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Examining Petrologic Linkages between Dacitic Ash-Flow Tuffs at Newberry Volcano through Textural and Compositional Analysis of Plagioclase Phenocrysts

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Abstract

Textural and compositional analyses of plagioclase phenocrysts in volcanic rocks have been utilized widely to decipher magmatic processes, in particular magma mixing. The features of plagioclase phenocrysts can also be used to correlate separate but potentially related deposits in volcanic terranes. This study focuses on plagioclase phenocrysts from two dacitic ash-flow tuffs (Qdt and Qto) exposed on the east side of Newberry Volcano. To explore possible petrogenetic relationships between the tuffs, the phenocrysts were characterized in terms of occurrence, morphology, disequilibrium textures, and zoning patterns. Plagioclase crystals from Qdt and Qto display similar textural attributes but differ with respect to compositional zoning types. The textural similarities suggest that the tuffs are comagmatic, but the difference in zoning patterns implies separate eruptive events. Further detailed studies of plagioclase phenocrysts from these ash-flow tuffs will provide greater insights into magmatic processes occurring at Newberry Volcano.

Geologic Setting

Newberry Volcano is located in central Oregon about 50 km east of the main crest of the High Cascades at the western edge of the High Lava Plains (Fig. 1). As one of the largest volcanoes in the contiguous United States, the main edifice covers an area >1600 km ^{2} and is dominantly composed of mafic lava flows with numerous cinder cones dotting the flanks (Jensen, 2000; Jensen and Chitwood, 2000). Silicic pyroclastic deposits on the east and west sides of the volcano record caldera-forming eruptions that tapped more evolved chambers at discrete moments in the evolution of the Newberry magma system (e.g., MacLeod et al; 1995). This study focuses on two Pleistocene ash-flow tuffs (Qdt and Qto) that are well exposed on the east side of Newberry Volcano (Fig. 2). Single pumice samples from each tuff are dacitic and remarkably similar in terms of whole rock major and trace elements compositions (Templeton, 2009). In the field, Qdt contains conspicuous vitric lithic fragments, whereas Qto lacks these lithics. The similarity in compositions yet distinct field characteristics suggests these tuffs may record separate eruptions from the same magma body. One of the key objectives of this project is consider this possible scenario.

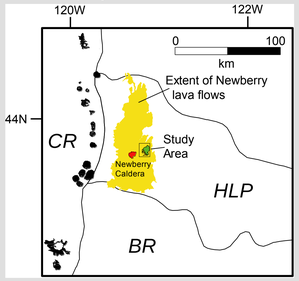

Figure 1: Map showing location of Newberry Volcano within the context of the regional geologic setting. CR=Cascade Range; HLP=High Lava Plains; BR=Basin & Range

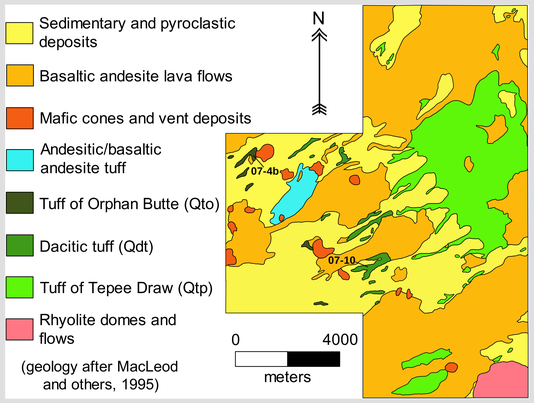

Figure 2: Geologic map of east side of Newberry emphasizing distributions of ash-flow tuffs in this area. Locations of samples 07-10 and 07-4b indicated. Area of map is shown in Figure 1.

Statement of Problem

Plagioclase is a common mineral phase in a wide variety of rock types, making it particularly useful for petrologic applications. In volcanic rocks, textural and compositional analyses of plagioclase phenocrysts have provided useful insights into magmatic processes, such as magma mixing (e.g., Tepley et al., 1999; Browne et al., 2006; Streck et al., 2008). This study focuses on plagioclase phenocrysts from two dacitic ash-flow tuffs located on the east side of Newberry Volcano in central Oregon (Figs. 1 and 2). Originally mapped as the 'dacitic tuff' (Qdt) and the 'tuff of Orphan Butte' (Qto) by MacLeod et al. (1995), the tuffs are strikingly similar in composition, yet the stratigraphic and petrologic relationships between the two units are unclear (Fig. 2). The objective of this project is to characterize the textural and compositional features of plagioclase phenocrysts in each tuff as a method for assessing the petrologic linkages between the two tuffs.

Figure 3

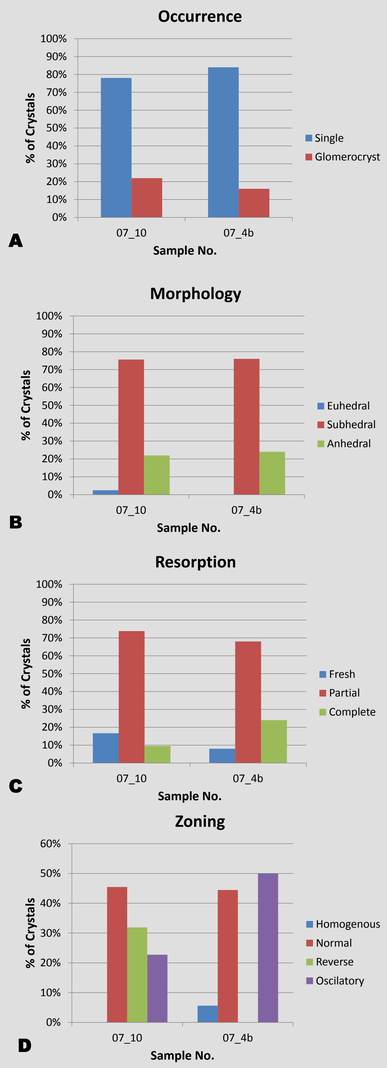

Figure 3: Graphs for textural and compositional features for two samples studied. Sample 07-10 is from Qdt, and Sample 07-4b is from Qto. See Figure 2 for sample locations. **A**: shows crystal occurrence for each sample; **B**: Shows the shapes of crystals within each sample; **C**: Shows how much (if any) resorption within crystals; **D**: Show types of zoning between tuff units.

Figure 4

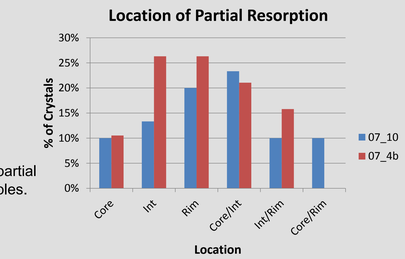

Figure 4: Graph showing locations of partial resorption between the samples.

Figure 5

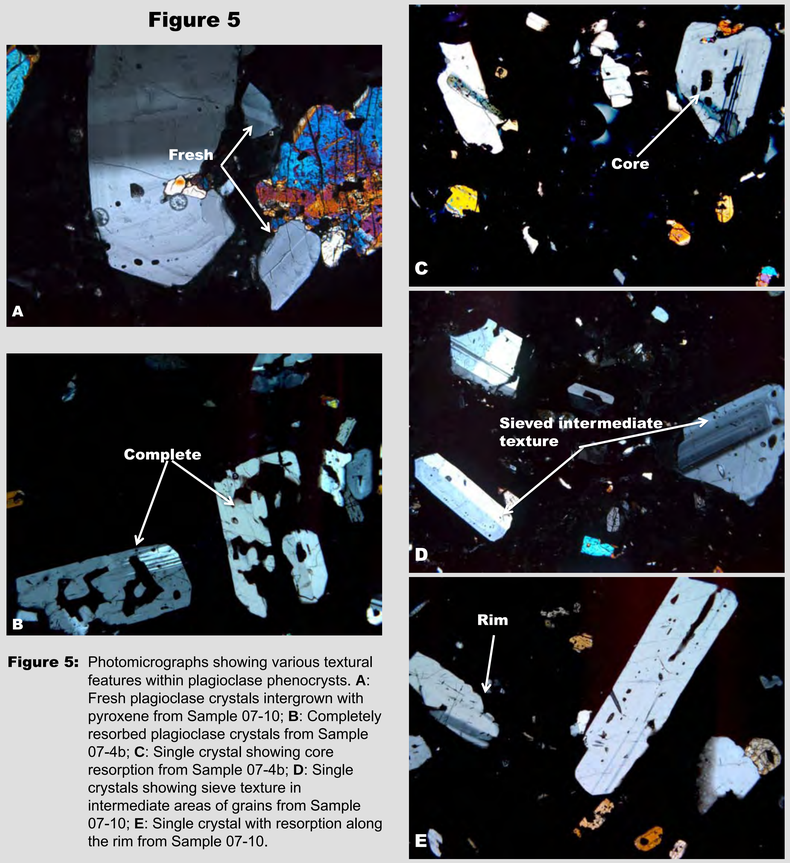

Figure 5: Photomicrographs showing various textural features within plagioclase phenocrysts. **A**: Fresh plagioclase crystals intergrown with pyroxene from Sample 07-10; **B**: Completely resorbed plagioclase crystals from Sample 07-4b; **C**: Single crystal showing core resorption from Sample 07-4b; **D**: Single crystals showing sieve texture in intermediate areas of grains from Sample 07-10; **E**: Single crystal with resorption along the rim from Sample 07-10.

Table 1: Compiled data for samples 07-10 (Odt) and 07-4b (Qto).

Sample No.	Bulk Pumice Composition (wt. % SiO2)	N-number of crystals	Morphology			Crystal Occurrence		Degree of Resorption			Type of Zoning			
			euhedral	subhedral	anhedral	single xl	glomerocryst	fresh	partial	complete	homogenous	normal	reverse	oscillatory
07_10	66.5	41	1	31	9	32	9	7	31	4	0	10	7	5
07_4b	66.4	25	0	19	6	21	4	2	17	6	1	8	0	9

Methods

This study centers on plagioclase phenocrysts from two representative pumice samples from Qdt and Qto. The phenocrysts were categorized in terms of textural attributes and compositional zoning. For textures, photomicrographs were examined of representative plagioclase grains that had been previously analyzed via electron microprobe. The crystals were classified according to occurrence, morphology, and disequilibrium textures. First, grains were subdivided into those occurring as single crystals and those as glomerocrysts. Secondly, the shapes of individual grains were characterized as euhedral, subhedral, or anhedral. For uniformity, the following guidelines were used: euhedral crystals are those having four well-formed crystal margins, subhedral crystals are those with two to three sharp boundaries, and anhedral crystals only show up to one regular margin. With respect to evidence for crystals being out of equilibrium, grains were characterized as either fresh or resorbed. The degree of resorption was recorded as a percent area based on visual estimate, and the specific areas of crystals that are sieved were noted. Using compositional data obtained from electron microprobe analyses, zoning patterns were distinguished based on the fluctuations in An content from the core of crystals to the rim. The following criteria were used to describe compositional zoning (e.g., Shelley, 1993): homogeneous crystals are those with <1% variation in An content from core to rim, normally zoned crystals are those that show a regular decrease in An content from core to rim, reversely zoned crystals display a regular increase in An content, and oscillatory zoned crystals vary irregularly from core to rim.

Results

The data collected over the course of this study are compiled in Table 1 and graphically represented in Figures 3 and 4. The following trends are noted in the data set:

- In both samples, most crystals are subhedral, some crystals are anhedral, and virtually no crystals are euhedral. In addition, the samples display the same percentages of both subhedral and anhedral crystals (Fig. 3A).
- In terms of occurrence, most of the phenocrysts analyzed are single crystals and a small percentage occurs as glomerocrysts intergrown with plagioclase and/or pyroxene grains (Fig. 3B). Sample 07-10 has a greater number of glomercrysts that were analyzed, which presumably reflects sampling bias during electron microprobe sessions.
- As a group, most phenocrysts display some degree of resorption (Fig. 3C). Sample 07-10 has a greater number of intact crystals, whereas 07-4b has a higher number of crystals that are completely resorbed.
- In terms of compositional zoning types (Fig. 3D), most crystals in sample 07-10 are normally zoned, and no crystals are homogeneous. For sample 07-4b, most of the crystals display oscillatory zoning, and none of the phenocrysts are reversely zoned.

Discussion & Conclusions

This study of plagioclase phenocrysts from two compositionally similar ash-flow tuffs provides a framework for comparing and contrasting the two units. Texturally, the plagioclase crystals from Qdt and Qto are remarkably similar, suggesting that the tuffs are comagmatic. This interpretation is consistent with whole-rock compositional data from single pumices. However, the compositional zoning patterns are distinct between the two tuffs, indicating that they do not represent the same eruption. This result is in agreement with field observations, in particular the conspicuous vitric lithics that are present in Qdt but lacking in Qto. Additional detailed studies of plagioclase phenocrysts from Qdt and Qto will provide better understanding into the evolution of the Newberry magma system.

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