Chemical variation in an historical monogenetic eruption (1256 AD Al-Madinah eruption) in the Kingdom of Saudi Arabia: Identifying magma sources

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The study of monogenetic volcanism has become increasingly important over the past decade, particularly in areas where small-scale but frequent volcanism can pose a threat to highly populated or culturally significant areas. Combined physical volcanology and geochemical studies have the potential to provide insights into the occurrence of future eruptions, and the study of well-preserved historical eruptions is particularly useful in this regard. We examined the most recent eruption of the Al-Madinah Volcanic Field in Saudi Arabia, which occurred in 1256 AD, 20 km from the centre of Al-Madinah City. This eruption created seven isolated and nested cones (cones 1-7, from S to N), along a ca.2 km-long fissure associated with a 56 km^2pahoehoe-and-aa lava flow field. Cones 1 to 4 are isolated and cones 5 to 7 are nested and the largest. Cone 1 original edifice was modified by repeated rafting while the others are well-preserved. Volcanological facies variations indicate that the eruptions were most explosive in the nested cones and Strombolian activity was the dominant style. The products generated were alkali basalts and hawaiites (SiO_2 45-47wt%) with some variation in composition, although all show trace element characteristics that lie between typical OIB and MORB. Three compositional groups can be identified: Group 1 has higher abundances of compatible elements (MgO 8-9.4wt%; Mg# 58-63; CaO 10-11wt%; Sc 29-34ppm; V 255-277ppm; Cr 139-329ppm; Ni 118-189ppm), Group 3 has lower abundances of compatible elements (MgO 5.6-6.3wt%; Mg# 46-51; CaO 8-9wt%; Sc 24-29ppm; V 190-217ppm; Cr 69-137ppm; Ni 45-76ppm), and Group 2 lies between these two compositions. Group 1 compositions are from cone 1 and rafted material >1 km from the cone. Group 2 compositions are from cone 2; and Group 3 compositions are from cones 3 to 7. These groups correlate with three groups of lava flows defined as erupting simultaneously in a previous study and described as Low-K, High-K and hybrid basalts. Preliminary results suggest polybaric melting with trace element behaviour indicating a spinel peridotite source for Group 1 (Tb_n/Yb_n=1.62-1.8; $(La/Yb)_n/(Sm/Yb)_n$=1.38-1.71) and a garnet peridotite source for Groups 2 and 3 (Tb_n/Yb_n=1.9-2.1; $(La/Yb)_n/(Sm/Yb)_n$=1.56-1.96) with variations in the degrees of melting: Group 1, La_n/Lu_n=3.1-4.8; La_n/Sm_n=1.5-2; Gd_n/Yb_n=1.8-2.2; Group 3, La_n/Lu_n=4-6.8; La_n/Sm_n=1.3-1.7; Gd_n/Yb_n=2-2.7; and Group 2 compositions lying between these values. This study contributes to the understanding of the temporal evolution of magma compositions and gives new insights into the origin of the magma(s), which is vital information for creating realistic hazard scenarios in this culturally important area.