Correlating Magnetic Anomalies & Geomorphology of Terrestrial Lava Tubes

AN ANALOG TO LUNAR PROSPECTING OF SUBSURFACE VOIDS

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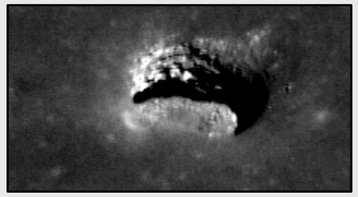
WHAT ARE LAVA TUBES?:

- "Tubes"/caves of basalt created from lava that solidifies on the surface and insulates flowing lava inside that drains, leaving a hollow tube
- Terrestrial variants: can be <1 m to >10's m diameter
- Lunar variants: theorized to be 100's to 1000's of m in diameter

Valentine Cave, LBNM. Diameter here is ~4 m.



Lunar collapsed pit, Marius Hills Hole (dia. ~65 m, depth ~85 m, roof ~25 m) [credit NASA/GSFC/ASU]

SCIENTIFIC & EXPLORATION MOTIVATIONS:

- Knowledge of the extent of lava tube systems will advance the understanding of lava flow transport processes
- Potential resource for providing human crews shelter from radiation, micrometeoroids, and large thermal fluctuations

GEOPHYSICAL PROBLEMS TO ADDRESS:

- External mapping currently conducted by inferring position by visually locating, and "connecting the dots" of collapsed features
- Internal geomorphologic characterization currently accomplished by entering and mapping (hand sketch and compass, or laser scanning)

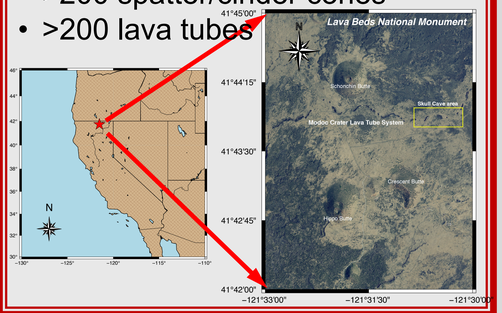
GOAL: Use lava tube magnetic signature to map & characterize

HYPOTHESIS: Lava tube magnetic anomalies are related to geometry & depth

ANALOG FIELD SITE:

LAVA BEDS NATIONAL MONUMENT

- Over 1125 km^2 of volcanic features associated with Medicine Lake volcano
- >30 major lava flows
- >200 spatter/cinder cones
- >200 lava tubes



FIELD METHODS:

Magnetic survey:

- Ground level magnetic survey of absolute field strength
- Survey conducted using parallel pattern at 2-4 m intervals

3-D LiDAR mapping:

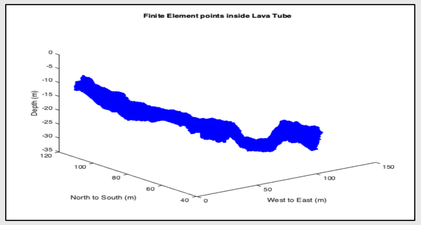
- Lava tube interior and ground surface laser scanning (LiDAR)
- Provides location & geometry

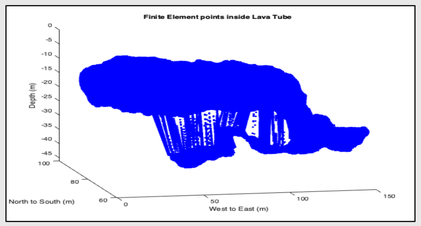
ANALYSIS: LBNM, Modoc Crater lava tube system caves...

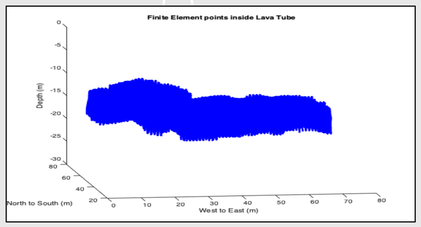
Incline Cave | *Skull Cave* | *Ship Cave*

Interior Photo

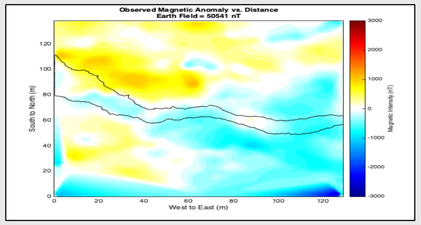
3-D LiDAR Derived Model of Cave Interior

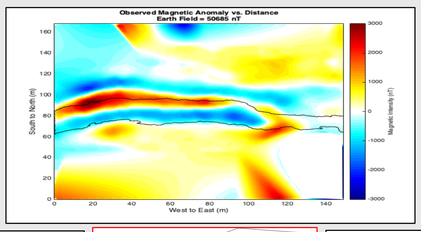


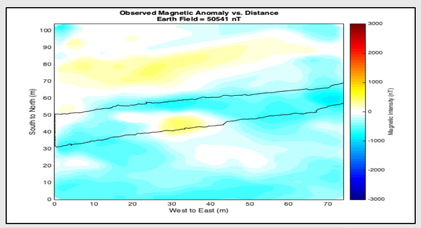




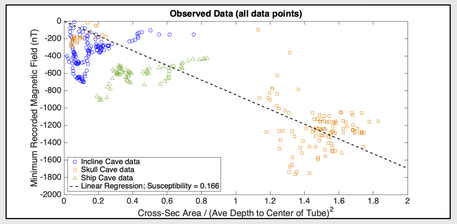
Magnetic Anomalies **OBSERVED DATA**

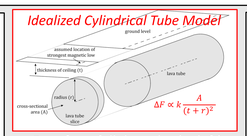




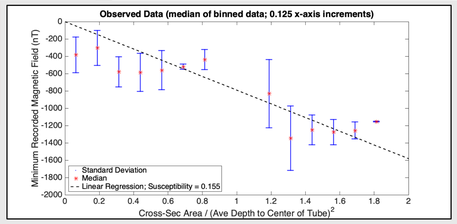


Geomorphic Analysis: **OBSERVED DATA**

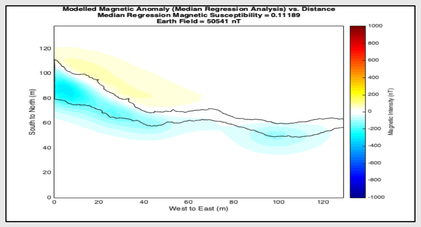


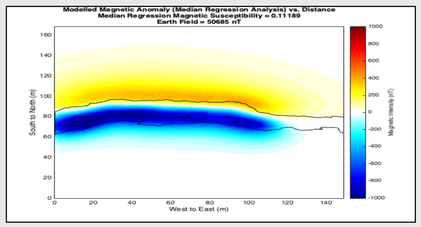


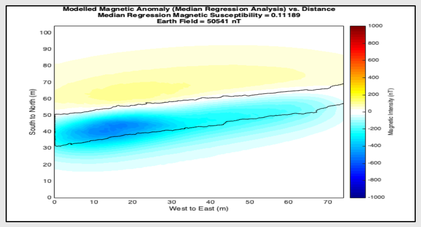
Data from full data plot (at left) binned at x-axis increments of 0.125 → to create median regression plot (at right)



Magnetic Anomalies **MODELED DATA** *based on magnetic susceptibility from observed geomorphic analysis*







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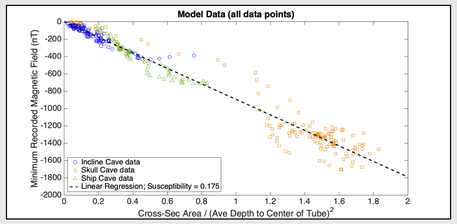

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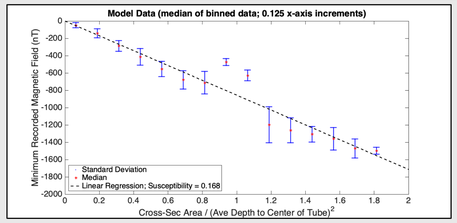

CONCLUSIONS

- Magnetic anomalies of a lava tube can be correlated to its geometric ratio (x-sec area & depth to center)
- Geophysical methods can be used to evaluate lunar lava tubes potential as future exploration targets

[1] Wagner, R., Robinson (2014), Icarus, 237, 52-60. [2] Horz, F. (1985) *Lunar Bases and Space Activities of the 21st Century*, 405-412. [3] Young, K. et al. (2018) *LPSC 49*, Abstract # *2504*. [4] Larson, C. & Larson J. (1990) *Lava Beds Caves*. [5] NPS Lava Beds (2017) https://www.nps.gov/labe/ planyourvisit/upload/GEOLOGY.pdf. [6] Tanaka, K. et al. (1986) *GSA Bulletin*, V97, 129-141. [7] U.S. Dept. of Agriculture Forest Service, (1/2/2020) https://www.fs.usda.gov/recarea/coconino/recreation/recarea/?recid=55122. [8] Whelley, P. et al. (2018, November). *GSA Annual Meeting, USA-2018*. [9] Garry, W.B. et al. (2017) *GSA Cordilleran Section Meeting*, Abstract 25-3. [10] Bell, E. et al. (2018) *LPSC 49*, Abstract # *2412*. [11] Blair, D. et al. (2017) *Icarus*, *282*, 47–55. [12] Hemingway, D., & Tikoo, S. (2018) *JGR: Planets*, *123*(8), 2223–2241.