Further Evidence of Enriched Uranium in guided weapons employed by the Israeli Military in Lebanon in July 2006
Ambulance Air Filter Analysis

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Background

We recently reported results of measurements made on soil samples from bomb craters in southern Lebanon (Busby and Williams, Green Audit Research Note, 6/2006). These showed the presence of enriched Uranium (EU) with an isotopic atomic ratio (U238/U235) of 108 in one of the samples taken from Khiam and suggested the presence of enriched Uranium in the other one from Taire. The normal environmental Uranium isotope ratio is 137.88 with a standard deviation of about 0.5 so values above 139 or below 136 are extremely unlikely. The activity concentration in the Khiam sample was about 180Bq/kg and the Uranium was located in a fine surface deposit of black dust. This implied that it was the bomb itself which had generated the dust i.e. that the EU was part of the bomb. The samples had also been examined by scintillation counting of beta and alpha activity and by alpha track analysis using CR39 plastic slides.

The origin of this enriched Uranium is puzzling. It cannot be an artefact (i.e. a natural variation), and EU can only originate from an enrichment plant or a nuclear reactor. Since the first report was published and in order to obtain further information which might point to a source pre- or post-nuclear reactor use, another portion of the Khiam sample taken from near the same crater has been analysed in a second laboratory. Long count time low temperature gamma spectrometry was used to look for fission product gamma signatures; chemical separation and alpha spectrometry was used to confirm the Uranium isotopic ratio and to look for Plutonium-239+240.

We report the results of these analyses here.

One question which is of interest from the point of view of the health of the population of Lebanon and surrounding countries is whether these samples are isolated examples of the use of enriched Uranium in this war, or whether there was more widespread contamination. We were able to address this issue since one of us (DW) had obtained another sample. This was the engine air filter from an ambulance which had been operating in south Beirut for the first two weeks of the bombardment until it was disabled in one of the attacks. It was reported to have been hit on day 16 of the war while taking bombing casualties from south Beirut to hospital. When we found it, the damaged ambulance was parked in Haret Hreyk, 50 metres from the ruins of former Hizbullah offices. Fig 1A shows a photo of the ambulance at this site The filter (Fig 1B) was examined in Green Audit's laboratory in Aberystwyth, Wales using CR39; a section was sent to the Harwell laboratory for Uranium isotope analysis and for analysis of 45 elements. These results are also reported here.

2. Results of further tests on the Khiam samples

Another sample from near the same Khiam crater as was examined in our previous report was sent to a second laboratory. This was at the School of Oceanographic Sciences, University of Wales, Bangor, which has a sophisticated gamma spectrometer and has carried out work for us in the past. In addition the lab. made an alpha spectrometric analysis for Uranium isotopes and Plutonium 239 + 240. Results are given in Table 1

Dr David Assinder, who carried out the analysis commented: *The 238/235U isotope ratio and the enhanced presence of 234U relative to 238U are unusual for environmental materials. I'm not particularly used to seeing this type of ratio but I think*

these results would seem to indicate enriched U? My values differ, but not by that much, from Harwell perhaps due to the incorporation of some of the underlying soil when removing the black surface layer plus inherent variability in the deposit.

Table 1. The results from the gamma (^{137}Cs and ^{234}Th - carried out on the total soil sample) and alpha analyses (remaining isotopes analysed in the black surface deposit only) on soil sample GA021006LS6B.

Isotope	Activity	Method	Comment
^{137}Cs (Bq/kg)	< 1.0	gamma	Not fission
^{234}Th (Bq/kg)	20.8 ± 1.2	gamma	Anomalous
^{234}U (Bq/kg)	235 ± 15	alpha	Anomalous
^{235}U (Bq/kg)	8.1 ± 1.0 (= 0.10 µg/g)	alpha	High
^{238}U (Bq/kg)	146 ± 8 (= 11.7µg/g)	alpha	High
^{239,240}Pu (Bq/kg)	< 0.4	alpha	Not fission
^{238}U/^{235}U (by activity)	18.0	alpha	Enriched
^{238}U/^{235}U (by mass)	117	alpha	Enriched

These results confirm the isotope ratios found by the Harwell laboratory which employed Mass Spectrometry (ICPMS). They also show that the material was not from a nuclear waste stream and that the Enriched Uranium was fairly pure.

Fig 1A The Islamic Health Society ambulance in Beirut from which the engine air filter was taken for analysis. This vehicle operated for two weeks of the war until it was disabled by a strike.

Photo: DW

Fig 1B Filter in situ in the ambulance in Beirut.

Photo: DW

2. The Ambulance Air Filter tests and their results

The air filter element (Fig 2) was cut into four quadrant pieces. One piece was examined for the presence of alpha activity using CR39 plastic and alpha track analysis. A second piece was sent to the Harwell laboratory in Oxfordshire for Uranium analysis by ICPMS and also for a standard 45 element analysis using Mass Spectrometry.

Fig 2. Beirut Ambulance air filter showing contamination.

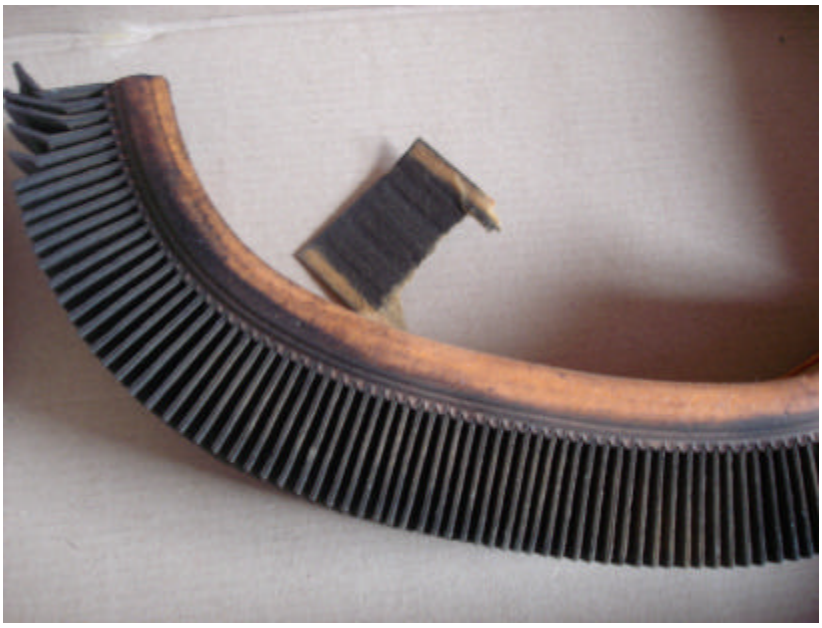

Photo: CB

2.1 CR39 tests were carried out as follows.

A piece of CR39 plastic the size of a microscope slide (which had been largely isolated from Radon exposure in storage following manufacture) was inserted between two of the crenellations of the filter element. It was left there in a freezer at -18 degrees for 15 hours. Half of the slide was inside the filter in contact with the element and the other half not exposed so that it could be used as a control. The slide was removed and etched with 6N Potassium Hydroxide for 5 hrs at 70 degrees Celsius. The slide was examined under a calibrated metallurgical microscope at 100X and the alpha tracks were counted in 5 representative transects across the width of the slide where it had been in contact with the filter and in similarly in the control area. The exposed area was also examined at low resolution to look for alpha stars which would indicate the presence in the filter of 'hot particles'.

Results are shown in Table 2

Table 2. CR 39 alpha track analysis results of Air Filter; 15hrs exposure; 10X objective Calibration graticule gives width of field as 1.7mm

Exposure	**Tracks in randomly selected fields across slide**	**Mean counts (SD)**
Filter element	60, 80, 61, 59, 53	63 (10.2)
Air	29, 26, 17, 35, 9	23 (10.2)
Hot particles	Yes	7

Examination of the slide showed the presence of at least two hot particles with an activity of 7 tracks each. A photograph is shown in Fig 3. Using the calibration of the microscope is was possible to show that these particle sources had an approximate diameter of 0.086mm each. If this is translated into a sphere of density equal to that of Uranium Oxide the particle activity was about 2-4 MBq /kg although there are many approximations involved in such a calculation. The specific activity of pure Uranium Oxide (U3O8) is about 5MBq/kg. This suggests that the particles are uranium particles of about 800μ diameter.

2.2 Harwell examination for Uranium isotopes

The sample was digested (in triplicate) in a mixture of concentrated nitric acid and hydrochloric acid using an open beaker / hotplate digestion method. Following digestion, the samples were made to a known volume with demineralised water having a resistivity of 18.2 MΩ cm.

Analytical measurements were performed on the sample digests by ICP-MS (Agilent 7500c), for which a combination of internal reference and the method of analyte addition were applied for quantification, in accordance with HS/GWI/1002 issue 17.

As a quality assurance measure, portions of the sample digests spiked with either 5.0, 10 or 20 $\mu g.L^{-1}$ uranium (using an alternative source stock solution from that used for the analyte additions) were prepared and measured along with the samples. The results obtained for these are denoted by the title 'QC Standard' in the table of results.

The samples were also analysed by ICP-AES (PE Optima 4300DV) for a 45 element scan, in accordance with HS/GWI/1075 issue 7, with a calibrated run using quality control standards.

Fig 3 Hot particle alpha tracks in Air Filter; Vickers metallurgical microscope; 100X

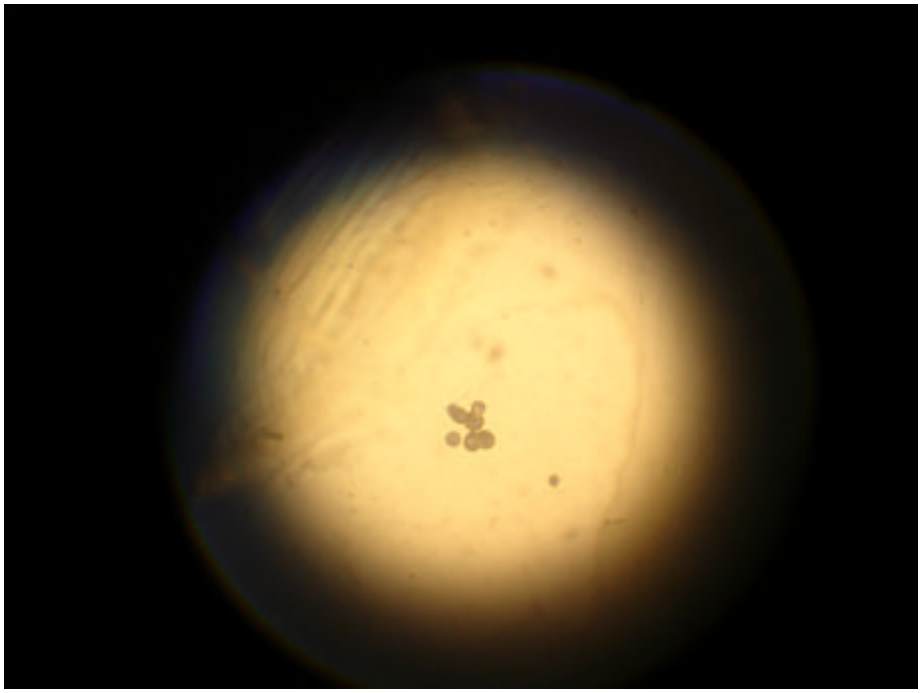

Photo: CB

The results obtained are detailed in Table 3 and are expressed as $mg.kg^{-1}$ in the sample as received. The suffixes 'D' and 'T' on the laboratory reference number indicate duplicate and triplicate preparation and measurement.

LOD is the limit of detection and is defined as three times the standard deviation obtained from the measurement of a series of at least four instrument blanks. Measurement uncertainty for those results significantly above the LOD is estimated to be ± 20%. Results within an order of magnitude of the LOD have a higher uncertainty.

The measurement of uranium in solution by ICP-MS and 45 element scan by ICP-AES falls within the scope of Harwell's UKAS Accreditation.

Table 3 Analysis of Ambulance Filter Sample for Uranium (Harwell Laboratory Results)

Customer Reference	Laboratory Reference	U-238	U-235	U Total	Ratio (238/235)
	LOD	0.0002	0.0001		
GA231006AF	EF1671	**0.12**	**0.001**	**0.12**	**113**
GA231006AF	EF1671D	**0.10**	**0.0008**	**0.10**	**123**
GA231006AF	EF1671T	**0.098**	**0.0007**	**0.098**	**133**
QC Standard $\mu g.L^{-1}$	Expected	10	0.022	NM	454
QC Standard $\mu g.L^{-1}$	Found	9.9,10	0.024,0.022	NM	413,455
QC Standard $\mu g.L^{-1}$	Expected	20	0.044	NM	454
QC Standard $\mu g.L^{-1}$	Found	20,21	0.038,0.042	NM	526,500
QC Standard $\mu g.L^{-1}$	Expected	40	0.088	NM	454
QC Standard $\mu g.L^{-1}$	Found	41,41	0.091,0.091	NM	451,451

2.3 Harwell examination for elements

Table 4 and table 5 gives results for 45 elements as reported. Results are given as mg per kg of the filter material provided.

Table 4 Elements found in air filter (1)

Customer Reference		**GA231006AF**	**GA231006AF**	**GA231006AF**
Laboratory Reference	LOD	EF1671	EF1671D	EF1671T
Ag	0.1	<0.1	<0.1	<0.1
Al	0.3	1200	970	830
As	5	<5	<5	<5
B	0.8	7	5	6
Ba	0.07	120	98	99
Be	0.08	<0.08	<0.08	<0.08
Bi	1	<1	<1	<1
Ca	0.3	20000	17000	16000
Cd	0.4	<0.4	<0.4	<0.4
Co	0.07	1.2	1.1	1.0
Cr	0.1	8.4	7.1	6.8
Cu	0.07	78	62	67
Fe	0.07	2700	2200	2100
Ga	0.7	<0.7	<0.7	<0.7
Ge	0.3	<0.3	<0.3	<0.3
Hf	0.2	<0.2	<0.2	<0.2
Hg	4	<4	<4	<4
In	2	<2	<2	<2
K	2	380	310	300
Li	0.02	0.93	0.71	0.61
Mg	0.3	1800	1600	1400
Mn	0.02	56	49	50

Table 5 Elements found in Air Filter (2)

Customer Reference		**GA231006AF**	**GA231006AF**	**GA231006AF**
Laboratory Reference	LOD	EF1671	EF1671D	EF1671T
Mo	0.2	<0.2	<0.2	<0.2
Na	0.2	4000	2800	3200
Nb	0.7	<0.7	<0.7	<0.7
Ni	0.1	6.1	5.2	5.1
P	3	150	140	130
Pb	0.7	360	320	350
Rb	3	<3	<3	<3
S	3	2600	2300	2500
Sb	4	<4	<4	<4
Sc	0.4	<0.4	<0.4	<0.4
Se	3	<3	<3	<3
Si	0.3	960	910	720
Sn	2	81	73	71
Sr	0.7	28	23	23
Ta	0.1	<0.1	<0.1	<0.1
Te	3	<3	<3	<3
Ti	0.02	57	52	43
Tl	2	<2	<2	<2
V	0.07	6.4	5.4	5.4
W	0.3	<0.3	<0.3	<0.3
Y	0.02	0.98	0.83	0.79
Zn	0.03	170	150	150
Zr	3	<3	<3	<3

3. Discussion

The results all clearly show enriched Uranium in the air filter and from the CR39 analysis at least some of the Uranium seems to be in the form of fairly large particles. This suggests that the Uranium is particulate. The total activity of EU in the dust in the filter is not easy to assess since we do not know how much mass of dust as represented by the elemental analysis is from materials which constitute the filter itself. Harwell used about 1.5g per estimation and calculated on the basis of mg/kg total filter (including the filter element, the plastic frame etc.). However, we can make certain assumptions about the quantity of dust in the filter by conducting shake-off weighings and on this basis we put the mass of dust at a maximum of between 1g and 10g per kg filter. The activity of the Uranium trapped in the filter can be calculated from the quantity in Table 3; it is

1.7Bq/Kg of filter. Using the conservative value of 10g dust per kg filter the Uranium activity in the dust is 170Bq/kg. If the dust concentration were 1g then this would be 1700Bq/kg. Of course, most of this dust would have been in the filter prior to the war, and vehicle air filters are rarely changed more than an interval of 1 year. Since the EU dust deposition must be assumed to have occurred in the final two week period of a year's operation of the filter then this activity must be about 25 times higher, suggesting a large air concentration of Uranium (from 4250 to 42,500 Bq/kg). In addition, the smaller Uranium particles (below 10microns) are unlikely to be trapped by a filter in a vehicle, and these particles (particularly those below 1 micron) are the main components of Uranium from weapons use and represent more than 2/3rds the total mass. Thus the true dust concentration in the material sucked in over the two week period of the ambulance operation in the war is more likely to be in the region of tens of thousands of Becquerels per kilogram. We should note that the intake by the vehicle can be used as a crude model for respiration of this material by humans and animals.

We know from photographs that the IDF have been using heavy metal penetrator shells. Such penetrators are made from Tungsten or Uranium. There have been suggestions that the IDF have not used Uranium but that these photographs show tungsten penetrators. No tungsten was found in the filter.

We conclude that the evidence reported here suggests strongly that weapons deployed in Lebanon by the Israeli assaults contain Enriched Uranium and that EU contamination of the country has been significant. The measurements made in the air filter show that at least part of Beirut has been contaminated and that the Uranium use was not restricted to areas near Khiam, where the Uranium was first detected by our sampling. Under these circumstances and in view of the serious health effects of Uranium particle exposure we recommend that urgent action is taken to determine the extent of the contamination both by surveys and through negotiations with the IDF.

The use of Enriched Uranium in weapons is puzzling and we have no persuasive explanation. One possibility was that it was used to mask the use of Depleted Uranium so that the final environmental signature would resemble natural Uranium (since it is only by measuring the isotope ratio that DU can be confirmed). On the other hand, there may be some new weapon that requires use of EU.

We should finally point out that to find Uranium contamination is not straightforward, owing to the need to look for beta activity from the decays of the U238 daughter isotopes Th234 and Pa234m. Lack of understanding of this has lead in the past (e.g. in Kosovo) to UN and other groups reporting no contamination when in fact there was significant contamination. Surveys have to be carried out with a sensitive, large window, scintillation counter deployed some 10cm from the ground. Areas of slightly increased activity can then be sampled and analysed in the laboratory. We are happy to advise.

An inexpensive method for determining alpha activity from Uranium which we have developed involves the use of CR39 plastic which we can also advise on and supply. All that is required for this method is a source of sodium or potassium hydroxide and a cheap light microscope so this method may be quite empowering for those who do not have access to the complicated and costly routines we have used and at minimum may be used to screen samples for activity prior to mass spectrometric analysis.

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