Volatile Bubble Growth in the Aztec Wash Pluton

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Abstract

The Aztec Wash Pluton, emplaced at ~18 Ma as part of the magmatic activity associated with intra-plate spreading along the Colorado River Extensional Corridor, represents a magma chamber that has been tilted ~90 degrees as a result of Basin and Range extension. This makes the pluton a unique location to study magma chamber dynamics. The pluton has a pancake shape and is ~3000 m in maximum thickness. The upper 1500 m of the pluton is compositionally homogenous granite and the lower 1500 m is more mafic in composition. The upper granitic portion is characterized by the presence of large cavities of unknown origin. We hypothesized that these cavities resulted from the exsolution of volatiles, or the sub-solidus dissolution of minerals. To test these hypotheses, we collected 17 samples at roughly equal spacing from the bottom to the top of the granite portion of the pluton and investigated the nature of the cavities by using polarized light microscopy. We determined the size of major modes of minerals, the size of individual cavities, the interconnectivity of cavities, and number density of cavities per thin section for all samples. The observations from thin sections are consistent with hypothesis one; that is, the cavities resulted from volatile overpressure. Observations indicate that the absolute size of individual cavities increase from the bottom to the top of the pluton. We suggest that this is the result of volatiles coalescing with decreasing depth.

Introduction

Magmas are composed of silicate melt, crystals, and volatiles. Volcanic eruptions are driven by the degassing of volatiles in the shallow crust. This process transfers volatiles such as CO_2, SO_2, and H_2O, which are greenhouse gases, to the atmosphere. Therfore, it is important for climate modelers to have an understanding of the processes of how these volatiles are transported.

The Aztec Wash Pluton is ~3000 m at maximum thickness and is divided roughly into two 1500 m zones. The upper 1500 m is compositionally homogenous granite and is characterized by the presence of large cavities of unknown origin.

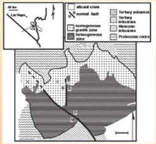


Figure 1. The location of the Aztec Wash pluton in southern Nevada, published by Robinson et al. (2009)

Hypotheses

I hypothesized that:

- Cavities were the result of volatile partial pressure rather than mineral dissolution.
- Cavity size would increase with decreasing depth due to bubles coalescing.
- Cavity density per section of rock would decrease stratigraphically up.

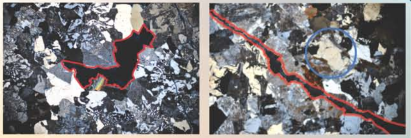
Figure 2. Hand sample from top of pluton with cavity.

Methods

We collected rock samples from the upper 1500 m portion of the pluton at roughly equal spacing. We prepared these samples to be analyzed by X-Ray Fluorescence (XRF) and to be turned into thin sections. XRF allows us to determine precise chemical compositions of the rock and shows us how the composition of the pluton evolves with respect to depth. Optical microscopy, which is the study of the optical properties a rock exhibits during its interaction with light, was used to analyze the thin sections.

Figure 3. The thin sections were stained with blue dye to contrast the cavities with the surrounding minerals.

Figure 4. (Left) Image of a cavity highlighted in red. (Right) Coalescing volatiles have formed a shear zone, highlighted in red. Feldspar circled in blue.



We recorded:

- The size of major modes of minerals
- The size of individual cavities
- The interconnectivity of cavities
- The number density of cavities per section of rock

We contrasted the mean sizes of minerals with the mean sizes of cavities to determine whether the cavities were the result of mineral dissolution.

Data

Depth ↑

Sample #	# Cavities	Cavity Size: Max (mm)	Cavity Size: Min (mm)	Orthoclase Diameters: Max (mm)	Orthoclase Diameters: Min (mm)	Orthoclase Diameters: Average (±1 SD)	Plagioclase Diameters: Max (mm)	Plagioclase Diameters: Min (mm)	Plagioclase Diameters: Average (±1 SD)
ZJH4	8	1.75 x 1.25	0.38 x 0.25	6.00	0.50	1.46 (±0.92)	2.50	0.38	1.13 (±0.59)
ZJH5	5	2.50 x 0.50	0.75 x 0.06	3.75	0.25	1.36 (±0.80)	2.75	0.25	0.95 (±0.55)
ZJH6	13	1.50 x 1.25	0.25 x 0.25	6.75	0.13	1.27 (±1.19)	2.00	0.25	0.92 (±0.44)
ZJH7	4	0.75 x 0.13	0.25 x 0.25	8.00	0.25	1.34 (±1.17)	2.50	0.13	0.93 (±0.49)
ZJH8	32	0.88 x 0.75	0.13 x 0.13	4.50	0.25	1.29 (±1.01)	3.00	0.25	1.03 (±0.67)
ZJH9	18	1.25 x 1.00	0.13 x 0.13	5.25	0.50	1.39(±0.84)	3.25	0.50	1.20(±0.64)
ZJH10	11	3.0 x 0.75	0.25 x 0.25	4.75	0.25	1.32 (±0.99)	2.75	0.25	1.05 (±0.62)
ZJH11	16	0.63 x 0.63	0.25 x 0.13	2.50	0.25	1.05 (±0.54)	2.75	0.25	1.08 (±0.61)
ZJH12	8	1.00 x 0.63	0.25 x 0.25	3.75	0.25	1.23 (±0.84)	2.50	0.25	0.96 (±0.46)
ZJH13	15	1.50 x 1.50	0.50 x 0.13	3.25	0.25	1.21 (±0.68)	4.00	0.25	1.09 (±0.66)
ZJH14	8	0.75 x 0.50	0.13 x 0.13	5.00	0.25	1.25(±0.94)	3.25	0.25	0.90(±0.50)
ZJH15	9	2.50 x 1.50	0.38 x 0.13	2.75	0.25	1.18(±0.44)	2.75	0.25	1.05(±0.47)
ZJH16	15	2.00 x 1.75	0.25 x 0.25	3.25	0.50	1.14(±0.57)	3.25	0.50	1.06(±0.62)
ZJH17	28	1.50 x 1.25	0.25 x 0.25	1.75	0.50	1.03(±0.32)	1.75	0.50	0.94(±0.31)

Sample Name	SiO2 (wt. %)	Al2O3 (wt. %)	TiO2 (wt. %)	Fe2O3 (wt. %)	MgO (wt. %)	Na2O (wt. %)	K2O (wt. %)	MnO (wt. %)	CaO (wt. %)	P2O5 (wt. %)	Total (wt. %)	H2O- (wt. %)	H2O+ (wt. %)
DETECTION LIMIT													
1	65.09	18.31	0.85	5.28	2.54	4.35	3.11	0.088	4.47	0.390	104.47	0.26	0.87
2	62.24	18.57	1.00	6.02	2.91	4.21	2.91	0.101	5.30	0.451	103.71	0.17	0.68
3	62.80	17.24	0.93	5.07	2.42	4.26	3.36	0.080	4.03	0.373	100.56	0.33	1.00
6	70.51	14.24	0.359	2.02	0.83	3.79	5.04	0.042	1.40	0.092	98.32	0.35	0.52
7	73.75	15.40	0.37	1.96	1.05	3.61	4.91	0.040	1.62	0.093	102.80	0.45	0.76
8	71.24	15.13	0.39	2.13	0.99	3.87	5.23	0.036	1.59	0.102	100.71	0.28	0.66
9	74.82	15.92	0.36	1.90	0.84	3.97	5.22	0.036	1.71	0.095	104.87	0.23	0.66
10	73.71	16.34	0.37	2.05	1.17	3.71	5.36	0.046	1.56	0.102	104.42	0.24	0.67
11	74.71	14.52	0.34	1.78	0.76	4.76	5.19	0.050	1.29	0.090	103.49	0.14	0.33
13	76.98	14.59	0.32	1.70	0.80	3.82	5.12	0.043	1.20	0.075	104.64	0.19	
14a	74.42	14.56	0.29	1.58	0.70	3.62	5.26	0.033	1.28	0.069	101.82	0.27	0.53
14b	75.44	14.86	0.32	1.64	0.93	3.59	5.07	0.037	1.42	0.077	103.38	0.24	0.58
15	73.11	14.68	0.34	1.81	0.80	3.56	5.28	0.037	1.43	0.079	101.13	0.36	0.62
17	74.70	14.23	0.30	1.66	0.77	3.72	5.24	0.034	1.21	0.072	101.93	0.18	0.62
22	77.05	12.86	0.16	0.91	0.39	3.47	5.17	0.041	0.65	0.014	100.72	0.14	0.21
27	78.36	12.68	0.13	0.76	0.37	3.62	4.98	0.030	0.54	0.006	101.47	0.17	0.36
Un #	80.69	13.27	0.14	0.78	0.36	3.60	5.06	0.033	0.57	0.040	104.55	0.11	0.38

Interpretations

- Cavities were the result of volatile partial pressure rather than mineral dissolution.
- Density of cavities with decreasing depth fluctuates from a higher to a lower number. I suggest that this may represent alternations between volatile depleted and volatile saturated zones.
- The number of large cavities per section increases with decreasing depth, which I suggest is the result of volatile coalescence.

Acknowledgments

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Reference

Robinson et al. (2009) American Mineralogist, 85, 1346-1353.