DEVITRIFICATION OF IMPACT GLASSES AT THE BOSUMTWI IMPACT STRUCTURE, GHANA: IMPLICATIONS FOR SUEVITE COOLING HISTORY AND PRESENCE OF WATER. R. Välja[1], K. Kirsimäe[1], C. Koeberl[2] and D. K. Boamah[3], [1]Department of Geology, University of Tartu, Estonia (rvalja@ut.ee), [2]Department of Lithospheric Research, University of Vienna, 1090 Vienna, Austria, and Natural History Museum, Burgring 7, 1010 Vienna, Austria, [3]Ghana Geological Survey Department, Accra, Ghana.

Introduction: The formation of suevite has been under discussion since its recognition as a specific type of impactite [1]. Several hypotheses, including turbulent ejecta plume [2], pyroclastic [3], or impact melt-flow [4], have been proposed to explain structural and textural peculiarities of the suevite varieties within crater fill and beyond the crater rim. Most recently a “fuel-coolant interaction” (FCI) model, explaining the suevite formation as resulting from vigorous explosive interaction of impact melt and water/water-rich sediments has been proposed to describe the properties and distribution of the suevites at the Ries crater, Germany [5], where suevitic impactites were first described and later studied in detail [6, 7].

The Bosumtwi impact crater is a young and well-preserved complex impact structure in Ghana, West Africa. The 10.5 km-diameter crater formed into 2.1-2.2 Gyr old Birimian Supergroup metasediments and metavolcanics in continental setting about 1.07 Myr ago (e.g., [8, 9]). The spatial distribution and appearance of the crater filling and outer suevite in Bosumtwi is similar to the Ries crater [10, 11]. The crater filling suevites at Bosumtwi are characterized by absence or low content of melt that could be explained using the FCI model, assuming that enough water (>10 vol%) was present in target rocks [7].

Impact glass formation, cooling history, and presence of volatiles during melt and/or suevite formation can be assessed from impact glass/melt devitrification processes and products (e.g., [12]). In this contribution we report petrography and geochemical composition of devitrification products in impact glasses in Bosumtwi suevites and we aim for refining the cooling history of suevitic impactites and estimate the presence-influence of water on the impact glass devitrification at this crater.

Material: Outer suevite samples were collected from (a) outcrops north of the Bosumtwi crater and (b) from shallow drillcores BH1 and BH3 described by Boamah and Koeberl [10, 13]. Texture and composition of samples were characterized by means of optical microscopy, analytical scanning electron microscopy, and X-ray diffraction (XRD).

Results and Discussion: Whole rock XRD analysis of outer suevite samples rich in vesicular glassy material shows a mineral composition of crystalline phases dominated by feldspar, micaceous minerals, and smectite clay minerals, with significant amounts of cristobalite and spinel type phases. Spinel was identified as hercynite and its content in crystalline phases can be as high as 8 wt%. Wide XRD peaks suggest that both feldspar and hercynite have either a highly disordered structure (small coherent stacking domain sizes) or occur as small microscopic crystallites. Also, small amounts of quartz and an ilmenite-type Fe-Ti mineral were identified in XRD patterns of melt-rich outer suevites, whereas pyroxene was not found in XRD analyses.

Devitrified glass contains numerous microlitic crystals and crystal aggregates of different shapes derived from rapid cooling (quenching). Shapes and sizes of microlites in Bosumtwi glasses vary from simple acicular and lath-like to complex dendritic-fan/feathery/fir-like forms. Spherulites are typically found in three forms: sheaf to stellate type microlitic crystals radiating from a common point; aggregates radiating from a rock-mineral core or from a tiny cavity/vesicule, and compound forms. Optical and scanning electron microscopy analyses indicate that the dendritic-spherulitic microlite lath-needle aggregates are of feldspar and biotite-type mica composition, whereas pyroxene occurs as single acicular and lath shape microlites, and fine feathery dendritic aggregates (Fig. 1). The matrix of the glass in Bosumtwi suevites contains abundant Mg-hercynite (pleonaste)-type spinels that occur as cubic-octahedral crystallites with sizes rarely exceeding few µm. In some cases individual crystallites form elongated skeletal aggregates (Fig.1d). Microprobe analyses of feldspar show composition varying from plagioclase An45 to An20, and anorthoclase Or50-Ab50 (An<20). Pyroxene is characterized by a metastable Al-rich and Ca-poor composition suggesting formation under strongly undercooled conditions.

Hercynite-type spinel has been reported to occur in impact melt rocks (tagamites) from the Popigai [14], Chesapeake Bay [15], and Zhamanshin [16] impact structures. The crystallization sequence at Bosumtwi suggests that, similar to the Chesapeake Bay structure, the Mg-hercynite and Opx were the earliest phases, followed by mica/biotite and feldspar. Fe-Ti oxide aggregates result most probably from melt immiscibility. According to Feldman et al. [16] the hercynite-type spinel appeared in Zhamanshin impact glasses at temperatures >1300 °C. However, phase equilibrium in

FeO-Al_2O_3-SiO_2 system suggests metastable eutectic point for hercynite crystallization at 1073 °C [17].

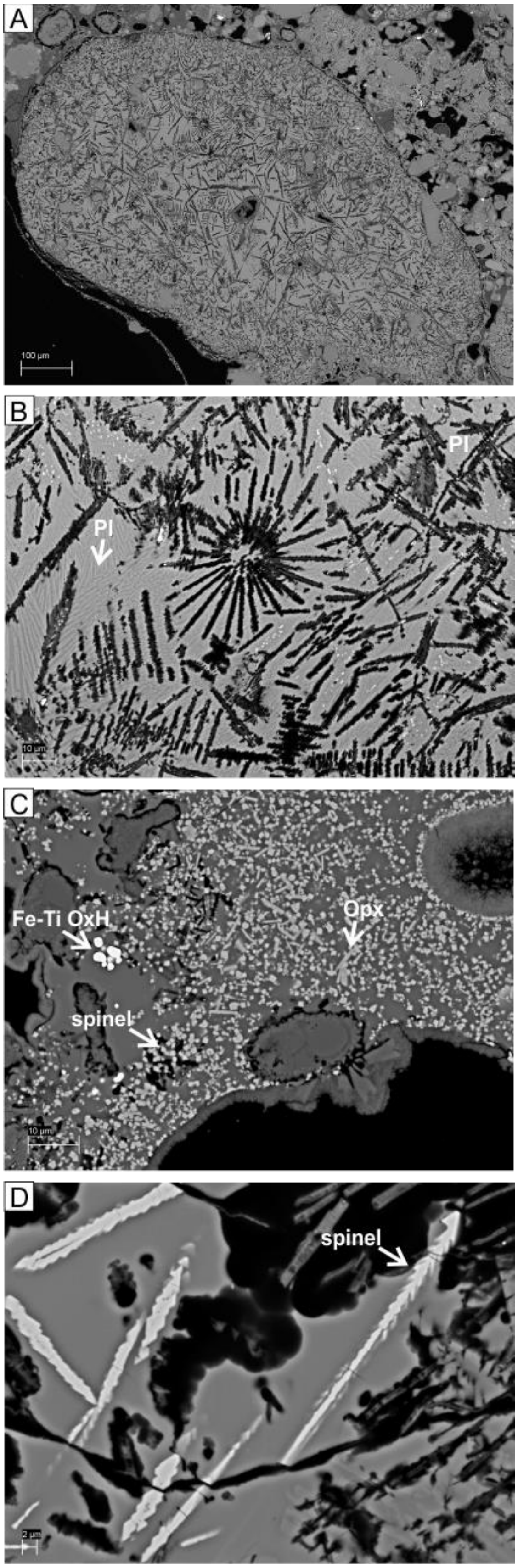

Fig. 1. Devitrified glass particle in sample LB-47 (from an outcrop north of the crater) showing (a) different microlite textures, (b) plagioclase (Pl) fan like laths and mica/orthopyroxene (Opx) microlite aggregates, (c) Mg-hercynite crystallites with Opx laths and Fe-Ti oxide exsolution aggregate Fe-Ti Ox and (d) elongated skeletal aggregate composed of spinel crystallites.

This agrees with the crystallization of Ca-poor composition Opx at equilibrium temperatures approximately of 1100 °C [18]. On the other hand, the biotite composition of microlites, and feldspar with composition varying between plagioclase (An50) and anorthoclase, suggest a second stage of cooling at temperatures possibly lower than 700 °C, whereas particularly high density of feldspar microlites indicates high nucleation rate at high undercooling.

Engelhardt et al. [12] have experimentally shown that crystallization of feldspar (plagioclase) requires water pressures >10 bar, while biotite is formed with or without feldspar at water pressures above 30 bar. Consequently, Engelhardt et al. [12] estimated that crystallization of pyroxene, plagioclase, and magnetite in melt fragments in fall-out suevites in 24-km-diameter Ries crater, Germany, at about 650–750 °C and water partial pressure of 20–30 bar. Similar conditions or even higher water pressures can be deduced from devitrification phases and textures of melt particles at Bosumtwi.

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