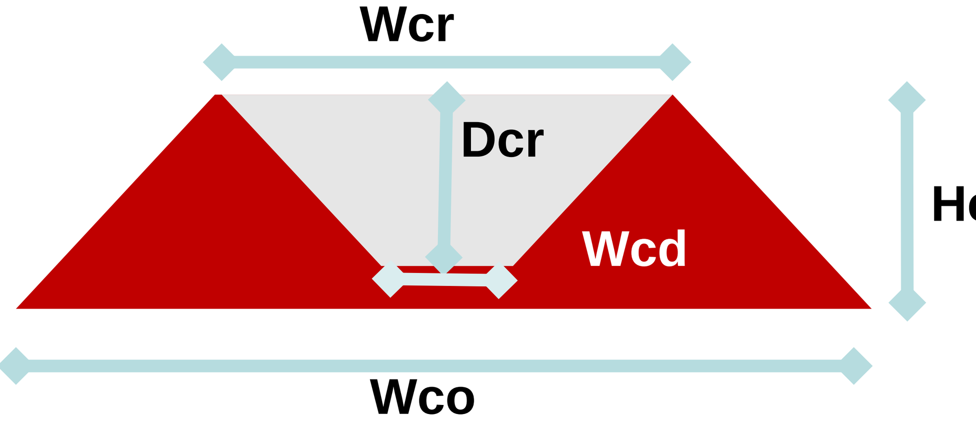
EGU2014-13546

Inferring conduit process from population studies of cinder cone craters

Karen G. Bemis
Institute of Marine and Coastal Studies, Rutgers The State University of New Jersey, New Brunswick, NJ

Cinder Cone Craters

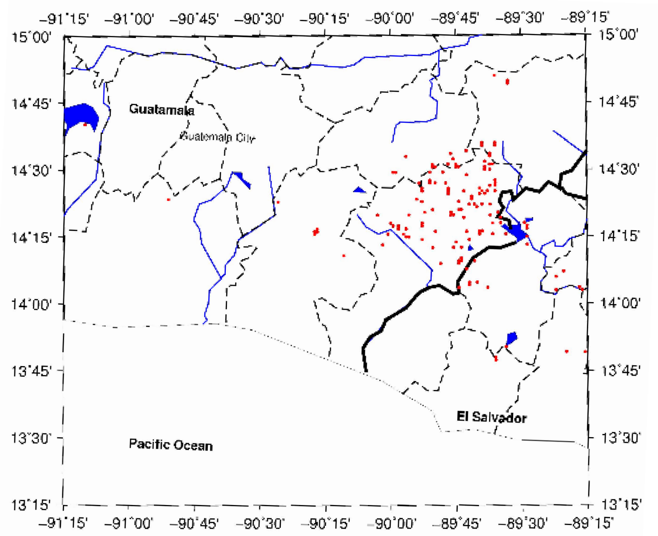
Objectives
1. Characterize the craters of a single cinder cone population
2. Test previous inferences about such craters
3. Infer constraints on conduit processes

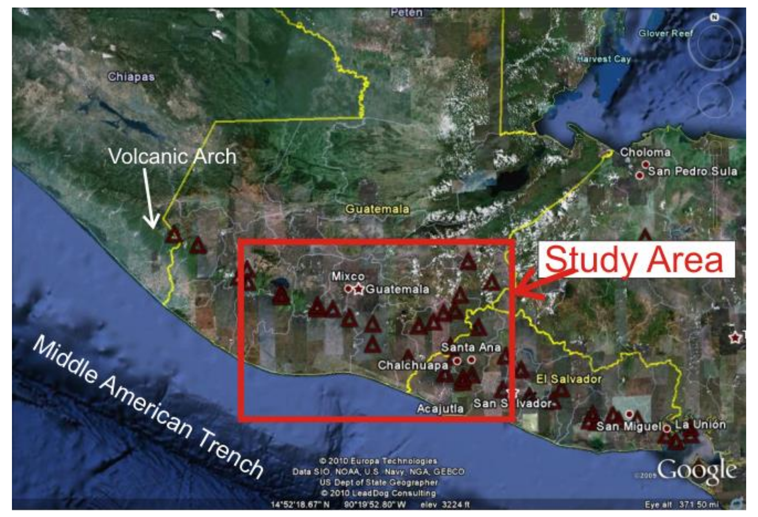


Inner (B) and Outer (A) Slopes specified as
$\tan A = 2 \cdot Hco/(Wco - Wcr)$
$\tan B = 2 \cdot Dcr/(Wcr - Wcd)$

Assuming
- crater depth is the maximum possible given a crater width
- crater slopes are at angle of repose or higher
- conduit width Wcd is finite (in vicinity of 10-50 m)

Guatemalan-Salvadoran Volcanic Field





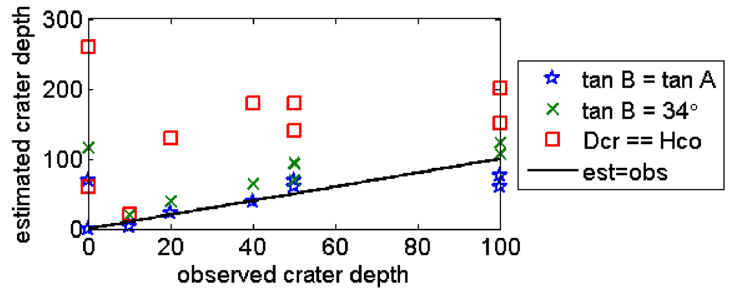
The population of cinder cones considered in this study are from the Guatemalan-Salvadoran Volcanic Field. Most are composed of basaltic scoria. Samples of scoria were collected from 9 selected cones.

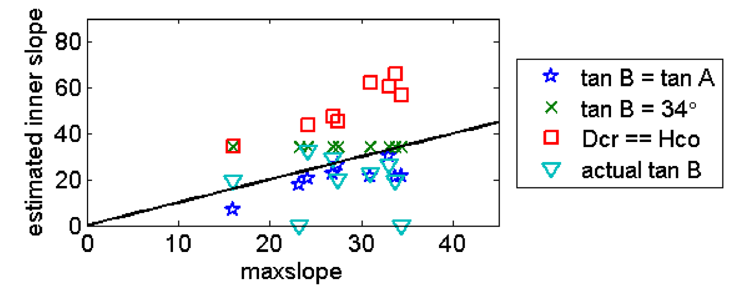
Controls on Morphology

- Erosion could infill craters or widen rims (e.g., Dohrenwend et al., 1987)
- Presence of spatter may support steeper crater walls (e.g., Kervyn et al., 2013)
- Finer particle grain sizes can increase the angle of repose (e.g., Riedel et al., 2003, Kervyn et al., 2013)
- Phreatomagmatic activity increases crater size (e.g., Carracedo et al., 1992)
- Wind drift and sloping ground elongate and displace craters (e.g., Kervyn et al., 2013)
- Vent level controls crater size (e.g., Kervyn et al., 2013)

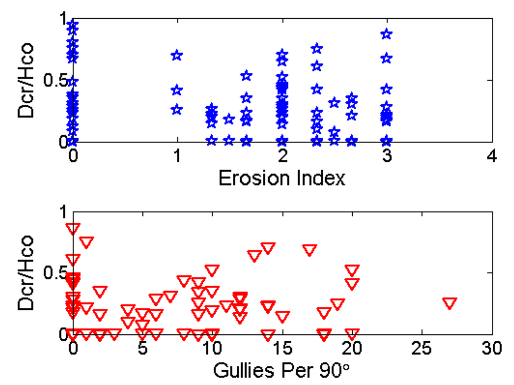
Expectations for Crater Depth

Three Possible Assumptions:
1. Inner slope same or higher than outer slope: $\tan B \geq \tan A$
   - $Dcr \geq Hco \cdot (Wcr-Wcd)/(Wco-Wcr)$
2. Inner slope always at angle of repose: $B = 34°$
   - $Dcr = \tan B \cdot (Wcr-Wcd)/2$
3. Crater base at substratum level: $Dcr=Hco$
   - Implies $\tan B = 2Hco/(Wcr-Wcd)$





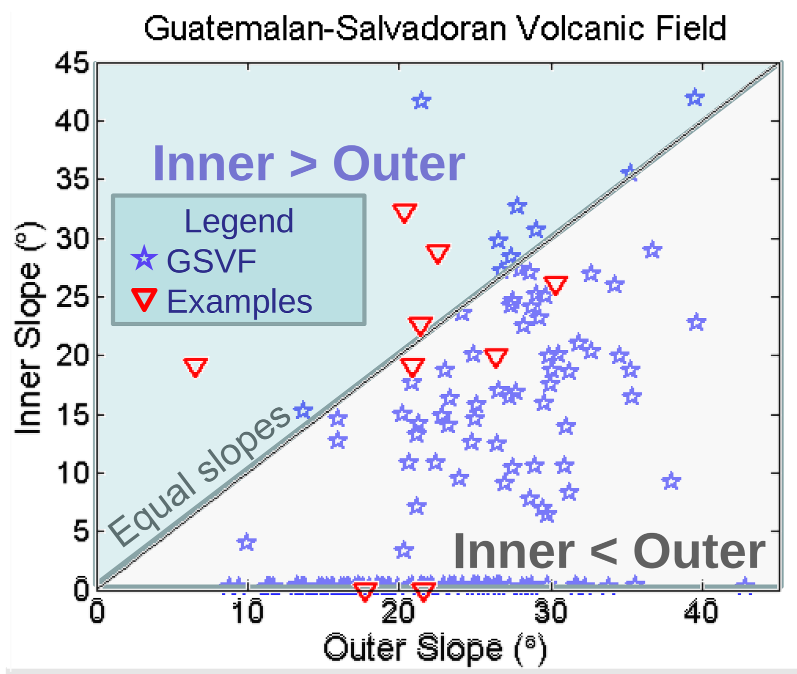
Best fit has inner crater slope varying with outer slope
Crater depth equal to cone height produces unrealistic slopes



No indication that shallow craters are due to erosional infilling is observed

Population Statistics

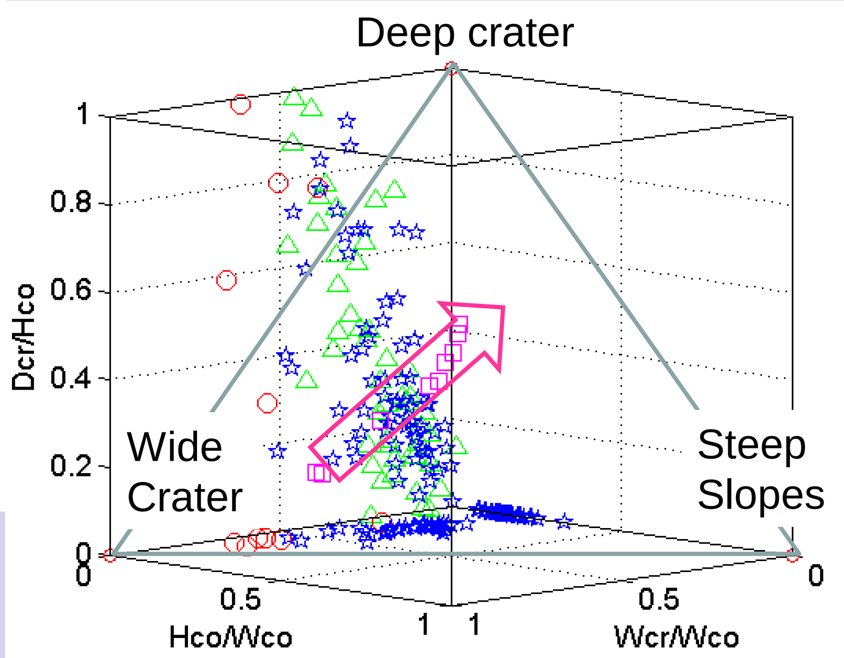
Inner Slope vs. Outer Slope



Experiments with granular materials find inner slopes larger than outer due to wall friction and particle chaining (Kervyn et al., 2013; Reidel et al., 2003).

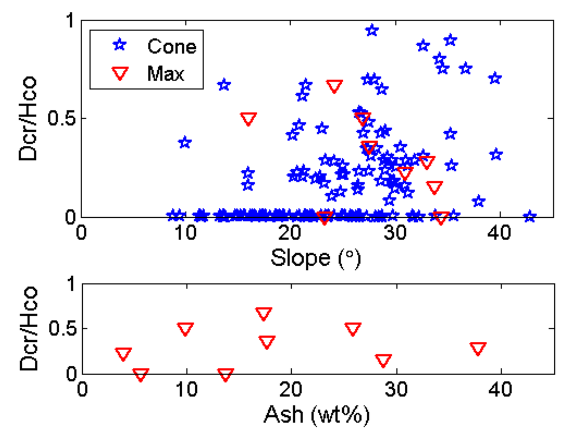
An inner slope larger than the outer is **RARELY** observed in GSVF cinder cones.

Crater Depth



- Cinder cone, Mauna Kea
- "maar", GSVF
- Cinder cone, GSVF
- Cinder cone, Laghetto

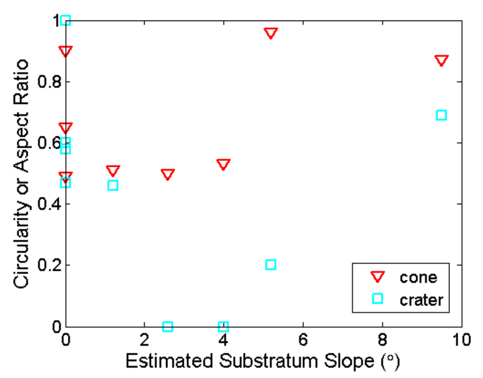
Both GSVF maars and the growth history of Laghetto suggest wider craters and shallower slopes indicative of phreatomagmatic processes.

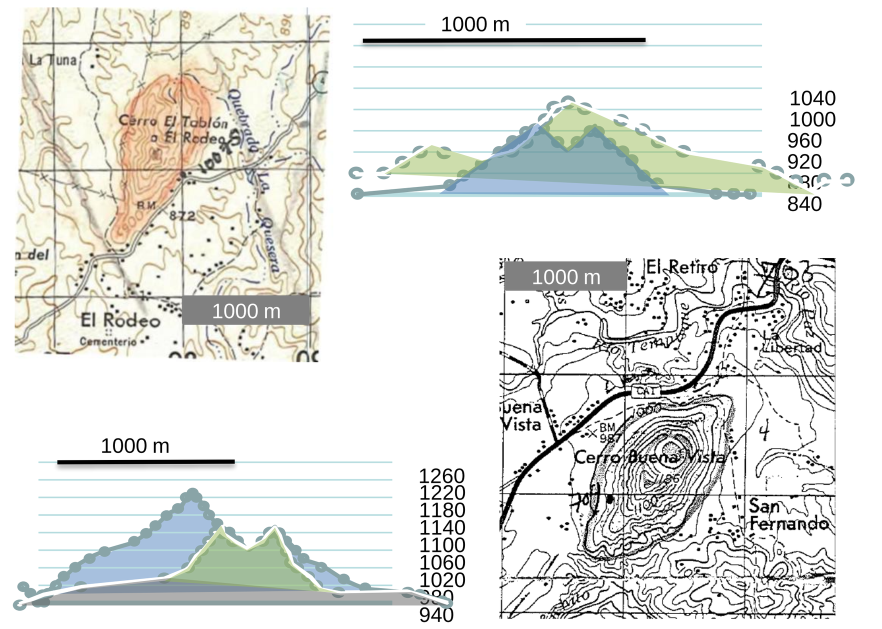


Phreatomagmatic processes are unlikely to control crater depth unless dominant throughout eruption.

Dcr/Hco uncorrelated with %ash and unlikely to be correlated with slope despite the apparent correlation (R^2=-0.5) with maximum slope.

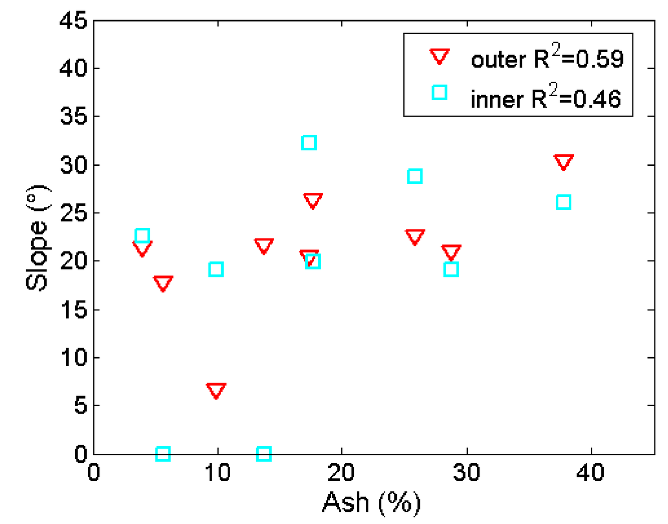
Crater Elongation





No obvious connection between crater elongation and substrate slope.

Slope vs. % Ash



Both inner and outer slope correlate with %ash.

Primary fragmentation of the magma may control slope for uneroded cones.

Conduit Processes

Observed crater depth/height varies significantly. Why?

- ❖ Over-pressured conduits may be one way to get higher crater base. Cone would then grow until conduit pressure dropped below atmospheric.
- ❖ Alternatively, "surface" level and conduit length may reset as cone grows upwards, with conduit pressure at or just above atmospheric.

Acknowledgements:

Thanks to Margot Ferenz for scanning maps and discussing cinder cone growth, to Mike Carr for discussion of Central American volcanism, and my colleagues in volcanology for inspiring papers.

References:

Carracedo, et al., (1992). The 1730–1736 eruption of Lanzarote, Canary Islands: a long, high-magnitude basaltic fissure eruption. *J.Volcanology and Geothermal Research*, *53*(1), 239-250.
Dohrenwend, et al., (1986). Development of Quaternary cinder cones in the Cima volcanic field, Mojave Desert, California. *Geological Society of America Bulletin*, *97*(4), 421-427.
Giberti, G., & Wilson, L. (1990). The influence of geometry on the ascent of magma in open fissures. *Bulletin of Volcanology*, *52*(7), 515-521.
Kervyn, M., et al., (2012). Geomorphometric variability of "monogenetic" volcanic cones: evidence from Mauna Kea, Lanzarote and experimental cones. *Geomorphology*, *136*(1), 59-75.
Mastin, L. G. (2002). Insights into volcanic conduit flow from an open-source numerical model. *Geochemistry, Geophysics, Geosystems*, *3*(7), 1-18.
Riedel, C., Ernst, G. G. J., & Riley, M. (2003). Controls on the growth and geometry of pyroclastic constructs. *Journal of Volcanology and Geothermal Research*, *127*(1), 121-152.
Valentine, G. A., & Gregg, T. K. P. (2008). Continental basaltic volcanoes—processes and problems. *Journal of Volcanology and Geothermal Research*, *177*(4), 857-873.