

Volcanic lightning: New global observations and constraints on source mechanisms

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New data on volcanic lightning from the Smithsonian Volcano Reference File are added to an existing database and greatly expand the number of cases available for study. Lightning has now been documented at 154 volcanoes in association with 394 eruptions, a significant increase from the earlier numbers of 89 volcanoes and 240 eruptions. Lightning and electrification at volcanoes are important because they represent a hazard in their own right, they are a component of the global electrical circuit, and because they contribute to ash particle aggregation and modification within ash plumes. The role of water substance (water in all forms) in particular has not been well studied. The Volcanic Explosivity Index (VEI) was determined for 177 eruptions. Eight percent of VEI=3-5 eruptions have reported lightning, and 10 percent of VEI=6, but less than 2 percent of those with VEI=1-2, suggesting consistent reporting for larger eruptions but either less lightning or under-reporting for small eruptions. Ash plume heights (142 observations) show a bimodal distribution with peaks at 7-12 km and 1-4 km. The former are similar to heights of typical thunderstorms and suggest involvement of water substance, whereas the latter suggest other factors contributing to electrical behavior near the vent. The distributions of the latitudes of volcanoes with lightning and eruptions with lightning roughly mimic the distribution of all volcanoes; flat with latitude. Meteorological lightning, on the other hand, is common in the tropics and decreases markedly with increasing latitude as the ability of the atmosphere to hold water decreases poleward. This finding supports the idea that if lightning in large eruptions depends on water substance, then the origin of the water is primarily magma and not entrainment from the surrounding atmosphere.