

MICRO-RAMAN SPECTROSCOPY OF DIAMONDS FROM HOT DESERT UREILITES. T. Jakubowski¹, A. Karczewska², M. Kozanecki³, A. Gucsik⁴, A. Stanishevsky⁵, S. Mitura¹. ¹ Technical University of Lodz, Institute of Materials Science and Engineering, Stefanowskiego 1/15, Lodz, Poland (illaenus@gmail.com); ² Technical University of Lodz, Institute of Turbomachinery, Wolczanska 219/223, Lodz, Poland; ³ Department of Molecular Physics, Technical University of Lodz, Poland; ⁴ Max Planck Institute for Chemistry, Department of Geochemistry, Mainz, Germany, Joh.-J.-Becherweg 27, D-55128; ⁵ University of Alabama at Birmingham, Birmingham, Alabama, USA

Introduction: Ureilites are the second largest achondrite group, classified as primitive achondrites. They are enigmatic due to their close relationship with chondritic matter (primitive oxygen isotopic ratios and achondritic igneous texture) [1]. Currently there are 240 officially classified ureilites, in a great majority from hot and cold deserts. They are ultramafic coarse-grained rocks, mainly composed of olivine and pyroxene (pigeonite) [2]. Relatively high abundances of carbon (up to 6 vol. %) are characteristic for this group. Other accessory phases are, for instance, iron and sulfide. Polymorphs of carbon in ureilites are represented by amorphous carbon, graphite, carbide, diamond and lonsdaleite [3]. Carbon is usually present as vein-like, long-shaped forms between mm-sized olivine and pyroxene grains and, in some cases, even inside of these minerals.

Experiments: We examined polished slices of 8 ureilites : DaG 868, DaG 999, NWA 2634, NWA 4231, Sahara 98505, JaH 054, Dho 836, Dho 1303. Selection of samples was based on their shock stages, from less shocked (DaG 868), to highly shocked (Sahara 98505). All samples were re-polished with non-diamond powder.

Mean and local elemental composition of samples were determined by energy dispersive X-ray (EDX) method using EDX Link 3000 ISIS X-ray microanalyser (Oxford Instruments) and X-ray microprobe analyser EDX THERMO NORAN. Scanning electron microscopes Vega 5135 (Tescan) and HITACHI S-3000 N were used to characterize the microstructure of selected samples.

Raman spectra were recorded using the confocal Raman micro-spectrometer T-64000 (Jobin-Yvon) equipped with the BX-40 microscope (Olympus). The 514.5 nm Ar line was used for sample excitation. Other parameters of spectrum acquisition (time, laser power) were adjusted to obtain spectra of sufficient quality. The laser beam diameter was 1,5 μm , the light intensity across the beam was of Gaussian distribution.

Results: Scanning Electron Microscopy (SEM) images show characteristic black vein-like carbon phases which fill spaces between mm-sized olivine and pyroxene (Fig.1). Carbon phases are usually rounded by iron phase (white color on SEM photographs) associated with olivine and pyroxene.

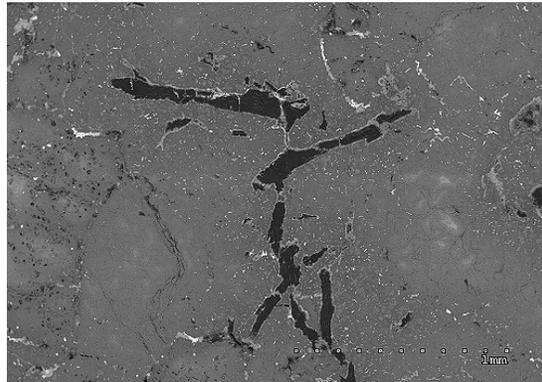


Figure 1. – SEM image of Sahara 98505 Ureilite.

Diamonds were found in all eight samples using microRaman spectroscopy. They were found in carbon, vein – like area, as well as in carbon associated with olivine crystals (JaH054).

The results of Raman spectroscopy (diamond peak positions and full width at half maximum values – FWHM) from eight ureilites are presented in Table 1. For a number of samples, we obtained several results from different locations in carbon veins. Figure 2 shows Raman spectra of chosen samples.

We obtained a few different Raman peaks of diamonds in our ureilite samples, ranging from 1323 cm^{-1} in JaH 054, to 1334 cm^{-1} in Sahara 98505 (see Table 1). In JaH 054 we acquired different Raman shifts from 1321 cm^{-1} to 1330 cm^{-1} . For the FWHM parameter, we also observed different results, from narrow peaks, such as 4,3 cm^{-1} in NWA 2634, to broad peaks of 22,2 cm^{-1} in Sahara 98505 (see Table 1 and Figure 2.). Figure 2 also indicates the coexistence of diamond and graphite. In a sample from Dho 836, the D band is at 1332 cm^{-1} and the G band is at 1616 cm^{-1} , for NWA 2634 they are at 1329 cm^{-1} and 1354 cm^{-1} , respectively, and for Sahara 98505 the D band is at 1333 cm^{-1} and the G band is at 1620 cm^{-1} .

For perfect monocrystalline graphite, only the G band is present in the first-order region at 1580 cm^{-1} . The 1350 cm^{-1} band (D1) is commonly called "the defect band" and appears in poorly-organized CM or microcrystalline graphite [4].

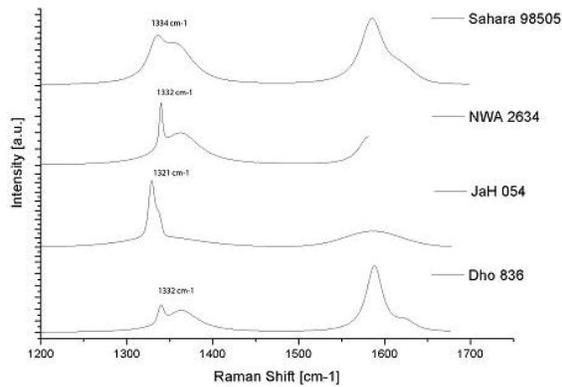


Figure 2. Raman spectra of diamonds from Sahara 98505, NWA 2634, Jah 054 and Dho 836.

Other bands in the second-order region which appear in poorly-organized CM are: 1150 cm^{-1} (strongly debated), 1500 cm^{-1} and 1620 cm^{-1} (D2) [5].

Ureilite Name :	Diamond Peak Raman Spectra:	FWHM (full width at half maximum)
DaG 868	1332 cm^{-1}	$9,7\text{ cm}^{-1}$
DaG 999	1332 cm^{-1}	11 cm^{-1}
Dho 836	1328 cm^{-1}	$11,2\text{ cm}^{-1}$
	1332 cm^{-1}	$8,05\text{ cm}^{-1}$
Dho 1303	1332 cm^{-1}	$11,6\text{ cm}^{-1}$
	1332 cm^{-1}	$10,5\text{ cm}^{-1}$
JaH 054	1330 cm^{-1}	$6,1\text{ cm}^{-1}$
	1321 cm^{-1}	$8,3\text{ cm}^{-1}$
	1323 cm^{-1}	$14,3\text{ cm}^{-1}$
NWA 2634	1332 cm^{-1}	$4,3\text{ cm}^{-1}$
	1329 cm^{-1}	$11,1\text{ cm}^{-1}$
Sahara 98505	1334 cm^{-1}	$22,2\text{ cm}^{-1}$
	1333 cm^{-1}	$15,2\text{ cm}^{-1}$
NWA 4231	1330 cm^{-1}	$6,3\text{ cm}^{-1}$
	1330 cm^{-1}	$10,6\text{ cm}^{-1}$

Table 1. Results of diamond peaks and FWHM in eight ureilite samples.

Conclusions: Our research of eight ureilites, based on micro-Raman spectroscopy, proved the occurrence of diamonds in all samples. Diamonds were found not only in highly-shocked ureilites, but also in the least-shocked specimens. This can give us new

insights into the origin of diamonds in ureilites, however, more research is needed in this area.

Various Raman shifts (from 1321 cm^{-1} to 1332 cm^{-1}) and FWHM (from $4,3\text{ cm}^{-1}$ to $14,3\text{ cm}^{-1}$) show the differences occurring within diamond samples (and even within the same sample), but do not lead to clear conclusions regarding examined diamonds.

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