Characterization and interpretation of volcanic activity at Bezymianny volcano from 2007 through 2010: A volcanic-gas perspective

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Volcanic gas measurements at Bezymianny volcano, Kamchatka, Russia, from 2007– 2010 are used herein to (1) infer the relative depth or degassing state of a source magma according to solubility differences among gas species, (2) distinguish between open and plugged conduit systems through changes in sulfur dioxide (SO_2) emission rates, and (3) estimate the first-order total eruptive mass of magma through estimates of total eruptive SO_2. To characterize and interpret recent activity at Bezymianny, we measured volcanic gas composition from fumarole samples, calculated SO_2 emission rates from scanning FLYSPEC ultraviolet (UV) spectrometer measurements, and derived eruptive SO_2 masses from Ozone Monitoring System (OMI) satellite data. During the study period, five explosive eruptions occurred at Bezymianny: May 2007, October/November 2007, August 2008, December 2009, and May/June 2010. Preliminary results are shown in the table below (note that samples marked by the asterisks were collected six weeks after the May 31, 2010 eruption).

We interpret the low ratios of CO_2/H_2O and SO_2/HCl observed in the August 2007 fumarole samples to indicate degassing of a shallow, largely degassed magma source, and the high total emission rates to suggest an open conduit system. If the system remained open, the October 2007 eruption may have been triggered by a partial lava dome collapse, which decreased pressure on the magmatic system at depth, prompted magma ascent, and culminated in an explosive eruption. Using the OMI SO_2 eruptive mass and the method by Blake (2003), the mass of eruptive magma was ~1.5 $x10^6$ tonnes for this eruption. In contrast, the high ratios of CO_2/H_2O and SO_2/HCl observed in the July 2009 fumarole samples may indicate degassing of a fresh and/or deep magma source and low total emission rates suggest a partially sealed conduit. Thus, we propose that the December 2009 eruption may have been the result of overpressure in the conduit due to confined degassing of a fresh, ascending magma. An alternate hypothesis is that hydrothermal or meteoric water preferentially scrubbed the highly water-soluble gases and decreased the overall emission rates. No SO_2 was detected by OMI for this event due to poor signal-to-noise for high latitude, winter conditions. Incomplete datasets in 2008 and 2010 prevent us from proposing eruption mechanisms for those events. In 2008, no gas composition data were acquired and the observed SO_2 emission rates were not significantly different from 2007 and 2009 emissions. Additionally, SO_2 from Bezymianny eruptions in 2008 was not conclusively detected by OMI due to a contemporaneous eruption of Kasatochi volcano, Alaska. Derived eruptive SO_2 masses from OMI for the 2007 and 2010 eruptions were strikingly similar, suggesting that these eruptions had similar eruption masses. This study suggests that combined measurements of volcanic gas composition, SO_2 emission rates, and eruptive SO_2 masses can be used to elucidate volcanic behavior and help characterize eruptive activity. Notably, the October 2007 and December 2009 eruptions of Bezymianny may have been triggered by partial dome collapse and intrusion of new magma combined with conduit sealing, respectively; multidisciplinary datasets could be used to test these hypotheses.

Year	CO_2/H_2O	SO_2/HCl	SO_2 Emission Rate (t/d)	Total Emission Rate (t/d)	OMI Eruptive SO_2 Mass (t)	Magma Eruptive Mass (t)
2007	0.02	0.42	278 +/-130	~33,900	~4,900	~$1.5*10^6$
2008	NA	NA	140 +/- 95	NA	NA	NA
2009	0.34	23.61	97 +/- 50	~800	NA	NA
2010	0.02*	6.03*	NA	NA	~4,900	~$1.5*10^6$