Paleomagnetic and Rock Magnetic Study to Determine the Emplacement Temperatures of the ~ 3580 BC Chachimbiro Pyroclastic Deposits, Ecuador

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Abstract

Two rock magnetic methods can be used to determine the emplacement temperature of pyroclastic deposits. The first is by looking at the unblocking temperature spectra of the thermoremanent magnetization (TRM) and the second is through the repeatability of thermomagnetic behavior. Chachimbiro volcanic complex is an andesitic-dacitic stratovolcano located at the northern zone of the Ecuadorian volcanic arc. The lateral blast eruption that occurred at 3640-3510 BC originated from a 650 m wide and 225 m high rhyodacite dome. This satellite lava dome, located 6 km to the east of the main vent, erupted, resulting in a large pyroclastic density current (PDC). PDCs are hot mixtures of lithic fragments, gas and pumice, varying in size from fine ash up to metric blocks that descend the flanks of a volcano at great speeds, being the primary cause of death during explosive eruptions. The resulting PDC from this violent laterally directed explosion covered an area of 62 km^2, with the thickest parts of the deposit displaying as much as 15 m. We collected ~63 oriented block samples from 6 locations; their distances varying between 1.8 km to 6.7 km away from the source. Here we present the emplacement temperatures of the Chachimbiro pyroclastic deposits and the potential factors controlling them. Our rock-magnetic results indicate low titanium Ti-magnetite as the main magnetization carrier; maghemite being present in trace amounts. We have recognized that, based on the unblocking analysis of the TRM, the overall temperatures vary from 250 °C to 450 °C depending on the clast size and type. In general, our results suggest a minimum temperature of ~250 °C, with a large portion of the juvenile clasts having temperatures up to about ~450 °C. Furthermore, the analysis and the comparison of the Curie temperature executed in ~30 samples, against the emplacement temperatures obtained through the typical paleomagnetic studies will be presented. This work highlights the usefulness of paleomagnetism and rock magnetism to evaluate the emplacement temperatures of PDCs, thereby allowing to better assess the associated risk.

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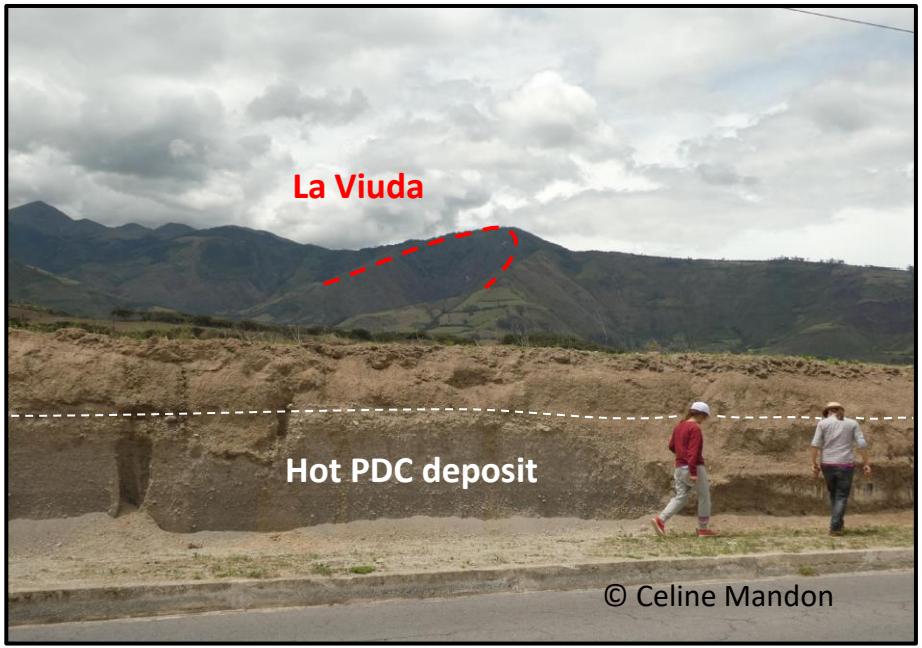
Chica Joseline, Piispa Elisa, Mandon Celine



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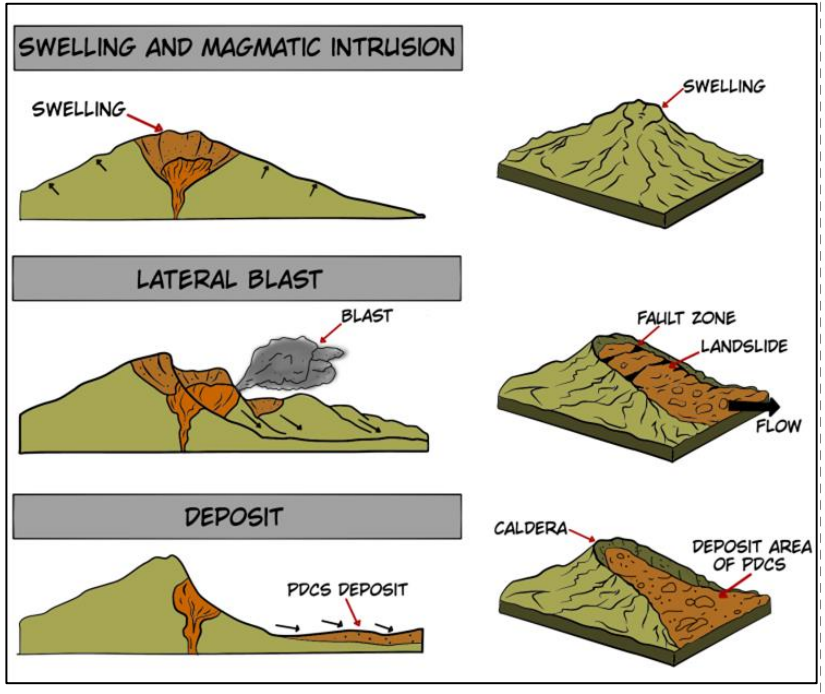
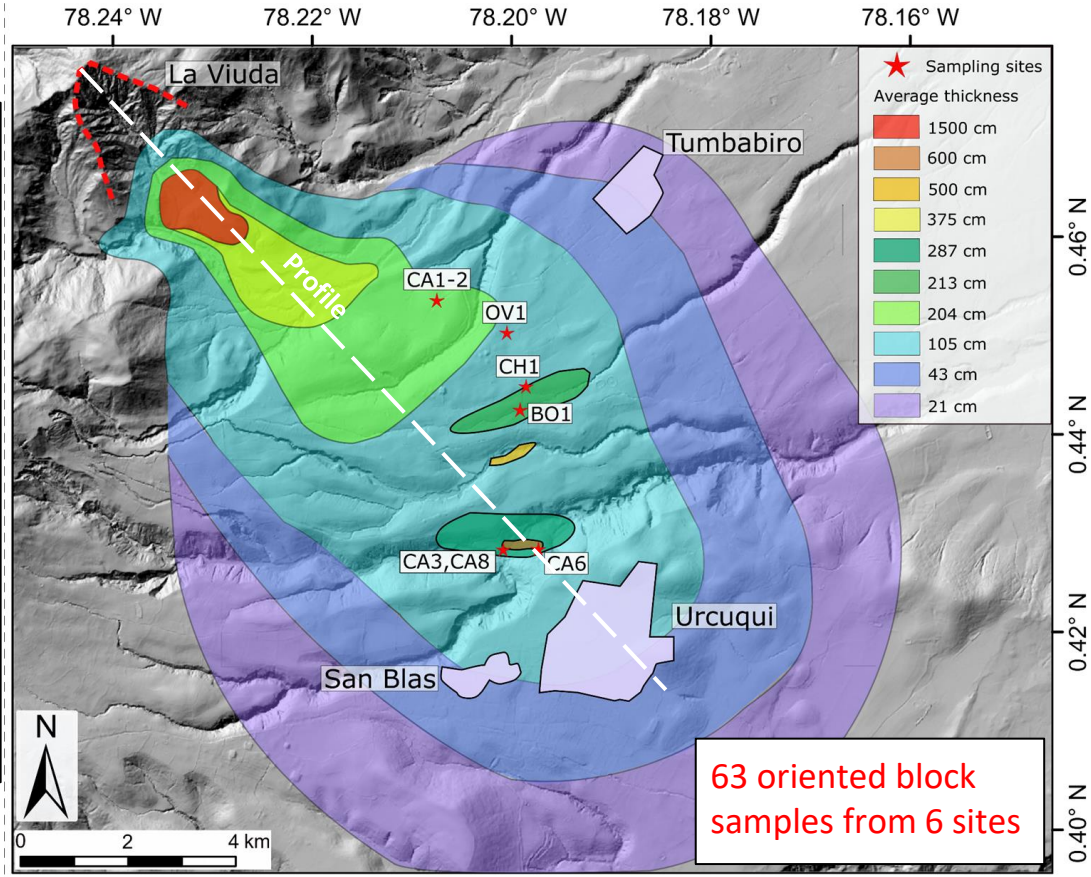
Lateral blast, areal distribution, thickness and sampling sites



Modified after Leyrit & Meteneat 2000



Modified after Bernard et al. 2014

Magnetization process in PDCs

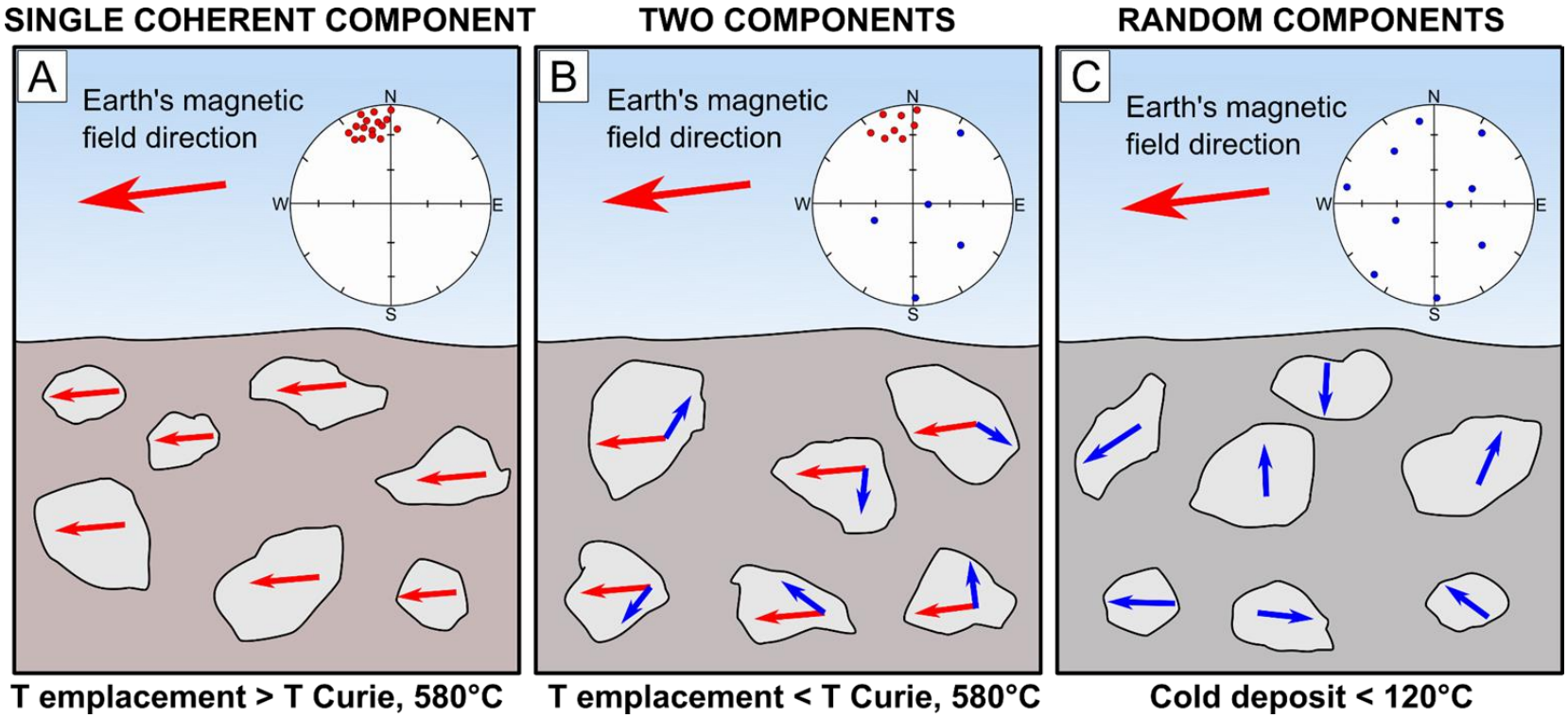
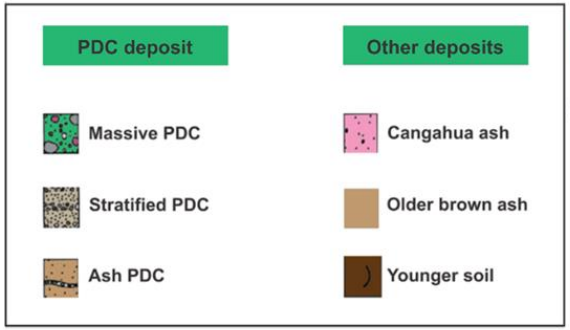
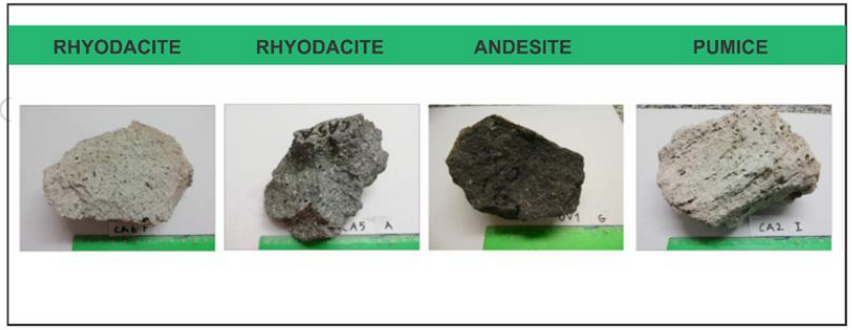
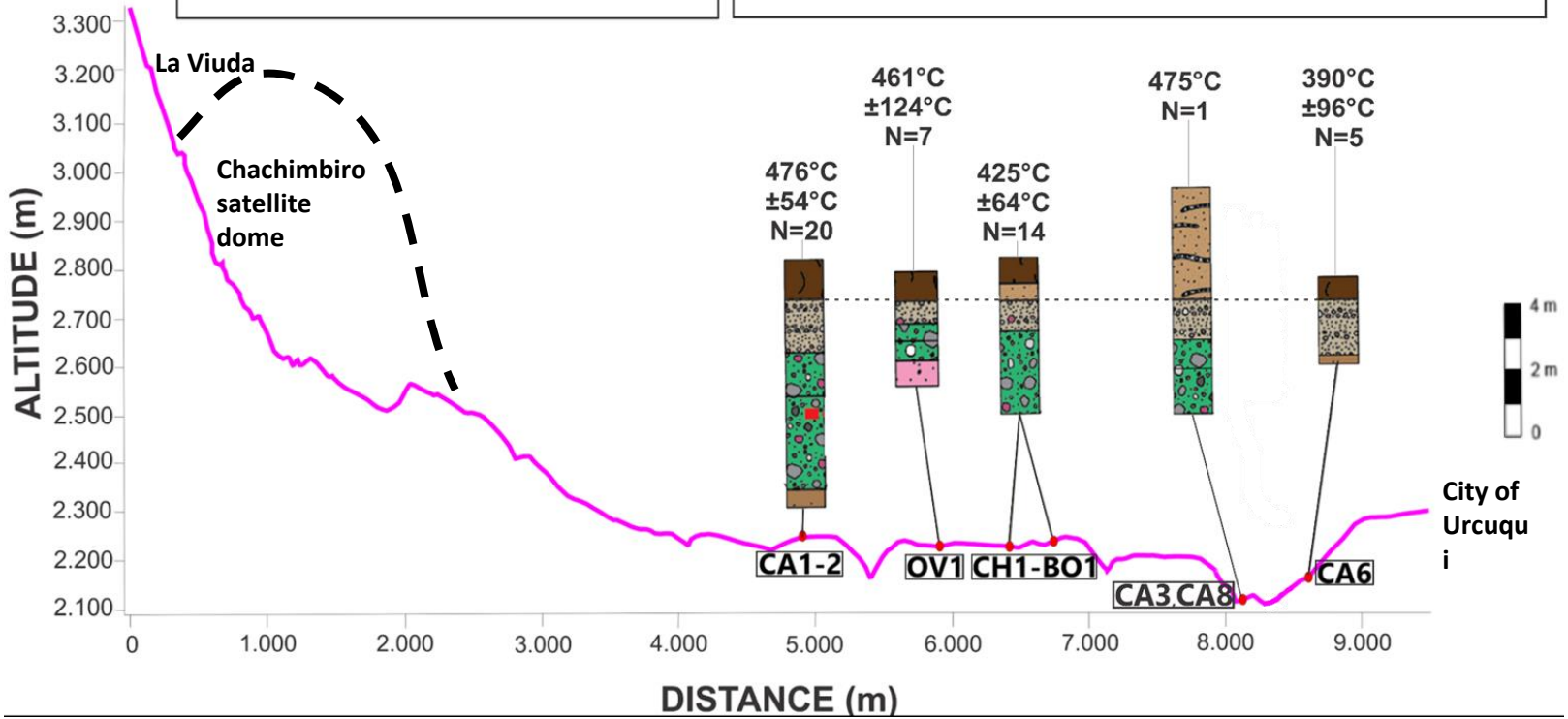


Image by E.Piispa

Estimated emplacement temperatures







Conclusions

1. Emplacement temperature estimate ~450°C (N = 48/54)

1. Consistent with Ts in the magmatic reservoir from geothermometry (679-858°C) and the fast growth of the lava dome (13-49 days) (Bernard et al. 2014)

1. Hazard aspect:
   - Even at 8 km distance from the dome the clasts show approximately 390°C average T
   - E.g. Pompei PDC has been estimated at 240-340°C (Cioni et al. 2004)
   - A similar directed blast (PDC) in the Inter-Andean valley now would be devastating due to higher present-day population density

If you are interested in hearing more about this study here is my contact information:

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