Vorlanite (CaU\textsuperscript{VI})O\textsubscript{4}—A new mineral from the Upper Chegem caldera, Kabardino-Balkaria, Northern Caucasus, Russia

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ABSTRACT

The new mineral vorlanite, (CaU\textsuperscript{VI})O\textsubscript{4}, \(D_{calc} = 7.29 \text{ g/cm}^3\), \(H = 4–5\), \(VHN_{10} = 360 \text{ kg/mm}^2\), was found near the top of Mt. Vorlan in a calcareous skarn xenolith in ignimbrite of the Upper Chegem caldera in the Northern Caucasus, Kabardino-Balkaria, Russia. Vorlanite occurs as aggregates of black platy crystals up to 0.3 mm long with external symmetry \(\text{Sm}\). The strongest powder diffraction lines are \([d(\text{Å})/hkl] : 3.107/(111), 2.691/(200), 1.903/(220), 1.623/(311), 1.235/(331), 1.203/(420), 1.098/(422),\) and \(1.010/(531)\). Single-crystal X-ray study gives isometric symmetry, space group \(\text{Fm\overline{3}m}\), \(a = 5.3813(2) \text{ Å}\), \(V = 155.834(10) \text{ Å}^3\), and \(Z = 2\). X-ray photoelectron spectroscopy indicate that all U in vorlanite is hexavalent. The mineral is isostructural with fluorite and uraninite (U\textsuperscript{VI}O\textsubscript{2}). In contrast to synthetic rhombohedral CaUO\textsubscript{4}, and most U\textsuperscript{VI} minerals, the U\textsuperscript{VI} cations in vorlanite are present as disordered uranyl ions. \(^{10}\)Ca\textsuperscript{II} and \(^{18}\)O\textsuperscript{VI} are disordered over a single site with average M-O = 2.33 Å.

Vorlanite is believed to be a pseudomorphic replacement of originally rhombohedral CaUO\textsubscript{4}. We assume that this rhombohedral phase transformed by radiation damage to cubic CaUO\textsubscript{4} (vorlanite). The new mineral is associated with larnite, chegemite, reinhardbraunsite, lakargiite, rondorfite, and wadalite, which are indicative of high-temperature formation (>800 °C) at shallow depth.

Keywords: Vorlanite, CaUO\textsubscript{4}, uranium, skarn, structure, Raman, XPS, Lakargi

INTRODUCTION

Vorlanite (CaU\textsuperscript{VI})O\textsubscript{4} [fluorite-type structure, \(\text{Fm\overline{3}m}, a = 5.3813(2) \text{ Å}\), \(V = 155.834(10) \text{ Å}^3\)] was found in 2008 in high-temperature skarns in the calcareous xenolith no. 7, hosted by ignimbrites of the Upper Chegem caldera in the Northern Caucasus, Kabardino-Balkaria, Russia. Vorlanite is another new mineral from altered xenoliths dispersed between Mt. Lagarky and Mt. Vorlan (coordinates 43°17′N 43°6.42′E; see geological map in Galuskin et al. 2009). They include calcio-olivine Ca\textsubscript{2}Si\textsubscript{O}\textsubscript{4} (Zadov et al. 2008), lakargiite Ca\textsubscript{2}Zr\textsubscript{O}\textsubscript{3} (Galuskin et al. 2008), chegemite Ca\textsubscript{3}Si\textsubscript{O}\textsubscript{4}\textsubscript{4}OH\textsubscript{2} (Galuskin et al. 2009), kunytyubeite Ca\textsubscript{3}Si\textsubscript{O}\textsubscript{4}F\textsubscript{2} (Galuskin et al. 2009), torutite Ca\textsubscript{4}Sn\textsubscript{2}Fe\textsubscript{2}Si\textsubscript{2}O\textsubscript{12} (Galuskin et al. 2010a), elbursite-(Zr) Ca\textsubscript{5}Zr\textsuperscript{4+}Fe\textsuperscript{2+}Fe\textsuperscript{2+}O\textsubscript{12} (Galuskin et al. et al. 2010b), bitikleite-(SnAl) Ca\textsubscript{4}Sn\textsubscript{2}Al\textsubscript{2}O\textsubscript{12} and bitikleite-(ZrFe) Ca\textsubscript{5}Zr\textsubscript{5}Fe\textsubscript{2}O\textsubscript{12} (Galuskin et al. et al. 2010c), KNa\textsubscript{2}Li(Mg,Fe)\textsubscript{2}Ti\textsubscript{2}Si\textsubscript{2}O\textsubscript{24} (IMA2009-009), and Ca\textsubscript{2}Sn\textsubscript{2}O\textsubscript{5} (IMA2009-090).

Vorlanite stoichiometry is identical with the synthetic rhombohedral calcium uranate CaUO\textsubscript{4}. However, while hexavalent uranium in the latter has characteristic 2+6 coordination of oxygen, as known for the uranyl ion (U\textsuperscript{VI}O\textsubscript{2}\textsuperscript{2+}) (Loopstra and Rietveld 1969), the U\textsuperscript{VI} cation in vorlanite is eightfold coordinated by equidistant O atoms, which is typical of the fluorite-type structure. In this respect, vorlanite is exceptional among U\textsuperscript{VI} minerals because the great majority of them show order of linear (U\textsuperscript{VI}O\textsubscript{2}\textsuperscript{2+}) uranyl ions (Burns 1999, 2005).

Vorlanite, named after Mt. Vorlan, was approved as a new mineral species by CNMNC IMA in July 2009 (IMA2009-032). The type specimen of vorlanite is deposited in the Fersman Mineralogical Museum in Moscow, Russia (catalog no. 3838/1).

In this paper we provide a detailed description of vorlanite.

Methods of investigations

Crystal morphology and chemical composition of vorlanite and associated minerals were examined using optical microscopes, analytical electron scanning microscope Philips XL30 ESEM/EDAX (Faculty of Earth Sciences, University of Silesia) and electron microprobe Cameca SX100 (Institute of Geochemistry, Mineralogy and Petrology, University of Warsaw). Electron-microprobe analyses of vorlanite were performed at 15 kV and 40–50 nA using the following lines and standards: Uβ for synthetic UO\textsubscript{2}, CaKα for wollastonite and diopside; FeKα for hematite. Raman spectra of single crystals of vorlanite were recorded using LabRAM HR800 (Jobin-Yvon-Horiba, Wrocław University of Technology) equipped with an 1800 line/mm grating monochromator, a charge-coupled device (CCD) Peltier-