Quantifying gas composition and yield from the 946 CE Millennium Eruption of Paektu volcano, DPRK/China

K. IACOVINO[1]*, J.S. KIM[2], T. SISSON[1], J. LOWENSTERN[1], K.H. RI[3], J.N. JANG[2], K.H. SONG[2], H.H. HAM[2], C. OPPENHEIMER[4], J.O.S. HAMMOND[5], A. DONOVAN[6], K. WEBER-LIU[7], K.R. RYU[8]

[1]US Geological Survey, Menlo Park, CA 94025
*correspondence: kiacovino@usgs.gov
[2]Earthquake Administration, Pyongyang, DPRK
[3]State Scientific Academy, Pyongyang, DPRK
[4]Dept. of Geography, University of Cambridge, UK
[5]Department of Earth and Planetary Sciences, Birkbeck, University of London, UK
[6]Dept. of Geography, King's College London, UK
[7]Environmental Education Media Project, Beijing, China
[8]Pyongyang International Information Centre of New Technology and Economy, Pyongyang, DPRK

Magmatic volatiles such as H_2O, CO_2, sulfur, and halogens (e.g. F, Cl) are injected into the atmosphere during explosive volcanic eruptions and can drive globally significant climate change. Accurate quantification of volatile yield and composition is critical in assessing the impact of an eruption but is elusive, particularly for pre-historic or unmonitored eruptions. We utilize a geochemical technique to calculate C-O-H-S-F-Cl gas composition and mass yield from silica-rich explosive volcanoes by examining trends in incompatible trace and volatile element concentrations in crystal-hosted melt inclusions. We apply this technique to one of the largest volcanic eruptions in recorded human history, the 946 CE Millennium Eruption (ME) of Paektu (Changbaishan) volcano, which produced comenditic tephra and a caldera that straddles the border between the Democratic People's Republic of Korea (DPRK) and China. We calculate a sulfur yield of up to 45 Tg S from the ME. An estimated column height of 29 km indicates injection of much of this S into the stratosphere. This sulfur yield is 1.5 times that released during the eruption of Tambora in 1815, which resulted in significant global cooling in 1816. We suggest that the minimal climate perturbations after the Millennium Eruption as inferred from polar ice cores was due to the high latitude and season of the eruption and is not reflective of the significant S output. The total gas yield is calculated to be 3517 Tg, made up of 88.7 wt% H_2O, 1.3 wt% S, 1.6 wt% F, 0.6 wt% Cl, and 7.8 wt% CO_2. Our work places the Millennium Eruption among the top ranking volcanic volatile emitters in recorded human history.