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Hydrothermal alteration and sealing at Turrialba as a mechanism for phreatic eruption triggering

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Turrialba is a basaltic to andesitic Holocene stratovolcano that after decades of quiescence re-activated in 1996 and has been highly active ever since. Turrialba is characterized by a highly active magmatic-hydrothermal system, and we propose that hydrothermal sealing and volatile accumulation are the mechanisms responsible for the reactivation and persistent phreatic activity at Turrialba since 2010. Evidence of sealing is found in pyroclastic breccias from phreatic eruptions as high concentrations of hydrothermal minerals coupled with low intrinsic permeability. The suite of volcanic breccias studied erupted from the main vent between 2014 and 2019 and has an alteration mineral assemblage of SiO_2polymorphs ± gypsum ± natroalunite ± pyrite. The mineral assemblage is indicative of acid sulphate alteration within the advanced-argillic alteration facies characterized by temperatures of approximately 200-350°C as indicated by the presence of gypsum and natroalunite, the high temperature endmember of the alunite series. Acid sulphate alteration is the result of extreme base leaching by acidic fluids (pH<4) with a high sulphate content. Measurements of permeability and porosity yielded variable porosity and very low to non-existent permeability in all hydrothermal breccia samples. Back-scatter electron (BSE) images reveal nano-, micro- and macro-scale fracture networks discontinuously filled with hydrothermal gypsum and pyrite which are responsible for diminished permeability, supporting the conclusion that hydrothermal sealing is active at Turrialba. Diminished permeability associated with the formation of a seal inhibits the escape of gases, causing them to accumulate below the seal and pressurize the system. Eventual seal failure releasing overpressure and possibly dynamic rapid seal formation result in the frequent phreatic eruptions seen at Turrialba.