X-ray computed microtomography of diamondiferous impact suevitic breccia and clast-poor melt rock from the Kara astrobleme (Pay-Khoy, Russia)

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ABSTRACT

X-ray computed microtomography (CT) of impact rock varieties from the Kara astrobleme is used to test the method’s ability to identify the morphology and distribution of the rock components. Three types of suevitic breccias, clast-poor melt rock, and a melt clast from a suevite were studied with a spatial resolution of 24 µm to assess CT data values of 3D structure and components of the impactites. The purpose is first to reconstruct pore space, morphology, and distribution of all distinguishable crystallized melt, clastic components, and carbon products of impact metamorphism, including the impact glasses, after-coal diamonds, and other carbon phases. Second, the data are applied to analyze the morphology and distribution of aluminosilicate and sulfide components in the melt and suevitic breccias. The technical limitations of the CT measurements applied to the Kara impactites are discussed. Because of the similar chemical composition of the aluminosilicate matrix, glasses, and some lithic and crystal clasts, these components are hard to distinguish in tomograms. The carbonaceous matter has absorption characteristics close to air, so the pores and carbonaceous inclusions appear similar. However, X-ray microtomography could be used to prove the differences between the studied types of suevites from the Kara astrobleme using structural-textural features of the whole rock, porosity, and the distributions of carbonates and sulfides.

Keywords: X-ray computed tomography, impactites, impact melt rocks, impact glasses, suevites, Kara astrobleme

INTRODUCTION

Shock metamorphism in large impact structures is one of the important processes significantly affecting regional geology and mineral deposits formation. Approximately 190 impact craters on the Earth’s surface are known (Schmieder and Kring 2020; Earth Impact Database). Impactites are the products of meteorite impact events. Their general specifics and systematics have been described in numerous works (Stöffler and Grieve 2007; Stöffler 2018; Osinski and Pierazzo 2013; French 1998; French and Koeberl 2010; Masaitis et al. 1998). Impactites are divided into three groups: shocked rocks (non-brecciated, melt-free), impact melt rocks (clast-free, clast-poor, and clast-rich), and impact breccias (lithic breccias and suevites; the latter contain lithic and melt clasts). The particulars of impactite formation are determined by numerous factors of the falling meteoritic bodies and by the compositions of target rocks. The Kara astrobleme is one of the largest astroblemes known on land, formed on a sedimentary target ~70 Ma ago (Machshak 1991; Masaitis et al. 1998; Koeberl et al. 1990; Trieloff et al. 1998; Masaitis 1999). The astrobleme is characterized by high concentrations of unusual after-coal diamonds and diamond pseudomorphs of organic relics (“diamond fossils”; Shumilova et al. 2018c, 2019b). One of the poorly studied aspects of this object is the diversity and structure of impactites, as well as the distribution and nature of diamond concentration levels. Among the impactites at the Kara astrobleme, clast-poor melt rocks form several layer-like bodies, some dikes, and some vein glass bodies (Shumilova et al. 2020). The suevites are very widely distributed and have been divided into three types according to geological, morphological, and structural characteristics (Shumilova et al. 2019a). These types presumably formed from different target substrates: type I suevites—predominantly silicate substrate; type II—mainly carbonate substrate; and type III—mainly carbonaceous deposits (Shumilova et al. 2019a). In addition, one of the most interesting varieties of the impactites in this astrobleme is that the impact melt rock has close spatial and genetic relationships with the type I suevites. In this regard, the assessment of the volumetric distribution of structural components in the varieties of clastic and melt impactites of the Kara astrobleme is very important.

X-ray computed microtomography (CT) is one of the potentially promising methods for studying this type of shocked-generated, complicated rock. In this study, the CT method was used to analyze the 3D structure of the impactites and attempt to estimate the distribution of impact diamonds within suevites, clast-poor melt rocks, and melt clasts within suevites.

X-ray computed tomography is a non-destructive method for internal structure studies that was proposed by Godfrey Hounsfield and Allan Cormac (Hounsfield 1973). Over the past decades, this method has been proven in many branches of science, including