"SUEVITES" OF THE POPIGAI IMPACT STRUCTURE, RUSSIA: (MIS)UNDERSTOOD? G. R. Osinski[1], R. Sukara[1], and R. A. F. Grieve[1,2], [1]Dept. Earth Sciences / Physics and Astronomy, University of Western Ontario, 1115 Richmond St. London, ON N6A 5B7, Canada (gosinski@uwo.ca), [2]Earth Sciences Sector, Natural Resources Canada, Ottawa, ON K1A 0E4, Canada

Introduction: The energy released during a meteorite impact event causes irreversible damage to a large volume of the target, which results in the formation and transportation of huge amounts of broken and altered rock material (i.e., breccias). "Suevite" is a term used for such impact breccias containing shock-melted, shock-metamorphosed and unshocked clasts of target rocks. It was first described at the Ries impact structure, Germany, where it is most familiar as a surficial deposit in the outer crater and beyond the rim and interpreted as some form of ejecta [1]. The historical definition of "suevite" included the "fact or observation" that it had a clastic (i.e., fragmental) matrix [2].

The term "suevite" has since been applied to many different types of impactites from a number of impact structures, often without due consideration of the original definition. Furthermore, the recent application of scanning electron microscopy (SEM) to the study of impactites, however, has resulted in a change to their basic definition and challenged the interpreted origin for "suevites" at the Ries [3] and Rochechouart [4] impact structures. Here, we present new data on "suevites" from the Popigai impact structure, Russia, that raises questions concerning their nomenclature and origin.

Fig. 1. Impact breccias along the Rassokha River, capped by impact melt rock, Popigai structure.

Popigai impact structure: The ~100 km diameter Popigai structure was formed ~36 Ma on the north-eastern margin of the Anbar Shield, Siberian Platform (71° 28' N, 111° 11'E). The target rocks comprised a sequence of ~1.5 km thick sedimentary rocks – Proterozoic to Cambrian conglomerates, quartzites, dolomites and limestones, overlain by Permian to Cretaceous mudstones and sandstones – overlying the Archean crystalline basement rocks[5].

Suevites. A wide variety of impactites are found within the Popigai structure, distributed over an area of ~5,000 km^2 [5]. The two main types are impact melt rocks (called locally as tagamites) and suevites. The latter may reach ~1 km in thickness [5]. Thus understanding their origin is critical for understanding the nature and formation of the Popigai structure.

Samples and analytical techniques: This study focused on 10 "suevite" samples collected from various localities along the Rassokha River (Fig. 1) and Sogdoku Uplands. Polished thin sections were studied using optical microscopy and back-scattered electron (BSE) imagery. Quantitative analyses were carried out using wavelength dispersive X-ray (WDS) techniques on a JEOL JXA-8900 L electron microprobe.

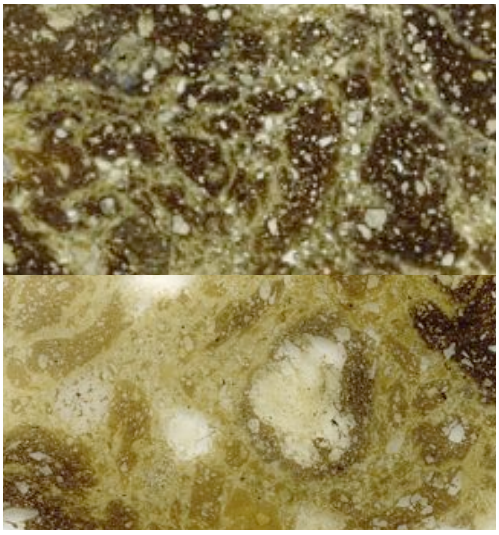

Fig. 2. Scanned thin sections showing the inter-sample variability, particularly in terms of glass content.

Petrography of the groundmass: We define the groundmass of the Popigai "suevites" as the fine-grained material that encloses fragments of shocked/unshocked target material. The groundmass, as defined here, comprises fine-grained mesostasis and crystallites (clinopyroxene, plagioclase). Calcite is also present but is unclear whether this is a primary impact melt phase or the product of hydrothermal alteration.

The attributes of the groundmass phases are presented below. Two important points are of note: (1) the "suevites" are typically groundmass-supported; (2) the proportions of the various groundmass phases and clasts vary considerably, both between different samples (e.g., Fig 2) and over the scale of a thin section.

Mesostasis. The groundmass of suevite is dominated by fine-grained mesostasis in the majority of samples investigated, with modal abundances ranging from ~20 to 60 vol%. This material is partly to fully isotropic and it is unclear whether it comprises clay minerals and/or impact glass.

Crystallites. Clinopyroxene crystallites are common in the impact melt rocks at Popigai [6]. BSE imagery reveals that clinopyroxene is also present in the groundmass of the suevites as acicular crystallites (Fig. 2a) and, more commonly, as irregularly-shaped masses (Fig. 2b). EMPA analysis reveals that they are typically very Ca-rich ($En_{52–58}Fs_{38–47}Wo_{1–7}$), particularly when compared to clinopyroxene in the melt rocks ($En_{30–47}Fs_{2–12}Wo_{47–63}$ [6]). These clinopyroxenes are also very Al-rich and can also be intergrown with plagioclase feldspar.

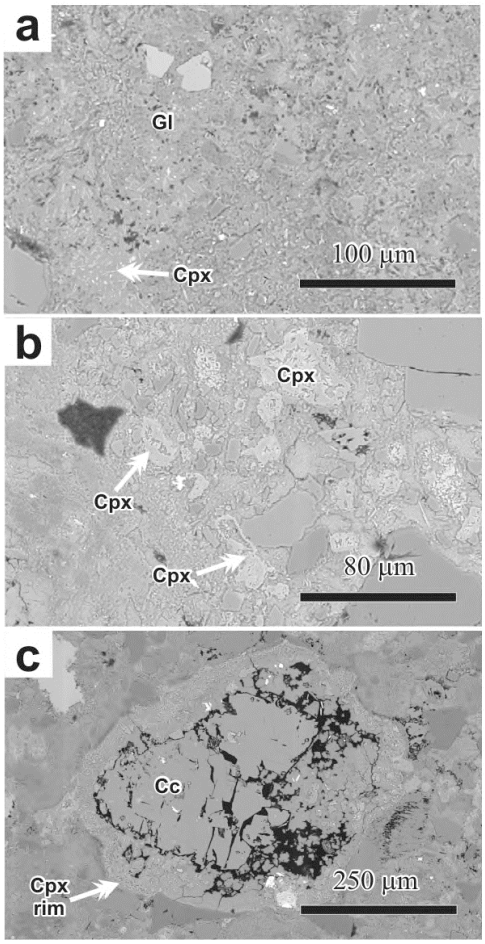

Fig. 3. BSE images of Popigai suevites. (a) fine-grained clinopyroxene (Cpx; bright) crystallites within mesostasis. (b) irregular clinopyroxene (Cpx) masses within the groundmass. (c) limestone clast (Cc) with a reaction rim of glass + clinopyroxene.

Clast reaction textures: An interesting feature of many of the suevite samples studied are reaction rims around carbonate clasts (Fig. 3c). The reaction rims typically comprise intergrowths of glass (now devitrified) plus clinopyroxene, with the latter displaying the same composition as the groundmass clinopyroxenes.

Discussion: "Suevites" are a poorly understood impactite lithology. Originally thought to comprise a purely clastic groundmass/matrix, it has been demonstrated that certain impactites previously termed "suevites" at the Ries [3] and Rochechouart [4] impact structures do not actually conform to the original definition, as they possess a groundmass comprising a series of (albeit heterogeneous) melt phases.

Here, we have shown that at least some of the "suevites" within the Popigai impact structure comprise a groundmass that does not appear to be clastic. Much of the groundmass comprises "mesostasis". It is unclear at present as to whether this material glass, X-ray amorphous clay, or clay (does not make sense). Whatever its current state, it is clear that this material was likely originally glassy (cf. the Ries structure [7]). The presence of primary clinopyroxene that grew within the groundmass following emplacement (which is required by the preservation of delicate crystal shapes and textures) strongly suggests that this material was not in a clastic state, but was at least partially molten following deposition. This is supported by the observation of carbonate clasts that possess reaction rims. The formation of diopside from calcite requires temperatures in excess of ~650 ^{o}C [8]; or if decomposition played a role, temperatures >900 ^{o}C are required [9]. Importantly, the rims are neither cut by or diffuse into the groundmass, indicating that reaction/decomposition occurred after deposition. Together, these observations are similar to recent observations from the Ries structure [3]. Importantly, these impactites do not conform to the original definition of "suevite". This clearly also has implications for their origin and mode of emplacement.

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