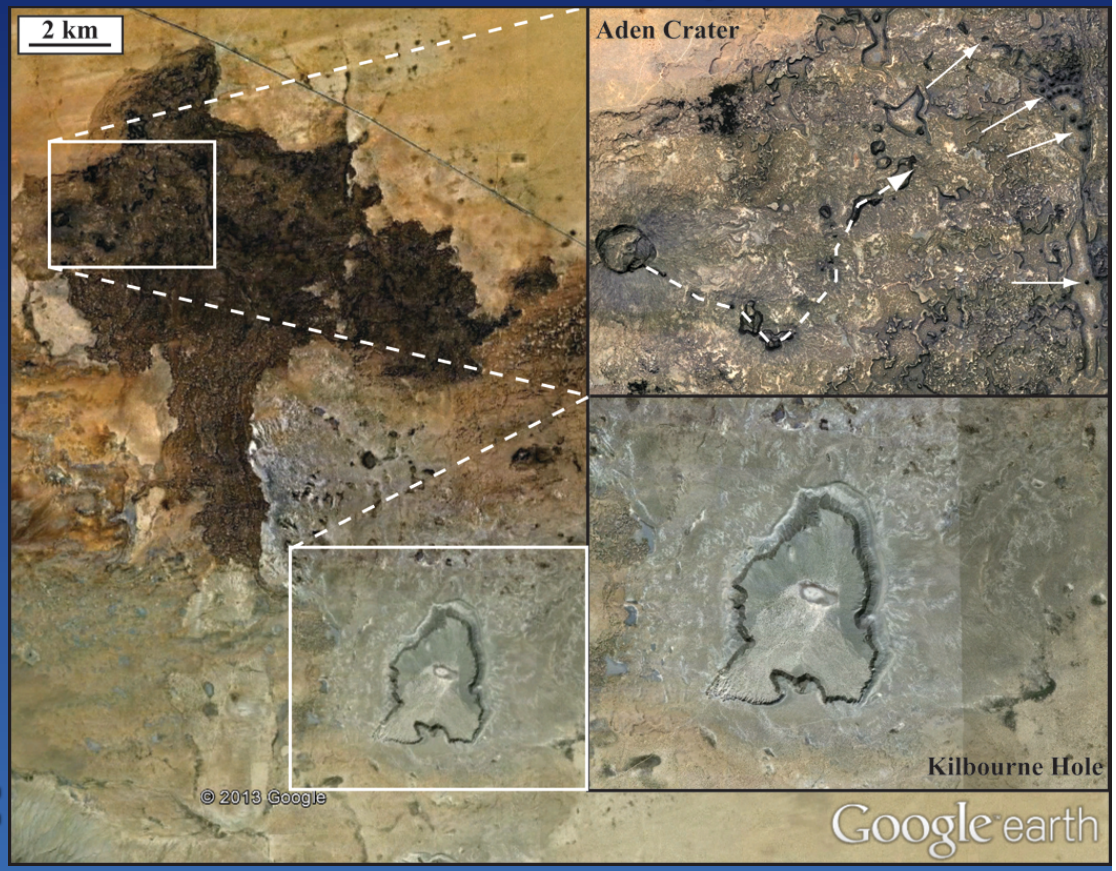

Roof between pits
Collapse Trench
Pit within trench


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

Potrillo Voclanic Field, NM
Primary RIS^{4}E field site



Aden Flow, Potrillo Volcanic Field, NM