Latest explosive eruptive episodes of Ulleung Island, Korea: eruption styles, transport mechanisms, and stratigraphy of an intra-caldera tephra sequence

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Ulleung Island is a Quaternary volcanic island located in the mid-western part of the East Sea (Sea of Japan), which has been active until the recent geological past. This study focuses on reconstructing the latest eruptive history of the island by delineating the sedimentological and stratigraphic characteristics of the most recent tephra sequence, named the Nari Tephra Formation. This entire formation is preserved as a succession of unwelded pyroclastic and epiclastic deposits within an embayed margin of the Nari Caldera. The embayment acted as a topographic trap for proximal pyroclastic deposits, and contains a complete record of the past 19,000 years of eruption history. Field measurements reveal that the Nari Tephra Formation comprises five pumiceous tephra units of trachytic/phonolithic composition (Members N-1 to N-5 in descending stratigraphic order), with intervening weathering horizons and/or soil horizons indicating hundreds to thousands of years of repose between each event. Eruption styles and depositional mechanisms were variable between the eruption episodes, as well as during the individual episodes, depending on the dynamics of the magma plumbing system and the role of external water. The eruption history can be reconstructed as follows: (1) the earliest eruption associated with cryptodome disintegration (N-5), (2) a plinian eruption that emitted voluminous pumiceous tephra (N-4), (3) a sustained fountaining eruption with precursory hydrovolcanic activity (N-3), (4) a subplinian eruption that gradually changed from wet to dry eruption (N-2), and (5) the final hydrovolcanic activity followed by effusive lava dome extrusion (N-1). Mapping medial extra-caldera sequences reveals that only a few of the recognized eruptive episodes generated sustained eruption columns or pyroclastic density currents (PDCs) with sufficient inertia or buoyancy to surmount the caldera wall and deposit substantive tephras beyond the caldera rim. The results imply that the tephra sequences outside the caldera are incomplete records of the eruptions of the volcano, and that the topographic effects of the caldera should be considered not only for the assessment of PDC-related hazards but also for the interpretation of terrestrial or marine tephra records.