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Temporal evolution of micro-eruptions within the crater lake of White Island (Whakaari) during January/February 2013

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Micro-eruptions are potentially modulated by hydrothermal systems and crater lakes but to date have not been well studied. In January/February 2013 White Island (Whakaari), New Zealand, experienced an about three week long period of atypical, frequent micro-eruptions within its crater lake. Many of these micro-eruptions were recorded by tour operators and GNS personnel monitoring the lake activity. Analysis of this video footage reveals an increasingly energetic eruption style. Deformation of the muddy lake surface by ascending bubbles begins as irregularly shaped bursts, producing liquid strings of mud ejected to heights of less than 10m at 10-15m/s. As the episode progresses, eruption frequency is maintained at semi-regular <10s intervals. Each eruption however starts with an increasingly hemispheric surface deformation $\sim$6m in diameter, and bursts occur as “star-bursts” with ejection of less fluidal ash/mud clots. In addition, these bursts are commonly followed within 2s by a more vertical and energetic secondary ejection of material, which occasionally ejects through the deformed hemispheric surface up to >100m high, and reaches ejection velocities up to 45m/s. The period of frequent “star-bursts” is then followed by a two day phase of constant $\sim$30-75m high ash ejection resulting in the formation of a tuff cone with a central open conduit of 6m within the former crater lake. We theorise that this behaviour is influenced by evolving bubble overpressure/volume, including the presence or absence of a trailing wake of smaller bubbles and is modulated over the eruption episode by the viscosity of the crater lake. In the early stages of the episode a lower viscosity lake provides little resistance to rising gas/ash mixtures. Bubble coalescence and/or overpressure development is therefore minimised, resulting in low energy bursts. Over the course of this episode the viscosity of the lake increases due to addition of ash from ash-carrying gas flux and fluid loss by boiling. Thus higher pressurized gas bubbles can form within the conduit which burst with increasing explosivity. Two experiments are planned simulating this evolving eruption style. In the first, controlled cold volumes of pressurized gas bubbles within a vertical pipe will be released into an overlying chamber filled with varying viscosity fluids, to investigate energy and acoustics of bubble bursts. The second will involve sudden depressurisation of a mud-filled autoclave at elevated temperature (>100°C) to provide eruption metrics. Comparing the eruption styles generated in the lab with those identified at White Island in video analysis will allow us to investigate the dominant controls on the eruption style.