DETAILED MAPPING IN THE LOST MINE TRAIL AREA, BIG BEND NATIONAL PARK

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Abstract

The Lost Mine Trail (LMT) area of the Chisos Mountains lies just outside the north-eastern margin of the Pine Canyon Caldera (PCC). The South Rim Formation (SRF) in the high Chisos Mountains is thought to involve two separate and distinct peralkaline magmas, one producing the lava and tuffs of the Pine Canyon Rhyolite (PCR) and Boot Rock Members (BRM), and the other producing the lava and tuffs of the Emory Peak Rhyolite (EPR). Included in the SRF is a swarm of dikes that strike west-southwest from the north-eastern margin of the PCC toward extra-caldera vents at Casa Grande, Toll Mountain, and Emory Peak. Detailed field mapping at a 1:10,000 scale of the LMT area has recorded a more accurate spatial distribution of these dikes, as well as providing some new information on the structure and general geology of the area. Mass balance modeling combined with further trace element modeling has provided evidence for a co-magmatic relationship for the dikes on top of the LMT, and the Casa Grande Lava Dome. Pearce element ratios indicate that these dikes and the Casa Grande Lava Dome are related to the source magma for the PCR and BRM, and not the source magma of the EPR. The geologic map combined with the geochemical modeling provides evidence for a complex plumbing system that connects the PCC to the extra-caldera vent at Casa Grande. Ideas are also proposed about the structure and sequence of geologic events in the area.

Petrogenesis

Differentiation of the dikes of the Lost Mine Trail area and Casa Grande lava dome was modeled using single-stage fractional crystalization. No assimilation of crustal rock is apparent when looking at trace element data. Also, the narrow band of activity between the emplacement of the dikes and the eruption of the lava dome leads to the low probability that assimilation would have been a significant factor in the differentiation of these rocks.

Major element mass balance modeling suggest that differentiation of the trachytes and rhyolites from 68.9% (TXCH-NE10) to 69.6% (TXCH-OSRLD3) can be achieved by 58.2% fractionation of an assemblage consisting of 72.7% K-feldspar, 15.6% quartz, 10.5% clinopyroxene, 0.6% ilmenite, and 0.6% fayalite. Major element data for these phases were provided by White et al. (2006). The residual sum ($\sum r^2$) in this major element model was good at $\sum r^2 = 0.045$. The results of the mass balance model were enough evidence to further test the hypothesis using trace element modeling shown in figure 8.

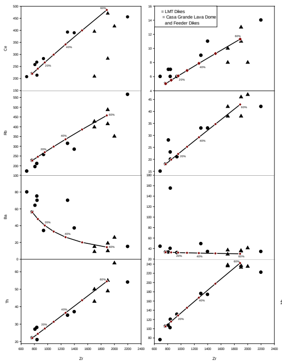

Figure 8. The trace element model using Zr as the differentiation index seems to fit the behavior of the incompatible elements pretty well. The model was built using 60% fractionation which is just slightly greater than the 58.2% suggested by the mass balance model. Many of the model curves fit very well, but Ce, and Yb have plots which show more scatter compared to the other trace elements.

Conclusions

The evidence produced by this research suggests that the dikes of the Lost Mine Trail area, and the Casa Grande lava dome are co-magmatic. These dikes may be the remnants of the magmatic plumbing system that fed the eruptions at Casa Grande. These eruptions produced maar-type gas surge deposits, than emplaced the lava domes.

The geologic map illustrates the behavior of how these dikes intruded outside the Pine Canyon Caldera. The results of the major element mass balance model show that the chemistry of the magma of the Casa Grande lava dome could hypothetically be derived by single stage fractional crystalization of the magma of the dikes on top of Lost Mine Trail. The trace element models also match well with the raw trace element data fortifying the idea of co-magmatic relationships.

Pearce element ratios indicate that these dikes were part of the Pine Canyon suite, and not associated with the magma of the Emory Peak suite. These dikes are most likely associated with the later eruptions of the Boot Rock Member outside the Pine Canyon Caldera. These dikes cross-cut Boot Rock Member on top of Lost Mine Trail which supports the idea that the Boot Rock Member was erupted out of multiple vents, and in multiple episodes.

Evidence from recent mapping also suggests that the folding of the Chisos Formation was a result of the emplacement of the Osri large intrusion/lava dome, which would require a revision to the sequence of geologic events in the Chisos Mountains. Further research in to the details of the Osri large intrusion/lava dome would help confirm this.

Cited References

Maxwell, R.A., Lonsdale, J.T., Hazzard, R.T., Wilson, J.A., 1967, Geology of Big Bend National Park, Brewster County, Texas: University of Texas at Austin Bureau of Economic Geology, p. 271-298

Ogley, D.S., 1978, Eruptive history of the Pine Canyon Caldera, Big Bend National Park, Texas [M.S. thesis]: University of Texas at Austin.

Turner, K.J., Berry, M.E., Page, W.R., Lehman, T.M., Bohannon, R.G., Scott, R.B., Miggins, D.P., Budhan, J.R., Cooper, R.W., Drenth, B.J., Anderson, E.D., Williams, V.S., 2011, Geologic map of Big Bend National Park, Texas: U.S. Geological Survey Scientific Investigations Map 3142, scale 1:75,000, pamphlet 84 p.

Urbanczyk, K.M., White, J.C., 2000, Pine Canyon caldera, Big Bend National Park, Texas: a new interpretation: Geological Society of America Abstracts with Programs, v. 32, no. 3, p. 43.

White, J.C., Benker, S.C., Ren, M., Urbanczyk, K.M., Corrick, D.W., 2006, Petrogenesis and tectonic setting of the peralkaline Pine Canyon Caldera, Trans-Pecos Texas, USA: Lithos, v. 91, p. 74-94, doi: 10.1016/j.lithos.2006.03.015.

Geology of the Lost Mine Trail Area

Introduction

The Lost Mine Trail is one of the most popular trails in Big Bend National Park. It also happens to be in a very interesting area just outside the north-eastern margin of the Pine Canyon Caldera. The area host Paleogene rocks of the Chisos Formation and South Rim Formation. The Chisos Formation in this mapping area is made up of two mafic flows; the Ash Spring Basalt (40.92 +/- 0.07 Ma) and the Bee Mountain Basalt (34.03 +/- 0.17 Ma to 33.07 +/- 0.15 Ma) (Turner and others, 2011). These two lava flows lie in between inter-beds of undifferentiated tuffaceous sediments. The South Rim Formation is made up of felsic extrusive and intrusive rocks associated with multiple episodes of volcanism between 32.04 Ma and 32.40 Ma (Turner and others, 2011). The South Rim Formation is made up of 3 extrusive units; the Pine Canyon Rhyolite, the Boot Rock Member, and the Emory Peak Rhyolite. Also included in the South Rim Formation are the dikes, and the large intrusions that frame the Basin area.

Field Observations

The geologic map in this paper shows the spatial distribution of these dikes and intrusions between the western margin of the Pine Canyon Caldera and the extra-caldera vents at Casa Grande, Toll Mountain and Emory Peak. Most of the dikes do not have continuous surface expressions through the area and many are arcuate in nature.

The general orientation of the dikes seem to begin at the northwest wall of the Pine Canyon Caldera near the top of Lost Mine Trail. At this location they have a general strike of 265 to 275 degrees and make a slight curve going into Juniper Canyon as their orientation changes from 230 to 240 degrees (fig. 1). The set of dikes on top of Lost Mine Trail can be traced going into Juniper Canyon to the west, and ending at the south face of Casa Grande (fig. 2). At Chinese Wall the large dikes continue up to the top of Casa Grande Mountain (fig. 3).

Folding and uplift of Chisos Formation rock units took place between the timing of the eruption and partial erosion of the Bee Mountain Basalt, and the eruption of the Boot Rock Member. This folding is visible (fig. 4) toward the top of Lost Mine Trail. Dips were measured at over 40 degrees in the Chisos Formation in this area. An angular unconformity is present between the Bee Mountain Basalt and the Boot Rock Member implying that this folding event took place before the eruption flow of the Boot Rock Member in the area.

Small scale faulting of the Chisos Formation was observed along the eastern wall of Juniper Canyon. A larger fault structure mapped on the northern wall adjacent to the switchbacks, causes significant off-set of Chisos units, but very limited off-set in the Boot Rock Member. Fractures and small offset are observed in the Boot Rock Member, but could be from reactivation of this fault. A pair of fault structures causing significant displacement of rock units was discovered on the southern wall of Casa Grande. The specific cause and timing for the faulting in this area is not yet known.

Progression of Events

The progression of geologic events starts with the deposition and eruption of Chisos Formation sediments and mafic lava flows (Maxwell and others, 1967). This was followed by the eruption of the Pine Canyon Rhyolite and the subsequent collapse of the Pine Canyon Caldera. (Ogley, 1978) Interpretations from data collected from recent mapping concludes that the next event involved the large intrusion/lava dome being emplaced causing the uplift and folding of the Chisos Formation. The Boot Rock Member was then erupted out of multiple vents in a semi-circular ring around the PCC as well as outside the caldera. These maar-type vents erupted gas rich surge deposits followed by the emplacement of lava domes. There are multiple lava domes located in the area surrounding the PCC, including Pummel Peak, Lost Mine Peak and Crown Mountain. Outside the PCC lies the extra-caldera vents capped by lava domes at Casa Grande, Toll Mountain, and Emory Peak. (Urbanczyk and White, 2000)

Figure 1. Photo looking north north-west and shows a large dike in foreground curving from the eastern margin of Pine Canyon Caldera into Juniper Canyon. Other dikes can be seen just to the north at Chinese Wall.

Figure 2. Photo looking south-southeast from Casa Grande Mountain. It shows a dike swarm trailing from the area near the top of Lost Mine Trail into Juniper Canyon.

Figure 3. Photo looking west from Chinese Wall and shows the main set of feeder dikes for the Casa Grande Lava Dome. These dikes are on the south eastern flank of Casa Grande.

Figure 4. Photo looking southeast from near the top of Casa Grande Mountain. It shows the uplifting of the Chisos Formation by the Osri large intrusion/lava dome which is located toward the left side of the photo.

Petrography

The Casa Grande lava dome and Dike samples range from per-alkaline trachytes to rhyolites (figures 5 thru 7), and show the presence of minerals such as sanidine, arfvedsonite, quartz, apatite, iron oxides ,and aegerine–augite in their groundmass. The rocks of both localities show a similar Or content in both phenocrysts and groundmass feldspars. However, there are differences in the distribution of these minerals as well as differences in texture of these rocks that becomes apparent after detailed study.

Figure 5. 10X XPL photomicrograph of sample from the Casa Grande lava dome showing a sanidine microphenocryst in a groundmass of alkali feldspar, arfvedsonite, quartz, and iron-oxides.

Figure 6. 10X XPL photomicrograph of sample taken from dike on LMT showing a sanidine microphenocryst in a groundmass of alkali feldspar, arfvedsonite, quartz, and iron-oxides.

Figure 7. 20X PPL photomicrograph of dike sample showing crystal of arfvedsonite