CHEMICAL COMPOSITION OF IMPACT GLASS AND SUEVITE-TYPE PARTIAL MELTS OF THE RAB AND KRK ISLANDS AND THEIR RELATION WITH THE PROPOSED KRK IMPACT STRUCTURE IN NORTHERN ADRIATIC, CROATIA.

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Introduction: Large chunks of vesicular glass and fragments of suevite-type partial melts are found in secondary position on the Rab and Krk islands in Northern Adriatic Sea (Fig. 1). These are largely misplaced today due to collecting by local rock-hunters, but nevertheless still available for research. Some of the glass chunks were originally laying free on the base-rock made of Eocene quartz sandstones, whereas some were embedded in an old Roman villa wall on the Rab Island (Fig. 2). The blocks are usually 10-30 kg in weight, but no primary layer has ever been found. Scattered fragments of incomplete melt rocks have also been found on other Northern Adriatic islands, but are not studied so far.

The Rab Island is located 10 km southward from the Krk Island. The proposed impact structure is located 26 km north from the Rab Island, and was attributed post-Eocene age [1]. The studied melt-rocks and glasses are found ca. 19 km from the impact structure outer rim.

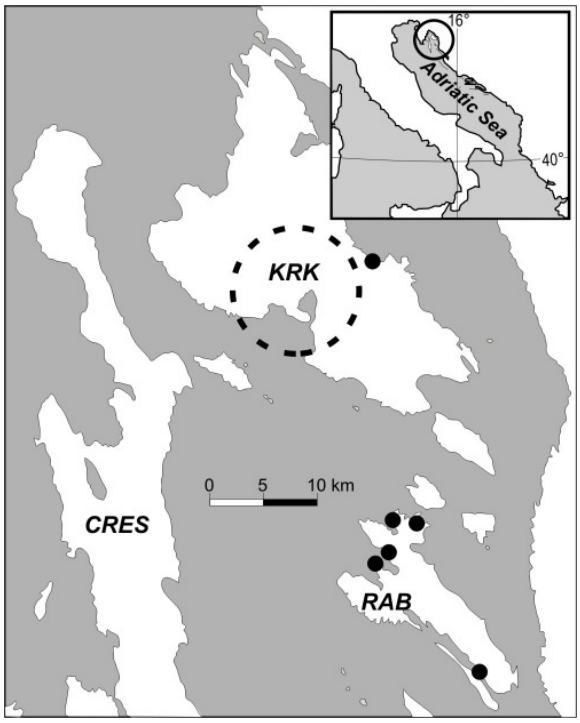

Fig. 1) Localities with glasses and partial melt rocks on the Rab and Krk islands (black dots), and the proposed Krk impact structure.

Fig. 2) Block of dark green vesicular glass still embedded in an old Roman wall. The block is 40 cm wide.

Research methods: The samples of glasses and impact melts were cut and polished, and studied under polarizing microscope for their texture and structures. Mineralogical analysis was performed on Philips XPert-Pro powder diffractometer at 40 kV and 40 mA. The analysis of chemical composition was performed at the Rudjer Bošković Institute Accelerator facility using PIXE Spectroscopy in high vacuum at the ion micro-beam end-station. The 2 MeV proton beam of about 50 pA current was positioned on selected areas on samples. X-rays from the selected areas of the samples were collected by SDD and PGT Si(Li) detectors. Quantitative analysis of collected PIXE spectra was performed using fundamental parameter approach with GupixWIN Software [2]. Iterated matrix solution algorithm was used assuming that all the elements are present as oxides with the option of normalization to 100%. Glass standards NIST 620 and NIST 1107 were used for calibration.

Results: The vesicular glass is turquoise to dark bluish coloured, macroscopically massive, crystalline. The number of vesicles locally varies, some vesicles are filled with secondary calcite cement, whereas some are empty. Microscopically, the glass shows spinifex texture made of intergrown pyroxene fibres (Fig. 3). X-ray powder diffraction of glass revealed the presence of Cristobalite, Augite, Wollastonite, Kamacite and

Graphite, whereas PIXE spectroscopy showed predominance of SiO_2 (64.03-70.81 wt %), wide range of CaO (0.9-20.9 wt %) and FeO in range 1.6-4.7 wt %.

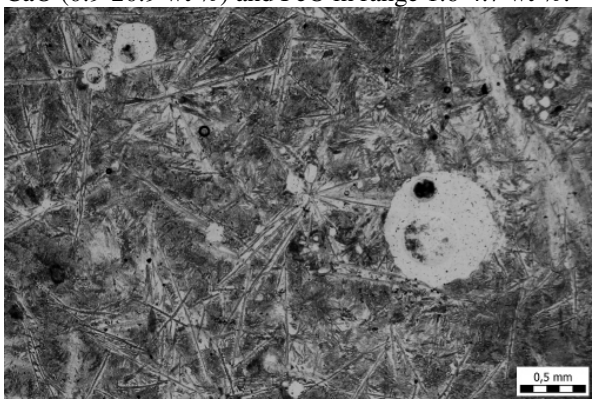

Fig. 3) The glass sample GR-2, spinifex texture with glass psherules.

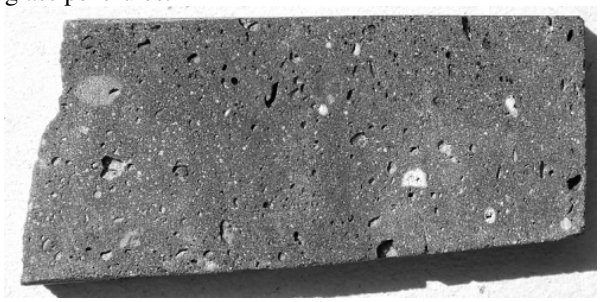

Fig. 4) Cut sample KC-3 of suevite-type partial melt from the northern Rab Island. The sample is 5 cm long. Note unmelted chert (white).

Table: Chemical composition of impact glasses and melts from the Rab and Krk islands.

	Sample					
	GR 2	GR 2/2	365/5	VR-6	KC-3*	KC-4*
SiO_2	64.03	67.82	66.75	70.81	65.74	68.67
Al_2O_3	7.82	8.86	8.71	15.80	16.23	17.80
K_2O	1.52	1.64	1.41	3.70	1.92	1.67
CaO	20.90	15.85	16.30	0.90	5.89	0.86
TiO_2	0.60	0.68	0.62	0.77	0.95	0.95
MnO	0.09	0.10	0.10	0.06	0.07	0.04
FeO	2.89	3.49	1.60	4.70	5.31	7.24
Na_2O	0.99	1.23	1.21	1.82	1.01	0.65
MgO	1.52	1.36	1.36	1.46	1.62	1.71
Cr_2O_3	0.05	0.05	0.04	0.08	0.03	0.04
SrO	0.05	0.03	0.03	na	0.01	na
ZrO_2	na	0.04	0.04	0.03	0.02	0.03
NiO	0.01	0.01	0.01	0.005	0.03	0.02
CuO	na	na	na	0.004	0.01	0.01
ZnO	na	0.01	na	0.02	0.01	0.02

*partial melt rocks. Sample VR-6 is from the Krk Island and shows clear flow structure, all others are from the Rab Island, massive.

Suevite - type partial melts (Fig. 4) occur as cobbles to small boulders laying on the surface, or sometimes imbedded in soil. These melts are characterized by irregular "mottled" colouration, and presence of incompletely melted sandstone clasts with melted rims. They always comprise two types of dense glassy material; light beige to yellowish, and dark bluish-gray in colour. PIXE spectroscopy revealed predominance of SiO_2 (65.74-68.67 wt %), low CaO (0.86-5.89 wt %) and relativelly high FeO (5.31-7.24 wt %) (Table).

Discussion: The glass compositionally differs from the Eocene sandstones of the Krk Island which is relativelly poor in SiO_2 (38.06 wt %), relativelly rich in CaO (28.76 wt %) and poor in FeO (1.94 wt %) [3], but correlates better with the composition of Adriatic loess [4] by its higher SiO_2, Al_2O_3, K_2O, CaO, TiO_2 and MnO contents which are closer or within the measured ranges in Table. The chemical composition of glass and melt rock suggests that the Krk "flysch" did not contribute to the formation of melt rocks and glasses (as expected), but it is more likely that the target rocks was Pleistocene loess.

Conclusion: The chemical composition of glasses and partial melt rocks suggests that the impact target was Pleistocene loess, which contibuted to the high SiO_2 content. If the genetic relation with loess will be confirmed by future study, this will provide new age of the Krk structure, most likely Pleistocene.

References: [1] Marjanac T. et al. (2003) Krk-breccia, Possible Impact-Crater Fill, Island of Krk in Eastern Adriatic Sea (Croatia). Cratering in Marine Environments and on ice (eds. H. Dypvik, M. Burchell, P. Claeys), Impact Studies, 115-134, Springer, Berlin, [2] Campbell J.L. (2010) *in Nuclear Instruments and Methods in Physics Research Section B – Beam Interactions with materials and atoms* B 268, 3356-3363, [3] De Min A. et al. (2014) Geochemistry of Late Mesozoic - Early Cenozoic turbidites from the NE part of the Adria microplate. Periodico di Mineralogia 83/2, 141-158. [4] Mikulčić Pavlaković S. (2006) Mineraloške karakteristike pijesaka i piroklastita otoka Suska. MSc. Thesis, University of Zagreb.