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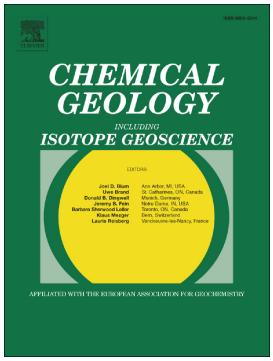

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M. Zelenski, V.S. Kamenetsky, J.A. Mavrogenes, A.A. Gurenko, L.V. Danyushevsky

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Silicate-sulfide liquid immiscibility in modern arc basalt (Tolbachik volcano, Kamchatka): Part I. Occurrence and compositions of sulfide melts.

M. Zelenski [a], V.S. Kamenetsky [b,a*], J.A. Mavrogenes [c], A.A. Gurenko [d], L.V. Danyushevsky [b,e]

[a] *Institute of Experimental Mineralogy RAS, Chernogolovka 142432, Russia*
[b] *CODES and Earth Sciences, University of Tasmania, Private Bag 79, Hobart, TAS 7001, Australia*
[c] *Research School of Earth Sciences, Australian National University, Canberra, ACT 2601, Australia*
[d] *Centre de Recherches Pétrographiques et Géochimiques (CRPG), UMR 7358, Université de Lorraine, 54501 Vandoeuvre-lès-Nancy, France*
[e] *ARC TMVC Research Hub, University of Tasmania, Private Bag 79, Hobart, TAS 7001, Australia*

* Corresponding author at: School of Physical Sciences, University of Tasmania, Hobart, TAS 7001, Australia.
E-mail address: Dima.Kamenetsky@utas.edu.au (V. Kamenetsky).

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ABSTRACT

Silicate-sulfide liquid immiscibility plays a key role in the formation of magmatic sulfide ore deposits but incipient sulfide melts are rarely preserved in natural rocks. This study presents the distribution and compositions of olivine-hosted sulfide melt globules resulting from silicate-sulfide liquid immiscibility in primitive arc basalts. Abundant sulfide droplets entrapped in olivine from primitive basalts of the 1941 eruption and pre-historic eruptive cone "Mt. 1004" of the Tolbachik volcano, Kurile-Kamchatka arc. Inclusions range from submicron to 250 μm in size, coexist with sulfur-rich glass (≤ 1.1 wt% S), and, in some cases, with magmatic anhydrite. Saturation in sulfide occurred early in the evolution of a water- and sulfur-rich magma, moderately oxidized (QFM+1…+1.5), which crystallized high-Mg olivine (Fo_{86-92}), clinopyroxene and Cr-spinel. The process developed dense "clouds" of sulfide in relatively small volumes of magma, with highly variable abundances of chalcophile metals. The low degree of sulfide supersaturation promoted diffusive equilibration of the growing droplets with the melt in Ni and Cu, resulting in high concentrations (≈38 mol%) of CuS and NiS in the earliest sulfide liquids. The Tolbachik samples provide a glimpse into deep arc processes not seen elsewhere, and may show how arc magmas, despite their oxidized nature, saturate in sulfide.

1. Introduction

Immiscible sulfide melt segregates from silicate melt if the concentration of S^{2-} (sulfide) in the silicate melt surpasses the sulfur content at sulfide saturation (SCSS, e.g. Li and Ripley, 2005; O'Neill and Mavrogenes, 2002; Wykes et al., 2014). Chalcophile and highly siderophile elements (Cu, Ni, Au, PGE etc.) are present in the silicate melt in low concentrations but strongly partition into sulfide, such that even small amounts of sulfide melt collect most or all of the chalcophile elements. Because of its high specific gravity, sulfide melt tends to accumulate in lower parts of magma chambers, which become potential Cu-Ni-(PGE) magmatic sulfide ore deposits (e.g. Naldrett, 2004). The phenomenon of sulfide-silicate immiscibility plays a key role in the formation