**Annex A**


**Institute for Environment and Health**

# POSSIBLE HEALTH AND ENVIRONMENTAL IMPACTS OF TUNGSTEN IN LEAD REPLACEMENT SHOT

An IEH Client Report for Defra

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# CONTENTS

**1 SCOPE AND OBJECTIVES** 1

**2 INTRODUCTION** 2

**3 REVIEW OF REPORTS AND PAPERS REFERENCED BY PETER HURLEY** 3

3.1 Peer-reviewed papers 3

3.2 Research reports 4

3.3 Conference abstracts 6

3.4 Miscellaneous articles 6

**4 OTHER SOURCES** 8

**5 LITERATURE SEARCHES** 10

5.1 Toxicity searches 10

5.2 Environmental fate and behaviour searches 11

5.3 Results 12

**6 SUMMARY CONCLUSIONS** 13

**7 RECOMMENDATIONS** 14

**Bibliography** 15

**Annex 1: Literature Search on the Toxicity of Tungsten (selected titles and abstracts)** 16

Biosis 18

Embase 21

Medline 22

ToxFile 30

**Annex 2: Literature Search on the Environmental Fate and Behaviour of Tungsten (titles only)** 32

# 1 SCOPE AND OBJECTIVES

Concern has been raised, specifically by Dr Peter Hurley of Blake International Limited, Huddersfield, about the use of tungsten and tungsten alloys as replacements for lead in shot and other munitions. In response to Dr Hurley's communications to Defra on the possible environmental and human health risks resulting from the use of tungsten based ammunition, IEH was commissioned by Defra to undertake a short overview of the subject, with particular reference to the material referenced by Dr Hurley. The specific objectives were to:

i. Obtain and review the papers cited in the correspondence and assess and collate the findings;

ii. Conduct a literature search on the toxicity of tungsten, addressing all possible forms and routes of exposure to people and wildlife, review the search output on the basis of titles/abstracts, and highlight the papers of likely relevance but not review them;

iii. Indicate any further work that might be useful to inform consideration of this matter.

Note: *This report is intended to provide a broad overview on the issue and must not be taken to represent a systematic critical review of the literature.*

# 2 INTRODUCTION

## Background

Pressures to find a 'green' replacement for lead (and depleted uranium) based ammunition, especially in the United States, have led to increasing use of tungsten in these applications. Tungsten alloy used in munitions typically comprises tungsten (W), nickel (Ni) and cobalt (Co). A tungsten-polymer composite (powdered tungsten dispersed in a thermoplastic matrix) has also been developed for small-arms use.

A ban on the use of lead shot for hunting waterfowl was phased in with the 1987-88 hunting season and became nationwide in the US in 1991. The US Fish and Wildlife Service subsequently approved a number of shot types as 'non-toxic' for waterfowl hunting in the US. These included tungsten-bronze, tungsten-iron (2 types), tungsten matrix[1], tungsten-nickel-iron, tungsten-polymer[2], tungsten-tin-bismuth, and tungsten-tin-iron-nickel.

In the UK, the Environmental Protection (Restriction on Use of Lead Shot) (England) Regulations 1999 were introduced following a voluntary phase-out of lead shot. These Regulations prohibit the use of lead shot in England on the foreshore, on certain wetland sites, and for shooting of certain waterfowl species in any place. Similar regulations are in place in Scotland and Wales. As a consequence, tungsten-based shot is increasingly being used in the UK.

Dr Peter Hurley of Blake International believes there are issues relating to certain tungsten-based materials used as substitutes for lead that 'should give cause for significant concern' for both human health and the environment, and that the wider human health and environmental aspects of the proposed substitutes should have been evaluated prior to the introduction of these new materials.

## Uses and natural occurrence of tungsten

Tungsten is a naturally occurring element that, in most environments, is a solid. In nature, it occurs in rocks and soil as minerals, but not as the pure metal. Two kinds of tungsten-bearing mineral rocks, wolframite and scheelite, are mined commercially. Tungsten can be used as a pure metal or mixed with other metals to make alloys. Tungsten alloys tend to be strong and flexible, resist wear, and conduct electricity well. In addition to their use in bullets and shot (as a replacement for lead) and in armor penetrators (as a substitute for depleted uranium), tungsten and its alloys are used as light-bulb filaments, in X-ray tubes, as a catalyst to speed up chemical reactions, as a component of steel in high-speed tools, as welding electrodes and as gyroscope wheels. Chemical compounds of tungsten are used for many purposes. Cemented tungsten carbide, a hard substance used to make grinding wheels and cutting or forming tools, is the most common tungsten compound. Other tungsten compounds are used in ceramic pigments, as fire retardant coatings for fabrics, and as colour-resistant dyes for fabrics (ATSDR, 2003). Also, tungsten is occasionally found as a minor component in the alloys of orthopaedic prostheses.

[1] e.g. finely divided tungsten or tungsten and molybdenum particles in a polymer matrix
[2] e.g. tungsten particles in nylon 6

# 3 REVIEW OF REPORTS AND PAPERS REFERENCED BY DR PETER HURLEY

Of the reports and articles cited by Dr Hurley and listed below, only two (Kalnich *et al.,* 2005 and Wei *et al.,*1987) are published in the peer-reviewed literature. The remainder are unpublished research reports and accounts of various kinds covering the chemistry, materials science, environmental fate and behaviour, toxicology and ecotoxicology of tungsten and tungsten compounds.

## 3.1 Peer-reviewed papers

### Induction of muscle tumours by embedded tungsten alloy shrapnel (Kalnich *et al.,* 2005)

Few data are available concerning the effects of implanted tungsten. Ni and Co are both known to induce malignant muscle tumours when injected in soluble form into the leg muscle of rats, but there is apparently no evidence for carcinogenicity of intramuscular implants of nickel or cobalt alloys used in orthopaedic prostheses.

In the study by Kalinch et al. (2005), using group sizes of 36 or 46 anu=iamlks) implanted tungsten alloy pellets (91.1% tungsten; 6.0% nickel and 2.9% cobalt) induced malignant rhabdomyosarcomas in rat muscle within 4-5 months of implantation. Tumour yield was 100% in both 'low' and 'high' dose groups (group size n=46). Similar pellets made from nickel also induced tumours but at a slower rate. Implanted tantalum pellets, in a similar physical form, did not produce tumours. Haematological changes observed in tungsten and nickel implanted rats may have been a direct consequence of toxicity or secondary to the tumours (although the haematological changes were said to be observed before the tumours were clinically palpable). It is not known for sure whether the tungsten or the other components of the alloy (Ni and Co) - or the combined effects of all three metals - were responsible for the observed effects. There is evidence [to be confirmed] for possible synergistic effects between Ni and Co (and tungsten, Ni and Co) in pathogenicity, and *in vitro* experiments using osteoblasts have allegedly indicated genotoxic effects induced by tungsten alloy metals.

Foreign body (solid-state) carcinogenesis is known to occur in some instances, especially with implanted smooth plastic films. However, the lack of tumours with tantalum and the rapidity of the formation of tumours around the tungsten-alloy and Ni pellets suggests that this is not the cause (or at least the principal cause) of the observed effects. Free-radical reactions at the surface of the W-alloy and Ni pellets may be involved in the carcinogenic process.

Note that this study did not investigate tungsten-polymer as commonly used in 'environmentally friendly' shot. It is not thought that the tungsten used in tungsten-polymer bullets is the same as the tungsten alloy tested in this study.

### Effects of tungsten ingestion on rat mammary tumour formation (Wei *et al.,*1987)

This paper is published in Chinese and only the abstract is available in English.

The study investigated the effect of tungsten (and also molybdenum) in the drinking water on the incidence of rat mammary tumours induced by N-nitroso-N-methylurea (NMU).

Sprague-Dawley rats were administered 150 ppm tungsten in the drinking water and after 15 days received an intravenous injection of the potent carcinogen NMU. After 125 days, mammary cancer incidence (79.2%) was significantly higher than in the group receiving NMU only (50%), and palpable tumours were found sooner in the W-treated group (56 days) than in the NMU only group (71 days). The authors concluded that tungsten is a promoter of mammary carcinogenesis.

Because this study administered tungsten in the drinking water it is of limited relevance to the consideration of the environmental and health effects of tungsten shot. Moreover, there is no information on the effects of tungsten in drinking water without co-administration of NMU, and no information was provided regarding systemic concentrations achieved in this study. The findings of this study do not appear to have been replicated.

# 3.2 Research reports

## Tungsten as a 'Green' Replacement for Depleted Uranium Munitions (Cooper, 2005)

According to this unpublished report from the University of Bristol, tungsten and tungsten heavy alloys used as 'alternative' munitions are not as geochemically or toxicologically stable as once thought. Experimental studies were said to demonstrate significant dissolution of tungsten when alloy powders and fragments were immersed in aqueous solutions. This dissolution acidified the soil-water and lowered the dissolved oxygen concentrations. At concentrations of 3% (w/w) in the soil, microbial life and all plants died within 3 months. In the presence of alloying elements such as iron, nickel and cobalt, on increased pH tungsten was found to absorb strongly to montmorillonite and illite clays as well as organic soils. This may serve to retard tungsten mobility in the ground. Tungsten is also taken up into plants and worms which may facilitate entry into the food chain (and also has potential application in the bioremediation of tungsten contaminated sites).

## Review of Toxicological Literature on Tungsten and Selected Tungsten Compounds (NIEHS, 2003)

The primary objective of this review was to determine the toxicity of tungsten in light of reported elevated tungsten body burdens in the residents of Fallon, NV, USA (and its alleged association with childhood leukaemia clusters; see below) and the limited data available to assess the potential long-term health effects of tungsten exposure. The majority of toxicological data included in this report relate to studies with tungsten metal powder, sodium tungstate and tungsten trioxide.

This report is a useful survey of the available literature, supplementing the HSDB and ATSDR documents (see below), but it does not provide a concise summary of the data or make any conclusions regarding the effects of the reported tungsten body burdens. Generally, elemental tungsten is basically insoluble and is thus considered to be of low toxicity; soluble tungsten compounds are considered to be more toxic than the insoluble forms.

## Elimination of Toxic Heavy Metals from Small Caliber Ammunition (Work in progress; Bunting, 1998)

An investigation of the chemical stability and mobility of tungsten as contained in non-lead bullets was conducted. The environmental stability and mobility of the powdered tungsten as part of fragmented bullets was examined employing combinations of leaching and aging (corrosion) experiments. Materials used in the non-lead bullets were exposed to simulated environments (soil, solvents, temperatures, etc) to determine what compounds would form,

and their solubility and mobility were examined. According to preliminary results and conclusions presented, tungsten and its compounds, most likely tungsten oxide and tungstic acid, will be present and available for uptake by plants and animals. In an early bio-uptake study, a linear relationship was shown between tungsten concentration in the soil and tungsten concentration in fast-growing bean plants.

In addition, a study is being conducted to assess the sub-lethal effects of contaminants in soils on earthworms. Preliminary results are said to indicate that worms in the lead-containing samples lost significantly more weight on average than the control sample or samples containing other metal mixtures.

## Galvanic Corrosion of Tungsten (Chang *et al.,* 1998)

The authors of this report state that from an environmental perspective, tungsten is a more desirable material than depleted uranium for penetrator applications, but the ballistic performance is inferior. Recently, advanced tungsten-metal composites have been developed to improve ballistic penetration, but the corrosion properties are unknown and need to be determined. In this work, the galvanic corrosion behaviour of W coupled with several selected metals/alloys was investigated. It was shown that tungsten alloys utilising pure titanium, nickel and hafnium as the matrix material should show little or no galvanic corrosion.

## Environmental Effects of Tungsten and Tantalum Alloys (Meijer et al.,1998)

The four tungsten alloys tested in this study were composed primarily of tungsten (88-92%) and nickel (5.0-6.6%), plus several percent of either copper, cobalt or manganese. The potential environmental impacts were quantified using the Multimedia Environmental Assessment System (MEPAS).

The results of leaching/corrosion studies indicated that the copper-containing tungsten alloy is leached most readily whereas tantalum metal is least readily leached or corroded. Metal concentrations in water infiltrating below the soil zone will primarily reflect leaching reactions, unhindered by compound formation. Sorption experiments indicated that tantalum and tungsten are strongly bound on mineral grains in the soil zone and will remain in the zone indefinitely.

Although a number of metals in the alloys have various human and ecologic effects at sufficiently high doses, tungsten (and tantalum) appear to have minimal human and ecological impacts based on the available data.

Calculated site-specific risk factors showed that any of the allows investigated could be used in munitions testing at that (named) site without unacceptable human or ecological risk. Calculations suggested that use of the copper-containing alloy would pose the highest risk, because of uptake by agricultural products grown and consumed on the site; no unacceptable ecological risks were predicted to result from the use of tantalum and/or tungsten alloys in the testing of penetrator munitions at the site investigated.

## Structure, Redox Corrosion and Protection of Commercial Lead-antimony Shot (Hurley, *undated*)

According to the author, results of this study show that in addition to accelerating lead corrosion, the firing of steel shot on ranges already containing lead shot will adversely influence site pH and provide a ‘transport metal’ which will facilitate migration of lead, antimony and other heavy metals from the contaminated site. Commercial steel shot corrosion also gave rise to manganese and nickel corrosion products as additional undesired pollutants.

### Carcinogenic Potential of Depleted Uranium and Tungsten Alloys (On-line summary of US Department of Defense research project)

The objective of this study is to assess the carcinogenic potential of embedded fragments of depleted uranium (DU) and heavy metal tungsten alloy (HMTA) using both cell culture experiments and laboratory animals. In the *in vivo* studies, rats were implanted with pellets of DU, HMTA, nickel (positive control), lead or tantalum (negative control). Results so far are said to indicate that exposure to DU or HMTA cause cellular changes both *in vitro* and *in vivo*. Exposure of cultured human bone cells to HMTA resulted in transformation of those cells to a type with characteristics typical of tumour cells. The magnitude of transformation was similar to that for nickel, and the transformed cells produced tumours when injected into immune deficient mice. DU and HMTA were also shown to be genotoxic and mutagenic in model system studies. All other results reported in the summary relate to DU or the 'control' groups. [This project has now been terminated and the objectives incorporated into a USAMRMC grant "Carcinogenicity and Immunotoxicity of Embedded Depleted Uranium and Heavy Metal Tungsten Alloy in Rats"].

## 3.3 Conference abstracts

### Corrosion behavior of tungsten alloys in the environment (Ogundipe *et al.,* 2004)

Tungsten has a wide variety of stereochemistries and oxidation states, making its chemistry one of the most complex of the transition elements. The rate of release of ions from the tungsten alloy surface and the formation of solid coatings is generally controlled by the redox phenomena prevailing in the surrounding medium. Factors affecting the rate of corrosion in soils include the soil pH, redox potential, moisture content and the soil's mineralogical and chemical composition. The dissolution of tungsten and the subsequent formation of condensed polytungstates involve complicated chemical processes. Preliminary results have suggested the presence of non-stoichometric tungsten oxides as possible intermediates in the process. X-ray diffraction has revealed the presence of tungsten bronzes and intermetallic compounds.

### Tungsten effects on soil environments (Strigul *et al.,* 2004)

The objective of this study was to investigate the effects of tungsten on soil communities and soil-plant systems. Target compounds were pure chemical tungsten, ammunition grade tungsten and common alloying elements such as nickel and cobalt. Dissolution of munitions grade tungsten powder significantly acidified the soil solution; other alloying elements behaved differently. Tungsten had strong toxic effects on the soil microbial community, soil microfauna (mites and nematodes) and plant growth. Results suggested the death of a substantial fraction of soil organisms. Death of 95% of soil bacteria was observed after 4 months in soils containing 3% (w/w) of tungsten. Tungsten appeared to be more toxic to environmental systems than cobalt or nickel.

## 3.4 Miscellaneous articles

A number of US newspapers and journals have picked up the issue of a leukaemia cluster in Fallon, Nevada and its possible link with tungsten body burdens in the residents - allegedly linked to past mining operations, a local tungsten smelter, and/or the proximity of the Fallon Naval Air Station and the use there of tungsten ammunition. While there is no basis for suggesting a causal link between the cancer cluster and measured blood tungsten levels, these

observations have sparked interest in the toxicity of tungsten and specifically its possible role in childhood leukaemia. Further research is said to be underway.

Many articles on the Fallon leukaemia issue quote Dr Mark Witten and Dr Paul Sheppard, researchers at the University of Arizona who, inspired by the childhood leukaemia clusters in Fallon (and also Sierra Vista, another tungsten mining area), investigated the transcriptome effects of metal ores from these areas using a human T-cell acute lyphoblastic leukaemia cell line. Significantly increased cell growth was demonstrated after incubation with these ores, and human cDNA microarray analysis showed a number of genes to be up- or down-regulated (Sun *et al.*, 2003).

# 4 OTHER SOURCES

InChem[3] and ToxNet[4] were searched in order to identify any major reviews on tungsten. Only one record was identified and downloaded from these hosts from the Hazardous Substances Databank (HSDB, 2002).

A draft toxicological profile for tungsten (ATSDR, 2003), which is currently out for public comment, was also downloaded.

## Hazardous Substances Data Bank: Elemental Tungsten (HSDB, 2002)

The HSDB on Tungsten contains the following relevant information.

### *Health effects and toxicity*

Tungsten metal dust is an eye, skin, and respiratory irritant. Following ingestion, tungsten is eliminated in urine and faeces and accumulates in rat bones and spleen, with some deposition in the kidneys and liver; traces have been detected in the lung, testes and skeletal muscle.

There are very limited data on effects following human exposure to tungsten metal. Ingestion of ethanol reportedly contaminated with tungsten has been associated with the development of nausea and vomiting, seizures, metabolic acidosis, renal failure, rhabdomyolysis, and coma. Chronic occupational exposure to hard metals involving cemented tungsten carbide (a mixture containing cobalt, used as a binding agent, and tungsten carbide) may result in lung fibrosis and is attributed to exposure to the cobalt. At the time of this review, no studies were found on the potential reproductive effects or the possible carcinogenic activity of tungsten in humans.

In animals, other reported effects following exposure to tungsten include anorexia, colic, weight loss, incoordination, trembling, and dermatitis. Oral administration of tungsten to female rats prior to mating was associated with post-implantation mortality of the fetus and resulted in musculoskeletal developmental abnormalities of the fetus.

### *Environmental fate and behaviour*

The average tungsten concentration in the earth's crust is about 0.006%. Tungsten occurs naturally as tungstate, mainly in compounds such as wolframites and scheelites. Tungsten exists in several oxidation states; 0, 2+, 3+, 4+, 5+, and 6+. The most stable is 6+ with the lower states being relatively unstable. Tungsten exist as ions in combination with one or more elements, e.g. oxygen.

Only small concentrations of tungsten have been released [by human activity] into the atmosphere, primarily by industrial emissions and nuclear fall-out. If released to air, most tungsten compounds have low vapour pressures and will exist solely in the particulate phase in the ambient atmosphere. If released to soil, tungsten compounds will have moderate to low mobility based upon a sorption coefficients ranging from 10 to 50,000 at pH 5 to 6.5. Tungsten compounds will exist as ions or insoluble solids in the environment and therefore volatilization from moist soil surfaces will not be an important fate process. Tungsten

[3] Chemical Safety Information from Intergovernmental Organizations, available [June 2005] at http://www.inchem.org

[4] ToxNet is available via the National Library of Medicine, Specialised Information Service, available [June 2005] at http://toxnet.nlm.nih.gov/

compounds will not volatilize from dry soil surfaces based upon their ionic character and low vapour pressures. If released into water, tungsten compounds will adsorb to suspended solids and sediment based upon their range of sorption coefficients. Tungsten in natural waters is in the form of tungstate and other tungsten polyanions. Tungsten compounds will exist as ions or insoluble solids in the environment and therefore volatilization from water surfaces will not be an important fate process.

## Agency for Toxic Substances and Disease Registry (ATSDR) Draft Toxicological Profile for Tungsten (2003)

### *Health effects*

Pulmonary fibrosis, memory and sensory deficits, and increased mortality due to lung cancer have been associated with occupational exposure to dusts generated in the hard metal industry. Hard metal is an alloy or encapsulated mixture that is composed of tungsten or tungsten carbide and cobalt (primarily, although the alloys may also contain yttrium, thorium, copper, nickel, iron, or molybdenum). Historically, the respiratory and neurological effects observed in hard metal workers have been attributed to cobalt, not tungsten. However, based on the presence of tungsten oxide fibers in air samples taken at some hard metal facilities and demonstrations that tungsten oxide fibers are capable of generating hydroxyl radicals in human lung cells *in vitro*, it has been suggested that tungsten oxide fibers may contribute to the development of pulmonary fibrosis in hard metal workers.

Limited reports associate tungsten exposure with reproductive and developmental effects such as decreased sperm motility, increased embryotoxicity, and delayed fetal skeletal ossification in animals. However, more detailed accounts of tungsten-induced reproductive and developmental toxicity were not located. Tungsten has been observed to cross the placental barrier and enter the fetus. Dermal or ocular exposure to tungsten may result in localized irritation. No adequate animal data are available to assess the carcinogenic potential of tungsten or tungsten compounds. Tungsten has recently been nominated to the National Toxicology Program (NTP) for toxicological characterization, which includes carcinogenicity testing.

### *Environmental fate in water and soil*

The reaction of tungsten in water is controlled by chemical speciation by which one species is converted to another. Tungsten exists in several oxidation states, 0, 2+, 3+, 4+, 5+, and 6+. The most stable is 6+ with the lower states being relatively unstable. Tungsten can exist as ions in water with one or more elements such as oxygen. In natural waters, tungsten is primarily in the form of the soluble tungstate ion under alkaline conditions or other tungsten polyanions under acidic conditions. Tungsten has a strong tendency to form complexes; this is exemplified by the large series of heteropoly acids formed with oxides of phosphorous (e.g. phosphotungstic acid), arsenic, vanadium, silicon, and others. Tungsten combines with a large number of organic ligands. However, no information on natural tungsten organic matter complexes was located by ATSDR in the literature.

Typical transformation processes for tungsten in soil include precipitation, complexation, and anion exchange. Important factors affecting the transformation of tungsten in soils and sediments include pH, ionic strength (i.e. salinity), concentration and distribution of species, composition of the mineral matrix, organic matter, and temperature. According to the ATSDR, no data were located in the literature suggesting the biotransformation of tungsten or its compounds in soil.

# 5 LITERATURE SEARCHES

A thorough literature search was conducted to identify relevant papers, addressing all possible forms and routes of exposure to people and wildlife.

## 5.1 Toxicity searches

Searches were performed in the major biomedical databases (Table 1.1) available on Datastar in June 2005 to identify papers reporting the toxicity of tungsten. Table 1.2 summarises the descriptors, search phrases and operators used. No search limits were applied.

**Table 1.1** Datastar databases searched

| Database | Producer | Coverage |
|---|---|---|
| Biosis Previews® | Biosis | 1996-present |
| Embase | Elsevier BV | 1974-present |
| Medline | US National Library of Medicine | 1951-present |
| ToxFile | Dialog Corporation AG | 1965-present |

**Table 1.2** Toxicity search strategy summary

| | | |
|---|---|---|
| **Medline, ToxFile** | | |
| tungsten.de.[1] NOT[2] tungsten-compound#[3]<br>tungsten WITH alloy$1.ti,ab. | AND[4] | health adj[5] effect$1[6].ti,ab.<br>adverse adj effect$1.ti,ab.<br>toxicology#<br>toxicity-tests#<br>toxic$8.ti,ab.<br>carcinogen$5.ti,de,ab.<br>teratogen$5.ti,de,ab.<br>mutagen$5.ti,de,ab.<br>neurotoxic$5.ti,de,ab.<br>cytotoxic$5.ti,de,ab.<br>genotoxic$5.ti,de,ab.<br>poison$3.ti,ab.<br>toxicokinetic$1.ti,ab.<br>ecotoxic$8.ti,ab. |
| tungsten.de. NOT tungsten-compound# | WITH[7] | toxicity.de.<br>adverse adj effect$1.de<br>poisoning.de. |
| **Biosis** | | |
| tungsten.ti,de. | AND | health adj effect$1.ti,de,ab.<br>adverse adj effect$1.ti,de,ab.<br>225#<br>toxic$8.ti,ab.<br>carcinogen$5.ti,de,ab.<br>teratogen$5.ti,de,ab.<br>mutagen$5.ti,de,ab.<br>neurotoxic$5.ti,de,ab.<br>cytotoxic$5.ti,de,ab.<br>genotoxic$5.ti,de,ab.<br>poison$3.ti,de,ab.<br>toxicokinetic$1.ti,de,ab. |
| tungsten.ti,de. | WITH | toxic$8.de. |

| Embase | | | |
|---|---|---|---|
| tungsten.de. NOT tungsten-derivative.de.<br>tungsten WITH alloy$1.ti,ab. | AND | health adj effect$1.ti,ab.<br>adverse adj effect$1.ti,ab.<br>toxicology#<br>toxic$8.ti,ab.<br>toxicity#<br>toxicity-testing#<br>carcinogen$5.ti,de,ab.<br>mutagen$5.ti,de,ab.<br>teratogen$5.ti,de,ab.<br>neurotoxic$5.ti,de,ab.<br>cytotoxic$5.ti,de,ab.<br>genotoxic$5.ti,de,ab.<br>poison$3.ti,de,ab.<br>toxicokinetic$1.ti,de,ab.<br>ecotoxic$8.ti,ab. |
| tungsten.de. NOT tungsten-derivative.de | WITH | drug-toxicity.de. |

1 ti,ab,de. – indicates the fields searched – ti = title, de = descriptors, ab = abstract
2 NOT – proximity operator – database records must be indexed with the first descriptor but not the second
3 # – the descriptor was 'exploded' to include all terms below it in the descriptor tree
4 AND – proximity operator – phrases must appear in the same field as each other
5 adj – proximity operator – adjacent to
6 $ - truncation symbol, a number after indicates the number of characters allowed
7 WITH – proximity operator – words must in the same sentence but can be in any order

# 5.2 Environmental fate and behaviour searches

Fate and behaviour searches were performed in June 2005 on the host Dialog. Databases searched and coverage are summarised in Table 1.3. Table 1.4 describes the search terms used and how they were combined. No search limits were applied.

**Table 1.3** Dialog databases searched

| Database | File number | Producer | Coverage |
|---|---|---|---|
| Biosis Previews® | 5 | Biosis | 1969-present |
| CAB abstracts | 50 | CAB publishing | 1972-present |
| Enviroline® | 40 | Congressional information Services Inc | 1975-present |
| SciSearch® | 34 | Thomson Scientific | 1990-present |
| Pascal | 144 | INIST of the French National Research Council | 1973-present |
| GeoBase™ | 292 | Elsevier Science B.V. | 1980-present |

**Table 1.4** Strategy summary for fate and behaviour

| All databases | | | | |
|---|---|---|---|---|
| Tungsten/ti,de,ab[1] | AND[2] | Bioaccumulation/ti,de,ab<br>Bioconcentration/ti,de,ab<br>Biodegradation/ti,de,ab<br>Accumulation/ti,de,ab<br>Behaviour/ti,de,ab<br>Deposition/ti,de,ab<br>Distribution/ti,de,ab<br>Dispersal/ti,de,ab<br>Exposure/ti,de,ab<br>Fate/ti,de,ab | 5N[3] | Environment??[4]/ti,de,ab<br>Water/ti,de,ab<br>Air/ti,de,ab<br>Food?/ti,de,ab<br>Sediment/ti,de,ab<br>Sludge/ti,de,ab<br>Soil/ti,de,ab<br>River??/ti,de,ab |

1 /ti,de,ab indicates the fields searched; ti = titles, de = descriptors, ab = abstracts
2 AND – proximity operator – phrases must appear in the same field as each other

3 proximity operator – words must within 5 words of each other and can be in any order
4 ?? - truncation symbol, the number of question marks indicates the number of characters allowed

# 5.3 Results

## Toxicity

The search output (over 450 titles) was reviewed on the basis of the article title and, where available, the abstract. Nearly 50 potentially relevant articles relating to the toxicity of tungsten were identified. Details of these are listed in Annex 1.

## Environmental Fate and Behaviour

The environmental fate and behaviour search identified over 300 articles of potential interest and relevance (not reviewed). The titles (only) of these articles are listed in Annex 2.

# 6 SUMMARY CONCLUSIONS

Tungsten metal is generally regarded as insoluble and of low toxicity, but the toxicology database is limited. Tungsten metal dust is an eye, skin and respiratory irritant and has been shown in animals to have possible reproductive toxicity effects. Exposure to tungsten in the hard-metal industries may contribute to the pulmonary fibrosis seen in these occupations.

The study by Kalnich *et al.*(2005) showed tungsten alloy to be carcinogenic when implanted into rat muscle. Similar properties have been ascribed to cobalt, cadmium, and other metals. If tungsten matrix and tungsten-polymer lead replacement shot (and other munitions) behave the same way as the tungsten alloy tested in the Kalinch study, then caution would appear to be necessary concerning the possible consequences of accidental wounding with these materials, as shot residing in muscle tissue for extended periods could give rise to malignant tumours in people so wounded.

Tungsten *in the diet* allegedly promotes mammary carcinogenesis induced by the N-nitroso compound NMU, a potent carcinogen (Wei *et al.,* 1987) but the significance of this is unclear.

Suggestions of links between tungsten exposure and leukaemia appear presently to be very speculative, but there appears to be some evidence (to be confirmed) for the carcinogenic transformation of cells *in vitro* by tungsten, and for tungsten to demonstrate mutagenicity and genotoxicity. Experiments with a human T-cell lymphoblastic leukaemia cell line have allegedly demonstrated effects of tungsten ores on cell growth and gene transcription/ regulation.

Information on the environmental fate and behaviour of tungsten indicates that if released into water, tungsten compounds are likely to adsorb to suspended solids and sediments, and to have moderate to low mobility in soil. Tungsten has a strong tendency to form complexes and to combine with organic ligands. The chemical behaviour of tungsten in the environment is said to be complex.

It has been alleged that tungsten and tungsten alloys dissolve in water and soil solutions faster than lead, and there are also questions and issues concerning possible interactions between tungsten and lead co-located in the environment (as may occur as tungsten-based shot replaces lead shot for shooting game birds).

There is evidence that tungsten in the soil, derived from tungsten and tungsten alloys as used in munitions, can reduce soil-water pH, lower dissolved oxygen concentrations and adversely impact soil microbes and plant life. Tungsten appears to be readily taken up by plants and there is some evidence for uptake by earthworms and of toxicity to soil microfauna. However, a site-specific assessment in the US indicated that tungsten is least hazardous to human health and the environment compared with copper and other metallic alloy components used in ammunition, and no unacceptable ecological risks from the use of tungsten were predicted.

The literature searches conducted for this project have indicated several relevant reports that are not covered in the present report. For example, there are a number of studies that have investigated the toxicity of tungsten-based shot in mallard duck (see Annex 1). The literature on the chemical fate and behaviour of tungsten is diverse (Annex 2) and warrants further investigation.

# 7 RECOMMENDATIONS

In view of the previous involvement of the Advisory Committee on Hazardous Substances (ACHS) in the specific issue of shooting over wetlands with lead shot and its more general interests and responsibilities relating to the assessment of risks to the environment from hazardous substances, it is recommended that ACHS be asked to address the whole question of the possible environmental impacts of tungsten in bullets (specifically tungsten matrix and tungsten-polymer shot) and to survey the environmental/eco-chemistry data presented. In particular, it is important to understand how the presence of tungsten in the environment might directly affect the biota of the soil and water environment, and whether it can influence (enhance) the bioavailability of lead already present in water and soil, for example as a result of previous game shooting using lead shot.

It is probably important to ascertain whether tungsten-based bullets and shot fragment in use, thus releasing tungsten particles from the matrix, and/or whether the plastic matrix itself affects the leaching of the metal into the environment over the short and long term. Also it will be appropriate to compare the relative toxicity and environmental impacts of tungsten with other materials used in or as lead replacement shot.

### *Possible further work*

This report presents only a brief and limited overview of the topic. The output of the literature searches on the toxicity and environmental fate and behaviour of tungsten should be reviewed, relevant papers obtained, and a more detailed critical literature review prepared.

There are many kinds of ‘lead-replacement’ bullet available, and research has been undertaken on a variety of different forms, mostly the tungsten alloys being used as replacements for larger sized munitions (rather than shot). This makes it difficult to generalise about the likely environmental and health impacts of tungsten matrix and tungsten-polymer materials commonly used as lead shot replacements that are perhaps more relevant. Following a more comprehensive review of the literature it would be appropriate to consider constructing a programme of research specifically addressing the possible environmental consequences of widespread use of tungsten matrix and tungsten-polymer shot in game-shooting, and perhaps to review the toxicity and environmental impacts of materials used in the manufacture of other types of lead replacement shot.

# Bibliography


ATSDR (2003) *Toxicological Profile for Tungsten* (Draft for Public Comment), Atlanta GA, USA, Agency for Toxic Substances and Disease Registry, available [June 2005] at http://www.atsdr.cdc.gov/toxpro2.html

Bunting W (1998) *Elimination of Toxic Heavy Metals from Small Caliber Ammunition* (A820173), Picatinny Arsenal NJ, USA, US Army Research and Development Engineering Centre

Chang FC, Beatty JH, Kane MJ & Beck J (1998) *Galvanic Corrosion of Tungsten Coupled with Several Metals/Alloys* (ARL-TR-1845 XA-AR), USA, Army Research Lab Aberdeen Proving Ground MD

Cooper JM (2005) *Tungsten as a 'Green' Replacement to Depleted Uranium Munitions*, Bristol, UK, University of Bristol, Department of Earth Sciences

DOD (2004) *Carcinogenic Potential of Depleted Uranium and Tungsten Alloys* (DOD-122), USA, Armed Forces Radiobiology Research Institute (AFRRI), Department of Defense

HSDB (2002) *Tungsten*. From: Hazardous Substances Data Bank, Bethesda MD, USA, US National Library of Medicine, available [June 2005] at http://www.toxnet.nlm.nih.gov

Hurley PJ (Date unknown) The structure, redox corrosion and protection of commercial lead-antimony shot [Submitted].

Kalinich JF, Emond CA, Dalton TK, Mog SR, Coleman GD, Kordell JE, Miller AC & McClain DE (2005) Embedded weapons-grade tungsten alloy shrapnel rapidly induces, metastatic high-grade rhabdomyosarcomas in F344 rats. *Environ Health Perspect, 113*, 729-734

Meijer A, Wroblicky G, Thuring S & Marcell MW (1998) *Environmental Effects of Tungsten and Tantalum Alloys* (AFRL-MN-EG-TR-2000-7017 F08630-95-C-0071), USA, GCX Albuquerque NM

NIEHS (2003) *Tungsten and Selected Tungsten Compounds - Tungsten (7440-3-7), Sodium Tungstate (13472-45-2), Tungsten Trioxide (1314-35-8): Review if Toxicological Literature*, Research Triangle Park NC, USA, National Institute of Environmental Health Services

Ogundipe A, Braida W, Dermatas D, Christodoulakis M & Los M (2004) Corrosion behavior of tungsten alloys in the environment. In: *Annual International Conference on Soils, Sediments and Water, 18-21 October 2004*, Massachusetts, USA, University of Massachusetts

Strigul N, Braida W, Dermatas D, Christodoulatos C & Los M (2004) Tungsten effects on soil environments. In: *Annual International Conference on Soils, Sediments and Water, 18-21 October 2004*, Massachusetts, USA, University of Massachusetts

Sun NN, Fastje CD, Wong SS, Sheppard PR, Macdonald SJ, Ridenour G, Hyde JD & Witten ML (2003) Dose-dependent transcriptome changes by metal ores on a human acute lymphoblastic leukaemia cell line. *Toxicology and Industrial Health,19*, 157-163

US Fish and Wildlife Service (2004) Nontoxic shot regulations for hunting waterfowl and coots in the US, available [August 2005] at; http://migratorybirds.fws.gov/issues/nontoxic_shot/nontoxic.htm, Washington DC, USA, US Fish and Wildlife Service, Division of Migratory Bird Management

Wei HJ, Luo XM & Yang XP (1987) Effect of molybdenum and tungsten on mammary carcinogenesis in Sprague-Dawley (SD) rats. *Chung Hua Chung Liu Tsa Chih, 9*, 204-207

# Annex 1: Literature Search on the Toxicity of Tungsten (selected titles and abstracts)

# Biosis

1.
**Genotoxic effects of tungsten microparticles under conditions of biolistic transformation.**
Buchowicz J, Krysiak C.
In: Genetic Transformation of Plants.
Jackson JF, Linskens HF, eds.
New York, USA, Springer-Verlag, (2003), pp 175-193.

2.
**Arsenic, molybdenum, selenium, and tungsten contents of fertilizers and phosphate rocks.**
Charter RA, Tabatabai MA, Schafer JW.
*Communications in Soil Science and Plant Analysis* 26(17-18): 3051-3062. (1995)
Contamination of soils with trace metals or semi-metals has become a major public concern in recent years. Potential sources of these contaminants include commercial phosphorus (P) fertilizers and the phosphate rocks used in production of the P fertilizers. Solid commercial P fertilizers marketed in Iowa and phosphate rock samples (PRs) obtained from deposits around the world were analyzed for arsenic (As), molybdenum (Mo), selenium (Se), and tungsten (W). The fertilizer materials included 24 samples of triple superphosphate (TSP), 23 samples of monoammonium phosphate (MAP), and 25 samples of diammonium phosphate (DAP). Twelve PRs from different PR deposits in Africa, United States, and Peru were also analyzed. The concentrations of As and Mo were greater Ind more variable than those of Se and W in TSP, MAP, DAP, and PRs. The ranges and median values of As, expressed in mg/kg, were: TSP (2.4-18.5, 10.1), MAP (8.1-17.8, 12.4), DAP (6.8-15.6, 12.4), and PR (3.2-32.1, 9.6). The range and median values for Mo contents of TSP, MAP, DAP, and PR were: 8-17, 13; 12-17, 15; 10-21, 14; and 2-21, 6, mg/kg, respectively. The median values for the Se and W contents were: TSP (1.1 and 2.7), MAP (0.3 and 2.1), DAP (0.1 and 2.4), and PR (1.0 and 1.9). One each of the TSP and PRs contained much higher concentrations of Se than the other samples analyzed. The concentrations of As, Mo, Se, and W in the fertilizer materials and PRs analyzed were generally greater than those found in Iowa surface soils.

3.
**A comparative study of the cytotoxicity and mechanisms of action of antidiabetic agents derived from Tungsten and Vanadium.**
Dominguez J, Munoz MC, Mercurio C, Guinovart JJ.
61st Scientific Sessions of the American Diabetes Association June 22-26, 2001 Philadelphia, Pennsylvania, USA
*Diabetes* 50(Supplement 2): A110. (2001)

4.
**Determination of As, Mo, V, W in environmental samples.**
Ferri T, Morabito R, Sangiorgio P, Valentini M.
Article
*Annali di Chimica* 89(9-10): 699-710. (1999)
The paper describes the combined use of a preconcentration method using a chelating resin (iron(III)-loaded) and ICP-AES for determining As, Mo, V and W simultaneously in polluted waters. The method, suitably modified, can also be used for studying the analytes at natural levels down to mug g-1 in solid environmental matrices. The method has been applied to five geological reference samples (GXR series) kindly supplied by the U.S.G.S. The method, whose reliability has been checked on standard reference materials (NIST), is easy to apply and also characterised by good precision.

5.
**Generation of DNA double-strand breaks and inhibition of somatic embryogenesis by tungsten microparticles in wheat.**
Krysiak C, Mazus B, Buchowicz J.
*Plant Cell Tissue and Organ Culture* 58(3): 163-170. (1999)
Particles of metallic tungsten, known also as tungsten microprojectiles, are routinely used to deliver foreign DNA into target cells and tissues. Some side effects of biolistic transformation have been observed but never studied in detail. Here we present evidence that intact tungsten particles can promote a breakage of phosphodiester bonds in native DNA, at a limited number of sites. A single,

double-strand break appeared within almost each of the circular pUC119 molecules after a short incubation of plasmid DNA with a suspension of tungsten particles. No further DNA cutting could be induced even if the reaction rate was accelerated by increasing the concentration of tungsten in the incubation mixture. Indirect evidence indicates that similar lesions may be generated in cellular DNA of bombarded tissues. These lesions are rapidly repaired, as evidenced by increasing incorporation of labelled DNA precursors in bombarded wheat embryos. The rate of repair is, however, not high enough to restore all the genome functions. Neither germination of mature embryos nor initiation of callus tissues from immature embryos was inhibited by biolistic bombardment. Nevertheless, the frequency of formation of somatic embryos in calli derived from bombarded embryos was markedly lower than in calli derived from control embryos. Both immediate (generation of a limited number of double-strand breaks) and remote (selective inhibition of somatic embryogenesis) side effects of the biolistic process strongly suggest that biological activity of tungsten deserves special attention.

6.
**Tungsten particle-induced nicking of supercoiled plasmid DNA.**
Mazus B, Krysiak C, Buchowicz J.
*Plasmid* 44(1): 89-93. (2000)
Small particles of metallic tungsten, known also as tungsten microprojectiles, are routinely used for biotechnological purposes. In such applications, tungsten was observed to affect the integrity of plasmid DNA. Here we present evidence that interaction between tungsten particles and intact circular plasmids pU19, pUC119, and ColE1 may result in generation of a limited number of single-strand DNA breaks. As a consequence, supercoiled DNA is converted into its open circular form and no fragmentation products can be detected. The rate of the tungsten-mediated reaction depends on pH but is not influenced by ascorbate, Tris, or EDTA. No DNA nicking can be observed when the tungsten particles are replaced by substances that can be leached out from these particles with water or incubation buffers. Likewise, commercial sodium tungstate, tungsten (VI) oxide, and tungsten (VI) chloride and products of its decomposition remain DNA undamaged. Native plasmid DNA molecules, upon adsorption on the surface of tungsten microparticles, may undergo some nicking without a need for participation of external catalysts.

7.
**Transformation of human cells by tungsten in combination with nickel and cobalt metal.**
Miller AC, Whittaker T, Xu J, Page N.
89th Annual Meeting of the American Association for Cancer Research March 28-April 1, 1998 New Orleans, Louisiana, USA
*Proceedings of the American Association for Cancer Research Annual Meeting* 119: 119. (1998)

8.
**Mutagenicity of heavy metals used in military applications: Comparison of depleted uranium, tungsten, and nickel.**
Miller AC, Page N.
1999 Environmental Mutagen Society Meeting March 27-April 1, 1999 Washington DC, USA
*Environmental and Molecular Mutagenesis* 33(SUPPL. 33): 45. (1999)

9.
**Degradation of tungsten coils implanted into the subclavian artery of New Zealand white rabbits is not associated with local or systemic toxicity.**
Peuster M, Fink C, Wohlsein P, Bruegmann M, Guenther A, Kaese V, Niemeyer M, Haferkamp H, Schnakenburg CV.
*Biomaterials* 24(3): 393-399. (2003)
Objective: To assess whether corrosion of tungsten coils is related to residual shunting and to evaluate whether elevated tungsten serum levels are associated with local or systemic toxicity. Methods: Tungsten coils (SPI, Bait, France) were implanted into the subclavian artery of New Zealand white rabbits leading to a residual high-flow shunt in 5/10 rabbits. Serial serum tungsten levels, complete blood count and clinical chemistry were analysed prior to the implantation as well as 15 min, 2 and 4 months thereafter. After 4 months the rabbits underwent repeat angiography before they were sacrificed and the internal organs were evaluated histopathologically. Results: Mean tungsten levels rose from 0.48 mug/l prior to the implantation to 12.4 mug/l 4 months post-implantation. The rise in serum tungsten levels was neither associated with residual shunting present at the time of implantation nor with residual shunting at the time of explantation. One animal had to be sacrificed

because of non-resolving palsy of the upper extremity. The remaining animals had an uneventful clinical course with no signs of toxicity of the elevated tungsten levels. Histological examination revealed no evidence of local or systemic toxicity of the tungsten coils. Conclusion: Tungsten coils corrode and lead to a steady increase in serum tungsten levels starting as early as 15 min after implantation. Residual shunting does not seem to influence the kinetics of corrosion of tungsten coils. Despite markedly elevated serum tungsten levels 4 months after implantation degradation of tungsten coils is not associated with local or systemic toxicity.

10.
**Obtaining of plant cell lines resistant to tungsten.**
Sergeeva LE, Trukhanov VA.
*Fiziologiya i Biokhimiya Kul'turnykh Rastenii* 29(1): 51-55. (1997)
Resistant tobacco cell lines which possess viability for more than 3 years on the media with 1.5 or 2.0 mM selecting factor and which form regenerants have been chosen on selective media containing sodium tungstate. Soybean line, resistant to 0.8 mM of the same salt, preserves this resistance for more than one year. Within tobacco and soybean resistant lines a considerable delay in callus tissue grain and strong morphological changes of soybean callus have been found, correspondingly.

11.
**Mechanism of growth inhibition by tungsten in Acidithiobacillus ferrooxidans.**
Sugio T, Kuwano H, Negishi A, Maeda T, Takeuchi F, Kamimura K.
*Bioscience Biotechnology and Biochemistry* 65(3): 555-562. (2001)
Cell growth of three hundred iron-oxidizing bacteria isolated from natural environments was inhibited strongly by 0.05 mM, and completely by 0.2 mM of sodium tungstate (Na2WO4), respectively. Since no great difference in the level of tungsten inhibition was observed among the 300 strains tested, the mechanism of inhibition by Na2WO4 was studied with Acidithiobacillus ferrooxidans strain AP19-3. When resting cells of AP19-3 were incubated in 0.1 M beta-alanine-SO42- buffer (pH 3.0) with 0.1 mM Na2WO4 for 1 h, the amount of tungsten bound to the cells was 12 mug/mg protein. The optimum pH for tungsten binding to the resting cells was 2apprx3. Approximately 2 times more tungsten bound to the cells at pH 3.0 than at pH 6.0. The tungsten binding was specifically inhibited by sodium molybdenum. However, copper, nickel, cadmium, zinc, manganese, cobalt, and vanadate did not disturb tungsten binding to the resting cells. The iron-oxidizing activity of AP19-3 was inhibited 24, 62, and 77% by 1, 5, and 10 mM of Na2WO4, respectively. Among the components of iron oxidation enzyme system, iron:cytochrome c oxidoreductase activity was not inhibited by 10 mM of Na2WO4. In contrast, the activity of cytochrome c oxidase purified highly from the strain was inhibited 50 and 72%, respectively, by 0.05 and 0.1 mM of Na2WO4. The amounts of tungsten bound to plasma membrane, cytosol fraction, and a purified cytochrome c oxidase were 8, 0.5, and 191 mug/mg protein, respectively. From the results, the growth inhibition by Na2WO4 observed in A. ferrooxidans is explained as follows: tungsten binds to cytochrome c oxidase in plasma membranes and inhibits cytochrome c oxidase activity, and as a results, the generation of energy needed for cell growth from the oxidation of Fe2+ is stopped.

# Embase

1.
**Effect of tungsten on nitrate and nitrite reductases in Azospirillum brasilense Sp7.**
Chauret C, Knowles R.
*Canadian Journal of Microbiology* 37(10): 744-750. (1991)
Tungstate, at concentrations that completely suppressed nitrate reductase activity in Paracoccus denitrificans, caused only partial inhibition of nitrate reductase in Azospirillum brasilense Sp7. Nitrate reductase activity in cell-free extracts was much more sensitive than whole cells to tungstate, suggesting that there may be a barrier to its transport. Nitrite reductase activity was partially inhibited by tungstate in both whole cells and cell-free extracts. Azospirillum brasilense apparently scavenged enough contaminating molybdenum from molybdenum-limited medium to allow maximum nitrate reductase activity, which was not stimulated by added molybdate. Cells grown in molybdenum-depleted medium could not reduce nitrate. Nitrate concentrations less than 0.25 mM inhibited activity, but not synthesis, of nitrite reductase and caused significant accumulation of nitrite during reduction of nitrate.

2.
**Toxicity of tungsten (multiple letters) [10].**
Lison D, Buchet J-P, Hoet P, Marquet P, Francois B, Vignon P, Lachatre G.
*Lancet* 349(9044): 58-59. (1997)

3.
**A case of immediate hypersensitivity reaction with tungsten.**
Miyamoto T, Inoue S, Watanabe T.
*Allergy* 60(3): 415-416. (2005)

4.
**Protective effect of tungsten on cardiac injury induced by endotoxic shock in rats.**
Xiao X, Lueo Z, Zhou Q, Zhan Q, Chen Z.
*Bulletin of Hunan Medical University* 16(1): 11-14. (1991)

# Medline

1.
**Acute toxicity of lead, steel, and an iron-tungsten-nickel shot to mallard ducks (Anas platyrhynchos).**
Brewer L, Fairbrother A, Clark J, Amick D.
*Journal of Wildlife Diseases* 39(3): 638-648. (2003)
Twenty mallards (Anas platyrhynchos) of both sexes were dosed by oral gavage with Heavi-Shot (H-S; Environ-Metal, Inc., Sweet Home, Oregon, USA) pellets, 20 with steel shot, and 10 with lead (Pb) pellets, all of equal size. All pellets were fired from a shotgun into an absorbent material, retrieved, and weighed prior to introduction into the ducks. Birds were fed whole kernel corn and grit and observed for signs of toxicity for 30 days following dosing. Hevi-Shot pellets lost an average of 6.2% of their mass and steel shot pellets lost 57% of their mass in the birds' gizzards. Almost all (90%) of the Pb shot dosed birds died before the end of the study, while no mortality was observed in the steel or H-S dosed groups. Even though total food consumption differed between the H-S and steel shot groups, mean bird weight change was not different. There were no significant morphologic or histopathologic abnormalities of the liver and kidney in the H-S and steel shot groups. Res! ults indicated that mallards dosed orally with eight No. 4 H-S pellets were not adversely affected over a 30-day period, and that H-S provides another environmentally safe nontoxic shot for use in waterfowl hunting.

2.
**Vanadium and tungsten derivatives as antidiabetic agents: a review of their toxic effects. [Review] [85 refs].**
Domingo JL.
*Biological Trace Element Research* 88(2): 97-112. (2002)
Tungstate is an oxyanion that has biological similarities to vanadate. In recent years, a number of studies have shown the antidiabetic effects of oral tungstate in animal models of diabetes. However, because of the tissue accumulation and potential toxicity derived from chronic administration of vanadium and tungsten compounds, the pharmacological use of vanadate or tungstate in the treatment of diabetes is not necessarily exempt from concern. In the context of a potential use in the treatment of human diabetes mellitus, the most relevant toxic effects of vanadium derivatives are reviewed and compared with those reported for tungsten. Hematological and biochemical alterations, loss of body weight, nephrotoxicity, immunotoxicity, reproductive and developmental toxicity, and behavioral toxicity have been reported to occur following exposure to vanadium compounds. Moreover, vanadium also has a mitogenic activity affecting the distribution of chromosomes during mitosis and i! nducing aneuploidy-related end points. In contrast to vanadate, studies about the toxic effects of tungstate are very scant. Early investigations in cats, rabbits, dogs, mice, and rats showed that tungstate was less toxic than vanadate when given intravenously. Although in vitro investigations showed a direct effect of tungstate on the embryo and fetus of mice at concentrations similar to those causing effects in vivo, information on the potential cellular toxicity of tungstate is particularly scarce. Taking into account the recent interest of tungstate as a new potential oral antidiabetic agent, an exhaustive evaluation of its toxicity in mammals is clearly necessary. [References: 85].

3.
**Alternative to depleted uranium is carcinogenic in rats.**
Furlow B.
*Lancet Oncology* 6(4): 198. (2005)

4.
**Acute effects of lead, steel, tungsten-iron, and tungsten-polymer shot administered to game-farm mallards.**
Kelly ME, Fitzgerald SD, Aulerich RJ, Balander RJ, Powell DC, Stickle RL, Stevens W, Cray C, Tempelman RJ, Bursian SJ.
*Journal of Wildlife Diseases* 34(4): 673-687. (1998)
Sixteen-bird groups (sexes equal) of adult mallards (Anas platyrhynchos) were orally dosed with eight #4 steel short, eight #4 lead shot, eight BB-size tungsten-iron shot, eight BB-size tungsten-polymer shot, or were sham-dosed and maintained for 30 days (16 January 1996 to 15 February 1996). Half of the lead-dosed ducks (five males, three females) died during the study, whereas no ducks died in the

other dosage groups. For lead-dosed ducks, hematocrit and hemoglobin concentration were decreased on day 15 of the trial, but not on day 30. Delta aminolevulinic acid dehydratase activity in lead-dosed ducks was lower when compared to steel-dosed ducks only. Plasma activities of selected enzymes were elevated in lead-dosed ducks when compared to enzyme activities of ducks in the other groups. For lead-dosed ducks, relative heart, liver, and kidney weights increased in comparison to relative weights of those organs of ducks in other groups. Histology of tissues indicated that r! enal nephrosis accompanied by biliary stasis was present in the eight lead-dosed ducks that died. For the eight lead-dosed ducks that survived, six had mild to severe biliary stasis. Mild biliary stasis was noted in five tungsten-iron dosed ducks and three tungsten-polymer dosed ducks. Amounts of lead in the femur, liver, and kidneys were higher in lead-dosed ducks than in ducks of the other four groups. Small amounts of tungsten were detected in the femur and kidneys of two tungsten-polymer dosed ducks. Higher concentrations of tungsten were detected in the femur, liver, and kidneys of all tungsten-iron dosed ducks. The rate of shot erosion was highest (80%) for the tungsten-polymer shot, followed by tungsten-iron (55%), lead (50%), and steel shot (33%). Results indicated that tungsten-iron or tungsten-polymer shot (8 shot/duck) orally administered to mallards did not adversely affect them during a 30-day trial.

5.
**Effects of embedded tungsten-bismuth-tin shot and steel shot on mallards (Anas platyrhynchos).**
Kraabel BJ, Miller MW, Getzy DM, Ringelman JK.
*Journal of Wildlife Diseases* 32(1): 1-8. (1996)
We assessed the potential for embedded steel and tungsten-bismuth-tin (TBT) shot to adversely affect health of mallards (Anas platyrhynchos). Ducks were implanted with three number four steel (n = 19) or TBT (n = 20) shot pellets in their pectoral muscles. None of seven hematology parameters measured differed in response to treatment (P > or = 0.17). At necropsy 1, 2, 4, and 8 wk posttreatment, we observed only localized tissue reactions to embedded steel or TBT shot. Reactions differed grossly: after wk 1, embedded steel shot were enveloped in 0.5 to 2 mm grayish capsules, whereas TBT shot were surrounded by thinner (< 0.5 mm), translucent capsules. Corrosion of steel shot was apparent. Microscopic lesions associated with steel shot were characterized by moderate to severe histiocytic and lymphocytic inflammation and considerable particle deposition, whereas histiocytic inflammation was mild and particle deposition minimal in TBT lesions. Overall scores of inflammation a! t steel shot implant sites were greater (P < or = 0.043) than at TBT sites during wk 1 and 8. Inflammation at steel implant sites was relatively consistent over the 8-wk period, but decreased (P = 0.0017) at TBT sites by wk 8. Weights of steel shot recovered from muscle tissue declined logarithmically (R2 = 0.978, P = 0.0014) over 8 wk, but TBT shot weights remained unchanged (P = 0.255). Embedded TBT shot, as compared to steel, resisted corrosion and induced comparatively mild inflammatory responses in mallard muscle tissue. However, inflammatory reactions to both embedded steel and TBT shot were localized and had no detectable systemic effects on mallard health under experimental conditions.

6.
**Exposure assessment in the hard metal manufacturing industry with special regard to tungsten and its compounds.**
Kraus T, Schramel P, Schaller KH, Zobelein P, Weber A, Angerer J.
*Occupational & Environmental Medicine* 58(10): 631-634. (2001)
OBJECTIVES: To assess the exposure to tungsten, cobalt, and nickel in a plant producing hard metals. The main components of hard metals are tungsten carbide and cobalt metal. According to recent studies, these two components may be responsible for both fibrogenic and carcinogenic effects. METHODS: 87 workers were investigated (86 male, one female) with a median age of 42 (range 22-58) and a mean duration of exposure of 13 years (range 1-27 years). Stationary and personal air sampling, and biological monitoring were carried out. RESULTS: Ambient monitoring yielded maximum tungsten concentrations of 417 microg/m3 in the production of heavy alloys. A maximum cobalt concentration of 343 microg/m3 and a maximum nickel concentration of 30 microg/m3 were found at the sintering workshop. The highest urinary cobalt concentrations were found in the powder processing department. The mean concentration was 28.5 microg/g creatinine and the maximum value was 228 microg/g creatinine. Th! e maximum nickel concentration in urine of 6.3 microg/g creatinine was detected in the department producing heavy alloys. The highest tungsten concentrations excreted in urine were found in grinders and had a mean value of 94.4 microg/g creatinine and a maximum of 169 microg/g creatinine. Due to the different solubility and bioavailability

of the substance, there was no correlation between the tungsten concentrations in air and urine on a group basis. CONCLUSIONS: Despite its low solubility, tungsten carbide is bioavailable. The different bioavailability of tungsten metal and tungsten compounds has to be considered in the interpretation of ambient and biological monitoring data in the hard metal producing industry. The bioavailability increases in the order: tungsten metal, tungsten carbide, tungstenate. Only if both monitoring strategies are considered in combination can a valid and effective definition of high risk groups be derived.

7.
**Relaxation, linearization and fragmentation of supercoiled circular DNA by tungsten microprojectiles.**
Krysiak C, Mazus B, Buchowicz J.
*Transgenic Research* 8(4): 303-306. (1999)
The aim of the study was to characterize DNA lesions caused by microprojectile bombardment and by the post-bombardment presence of tungsten particles in transformed cells. For the sake of simplicity, plasmid DNA was used as a target for bombardment with naked tungsten particles. Unexpectedly extensive DNA degradation was observed under standard bombardment conditions. However, no further DNA fragmentation occurred under post-bombardment conditions, simulated by incubation of plasmid DNA with a suspension of tungsten particles. Instead, relaxation and linearization of supercoiled circular plasmids (pAHC25 and others) took place. It is concluded that the observed linearization (a single site double-strand break in DNA circle) results from the ability of tungsten to catalyse the hydrolysis of phosphodiester bonds in torsionally strained sites of native DNA selectively.

8.
**Metabolism and toxicity of tungsten in humans and animals. [Review] [64 refs].**
Lagarde F, Leroy M.
*Metal Ions in Biological Systems* 39: 741-759. (2002)

9.
**A model of the distribution and retention of tungsten in the human body.**
Leggett RW.
*Science of the Total Environment* 206(2-3): 147-165. (1997)
Expanding industrial and military uses of tungsten could result in substantially increased levels of this metal in the environment in the next few years. Although occupational experiences and available toxicological studies on laboratory animals suggest that tungsten may have a relatively low order of toxicity, the data are weak and inconclusive. There is a need not only for more systematic studies of the behavior and effects of tungsten in different animal species but also for a reliable, biologically realistic biokinetic model for tungsten in man that can be used to relate concentrations of this metal in environmental media to concentrations in tissues of exposed persons and translate results of experimental studies into terms of environmental exposures. This paper is intended as a first step toward development of such a biokinetic model. Information related to the biokinetics of tungsten in mammalian species is examined, a biologically meaningful compartmental model st! ructure is proposed, provisional transfer rates between compartments are selected, areas are identified where additional biokinetic data on tungsten are most needed and suggestions are made for further research into the biokinetics of tungsten.

10.
**Toxicity of tungsten (multiple letters) [10].**
Lison D, Buchet J-P, Hoet P, Marquet P, Francois B, Vignon P, Lachatre G.
*Lancet* 349(9044): 58-59. (1997)

11.
**Inhibitory effects of molybdenum on esophageal and forestomach carcinogenesis in rats.**
Luo XM, Wei HJ, Yang SP.
*Journal of the National Cancer Institute* 71(1): 75-80. (1983)
Male weanling inbred SD rats were given ad libitum a nutritionally adequate semipurified diet and demineralized drinking water without or with 100 or 200 ppm tungsten (W) or 2 or 20 ppm molybdenum (Mo) added to the drinking water. The animals were gastrically intubated with a solution of N-nitrososarcosine ethyl ester (NSEE) from the 4th week twice weekly for 2-8 consecutive weeks. The addition of Mo at either the 2- or 20-ppm level significantly inhibited NSEE-induced esophageal

and forestomach carcinogenesis. The 200 ppm W significantly countered the inhibitory effect of a low level of Mo naturally occurring in the diet.

12.
**Tungsten determination in biological fluids, hair and nails by plasma emission spectrometry in a case of severe acute intoxication in man.**
Marquet P, Francois B, Lotfi H, Turcant A, Debord J, Nedelec G, Lachatre G.
*Journal of Forensic Sciences* 42(3): 527-530. (1997)
A healthy 19-year-old recruit in a French artillery regiment drank 250 mL of a mixture of beer and wine that had rinsed in a hot 155-mm gun-barrel. Fifteen minutes later, he complained of nausea followed by seizures. He was comatose for 24 h, presenting signs of encephalopathy. A moderate renal failure was noted initially and worsened to an extensive tubular necrosis with anuria on the day after the incident. The first toxicological investigations only showed a 0.31 g/L blood ethanol. Then inductively-coupled plasma (ICP) emission-spectrometry revealed very high concentrations of tungsten in the "beverage" as well as in gastric content, blood and urine (1540 mg/L, 8 mg/L, 5 mg/L, and 101 mg/L, respectively). The nature of the metal was confirmed by ICP coupled to mass spectrometry. A simple and reliable ICP quantitative assay of tungsten in biological fluids, hair and nails was then developed. It showed high blood levels (> 0.005 mg/L) until day 13 in spite of six hemodia! lyses, and in urine until D33. Tungsten was also incorporated in hair and nails. To the best of our knowledge, such an intoxication has never been reported before though this drinking seems to be traditional in the French Artillery. It has probably been favored by the unusually high volume of beverage absorbed and by the new alloy of the gun, containing tungsten. The clinical evolution was satisfactory over weeks and the patient was declared totally cured after five months.

13.
**Neoplastic transformation of human osteoblast cells to the tumorigenic phenotype by heavy metal-tungsten alloy particles: induction of genotoxic effects.**
Miller AC, Mog S, McKinney L, Luo L, Allen J, Xu J, Page N.
*Carcinogenesis* 22(1): 115-125. (2001)
Heavy metal-tungsten alloys (HMTAs) are dense heavy metal composite materials used primarily in military applications. HMTAs are composed of a mixture of tungsten (91-93%), nickel (3-5%) and either cobalt (2-4%) or iron (2-4%) particles. Like the heavy metal depleted uranium (DU), the use of HMTAs in military munitions could result in their internalization in humans. Limited data exist, however, regarding the long-term health effects of internalized HMTAs in humans. We used an immortalized, non-tumorigenic, human osteoblast-like cell line (HOS) to study the tumorigenic transforming potential of reconstituted mixtures of tungsten, nickel and cobalt (rWNiCo) and tungsten, nickel and iron (rWNiFe). We report the ability of rWNiCo and rWNiFe to transform immortalized HOS cells to the tumorigenic phenotype. These HMTA transformants are characterized by anchorage-independent growth, tumor formation in nude mice and high level expression of the K-ras oncogene. Cellular exposure ! to rWNiCo and rWNiFe resulted in 8.90 +/- 0.93- and 9.50 +/- 0.91-fold increases in transformation frequency, respectively, compared with the frequency in untreated cells. In comparison, an equivalent dose of crystalline NiS resulted in a 7.7 +/- 0.73-fold increase in transformation frequency. The inert metal tantalum oxide did not enhance HOS transformation frequency above untreated levels. The mechanism by which rWNiCo and rWNiFe induce cell transformation in vitro appears to involve, at least partially, direct damage to the genetic material, manifested as increased DNA breakage or chromosomal aberrations (i.e. micronuclei). This is the first report showing that HMTA mixtures of W, Ni and Co or Fe cause human cell transformation to the neoplastic phenotype. While additional studies are needed to determine if protracted HMTA exposure produces tumors in vivo, the implication from these in vitro results is that the risk of cancer induction from internalized HMTAs exposure ma! y be comparable with the risk from other biologically reactive! and ins oluble carcinogenic heavy metal compounds (e.g. nickel subsulfide and nickel oxide).

14.
**Potential late health effects of depleted uranium and tungsten used in armor-piercing munitions: comparison of neoplastic transformation and genotoxicity with the known carcinogen nickel.**
Miller AC, Xu J, Stewart M, Prasanna PG, Page N.
*Military Medicine* 167(2 Suppl): 120-122. (2002)
Limited data exist to permit an accurate assessment of risks for carcinogenesis and mutagenesis from embedded fragments or inhaled particulates of depleted uranium (DU). Ongoing studies have been

designed to provide information about the carcinogenic potential of DU using in vitro and in vivo assessments of morphological transformation as well as cytogenetic, mutagenic, and oncogenic effects. For comparison, we also examined tungsten alloys used in military projectiles and the known carcinogen nickel. Quantitative and qualitative in vitro transformation studies were done to assess the carcinogenic potential of radiation and chemical hazards. Using a human osteosarcoma cell model, we demonstrated that soluble and insoluble DU compounds can transform cells to the tumorigenic phenotype, as characterized by morphological, biochemical, and oncogenic changes consistent with tumor cell behavior. Tungsten alloys and nickel were also shown to be neoplastic transforming agents, alt! hough at a frequency less than that of DU. Sister chromatid exchange, micronuclei, and alkaline filter elution assays showed DU and tungsten alloys were genotoxic. Exposure to a nontoxic, nontransforming dose of DU induced a small but statistically significant increase in the number of dicentrics formed in cells. These results suggest that long-term exposure to DU or tungsten alloys could be critical to the development of neoplastic disease in humans and that additional studies are needed.

15.
**Effect of the militarily-relevant heavy metals, depleted uranium and heavy metal tungsten-alloy on gene expression in human liver carcinoma cells (HepG2).**
Miller AC, Brooks K, Smith J, Page N.
*Molecular & Cellular Biochemistry* 255(1-2): 247-256. (2004)
Depleted uranium (DU) and heavy-metal tungsten alloys (HMTAs) are dense heavy-metals used primarily in military applications. Chemically similar to natural uranium, but depleted of the higher activity 235U and 234U isotopes, DU is a low specific activity, high-density heavy metal. In contrast, the non-radioactive HMTAs are composed of a mixture of tungsten (91-93%), nickel (3-5%), and cobalt (2-4%) particles. The use of DU and HMTAs in military munitions could result in their internalization in humans. Limited data exist however, regarding the long-term health effects of internalized DU and HMTAs in humans. Both DU and HMTAs possess a tumorigenic transforming potential and are genotoxic and mutagenic in vitro. Using insoluble DU-UO2 and a reconstituted mixture of tungsten, nickel, cobalt (rWNiCo), we tested their ability to induce stress genes in thirteen different recombinant cell lines generated from human liver carcinoma cells (HepG2). The commercially available CAT-To! x (L) cellular assay consists of a panel of cell lines stably transfected with reporter genes consisting of a coding sequence for chloramphenicol acetyl transferase (CAT) under transcriptional control by mammalian stress gene regulatory sequences. DU, (5-50 microg/ml) produced a complex profile of activity demonstrating significant dose-dependent induction of the hMTIIA FOS, p53RE, Gadd153, Gadd45, NFkappaBRE, CRE, HSP70, RARE, and GRP78 promoters. The rWNiCo mixture (5-50 microg/ml) showed dose-related induction of the GSTYA, hMTIIA, p53RE, FOS, NFkappaBRE, HSP70, and CRE promoters. An examination of the pure metals, tungsten (W), nickel (Ni), and cobalt (Co), comprising the rWNiCo mixture, demonstrated that each metal exhibited a similar pattern of gene induction, but at a significantly decreased magnitude than that of the rWNiCo mixture. These data showed a synergistic activation of gene expression by the metals in the rWNiCo mixture. Our data show for the first time tha! t DU and rWNiCo can activate gene expression through several s! ignal tr ansduction pathways that may be involved in the toxicity and tumorigenicity of both DU and HMTAs.

16.
**Transferrin and ceruloplasmin levels in long-term occupational exposure to gasoline, tungsten, vanadium, cobalt and titanium.**
Misiewicz A.
Journal Article
*Medycyna Pracy* 32(4): 241-245. (1981) [polish]

17.
**Health effects following chronic dosing with tungsten-iron and tungsten-polymer shot in adult game-farm mallards.**
Mitchell RR, Fitzgerald SD, Aulerich RJ, Balander RJ, Powell DC, Tempelman RJ, Stickle RL, Stevens W, Bursian SJ.
*Journal of Wildlife Diseases* 37(3): 451-458. (2001)
Permanent approval of shot composed of tungsten-iron and tungsten-polymer for waterfowl hunting by the U.S. Fish and Wildlife Service was pending the results of the present study that examined the health and reproductive effects of the two shot types on mallards (Anas platyrhynchos) over a 150-

day period. We collected data pertaining to the effects of tungsten-iron and tungsten-polymer shot on mortality, body weight, organ weight, tissue pathology, and shot erosion. Thirty-two bird groups (sexes equal) of adult mallards were dosed orally with eight #4 steel shot (control), eight #4 tungsten-iron shot, or eight #4 tungsten-polymer shot on days 0, 30, 60, 90, and 120 of a 150-day trial (26 January 1998 to 25 June 1998). An additional 12 mallards (sexes equal) were dosed orally with eight #4 lead shot (positive control) on day 0 of the study. All lead-dosed ducks died by day 25, whereas no ducks died in the other treatment groups. Significant liver hemosiderosis was present ! in all control and tungsten-iron-dosed males, in five of eight control and three of eight tungsten-iron-dosed females, and in one tungsten-polymer-dosed male examined. The rate of shot erosion was highest for tungsten-polymer shot (99%), followed by tungsten-iron (72%), and steel (55%) shot. Tungsten-iron or tungsten-polymer shot repeatedly administered to adult mallards did not have deleterious health effects during the 150-day trial based on mortality, body weights, organ weights, and histology of the liver and kidneys.

18.
**Hematological effects and metal residue concentrations following chronic dosing with tungsten-iron and tungsten-polymer shot in adult game-farm mallards.**
Mitchell RR, Fitzgerald SD, Aulerich RJ, Balander RJ, Powell DC, Tempelman RJ, Cray C, Stevens W, Bursian SJ.
*Journal of Wildlife Diseases* 37(3): 459-467. (2001)
The U.S. Fish and Wildlife Service required a chronic dosing study that assessed the health and reproductive effects of tungsten-iron and tungsten-polymer shot in adult game-farm mallards (Anas platyrhynchos) prior to granting permanent approval of the shot for waterfowl hunting. Herein, we present the effects of tungsten-iron and tungsten-polymer shot on various hematologic parameters and metal residue concentrations in the femur, liver, kidneys, and gonads. Thirty-two-bird groups (sexes equal) of adult mallards were dosed orally with eight #4 steel shot (control), eight #4 tungsten-iron shot, or eight #4 tungsten-polymer shot on days 0, 30, 60, 90, and 120 of a 150 day trial (26 January 1998 to 25 June 1998). An additional 12 mallards (sexes equal) received eight #4 lead shot (positive control) on day 0 of the study. Lead-dosed mallards had significantly decreased hematocrit, hemoglobin concentration, and whole-blood delta aminolevulinic acid dehydratase activity on day! 7, as well as significant changes in a number of plasma chemistry parameters compared to ducks in the control, tungsten-iron, or tungsten-polymer groups. Mallards dosed with tungsten-iron or tungsten-polymer shot had occasional significant differences in hematocrit and plasma chemistry values when compared to control mallards over the 150 day period, but these changes were not considered to be indicative of deleterious effects. Low concentrations of tungsten were detected in gonad and kidney samples from males and females and in liver samples from females dosed with tungsten-polymer shot. Tungsten was also detected in femur samples from tungsten-polymer-dosed mallards. Higher concentrations of tungsten were detected in femur, liver, kidney, and gonad samples from tungsten-iron-dosed ducks. Tungsten-iron or tungsten-polymer shot repeatedly administered to adult mallards did not cause adverse hematological effects during the 150 day trial. Concentrations of tungsten in the f! emur, liver, kidneys, and gonads were generally higher in tung! sten-iro n-dosed ducks when compared to tungsten-polymer-dosed ducks.

19.
**Reproductive effects and duckling survivability following chronic dosing with tungsten-iron and tungsten-polymer shot in adult game-farm mallards.**
Mitchell RR, Fitzgerald SD, Aulerich RJ, Balander RJ, Powell DC, Tempelmen RJ, Stevens W, Bursia SJ.
*Journal of Wildlife Diseases* 37(3): 468-474. (2001)
Tungsten-iron and tungsten-polymer shot were given conditional approval for waterfowl hunting by the U.S. Fish and Wildlife Service based partly on the results of a 30-day acute toxicity trial utilizing mallards (Anas platyrhynchos). Final approval of the two tungsten-containing shot was contingent on the results of a 150-day study that assessed the health and reproductive effects of tungsten-iron and tungsten-polymer shot in adult mallards. Reproductive data are presented in this paper. Sixteen male and 16 female adult mallards were dosed orally with eight #4 steel shot (control), eight #4 tungsten-iron shot, or eight #4 tungsten-polymer shot on days 0, 30, 60, 90, and 120 of a 150-day trial (26 January 1998 to 25 June 1998). Reproductive performance was assessed during the last 90 days (day 61 to day 150) of the trial. There were no significant differences in egg production and fertility and hatchability of eggs from tungsten-iron- and tungsten-polymer-dosed ducks compa! red to control ducks. There was no evidence of differences in percent survivability and body weight of ducklings

from tungsten-iron and tungsten-polymer mallards compared to ducklings from control ducks. Tungsten-iron or tungsten-polymer shot repeatedly administered to adult mallards during the 150 day trial did not adversely affect reproduction or their offspring.

20.
**The influence of tungsten on the molybdenum status of poultry.**
Nell JA, Annison EF, Balnave D.
*British Poultry Science* 21(3): 193-202. (1980)
1. Large doses of tungsten, administered to the chick either by injection or by feeding, increased tissue concentrations of tungsten and decreased tissue concentrations of molybdenum and tissue activities of xanthine dehydrogenase. 2. The rate of loss of large doses of tungsten from the liver occurred in an exponential manner with a half-life of 27 h. 3. When tungsten was administered to chicks fed on a semi-synthetic diet containing abnormally low concentrations of molybdenum, the activity of hepatic xanthine dehydrogenase was reduced to negligible levels. 4. The alterations in molybdenum metabolism resulting from the administration of large doses of tungsten to the chick appears to be the result of tungsten toxicity and not of molybdenum deficiency. 5. Deaths from tungsten toxicity occurred when tissue concentrations of tungsten were increased to approximately 25 micrograms/g liver. At this tissue tungstencon centration the activity of xanthine dehydrogenase was zero.

21.
**Potential hazards in the use of tungsten mechanical detachable coils.[comment].**
Pelz D.
*Radiology* 214(2): 602-603. (2000)

22.
**Dissolution of tungsten coils does not produce systemic toxicity, but leads to elevated levels of tungsten in the serum and recanalization of the previously occluded vessel.**
Peuster M, Fink C, von Schnakenburg C, Hausdorf G.
*Cardiology in the Young* 12(3): 229-235. (2002)
AIM: To evaluate the failure of mechanically detachable spirals produced from tungsten (MDS, Balt, Montmorency, France) and the toxicity of elevated levels of tungsten in the serum subsequent to their implantation. METHODS: We reviewed findings in 21 patients in whom tungsten coils had been used to occlude pathologic vessels, aneurysms and fistulas between 1996 and 1999. We achieved clinical follow-up, and measured renal and hepatic function, in 14 of the 21 patients. RESULTS: Decreased radiopacity of the coils was observed in 9 of 13 patients who had follow-up fluoroscopy during repeat cardiac catheterization. Repeat angiography of the vessel occluded by the coil was performed in 7 patients, 5 of whom showed recanalization. Levels of tungsten in the serum were analyzed 6 to 35 months after implantation of coils in 8 patients. The mean concentration was 6.43 micrograms/l, with a range from 2 to 14.4 micrograms/l, normal values being less than 0.2 microgram/l. CONCLUSION: ! Tungsten coils may dissolve over time and lead to markedly elevated levels of tungsten in the serum, with recanalization of previously occluded vessels. Despite lack of clinical and laboratory data in patients with elevated levels of tungsten in the serum, our study suggests that the clinical use of mechanically detachable coils produced from tungsten should no longer be recommended.

23.
**A case of pulmonary fibrosis: possible role of tungsten dust.**
Rochemaure J, Ancla M, Trinquet G, Meyer A.
*Journal Francais de Medecine et Chirurgie Thoraciques* 26(4): 305-312. (1972) [french]

24.
**Tungsten modulates the toxicity of paraquat for epithelial cells.**
Sakai M, Yamagami K, Kawamoto K, Tanaka T.
*Human Cell* 6(4): 287-293. (1993)
The modulation of paraquat toxicity by tungsten was studied in vitro using cultured MDCK epithelial cells. MDCK cells were cultured in minimal essential medium with or without 1 ppm tungsten. Proliferation of cells cultured with tungsten was not inhibited after exposure to 0.25 mM or 0.5 mM paraquat. In addition, lactate dehydrogenase release into the culture medium was lower for tungsten-treated cells than for cells cultured without tungsten. Cells cultured in medium alone showed reduced viability compared with controls after exposure to 0.5 mM paraquat, but 0.25 mM paraquat did not

decrease cell viability. Tungsten-treated cells showed no decrease viability in after exposure to either concentration of paraquat. Cells exposed to paraquat developed a honeycomb morphology with scanty cytoplasm and abnormal nucleoli. However, these major structural changes were not observed in cells cultured with tungsten. Our study showed that cell damage after paraquat exposure was modula! ted by addition of tungsten to the culture medium. It is suggested that cytosolic xanthine oxidase activity was reduced by tungsten, leading to less production of superoxide and other radicals and thus conferring resistance to paraquat toxicity.

25.
**Combined effect of tungsten and sulfurous anhydride on the body.**
Tkachev PG, Voronov VP.
*Gigiena i Sanitariia* (7): 81-82. (1982) [russian]

26.
**Effects of molybdenum and tungsten on mammary carcinogenesis in SD rats.**
Wei HJ, Luo XM, Yang SP.
*Journal of the National Cancer Institute* 74(2): 469-473. (1985)
Virgin female rats of the SD strain were fed ad libitum a nutritionally adequate semipurified diet and demineralized water (groups 1 and 2), or the same diet with 10 ppm molybdenum (group 3) or 150 ppm tungsten (group 4) added to the drinking water. The animals in groups 2-4 received a single iv injection of 5 mg N-nitroso-N-methylurea (NMU; CAS: 684-93-5)/100 g body weight at 50 days of age. One hundred and twenty-five days after the NMU treatment, group 2 exhibited a 50.0% incidence of mammary carcinoma. Group 4 exhibited a significant increase in carcinoma incidence (79.2%) and the value for group 3 (45.5%) was not significantly different from that of group 2. The carcinoma incidence of group 3 (50.0%) was significantly lower than that of group 2 (90.5%) or group 4 (95.7%) 198 days after NMU treatment.

27.
**Effect of molybdenum and tungsten on mammary carcinogenesis in Sprague-Dawley (SD) rats.**
Wei HJ, Luo XM, Yang XP.
*Chinese Journal of Oncology* 9(3): 204-207. (1987) [chinese]
Virgin female rats of SD strain were given ad libitum a nutritionally adequate semipurified diet containing 0.026 ppm molybdenum and deionized water (groups 1-3) or the same diet with 150 ppm tungsten and the drinking water (group 4). Group 1 was used as control. After 15 days, all the animals in groups 2-4 received an intravenous injection of N-nitroso-N-methylurea (NMU) 5 mg/100 g body weight. One week after administration of carcinogen, 10 ppm Mo was added to the drinking water in group 3. After 125 days, the mammary cancer incidence in group 4 (79.2%) was significantly higher than that in group 2 (50.0%) or group 3 (45.5%) (P less than 0.05). After 198 days, the average number of mammary cancer in each animal and mammary cancer incidence in group 3 (1.5 and 50.0%) were obviously lower than those in group 2 (2.0 and 90.5%) or group 4 (2.6 and 95.7%). The first palpable mammary tumor was found in the W-supplemented group only 56 days after the injection of NMU, whereas ! in the W-unsupplemented and Mo-supplemented groups, the first mammary tumor was observed 71 and 85 days after NMU treatment. Of these 181 mammary tumors, 177 (97.8%) were adenocarcinoma or papillary carcinoma, only 4 (2.2%) fibroadenocarcinoma. The results of this study show, for the first time, the inhibitory effect of Mo on the mammary carcinogenesis and promoting effect of Tungsten, an antagonist of molybdenum, on the tumor growth.

# ToxFile

1.
**Tungsten, Cobalt, and Their Compounds.**
Alexandersson R.
In: Occupational Medicine: Principles and Practical Applications.
Zenz C, ed.
Chicago, USA, Year Book Medical Publishers, (1988), pp 624-629.
The biological effects of occupational exposure to tungsten (7440337) , cobalt (7440484) and related compounds were reviewed and discussed. The properties and industrial uses of these elements were described. Respiratory disease has been seen in workers in the cemented tungsten-carbide, or hard metal industry. Animals studies have indicated that the pathology associated with exposure to hard metal was a result of the cobalt and not the tungsten component of the hard metal. Hard metal pneumoconiosis has been reported in hard metal workers with long term exposures to tungsten cemented dust, and obstructive lung disease has been seen in workers exposed to lower levels. Long term exposure to cobalt has been reported to result in rare cases of pneumoconiosis, and a study of occupational exposure to 0.06mg/m3 reported the development of obstructive pulmonary symptoms that resolved when the workers were away from work. Other biological effects of cobalt exposure include skin allergy, myocardial, carcinogenic, and teratogenic effects. The threshold level values for both tungsten and cobalt were discussed.

2.
**Tungsten.**
Browning E.
In: Toxicity of Industrial Metals.

London, UK, Butterworth and Co, (1961), pp 301-304.
The toxicity of tungsten (7440337) is reviewed. The physical properties of tungsten are described. It is a steel grey metal resembling molybdenum but less fusible, is highly resistant to acids, oxidizes in air only at red heat, gives good electrical conductivity, and has an atomic weight of 183.92, a specific gravity of 19.3, a melting point of 3410 degrees-C, and a boiling point of 5930 degrees- C. The industrial uses of tungsten are listed for alloy production, in the tungsten-carbide tool industry, as a plating material on brass and other metals, as an electrode for ultraviolet radiation, as an anticathode in X-ray tubes, in the textile industry for rendering fabric nonflammable, and in the preparation of blue and green pigments. The metabolism of tungsten is discussed. In plants it is an antagonist to molybdenum and plays a part in nitrate assimilation. In animals, it antagonizes molybdenum and selenium and inhibit deposition of intestinal xanthine-oxidase. Retention is greatest in bone and spleen. In animals, large doses can cause acute or lethal poisoning; however, in humans, tungsten dust inhalation has no specific fibrogenic effect. Oral toxicity in animals is assessed. Toxic effects in humans are cited with some instance of pulmonary involvement and pneumoconiosis. The author concludes that most researchers believe that cobalt (7440484), rather than tungsten, is the most probable toxic agent in pneumoconiosis.

3.
**Toxicity of tungsten and molybdenum compounds.**
Karantassis MT.
*Annales de Medecine Legale* 5: 44-50. (1924)
The toxicity of sodium-tungstate (13472452) and ammonium-molybdate (13106768) is tested in guinea-pigs. Doses ranging from 0.50-0.75 gram given orally to 575-640 gram guinea-pigs produced death after 5-23 hours. Symptoms before death included anorexia, colic, uncoordinated movements, sudden jumps, trembling and dyspnea. Autopsy showed the stomach full or containing a bloody, greenish pap like substance; the large intestine almost always full or soft, bloody, diarrheic fecal matter; small discolored spots in the liver approximately 4 millimeters in diameter; and Tardieu's spots in the lungs. Tungstate was found in the stomach, intestine, their content and walls, liver, kidneys, lungs, blood and urine. Hypodermic administration of doses ranging from 0.10-0.50 gram gave more pronounced and sustained symptoms. Autopsy showed intense liver congestion, large infarction in each lung, dark blood in the heart, and yellow patches of degeneration in the liver and kidneys. The studies with the molybdenum (7439987) compound showed it to be less toxic than the tungsten (7440337) compound. Both act as slow toxins, with death resulting from asphyxial symptoms. Tests

for detecting tungsten and molybdenum in biological materials are briefly outlined. (French; English translation available).

4.
**Tungsten, Alloys And Compounds.**
Lee S, Kye RK.
In: Encyclopaedia of Occupational Health and Safety, Volume 2.
(1983), pp 2225-2226.
The hazards of tungsten (7440337) and its alloys and compounds are reviewed. Safety and health measures are recommended. Chemical and physical properties are listed. Countries that produce tungsten are named. Occurrence of tungsten in the environment is examined. Production methods are summarized. Tungsten is used in the production of tungsten steel, in lamp vacuum tubes, electric contacts, X-ray tubes, and fluorescent light tubes. In toxicity studies, the median lethal dose of sodium-tungstate (12737869) was determined to be between 223 and 255 milligrams per kilogram in rats and showed significant postprandial and age effects. Feeding studies resulted in no marked effects. Industrial exposure is not a significant health hazard. Hazards are related to substances associated with the production and uses of tungsten instead of tungsten itself; these hazards relate to quartz (14808607) dust and cobalt (7440484) fumes. The incidence of accidents and diseases in tungsten mines and mills is not well documented. Ventilation is one of the most important engineering control measures. General safety recommendations such as good housekeeping and hygiene, protective clothing and equipment, preemployment medical screening, and periodic medical examinations are suggested.

5.
**Tungsten and Its Compounds.**
Svartengren M, Elinder CG.
In: Occupational Medicine.
Zenz C, Dickerson OB, Horvath EP, Jr., eds.
St. Louis, USA, Mosby-Year Book, Inc, (1994), pp 582-583.
The production, use, and health effects of tungsten (7440337) and its compounds were discussed in this review. Due to the extreme hardness of this metal, it has found wide industrial applications in power tools and has replaced diamond in many drills. At least 30,000 employees in the United States have been estimated to be at potential risk for exposure to tungsten and its compounds. Following inhalation, tungsten was found to collect in the bone, lung, and kidney of experimental animals. Tungsten and its compounds have been identified in the lungs of patients with hard metal exposure. A tungsten-carbide (12070121)/cobalt (7440484) mixture has been reported to be cytotoxic in an in-vitro system and the addition of tungsten-carbide to a cobalt instillation mixture in experimental animals resulted in severe alveolitis and fatal pulmonary edema, while only a moderate inflammatory response was seen with cobalt alone. The effects of tungsten exposure on humans have not been determined as no cases of exposure to tungsten or tungsten compounds alone without concomitant exposure to other agents have been reported. The recommended threshold limit values have been 5mg/m3 and 1mg/m3 for insoluble and soluble tungsten compounds, respectively.

6.
**Cytogenetic Effects of Inorganic Compounds of Tungsten, Zinc, Cadmium and Cobalt on Animal and Human Cells.**
Voroshilin S, I, Plotko EG, Fink T, V, Nikiforova VY.
*Tsitologiya i Genetika* 12(3): 241-243. (1978) (russian)
A study was conducted on the mutagenic activities of tungsten (7440337), zinc (7440020), cadmium (7440439), and cobalt (7440484) salts. In-vitro toxicity was assessed in human leukocytes exposed to the test compounds and in-vivo effects were determined following exposure of rats to aerosols of zinc-oxide (1314132). An increase in the frequency of chromosomal alterations was seen following exposure of the leukocytes to all of the compounds. The lowest concentrations of the metals demonstrating mutagenic activity were close to or higher than those reported in the literature in the blood of workers occupationally exposed to such compounds. Aberrations induced by exposure to tungsten, cadmium, or cobalt included hyperdiploid cells while chromosomal aberrations were noted following exposure to zinc. A statistically significant increase in hyperdiploid cells in the bone marrow was seen following in-vivo exposure of rats to zinc-oxide aerosol.

# Annex 2: Literature Search on the Environmental Fate and Behaviour of Tungsten (titles only)

# Fate and Behaviour Titles

30/TI,AN/1 (Item 1 from file: 5)
DIALOG(R)File 5:(c) 2005 BIOSIS. All rts. reserv.

Metal leachability and anthropogenic signal in roadside soils estimated from sequential extraction and stable lead isotopes.

30/TI,AN/2 (Item 2 from file: 5)
DIALOG(R)File 5:(c) 2005 BIOSIS. All rts. reserv.

Factor analytical approaches for evaluating groundwater trace element chemistry data.

30/TI,AN/3 (Item 3 from file: 5)
DIALOG(R)File 5:(c) 2005 BIOSIS. All rts. reserv.

Cross-sectional exposure assessment of environmental contaminants in Churchill County, Nevada.

30/TI,AN/4 (Item 4 from file: 5)
DIALOG(R)File 5:(c) 2005 BIOSIS. All rts. reserv.

Natural contribution of harmful elements in thermal groundwaters of Ischia Island (southern Italy).

30/TI,AN/5 (Item 5 from file: 5)
DIALOG(R)File 5:(c) 2005 BIOSIS. All rts. reserv.

Effects of high molybdenum intake on 1,2-dimethylhydrazine-induced intestinal tumors in rats.

30/TI,AN/6 (Item 6 from file: 5)
DIALOG(R)File 5:(c) 2005 BIOSIS. All rts. reserv.

Relationship between ore deposits in river catchments and geochemistry of suspended particulate matter from six rivers in southwest France.

30/TI,AN/7 (Item 7 from file: 5)
DIALOG(R)File 5:(c) 2005 BIOSIS. All rts. reserv.

Target for production of x-rays

30/TI,AN/8 (Item 8 from file: 5)
DIALOG(R)File 5:(c) 2005 BIOSIS. All rts. reserv.

Arsenic, Sb and Bi contamination of soils, plants, waters and sediments in the vicinity of the Dalsung Cu-W mine in Korea

30/TI,AN/9 (Item 9 from file: 5)
DIALOG(R)File 5:(c) 2005 BIOSIS. All rts. reserv.

Geochemical behaviors of multi-elements in water samples from the Fuji and Sagami rivers, Central Japan, using vanadium as an effective indicator

30/TI,AN/10 (Item 10 from file: 5)
DIALOG(R)File 5:(c) 2005 BIOSIS. All rts. reserv.

Simultaneous separation and preconcentration of trace elements in water samples by coprecipitation on manganese dioxide using D-glucose as reductant for KMnO4

30/TI,AN/11 (Item 11 from file: 5)
DIALOG(R)File 5:(c) 2005 BIOSIS. All rts. reserv.

Trace elements in blood and serum of Swedish adolescents: Relation to gender, age, residential area, and socioeconomic status

30/TI,AN/12 (Item 12 from file: 5)
DIALOG(R)File 5:(c) 2005 BIOSIS. All rts. reserv.

Exposure assessment in the hard metal manufacturing industry with special regard to tungsten and its compounds

30/TI,AN/13 (Item 13 from file: 5)
DIALOG(R)File 5:(c) 2005 BIOSIS. All rts. reserv.

The leaching behavior of cement stabilized air pollution control residues: A comparison of field and laboratory investigations

30/TI,AN/14 (Item 14 from file: 5)
DIALOG(R)File 5:(c) 2005 BIOSIS. All rts. reserv.

A selenopyrylium photosensitizer for photodynamic therapy related in structure to the antitumor agent AA1 with potent in vivo activity and no long-term skin photosensitization

30/TI,AN/15 (Item 15 from file: 5)
DIALOG(R)File 5:(c) 2005 BIOSIS. All rts. reserv.

Modelling of a 188W/188Re beta line source for coronary brachytherapy by means of EGS4 Monte Carlo simulations

30/TI,AN/16 (Item 16 from file: 5)
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Long-term leaching of trace elements in a heavily sludge-amended silty clay
loam soil

30/TI,AN/17 (Item 17 from file: 5)
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Selective determination of ultra trace concentrations of molybdenum by

catalytic adsorptive stripping voltammetry

30/TI,AN/18 (Item 18 from file: 5)
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Cobalt

30/TI,AN/19 (Item 19 from file: 5)
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Determination of sulfates in drinking water

30/TI,AN/20 (Item 20 from file: 5)
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Postprocess contamination of flexible pouches challenged by in situ immersion biotest

30/TI,AN/21 (Item 21 from file: 5)
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A model of the distribution and retention of tungsten in the human body

30/TI,AN/22 (Item 22 from file: 5)
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The determination of metals (antimony, bismuth, lead, cadmium, mercury, palladium, platinum, tellurium, thallium, tin and tungsten) in urine samples by inductively coupled plasma-mass spectrometry

30/TI,AN/23 (Item 23 from file: 5)
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A new method for assessing the gloss of human skin

30/TI,AN/24 (Item 24 from file: 5)
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Comparison of direct alpha spectrometry and neutron activation analysis of aerosol filters for determination of workplace thorium air concentrations

30/TI,AN/25 (Item 25 from file: 5)
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Airborne inorganic fibre level monitoring by transmission electron microscope (TEM): Comparison of direct and indirect sample transfer methods

30/TI,AN/26 (Item 26 from file: 5)
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Exposure to airborne metals in the manufacture and maintenance of hard

metal and stellite blades

30/TI,AN/27 (Item 27 from file: 5)
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Measurements of air concentrations of thorium during grinding and welding operations using thoriated Tungsten electrodes

30/TI,AN/28 (Item 28 from file: 5)
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Maintenance of stellite and tungsten carbide saw tips, determinants of exposure to cobalt and chromium

30/TI,AN/29 (Item 29 from file: 5)
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Complex assessment of environmental pollution and level of genetic aberrations in residents of Atbasar town (Kazakhstan)

30/TI,AN/30 (Item 30 from file: 5)
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Health risks associated with cobalt exposure: An overview

30/TI,AN/31 (Item 31 from file: 5)
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Biologic monitoring of chromium and nickel among stainless steel welders using the Tungsten inert gas-method

30/TI,AN/32 (Item 32 from file: 5)
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Epidemiological survey of workers exposed to cobalt oxides, cobalt salts, and cobalt metal

30/TI,AN/33 (Item 33 from file: 5)
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Evaluation of personal breathing zone and area air concentrations of thorium during grinding and welding operations using thoriated tungsten electrodes

30/TI,AN/34 (Item 34 from file: 5)
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A NESTED CASE-CONTROL STUDY OF LUNG CANCER AMONG SILICA EXPOSED WORKERS IN CHINA

30/TI,AN/35 (Item 35 from file: 5)
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DETERMINATION OF LEAD IN WATER BY ELECTROTHERMAL ATOMIC ABSORPTION SPECTROMETRY WITH A NICKEL-II AMMONIUM TARTRATE MODIFIER

30/TI,AN/36 (Item 36 from file: 5)
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BIOLOGICAL RESPONSES OF ISOLATED MACROPHAGES TO COBALT METAL AND TUNGSTEN CARBIDE COBALT POWDERS

30/TI,AN/37 (Item 37 from file: 5)
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DETERMINATION OF MOLYBDENUM BY ATOMIC-ABSORPTION SPECTROMETRY AFTER SEPARATION BY 5 5' METHYLENEDISALICYLOHYDROXAMIC ACID EXTRACTION AND FURTHER REACTION WITH THIOCYANATE AND TIN-II

30/TI,AN/38 (Item 38 from file: 5)
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ROLE OF BIOGENIC PROCESSES IN THE FORMATION OF VULCANOGENIC-SEDIMENTARY SULFIDE AND TUNGSTEN MINERALIZATION

30/TI,AN/39 (Item 39 from file: 5)
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EFFECT OF HEAVY METAL ENVIRONMENTAL POLLUTION ON THE STRUCTURE OF THE INTERPHASE NUCLEI OF HUMAN SOMATIC CELLS

30/TI,AN/40 (Item 40 from file: 5)
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TRACE OXYANIONS AND THEIR BEHAVIOR IN THE RIVERS PORONG AND SOLO JAVA INDONESIA THE JAVA SEA AND THE ADJACENT INDIAN OCEAN

30/TI,AN/41 (Item 41 from file: 5)
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ANALYSIS OF DUSTS AND EVALUATION OF DUST EXPOSURE IN A HARD METAL FACTORY

30/TI,AN/42 (Item 42 from file: 5)
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PRIMARY PRODUCTION AND PIGMENTS IN THREE LOW ALKALINITY CONNECTED RESERVOIRS RECEIVING MINE WASTES

30/TI,AN/43 (Item 43 from file: 5)
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EFFECTS OF STUDDED TIRES ON ROADSIDE AIRBORNE DUST POLLUTION IN NIIGATA JAPAN

30/TI,AN/44 (Item 44 from file: 5)
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RESPIRATORY DISEASE IN TUNGSTEN CARBIDE PRODUCTION WORKERS

30/TI,AN/45 (Item 45 from file: 5)
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HARD METAL LUNG DISEASE IMPORTANCE OF COBALT IN COOLANTS

30/TI,AN/46 (Item 46 from file: 5)
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STUDIES ON POLLUTANTS 3. ANALYSIS OF URANIUM AT MICROGRAM AND MILLIGRAM LEVELS IN WATERS WITH N-O METHOXYNAPHTHOYL-N-P-TOLYL HYDROXYLAMINE

30/TI,AN/47 (Item 47 from file: 5)
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DOCUMENTATION OF ENVIRONMENTAL EXPOSURE USING OPEN BIOPSY TRANS BRONCHIAL BIOPSY AND BRONCHO PULMONARY LAVAGE IN GIANT CELL INTERSTITIAL PNEUMONIA

30/TI,AN/48 (Item 48 from file: 5)
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NEW DATA FOR STANDARDIZATION OF TUNGSTEN AND MOLYBDENUM IN THEIR SEPARATE AND SIMULTANEOUS PRESENCE IN WATER BODIES

30/TI,AN/49 (Item 49 from file: 5)
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ROLE OF SOIL ORGANIC MATTER IN A DESERT SOIL ON PLANT RESPONSE TO SILVER TUNGSTEN COBALT AND LEAD

30/TI,AN/50 (Item 50 from file: 5)
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EFFECTS OF TRACE ELEMENTS ON UREASE ACTIVITY IN SOILS

30/TI,AN/51 (Item 51 from file: 5)
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THE ACCUMULATION OF TUNGSTEN BY NOTHOFAGUS-MENZIESII

30/TI,AN/52 (Item 1 from file: 40)
DIALOG(R)File 40:

00677128
Factors Controlling Tungsten Concentrations in Ground Water, Carson Desert,
Nevada

30/TI,AN/53 (Item 2 from file: 40)
DIALOG(R)File 40:

00671305
Fluorescence Quenching Method for Determination of Trace Tungsten in
Environmental Samples with Dibromohydroxyphenylfluorone

30/TI,AN/54 (Item 3 from file: 40)
DIALOG(R)File 40:

00655220
Toxicological Profile for Tungsten

30/TI,AN/55 (Item 4 from file: 40)
DIALOG(R)File 40:

00633619
Investigation of Influence of Tungsten Mine Wastes on the Elemental
Composition of Some Alpine and Subalpine Plants on Mount Uludag, Bursa, Turkey

30/TI,AN/56 (Item 5 from file: 40)
DIALOG(R)File 40:

00629544
Heavy Metals in Aquatic Bryophytes from the Ore Mountains (Germany)

30/TI,AN/57 (Item 6 from file: 40)
DIALOG(R)File 40:

00620814
ETAAS Determination of Copper in Sediments Using W-Rh Permanent Modifier

30/TI,AN/58 (Item 7 from file: 40)
DIALOG(R)File 40:

00597382
Application of Waste Ashes to Agricultural Land-Effect of Incineration
Temperature on Chemical Characteristics

30/TI,AN/59 (Item 8 from file: 40)
DIALOG(R)File 40:

00581016
Metal Cycling Along the Northwestern Seward Peninsula, Alaska: A Possible
Natural Cause of Metal Contamination in the Arctic

30/TI,AN/60 (Item 9 from file: 40)
DIALOG(R)File 40:

00457079
Inhibition of Mercury Methylation in Anoxic Freshwater Sediment by Group VI
Anions

30/TI,AN/61 (Item 10 from file: 40)
DIALOG(R)File 40:

00429099
Environmental Contamination by Cobalt in the Vicinity of a Cemented
Tungsten Carbide Tool Grinding Plant

30/TI,AN/62 (Item 11 from file: 40)
DIALOG(R)File 40:

00385969
Mineral Resources of the Diablo Mountain Wilderness Study Area, Lake
County, Oregon

30/TI,AN/63 (Item 12 from file: 40)
DIALOG(R)File 40:

00383551
Geochemical Exploration in the Jilove Belt: Case History of the Celina
Deposit, Bohemian Massif, Czechoslovakia

30/TI,AN/64 (Item 13 from file: 40)
DIALOG(R)File 40:

00371059
Mineral Resources of the Sierra de las Canas Wilderness Study Area, Socorro
County, New Mexico

30/TI,AN/65 (Item 14 from file: 40)
DIALOG(R)File 40:

00363766
Trace Elements in Magnetic Concentrates from Stream Sediments in
Southwestern New Mexico: a Potential Tool for Reconnaissance Geochemical
Exploration in Arid Lands

30/TI,AN/66 (Item 15 from file: 40)
DIALOG(R)File 40:

00304382
Analyse DES Elements Traces Dans les Eaux Naturelles PAR Activation
Neutronique (Aan) Et Absorption Atomique (Saa)

30/TI,AN/67 (Item 16 from file: 40)
DIALOG(R)File 40:

00261655
Agrostis castellana and Agrostis delicatula on Heavy Metal and Arsenic
Enriched Sites in NE Portugal

30/TI,AN/68 (Item 17 from file: 40)
DIALOG(R)File 40:

00254953
The Alaska Mineral Resource Assessment Program: Background Information to
Accompany Mineral-Resource and Geologic Maps of the Anchorage Quadrangle, South-Central Alaska

30/TI,AN/69 (Item 1 from file: 50)
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0008703968 CAB Accession Number: 20043118056
Elements and their compounds in the environment: occurrence, analysis and biological relevance.
Elements and their compounds in the environment: occurrence, analysis and biological relevance

30/TI,AN/70 (Item 2 from file: 50)
DIALOG(R)File 50:(c) 2005 CAB International. All rts. reserv.

0008607481 CAB Accession Number: 20043051683
Surface-water quality for the Sali River watershed in NW Argentina.

30/TI,AN/71 (Item 3 from file: 50)
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0008595811 CAB Accession Number: 20043044733
Analysis of 57 elements in Japanese soils, with special reference to soil group and agricultural use.

30/TI,AN/72 (Item 4 from file: 50)
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0008414231 CAB Accession Number: 20033039794
Toxicity of density separation media to Escherichia coli and Mycobacterium strain PC01: implications for density-separation of soils
and sediments.

30/TI,AN/73 (Item 5 from file: 50)
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0008180855 CAB Accession Number: 20023034937
Geochemical atlas of the Slovak Republic. Part V: Soils.
Geochemical atlas of the Slovak Republic. Part V: Soils

30/TI,AN/74 (Item 6 from file: 50)
DIALOG(R)File 50:(c) 2005 CAB International. All rts. reserv.

0007712512 CAB Accession Number: 19991905746
Heavy metal concentration of soils and plants in Baekdong serpentinite area, Chungnam - a case of Pinus densiflora and Pinus rigida .

30/TI,AN/75 (Item 7 from file: 50)
DIALOG(R)File 50:(c) 2005 CAB International. All rts. reserv.

0006075120 CAB Accession Number: 19891932725
Determination of tungstate in soils and sludges by using single-column ion chromatography.

30/TI,AN/76 (Item 8 from file: 50)
DIALOG(R)File 50:(c) 2005 CAB International. All rts. reserv.

0004964263 CAB Accession Number: 19802603430
The distribution of tungsten in limestone contact environments as viewed at the Silver Bell Mine, Dos Cabezas Mountains, southeastern Arizona Geosciences Daze, Student Presentations in the Geosciences, March 5-7, 1980, Tucson, Arizona, 8th Annual.

30/TI,AN/77 (Item 9 from file: 50)
DIALOG(R)File 50:(c) 2005 CAB International. All rts. reserv.

0004129922 CAB Accession Number: 19740324918
Long Ashton Research Station - Report 1973.

30/TI,AN/78 (Item 10 from file: 50)
DIALOG(R)File 50:(c) 2005 CAB International. All rts. reserv.

0004118983 CAB Accession Number: 19730603853
The tungsten content of some plants from a mineralised area in New Zealand.

30/TI,AN/79 (Item 1 from file: 34)
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14000820
Title: Rapid degradation of bisphenol A using air as the oxidant catalyzed by polynuclear phthalocyanine complexes under visible light irradiation

30/TI,AN/80 (Item 2 from file: 34)
DIALOG(R)File 34:(c) 2005 Inst for Sci Info. All rts. reserv.

13972771
Title: Mineral/water interactions in tailings from a tungsten mine, Mount Pleasant, New Brunswick

30/TI,AN/81 (Item 3 from file: 34)
DIALOG(R)File 34:(c) 2005 Inst for Sci Info. All rts. reserv.

13857572
Title: Effects of microstructure and environment on fatigue properties of investment cast Ti-6Al-4V alloy welds

30/TI,AN/82 (Item 4 from file: 34)
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13760513
Title: Release of trace oxyanions from littoral sediments and suspended particles induced by pH increase in the epilimnion of lakes

30/TI,AN/83 (Item 5 from file: 34)
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13671672
Title: Inductively coupled plasma mass spectrometry to measure multiple toxic elements in urine in NHANES 1999-2000

30/TI,AN/84 (Item 6 from file: 34)
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13378795
Title: A Monte Carlo dosimetry study of vaginal Ir-192 brachytherapy applications with a shielded cylindrical applicator set

30/TI,AN/85 (Item 7 from file: 34)
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13228783
Title: The structure and electrical conductivity of vacuum-annealed WO3 thin films

30/TI,AN/86 (Item 8 from file: 34)
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12830568
Title: The reduction of tris-dithiolene complexes of molybdenum(VI) and tungsten(VI) by hydroxide ion: Kinetics and mechanism

30/TI,AN/87 (Item 9 from file: 34)
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12596610
Title: The interface between benzenes (C6H6; C6H5Cl;2-C6H4OHCl) and amorphous solid water studied with metastable impact electron spectroscopy and ultraviolet photoelectron spectroscopy (HeI and II)

30/TI,AN/88 (Item 10 from file: 34)
DIALOG(R)File 34:(c) 2005 Inst for Sci Info. All rts. reserv.

12465895
Title: Radiological design study of First Optics Enclosure against secondary gas bremsstrahlung for the Canadian Light Source

30/TI,AN/89 (Item 11 from file: 34)
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12404003
Title: Attractive or repulsive interactions in different structure types

30/TI,AN/90 (Item 12 from file: 34)
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12388892
Title: Environmental and health consequences of depleted uranium use in the
1991 Gulf War

30/TI,AN/91 (Item 13 from file: 34)
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12316067
Title: Tribological performance of a DLC coating in combination with water-based lubricants

30/TI,AN/92 (Item 14 from file: 34)
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11999491
Title: Effect of NH3 thermal treatment on an atomic layer deposited on tungsten films and formation of W-B-N

30/TI,AN/93 (Item 15 from file: 34)
DIALOG(R)File 34:(c) 2005 Inst for Sci Info. All rts. reserv.

11999487
Title: Selective sublimation processing of a molybdenum-tungsten mixed oxide thin film

30/TI,AN/94 (Item 16 from file: 34)
DIALOG(R)File 34:(c) 2005 Inst for Sci Info. All rts. reserv.

11996204
Title: Structure analysis of the constitutional phases in liquid phase sintered W-Mo-Ni-Fe heavy alloys

30/TI,AN/95 (Item 17 from file: 34)
DIALOG(R)File 34:(c) 2005 Inst for Sci Info. All rts. reserv.

11977977
Title: Ionization and solvation of CsCl interacting with solid water

30/TI,AN/96 (Item 18 from file: 34)
DIALOG(R)File 34:(c) 2005 Inst for Sci Info. All rts. reserv.

11877911
Title: A room-temperature operated hydrogen leak sensor

30/TI,AN/97 (Item 19 from file: 34)
DIALOG(R)File 34:(c) 2005 Inst for Sci Info. All rts. reserv.

11877860
Title: Sensing characteristics of an optical fiber sensor for hydrogen leak

30/TI,AN/98 (Item 20 from file: 34)
DIALOG(R)File 34:(c) 2005 Inst for Sci Info. All rts. reserv.

11721492
Title: Kinetic modeling for methane reforming with carbon dioxide over a mixed-metal carbide catalyst

30/TI,AN/99 (Item 21 from file: 34)
DIALOG(R)File 34:(c) 2005 Inst for Sci Info. All rts. reserv.

11583876
Title: Determination of halogens by low-pressure helium ICP-MS

30/TI,AN/100 (Item 22 from file: 34)
DIALOG(R)File 34:(c) 2005 Inst for Sci Info. All rts. reserv.

11516699
Title: The effect of relative humidity on wear of a diamond-like carbon coating

30/TI,AN/101 (Item 23 from file: 34)
DIALOG(R)File 34:(c) 2005 Inst for Sci Info. All rts. reserv.

11488422
Title: Photocurrent spectroscopy study of passive films on hafnium and hafnium-tungsten sputtered alloys

30/TI,AN/102 (Item 24 from file: 34)
DIALOG(R)File 34:(c) 2005 Inst for Sci Info. All rts. reserv.

11353407
Title: Effects of helium bombardment on the deuterium behavior in tungsten

30/TI,AN/103 (Item 25 from file: 34)
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11266789
Title: Effects of breach size and dust density on activated dust mobilization in ITER during a loss-of-vacuum event

30/TI,AN/104 (Item 26 from file: 34)
DIALOG(R)File 34:(c) 2005 Inst for Sci Info. All rts. reserv.

11101555

Title: Mechanical and tribological properties of aluminide coating modified
with yttrium

30/TI,AN/105 (Item 27 from file: 34)
DIALOG(R)File 34:(c) 2005 Inst for Sci Info. All rts. reserv.

11098024
Title: Energy-loss straggling algorithms for Monte Carlo electron transport

30/TI,AN/106 (Item 28 from file: 34)
DIALOG(R)File 34:(c) 2005 Inst for Sci Info. All rts. reserv.

11081795
Title: Advanced Hi-Fill (R) for interconnect liner applications

30/TI,AN/107 (Item 29 from file: 34)
DIALOG(R)File 34:(c) 2005 Inst for Sci Info. All rts. reserv.

10775033
Title: Modelling the response of a tungsten oxide semiconductor as a gas sensor for the measurement of ozone

30/TI,AN/108 (Item 30 from file: 34)
DIALOG(R)File 34:(c) 2005 Inst for Sci Info. All rts. reserv.

10760113
Title: Reactive RF magnetron sputtering deposition of WO3 thin films

30/TI,AN/109 (Item 31 from file: 34)
DIALOG(R)File 34:(c) 2005 Inst for Sci Info. All rts. reserv.

10688043
Title: In situ four-point conductivity and Hall effect apparatus for vacuum
and controlled atmosphere measurements of thin film materials

30/TI,AN/110 (Item 32 from file: 34)
DIALOG(R)File 34:(c) 2005 Inst for Sci Info. All rts. reserv.

10348842
Title: Synthesis and X-ray characterization of nickel(II) arsenatotungstate
complexes: isolation of an intermediate leading to the formation of a sandwich-type polyoxometalate

30/TI,AN/111 (Item 33 from file: 34)
DIALOG(R)File 34:(c) 2005 Inst for Sci Info. All rts. reserv.

10331851
Title: "Seedless" electrochemical deposition of copper on physical vapor deposition-W2N liner materials for ultra large scale integration (ULSI) devices

30/TI,AN/112 (Item 34 from file: 34)
DIALOG(R)File 34:(c) 2005 Inst for Sci Info. All rts. reserv.

10130760
Title: A contribution to the surface analysis and characterisation of HVOF coatings for petrochemical application

30/TI,AN/113 (Item 35 from file: 34)
DIALOG(R)File 34:(c) 2005 Inst for Sci Info. All rts. reserv.

09983589
Title: Tritium contamination and decontamination study on materials for ITER remote handling equipment

30/TI,AN/114 (Item 36 from file: 34)
DIALOG(R)File 34:(c) 2005 Inst for Sci Info. All rts. reserv.

09812027
Title: Semiconductor gas sensors based on nanostructured tungsten oxide

30/TI,AN/115 (Item 37 from file: 34)
DIALOG(R)File 34:(c) 2005 Inst for Sci Info. All rts. reserv.

09811420
Title: Nanocrystalline tungsten oxide thick-films with high sensitivity to H2S at room temperature

30/TI,AN/116 (Item 38 from file: 34)
DIALOG(R)File 34:(c) 2005 Inst for Sci Info. All rts. reserv.

09794106
Title: An improved flow system for spectrophotometric determination of anions exploiting multicommutation and multidetection

30/TI,AN/117 (Item 39 from file: 34)
DIALOG(R)File 34:(c) 2005 Inst for Sci Info. All rts. reserv.

09750623
Title: Electroless-deposited Ag-W films for microelectronics applications

30/TI,AN/118 (Item 40 from file: 34)
DIALOG(R)File 34:(c) 2005 Inst for Sci Info. All rts. reserv.

09537996
Title: Oxidation and volatilization from tantalum alley during air exposure

30/TI,AN/119 (Item 41 from file: 34)
DIALOG(R)File 34:(c) 2005 Inst for Sci Info. All rts. reserv.

09385468
Title: The role of tungsten in formation of active sites for no SCR on the

V-W-O catalyst surface - quantum chemical modeling (DFT)

30/TI,AN/120 (Item 42 from file: 34)
DIALOG(R)File 34:(c) 2005 Inst for Sci Info. All rts. reserv.

09278943
Title: Catalysis on Pd/WO3 and Pd/WO2 - II. Effect of redox treatments in hexanes and hexenes re-forming reactions

30/TI,AN/121 (Item 43 from file: 34)
DIALOG(R)File 34:(c) 2005 Inst for Sci Info. All rts. reserv.

09174025
Title: Cathodic insertion of ions in tungsten(VI) oxide from aqueous media

30/TI,AN/122 (Item 44 from file: 34)
DIALOG(R)File 34:(c) 2005 Inst for Sci Info. All rts. reserv.

09036979
Title: Micelle formation in liquid - Liquid extraction of tungsten(VI), molybdenum(VI), and rhenium(VII) by diisododecylamine, dioctylamine, and trioctylamine from sulfuric acid solutions

30/TI,AN/123 (Item 45 from file: 34)
DIALOG(R)File 34:(c) 2005 Inst for Sci Info. All rts. reserv.

08976737
Title: Thin films of fullerene-like MoS2 nanoparticles with ultra-low friction and wear

30/TI,AN/124 (Item 46 from file: 34)
DIALOG(R)File 34:(c) 2005 Inst for Sci Info. All rts. reserv.

08879038
Title: Anodic behavior of tungsten in water-organic solutions of sodium chloride

30/TI,AN/125 (Item 47 from file: 34)
DIALOG(R)File 34:(c) 2005 Inst for Sci Info. All rts. reserv.

08855466
Title: Variations in the surface structure and composition of tungsten oxynitride catalyst caused by exposure to air

30/TI,AN/126 (Item 48 from file: 34)
DIALOG(R)File 34:(c) 2005 Inst for Sci Info. All rts. reserv.

08790775
Title: Spectroscopic studies of the tungsten-containing formaldehyde ferredoxin oxidoreductase from the hyperthermophilic archaeon Thermococcus litoralis

30/TI,AN/127 (Item 49 from file: 34)

DIALOG(R)File 34:(c) 2005 Inst for Sci Info. All rts. reserv.

08700200
Title: High productivity methanol carbonylation catalysis using iridium - The Cativa(TM) process for the manufacture of acetic acid

30/TI,AN/128 (Item 50 from file: 34)
DIALOG(R)File 34:(c) 2005 Inst for Sci Info. All rts. reserv.

08573581
Title: Preparation and crystal structures of formato complexes of the [(M3O4)-O-IV](4+) and [(M3S4)-S-IV](4+) (M = Mo, W) clusters. Convenient precursors to the corresponding aqua complexes

30/TI,AN/129 (Item 51 from file: 34)
DIALOG(R)File 34:(c) 2005 Inst for Sci Info. All rts. reserv.

08550275
Title: Synthesis and molding of niobium oxynitrides with macropores generation - Reactivity and stability in cyclohexane dehydrogenation

30/TI,AN/130 (Item 52 from file: 34)
DIALOG(R)File 34:(c) 2005 Inst for Sci Info. All rts. reserv.

08512016
Title: Extraction of tungsten (VI), molybdenum (VI) and rhenium (VII) by diisododecylamine

30/TI,AN/131 (Item 53 from file: 34)
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08502447
Title: Analyses of loss of vacuum accident (LOVA) in ITER

30/TI,AN/132 (Item 54 from file: 34)
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08486534
Title: The corrosion of materials in water irradiated by 800 MeV protons

30/TI,AN/133 (Item 55 from file: 34)
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08415647
Title: Oxyanion concentrations in eastern Sierra Nevada rivers - 3. Boron, molybdenum, vanadium, and tungsten

30/TI,AN/134 (Item 56 from file: 34)
DIALOG(R)File 34:(c) 2005 Inst for Sci Info. All rts. reserv.

08208199
Title: Contrasting behavior of tungsten and molybdenum in the Okinawa Trough, the East China Sea and the Yellow Sea

30/TI,AN/135 (Item 57 from file: 34)
DIALOG(R)File 34:(c) 2005 Inst for Sci Info. All rts. reserv.

08206583
Title: Electrochemical study of copper in a basic 1-ethyl-3-methylimidazolium tetrafluoroborate room temperature molten salt

30/TI,AN/136 (Item 58 from file: 34)
DIALOG(R)File 34:(c) 2005 Inst for Sci Info. All rts. reserv.

07948401
Title: Low-stress W/Cr films for SCALPEL(R) mask scattering layers

30/TI,AN/137 (Item 59 from file: 34)
DIALOG(R)File 34:(c) 2005 Inst for Sci Info. All rts. reserv.

07861009
Title: Characterization of sol-gel prepared WO3 thin films as a gas sensor

30/TI,AN/138 (Item 60 from file: 34)
DIALOG(R)File 34:(c) 2005 Inst for Sci Info. All rts. reserv.

07789448
Title: The biochemical diversity of life near and above 100 degrees C in marine environments

30/TI,AN/139 (Item 61 from file: 34)
DIALOG(R)File 34:(c) 2005 Inst for Sci Info. All rts. reserv.

07707781
Title: Tribology of tungsten disulfide films in humid environments: The role of a tailored metal-matrix composite substrate

30/TI,AN/140 (Item 62 from file: 34)
DIALOG(R)File 34:(c) 2005 Inst for Sci Info. All rts. reserv.

07549097
Title: Direct visualization of the dynamic behavior of a water meniscus by scanning electron microscopy

30/TI,AN/141 (Item 63 from file: 34)
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07370720
Title: Resonant grating sensors using frustrated total-internal reflection

30/TI,AN/142 (Item 64 from file: 34)
DIALOG(R)File 34:(c) 2005 Inst for Sci Info. All rts. reserv.

07290606
Title: Design and performance of a high velocity air-sand jet impingement erosion facility

30/TI,AN/143 (Item 65 from file: 34)
DIALOG(R)File 34:(c) 2005 Inst for Sci Info. All rts. reserv.

07067363
Title: Creep properties of non-sag tungsten recrystallized in stagnant oxygen-doped argon

30/TI,AN/144 (Item 66 from file: 34)
DIALOG(R)File 34:(c) 2005 Inst for Sci Info. All rts. reserv.

06964160
Title: Chemical vapor deposition in the corona discharge of electrostatic air cleaners

30/TI,AN/145 (Item 67 from file: 34)
DIALOG(R)File 34:(c) 2005 Inst for Sci Info. All rts. reserv.

06881630
Title: Gasochromic effect in platinum-doped tungsten trioxide films prepared by the sol-gel method

30/TI,AN/146 (Item 68 from file: 34)
DIALOG(R)File 34:(c) 2005 Inst for Sci Info. All rts. reserv.

06506136
Title: Catalytic decomposition of hydrazine as a source of power

30/TI,AN/147 (Item 69 from file: 34)
DIALOG(R)File 34:(c) 2005 Inst for Sci Info. All rts. reserv.

06341851
Title: Grain refinement and hydrogen embrittlement in iron aluminide alloy FA129

30/TI,AN/148 (Item 70 from file: 34)
DIALOG(R)File 34:(c) 2005 Inst for Sci Info. All rts. reserv.

06322160
Title: Studies on layer disorder, microstructural parameters and other properties of tungsten-substituted molybdenum disulfide, Mo1-xWxS2 (0<=x<=1)

30/TI,AN/149 (Item 71 from file: 34)
DIALOG(R)File 34:(c) 2005 Inst for Sci Info. All rts. reserv.

06047169
Title: Direct evolution of W-rich brines from crystallizing melt within the
Mariktikan granite pluton, west Transbaikalia

30/TI,AN/150 (Item 72 from file: 34)
DIALOG(R)File 34:(c) 2005 Inst for Sci Info. All rts. reserv.

05994767
Title: Corrosion behavior of Ni-Cr-base commercial alloys in flowing Ar-42.6%O-2-14.7%Br-2 gas mixture et 700 degrees C

30/TI,AN/151 (Item 73 from file: 34)
DIALOG(R)File 34:(c) 2005 Inst for Sci Info. All rts. reserv.

05943291
Title: Studies on layer disorder, microstructural parameters and other properties of tantalum substituted tungsten-molybdenum selenide, W0.65Mo0.35-xTaxSe2 (0<=x<=0.35)

30/TI,AN/152 (Item 74 from file: 34)
DIALOG(R)File 34:(c) 2005 Inst for Sci Info. All rts. reserv.

05806761
Title: Synthesis of diamond by DC plasma chemical vapor deposition above the surface of a water-ethylene glycol solution

30/TI,AN/153 (Item 75 from file: 34)
DIALOG(R)File 34:(c) 2005 Inst for Sci Info. All rts. reserv.

05803014
Title: Spatially resolved measurements of absolute CH3 concentration in a hot-filament reactor

30/TI,AN/154 (Item 76 from file: 34)
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05802977
Title: Insulating diamond coatings on tungsten electrodes

30/TI,AN/155 (Item 77 from file: 34)
DIALOG(R)File 34:(c) 2005 Inst for Sci Info. All rts. reserv.

05708448
Title: Magnetic properties of graphitically encapsulated nickel nanocrystals

30/TI,AN/156 (Item 78 from file: 34)
DIALOG(R)File 34:(c) 2005 Inst for Sci Info. All rts. reserv.

05707052
Title: Interaction of water with clean and gold-precovered tungsten field emitters: Adsorption and desorption

30/TI,AN/157 (Item 79 from file: 34)
DIALOG(R)File 34:(c) 2005 Inst for Sci Info. All rts. reserv.

05603457
Title: Effect of filler type on the response of polysiloxane elastomers to cyclic stress at elevated temperatures

30/TI,AN/158 (Item 80 from file: 34)
DIALOG(R)File 34:(c) 2005 Inst for Sci Info. All rts. reserv.

05602988
Title: Photoemission monitored cleaning of pure and implanted tungsten photocathodes by picosecond UV laser

30/TI,AN/159 (Item 81 from file: 34)
DIALOG(R)File 34:(c) 2005 Inst for Sci Info. All rts. reserv.

05554838
Title: Oxidative additions of coordinated ligands at unsaturated molybdenum
and tungsten diphosphine-bridged carbonyl dimers .1. Decarbonylation reactions of [W-2(eta(5)-C5H5)(2)(CO)(4)(mu-R(2)PCH(2)PR(2))] (R=Ph, Me)

30/TI,AN/160 (Item 82 from file: 34)
DIALOG(R)File 34:(c) 2005 Inst for Sci Info. All rts. reserv.

05553006
Title: Thermal oxidation of tungsten-based sputtered coatings

30/TI,AN/161 (Item 83 from file: 34)
DIALOG(R)File 34:(c) 2005 Inst for Sci Info. All rts. reserv.

05434541
Title: OXIDATION OF TUNGSTEN AND TUNGSTEN CARBIDE IN DRY AND HUMID ATMOSPHERES

30/TI,AN/162 (Item 84 from file: 34)
DIALOG(R)File 34:(c) 2005 Inst for Sci Info. All rts. reserv.

05380432
Title: IN-SITU VANADIUM K-EDGE AND TUNGSTEN L(III)-EDGE X-RAY-ABSORPTION FINE-STRUCTURE OF VANADIUM-SUBSTITUTED HETEROPOLYTUNGSTATES IMMOBILIZED IN A HIGH-AREA CARBON ELECTRODE IN ACID AQUEOUS-ELECTROLYTES

30/TI,AN/163 (Item 85 from file: 34)
DIALOG(R)File 34:(c) 2005 Inst for Sci Info. All rts. reserv.

05339281
Title: EFFECT OF ROLL COOLING WATER PROPERTY ON CORROSIVE WEAR OF TUNGSTEN CARBIDE ROLLS

30/TI,AN/164 (Item 86 from file: 34)
DIALOG(R)File 34:(c) 2005 Inst for Sci Info. All rts. reserv.

05210263
Title: NANOINDENTATION STUDIES IN A LIQUID ENVIRONMENT

30/TI,AN/165 (Item 87 from file: 34)
DIALOG(R)File 34:(c) 2005 Inst for Sci Info. All rts. reserv.

05184511
Title: ENHANCED METALORGANIC CHEMICAL-VAPOR-DEPOSITION TITANIUM NITRIDE FILM FABRICATED USING TETRAKIS-DIMETHYLAMINO-TITANIUM FOR BARRIER METAL APPLICATION IN SUB-HALF-MICRON TECHNOLOGY

30/TI,AN/166 (Item 88 from file: 34)


05050298
Title: FRICTION PROPERTIES OF WS2/GRAPHITE FLUORIDE THIN-FILMS GROWN BY PULSED-LASER DEPOSITION

30/TI,AN/167 (Item 89 from file: 34)


05016456
Title: CARBON DEPOSITION BY ELECTROLYTIC HEATING OF A WATER-ETHANOL SOLUTION

30/TI,AN/168 (Item 90 from file: 34)


04963628
Title: INFLUENCE OF NONSTOICHIOMETRY ON THE FERROELECTRIC, CONDUCTION AND RELAXATION PROPERTIES OF SR6TI2NB8O30-TYPE CERAMICS

30/TI,AN/169 (Item 91 from file: 34)


04947486
Title: IN-SITU SURFACE CLEANING OF PURE AND IMPLANTED TUNGSTEN PHOTOCATHODES BY PULSED-LASER IRRADIATION

30/TI,AN/170 (Item 92 from file: 34)


04682221
Title: X-RAY SPOTS EMITTED IN A HOLLOW-CATHODE NS-DISCHARGE

30/TI,AN/171 (Item 93 from file: 34)


04525805
Title: PRECONCENTRATION OF COBALT(II) AND NICKEL(II) ON CHITIN AS 1-NITROSO-3,6-DISULFO-2-NAPHTHOLATO COMPLEXES AND THEIR DETERMINATION BY TUNGSTEN METAL FURNACE ATOMIC-ABSORPTION SPECTROPHOTOMETRY WITH DIRECT-INJECTION OF CHITIN WATER SUSPENSION

30/TI,AN/172 (Item 94 from file: 34)


04447933
Title: NUCLEATION AND GROWTH OF CVD-W ON TIN STUDIED BY X-RAY-FLUORESCENCE

SPECTROMETRY

30/TI,AN/173 (Item 95 from file: 34)
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04335427
Title: SLURRY EROSION BEHAVIOR OF THERMALLY SPRAYED WC-M COATINGS

30/TI,AN/174 (Item 96 from file: 34)
DIALOG(R)File 34:(c) 2005 Inst for Sci Info. All rts. reserv.

04211220
Title: A STUDY OF GAS-SENSING PROPERTIES OF SPUTTERED ALPHA-SNWO4 THIN-FILMS

30/TI,AN/175 (Item 97 from file: 34)
DIALOG(R)File 34:(c) 2005 Inst for Sci Info. All rts. reserv.

04160813
Title: SELECTIVE CHEMICAL-VAPOR-DEPOSITION OF COPPER USING (HFAC) COPPER(I)
VINYLTRIMETHYLSILANE IN THE ABSENCE AND PRESENCE OF WATER

30/TI,AN/176 (Item 98 from file: 34)
DIALOG(R)File 34:(c) 2005 Inst for Sci Info. All rts. reserv.

04133859
Title: EFFECT OF APPLIED POTENTIALS ON ENVIRONMENTAL CRACKING BEHAVIOR OF 17-4 PH STAINLESS-STEEL WELDMENTS

30/TI,AN/177 (Item 99 from file: 34)
DIALOG(R)File 34:(c) 2005 Inst for Sci Info. All rts. reserv.

04033745
Title: SURFACE OXIDATION OF POLYCRYSTALLINE CADMIUM TELLURIDE THIN-FILMS FOR SCHOTTKY-BARRIER JUNCTION SOLAR-CELLS

30/TI,AN/178 (Item 100 from file: 34)
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03971556
Title: THE EFFECT OF COMPOSITION ON VOLATILITY FROM A COPPER ALLOY

30/TI,AN/179 (Item 101 from file: 34)
DIALOG(R)File 34:(c) 2005 Inst for Sci Info. All rts. reserv.

03966800
Title: ANOMALOUS GOLD, ANTIMONY, ARSENIC, AND TUNGSTEN IN-GROUND WATER AND ALLUVIUM AROUND DISSEMINATED GOLD DEPOSITS ALONG THE GETCHELL TREND, HUMBOLDT COUNTY, NEVADA

30/TI,AN/180 (Item 102 from file: 34)
DIALOG(R)File 34:(c) 2005 Inst for Sci Info. All rts. reserv.

03599456
Title: DEPENDENCE OF ULTRASONIC VELOCITY IN MOLTEN COPPER ON TEMPERATURE AND IMPURITY CONTENT OF THE MELT

30/TI,AN/181 (Item 103 from file: 34)
DIALOG(R)File 34:(c) 2005 Inst for Sci Info. All rts. reserv.

03448702
Title: SELECTIVITY AND COMPOSITION DEPENDENCE OF RESPONSE OF GAS-SENSITIVE RESISTORS .1. PROPANE CARBON-MONOXIDE SELECTIVITY OF BA6FEXNB10-XO30 (1-LESS-THAN-OR-EQUAL-TO-X-LESS-THAN-OR-EQUAL-TO-2)

30/TI,AN/182 (Item 104 from file: 34)
DIALOG(R)File 34:(c) 2005 Inst for Sci Info. All rts. reserv.

03190224
Title: FIBEROPTIC EVANESCENT-WAVE SENSOR FOR IN-SITU DETERMINATION OF NONPOLAR ORGANIC-COMPOUNDS IN WATER

30/TI,AN/183 (Item 105 from file: 34)
DIALOG(R)File 34:(c) 2005 Inst for Sci Info. All rts. reserv.

03190162
Title: ORIGIN AND EVOLUTION OF W-MO-PRODUCING FLUIDS IN A GRANITIC HYDROTHERMAL SYSTEM - GEOCHEMICAL STUDIES OF QUARTZ VEIN DEPOSITS AROUND THE SUSAN GRANITE, HWANGGANGRI DISTRICT, REPUBLIC-OF-KOREA

30/TI,AN/184 (Item 106 from file: 34)
DIALOG(R)File 34:(c) 2005 Inst for Sci Info. All rts. reserv.

03085755
Title: HIGH-SELECTIVITY AND HIGH-DEPOSITION RATE TUNGSTEN CVD FREED FROM CHAMBER CLEANING

30/TI,AN/185 (Item 107 from file: 34)
DIALOG(R)File 34:(c) 2005 Inst for Sci Info. All rts. reserv.

02997520
Title: IN-SITU RAPID THERMAL NITRIDATION OF COLLIMATED TITANIUM BY PHYSICAL
VAPOR-DEPOSITION AS A BLANKET TUNGSTEN BARRIER

30/TI,AN/186 (Item 108 from file: 34)
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02997500
Title: CHARACTERIZATION AND CONTROL OF NATIVE-OXIDE ON SILICON

30/TI,AN/187 (Item 109 from file: 34)
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02903519
Title: TUNGSTEN AND TUNGSTEN-CARBON PVD MULTILAYERED STRUCTURES AS

EROSION-RESISTANT COATINGS

30/TI,AN/188 (Item 110 from file: 34)
DIALOG(R)File 34:(c) 2005 Inst for Sci Info. All rts. reserv.

02775518
Title: ATOMIC-FORCE MICROSCOPY AND X-RAY PHOTOELECTRON-SPECTROSCOPY INVESTIGATION OF THE ONSET OF REACTIONS ON ALKALI SILICATE GLASS SURFACES

30/TI,AN/189 (Item 111 from file: 34)
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02704141
Title: ATOMIC-FLUORESCENCE SPECTROMETER WITH TUNGSTEN FILAMENT ATOMIZER

30/TI,AN/190 (Item 112 from file: 34)
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02669753
Title: EFFECT OF WATER ON HYDROGEN-SENSITIVE TUNGSTEN-OXIDE FILMS

30/TI,AN/191 (Item 113 from file: 34)
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02441627
Title: SOLID-STATE INTERACTION BETWEEN NAY ZEOLITE AND VANADIUM PENTOXIDE, MOLYBDENUM TRIOXIDE, OR TUNGSTEN TRIOXIDE

30/TI,AN/192 (Item 114 from file: 34)
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02105973
Title: SOLID-STATE CESIUM ION GUN FOR ION-BEAM SPUTTER DEPOSITION

30/TI,AN/193 (Item 115 from file: 34)
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01995794
Title: ISOTOPE-DILUTION MASS-SPECTROMETRY

30/TI,AN/194 (Item 116 from file: 34)
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01888443
Title: STUDY OF OPTICAL DISPERSION PARAMETERS OF WO3 POLYCRYSTALLINE THIN-FILMS

30/TI,AN/195 (Item 117 from file: 34)
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01859592

Title: USE OF FLUIDIZING BED AEROSOL GENERATORS TO ESTABLISH A DUST MIXTURE
OF 2 SUBSTANCES AT A FIXED-RATIO FOR INHALATION TOXICITY STUDIES

30/TI,AN/196 (Item 118 from file: 34)
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01710017
Title: MEASURING ADHESION, ATTRACTION, AND REPULSION BETWEEN SURFACES IN LIQUIDS WITH AN ATOMIC-FORCE MICROSCOPE

30/TI,AN/197 (Item 119 from file: 34)
DIALOG(R)File 34:(c) 2005 Inst for Sci Info. All rts. reserv.

01687291
Title: RADIANT HEATER ASSEMBLY FOR LIMITED REACTION-RATE PROCESSING APPLICATIONS

30/TI,AN/198 (Item 120 from file: 34)
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01674769
Title: COBALT EXPOSURE IN A CARBIDE TIP GRINDING PROCESS

30/TI,AN/199 (Item 121 from file: 34)
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01653899
Title: GOLD-LOADED TUNGSTEN-OXIDE SENSOR FOR DETECTION OF AMMONIA IN AIR

30/TI,AN/200 (Item 122 from file: 34)
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01474378
Title: USE OF FLUID INCLUSION GAS SURVEYS FOR THE ASSESSMENT OF LODE DEPOSITS (WITH REFERENCE TO GOLD AND TUNGSTEN DEPOSITS)

30/TI,AN/201 (Item 123 from file: 34)
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01466894
Title: A STUDY OF LASER-ION-DEPOSITED CARBON-FILMS ON TUNGSTEN BY X-RAY-DIFFRACTION, FIELD-ION MICROSCOPY, AND ELECTRON-SPECTROSCOPY

30/TI,AN/202 (Item 124 from file: 34)
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01319919
Title: FRACTURE-BEHAVIOR OF METAL PARTICULATE REINFORCED WC-CO COMPOSITES

30/TI,AN/203 (Item 125 from file: 34)
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01134445
Title: DITHIOLENES - A CHEAP ALTERNATIVE TO PLATINUM FOR CATALYTIC DIHYDROGEN FORMATION - THE CASE OF TRIS-[1-(4-METHOXYPHENYL)-2-PHENYL-1,2-ETHYLENODITHIOLENIC-S,S'] TUNGSTEN

30/TI,AN/204 (Item 126 from file: 34)


01087584
Title: FT-IR DIAGNOSTICS OF TUNGSTEN-HALOGEN LAMPS - ROLE OF HALOGEN CONCENTRATION, PHOSPHORUS, WALL MATERIAL, AND BURNING ENVIRONMENT

30/TI,AN/205 (Item 127 from file: 34)


01057596
Title: TUNGSTEN FILM DEPOSITION BY HYDROGEN-ATOM REACTION WITH WF6

30/TI,AN/206 (Item 128 from file: 34)


00912865
Title: EROSIVE WEAR OF THERMALLY SPRAYED TUNGSTEN COATINGS

30/TI,AN/207 (Item 129 from file: 34)


00852202
Title: PROPERTIES AND MICROSTRUCTURE OF TUNGSTEN FILMS DEPOSITED BY ION-ASSISTED EVAPORATION

30/TI,AN/208 (Item 130 from file: 34)


00852201
Title: OXIDATION PROTECTION FOR A VARIETY OF TRANSITION-METALS AND COPPER VIA SURFACE SILICIDES FORMED WITH SILANE CONTAINING ATMOSPHERES

30/TI,AN/209 (Item 1 from file: 144)


16985230 PASCAL No.: 05-0045544
The state of the iron promoter in tungstated zirconia catalysts

30/TI,AN/210 (Item 2 from file: 144)


16902877 PASCAL No.: 04-0565620
Cr SUB 2 O SUB 3 , WO SUB 3 single and Cr/W binary oxide prepared by physical methods for gas sensing applications
Electroceramics VIII '02, Rome, Italy: refereed reports

30/TI,AN/211 (Item 3 from file: 144)
DIALOG(R)File 144:(c) 2005 INIST/CNRS. All rts. reserv.

16652499 PASCAL No.: 04-0303492
Pt/PZT/Pt and Pt/barrier stack etches for MEMS devices in a dual frequency high density plasma reactor
ASMC 2002 : advancing the science and technology of semiconductor manufacturing : Boston MA, 30 April - 2 May 2002

30/TI,AN/212 (Item 4 from file: 144)
DIALOG(R)File 144:(c) 2005 INIST/CNRS. All rts. reserv.

16638903 PASCAL No.: 04-0289440
Wear behavior of ceramic nozzles in coal water slurry burning

30/TI,AN/213 (Item 5 from file: 144)
DIALOG(R)File 144:(c) 2005 INIST/CNRS. All rts. reserv.

16475979 PASCAL No.: 04-0119855
The interface between benzenes (C SUB 6 H SUB 6 ;C SUB 6 H SUB 5 Cl;2-C SUB 6 H SUB 4 OHCl) and amorphous solid water studied with metastable impact electron spectroscopy and ultraviolet photoelectron spectroscopy (HeI and II)

30/TI,AN/214 (Item 6 from file: 144)
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16473573 PASCAL No.: 04-0116636
Coatings of nb-based alloy by Cr and/or Al pack cementations and its oxidation behavior in air at 1273-1473 K

30/TI,AN/215 (Item 7 from file: 144)
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16473401 PASCAL No.: 04-0116444
Thermal performance of cold storage in thermal battery for air conditioning

30/TI,AN/216 (Item 8 from file: 144)
DIALOG(R)File 144:(c) 2005 INIST/CNRS. All rts. reserv.

16290411 PASCAL No.: 03-0454005
Catalytic activity of Pd loaded on WO SUB 3 /Al SUB 2 O SUB 3 for NO-CH SUB 4 -O SUB 2 in the presence of water vapor
Catalysis for the Environment and New Energy Sources, Pre-Conference TOCAT4, July 12, 2002, Sapporo, Japan

30/TI,AN/217 (Item 9 from file: 144)
DIALOG(R)File 144:(c) 2005 INIST/CNRS. All rts. reserv.

16277874 PASCAL No.: 03-0441034
The comparative effect of two different annealing temperatures and times on the sensitivity and long-term stability of WO SUB 3 thin films for detecting NO SUB 2

30/TI,AN/218 (Item 10 from file: 144)
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16234956 PASCAL No.: 03-0395711
Spectrophotometric determination of tungsten(VI) enriched by nanometer-size titanium dioxide in water and sediment

30/TI,AN/219 (Item 11 from file: 144)
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16193095 PASCAL No.: 03-0351525
Effect of NH SUB 3 thermal treatment on an atomic layer deposited on tungsten films and formation of W-B-N

30/TI,AN/220 (Item 12 from file: 144)
DIALOG(R)File 144:(c) 2005 INIST/CNRS. All rts. reserv.

16188324 PASCAL No.: 03-0346672
Speciation of heavy metals in road runoff and roadside total deposition

30/TI,AN/221 (Item 13 from file: 144)
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16185908 PASCAL No.: 03-0344204
Aluminum-promoted tungstated zirconia catalyst in n-butane isomerization reaction

30/TI,AN/222 (Item 14 from file: 144)
DIALOG(R)File 144:(c) 2005 INIST/CNRS. All rts. reserv.

16153005 PASCAL No.: 03-0308326
Sensing characteristics of an optical fiber sensor for hydrogen leak

30/TI,AN/223 (Item 15 from file: 144)
DIALOG(R)File 144:(c) 2005 INIST/CNRS. All rts. reserv.

16097352 PASCAL No.: 03-0254985
The effect of relative humidity on wear of a diamond-like carbon coating
Selected papers from the Symposium on Technological Advances and Performance of Engineering Thin Films and Surface Coatings at the 1st International Conference on Materials Processing for Properties and Performance (MP3), Singapore, 1-3 August 2002

30/TI,AN/224 (Item 16 from file: 144)
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16090959 PASCAL No.: 03-0248244
Iodate reduction by Isochrysis galbana is relatively insensitive to de-activation of nitrate reductase activity: are phytoplankton really responsible for iodate reduction in seawater?

30/TI,AN/225 (Item 17 from file: 144)
DIALOG(R)File 144:(c) 2005 INIST/CNRS. All rts. reserv.

15960346 PASCAL No.: 03-0103787
The influence of a corrosive wood-cutting environment on the mechanical properties of hardmetal tools
Science and hard materials - 7: Selected papers from the 7th international conference on the science of hard materials, 5-9 March, 2001,
Ixtapa, Mexico

30/TI,AN/226 (Item 18 from file: 144)
DIALOG(R)File 144:(c) 2005 INIST/CNRS. All rts. reserv.

15881354 PASCAL No.: 03-0019034
Evaluation of different permanent modifiers for the determination of arsenic, cadmium and lead in environmental samples by electrothermal atomic
absorption spectrometry

30/TI,AN/227 (Item 19 from file: 144)
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15801192 PASCAL No.: 02-0516491
Thermal stability of Ti-46Al-5Nb-1W alloy
5th International Conference on Structural and Functional Intermetallics

30/TI,AN/228 (Item 20 from file: 144)
DIALOG(R)File 144:(c) 2005 INIST/CNRS. All rts. reserv.

15760345 PASCAL No.: 02-0473057
Investigation of removal of Cr(VI), Mo(VI), W(VI), V(IV), and V(V) oxy-ions from industrial waste-waters by adsorption and electrosorption at high-area carbon cloth

30/TI,AN/229 (Item 21 from file: 144)
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15736421 PASCAL No.: 02-0447833
Electrochemical NO SUB 2 sensors with WO SUB 3 electrodes for high temperature applications

30/TI,AN/230 (Item 22 from file: 144)
DIALOG(R)File 144:(c) 2005 INIST/CNRS. All rts. reserv.

15484241 PASCAL No.: 02-0178959
Comportement d'un lubrifiant aqueux dans un contrat a tres hautes pressions Application au trefilage de fils d'acier laitonnes
(Behaviour of a water-based lubricant in a very high pressure contact Application to wire drawing of brass-coated steel)

30/TI,AN/231 (Item 23 from file: 144)
DIALOG(R)File 144:(c) 2005 INIST/CNRS. All rts. reserv.

15456518 PASCAL No.: 02-0149650
"Seedless" electrochemical deposition of copper on physical vapor deposition-W SUB 2 N liner materials for ultra large scale integration

(ULSI) devices

30/TI,AN/232 (Item 24 from file: 144)
DIALOG(R)File 144:(c) 2005 INIST/CNRS. All rts. reserv.

15228048 PASCAL No.: 01-0394855
Gas-phase photocatalyzed acetone oxidation

30/TI,AN/233 (Item 25 from file: 144)
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15219505 PASCAL No.: 01-0386039
Nanocrystalline tungsten oxide thick-films with high sensitivity to H 2S at room temperature

30/TI,AN/234 (Item 26 from file: 144)
DIALOG(R)File 144:(c) 2005 INIST/CNRS. All rts. reserv.

15126190 PASCAL No.: 01-0288670
Dispersing WC-Co powders in aqueous media with polyethylenimine

30/TI,AN/235 (Item 27 from file: 144)
DIALOG(R)File 144:(c) 2005 INIST/CNRS. All rts. reserv.

15035642 PASCAL No.: 01-0193065
Effects of flue gas composition on the catalytic destruction of chlorinated aromatic compounds with a V-oxide catalyst
International Conference on Incineration and Thermal Treatment Technologies, Portland, Oregon, May 2000

30/TI,AN/236 (Item 28 from file: 144)
DIALOG(R)File 144:(c) 2005 INIST/CNRS. All rts. reserv.

15027264 PASCAL No.: 01-0184308
Environmental impact of ferrochrome slag in road construction
WASCON 2000: Science and Engineering of Recycling for Environmental Protection

30/TI,AN/237 (Item 29 from file: 144)
DIALOG(R)File 144:(c) 2005 INIST/CNRS. All rts. reserv.

15016613 PASCAL No.: 01-0173208
Thermal stability of nanocrystalline WC-Co powder synthesized by using mechanical milling at low temperature

30/TI,AN/238 (Item 30 from file: 144)
DIALOG(R)File 144:(c) 2005 INIST/CNRS. All rts. reserv.

14926939 PASCAL No.: 01-0077642
Catalysis on Pd/WO SUB 3 and Pd/WO SUB 2 . II. Effect of redox treatments in hexanes and hexenes re-forming reactions

30/TI,AN/239 (Item 31 from file: 144)

DIALOG(R)File 144:(c) 2005 INIST/CNRS. All rts. reserv.

14831227 PASCAL No.: 00-0514649
Thin films of fullerene-like MoS SUB 2 nanoparticles with ultra-low friction and wear

30/TI,AN/240 (Item 32 from file: 144)
DIALOG(R)File 144:(c) 2005 INIST/CNRS. All rts. reserv.

14809989 PASCAL No.: 00-0491174
Thermal sprayed nanostructured WC/Co hardcoatings

30/TI,AN/241 (Item 33 from file: 144)
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14798095 PASCAL No.: 00-0478552
Polymerization of tetrahydrofuran initiated by heteropolyacid in the presence of substituted oxirane

30/TI,AN/242 (Item 34 from file: 144)
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14783949 PASCAL No.: 00-0463805
Dynamics of SCR reaction over a TiO SUB 2 -supported vanadia-tungsta commercial catalyst
Reactor engineering and catalytic technologies

30/TI,AN/243 (Item 35 from file: 144)
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14629201 PASCAL No.: 00-0299815
Laser coloration and bleaching of amorphous WO SUB 3 thin film

30/TI,AN/244 (Item 36 from file: 144)
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14543589 PASCAL No.: 00-0208642
Microtribology and direct force measurement of WS2 nested fullerene-like nanostructures

30/TI,AN/245 (Item 37 from file: 144)
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14530769 PASCAL No.: 00-0195510
NOx sensing properties of Ba2WO5 element at elevated temperature

30/TI,AN/246 (Item 38 from file: 144)
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14416115 PASCAL No.: 00-0072868
A method for measuring the corrosion rate of materials in spallation neutron source target/blanket cooling loops
Characterization and qualification of materials for use in the accelerator production of tritium

30/TI,AN/247 (Item 39 from file: 144)
DIALOG(R)File 144:(c) 2005 INIST/CNRS. All rts. reserv.

14349093 PASCAL No.: 99-0558355
Experimental flume study of the deposition of heavy minerals in a simulated Witwatersrand sandstone unconformity
A special issue on placer deposits

30/TI,AN/248 (Item 40 from file: 144)
DIALOG(R)File 144:(c) 2005 INIST/CNRS. All rts. reserv.

14340260 PASCAL No.: 99-0549283
Characteristics of sputtered TaX absorbers for X-ray mask
Emerging lithographic technologies III : Santa Clara CA, 15-17 March 1999

30/TI,AN/249 (Item 41 from file: 144)
DIALOG(R)File 144:(c) 2005 INIST/CNRS. All rts. reserv.

14145659 PASCAL No.: 99-0342771
Exposures from thorium contained in thoriated tungsten welding electrodes

30/TI,AN/250 (Item 42 from file: 144)
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14135895 PASCAL No.: 99-0332314
Synthesis, characterisation and voltammetric study of a beta -Keggin-type (PW SUB 1 SUB 2 O SUB 4 SUB 0 ) SUP 3 SUP - complex

30/TI,AN/251 (Item 43 from file: 144)
DIALOG(R)File 144:(c) 2005 INIST/CNRS. All rts. reserv.

13939062 PASCAL No.: 99-0121479
Study of the surface morphology and gas sensing properties of WO SUB 3 thin films deposited by vacuum thermal evaporation

30/TI,AN/252 (Item 44 from file: 144)
DIALOG(R)File 144:(c) 2005 INIST/CNRS. All rts. reserv.

13848812 PASCAL No.: 99-0025346
Examination of the kinetics and performance of a catalytically switching (gasochromic) device
EUROSUN 1996

30/TI,AN/253 (Item 45 from file: 144)
DIALOG(R)File 144:(c) 2005 INIST/CNRS. All rts. reserv.

13797441 PASCAL No.: 98-0511938
Vaporization rate of Li SUB 2 O from double oxides

30/TI,AN/254 (Item 46 from file: 144)
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13790802 PASCAL No.: 98-0505188
Microstructural inhomogeneities and sea water corrosion in laser-deposited Ti-6Al-4V alloy matrix/carbide particulate composite surfaces

30/TI,AN/255 (Item 47 from file: 144)
DIALOG(R)File 144:(c) 2005 INIST/CNRS. All rts. reserv.

13746766 PASCAL No.: 98-0439479
Characterization, kinetics and mechanism of thermal decomposition of photosubstituted ethylenediamine complexes of molybdate(IV) and tungstate(IV) with chromium(III)

30/TI,AN/256 (Item 48 from file: 144)
DIALOG(R)File 144:(c) 2005 INIST/CNRS. All rts. reserv.

13661220 PASCAL No.: 98-0368646
Microstructural stability of thermal srayed WC-Co composite coatings in oxidising atmospheres at 450 Degree C

30/TI,AN/257 (Item 49 from file: 144)
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13658154 PASCAL No.: 98-0365432
Gas-sensing properties of SnxWO3+x mixed oxide thick films

30/TI,AN/258 (Item 50 from file: 144)
DIALOG(R)File 144:(c) 2005 INIST/CNRS. All rts. reserv.

13377098 PASCAL No.: 97-0562493
Pressure Induced Water Insertion in the Defect Pyrochlore NH SUB 4 NbWO SUB 6

30/TI,AN/259 (Item 51 from file: 144)
DIALOG(R)File 144:(c) 2005 INIST/CNRS. All rts. reserv.

13289001 PASCAL No.: 98-0011747
Studies on layer disorder, microstructural parameters and other properties of tungsten-substitued molybdenum disulfide, Mo SUB 1 SUB - SUB x W SUB x S SUB 2 (0 <= x <= 1)

30/TI,AN/260 (Item 52 from file: 144)
DIALOG(R)File 144:(c) 2005 INIST/CNRS. All rts. reserv.

13267313 PASCAL No.: 97-0540366
Bilan des mesures effectuees dans neuf usines productrices de metaux durs. Contribution a une etude epidemiologique
(Results of measurements carried out in nine hard metal factories. Contribution to an epidemiological study)

30/TI,AN/261 (Item 53 from file: 144)
DIALOG(R)File 144:(c) 2005 INIST/CNRS. All rts. reserv.

13213850 PASCAL No.: 97-0480770

SAW NO SUB x gas sensor using WO SUB 3 thin-film sensitive coating

30/TI,AN/262 (Item 54 from file: 144)
DIALOG(R)File 144:(c) 2005 INIST/CNRS. All rts. reserv.

13181675 PASCAL No.: 97-0445090
Corrosion behavior of Ni-Cr-base commercial alloys in flowing Ar-42.6%O SUB 2 -14.7%Br SUB 2 gas mixture at 700 Degree C

30/TI,AN/263 (Item 55 from file: 144)
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13170259 PASCAL No.: 97-0432291
Evaluation de l'exposition des soudeurs au chrome et au nickel pour differents procedes de soudage a l'arc
(Assessment of exposure of welders to chromium and nickel in different arc welding processes)

30/TI,AN/264 (Item 56 from file: 144)
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13074291 PASCAL No.: 97-0365540
Studies on layer disorder, microstructural parameters and other properties of tantalum substituted tungsten-molybdenum selenide, W SUB 0 SUB . SUB 6 SUB 5 Mo SUB 0 SUB . SUB 3 SUB 5 SUB - SUB x Ta SUB x Se SUB 2 (0<=x<=0.35)

30/TI,AN/265 (Item 57 from file: 144)
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12959762 PASCAL No.: 97-0235788
Production capability and processing methods for nanostructured WC-Co powder

30/TI,AN/266 (Item 58 from file: 144)
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12959755 PASCAL No.: 97-0235781
The relationship between electrochemical behaviour and in-service corrosion of WC based cemented carbides

30/TI,AN/267 (Item 59 from file: 144)
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12956510 PASCAL No.: 97-0232369
Corrosion behaviour and microstructure of two thermal spray coatings

30/TI,AN/268 (Item 60 from file: 144)
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12757435 PASCAL No.: 96-0471143
Preliminary data on hard metal workers exposure to tungsten oxide fibres

30/TI,AN/269 (Item 61 from file: 144)
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12690835 PASCAL No.: 96-0392289
Mercury concentration in the abiogenic environmental components near gold and tungsten mining and concentration complexes in eastern Transbaikalia

30/TI,AN/270 (Item 62 from file: 144)
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12677235 PASCAL No.: 96-0377558
Effects of film formation parameters on stress generation during anodic oxidation of metals in corrosive media

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12597011 PASCAL No.: 96-0284175
Friction properties of WS SUB 2 / graphite fluoride thin films grown by pulsed laser deposition

30/TI,AN/272 (Item 64 from file: 144)
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12552662 PASCAL No.: 96-0233074
Sensitive detection of nitrogen oxides based upon capacitance changes in binary oxide mixture

30/TI,AN/273 (Item 65 from file: 144)
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12526187 PASCAL No.: 96-0200640
Cobalt exposure level and variability in the hard metal industry of Japan

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12503211 PASCAL No.: 96-0173162
Gas-sensitive resistors : surface interaction of chlorine with semiconducting oxides

30/TI,AN/275 (Item 67 from file: 144)
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12494683 PASCAL No.: 96-0164078
A comparative study of hillock formation in aluminum films

30/TI,AN/276 (Item 68 from file: 144)
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12457961 PASCAL No.: 96-0119463
Exposure to airborne metals in the manufacture and maintenance of hard metal and stellite blades

30/TI,AN/277 (Item 69 from file: 144)
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12424050 PASCAL No.: 96-0079079
Comparison of the chemical erosion yields of doped graphites

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12260055 PASCAL No.: 95-0486015
A study of gas-sensing properties of sputtered alpha -SnWO SUB 4 thin films

30/TI,AN/279 (Item 71 from file: 144)
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12253529 PASCAL No.: 95-0478740
Desorption of tungsten fluorides from tungsten

30/TI,AN/280 (Item 72 from file: 144)
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12176806 PASCAL No.: 95-0391567
Structural rearrangements in the C/W(001) surface system

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12126778 PASCAL No.: 95-0358496
Modification of the B2-type matrix of aluminide diffusion coatings on nickel-base superalloys-bulk aluminide analogues

30/TI,AN/282 (Item 74 from file: 144)
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11930903 PASCAL No.: 95-0105195
Electrochemical study of isopoly and heteropoly anion transfer across the water-nitrobenzene interface. II: Vanadium-containing heteropolytungstate anions

30/TI,AN/283 (Item 75 from file: 144)
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11729058 PASCAL No.: 94-0594611
Oxidation rates of niobium and tantalum alloys at low pressures

30/TI,AN/284 (Item 76 from file: 144)
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11325130 PASCAL No.: 94-0146356
Atomic force microscopy and X-ray photoelectron spetroscopy investigation of the onset of reactions on alkali silicate glass surfaces

30/TI,AN/285 (Item 77 from file: 144)
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11313014 PASCAL No.: 94-0133780
Diffusion barrier properties of TiW between Si and Cu

30/TI,AN/286 (Item 78 from file: 144)
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11026826 PASCAL No.: 93-0536332
Retention of vanadium(V), molybdenum(VI) and tungsten(VI) by kaolin

30/TI,AN/287 (Item 79 from file: 144)
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10935585 PASCAL No.: 93-0444948
Determination of some oxyacid elements and manganese in seawater and their distributions in some unique environments of the North Pacific

30/TI,AN/288 (Item 80 from file: 144)
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10855671 PASCAL No.: 93-0365032
Risque d'asbetose dans une mine de tungstene
(Health implications of environmental exposure to asbestos in a mina of tungsten)

30/TI,AN/289 (Item 81 from file: 144)
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10830525 PASCAL No.: 93-0339881
Formation of isopolyoxometallate(VI) anions in the reaction between M(CO) SUB 6 (M=W, Mo) and acetic acid : X-ray crystal structure of (W SUB 3 ( mu SUB 3 -O) SUB 2 ( mu SUB 2 eta SUP 2 -O SUB 2 CCH SUB 3 ) SUB 6 (H SUB 2
O) SUB 3 ) SUB 2 (W SUB 1 SUB 0 O SUB 3 SUB 2 ).solvent

30/TI,AN/290 (Item 82 from file: 144)
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10814374 PASCAL No.: 93-0323730
Zeolitic behaviour of water in a new WO SUB 3 polymorph with a pyrochlore-type structure and vacant 3D tunnels

30/TI,AN/291 (Item 83 from file: 144)
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10728776 PASCAL No.: 93-0238091
Health hazard of poorly regulated exposure during manufacture of cemented tungsten carbides and cobalt

30/TI,AN/292 (Item 84 from file: 144)
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10545384 PASCAL No.: 93-0054636
Controls on ore metal ratios in granite-related ore systems : an experimental and computational approach
The origin of granites and related rocks

30/TI,AN/293 (Item 85 from file: 144)
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10389305 PASCAL No.: 92-0592778
Gold-loaded tungsten oxide sensor for detection of ammonia in air

30/TI,AN/294 (Item 86 from file: 144)
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10247940 PASCAL No.: 92-0453848
A quartz crystal microbalance analysis of ion insertion into WO SUB 3
Fundamentals of electrochronic devices

30/TI,AN/295 (Item 87 from file: 144)
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09952566 PASCAL No.: 92-0164048
W-Re(6 wt.%) and W-Ti(10 wt.%) alloys as diffusion barriers between aluminium and silicon

30/TI,AN/296 (Item 88 from file: 144)
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09740403 PASCAL No.: 91-0537537
Mehrjaehrige Beobachtungen an Grundwasserbeobachtungsrohren in einem Uferfiltratgebiet.
(Several years' investigations at groundwater observation wells in an area of bankfiltration.)

30/TI,AN/297 (Item 89 from file: 144)
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09158809 PASCAL No.: 90-0327190
Chromatography of Mo(VI) and W(VI) chelates with 2,3-dihydroxynaphthalene

30/TI,AN/298 (Item 90 from file: 144)
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09144486 PASCAL No.: 90-0312867
Surface-enhanced Raman spectroscopy at a silver electrode as a detection system in flowing streams

30/TI,AN/299 (Item 91 from file: 144)
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09028596 PASCAL No.: 90-0196872
Prospeccion geoquimica a la batea y estudio de las mineralizaciones del area de Guijuelo-Cespedosa, S. de Salamanca

(Prospection geochimique a la batee et etude des mineralisations de la region de Guijuelo-Cespedosa, partie meridionale de la province de Salamanque)

30/TI,AN/300 (Item 92 from file: 144)
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08295641 PASCAL No.: 88-0296197
Etude methodologique sur le comportement du tunstene et de ses accompagnateurs dans les sols appliquee a la prospection geochimique
(Methodological study of the behavior of tungsten and surrounding soil elements applied to geochemical prospecting)

30/TI,AN/301 (Item 93 from file: 144)
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08162524 PASCAL No.: 88-0162870
Tungsten content of soils, plants, and sewage sludges in Iowa

30/TI,AN/302 (Item 94 from file: 144)
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07860336 PASCAL No.: 87-0340110
Influence of electrokinetic environment in slime gravity concentration
(Einfluss von elektrokinetischer Umgebung auf die Schlamm-Schwerkraft-Konzentration)

30/TI,AN/303 (Item 95 from file: 144)
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05850964 PASCAL No.: 84-0352418
Metal concentrations and restricted environments, meeting
(Compte rendu)/Concentrations metalliques et milieux confines, reunion commune GRECO 52 et SGA, Paris, 25-26 avril 1984

30/TI,AN/304 (Item 96 from file: 144)
DIALOG(R)File 144:(c) 2005 INIST/CNRS. All rts. reserv.

04844646 PASCAL No.: 83-0090461
Ore deposits research; the search for concealed orebodies is prompting researchers to look more closely at the environments in which ore deposition occurs
(La prospection de minerais: la recherche de gites caches impose aux chercheurs de regarder plus attentivement les milieux dans lesquels se produisent les depots)

30/TI,AN/305 (Item 97 from file: 144)
DIALOG(R)File 144:(c) 2005 INIST/CNRS. All rts. reserv.

03959007 PASCAL No.: 75-0060721
TRANSITION METAL EIGHT-COORDINATION. VI. ISOMERIZATION THROUGH ELECTRONIC AND ENVIRONMENTAL EFFECTS-ELECTRON SPIN RESONANCE, MAGNETIC CIRCULAR DICHROISM, AND ELECTRONIC SPECTRA OF OCTACYANOTUNGSTATE (IV) AND (V).

30/TI,AN/306 (Item 98 from file: 144)
DIALOG(R)File 144:(c) 2005 INIST/CNRS. All rts. reserv.

03954097 PASCAL No.: 75-0027323
STRUCTURE AND BONDING IN SOME SIMPLE TUNGSTEN COMPOUNDS. DEDUCTIONS FROM TUNGSTEN-182 MOESSBAUER SPECTRA.

30/TI,AN/307 (Item 99 from file: 144)
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03383798 PASCAL No.: 81-0424353
USE OF A TUNGSTEN FILTER TO IMPROVE BEAM UNIFORMITY

30/TI,AN/308 (Item 100 from file: 144)
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01651611 PASCAL No.: 77-0321282
EN RUSSE.
(NOUVELLES DONNEES POUR LA CODIFICATION DU TUNGSTENE ET DU MOLYBDENE LORS DE LEUR PRESENCE SEPAREE ET SIMULTANEE DANS LES RESERVOIRS)

30/TI,AN/309 (Item 101 from file: 144)
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00681501 PASCAL No.: 74-0005821
EN RUSSE
(ESSAI, A L'ECHELLE SEMI-INDUSTRIELLE, D'UN SYSTEME DE FLOTTATION SELECTIVE DE MINERAIS DE MOLYBDENE ET DE SCHEELITE, AVEC EMPLOI D'EAU RECYCLEE)

30/TI,AN/310 (Item 102 from file: 144)
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00305496 PASCAL No.: 73-0004520
TUNGSTEN-181 PRODUCED BY THE SCHOONER EVENT: AIR CONCENTRATION AND DEPOSITION IN ITALY

30/TI,AN/311 (Item 1 from file: 292)
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Lead fishing sinkers and jigs in Canada: Review of their use patterns and toxic impacts on wildlife

30/TI,AN/312 (Item 2 from file: 292)
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The mineralized veins and the impact of old mine workings on the environment at Segura, central Portugal

30/TI,AN/313 (Item 3 from file: 292)
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Isotopic characteristics of the mineralizing fluid at the Felbertal scheelite deposit, Austrian Alps

30/TI,AN/314 (Item 4 from file: 292)


Origin and evolution of W-Mo-producing fluids in a granitic hydrothermal system: geochemical studies of quartz vein deposits around the Susan granite, Hwanggangri district, Republic of Korea

30/TI,AN/315 (Item 5 from file: 292)


Rare elements in salt-lake sediments in the Sasykkul' Basin, east Pamir

30/TI,AN/316 (Item 6 from file: 292)


Features of a fluid phase of rare metal granite melt in central Sikhote-Alin'

30/TI,AN/317 (Item 7 from file: 292)


Definition of large-scale zones of hydrothermal alteration by geochemical mapping using organic lake sediment

30/TI,AN/318 (Item 8 from file: 292)


Trace oxyanions and their behaviour in the rivers Porong and Solo, the Java Sea and the adjacent Indian Ocean

30/TI,AN/319 (Item 9 from file: 292)


Mineral resources of the Owens Peak and Little Lake Canyon Wilderness Study Areas, Inyo and Kern Counties, California.

30/TI,AN/320 (Item 10 from file: 292)


Wolframite deposition in a hydrothermal vein system: the Grey River tungsten prospect, Newfoundland, Canada.

30/TI,AN/321 (Item 11 from file: 292)


Ore deposition environments.

30/TI,AN/322 (Item 12 from file: 292)

Effects of meteorological variables on certain soil gases used to detect buried ore deposits.

30/TI,AN/323 (Item 13 from file: 292)
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A simple design for automation of the tungsten(VI) oxide technique for measurement of NH SUB 3 and HNO SUB 3 .

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The identification of mineralized granitoid plutons from ore- element distribution patterns in regional lake sediment geochemical data.
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