Consistent magma conditions at Mount Pinatubo, Philippines, over 2.5 million years

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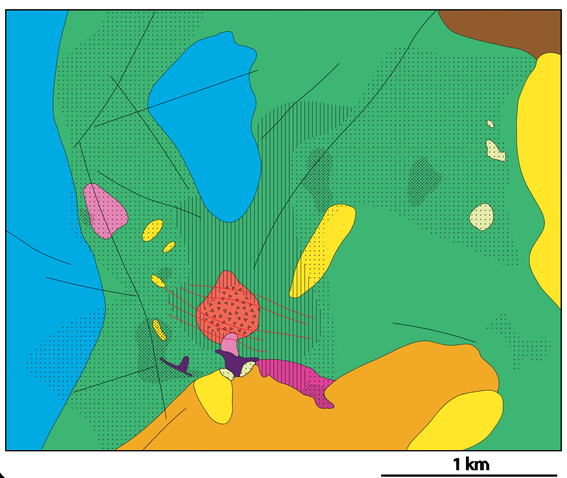
Introduction

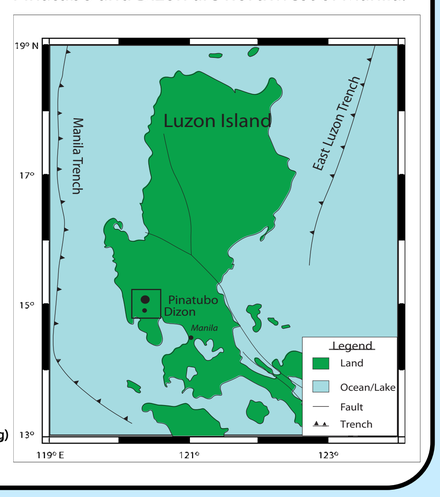
Mount Pinatubo is in the Luzon arc in the Philippines. The study area, the Dizon mine porphyry Au-Cu deposit is located ~ 15 km south of the current summit on the southern foothill of the volcano. The mineralization is hosted in quartz diorite of ~2.5 Ma (Imai, 2005). Samples from Dizon were compared to younger eruption products of Mount Pinatubo to characterize the magma evolution in the volcano through time.

Above: Image of Mount Pinatubo's summit and the Dizon mine ~15 km to the south.

Below: Geologic map of Dizon mine displaying the different lithologies, alteration zonation and structures. There is advanced argillic alteration with quartz/pyrophyllite/diaspore (Qz-Prl-Dsp) and quartz/kaolinite/alunite (Qz-Kln-Alu), white mica-chlorite alteration (WM-Chl), biotite alteration (Bt) and veins containing sphalerite (Sp), galena (Gn), tetrahedrite (Ttr), stibnite (Stb), enargite (En), gold and silver. Modified after Imai (2005).

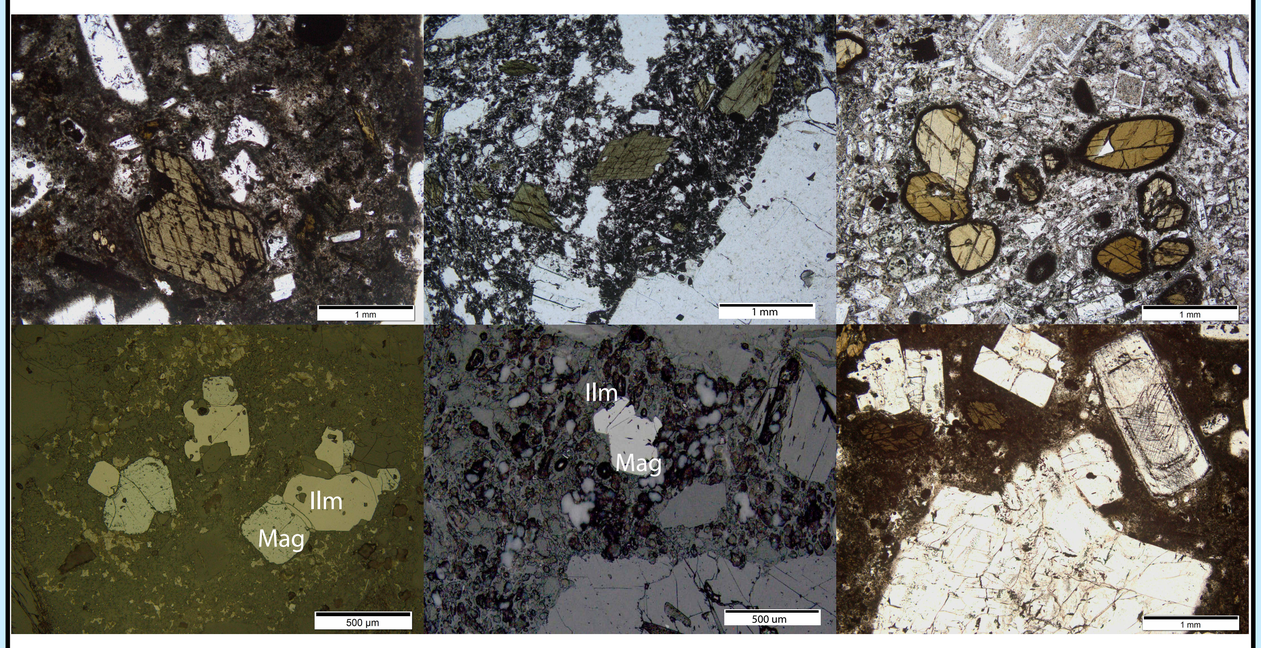


Below: Map of Luzon Island (Philippines), Pinatubo and Dizon are northwest of Manila.



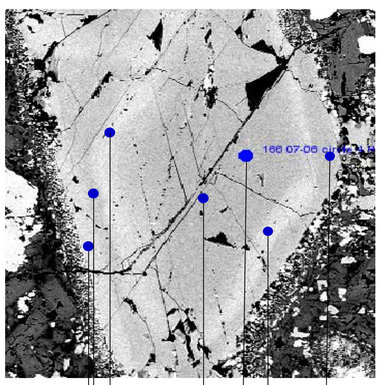
Samples

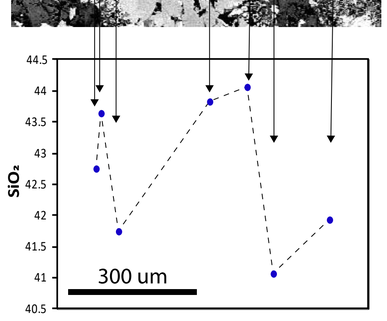
Samples include altered and mineralised quartz diorite porphyry and andesite, and unaltered porphyritic andesite (07-02) and diorite (07-06) at the Dizon mine, and a 5100 BP dacite (06-15). Compositions of amphibole and Fe-Ti oxides in the unaltered samples are used to calculate the oxidation state, temperature and water content of magmas.



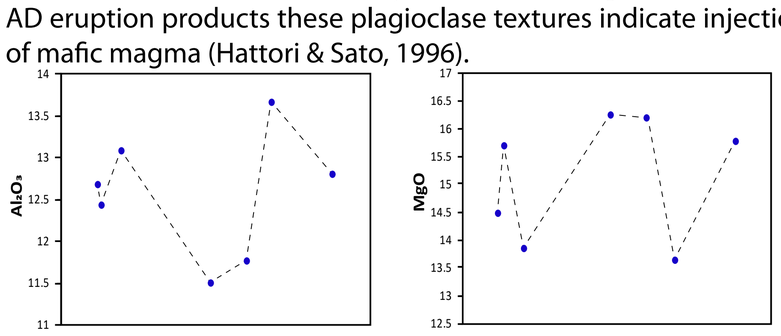
Left: Hornblende and Fe-Ti oxides in Dizon andesite (Sample 07-02). *Middle*: Hornblende and Fe-Ti oxides in 5100 BP dacite (Sample 06-15). *Right*: Amphibole in Dizon diorite (Sample 07-06) in the upper right and plagioclase showing dusty zones and overgrowths in Dizon andesite in the bottom right.

Amphibole Zonation



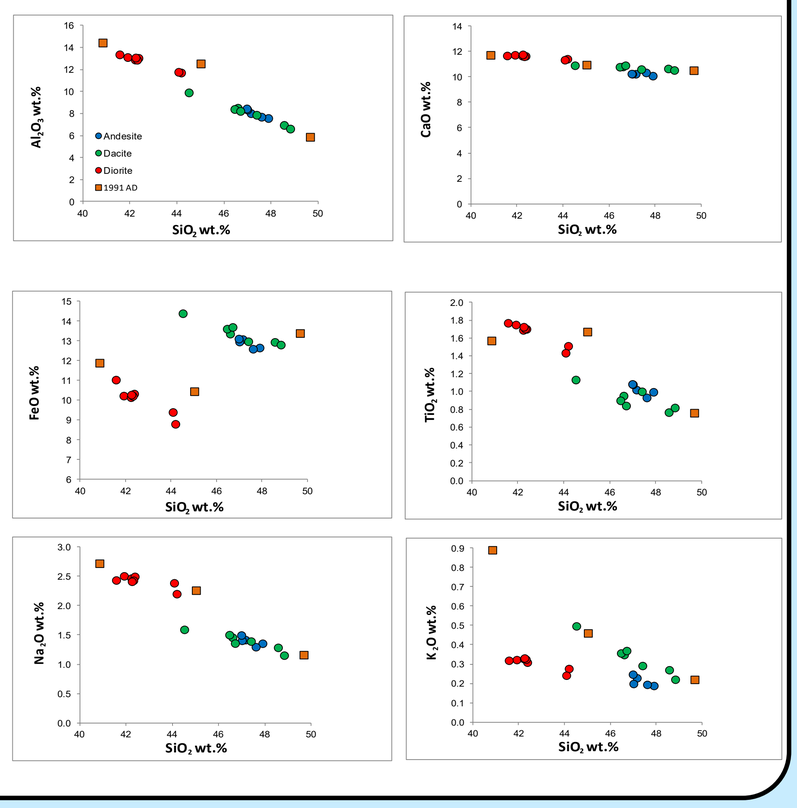


Amphibole grains in diorite at Dizon (07-06) show compositional zoning. including variations in Mg, Fe, Si and Al. Three zones are recognized: core, mantle and rim. The core has higher Mg and Si, dark in back-scattered electron image, compared to the mantle (bright) which has higher Fe and Al contents. The rim, shown in grey, has a similar composition to the core. The zoning suggests the normal zoning of amphibole and the introduction of a new batch of magma to form the rim. The texture of amphibole in the Dizon diorite is consistent with destabilization textures on plagioclase from the andesite, such as dusty zones and overgrowths. In 1991 AD eruption products these plagioclase textures indicate injection of mafic magma (Hattori & Sato, 1996).

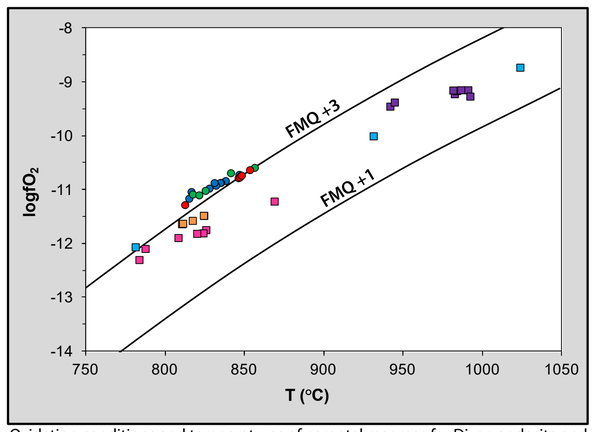


Amphibole Composition

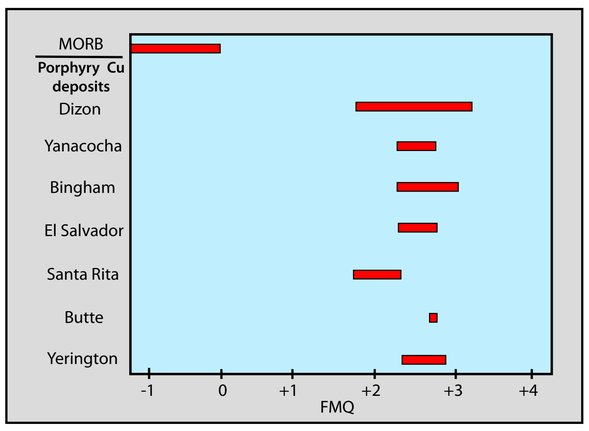
The composition of amphibole in Dizon samples of andesite, diorite and dacite is compared with that of 1991AD eruption products reported by Bernard et al. (1996). Decreasing Al and alkalis with increasing Si in amphibole is consistent with evolution in a calc-alkaline magma (Ridolfi et. al., 2010).



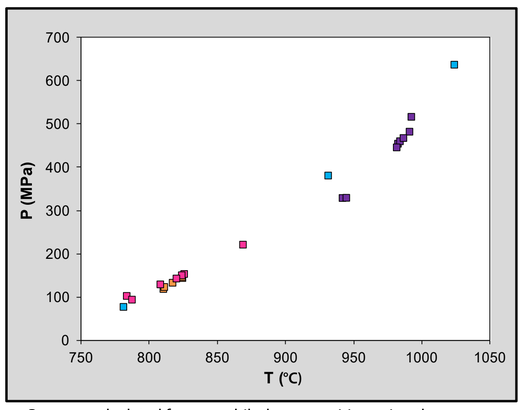
Oxidation State, Water Content, Temperature



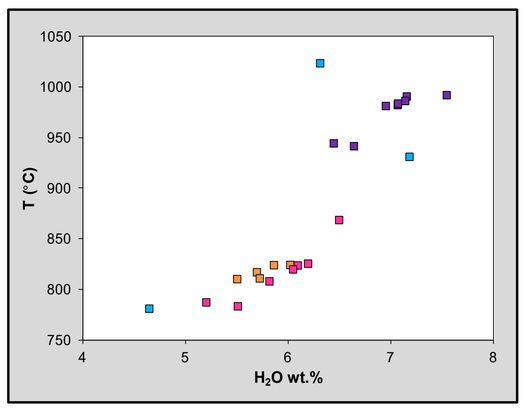
Oxidation conditions and temperatures of parental magmas for Dizon andesite and diorite, and 5100 BP dacite obtained using the Fe-Ti oxide geothermobarometry of Spencer & Lindsley (1985). The values for 1991 AD oxides are from Hattori (1993). The Ridolfi et al. (2010) amphibole geothermobarometry was used for all amphibole grains.



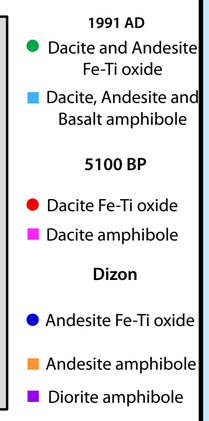
Oxidation state of Dizon magmas is compared to other deposits. The magmas of porphyry Cu deposits are oxidised, ~FMQ +2 to +3 (Dilles et al., 2015 & Hattori, 2018).



Pressure calculated from amphibole composition using the geothermobarometry of Ridolfi et al. (2010). The pressure corresponds to depths of ~16 km for diorite amphibole and ~4 km for andesite amphibole using a rock density of 2.9 g/cm³.



Water content of andesite, dacite and diorite is shown. The amphibole in diorite yields higher water contents, due to greater depths.



Conclusions

- Dizon whole rock and amphibole compositions are similar to those of 1991 AD Pinatubo eruption products.
- Compositional zoning of amphibole suggests an introduction of mafic melt into an evolved magma reservoir. Dusty zones in plagioclase phenocrysts indicate the destabilization of Na-rich portion during the injection of hot mafic melt into a felsic magma chamber at Dizon.
-Temperatures of magmas are around 820 °C for 2.5 Ma Dizon samples, which are similar to those of the magma for 1991 AD eruption products.
- The water contents of magmas at Dizon and 1991 AD magmas were elevated, at ~6 wt%.
- Parental magmas for 2.5 Ma Dizon rocks are highly oxidized, around FMQ +3, similar to the magma resevoir for the 1991 AD eruption products.

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Acknowledgements

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