Uranium Contamination of Afghanistan ©

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Uranium Medical Research Centre
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Uranium Contamination of Afghanistan

Radiological studies' results, May 2003: Operation Enduring Freedom & Afghanistan

Uranium Medical Research Centre

- UMRC's recent findings, released May 2003, reveal a wider scope of human and environmental contamination in Afghan civilians, corroborating the November 2002 Jalalabad findings.
- New bioassay studies identify uranium internal contamination in Spin Gar (Tora Bora) area and the City of Kabul, up to 200 X's the Reference Level of the unexposed population.
- Analyses of soils and debris collected inside OEF bomb-craters and target sites have uranium values 3 X's to 6 X's normal. Surface soils surrounding the bombsites and downwind from ground-zero are elevated close to 3 X's Reference Levels.
- Surface water, rice fields and catchments adjacent to and surrounding the bombsites have high values of uranium, up to 27 X's normal.
- Biological, hydrological and geological specimens' radiological measurements and their spatial arrangement point to Operation Enduring Freedom's ordnance as the origin of the contamination.
- Summaries of the recent findings are accompanied by a discussion of uranium weapons and their effects on the people of Afghanistan. www.UMRC.net

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Operation Enduring Freedom - Afghanistan studies' results, May 2003

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Radiological analyses of uranium levels in Afghans

- Jalalabad area, November 2002: New Reference Levels based on recent collections of samples and controls have revised the Jalalabad results upward to uranium values 45 X's normal.

- Spin Gar (Tora Bora) and Kabul areas, May 2003: Levels of uranium up to over 200 X's the reference level for unexposed populations.

- Operation Enduring Freedom bomb-craters and surrounding soils: Uranium levels found to be 3 X's to 6 X's above geological standards and local controls.

- Watercourses and catchment areas close to bombsites: Uranium found to be up to 27 X's hydrological baseline levels.

- Analyses of the radioisotopes of uranium in urine specimens reveal that Afghans are contaminated with artificial, non-depleted uranium (NDU) with distinct readings of U^{236}. This implies that the NDU is "commercial natural uranium".

Characteristics of the battlefield contaminant

- Ceramic uranium is produced by the ballistic pulverisation and thermal aerosolisation of uranium alloyed and uranium ballast ordnance by the detonation of high explosives and the energy of kinetic impacts.

- Physical and chemical form of ceramic uranium:
  - U_3O_8, UO_2, UO_3 uranium oxides, mixed alloy compound oxides, and slow-oxidising uranium metal particulate.
  - Aerosols of uranium-rich dust are comprised of a high fraction of ultra-fine, respirable aerosols: < 0.1 micron (particle diameter).

- Lung retention of ceramic uranium: Official standard of nuclear regulators is a clearance rate of a total of 10% of the inhaled lung burden absorbed into the blood over the lifetime.

- Blood circulatory system retention: For the fraction that reaches the blood, the official position is that it takes 3 years to 10,000 days for blood circulated ceramic uranium to be cleared from the body.

- Whole-body retention in research literature: Inhaled ceramic uranium remains in body for a lifetime; found in lungs, bones and target organs during autopsies.

- Health risk classification category of ceramic uranium: Chemical, heavy metal toxin and pervasive, systemic radiological toxin.

- Research findings of deleterious health effects of ceramic uranium/alpha particle emitters: Lymphatic and lung cancer; kidney damage; genetic damage to off-spring; classed by International Agency for Research of Cancer (IARC) as a carcinogen.

Characteristics of the alleged, new generation of composite uranium, high explosive weapons

- Composite weapons combining Non-Depleted Uranium and High Explosives.
- Suspected ordnance categories: Deeply buried hardened target - bunker busters; seismic shock weapons (tectonic disrupters); surface hardened-target penetrators including special classes of munitions such as shaped-charges and self-forging armour and bunker defeat ordnance; wide-area denial, fragmentation bombs; and, thermobaric bombs.
- Mass range estimates: 100's to 1,000's of pounds of uranium per weapon, depending on type.
- Weight of a DU kinetic energy penetrator: <1/2 to ~12 pounds for those warheads admitted to by Defense departments.
- % DU kinetic energy penetrator (DU-KEP) aerosolising upon impact with target: 20% to 80% (increases with exposure to fire).
- % NDU aerosolising upon detonation of composite, uranium-high explosive weapons: up to 100%; except for fragmentation and area-denial ordnance.
- High explosives in NDU-HEO ordnance: 100's to 1000's of pounds per weapon.
- High explosives in DU kinetic energy penetrators: None
- Terminal ballistics: Heat - 5000° to 8000° C; Pressures – detonation front travels at 21,000 mph; Uranium explodes in contact with CO_2 (a product of chemical explosive blasts); Impact velocities – over 1.5 Km/second, depending on function, weapons' design and delivery system.
- Aerosol production: "Going-in factors" combine to instantaneously "phase-shift" the uranium and convert it to a plasma, ionising and electrostatically charging the by-products, lofting and dispersing the contaminant as a colloid and uranium-rich compounds. Up to 100% of material aerosolised along with target materials, creating a wide size-range of pure uranium respirable particles along with compounds and agglomerates of uranium-rich dust and metallic uranium fines.
- Dispersal of aerosols: Colloidally suspended aerosols behave as a gas, adhering to fluid-dynamic principles. The contaminant will be deposited at ground-zero and at decreasing densities along the particle deposition pathway of the weapons' ballistic plume. The aerosols can travel 1,000's of kilometres and 10's of 1000's of feet vertically – classified as a mesospheric contaminant.

Preface

> Walking home late one night, a man came upon Hodja Nasreddin on his hands and knees searching for something in the dark. "What is it your looking for, Hodja?" asked the man. The Hodja grumbled: "I recently lost my wallet somewhere over there under that street lamp." "Then for Goodness' sake, why not look over there?" the man said. The Hodja stood up, scratched his head, stared into the dark and replied: "If I did that, I might find it."
>
> The stories of Hodja Nasreddin, Idris Shaw.

UMRC's November 2002 Jalalabad findings raised a question as to the origins of contamination: is the uranium an artificial or a natural species; is its mechanism of presentation human or geological. Although the ratios of the isotopes of uranium in the urine samples matched the signature of natural uranium, this does not preclude an artificial source or manmade species. The ratios of the isotopes of uranium do preclude depleted uranium (DU). Finding high total quantities per specimen requires a bioavailable form of uranium with a presentation suitable for inhalation or ingestion, or both. Human up-take at the Jalalabad levels (now known to be the case throughout Afghanistan) is not a normal occurrence except from technological sources (agriculture, uranium mining, and processing) or unique geological conditions. Pending evidence to the contrary, such a situation would most likely have been attributed to ingestion, specifically drinking water high in uranium values, usually from its migration out of bedrock into deep wells. Some fertilisers using uranium-rich phosphate rock have also been known to present uranium this way although it does not perceptibly raise the uranium values where it is applied to topsoil.

The question of origin precipitated UMRC's follow-up field investigations and laboratory work on newly collected samples associated spatially with the study population and Operation Enduring Freedom bombsites. Laboratory analysis had to ensure careful examination for the presence of other isotopes that would confirm or refute preliminary evidence – in which control and subjects' samples, conflict histories, spatial and chronological factors pointed to OEF bombing. Finding quantities of U^{236} (a manmade isotope) and the highest uranium values in OEF bomb craters is reasonably conclusive as to origin. The details of the investigation, its recent findings, and conclusions are addressed thoroughly in this report. Omissions or confusions are inadvertent and the sole responsibility of the author, not UMRC's scientists or laboratories.

"Battlefield uranium" refers to the physical and chemical form and manner of presentation of the by-products of DU and non-depleted uranium munitions aerosolised and oxidised in military applications. "Non-depleted uranium" (NDU), introduced in earlier UMRC reports, is coined to describe a particular class of artificial uranium. It represents uranium found at a specific point in the uranium processing, nuclear fuels and weapons' metallurgical processing cycle. NDU is a blend of "virgin uranium" (pure, unadulterated uranium from the mill) combined with recycled spent fuel and reactor by-products, mixed at the front-end of the cycle and extracted just prior to being (re)processed in the enrichment facilities. Non-depleted uranium is radioactively and physically different from depleted uranium – and is not correctly represented by such terms as "pure milled uranium", "natural uranium" or "un-depleted uranium". Of interest to pinpointing the source of the uranium, it is noteworthy that the US industrial metallurgical standard set by the American Society for Testing of Material's classifies a concoction of pure milled, virgin uranium and recycled spent fuel as "commercial natural uranium" (See: www.ASTM.org). The permissiveness of this metallurgical standard is no less insidious

than an earlier exposed practice of alloying pure DU metal feedstock with 0.75% titanium and then calling the ordnance "titanium penetrators".

It is to be kept in mind that the purpose of this work is not to prove anything other than the truth –- UMRC's Afghanistan studies, just as its on-going Gulf War I veterans' studies, are scientific and medical investigations. Initial data lead to hypotheses and research attempts to replicate and develop a thorough understanding using logical progressions of new data collection and analyses. The presence of artificial uranium products in the biosphere – whether accidental or intentional -- represents an immediate and pervasive risk to human health. Before this problem can be mitigated, the extent of its (artificial uranium's) presence, human and environmental exposure levels and subsequent effects have to be measured. Talking about it without finding it in the human body and environment and without determining its type and source is not very useful and is largely the reason no one is listening.

Detecting uranium internal contamination in any population irrespective of the cause and irrespective of the nationality, religion and ethnicity of the peoples is a medical, public health and social concern. Considering the limited resources and technology available in Afghanistan, a moral obligation for the fate of the affected population is incumbent upon all others possessing the resources and knowledge to intervene. Detecting uranium contamination in Afghanistan, where there was none before, coincident with Operation Enduring Freedom is ethically troublesome. This is a legacy that morally responsible people, particularly in the nations responsible for creating this problem are compelled to address beyond an expression of sympathy – holding true for the consequences to Coalition veterans, civilians of Iraq, Puerto Rico, Japan, Kosovo, Serbia and any other nation that may now or in the future, suffer from it.

About the references:

The footnoted references in this report contain source identifiers except where they are only known to be available on the Internet. Those without journal or other publication identifiers are available by putting a document's name into an Internet browser. Internet sites may change a document's availability and some references may have been permanently removed or had their URL's modified since 9/11, particularly the military and weapons' R&D URL's. These may be available in cache archives on Yahoo or Google.

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Background to the Operation Enduring Freedom – Afghanistan studies

As of the end of April 2003, UMRC has completed radiological and radiochemical analyses on four rounds of samples collected during post-conflict field trips to Afghanistan. Field teams collected biological, geological and hydrological samples from several communities in a 4 to 10 month period following the cessation of Operation Enduring Freedom's (OEF) main bombing campaign.

Sample and specimen types and inventories discussed in this report[1]:

1. Biological (analysis of total concentrations and ratios of isotopic abundances excreted in urine, measured in nanograms/litre)[2].
2. Geological and artificial artefacts from bombsites (soil, silt and bomb-crater debris, farm field and garden topsoil, and hajarat soils).
3. Hydrological samples (catch basins, surface irrigation water, flooded rice fields and karaize well water).

In November 2002, UMRC released its preliminary findings from the Jalalabad area showing uranium internal contamination in civilians who witnessed OEF bombing sorties on targets close to their residences and places of work. The bombings were reported to have occurred in the early morning hours between dawn and sunrise.

All subjects providing specimens in the first study personally witnessed the bombing from down-wind vantage-points. Shortly after observing the attacks they were inundated by dense ballistic plumes of smoke and dust. The subjects in the study and approximately 2/3's of residents from areas where samples were collected report health problems coinciding with the bombing. Follow-up visits confirmed a continuing progression of health effects, including postnatal problems in new-borns conceived since OEF bombing.

During and following the OEF bombing campaign, a common set of symptoms was shared by subjects and their families. During and immediately following the inundation by smoke and dust, residents experienced burning in the nose, mouth and throat. The burning progressed to nasal and sinus bleeding and dry, unproductive coughing followed by several weeks to months of flu- and cold-like symptoms (i.e. respiratory, nasal, throat, sinus, and gastrointestinal problems). A summary of the health problems inventoried in

[1] See: Understanding UMRC's Research, www.UMRC.net

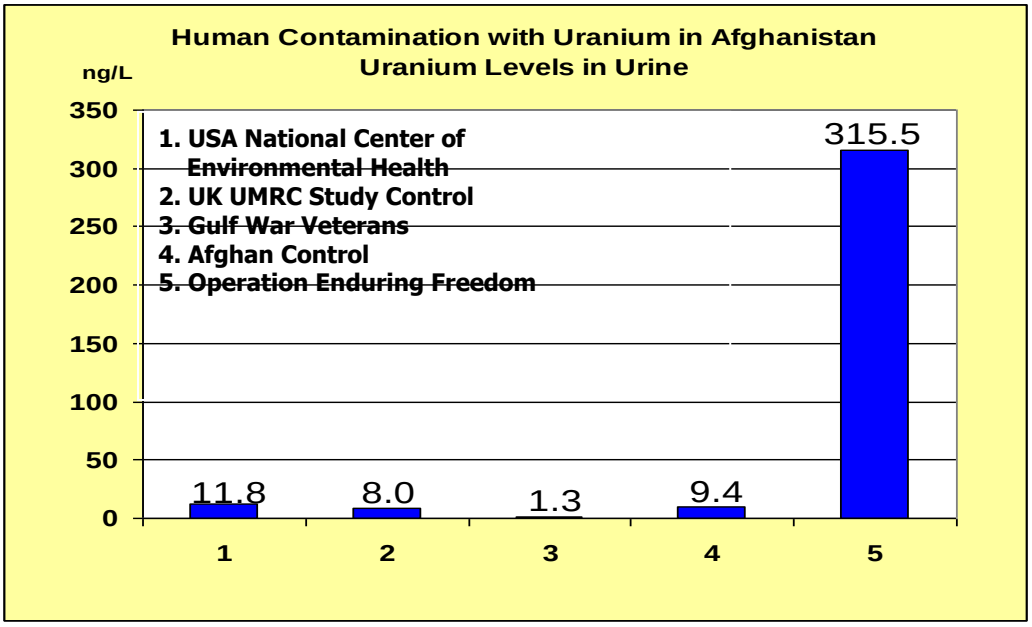
[2] Full descriptions of laboratory and analytical methodologies of detecting and measuring the isotopes and their ratios are available by referring to UMRC's papers and conference proceedings listed in the Annex to this report and at www.UMRC.net.

the field can be read in excerpts of UMRC's Field Trip #2 Report, November 2002[3]. A list of acute and chronic symptoms associated with uranium internal contamination can be seen at UMRC.net[4].

The first Jalalabad results were unexpected – not because of the high levels of uranium but because the uranium in the urine of 100% of participating subjects is Non-Depleted Uranium (NDU)[5] – not Depleted Uranium (DU). UMRC had anticipated DU associated with the US and its Coalition partners' strategic and tactical delivery of a wide variety of ordnance. It was expected that the weapons' alloys and the species of uranium would be consistent with the "dirty uranium" ordnance deployed in the Persian Gulf and Balkan conflicts – manufactured out of metallurgical feed stock diverted for weapons development from the uranium enrichment and recycled spent fuel cycles.

It was postulated that radiological testing in Afghanistan might reveal a wider application of DU in new and re-engineered ordnance deployed against the alleged types of targets specific to Afghanistan and other states accused of possessing weapons of mass destruction. The information and analysis that led to this suspicion is discussed on UMRC's web-site. Since that announcement UMRC has revised its Jalalabad findings to reflect newly established Reference Levels (locally established baselines) of the concentrations of uranium in urine based on a wider geographic collection of control samples.

Figure 1 – Comparison of Reference Levels to the average values of total concentrations of uranium associated with OEF.



[3] Precise Destruction – Indiscriminate Effects, Excerpts of Afghan Field Trip #2 Report, November 2002; www.UMRC.net

[4] Uranium Internal Contamination, Self Assessment Questionnaire; www.UMRC.net

[5] Authors note: NDU is 1.7 X's more radioactive than DU. Any addition of transuranics will increase radioactivity levels 100's to 1000's of x's.

The need for early assessment and an honest analysis

Prior to 9/11, UMRC identified DU in the urine of Gulf War veterans. UMRC was not able and governments were unwilling to conduct radiological studies immediately after the conflict. See: The Quantitative Analysis of Depleted Uranium Isotopes in British, Canadian and US Gulf War Veterans, Durakovic et al, 2002[6]. Even though UMRC's work was conducted several years after the Gulf War, DU was conclusively detected and measured in the urine, bones and organs of veterans. Afghanistan and OEF provided the opportunity to undertake radiological and clinical studies of the effects of battlefield uranium close to the time of deployment.

There are seven critical gaps in the US's and its Coalition partners', NATO's and the UN's response to Gulf War contamination by Depleted Uranium[7]:

(1) A government delay (of 7 years) in beginning radiological analysis of biological samples from veterans (whose exposure was acute) and a delay in analysing geological and hydrological artefacts from the battlefield.

(2) Failing to measure the ratios of the radioisotopes in biological specimens[8] (urine) to identify the type of uranium in veterans bodies (artificial uranium or natural uranium)[9].

(3) No peer-reviewed studies have been found regarding exposure or health effects on civilians in the conflict areas who were acutely and remain chronically exposed to the contaminant.

(4) Making clinical decisions based on the "total concentrations of uranium in urine" rule[10].

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[6] The Quantitative Analysis of Depleted Uranium Isotopes in British, Canadian and U.S. Gulf War Veterans, Durakovic et al, Journal of Military Medicine, 167, 8:622-627, 2002.

[7] Refer to: 12 Years Too Late ?: How Canadian and U.S. Defense Departments' Veterans' Post Conflict Follow-up Programs Reveal They are Unable to Detect Depleted Uranium, T. Weyman, March 2003, www.UMRC.net.

[8] Industrial Uranium Compounds: Exposure Limits, Assessments of Intake and Toxicity after Inhalation – NRPB-W22; N Stradling et al, National Radiation Protection Board, United Kingdom, 2002. "For those who may have been exposed at some time in the past to substantial intakes of DU, an analysis of uranium isotopes is required to assess intakes and any possible health consequences."

[9] Ed. There are a few exceptions: Urine specimens from a group of US Gulf veterans were analysed for the isotopic ratios of DU by the Department of Veterans Affairs as an experiment to see if negative findings would quell the anxiety of all veterans in the DVA's Follow-Up Program. This experiment was conducted using laboratory methods and equipment technically incapable of detecting DU 10 years after exposure. Isotopic analysis has also been conducted on the urine of veterans retaining DU shrapnel.

[10] Ed. "Total concentrations" of the uranium excreted in urine is the Coalition countries' Defense Departments' diagnostic decision point for risk assessment of veterans' exposure, with no regard to the type of uranium that might have been in their urine if radioisotopic analyses were conducted. US, Canada, Italy, Germany, Sweden, the UK and a host of other countries' Gulf and Balkan veterans have been rejected from clinical assistance and restitution using the "the total concentrations" rule. See footnotes 12 & 13.

(5) Setting impossible urinary uranium excretion Reference Levels[11] unlikely for any veteran of the Gulf or Balkan conflicts to present in bioassay studies, years after exposure (other than those with retained shrapnel).

(6) Refusing to make assessments of veterans' exposures in consideration of the "material specific" properties and biokinetics unique to battlefield uranium[12].

(7) No clinical studies of biopsied lung tissue or external radiological measurements of the chest are reported; demonstrating that inhalational contamination by (retention of) DU ceramic aerosols is not being considered as a possible factor in the aetiology of Gulf War Illness[13].

UMRC began its sample collection activities in Afghanistan as early as possible to ensure timely investigation of OEF's weapons. Operation Anaconda ended just at the time the first Field Team entered the country. The civilian population was in shock from being bombed. The repatriation of internally displaced people and international refugees was beginning for the 5,000,000 civilians who left their communities to avoid the bombing or had been exiled since the Soviet invasion and the ensuing, foreign-backed civil war (dating back to the 1970's). Many people were suffering inexplicable health problems. Severe infrastructure destruction made long distance travel on the ground impossible and no domestic air flights were permitted. OEF military personnel occupied

[11] Ed. Except for standards established in the US and Canada, Reference Levels world-wide for excretion rates in urine are normally between 1 and 10 nanograms per day. The US takes a position that the values can be up to 400 Ng/day, effectively eliminating the possibility of any population (civilian, military and occupational) ever being considered contaminated by artificially or technologically derived exposures. Setting high Reference Levels reduces the spectre of endemic contamination of North American environments by nuclear reactors, nuclear processing, mining and weapons testing. [See: Exposures to the public from man-made sources of radiation, Annex C, UNSCEAR 2000, United Nations Scientific Committee on the Effects of Atomic Radiation, Sources and Effects of Ionising Radiation, 2000 Report to the General Assembly, United Nations, New York.]

[12] Ed. The aerosols encountered in uranium battlefields are physically and chemically different from the most prolific forms encountered in the industrial and nuclear complex. According to the British National Radiation Protection Board: "Virtually all the uranium compounds encountered in industry, …can in broad terms be considered as being highly soluble, or moderately soluble after deposition in the lungs." Contrast the industrial uranium contaminants to the products of uranium battlefield weapons. NRPB distinguishes fast-clearing to slow-clearing uranium: "Generally, uranium octoxide [U_3O_8] and dioxide [UO_2] are considered poorly soluble; ie default Type S…" ["S" – "Slow dissolving uranium oxides", the type produced in the battlefield, take years and may never clear the body.]

[13] Ed. NATO governments and Defence Departments define uranium internal contamination by "elevated total concentrations" of uranium in urine, not according to the "type" of uranium. In contrast, the World Health Organisation (WHO) states: "The amounts of DU in urine following a DU exposure may well be similar to, or even less than, the naturally occurring amount [of uranium excreted daily]. For instance, an intake of 100 mg [milligrams] of DU by inhalation would give rise to 25 Ng [nanograms] of DU in a 24-hour urine sample taken ten years after the exposure … it is therefore necessary to measure the … isotopic ratio to determine … DU intake." "… DU in urine can [be] detected …, ten years after exposure." Depleted Uranium: Sources, Exposure and Health Effects, S 11.2 Urine and faecal monitoring, Page 108, World Health Organisation, April 2001. When levels in urine are too low to detect years after exposure, ceramic uranium may be detectable in the lungs, lymph nodes and target organs.

several compounds and cordoned-off many bombsites, making them inaccessible for study.

The few mobile, heavy military assets possessed by the Afghan government and targeted by OEF had been removed. For example, a small tank unit hidden in orchards outside Jalalabad, attacked and destroyed by A 10's and a C-130, had mysteriously disappeared. The Field Team had only stationary targets and fixed assets to examine. Unexploded ordnance (UXO) had also been efficiently collected and stored in secure warehouses by official agencies while debris of exploded ordnance (XO) has been recycled as salvage – much being shipped to Pakistan and sold as scrap metal.

Conditions and risks in Afghanistan

- **Community health**

UMRC's earlier and most recent surveys of civilian communities reveal a pattern of public health problems and symptoms consistent with chemical, heavy metal and radiological toxicity. Conditions in new study areas – Spin Gar (Tora Bora) and Kabul -- match the Jalalabad findings discussed in earlier reports. Up to two-thirds of members of each family interviewed in each community bombed (or living close, down-wind), selected because of reports of unexplained illnesses coinciding with the bombing, are ill or suffering from repetitive illnesses.

Those exposed directly to the ballistic plumes have the most problems with their health. Many complain of never seeming to be able to recover from recurring viral illnesses, lethargy, physical weakness, headaches, lower back aches, joint and soft tissue pain, cervical column pain, numbness and shooting pains in extremities, and fevers. Respiratory conditions are rampant and chronic in the study subjects – including persistent, dry coughs, chest pain and conditions resembling asthma and bronchitis, nasal/throat infections and persistent nasal dripping. Gastrointestinal problems (pain, gas, loose bowel movements and diarrhea) have become the norm.

Immune deficiencies and environmental hypersensitivity plague children, infants and many adults who say they were not ill prior to the bombing. Infants are underdeveloped, weak and lethargic. Parents are very concerned about new-borns who are often uninterested in feeding and are not adding body weight at expected rates. There is a kind of panic response to inquiring about infants and young children. Afghanistan is a stoic nation and adults rarely complain about their personal problems. But they are desperate to understand the health problems suffered by infants and the inexplicable conditions of new-borns. The physical weakness and lethargy of adult males complicated by mental confusion, memory problems and general malaise are mysterious, invisible conditions that bear significant social stigma – exacerbated by chronic physical problems which have no apparent cause or medical solution, resulting in depression and anxiety.

Residents who had evacuated the targeted communities during the main campaign and returned to resume their lives in localities adjacent to OEF targets also show effects. UMRC revisited the communities where the first urine uranium bioassays were high. The team found a progressive deterioration of health including post-natal problems in new-borns conceived after the bombing. Symptom profiles remained consistent with earlier problems and advancing indications of chronic, uranium internal contamination.

- **Patterns of risk**

Follow-up investigations show the health of subjects and neighbourhoods exposed to the detonation-plumes of OEF ordnance has not improved. Arrangements were made with health officials to begin follow-on, clinical studies of lungs, kidneys and bone. An apparent progression of health problems has two possible explanations: (1) Single or multiple, acute incident's exposure have been high enough that the incorporation of the contaminant into lungs, target organs and the lymphatic and blood circulatory systems continues to assault the body and exacerbate acute effects; or, (2) recurring uptakes from the environment poses an external assault by repeated exposure. The results of biological and environmental samples point to both conditions: unusually high levels of acute exposure followed by environmentally persistent, chronic exposure.

Results from geological and hydrological samples' analyses show several study subjects' environments are contaminated – high uranium values in soils and water. For many locations where biological specimens measured with high uranium concentrations in urine, corresponding environmental samples were consistent. Subjects and their families are living, working, gardening, farming, playing and travelling in environments where surface soils and ground waters are contaminated by abnormally high levels of uranium. UMRC identified high levels of uranium in shallow wells (drinking, cooking and washing water), farm fields and gardens where surface-fed and rain water and mechanical irrigation practices appear to be concentrating the uranium contaminant in catchment areas.

Afghans, international NGO field staff, and OEF military personnel are residing in or frequenting the areas where they are exposed to re-suspended, airborne radioactive particulate and contaminated water. Because of the lifestyles, building methods and agrarian nature of the society, combined with the play and social behaviour of children, skin absorption and oral ingestion of the battlefield-uranium is a concern. In addition to being a naturally, extremely dusty environment with frequent high winds and dust storms, Afghanistan has recently been suffering from an exacerbating drought. These factors are very efficient at causing re-exposure by re-suspension of uranium particulate deposited after the ballistic plumes settle. These conditions contribute to the radiological risk by environmental effects on the physiochemical properties of the contaminant. They also establish environmental parameters that slow the absorption of uranium contaminant in soils, prolonging its bioavailability.

In the first Jalalabad study, all subjects reported acute incident exposure to ballistic plumes of one or more weapons. In later field collection trips, persons presenting with the symptoms of uranium internal contamination[14] were not, in all cases, directly exposed to the plumes at the time of weapons' detonation. They may have been unknowingly exposed: too distant from the bombs to recognise the ballistic plumes; after entering bombsites (or areas close to the sites); or, exposed to the contaminant after down-wind deposition in locations where water concentrated and/or soils collected the fall-out.

Biological and environmental findings cannot necessarily be expected to correspond directly. Acute, one-time incidents (a single bomb or group of bombs at one time) may not deposit sufficient volumes in soils and water to raise the baselines of uranium occurring naturally[15] but can be sufficient to raise significantly, the concentrations of

[14] Medicine terms uranium internal contamination symptomatology as "non-specific symptoms".

[15] Kabata-Pendiahs and Pendiahs, Trace Elements in Soil and Plants, CRC Press, 1992.

uranium in urine. Persons returning to an environment presenting artificially high uranium values in soil and water may not take up quantities sufficient to produce the high concentrations in urine expressed by those with acute exposure to the ballistic plumes. The physical and chemical features of deposited artificial uranium aerosols and their presence in the environment are not comparable to naturally present uranium in soils, which is not typically in a physical form available for re-suspension followed by inhalation.

Many factors influence the densities and spread of weapons-released, airborne contaminant. Although plume pathway and deposition pattern analysis is beyond the scope of UMRC's field trips, the United Nations Environment Program's and Green Audit's (www.llrc.org) examinations in the Balkans and the Persian Gulf report unusual patterns of environmental readings in soil, air and water that do not adhere to predicted deposition, accumulation and re-suspension patterns. In Afghanistan, the alleged weapons produce much higher volumes and air-densities of uranium per weapon. High-explosive, ballistically aerosolised and ejected, detonation by-products form vertically rising clouds of dirt, dust, target materials and toxic gasses. Plume behaviour and particulate deposition may adhere to the wider principles of conventional ballistic-plume and dust cloud pathway behaviour – well studied and available in the literature[16,17].

- **Sample and specimen collection**

A triaging process was used to select study subjects for UMRC's first round of radiological OEF-Afghanistan studies. They had to fulfil three criteria: (1) present with the symptoms resembling uranium internal contamination; (2) the onset of symptoms had to coincide with the time and place of the bombing; and, (3) a continued residency in, or frequenting of neighbourhoods or communities close to OEF bombsites. Follow-up trips revised these rules to allow the study of civilians who were not knowingly exposed to the detonation plumes but returned to live in environments known to be contaminated. Follow-up trips benefited from laboratory studies that pinpointed contaminated populations and therefore allowed for better co-ordination of water and soil sample collection. Control subjects were selected to ensure they neither present with the symptoms of contamination nor exposed to the bombs' ballistic plumes at the time of detonation or live in known contaminated areas.

Environmental samples of water and various surface materials were taken from the immediate environment of all subjects whose urine uranium values were high in the first study from Jalalabad. The Field Team established a practice of taking samples of drinking water and soil from the hajarats (common areas of living compounds and homes) corresponding to the urine samples. Soil, debris and dust samples were collected from bomb craters and target sites estimated to be closest and/or up-wind from the study subjects' residences and, if different, locations where they were initially exposed to the ballistic plumes.

The same practice was applied to the controls, collecting corresponding urine, soil and water. It was not possible to ensure the control subjects do not reside in environments contaminated by OEF bombing or other origins of contamination without comprehensive environmental assessment. The plume behaviour and weather conditions

[16] Z. Mian et al, Plutonium dispersal and health hazards from nuclear weapons accidents, Current Science, Vol 80, No. 10, May 2001.

[17] L.J. Schmidt, When the Dust Settles, Earth Observatory NASA, U.S. National Aeronautics and Space Administration, 2001.

at the time of bombing are likely to have dispersed the uranium contaminant over a wide area. As such, acute effects of airborne and chronic effects of re-suspended material are not only possible, they are to be expected in areas down-wind and at some distance (several kilometres). It is likely there is a significant population that inhaled uranium particulate at descending densities (progressively smaller volumes of up-take) who are contaminated but may not present endemically-outstanding symptoms – but may suffer from chronic and long-term, systemic effects.

Since not all bombs are suspected of containing uranium, not all bombsites were expected to be contaminated. The Field Team was not able to ensure that bombsites' samples always represent the materials released by the weapons in all sites investigated. Sample collection is limited by obvious safety constraints. Many sites are mined and the team sometimes worked where de-mining was not finished and/or where demarcated safety boundaries were not reliable. Bunker buster munitions made the larger buildings with steel and concrete superstructures unstable. Any area with tenuous footing, heavy debris leaning into the craters and unstable super-structure hanging precariously overhead is to be avoided. It was unsafe to go deeply into target sites and craters or dig under heavy materials and slabs of concrete to get beyond the recently deposited (post-conflict) wind-blown dust and sand. Disturbing the soils and dust or languishing in the craters is obviously unwise. It is possible that site samples showing one level of uranium at the top of the crater or surface of the soil may have different values at lower elevations, a few inches below grade, or under debris.

UMRC collected all specimens and samples in containers supplied and prepared by our laboratory. The sample bottle sterilisation process has to purge the containers of environmentally present artefacts of uranium. The details are outlined in the methodology discussions in the peer-reviewed papers slated for scientific conference presentations and publication. All study subjects and controls were briefed by Pashtu and Dari translators, as to sample collection protocols aimed at protecting the integrity of the specimens and containers. Medical Histories, Conflict Histories and Release Forms were completed and signed by each specimen donor. A strict chain-of-evidence protocol is followed from the start to the finish of each field trip.

New bioassay studies from Afghanistan

- **Contamination in Kabul and Tora Bora (Spin Gar) areas - 200 X's normal**

UMRC's first set of results from the Jalalabad area, released publicly November 2002 revealed abnormally high values of Non-Depleted Uranium for 100% of the study subjects[18]. Uranium concentrations at that time were stated as being in a range of 4 X's to 20 X's normal values for the abundance of uranium excreted in a 24-hour sample. Since then a wider geographic collection of control specimens has caused a revision of the Reference Levels. UMRC also collected new control and subject specimens over a wider area and population around Jalalabad. As a result, Reference Levels have modified the original Jalalabad results upward, corrected to a range of 8 X's to 45 X's the unexposed population's baseline (Fig. 2).

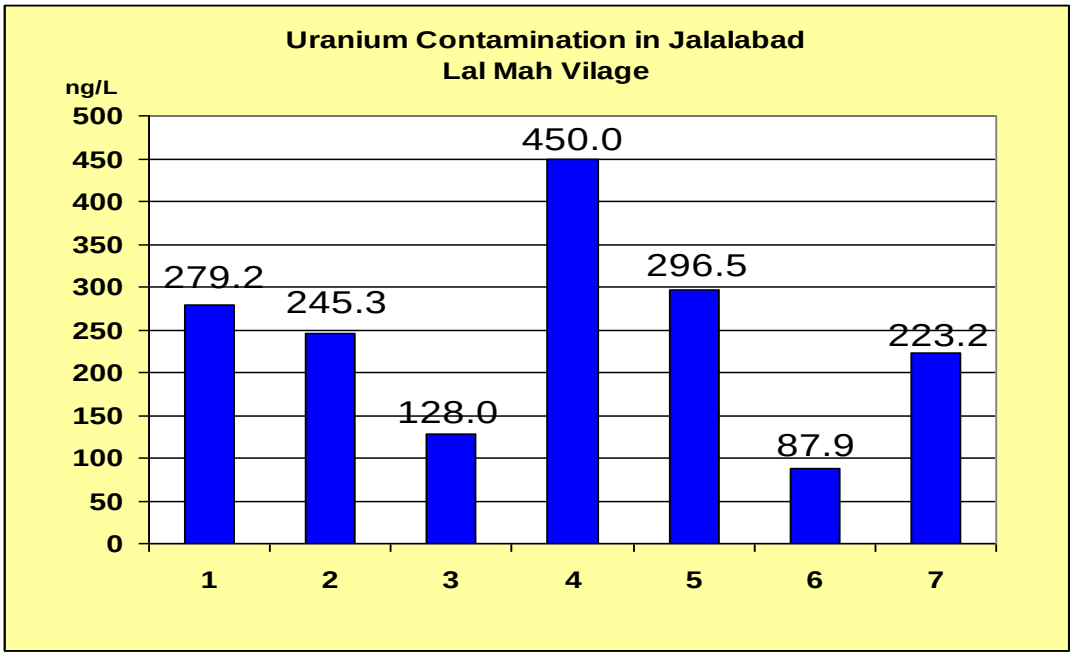
The inventories of biological specimens collected and analysed for this May 2003 report are derived from follow-up trips to Jalalabad as well as extensive geographic expansion to new communities and bombsites. The newly summarised findings presented in this report represent urine samples taken from the following villages, neighbourhoods

[18] UMRC Information Bulletin: Preliminary Findings in Afghanistan and Operation Enduring Freedom, February 2003, www.UMRC.net.

and Districts: Spin Gar/Tora Bora, Yaka Toot, Lal Ma Kelai, Makam Khan and Arda Farm Districts, Bibi Mahro, Poli Cherki and the Kabul airport District.

Radiological analyses of the majority of new biological specimens also show abnormally high levels of uranium. Samples from Spin Gar (Tora Bora), Kabul and new Jalalabad samples reveal that most subjects have elevated to very high values for the total concentrations of uranium in urine. With the increase in the size (numbers) of the specimen inventory, the range of values of uranium in urine is expectedly wider than the original Jalalabad results. Total concentrations of uranium in urine begin at the local Reference Level and ascend to over 200 X's the unexposed population. Analyses of the new specimens' ratios of the isotopes of uranium are consistent with the signature of Non-Depleted Uranium – the same species of artificial uranium identified in the original, Jalalabad study.

Figure 2 - Excerpts of measured values of uranium in urine collected in Jalalabad, 4 months after exposure to the ballistic plumes of OEF ordnance. The Afghan Reference Level is 9 Ng/L – 10Ng/L.

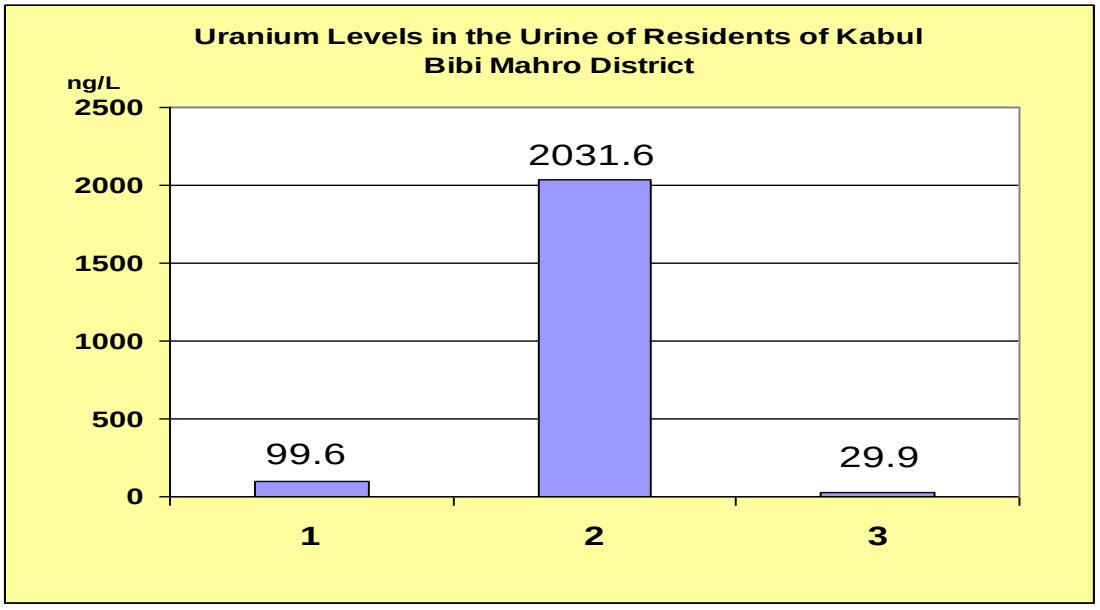


Normal levels of uranium concentrations in urine were found in most but not all control subjects' urine. Controls are defined as those selected for negative symptoms and history profiles. Exceptions are a small number of controls with elevated urine uranium values in Kabul and Jalalabad. The lower end of the elevated urine uranium values are found in subjects with no known history of direct exposure to ballistic plumes. The controls with elevated uranium levels may be explained by natural environmental occurrences or as a result of lower levels of weapons' derived contaminant dispersing in the air and deposited over a wide area down-wind.

The concentrations of Non-Depleted Uranium in the urine of residents in districts and neighbourhoods in and around Kabul are more disturbing than the first round of results from Jalalabad. Most distressing are high levels of uranium in urine in one very densely populated neighbourhood. One 10 year old boy's urine sample shows he is releasing

2000 (+) nanograms of uranium daily in urine 9 months after he survived the bombing of his home where he lost two younger brothers, his mother and eight women and young girls in his neighbour's home. His uranium concentrations are 200 X's the Reference Level of the unexposed, civilian population. Coincidentally, this boy's experience is discussed in Precise Destruction – Indiscriminate Effects (excerpts of Field Trip #2 Report), which was posted on UMRC.net prior to the completion of laboratory analysis of his and his family's urine samples. The two households were hit by a high-explosive, hardened-target weapon overshooting a radar station located at the top of a hill behind the neighbourhood.

Figure 3 – A selected summary of findings representing the range of urine uranium values in the Tora Bora and Kabul areas associated with OEF ballistic plume exposure and post-conflict up-take from contaminated soils and water.



- **U^{236} in Afghans' biological specimens**

To further understand the characteristics of the alleged new generation of munitions deployed in Afghanistan, UMRC analysed the uranium in the urine of study subjects for "markers" of recycled uranium. Reports by the US Department of Energy (DOE) reveal that the uranium stockpiles feeding the metallurgical manufacturing cycles of DU-KEP's (Depleted Uranium - Kinetic Energy Penetrators) are adulterated by recycled transuranic waste from spent reactor fuels and the uranium enrichment process[19]. DU is made from the tails of the enrichment phase[20], which constitutes about 4/5th's of this material after it has been depleted of its U^{235} isotope component.

[19] A Preliminary Review of the Flow and Characteristics of Recycled Uranium throughout the DOE Complex, 1952 – 1999; Project Overview and Field Site Reports; U.S. Department of Energy, March 2001.

[20] PR Danesi et al, Isotopic composition and origin of uranium and plutonium in selected soil samples collected in Kosovo, Journal of Environmental Radioactivity, Vol. 64, Issues 2-3, pp 121-131, 2003.

Spent fuel and uranium processing waste contain several isotopes of uranium and transuranics (e.g.; U^{236}, Plutonium, Americium; etc) that do not exist in nature and are created artificially in the military and commercial nuclear complex. Artificial materials have been recycled and blended into DOE's stockpile of "virgin uranium" at the front-end of the uranium enrichment and metallurgical processing streams. Any amount of these products found in laboratory analyses of urine, soil and/or water confirms an artificial source of the uranium has been found in the field. NDU may be made from this blended feedstock material, technically called "commercial natural uranium", extracted prior to entering the enrichment stage in the fuel cycle.

The volumes of the spent fuel and enrichment waste products recycled into the virgin uranium stockpiles are estimated (by DOE) to be, proportionately, only a small fraction of the total stockpile – about 1% - 3% of mass and responsible for about 13% total radioactivity (averaged over the total mass of the stockpile). Transuranics are 100's to 1,000's of times more radioactive than DU and NDU. A combination of the low volumes (mass) and the uneven distribution of these recycled materials mean that they are sporadically present in and are therefore considered by DOE's averaging formula to be below laboratory instruments' and methods' detection limits. But, the material does not behave according to the laws of averages – because of uneven distribution it can be concentrated or dispersed on a case by case and therefore a weapon by weapon basis. This "dirty uranium" has been identified in radiological studies of DU-KEP's in the Balkans[21, 22]. The US DOD has admitted to the presence of recycled, spent fuel products and other man-made, transuranic materials in its DU-KEP raw materials' stockpiles for weapons production.

When UMRC first analysed the laboratory readings of the isotopes of uranium in the Afghanistan specimens they expressed the signature of the contaminant as Non-Depleted Uranium (NDU). Accompanying the NDU signature were readings of one of the "markers" of artificial and recycled uranium: U^{236}. The quantities of U^{236} are low, hovering just above the instrument detection limits. Further investigations are underway. If the new specimens now being analysed in the laboratory corroborate the findings of U^{236}, it will confirm that the artificial, metallurgical origin of the weapons.

- **Afghan contamination exceeds regulatory "Action Levels"**

UMRC has found urine uranium excretion values in Afghanistan up to 2000 nanograms per litre. These levels are measured in civilians, 4 to 10 months after acute exposure to the ballistic plumes of OEF weapons followed by chronic, internal exposure to ceramic uranium incorporated in their bodies and recurring uptake from contaminated environments. Because Afghanistan is not a nuclear state (i.e. with no nuclear weapons, mining, processing or reactors) there are no regulatory agencies to monitor and protect against this newly created, pervasive public health problem.

Most nuclear states have well organised and well financed radiological protection regimes governed by international and national regulatory agencies. In the nuclear complex, where the risks are considered the highest, workers are protected by guidelines dictating exposure limits. There are also restrictions to the exposure levels that can be inadvertently released and presented to the public outside the complex. The ICRP (International Commission for Radiation Protection) is responsible for promulgating

[21] UN Environmental Program press release, reported in The Guardian, Feb 17, 2001, UK.

[22] McLaughlin et al, Plutonium in DU Penetrators, Archive of Oncology; 9(4), 225-9, 2001.

radiation protection standards and risk assessment models to guide national regulatory agencies, intended to protect the health of workers and civilians.

ICRP's models are used to calculate retroactively, the exposure values and subsequent risks to workers' health based on regular monitoring and measuring of the concentrations of uranium excreted in urine. The models consist of a set of mathematical calculating factors, assumptions and formulae used to derive from the values in urine: (1) the amount of uranium deposited in the lungs; (2) the incumbent chemical and radiological dose presented to body tissues and organs; and, (3) the rate of uranium clearance from (and fractions of retention in) the lungs and circulatory system. The models are considered to be largely applicable to contaminant intake via inhalation – now recognised as the primary medically significant route of uptake of uranium. This analytical procedure is called "dose reconstruction".

When a nuclear complex worker's urine uranium bioassay shows that inhalational exposure has reached a the ICRP's threshold level, "action levels" must be implemented. "Action levels" are guidelines instructing under what conditions and how a private or governmental nuclear facility must respond to a worker's over-exposure incident -- when the permitted exposure levels (PEL's) have been exceeded. For the most part, the nuclear complex ignores the type or species of uranium and its physical and chemical form responsible for any elevations found in routine urine monitoring – using quantity (abundance), not kind (form) as the decision rule. When the exposure is calculated to reach 10% of the maximum annual allowable dose the regulatory guidelines compel (under the auspices of UN treaty agreements) a legally binding response called the "Investigation Level" – the nuclear industry's euphemism for emergency response:

> "Investigation Level: The levels at which an intake should be investigated. Any intake greater than or equal to 0.1 [10%] the annual limit of intake (ALI)." … "For single intakes that are greater than 10% of the ALI, thorough investigation of exposure should be made…".[23]

In a recent publication examining the ICRP standards and models, the British NRPB (National Radiation Protection Board) outlines several scenarios resembling exposure risks to armed forces personnel and civilians from inhalation of the contaminant with the chemical and physical properties (the form) identical to battlefield uranium[24]. The scenarios are modelled using the ICRP's guidelines – extrapolating the lung and body burden and "effective dose". In evaluating the efficacy of the ICRP standards, the NRPB concludes the permitted values of exposure for radiation derived from acute inhalation of low to no soluble oxides are faulty:

> "…the effective radiation dose [recommended by the ICRP for U_3O_8 and UO_2] can substantially exceed the annual dose limit…".

[23] Acceptable Concepts, Models, Equations, and Assumptions for a Bioassay – NRC Regulatory Guide 8.9, U.S. Nuclear Regulatory Commission – DG 8009, July 1999.

[24] Industrial Uranium Compounds: Exposure Limits, Assessments of Intake and Toxicity after Inhalation – NRPB - W22, N Stradling et al, National Radiation Protection Board, United Kingdom, 2002.

The NRPB made the same assessment of the ICRP's standard for chemical toxicity from chronic exposure to the kidneys by ceramic uranium [a specific risk associated with ultrafine particulate and also with the medium clearance class of oxides, $UO_{3,}$ produced by uranium battlefield weapons, Ed.]. Based on a review of recent research and European standards compared to the ICRP's outdated standards, the NRPB states:

> "[An analysis of the ICRP PEL's] … suggest[s] that for the maximum kidney concentration … the exposure limit … is too high …".

ICRP regulatory standards are designed to protect workers in the nuclear complex and control also, incumbent civilian exposures from the complex. National nuclear regulatory agencies adhere to ICRP radiation protection standards and rules and require their application in nuclear facilities. National health and labour safety agencies monitor and assess civilian exposure levels, which are 10 X's lower than the permitted occupational exposure levels[25]. National heath and labour safety regulators have final or pre-eminent jurisdiction for the protection of nuclear workers.

When accepting employment, workers in the nuclear complex are required to waive their rights; thereby becoming ineligible to be protected by the higher standards afforded civilians. This is not the case for armed forces personnel whose job descriptions are not defined to have inherent risks of exposure to radiological contaminants and are expected to enjoy the same level of protection as civilians. In what the regulators consider an unlikely occurrence, if and when civilians receive an over-exposure (beyond civilian exposure levels), the responsible nuclear facility is legally liable and administratively accountable for safety violations under the auspices of the regulatory regime as well as applicable public health and labour safety regulations. If and when workers subject to the occupational exposure limits are overexposed, the nuclear regulatory agencies and the labour health and safety agencies have jurisdiction. The responsible facility is provided significant latitude to manage overexposures although it is required to implement a comprehensive regime stemming out of the ICRP models and procedures and falling, legally, under the jurisdictions of the respective national nuclear as well as labour health and safety regulators.

The NRPB's research update and assessment of the ICRP modelling framework shows the ICRP's International Basic Safety Standards for occupational exposures via inhalation of uranium in the physical and chemical form identical to the by-products of battlefield uranium weapons, exceeds safe limits. If the levels of uranium excreted in the urine of Afghan civilians were measured in an occupational setting in the nuclear complex, "action levels" would require implementing the (Emergency) Investigation Level response. Accordingly, if the contamination was attributed to an acute exposure incident 4 to 10 months earlier followed by chronic exposure (repeated up-takes) to ceramic uranium oxides, the risks and impending medical consequences would be classified as both chemotoxic and radiotoxic. If these levels were identified in civilians of UN/IAEA (International Atomic Energy Agency) signatory nations, a legal liability would ensue under civilian health and environmental protection regulations – strict sanctions would be applied.

[25] Occupational Safety and Health Guideline for Uranium and Insoluble Compounds, OSHA – Health Guidelines, Occupational Safety and Health Administration, US Department of Labor, undated Internet publication.

Regulatory guidelines for the Investigation Level of action specify detailed protocols, which hold the force of law in most national jurisdictions as well as under international law governing regulatory agreements with the UN/IAEA. With respect to uranium internal contamination via inhalation, clinical, safety and administrative obligations are explicit[26]. If the Investigation Level is reached, contamination mitigation procedures must be implemented, including removing exposed persons from the source of contamination. A clinical regime is also initiated. It includes more frequent urine uranium bioassays, medical evaluations and monitoring -- if necessary the exposed subjects must be provided medical treatment. Incident and clinical data are sent to environment, health and labour regulatory agencies (i.e., "national toxic substances and disease control registry", environmental protection agencies, labour health and safety departments); maintained for future reference by safety inspectors, exposure and risk managers as well as retained in permanent, worker health records. Health as well as facility response and exposure mitigation records are kept available as long-term reference documentation to adjudicate occupational health claims and inform regulatory-driven inspections, investigations and facility licence renewal applications.

Uranium levels in OEF bomb-sites, surrounding soils and water

The question posed by UMRC's Jalalabad results, and now by the Kabul and Spin Gar (Tora Bora) areas' findings is, of course, "What is the origin of the uranium internal contamination?" To investigate this question, UMRC collected laboratory study samples from (1) environments where contaminated civilians live and work, (2) inside bomb craters and surface targets, (3) in the immediate surroundings of the bombing, and (4) downwind towards contaminated civilians' neighbourhoods. In some cases the bombsites are situated among houses inside neighbourhoods and villages.

Geological specimens were collected for three additional reasons: (1) cross-referencing the locations and environments of biological specimens and their uranium values, geospatially; (2) plotting the scale, scope and circumference of the environmental contamination; and, (3) establishing Reference Levels (i.e. baseline uranium values). Geological controls were collected in localities where residents do not present with the symptom profile of uranium internal contamination and where there are no known bombsites in the vicinity. Since there can be biologically significant volumes and densities of plume dispersed uranium down-wind, the estimation of appropriate control sample sites (to avoid adulteration from artificial uranium) is more difficult.

- **Uranium levels in bombsites**

Matching geo-spatial arrangements of bombsites to civilian effects also has its difficulties. Field Teams were not aware of all bombsites. Neighbourhoods and Districts may be close to but visually separated from bombsites by hills, valleys, orchards, hajarat walls and buildings. These bombsites and their original ballistic plumes may by spatially located so as to pose a direct contamination risk from sites they cannot observe. Since most bombing sorties took place at night and in the early morning hours between dawn and sunrise, residents may not accurately identify visual co-ordinates of ground-zero and may have been preoccupied with more immediate concerns – especially when several sorties were targeting several neighbourhoods at once. Follow-up visits found bombsites

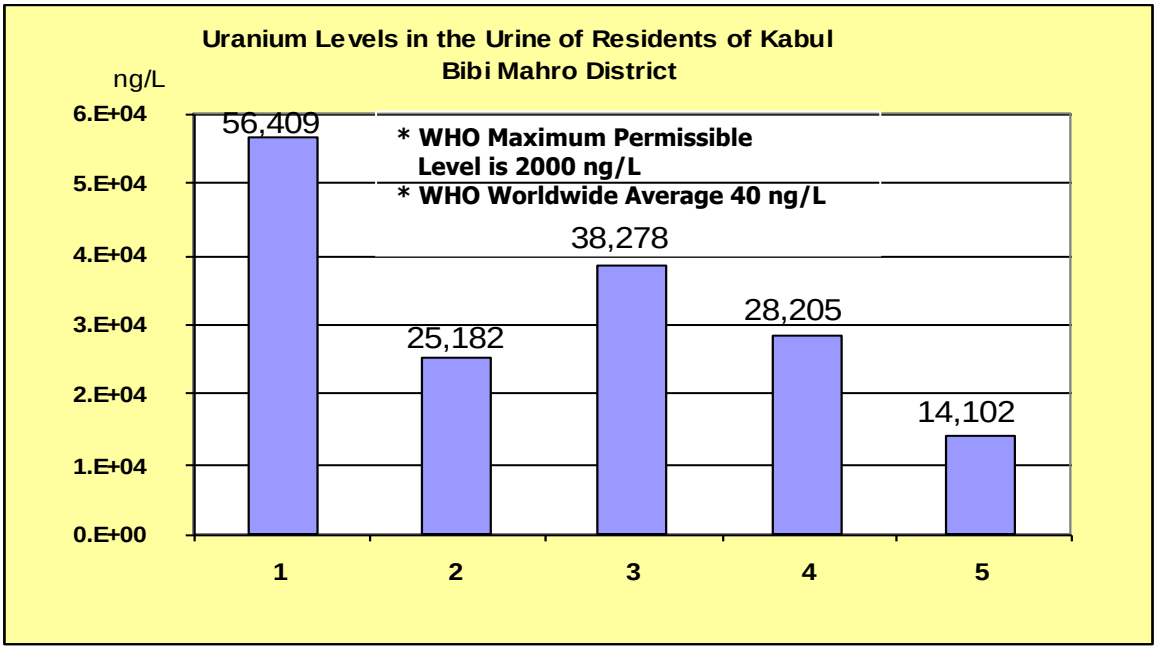
[26] Assessment of Occupational Exposure Due to Intakes of Radionuclides, Safety Guide No. RS-G-1.2, International Atomic Energy Agency and the International Labour Office, IAEA Safety Standards Series, IAEA, Vienna, 1999.

close to areas where urine samples were taken in earlier studies but had not been identified at the time.

Bomb-crater debris and bomb-crater soil samples were taken from sites where bunker-busting ordnance, incendiary ordnance, hardened-target ordnance, anti-armour and anti-personnel and area denial munitions were deployed. The delivery systems responsible are reported by eye-witnesses to include a combination of systems: Predator cruise missiles delivered presumably by ship-launchers or UAV's (unmanned air vehicles), high altitude bombers, tactical fighter-bombers (F series and A-10's), and low-altitude gun-ships (Apaches and C-130's).

Radiochemical analyses show bombsite uranium levels to be wide ranging: (1) normal compared to Reference Levels; (2) somewhat elevated above Reference Levels; and, (3) very high, compared to both geological averages and Reference Levels. The highest bombsite uranium levels to date have been found in Jalalabad. They range from 4 X's to 6 X's above normal soils' Reference Levels (measured in grams of uranium/ kilogram of soil). The high values of bombsite uranium were found in (1) deep-penetration weapons' craters (2) surface, hardened-target/armour-defeat ordnance used against heavy military assets, and (3) incendiary weapons.

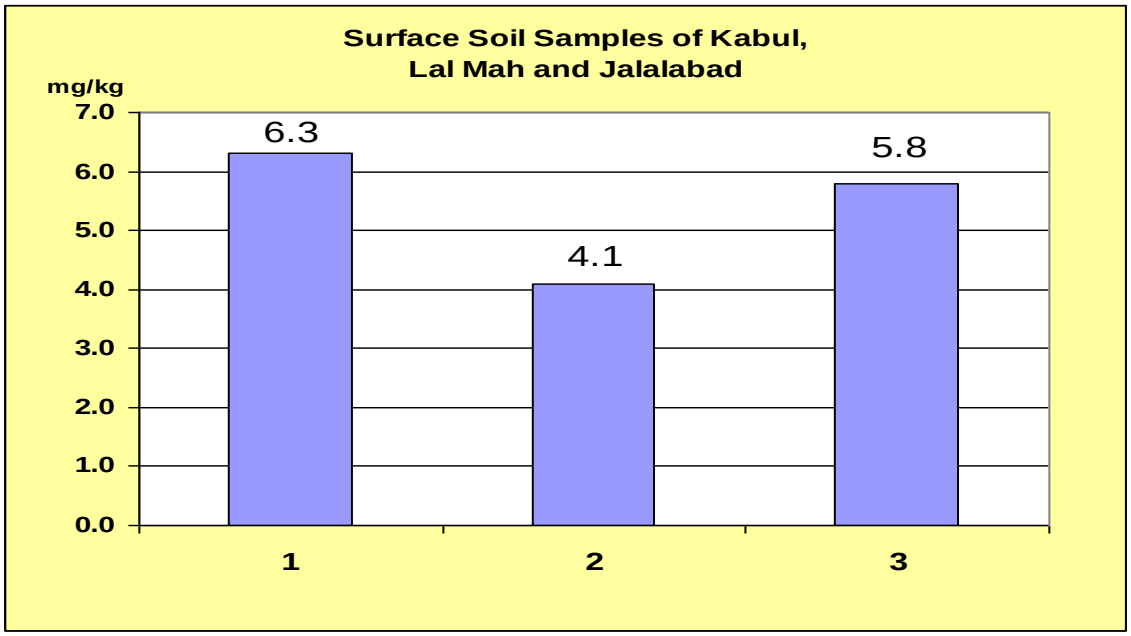
Figure 4 – Two examples of bomb-crater's uranium values geo-spatially associated with the Jalalabad urine uranium bioassay results.



- **Uranium levels in surrounding and down-wind soils**

Farm field top-soils, irrigation silt and common area (hajarats) surface soils were collected immediately surrounding bomb-sites, and downwind proceeding towards the localities where civilians reported exposure to the ballistic plumes. Follow-up samples were taken in areas known from the original Jalalabad studies to have high urine uranium values in civilians. Soils and dust taken outside bombsites and proceeding down-wind towards the known-to-be contaminated communities measured with a range of uranium values - from normal up to just under 3 X's the Reference Level.

Figure 5 – Examples of uranium in soils surrounding and downwind of OEF bombsites. Reference Level used is 3 mg/Kg.



USA Agency for Toxic Substances and Disease Registry
Worldwide Concentrations 3 mg/kg

- **Observations and conclusions on soils' data**

The high values of uranium in bomb craters, in surrounding soils and in soils down-wind of the bombsites point directly to Operation Enduring Freedom as the source. The spatial configuration of the measured samples shows the highest values in the craters, followed next by the values in soils immediately surrounding the bombsites. There is a progressive reduction in uranium values proceeding away from ground-zero in directions travelled by the ballistic plumes -- plume directions and prevailing winds being reported by witnesses. Control soil samples taken well outside the bombing zones, defined by the distance from ground zero and not being down-wind or having been inundated by the ballistic plumes, have normal values of uranium.

The values of uranium in the soils outside bomb craters and target sites were surprising – they are unexpectedly high beyond the ballistic circumference where the population lives close to the bombsites but not close enough to be affected by the bombs' explosive thermal fronts and pressures. Approaching distances of a few kilometres downwind from the bombsites, values of uranium are not perceptibly higher than geological standards and controls taken from the unexposed environment. This is not true for the water samples, discussed below. Where civilian samples indicate high uranium values in urine, contamination might be explained by direct exposure to ballistic plumes of a single sortie, several sorties concentrated in time and place, or several weeks of repeated bombing.

Soil and surface material uranium values are not good indicators of environmental contamination risks to humans. Even a high volume of uranium particulate in the air may

not translate into elevated concentrations in the soil. Electrostatic forces may concentrate or repel airborne particulate according to patterns and rules not readily identified in the field[27]. High concentrations of artificially deposited uranium-rich dust can raise surface radioactivity levels, particularly from short-lived isotopes – compared to naturally occurring uranium in the surface soils. UMRC's did not use radioactivity counters for security reasons.

Although calculations of the addition of several thousand pounds of aerosolised uranium dispersed by a ballistic plume over several square kilometres show it will not raise soil values perceptibly over background levels, this does not mean there is no contamination. The risks and exposure conditions depend upon the chemical, physical and mobility properties of the uranium[28]. Natural uranium is present in soil in mineral compounds and forms not readily available for human up-take. Battlefield uranium on the other hand is presented in forms considered bioavailable. The soil and environmental conditions in Afghanistan are not efficient neutralisers (absorbers and reducers) of deposited uranium particulate. In fact, Afghanistan's soil and weather features exacerbate risks by corrosion and oxidisation patterns and mechanical representation of the newly deposited contaminant. Refer to the World Health Organisation's[29] and United Nations Environment Program's[30] depleted uranium and post-conflict reports for a discussion of the chemistry and environmental features and conditions affecting the bioavailability of battlefield uranium.

The addition of ballistically pulverised and thermally aerosolised uranium at the levels measured in the bombsites, the surrounding soils and down-wind had not been expected to raise the values in soil outside the bomb's ballistic circumference. This finding therefore provides a clue to the high mass/volume of uranium in OEF weapons and the aerosolisation and dispersion efficiencies of combining uranium with high explosives. Measuring uranium values in bomb craters 4 X's to 6 X's normal and in soils hundreds of meters away from craters nearly 3 X's local baselines represents very high densities and volumes of uranium at ground-zero and transported down-wind.

- **Contamination of water and catchments**

Water samples are important for two reasons: (1) surface water and rain run-off can transport and concentrate uranium particulate and compounds of uranium-rich dust after it has settled; and, (2) human uptake of uranium from water is an important media (drinking water) and pathway (ingestion) of contamination. High values of uranium in water are normally associated with heavy metal chemical toxicity. When the contaminant ingested is ceramic uranium in the physical form of ultrafine particulate, the material is also radiotoxic. UMRC collected drinking water samples corresponding to each biological sample from the study subjects' and controls' drinking water sources. Samples of water were collected from surface-water, irrigation ditches and catch-basins (low-elevations where run-off and irrigation water concentrate), close to and surrounding the bombsites.

[27] JR Marshall, "Electrostructural Phase Changes" in Charged Particulate Clouds: Planetary and Astrophysical Implications, SETI Institute, NASA Ames Research Center, Lunar and Planetary Science, 1132.pdf, XXIX (undated).
[28] B Salbu et al, Oxidisation states of DU particles from Kosovo, Journal of Environmental Radioactivity, 64(2-3): 167-173, 2003.

[29] Depleted Uranium: Sources, Exposures and Health Effects, Part's I and II, 2001, World Health Organisation, <<www.WHO.int/en/>>

[30] United Nations Environment Program, Post-Conflict Assessment Unit. See: Depleted Uranium Assessment, Final reports on the Balkan countries, <<www.UNEP.org>>

Quantities of uranium in water range from 3 X's to 27 X's the Reference Level (Fig 6). These levels have the potential to contribute to high urinary uranium values if the contaminant is soluble uranium and less so when it is insoluble. If the urinary excretion values found in the study could be explained by the up-take of ceramic uranium from water, a proportionately very high quantity would be required – ceramic uranium being 100 X's less efficient at being absorbed into the blood stream during digestion. To be passed into the blood by normal digestion processes and measurable in urine at the levels of uranium found in the study, the Afghan findings would represent an additional public health risk.

UMRC has detected high uranium values in surface water, run-off catchment areas and in some drinking water sources (both deep and shallow). Water in flooded rice fields (irrigated regularly since the bombing) close to and down-wind of bombsites now known to have high uranium values also shows high values of uranium. Results show particularly high uranium values in "karaize" wells where the source of water is the bombed environments in the Tor Gar (Tora Bora) area. The spatial elevations of karaize with high values of uranium are such that they may also serve as catch-basins, collecting and concentrating runoff from the immediate environment.

The karaize results are noteworthy because of their primary fresh water feed source. The bombing of Tora Bora was publicly announced as the experimental, weapons proving grounds for cave busting penetrators, thermobaric, and seismic shock munitions (tectonic disrupters). The new generation of field-tested weapons specifically targeted the karaize systems – ancient, deep and long (many kilometres) well systems and water storage reservoirs. Apparently OEF suspected these wells and their underground channels feeding lowland wells from the mountains were being used to store munitions, weapons of mass destruction and Al Qaeda commanders.

The highest values in water have been found in wells and catchments within a few meters to several hundred meters from the bomb-craters high in values of uranium. At more distant locations (up to and over 2 kilometres down-wind of the responsible craters), where civilians are contaminated and soils are normal, the uranium values in water are elevated but not outstanding compared to the water adjacent to the bomb craters. For persons moving into or returning to contaminated environments after the cessation of the bombing campaign (levels of uranium are high both in soils and water), urine uranium excretion levels may be slightly elevated but do not approach the values of those exposed to the ballistic plumes.

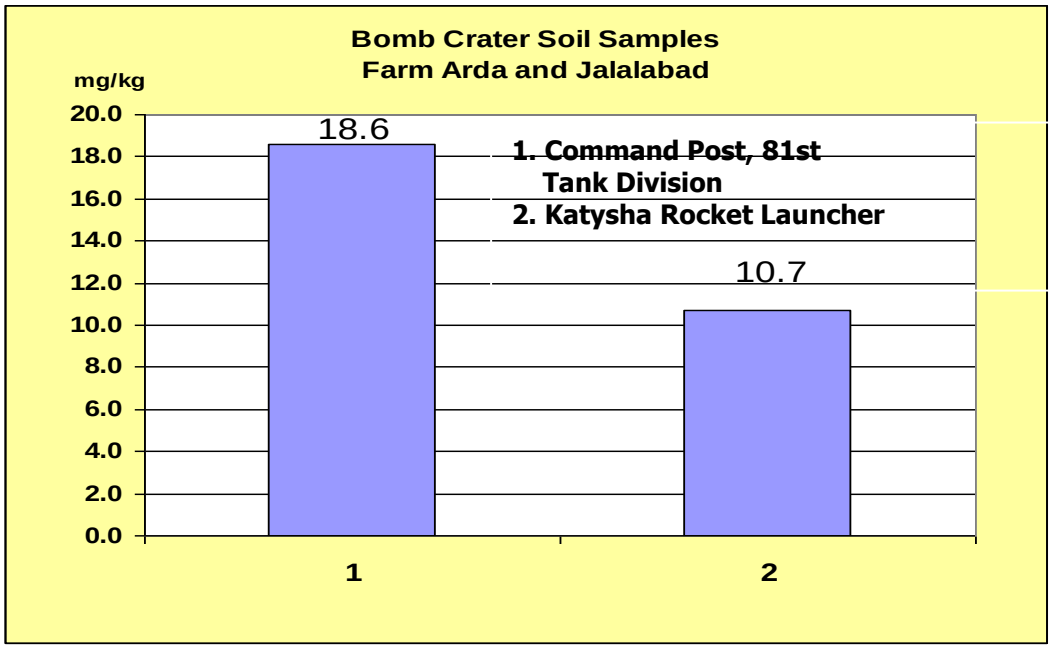
The levels of uranium in the water pose some questions:

- The water findings may indicate good hydrological mobility of battlefield uranium in the environment via surface water (i.e., rain, irrigation).

- Possible continuous uranium accumulation in water from uranium-rich dust blowing out of bomb craters and surrounding soils.

- Humidity may accelerate the rate and volume of plume deposition such as found in the air over wet ground, flooded fields and bodies of water.

Figure 6 – Cross-section of the high uranium values in water samples associated with OEF bombsites.



"Time zero" uranium up-take and lung burden studies

Naturally present uranium is a different species than the Non-Depleted Uranium ("commercial natural uranium"), adulterated with transuranics, found in UMRC's analysis of the isotopes in samples from Afghanistan. Natural uranium is considered ubiquitous. Although the public has been led to fear external radiation, it has been largely kept naïve to the threats of airborne contaminants. Unless a geological (e.g., phosphate-based fertilisers or soils rich in uranium) or technological (e.g., nuclear reactor, processing, or waste disposal site) anomaly is present, the pathway of human uptake has historically been considered to be predominantly oral. Until recently, the commonly held view has been that inhalational up-take is the anomalous pathway. The unlikely oral intake of industrial actinides and other radioisotopes, low-bioavailable natural uranium and an exposure to external radiation sources have been considered the mechanisms most worthy of acknowledgement by the Defence, regulatory and public health establishments. Unusually high, naturally present values of uranium in water are of course considered a potential risk although this form of exposure is different from the forms made bioavailable via industrially and ballistically produced uranium aerosols.

Uranium weapons introduce a new condition to the environment -- airborne uranium, where there was none before -- and establishes the presence of a pervasive environmental contaminant with different routes of invasion. The introduction and distribution of artificial aerosols of uranium oxides and other uranium-rich compounds in the environment is an acute biological over-exposure incident which in Afghanistan is followed by potentially repeated exposures, remaining long after the acute event ceases. Man-made conditions in the battlefield present several potential exposure scenarios and patterns requiring investigation:

- Have the subjects received the contaminant from a single acute (or series of acute) events?
- Are the high urinary excretion values at this late date the result of high acute quantities or repeated uptake from the environment?
- Is there evidence of repeated uptake (when the subject had no acute exposure to ballistic plumes) from the environment at values high enough to explain the current levels?
- Is there a combination of: an initially high level of acute exposure in conjunction with a repeated, chronic exposure?
- Which pathway is the most prolific route of chronic exposure: inhalation of re-suspended uranium from the soils or oral ingestion of uranium from the water?
- Do life style and environment present a risk of intake by skin absorption? If so, what is the fraction of contribution to internal contamination?

The most likely scenario being postulated is that detonation-produced uranium aerosols constitute a high-volume, acute inhalational contamination incident (or a series of incidents corresponding to exposure to several sorties). Those inundated by the contaminant will receive high volumes of particulate from the dense ballistic smoke and dust clouds. Those who visit the areas with the highest deposition rates and conduct various activities at the bombsites and surrounding contaminated environments close to the bombsites will most likely be next in the risk hierarchy of potential exposures. For those with acute exposure to the detonations and subsequently living in newly contaminated environments, the proportion of exposure risks derived directly from the high content of uranium at ground-zero verses the surrounding soils and water needs further study.

Time is not necessarily a mitigating factor. In other words, while acute exposure at detonation is probably the highest risk of inhaling the highest volumes of uranium aerosols, other factors may make later exposure exacerbating if not equal – depending on quantities available for up-take, time spent in the contaminated environments, the type of activity of the subjects, re-suspension and reactivation forces, and the weather and soil conditions. The risk appears particularly significant for children who play and live close to or even in the bombsites (houses have been built and rebuilt on bombsites, gardens are grown in crater soil).

Although the physiochemistry of the contaminant makes it available for mechanical and weather-driven re-entrainment, its post-ballistic re-suspension will not be as dense as at the time of detonation. Chronic exposure to the bioavailable material may be persistent enough to accumulate biologically deleterious volumes in the lungs and circulatory systems (lymphatic and blood)[31]. The post-ballistic exposure from inhalation of uranium-rich, re-suspended particulate and ingestion of water containing its bioavailable forms along with the highly mobile character of battlefield uranium particulate needs further examination in the field and the laboratory.

While not added to this report, UMRC's research associates have developed a model of calculating, retroactively, the volumes of contaminant inhaled and subsequent radioactivity levels for "time-zero" of the acute exposure incident. Applying these models will in the future, enable more effective clinical research on acute exposure, up-take

[31] "The team was surprised to find DU particles in the air two years after the conflict's end. … Any soil disturbances at the sites could risk releasing DU particles into the air." United Nations Environmental Program, DU Assessment Team, UNEP Press Release/105, March 27, 2002, <<www.UNEP.org>>

patterns and toxicity potentials from exposure to the ballistic plumes. Future reports and papers will include the calculations of: (1) the volumes of the aerosol deposited in the lungs and transported to the circulatory systems, organs and tissue; (2) the radiation dose associated with the volumes and the species of uranium present, including daughter and decay products; (3) the body and organ retention and clearance rates; and, (4) the time line values of excretion in the urine. This work is designed to account for the means of presentation of battlefield uranium, its unique physical and chemical form and its particular metabolic and biokinetic features.

Postulating a new generation of weapons: the properties, behaviour and effects of battlefield uranium

In November 2002, UMRC's radiobiological and radiochemical findings in Afghanistan, coinciding with Operation Enduring Freedom, of field samples from the Jalalabad area led to a preliminary hypothesis that a new generation of ordnance was now in the US's and perhaps other Coalition Partners' arsenals. Field, laboratory and documentation evidence were pointing to heavy weight, penetrating ordnance employing Non-Depleted Uranium for ballast, hardness and engineered synergistics that occur when uranium is pulverised and conflagrated by the detonation of high explosives.

UMRC's May 2003 environmental study findings appear to confirm the hypothesis that OEF ordnance contains Non-Depleted Uranium. Geo-spatial and population patterns of contamination match the ballistic and plume behaviour of the weapons. Bomb-craters are unusually high in NDU content whereas the locations of control specimens are normal for uranium values. The health problems in communities adjacent to the bombing reveal a chronology of exposure and symptoms in which the on-set of acute and development of chronic effects resembling uranium internal contamination coincide with the dates and locations of the bombing and environmental accumulations. Isotopic ratios of the uranium in the contaminated localities and people do not support postulations that the uranium has any other origin. The identification of low quantities of U^{236} is reasonably conclusive evidence of the artificial origins of the uranium.

In addition to soils, surface water catchment areas and bomb-crater studies, UMRC made extensive field inquiries. Geological literature and mineral reports were researched; mining, export and domestic commerce, manufacturing and processing industries were investigated; construction and agricultural practices, sites and raw materials were reviewed with local officials and geologists. As yet, no credible alternatives to the deployment of composite NDU-high explosive weapons have been found or are scientifically supportable by suggestions brought forth by critics.

Although there is no recent admission by NATO or its members' Defense Departments, there is some historical information from weapons R&D laboratories and military documentation of composite, uranium-high explosive weapons. Considering available documentation, field and laboratory results, the types of ordnance and delivery systems used in Afghanistan, the type of targets acquired, and the weapons' terminal-ballistic characteristics, two conclusions are drawn:

(1) The first is that some varieties of munitions have been reengineered and refitted with uranium alloys. Certain "conventional" high-explosive, fragmentation and conflagration bombs and some types of specialised asset-defeat ordnance have been up-dated with ballistic-enhancing alloys of uranium, replacing (or compounded with) iron, tungsten and titanium. The weapons suspected are the smaller (250 to 2000 pounds) surface-hardened target, anti-armour defeat penetrators, and speciality ordnance such as shaped charges, and gun-tube bunker-busters. Some thermobarics and area denial munitions may also be included in this category of reengineered, composite uranium-high explosive weapons. Some shoulder-held anti-armour and anti-hard target rocket launchers may also use uranium-high explosive penetrators.

(2) The second conclusion derives from public discourse, US Defense Department statements, Congressional publications promoting the DBHT (Deeply Buried Hard Target) program, the Science-based Stockpile Stewardship Program, and White House-OEF press announcements. It is well known that entirely new generations of heavy weight, deep penetrating ordnance have been added to the weapons'

inventories of several branches of the armed forces. Over the last decade (since Gulf War I) major financial appropriations have been pumped into US and NATO weapons' R&D – the object being to make more flexible weapons and modular ordnance assemblies, offering field commanders a longer menu of ballistic and target-effects' options.

One major line of R&D has been the non-battlefield, "strategic penetrators" designed to acquire and destroy Weapons of Mass Destruction and enemy leaders ("decapitation strikes") in underground bunkers. This ordnance class is being developed in concert with the mini-nukes and micro-fissile/fusion weapons[32] development program (quietly advanced by the Pentagon to avoid non-proliferation treaty conflicts). Penetration ordnance technology has direct application and is expected to be the delivery mantle for any new generations of low-yield, fissile (now considered strategic by the nature of their targets) and tactical battlefield weapons. Although the mini-nukes have so far failed to be accepted by the US Congress, the non-fissile heavy-metal, deep penetrators are[33]. They are included in the US Strategic Military Plan for deployment against "rogue states" suspected of developing and storing weapons of mass destruction in surface and underground, hardened bunkers and caves[34].

These weapons are on the larger size – 2000 pounds up to 10,000 (perhaps some in the weight range of 20,000[35]) pounds. Because they contain (or have bolted on) guidance instrumentation packages and sections of the weapons are filled with slurries of chemical high explosives and Thermite[36], the gross weight does not represent the total mass of uranium. The bigger bombs that may employ uranium are the deep penetrators and the above-ground battlefield detonation bombs. These include seismic shock bombs (tectonic disrupters), wide-area multiple targets' defeat ordnance with nano-engineered terminal-ballistics of fragmentation (dense, self-forging shrapnel), high-pressure thermobarics, and some versions of munitions with thermal/pyrophoric[37] wave propagation, conflagration and oxygen-depletion effects.

How extensive the military application and deployment of uranium (DU and NDU) is not known publicly. The advancement in precision guidance and accuracy of weapons delivery is impressive. In Afghanistan, there were almost no misses and therefore little "collateral damage". Since Operation Desert Fox (Iraq) and now Operation Enduring

[32] A. Gsponer et al; A comparison of delayed radiobiological effects of depleted-uranium munitions versus fourth-generation nuclear weapons; Independent Scientific Research Institute; Geneva; contributed to YUNSC-2002, Belgrade, Yugoslavia.

[33] Alterations, Modifications, Refurbishments, and Possible New Designs For the US Nuclear Weapons Stockpile, Nuclear Watch of New Mexico, May 2001. [Good bibliography of source material about Stockpile Stewardship Program and delivery missiles most likely being refitted with uranium ballast and hardening alloys for optimum penetration by mini-nukes.]

[34] M Bromley et al, Bunker busters: Washington's Drive for New Nuclear Weapons, Basic Research Report 2000.2, British American Security Information report, July 2002.

[35] The Direct Strike Hard target Weapons called the "Big BLU" (BLU – bomb live unit) is estimated to contain "20,000 pounds of dense metal ballast"; Federation of American Scientists, <www.fas.org>

[36] Thermite – generic name for an incendiary accelerant used to propagate supersonic combustion.

[37] I Martinez, Lectures on Thermodynamics, Based on: Thermodinamica basica y allicada, Ed. Dossat, 1992, ISBN 84-237-0810-1.

Freedom, reports of so-called collateral damage (civilian targets, wounding and deaths) must be viewed differently than during Gulf War I. The weapons have been so well refined that they simply don't miss their targets[38]. Where civilians and non-military targets were destroyed in Afghanistan, they were selected intentionally (even if post-ballistic inspection revealed that they did not house the enemy, WMD's, etc). Only in the case of the occasional human, mechanical or electronic malfunction do these bombs fail to acquire the target objective. Between guidance accuracy and engineered ballistics[39], the postulated new generation of composite, uranium-high explosive ordnance can be appropriately termed, "designer-bombs"[40].

An excellent analysis of the weapons suspected of containing various masses and alloys of uranium is presented by Dai Williams[41]. Weapons information available on the internet from the Federation of American Scientists[42] and Global Security[43] can also give clues as to the likely candidates of ordnance best suited for enhancements by uranium alloys and ballast.

The following sub-sections outline the key features and effects of uranium that makes it a valued military tool in the battlefield and a hazardous, long-term environmental and human toxin.

- **"Material specific" considerations**

The terminal ballistics of uranium weapons presents a unique scale and type of radiological hazard. DU-KEP's (Depleted Uranium - Kinetic Energy Penetrators) and composite NDU-HEO's (Non-Depleted Uranium - High Explosive Ordnance) produce environmentally contaminating aerosols with physical and chemical characteristics specific to and uniquely presented in the battlefield. The contaminant is a combination of ceramic oxides of uranium and metallic uranium particulate released in the form of ultra-fine respirable aerosols, which are estimated to be between 0.0001 and 100 microns diameter – with the bulk of particles below 0.1 micron[44].

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[38] Precision Guided Munitions and the New Era of Warfare, RP Hallion, APSC Paper No. 53, Air Power Studies Centre, RAAF, Australia, 1995. [Although somewhat dated, the discussion corresponds to Operation Desert Fox when NDU-HEO ordnance is suspected to have been deployed for the first time at any scale.]

[39] Structural Amorphous Metals Briefing, R.J. Dowding, U.S. Army Research laboratory, Aberdeen proving Ground, June 2000.

[40] Research opportunities – Weapons and Material Research, Army Research Laboratory, Postdoctoral Fellowship Program, American Society for Engineering Education, 2002, www.asee.org. [Rather enlightening window on weapons technology and modern ballistics engineering.]

[41] Hazards of Uranium Weapons in the proposed war on Iraq: Occupational, public and environmental health issues; Updating Mystery Metal Nightmare in Afghanistan, January 2002), Dai Williams, www.eoslifework.co.uk/u231.htm

[42] www.fas.org

[43] www.globalsceurity.org

[44] C.E. Lapple, Metallurgical Dust and Fines, Characteristics of Particles and Particle Disperisoids, Handbook of Chemistry and Physics, 53rd Edition, Stanford Research Journal V.5, 1961.

Depending on the metallurgical characteristics required, the raw metals used to manufacturer the weapons may be alloyed with Titanium, Tungsten, Molybdenum and Iron. The uranium component's ballistics produces three types of ceramic uranium oxides: U_3O_8 - Triuranium Octoxide; UO_2 - Uranium Dioxide; and, UO_3 - Uranium Trioxide[45]. The uranium that does not oxidise on impact/detonation will be present in the air and ground as slow-oxidising metallic particulate. The weapons may also produce compounded oxides of Ti/U (Titanium/U), W/U (Tungsten/U), Mb/U (Molybdenum), and Fe/U (Iron/U). Transuranics derived from the metallurgical stockpiles used to make uranium kinetic and uranium-high explosive weapons contain U^{236} and Plutonium (Pu), thus adding other oxide compounds to the content list of possible ceramic aerosols. The agglomeration of the aerosols with dirt, dust and target specific materials creates a variety of other uranium-rich compounds also lofted into the atmosphere.

The detonation oxides are classified as "high heat-formed" materials, referred to as baked-uranium. They are formed in the battlefield by a combination of effects stemming largely from the ballistic pulverisation and thermal aerosolisation of the kinetic impacts and the heat of high explosive detonations. Weapons employing uranium without high explosives are also heat producers – although significantly less so. A 120-mm, 5 Kg DU tank round travelling at 1.5 Km/sec will produce the equivalent heat and pressure of 1.4 Kg's of TNT with 60% to 69% aerosolisation of the metal[46]. Non-Depleted Uranium - High Explosive Ordnance will aerosolise most if not 100% of the uranium and all other metals in the weapon (exceptions would be fragmentation and area denial bombs releasing high velocity, hardened shrapnel, where aerosolisation will be avoided by design). The physical and chemical features of high heat-formed ceramic uranium and slow-oxidising uranium metal particulate present biological risks that classify them as both radiotoxic and chemotoxic.

The United Nations Environmental Program's (UNEP) Post Conflict Environmental Assessment expresses the risk of internal contamination by ceramic battlefield uranium[47]. Referring to the ceramic oxides' by-products of DU-KEP's:

> "… in the case of the inhalation of insoluble uranium aerosols [ceramic uranium], the biological half-life for a substantial part of the initial lung burden is very long, of the order of years. …Assuming the same clearance rate for children [as adults], it is concluded that the major part of the dose is received when the child grows up."

The World Health Organisation (WHO) also points to the unique health and exposure issues of battlefield uranium[48]:

[45] Depleted Uranium Exposure to Personnel Following the Camp Doha Fire, Kuwait, July 1999, R. Scherpelz, U.S. Army Center for Health Promotion and Preventative Medicine, Pacific North-West National Laboratory, June 2000.

[46] S. Fetter et al; The Hazards Posed by Depleted Uranium Munitions; Science and Global Security, 8(2), 1999.

[47] The Physiochemical Properties of Depleted Uranium, Appendix O, page 257, Post Conflict Environmental Assessment: Depleted Uranium in Bosnia and Herzegovina, United Nations Environmental Program,

[48] Depleted Uranium: Sources, Exposure and Health Effects, World Health Organisation, Geneva, 2001, <<www.WHO.int/en/>>.

> "…very few [biokinetic] studies have been conducted with DU. However since uranium and DU are identical chemically, the database on the former is relevant for the biokinetics of DU. However the discussion here is limited to the oxides, which are reported to be present in the air in the aftermath of the use of DU munitions, or after a uranium fire. For DU used in warfare, U_3O_8 and to a lesser extent UO_2 and UO_3 are the compounds of most immediate interest. In addition, consideration is also given to the bio-kinetics of mixed uranium-iron (U/Fe) oxides, which may also be present."

In Section 9.4 Internal exposure, WHO states:

> "Internal exposure to ionising radiation is a function of the route of a given nuclide [radioactive material] through the body and its residence time amongst various organs."

Later in Section 9.4:

> "IARC [International Agency for Research of Cancer], in its most recent review of ionising radiation, has also classified 'Internally deposited radionuclides that emit alpha particles' as carcinogenic to humans". [Author's note: Battlefield uranium by-products and aerosols are predominantly alpha emitters.]

- **Body retention and clearance features of battlefield uranium**

Applying nuclear industry and regulatory agency occupational models to assess veterans' and civilians' risks and dose effects from battlefield uranium is not directly relevant but it is the field of debate. The physiochemical characteristics, the metabolic behaviours, and exposure pathways and patterns are not the same in uranium battlefields as they are in the nuclear complex.

High heat-formed uranium oxides may be the single most serious radiological risk to health among the types and physical forms of inhaled and ingested uranium contaminant. When present in the air as ultra-fine particulate, the inhalation of battlefield uranium oxides is a compounding hazard. When a portion of the detonation by-products are larger uranium particles, alloys and agglomerates, the slower rate of environmental oxidisation is a long-term hazard[49]. These compounding physical and chemical conditions add significant complexities to the biokinetics and incumbent risks to health. These forms of uranium do not conform to conventional models used by Defense Departments to assess impacts on their veterans.

Ceramic or baked uranium is a slow-clearing /long-retained, low to no soluble contaminant. It is retained in the lungs and circulatory systems (blood and lymphatic)

[49] TL Rucker et al, Uranium Lung Solubility Class Selection at Bechtel Jacobs Company LLC-Operated Facilities, Bechtel Jacobs Co, Oak Ridge, TN (undated).

much longer than the forms of uranium more prolifically present in the nuclear complex. The official factors used for the "biological half-life" - the time it takes for 50% of a contaminant to be cleared - of ceramic uranium range from 3 years to 7,000 days up to 10,000 days, depending upon the regulatory agency[50] and the analytical factors used. When present in the physical form of ultrafine particulate, the lung-clearance rates are faster but organ and tissue absorption is more efficient and therefore the recycled clearance rates are longer lived (than fast-clearing, soluble uranium). Unlike other forms of uranium contaminant, when inhaled and eventually transported into the blood stream, the larger particles of ceramic uranium do not clear the body as quickly as the more soluble forms. When ingested, transfers to the blood are restricted by its relative insolubility, resulting in a proportionately lower % absorbed into the body from drinking water, for example. These characteristics make inhalation of ceramic uranium relatively more hazardous than ingested ceramic uranium if the biological half-life is a concern, as it is particularly with respect to radiation effects[51].

It is ceramic uranium's surface properties and chemistry that make it a low-soluble, slow-absorption compound. High heat creates a hard, glassy shell around the particle, reduces its diameter and increases its density. Interestingly, slow-oxidisation processes have the same effect when uranium particulate compounds and alloys are available for corrosion in the environment – the less humid the conditions the more efficient the effect of hardening the surface. When formed by heat (e.g. the detonation of an NDU-HEO weapon) the particles are smaller and therefore inhaled more deeply into the lungs to be accumulated and retained at higher total volumes. Once inhaled, it may never leave the lungs. Autopsies have found inhaled uranium contaminant in the lungs, skeleton, liver and kidneys of uranium workers, which may be attributed to the intake of ceramic oxides and low-soluble compounds[52]. A deceased Canadian Gulf War veteran's organs and bones, bioassayed by UMRC, were found full of Depleted Uranium several years after exposure (see UMRC publications and research annexed to this report).

Regulatory agencies are not consistent on lung clearance rates: a standard of 10% of inhaled insoluble uranium is used as the default factor for the quantities estimated to be able to reach the bloodstream (of all inhaled ceramic uranium in the person's lifetime)[53]. In other words, 90% is considered to be retained in the lungs and lymphatic system (some is carried by mucus into the upper regions of the lungs where it may be expelled). Ceramic uranium is classed by the regulatory agencies as the lowest risk to health among the potential types of internally incorporated uranium contaminant. Contrast this to soluble, fast clearing uranium – the type of uranium contaminant for which the regulatory radiation protection standards are written. Ninety percent (90%) of the inhaled soluble uranium contaminant is transported from the lungs into the blood stream within a few hours to a few days, after which it is rapidly cleared from the body in urine.

[50] (Basic Safety Standards) Assessment of Occupational Exposure Due to Intakes of Radionuclides – Safety Guide No. RS-G-1.2, International Atomic Energy Agency, 1999.

[51] A Durakovic, Medical Effects of Internal Contamination with Uranium, Department of Nuclear Medicine, Georgetown University School of Medicine, Croatian Medical Journal, Vol. 40, No. 1, Mach 1999.

[52] Kathren R. L. et al, Uranium in the tissues of occupationally exposed individuals; Health Physics, 57, 17-21, 1989.

[53] Guide to Good Practices for Occupational Radiological Protection in Uranium Facilities, DOE-STD-1136-2000, U.S. Department of Energy, October 2000.

Even though classified as a low risk contaminant, ceramic uranium is the physiochemical form of uranium most associated with mutagenic effects in the lungs and lymphatic system[54]. Its physiochemistry makes it the most likely inhaled uranium contaminant to be transported from the lungs directly to the lymphatic system. Epidemiologically, it is linked to cancers and childhood leukaemia[55].

Regulatory risk models assess inhaled uranium's toxicity mostly by its potential to damage the kidneys, chemically not radiologically. Since inhaled ceramic uranium is considered to be largely prevented from reaching the kidneys due to its low lung clearance rates, it is defined by regulators and Defense Departments as posing a much lower risk than equivalent quantities of non-ceramic, fast clearing uranium. This is an odd logic indeed. The regulatory models are saying that the uranium that clears the body quickly is the most hazardous to health, while the uranium that is retained in the body (the lungs, target organs, tissues and circulatory systems) posing the long-term radiological assault on the body, is the least hazardous.

Although the regulatory models say that no more than 10% (of inhaled ceramic uranium) ever reaches the blood (from the lungs), ceramic uranium has actually been shown to pose a risk to the kidneys. When ultrafine ceramic uranium (low soluble UO_2) is the material of contamination in occupational settings, clinical studies have detected nephrotoxicity. Ceramic uranium recycles in the circulatory system, posing a recurring assault to tissues and organs[56]. When ceramic uranium is presented in the ultrafine form (< 0.1 micron in diameter), its transport kinetics from the lungs to the lymph and blood circulatory systems make it a chemical toxin not only to the kidneys but other target organs as well. Quoting from the Royal Society report on DU[57]:

> "The studies of human exposure that are of most relevance to the intake of DU [ceramic aerosols] that occur in the battlefield are the small number of case reports that describe the effects of large acute intakes of uranium. These studies suggest that acute intakes predicted to result in peak concentration's of greater than 50 micrograms uranium per gram kidney are likely to result in very serious effects on the kidney that may be lethal …"

The risks from low-soluble, slow clearing uranium are more extensive than is reflected by its official classification of posing no to low chemical risk to kidneys. For

[54] T. Trosic et al, Pathway and quantification of insoluble particles in the lung compartments of the rat, Institute for Medical Research and Occupational Health, Zagreb, 1999.

[55] C Busby, Heatlh Risks Following Exposure to Aerosols Produced by the Use of Depleted Uranium Weapons, Occasional Paper 2001/12, Green Audit, November 2001, Low Level Radiation Committee, www.llrc.org.

[56] ICRP and NRC inhalational dose exposure models are based on a numerical calculation that factors a "once-through" cycle for metabolised and excreted uranium. The U.S. Department of Energy states "… the recycling model for uranium entering blood is the appropriate toxicokinetic model". Guide of Good Practices for Occupational Radiological Protection in Uranium Facilities, DOE – STD –1136 – 2000, October 2000.

[57] The health hazards of depleted uranium weapons: Part 1 and Part 2, The Royal Society, London, 2002.

uranium workers with occupational exposure in the nuclear complex, a host of "environmental diseases" and disease profiles (i.e. immunodeficiency diseases such a Chronic Fatigue Syndrome, Multiple Chemical Sensitivity) are associated with chemical heavy metal toxicity in the lymphatic system by slow-clearing, insoluble metals and high heat-formed oxides. Recent research conducted on uranium workers shows a correspondence of the contaminant's biological effects and resulting illnesses matching the aetiology of Gulf War veterans with inhalational exposure to ceramic, battlefield uranium[58] -- a fact generally ignored by the Defence Departments whose veteran's are ill from exposure in the Gulf and Balkans.

The oral and inhalational exposure to battlefield uranium in the form of a ceramic oxides and ultra-fine particulate presents its own unique aetiology not to be ignored because it behaves differently, biokinetically and is inadequately factored into the regulatory agencies occupational models. This contaminant has a more complicated metabolic life cycle than uranium that clears within days or weeks and cannot be dismissed simply because it is lower on the kidney risk hierarchy than industrial uranium.

- **Comparing DU penetrators to composite, uranium – high explosive ordnance**

The munitions identified and postulated as the origin of the uranium contamination in Afghan civilians and environments employ a much larger quantity of high-mass material than DU penetrators. The OEF weapons investigated by UMRC are a composite of Non-Depleted Uranium (NDU) and high explosives. Bombs suspected of being in this class of weapons contain in the range of 250 pounds and may reach up to 10,000 (or higher) pounds of high-density metal alloys (uranium alloys and pure uranium) combined with chemical high explosives.

A detonation of an NDU-HEO composite weapon is 1000's of times more energetic than the kinetics of DU-KEP's[59]. DU-KEP's contain no chemical explosives (although shaped charge armour and hard-target defeat, DU-High Explosive composite warheads suspected of being in use for over a decade, may). A consideration of the properties of uranium and the ballistics of high explosive weapons shows that composite Non-Depleted Uranium - High Explosives Ordnance will aerosolise virtually all the metal in the weapon, unlike DU-KEP's. Because of the much greater mass of heavy metal and chemical explosive blast effects, NDU-HEO's produce very high total volumes and densities of airborne, ultrafine particulate.

Being detonated ordnance (as opposed to kinetic ordnance), NDU-HEO's explode even if they miss their intended targets. DU-KEP's aerosolise only when they make positive contact with the intended target and or, if burned. DU-KEP's that miss their targets will slowly oxidise and release ultra-fine ceramic particulate as a natural process of corrosion.

The isotopic ratios of NDU makes it 1.7 X's more radioactive than the equivalent mass of DU. The higher volumes and densities in air and smaller particles released by NDU-HEO's have a much broader potential of radiochemical intrusion into the

[58] J. E. Phelps, Final Diagnosis: Environmental Toxic Pathway Analysis and Immune System Cytokine Modality Provide Key Insights into Chronic Fatigue Syndrome Mechanism and Etiology of Varied Pathogen Driver Illnesses, Department of Oncology, Orebro Medical Centre, Sweden, 2001.

[59] M. Bennet, Long Rod Penetrator Performance, Journal of Battlefield Technology, Vol 1 No.3, November 1998.

environment and greater potential for higher intake volumes by inhalation per individual exposure incident per weapon.

When NDU contaminant is released by high-explosive ballistics from detonation combined with high-velocity kinetics of the impact, it will proceed into the biosphere by direct deposition in the target and surrounding soils and water. The aerosols are carried aloft and dispersed down-wind in ballistic plumes as detonation by-products. For uranium used in deep-penetration ordnance, a higher fraction of the contaminant is left in the earth and target site. In this weapons' application, the uranium driven into the ground may remain in higher concentrations and macro-sized pieces which can burn for days, releasing toxic, smouldering smoke containing ceramic uranium oxides. Uranium fires will continue to burn until the material is fully oxidised. It has the ability to extract oxygen under circumstances that would smother other fuels -- a uranium fire will accelerate explosively when CO_2 is released by combustion and when hydrogen is released by dousing it with water.

- **Terminal ballistics of uranium weapons**

The detonation of high explosives combined with uranium ballast produces temperatures exceeding 5000°C[60] and may reach beyond 8000°C at the moment of impact-detonation. Uranium dust explodes in air concentrations of 55-60 grams per cubic meter. Uranium melts at 1,132°C and boils at 3,818°C. Uranium metal "flash-ignites" between 170°C to 255°C and fine particles will spontaneously ignite at 20°C (68° F - room temperature). It is explosive in the presence of CO_2, a gas by-product of the thermal and incendiary effects of high explosives[61, 62].

At the temperatures of a chemical, high explosive detonation combined with high-velocity kinetics[63], high pressures of 200 atmospheres and blast waves travelling at 21,000 mph[64], virtually 100% of an NDU-HEO's uranium and a certain portion of a target can be expected to vaporise and aerosolise. These temperatures and velocities produce "plasma effects" accompanied by ionisation and electrostatic charging of the particulate, the air and ground-zero[65]. Under these circumstances, a significant portion of the particulate will disperse in the form of colloidal aerosols (behaving according to Brownian principles)[66] along with high volumes of uranium-rich compounds and dust.

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[60] Warheads Primer, The Home of Ordnance and Energetics Excellence, U.S. Navy (undated).

[61] Advertising brochure, Nuclear Metals Inc. The information has been purged from internet. NMI was a manufacturer of military and civilian DU and U metal products and its factories are now a priority clean-up site for the US Environmental Protection Agency.

[62] JE Gindler, Physical and Chemical Properties of Uranium, in: Handbook of Experimental Pharmacology: Uranium, Plutonium, Transplutonic Elements, O Eichler et alSpringer-Verlag, Berlin-New York, 1973, pgs 69 – 164.

[63] D. Ranyaum et al, Spectroscopic study of radiation associated with hypervelocity impacts, Shock Wave Research Center, Tohoko University, Japan (undated).

[64] Moment of impact speeds in larger self-propelled ballistic weapons are reported to reach 5-10 Km/sec; Fundamentals of Naval Weapons Systems, www.fas.org.

[65] N. St. J. Braithwaite, Introduction to gas discharges, Oxford Research Unit, IOP Publishing Ltd, June 2000.

[66] RH Ottewill et al, Modern Aspects of Colloidal Dispersions, Results from the DTI Colloid Technology Program, Kluwer Academic Publishers, ISBN 0-7923-4819-2, 1998.

In the form of a colloid and with air supersaturated by dust, the particulate remains suspended and tends to disperse in all directions attempting to reach equilibrium (Ficks Law). As the plume lofts and mushrooms, prevailing winds will drag it down-wind. Accompanying electrostatic forces may act as accumulators and repellents, concentrating the contaminant at certain locations and driving it away from others[67]. Larger compounds of uranium agglomerated with target materials and dirt will be carried by the buoyancy of the ballistic heat and rising gasses. A certain portion of the aerosol may behave according to Stokes Law – particularly after thermal and saturation equilibrium are reached (thinning of the densities and cooling) accompanied by agglomeration of the particulate to form compounds with other ballistically vaporised materials. Applying Stokes' Law, UMRC Senior Research Consultant, Dr. Leonard Dietz has shown that the relatively larger sized particulate released by the kinetics of high-velocity DU-KEP's can overcome gravity – a surprising characteristic when considering the density and mass of uranium[68].

Ultra-fine particulate behaves as a gas, subject to the laws of fluid dynamics[69, 70]. It can stay aloft for weeks to months, allowing weather patterns to transport the particulate for hundreds to thousands of kilometres. Climate and weather will affect deposition and re-suspension rates, densities and volumes. Less humid environments such as Afghanistan and Iraq, with sandy, desert-like soils, subject to high winds and dust storms will keep the particulate airborne and make mechanical re-suspension forces more efficient. The ballistic-metallurgical interactions of the larger NDU-HEO's by-products can be classed as mesopheric contaminants – travelling 10's of 1000's of feet vertically and 1000's of kilometres horizontally[71].

- **Earlier hints of composite, uranium-high explosive weapons**

The physical properties of uranium makes it a well-suited material for a variety of applications such as anti-DBHT (Deeply Buried Hard Target) bunker-busters, seismic shock bombs and certain types of wide-area, thermobaric and fragmentation ordnance. Uranium's density, mass, volatility and physical properties offer weapons' designers a series of 'engineerable' terminal ballistics: thermal flash and pyrophorics; liquid-metal behaviours for self-forging effects[72]; and, amorphic "nanocrystalline"[73] characteristics for programmable kinetics, breaking-patterns[74] and self-sharpening (adiabatic shear)[75].

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[67] J. Chubb, Assessing the Influence of Electrostatic Charge Retained on Materials, Compliance Engineering Magazine internet site (undated).

[68] L. A. Dietz, Contamination of Persian Gulf War Veterans and Others by Depleted Uranium, Updated 1999, Internet publication.

[69] McPherson, The Hazardous Nature of Dusts, Subsurface Ventilation and Environmental Engineering, Kluwer Academic Publishers, 1993.

[70] HJS Fernando et al, Urban Fluid Mechanics: Air Circulation and Contaminant Dispersion in Cities, Environmental Fluid Mechanics 1: 107-164, 2001.

[71] M. Lazaradis et al, Long Range Transport of Aerosol Particulate, A Literature Review, Norwegian Institute for Air Research, EMEO/CCC, Report 8/99.

[72] Manufacturing Sciences Corporation has been experimenting with the development of DU-High Explosive and engineered plasma-effects, composite weapons which eject armour and hard target penetration liquid metal jets travelling up to 10 Km/sec. Shaped Charge Liners and Explosively formed Penetrators, Manufacturing products from Depleted Uranium, www.mfgsci.com/.

At the commencement of OEF the US announced it was live-fire testing and widely deploying new types of ordnance in Afghanistan. Afghanistan has been a proving ground for the new weapons and their delivery systems. The US has not explicitly admitted to composite NDU-HEO weapons. But it has acknowledged DU-HEO weapons. It has also been explicit about its intent to continue using DU-KEP's (Depleted Uranium – Kinetic Energy Penetrators)[76], its preference for uranium over other metals, and the deployment of the Afghanistan-tested ordnance in Iraq.

Researcher, Dai Williams[77] has uncovered seven (7) US weapons' Patents with explicitly stated design specifications for the use of depleted uranium and uranium – submitted from 1985 to 2000 to the US Patent Office. Each manufacturer specifies the use of uranium for various features of composite uranium-high explosive munitions and delivery systems. The ordnance are filed under such names as: the Multi-warhead Anti-armour Missile; the Segmenting Warhead Projectile; the Low Velocity Radial Deployment Interceptor Missile; the Tomahawk missile warhead; the Shrouded Aerial Bomb, Bomb Live Unit 109/B; the Precursor Explosively Formed Penetrator; K-Charge Multi-purpose Shaped Charge Warhead; and, High-energy Tungsten-loaded Castable Explosive.

UAV's (unmanned air vehicles) were used in Afghanistan on a wider scale that any previous conflict. The US Air Force's newest generations of weapons developed for both manned and unmanned aircraft demonstrate ballistic features that imply the suggest the use of uranium. The little publicly available documentation defines titanium as the primary metal component but the ballistics are not consistent with the properties of titanium-only warheads. Other, chemically highly reactive and physically heavy weight metals would have to be used in these munitions to achieve the battlefield performance and ballistic behaviour described by the Air Force. The only other option is tungsten, which offers only a slight weight advantage but none of the ballistic features described by the US Department of Defense.

In discussing various features and options of its Kinetic Energy penetrators the US Airforce reviews its newer generations of narrow-diameter, smaller but more powerful weapons[78]. The Inter-metallic Incendiary Warhead has ballistic terminal features that uranium, not titanium/boron alloys alone can produce. The description of the ballistics cannot be achieved by titanium alone. The Hard Target CW/BW (chemical warfare/biological warfare) Defeat Weapon, the SEAD UAV Interdiction Warhead, and the Kinetic Energy Runway Cratering Penetrator are kinetic energy penetrators combined with CL-20, high explosives. These weapons are called "kinetic energy penetrating

[73] Nanoscale chemistry yields better explosives, Science and Technology 2000, Science and Technology Review, Lawrence Livermore National Laboratory, October 2000.

[74] JB Stevens et al, Adiabatic Shear Banding in Axisymmetric Impact and Penetration Problems, Department of Engineering Science and Mechanics, Virginia Poltechnic Institute and State University, undated inter-net paper.

[75] DARPA Overhead Presentation: Structural Amorphous Metals, L. Christodoulou, Defense Advanced Research Projects Agency/Defense Science Office, US Department of Defense.

[76] DOD Briefing on Depleted Uranium; U.S. Army Materiel Command and Deployment Health Support Directorate, March 14, 2003. www.defenselink.mil/news/Mar2003/g030314-D-9085M.html

[77] www.eoslifework.co.uk/

[78] SAF/PA 96-1204 UAV Technologies and Combat Operations, US Air Force Scientific Advisory Board, 1996, www.fas.org/

missiles for hardened target destruction and SEAD" (Suppression of Enemy Air Defenses).

> "The utility of the kinetic energy penetrator is enhanced by its ability to penetrate into and destroy buried and hardened targets such as aircraft shelters and CW/BW facilities. … [At] 3,000 fps, … the weapons could penetrate the equivalent of 20 ft of reinforced, 5,000 psi concrete or 250 ft of compacted soil. … A titanium-boron intermetallic incendiary warhead would be used to incinerate agents within the room."

The high-explosive and intermetallic incendiary warhead discussions reveals the likelihood of composite, uranium-high explosive weapons depending on heavy weight and self-sharpening metals to get them to the target:

> "The new energetic, high explosive warhead delivering CL-20 explosives provides the ability to generate pressures up to 450 kbar. … The warhead can be used for function kill in CW/BW facilities and to crater runways, destroy aircraft shelters, and damage other targets."

> "NSWC defined and demonstrated a titanium-boron intermetallic, self-propagating, high-temperature, synthesis reaction warhead capable of generating a reactant cloud at 3700C. The warhead releases extremely large amounts of energy, providing the means to incinerate a variety of targets. Its fire-start capability is such that, once initiated, the fire cannot be quenched [authors emphasis]. When water is employed to quench the fire, the reaction disassociates the water into hydrogen and oxygen, and a secondary reaction forming oxides of titanium and boron releases additional energy to enhance the firestorm capability of the warhead."

The ballistic features of penetration and the defeat of a wide variety of target materials including the highest grade of surface hardened targets requires a heavy metal that can self-sharpen and self-forge. Describing the ballistics as being accompanied by secondary synergistic effects, long burn times from fires that cannot be extinguished, and extremely deep target acquisitions are all but admissions of the used of uranium as the primary solid metal component to the warheads. The incendiary and pyrotechnic effects require metal powders and oxidants for fuel. Metals in this state do not have the weight, hardness, density or forging behaviours described as accompanying the detonation ballistics.

An U.K. designed weapon called the BROACH[79] hard-target defeat warhead is a uranium-high explosive, composite weapon alloyed with DU. Any unitary self-forging warhead has a high probability of containing DU or U as cone ballast, possibly as the lining and as the follow-up slug[80]. Earlier evidence dismissed by researchers and

[79] Overhead sales presentation: BROACH US Market; Dick Wools, Director, BROACH Programs, Joint weapons development programs of Thales, Defence Evaluation and Research Agency and BAE Systems, Ministry of Defence, UK. (undated).

[80] See: Lawrence Livermore National Laboratory, PAM – Penetration Augmentation Munition. See, also: the Royal Society DU report describing DU-high explosive shaped-charge ordnance.

whistleblowers at the time, identified airborne uranium contaminant (NDU or natural uranium signatures) and biological up-take of radio-isotopes matching the NDU signature after the Balkan conflict -- suggesting that NDU-HEO weapons or NDU alloys in KEP's may have been deployed before Afghanistan[81, 82].

[81] A. Kerekes et al; Did NATO attacks in Yugoslavia cause a detectable environmental effect in Hungary?; Health Physics Society Journal; 80(2);177-178; 2001.

[82] R.J. Parsons, Natural Uranium Over Hungary and Greece, Not "Depleted"?; DU-List@yahoo groups; April 18, 2003.

Material properties and features of Tungsten, Uranium and Titanium			
Features & properties	**Tungsten – W "tung sten" or heavy stone**	**Uranium -U "uranus"**	**Titanium - Ti "titan"**
Element #	74	92	22
Form in nature	Earth's crust: 1.5 ppm. China has 75% of W resources. Very stable and non-reactive.	Earth crust: 0.5 – 5.0 ppm in soil and rock. Average 1.8 ppm in soils. 2.3 Tons/sq mile in top 30cms of soil. 3 isotopes in nature: U234 @ 0.0055% U235 @ 0.72 % U238 @ 99.27% US DOE U235 official % – 0.711% Alkali mineral and metal. Unstable and reactive.	9th most abundant element in earth's crust. Alkali mineral and metal. Unstable and reactive.
Classification	Transition metal, Group 6	Rare earth metal, Actinide Series	Transition metal, Group 4
Crystal structure	Body centred cubic	Orthorhombic	Hexagonal
Metal colour	Pure grey to tin white metal.	Silvery white/grey metal. Yellow and black oxides.	Dark grey, lustrous, silvery.
Specific gravity	19.33 gm/cc	18.95 gm/cc	4.54 gm/cc
Atomic mass	183.84 amu	238.0289 amu	47.867 amu
Density	18.7 @ 20C	U: 18.98 – 19.1 @ 25 C U/0.75 Ti: 18.6	4.54 @ 20 C
Molecular weight	183.84	238.03	47.867
Hardness	Vickers – 3430 Brinell 2570 Mineral 6.5 – 7.5 Used as hardening alloy	U - HRB – 93 U – 0.75Ti 52 HRC gamma quenched for maximum hardness. Not as hard as steel unless alloyed. Hardened with Molybdenum, Niobium, Titanium, Zirconium.	Vickers: 80 – 100 Strong as steel, 45% lighter than steel. Alloy used to lighten weight, increase tensile strength and resist corrosion.
Melting point	3410 - 3422 C – Highest melting point and lowest vapour pressure of all metals.	1132 C	1668 C (DOE) 1660 (HSL)
Boiling point	5530 - 5660 C	3818 - 3887 C	3260 C (DOE) 3287 C (Spectrum)
Combustibility	Moderately flammable dust with external ignition source.	Pyrophoric: High surface area material and powder subject to spontaneous ignition. Long-slow self sustained burn. Ignition: Large fragments 170 C Powder 20 C	Hypergolic: Requires ignition source. High surface area material and powder combustible. Ignition: Large fragments – 1200 C Powder 250 C
Powder explosive densities	Will ignite with external ignition source.	Autoigniting, spontaneous self combustion at room temperature. 55-60 gm/m3	Requires an ignition source. of 332 – 588 C.
Radioactivity	Not radioactive	All isotopes radioactive	Not radioactive
Biological effects	Chemically toxic when inhaled	Chemically and radioactively toxic when inhaled	Chemically toxic when inhaled
Pyrotechnic and incendiary synergies	N/A Features not suitable for metal powder or pyrotechnic effects.	Flourine and U burn green and react explosively. Unlikely to be too unstable for metal powder munitions.	Flourine and Ti reactive and accelerates violently with metal/metal and metal/polymer explosives.

Material properties and features of Tungsten, Uranium and Titanium			
Features & properties	**Tungsten – W "tung sten" or heavy stone**	**Uranium -U "uranus"**	**Titanium - Ti "titan"**
Reactivity/ stability	Vigorous reaction to bromine triflouride Very stable in large pieces when burned. W alloyed to other metals increases hardness. W Carbide very wear resistant.	Pyrophoric in O2. Explosive burn in CO2. Burns violently when subject to small amounts of water. Self ignites when submerged in water. Nitric acid causes violent explosions. Dissolved by acid, unaffected by alkalis. U/Ti alloys very explosive when subject to nitric acid.	Burns in pure CO2 and Nitrogen. Massive Ti shapes ignite spontaneously in contact with liquid oxygen. Molten particles exposed to moisture and water explode violently. Explosions reach very high velocities. Nitric acid and NO4 makes Ti spontaneously self-igniting and explosive. Progressive oxidising of surface area during burning suppresses the burn.
Sources: Depleted UF6, Depleted Uranium and Uranium Alloy Properties, US Department of Energy, www.ead.anl.gov/uranium/ US DOE Handbook – Primer On Spontaneous Heating And Pyrophicity, DOE Technical Standards, DOE-HDBK-1081-94.			

Conclusion

UMRC's biological, geological and hydrological studies, finding abnormally high values of Non-Depleted Uranium (NDU) contamination in Afghanistan have, to date, no other credible explanation of origin than Operation Enduring Freedom. The patterns of contamination are consistent with releases and subsequent inhalation of uranium aerosols coinciding in time and place with the bombing. Chronic public health problems have been recorded in areas adjacent to the bombing and in civilians down-wind, exposed to the bombs' dense smoke and dust plumes.

The radiological effects of slow-clearing ceramic uranium in the lungs may be exacerbated by heavy metal toxicity from weapons-derived, ingested and absorbed uranium recycling in the blood stream. Afghans now live in a permanently contaminated environment. The accumulation of ceramic uranium particulate in the lungs and metabolised uranium in target organs and circulatory systems (blood and lymph) mean many Afghan's bodies have become their own, long term sources of radioactivity and chronic heavy metal, chemical toxicity.

UMRC continues to conduct its Afghanistan research by field collection and laboratory analysis of human and environmental specimens. Public health surveys continue in communities reporting "unexplained illnesses" while long-term assessments are underway in communities where battlefield uranium has been identified in urine, water and soil. Clinical studies have been initiated to examine the radiotoxic and chemotoxic effects of the contamination on lungs, kidneys and bones. UMRC is also conducting clinical studies on Gulf War veterans who have been determined to have Depleted Uranium in their urine.

The "stand-off" and "force protection" tactics of the US in the first few months of Operation Enduring Freedom relied exclusively on air-delivered munitions with a bare minimum of ground forces. It is unlikely therefore, that the first wave of US veterans from Afghanistan have been contaminated - with the exception of forward target designators ("paint crews"), Special Operations and Exploitation Teams, and Psy-Ops/Public Affairs units. Later, US, Canadian, British and other Coalition partners (including the Northern Alliance) were assigned to carry-out US Cen-Com-directed tasks (i.e., ground searches after bombing; corralling Taliban and Al Qaeda troops into air-strike positions), which have put them at obvious risk of uranium contamination via inhalation.

Afghanistan's civilians and all subsequent generations are of course facing the worst threats from contamination. Post-conflict public health and environmental assessments by the UN and NGO's have been reporting for a year, health problems whose symptoms' profiles resemble uranium internal contamination, but which they attribute to other causes. The World Health Organisation and the UNEP have not been willing to challenge the regulators or Defense Departments' assumptions behind the dose-effects and exposure models used to dismiss uranium internal contamination or permanent environmental contamination with ceramic uranium oxides. These agencies consistently draw conclusions that battlefield uranium is not all that bad – yet they quietly recommend bombsites are cordoned-off and their field-staff take protective measures to avoid contamination.

The UK Royal Society has called for a comprehensive evaluation of the effects and extent of contamination of uranium weapons (DU specifically) in Iraq -- now that "Shock and Awe" is over. There remains a public preoccupation with DU, which considering the

findings in Afghanistan needs to recognise the more highly radioactive, higher volumes of aerosols produced by Non-Depleted Uranium - High Explosive Ordnance. Their deployment was regularly televised on daily reports from Baghdad and by unsuspecting embedded reporters in the field.

Environmental and human contamination from Operation Enduring Freedom's deployment of new generations of uranium - high explosive munitions is at a scale that would command a government, public health disaster response if it occurred in western, nuclear states. The situation in Afghanistan is a portent of the contamination expected to ensue from Operation Iraqi Freedom's deployment of the same radiation-dispersion weapons at a much larger scale than Afghanistan.

Uranium Contamination of Afghanistan©

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Annex 1: UMRC Publications

Contents:

1. Recent Journal Articles

DURAKOVIC, A.; DIETZ, L.; ZIMMERMAN, I.:
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Submitted for publication, March, 2003.

DURAKOVIC, A.; DIETZ, L.; HORAN, P.; ZIMMERMAN, I.:
"Estimate of the Time-zero Lung Burden of Depleted Uranium in Gulf War Veterans by the 24 Hour Urinary Excretion and Exponential Decay Analysis."
Accepted for publication, No. 02226, Military Medicine, June, 2003.

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