# Anthropogenic Sources

Earth 281

Main reference: Chapter 3 from Selinus O., Alloway B., Centeno J.A.,. Finkelman R.B, Fuge R., Lindh U., and Smedley P., 2005 & 2013. *Essentials Of Medical Geology: Impacts Of The Natural Environment On Public Health.* Academic Press.

# Anthropogenic Sources

- We will come back to natural concentrations, thresholds and distributions of elements and compounds.
- In order to compare natural versus man's influence on elemental distributions we need to discuss anthropogenic impacts
- Before humans, most changes were slow or intrinsically remediated by the earth's environment.

# Human Activities

1&2. Mineral extraction – smelting/processing – waste – MINING

3. Power generation, fossil fuels, nuclear, hydroelectric, geothermal
4. Industrial and manufacturing
5. Waste disposal – the leftovers from our activity
6. Agriculture – fertilizer, pesticides and herbicides
7. Transportation – cars, trucks, trains, planes, ships
8. Treatment and transport of water (metals, chemicals)

nunalogistics.com/files/imagecache

2.miq.com/cms/

lindachristas.org/highway-traffic

generalnewslive.blogspot.ca/

thebaron.ca/

freedomsphoenix.com

Gretar Ívarsson, geologist at Nesjavellir

# Human Activities

dustoff.tv/wp-content/uploads/2010/09/road_dust_3.jpg

For example:

a) Roads and dust – aerosols and ingestion

b) Mercury (Hg): Minimata disease – Hg released from plastics factory dumping waste into the local waterway. Mercury methylated $CH_3Hg$ or $(CH_3)_2Hg$ then went into the fish in local habitat and on into humans – resulting in damage to nervous system/brain of the local population with up to 20,000 people affected.

# I. and II. Mining and Mineral Extraction

## [A] Mineral Deposits

a) Composed of ore or mineral of interest.

e.g. A really good gold prospect. Amount of gold might run 30 oz per ton in the ore zone.

1 ton or tonne = 2000 lb

2000 lb = 2000 x 16 oz – 32,000 oz total rock

- So, in this case, 30 oz of 32,000 oz is what you harvest.
- The rest is waste rock – and that is only the ore zone.
- What about the mine openings (ramps, drifts, etc.) to get to the ore?

# I. and II. Mining and Mineral Extraction

## [A] Mineral Deposits

b) Many massive sulphide deposits are between 5-25% or more ore minerals (Table I, Chapter 3) BUT often NOT ALL are recovered OR the MINE GEOLOGIST decides that the grade is too low to process.

THEREFORE: A large percentage of sulphide and other GANGUE minerals end up in the waste piles.

**Mining = enrichment of many minerals that would normally not be readily accessible to surficial weathering processes.**

**Table I:** Main Ore's – recovery can be poor in many cases.

**Table 4.1** Some of the important, mostly metalliferous minerals

| Mineral | Composition | Comments |
|---|---|---|
| Arsenopyrite | $FeAsS$ | Frequently occurs as a gangue mineral |
| Barite | $BaSO_4$ | Major use in drilling muds |
| Bauxite | Mainly $Al(OH)_3$ | Only ore of aluminum |
| Bornite | $Cu_5FeS_4$ | Important ore of copper |
| Carrollite | $Cu(Co,Ni)_2S_4$ | Important ore of cobalt |
| Cassiterite | $SnO_2$ | Main ore of tin |
| Chalcocite | $Cu_2S$ | Important ore of copper |
| Chalcopyrite | $CuFeS_2$ | Major ore of copper |
| Chromite | $FeCr_2O_4$ | Main ore of chromium |
| Cinnabar | $HgS$ | Main ore of mercury |
| Galena | $PbS$ | Main ore of lead |
| Gold (native) | $Au$ | Main source of metallic gold |
| Haematite | $Fe_2O_3$ | Major ore of iron |
| Ilmenite | $FeTiO_3$ | Important ore of titanium |
| Magnetite | $Fe_3O_4$ | Important ore of iron |
| Molybdenite | $MoS_2$ | Main ore of molybdenum |
| Pentlandite | $(Fe,Ni)_9S_8$ | Major ore of nickel |
| Platinum | Pt (with other metals) | Main source of platinum |
| Pyrite | $FeS_2$ | Common gangue mineral |
| Pyrrhotite | $Fe_{(1-x)}S_2$ | Common gangue mineral |
| Rutile | $TiO_2$ | Important ore of titanium |
| Scheelite | $CaWO_4$ | Important ore of tungsten |
| Sphalerite | $ZnS$ | Major ore of zinc |
| Stibnite | $Sb_2S$ | Main ore of antimony |
| Tetrahedrite | $(Cu,Fe)_{12}Sb_4S_{13}$ | Copper ore—often contains silver |
| Uraninite (Pitchblende) | $UO_2$ | Main ore of uranium |
| Wolframite | $(Fe,Mn)WO_4$ | Important ore of tungsten |
| Zircon | $ZrSiO_4$ | Main ore of zirconium |

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# I. and II. Mining and Mineral Extraction

## [B] Processing

a) Mining Operation – gangue – waste
b) Ore – crush/grind – dust/waste fluid
c) Concentration – rolling – ball mills
d) Smelting/Refining – air and tailings; often use very toxic chemicals for extraction of metals (cyanide)


miningeducation.blogspot.ca/


www.dsmac-stonecrusher.com/

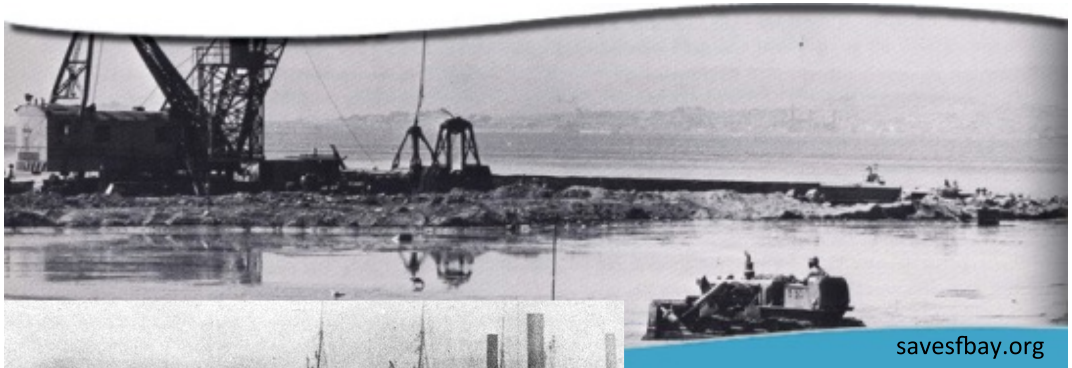

projects.inweh.unu.edu/


ak3.picdn.net/

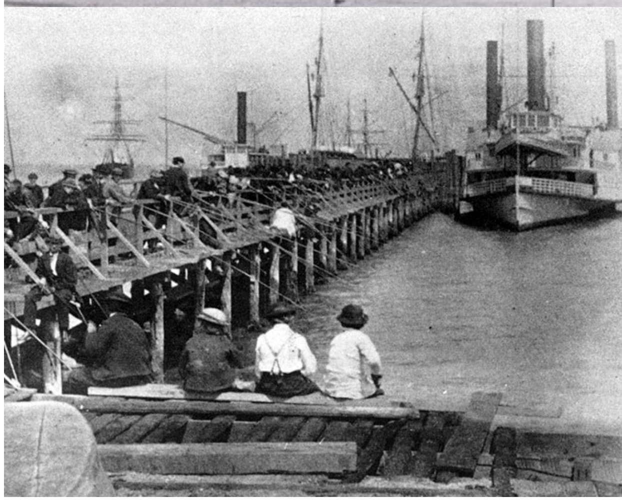
# I. and II. Mining and Mineral Extraction

*Historically:*

a) In the past poor practices – no containment paleo pollution – e.g. San Francisco Bay
b) Coal – coal tar (Sydney, Nova Scotia)
c) Silica dust from quarries, e.g. Where does your nice granite countertop come from?
d) Mining of phosphates or $PO_4$ minerals + F + As + Me (bird droppings and pathogens) or potassium fertilizers (KCl)



savesfbay.org



foundsf.org/images/

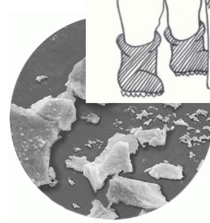

incnrmama.wordpress.com/

natgeocreative.com

raisethehammer.org

.leaderpost.com

nirmada.com



envirocare.org/

# I. and II. Mining and Mineral Extraction

*Other Aspects:*

1. As you grind a rock to finer material the **surface area** available to extract ions (weathering of metals) becomes greater.
   - Therefore potential for more leaching of metals.

www.ok.gov/

elementsunearthed.files.wordpress.com

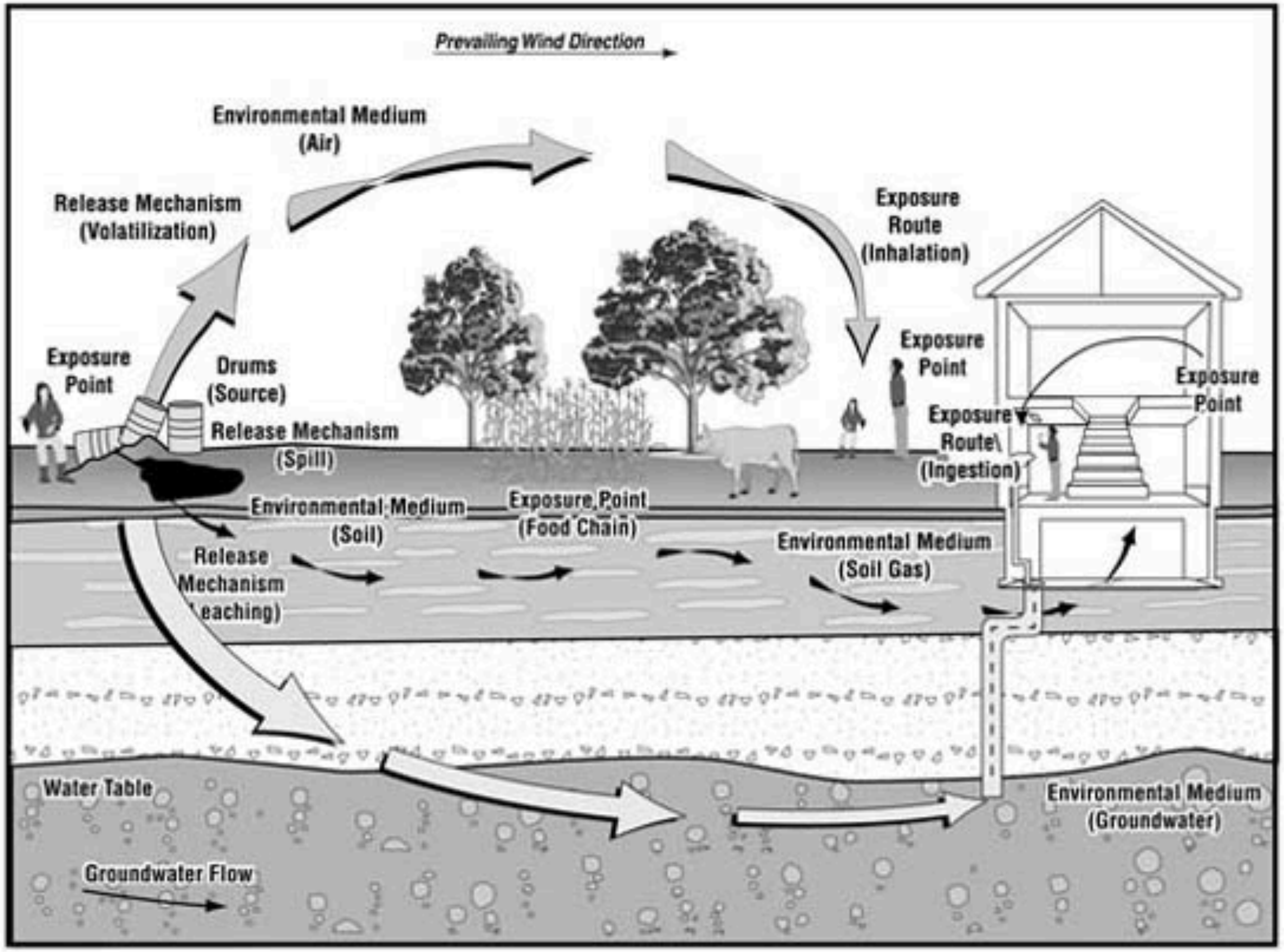



Figure 6-2. Site Conceptual Model—Exposure Pathway Schematic

http://www.atsdr.cdc.gov/

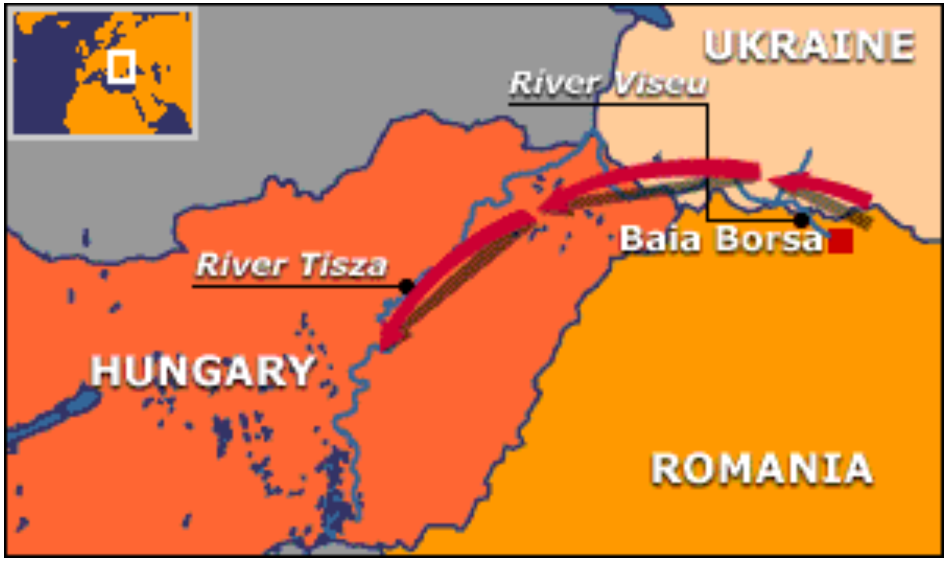
# I. and II. Mining and Mineral Extraction

tailgrab.org/2009/03/edward-burtynsky/

2. Tailings ponds
   a) Leak (slow release)
   b) Drying = dust (aerosols)
   c) Dam failures:
      i.e. Omai gold mine, Guyana (1995)
      Los Frailes tailing dam, Spain (1998)
      Borsa gold mine, Romania (2000)

# Red River: Hungary's Toxic Sludge

www.spiegel.de/




news.bbc.co.uk

e.g. Romania (gold) → cyanide and metals
Dead fish → into the Vaser-Tizla Rivers → Danube
BUT, what the chapter does not say is the Tizla and Vaser feed the major groundwater aquifers in the region (1000's kms) Flow west to east and **cyanide** has entered the system (cyanide oxidation vs. reduction).
*Stay tuned for this is a problem for humans or not?*

# I. and II. Mining and Mineral Extraction

3. Trace Element in Sulphide Minerals (Table II)

| | | |
|---|---|---|
| a) Galena | $Pb_2$ | |
| Sphalerite | $Zn_2$ | *common ions vs.* |
| Chalcopyrite | $CuFeS_2$ | *Pauling substitutions* |
| Pyrite | $FeS_2$ | |

b) Swedish Cd story – contained in the Zn ore (see map Figure)

**Table 4.2** Some trace constituents of selected sulfide minerals (values in mg $kg^{-1}$)

| Element | Normal range | Maximum found |
|---|---|---|
| *Galena (PbS)* | | |
| Ag | 500–5,000 | 30,000 |
| As | 200–5,000 | 10,000 |
| Bi | 200–5,000 | 50,000 |
| Cu | 10–200 | 3,000 |
| Sb | 200–5,000 | 30,000 |
| Tl | <10–50 | 1,000 |
| *Sphalerite (ZnS)* | | |
| As | 200–500 | 10,000 |
| Cd | 1,000–5,000 | 44,000 |
| Cu | 1,000–5,000 | 50,000 |
| Hg | 10–50 | 10,000 |
| Sn | 100–200 | 10,000 |
| Tl | 10–50 | 5,000 |
| *Chalcopyrite ($CuFeS_2$)* | | |
| Ag | 10–1,000 | 2,300 |
| Co | 10–50 | 2,000 |
| Ni | 10–50 | 2,000 |
| Sn | 10–200 | 770 |
| *Pyrite ($FeS_2$)* | | |
| As | 500–1,000 | 50,000 |
| Co | 200–5,000 | >25,000 |
| Cu | 10–10,000 | 60,000 |
| Ni | 10–500 | 25,000 |
| Pb | 200–500 | 5,000 |
| Sb | 100–200 | 700 |
| Tl | 50–100 | 100 |
| Zn | 1,000–5,000 | 45,000 |

From Levinson (1980)

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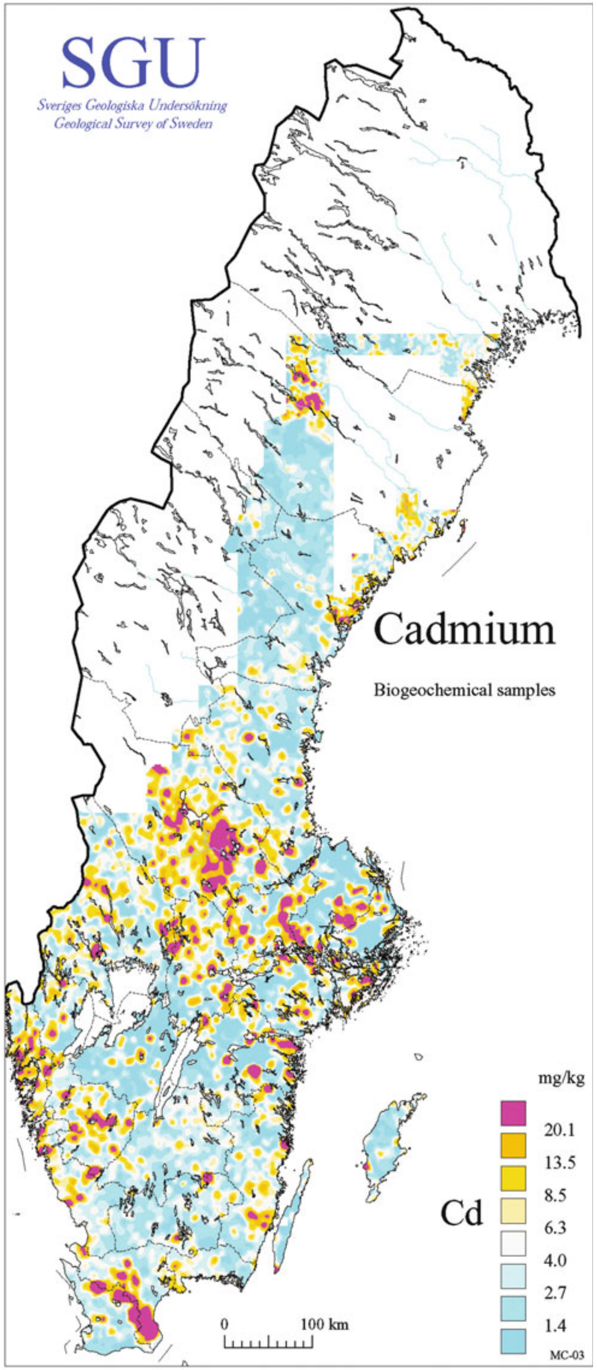


**Fig. 4.1** Geochemical map for cadmium in stream plants in part of Sweden. (Reproduced with permission of the Swedish Geological Survey.) The high cadmium concentrations in south central Sweden are due to anthropogenic sources, those on the east coast are due to long range aerial deposition, those in the central area are derived from metal mining, and those in the central eastern area are derived from fertilizer. The high cadmium concentrations in the extreme south of the country are natural and are derived from cadmium-rich sediments

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# I. and II. Mining and Mineral Extraction

4. a) pH – oxidation

   $Zn_2 + 2O_2 \rightarrow Zn\ SO_4$ (mobility)

   $SO_4$ can be very mobile in oxidizing conditions

   b) BUT sometimes

   $FeS_2 + O_2 + H_2O \rightarrow FeSO_4 + H_2SO_4$ (sulphuric acid)

   *many more examples*

   sulphates = ochre → ecosystem (fish)

   Water/Rock interaction $SO_4$ , O-$OH^-$, oxides gather more metals

   c) With coals, oil sands, etc. much of the waste is sulphides, e.g. $FeS_2$ pyrite which leads to acidification, organometallic compounds, organic releases.

# I. and II. Mining and Mineral Extraction

5. Refining

a) Waste – same idea but some really bad concentration of rare elements in the periodic table because the smelting/refining process only removes the “target” elements in most cases.

  e.g. Au, Ag, Pt removed but As, Cr, Co, Th in waste

Au smelting and Hg used to extract Au

$$\mathbf{HgAu\ 2HNO_3 + \text{->}\ Hg\ (NO_3) + H2 + Au}$$

$$\mathbf{Hg\ (NO_3)_2 + Cu\ \text{->}\ Cu\ (NO_3)_2 + Hg}$$

uwaterloo.ca/wat-on-earth/news/acid-mine-drainage-past-presentfuture

# I. and II. Mining and Mineral Extraction

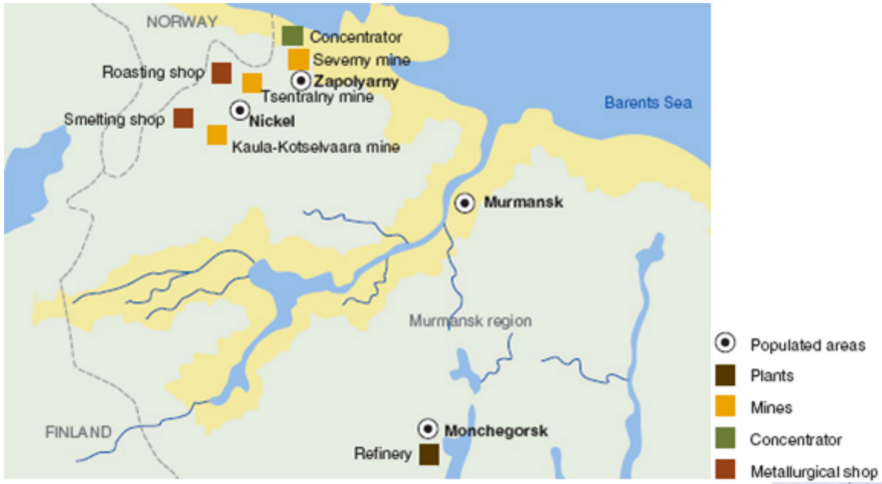
5. Refining continued

b) Aerosols

- What escapes the stack?
- Soils nearby are rich in metals, e.g. Kola in Russia/Finland

  Ni smelters released ~ 1619 tonnes of Ni in one year
- F from aluminum smelters Quebec, Norway, B.C.

wikimedia.org/




arcticecon.files.wordpress.com/

# Norilsk-Nickel company Kola Russia, Dead Land

Thomas Nilsen / BarentsObserver

# III. Power Generation

**Fossil Fuel - Coal**

1. $CO_2$ production leads to carbonic acid ($H_2CO_3$)
2. Trace elements – As, Cd, Hg, Cr, Cu, Ni all tied to organics – all can escape the stack AND all can end up in the "Fly Ash" waste

i.cbc.ca/

SUPRIYA SHARMA

lite.epaper.timesofindia.com/

# III. Power Generation

**Fossil Fuel cont'd**

3. Poor grade coal, e.g. Brown - Lignites – S rich = Acid rain and As, F release to the forests of Czech.

grid.unep.ch

…also remember the China pepper drying story (lignites as fuel)

# III. Power Generation

**Fossil Fuel cont'd**

4. Coal gasification

   Coal → (make methane gas $CH_4$ to burn) → left over is heavy oil like product = coal tar (metals As, Cd, Cu and organics like cyanide/phenols)


lakeunionhistory.org

# III. Power Generation

**Fossil Fuel cont'd**

**TORONTO**:

Old gasification sites – Toronto (refinery area, Gardiner Expressway and Parliament St.) or old railway yards. What's there today?

Parliament Street, 1979

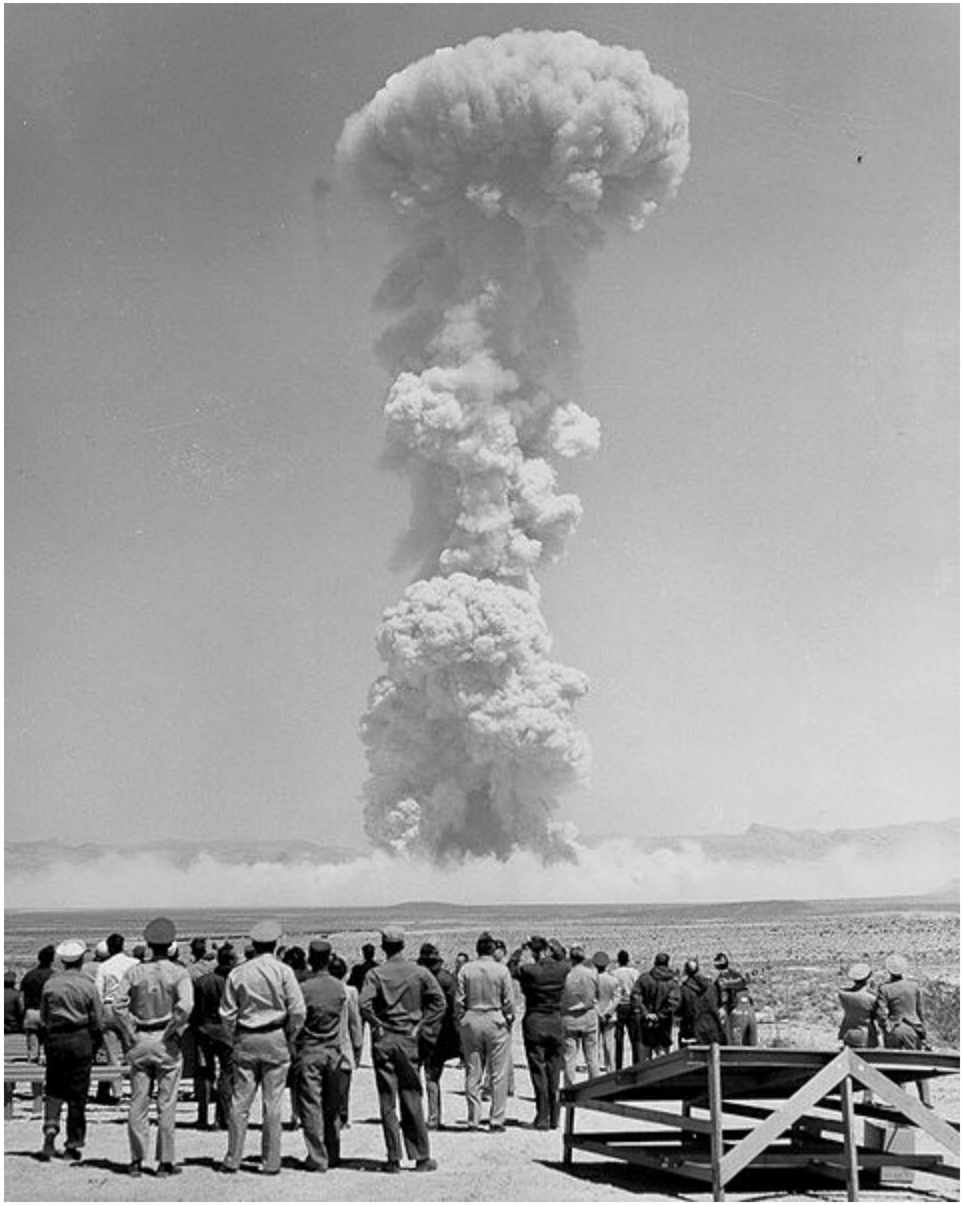

City of Toronto Archives, Series 372 s0372_ss0079_it0208

# III. Power Generation

**Nuclear**

Atmospheric releases

a) Bombs in the 40’s → 70’s



post-apo-2012.pl/

# III. Power Generation

**Nuclear**

Atmospheric releases cont'd

b) Nuclear Fuel:

i. Sellafield, Britain;

ii. Chalk River/Deep River, Canada

www.theguardian.com/

ofnuclearenergy.com/

# III. Power Generation

**Nuclear**

Atmospheric releases cont'd

iii. Chernobyl –

$^{134}Cs$, $^{131}I$ – Table III

Other egs. 1)Fukashima 2) Three Mile Island, USA 3) Los Alamos or Oak Ridges USA 4) Chalk River, Can.

Boston.com

*Website with before and after pictures of Chernobyl:* http://totallycoolpix.com/2011/04/chernobyl-25-years-later-then-and-now/

**Table 4.3** Some of the more important radioactive isotopes released by the chernobyl accident

| Isotope | $T_{1/2}$ |
|---|---|
| *Relatively short half-life isotopes* | |
| $^{132}Te$ | 78 h |
| $^{133}Xe$ | 5.27 days |
| $^{131}I$ | 8.07 days |
| $^{95}Nb$ | 35.2 days |
| $^{89}Sr$ | 52 days |
| *Isotopes with longer half-lives* | |
| $^{134}Cs$ | 2.05 years |
| $^{85}Kr$ | 10.76 years |
| $^{90}Sr$ | 28.1 years |
| $^{137}Cs$ | 30.23 years |
| *Actinides (some of the more problematic)* | |
| $^{241}Pu$ | 13.2 years |
| $^{244}Pu$ | $8 \times 10^7$ years |
| $^{241}Am$ | 458 years |

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# III. Power Generation

**Geothermal (Clean)?**

What is in that water?

- Most geothermal areas associated with rising hot thermal fluids from below or surface fluids that descend and leach the rock as they heat up. Take the easily leachable metals, often they carry organics which bind metals like As, Cd, etc.

- Radioactive material. Ra, Rd, U, etc. (hot springs)

theenergyreport.com

Iceland,
geothermal pool

Radium Springs,
B.C.

stephenmichaelson.ca/

# III. Power Generation

## Hydroelectric

- Flooding and pressure on waterlogged soil = Hg and metal release or methylation.

internationalrivers.org/

flickr.com/photos/7301137

ww2.hdnux.com/

# IV. Other Industry

## 1. Metallurgy:

Electroplating – your fancy car or your fancy bathroom fixtures – Cr, Cd, Ni, V

i. Electroplating – workers are regularly tested for heavy metals in their blood. These are often metals that interfere with Fe-Zn metabolism.

ii. Vanadium poisoning in cattle from local steel plant in South Africa.

iii. Steel and fluorite (CaF) flux = fluorosis (worse yet "slag" used as fill or fertilizer)

# IV. Other Industry

**2. Bricks:** Heat to cure = release of metals

e.g. Au in Perth Mint –bricks sorbed Millions $


www.perthmint.com.au/

# IV. Other Industry

3. **Cement:** Many impurities and fillers (eg fly ash)
4. **Tanneries:** Release of organics BUT major chrome releases – remember what Cr vs. Fe means in humans. Kingston – Davis Tannery on the river.

tracksidetreasure.blogspot.ca/

fashionnetasia.com

thehindubusinessline.com

# V. Waste Disposal

**How Does Geology/Earth Materials & Health Fit These Examples?**

1. Garbage: The most common problem in the first world. In other parts of the world recycling has been a major feature of life for hundreds of years.

msnbcmedia.msn.com/

media.sacbee.com/

Examples:

a) In India a household or merchant will dump the trash on the street in many towns and cities. First, you see the cattle and dogs that run free sort the pile – all organic material is used up. Second, in several days young children and others reclaim the metal, plastic, etc. materials. At the end a very small pile, ~ 10% original is left for the garbage collector.

pastorrick23.files.wordpress.com/

# V. Waste Disposal

## How Does Geology/Earth Materials & Health Fit These Examples?

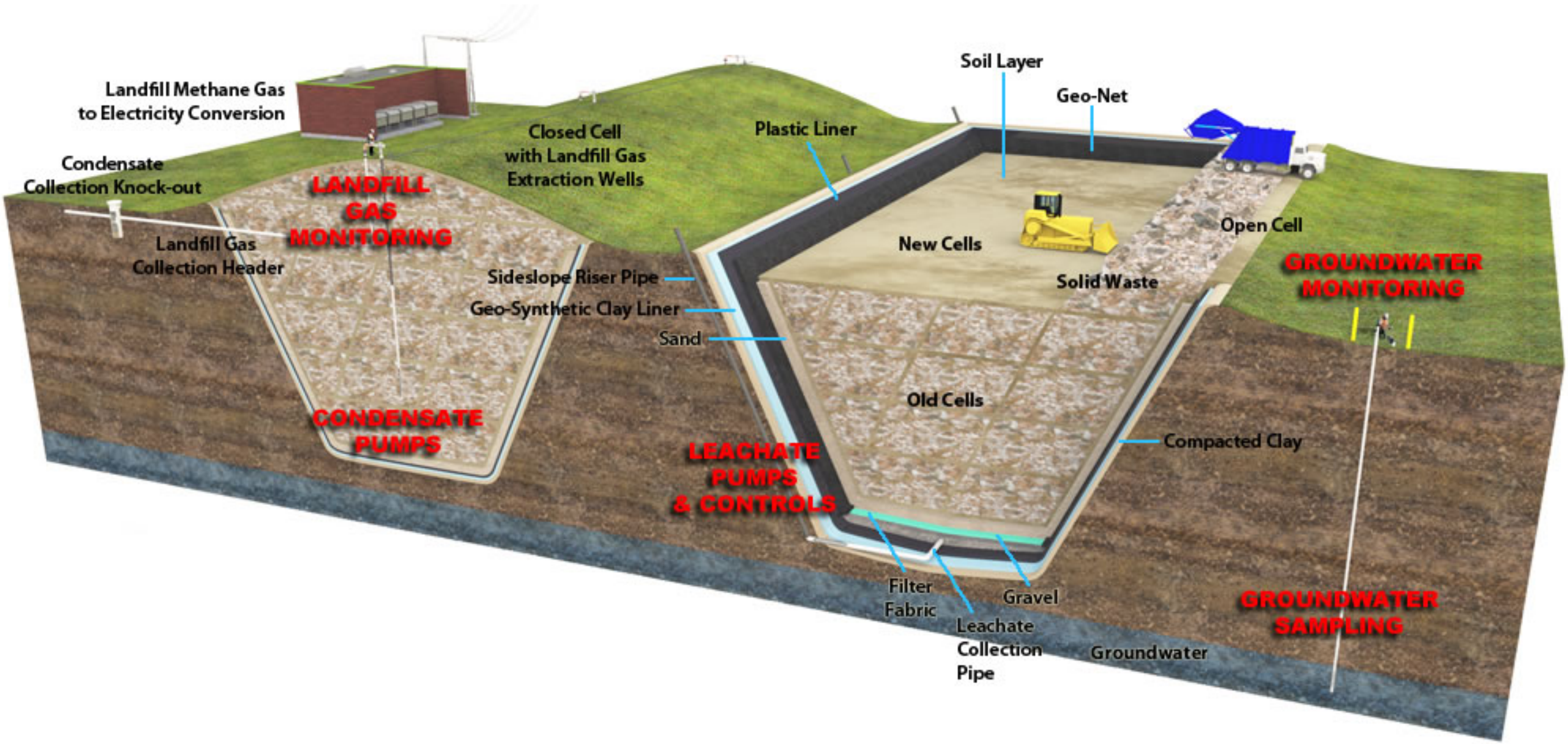
b) Buenos Aires, Argentina, the poor and others work the garbage dumps south of the city. Hundreds of children picking usable material from plastic bags to vegetables from the waste piles.

www.laht.com/

# V. Waste Disposal

**How Does Geology/Earth Materials & Health Fit These Examples?**

2. Garbage: Landfills
   - Landfills produce leachate, gas, etc. Composition is not only variable, but varies with time: Open – access to oxygen or Closed – anaerobic. Typical landfill in this area will have a multilayered base.
   - Note: What are the chances for this scenario to allow leachate to escape?
   - For example, compacted earth/clay overlain by leachate collector or gravel – geotextile plastic or other cover and possibly another collector system on top. The collector systems channel leachate to a location where it can be treated.




www.geotechenv.com/

# V. Waste Disposal

## How Does Geology/Earth Materials & Health Fit These Examples?

- Many systems that are anaerobic generate methane ($CH_4$) which in some cases can be burned for heat and power. Typical landfills of the modern era are in cells or blocks. The active life (say $CH_4$ production) of a cell might be 20-25 years (methyl compounds – escape into the air).
- Other compounds – ammonia, nitrate, sulphate, chloride. What you eat and throw away. Many cases 80% plus end up in the biosphere.
- Incineration = aerosols some of which are not human friendly (dioxins?)

*GEOLOGY COMES INTO THIS DEPENDING ON THE GEOLOGICAL MEDIUM OR SOIL OR OTHER EARTH/WATER SYSTEM*

# V. Waste Disposal

**How Does Geology/Earth Materials & Health Fit These Examples?**

3. Fly Ash: Coal + Heat = Ash (high pH)
    - The ash depending on the type of coal contains many of the worst trace metals – As, Cd, Cr, etc. They are attracted to organic compounds which mostly are in the middle of the periodic table. Those paleo swamps of the world 150-200 million years ago.
    - Ash is also used for bricks, lose fill in some construction sites, road (mix with asphalt), and to neutralize acidity in soils in agriculture.

nytimes.com


turner.com

Fly Ash Spill, Tennessee, US

# V. Waste Disposal

**How Does Geology/Earth Materials & Health Fit These Examples?**

4. Sewage

a) We spread and dispose of it on many different geological settings, e.g. karst open cavities in carbonate $CaCO_3$ rocks eg. Barbados or volcanic areas, lava tunnels-fractures.

b) $NO_3$, $PO_4$, Cl

c) Often applied to fields as fertilizer (so you buy organic food). Normally on non-root crops (eg. corn). Root crops are carrots, beets, potatoes, etc.

4.bp.blogspot.com/

# V. Waste Disposal

## How Does Geology/Earth Materials & Health Fit These Examples?

d) Sludge = variable, e.g. sewage from your house = you and what you eat. But the sewage from the University and/or Toyota = you, your friends, the laboratories, etc. (Hg? or organic chemicals).

e) Metal concentrations are high because you are a metal excreter. Also organics PAH's = polyaromatic hydrocarbons and chlorophenols.

# V. Waste Disposal

**How Does Geology/Earth Materials & Health Fit These Examples?**

5. Nuclear Waste: Various Levels

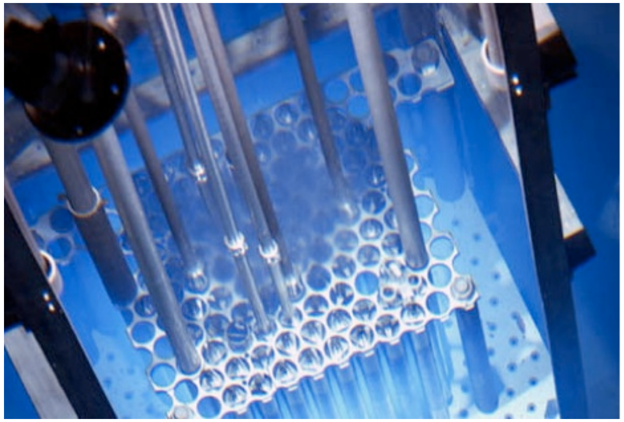
a) high level – fuel bundles

medium level – irradiated material that gets "hot"

low level – gloves, rags, etc. that may have nuclear ions on them

b) disposal deep in the earth in vaults

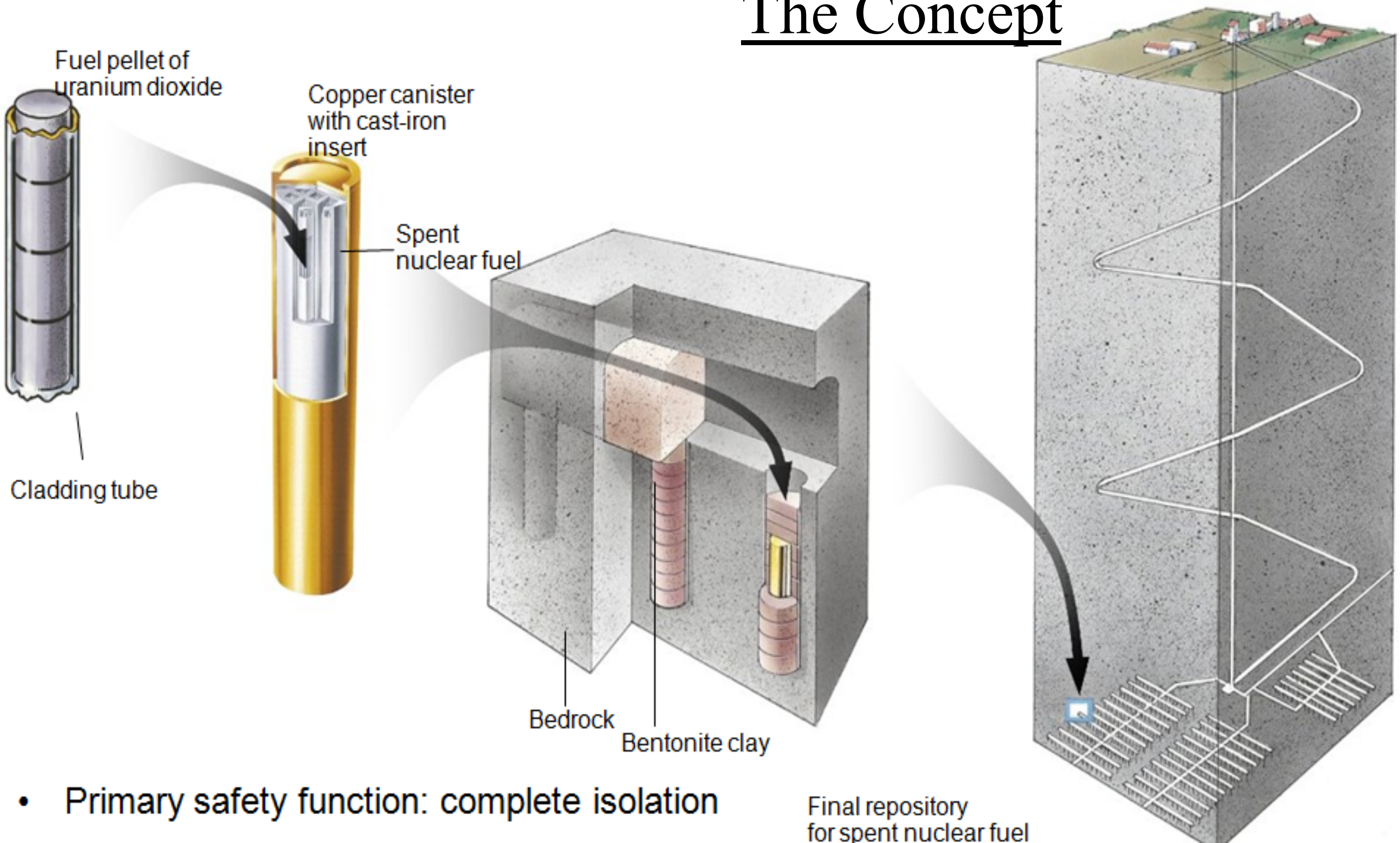
www.kernenergie.de/



media.treehugger.com/

# Geological Repository

## The Concept




- Primary safety function: complete isolation
- Secondary safety function: retardation

Courtesy of SKB/Posiva

# V. Waste Disposal

## How Does Geology/Earth Materials & Health Fit These Examples?

c) typical proposed vault for high or medium level. 700 → 1000 m depth;

   i. fuel bundle;
   ii. a framework (iron) around it;
   iii. silica beads and ~100 bundles and frames in a large (8 x 1m) thick walled (5 cm) copper canister
   iv. canisters spaced out because of heat (~100°C) in drilled holes in rock or in a room (vault);
   v. holes or vault are lined with clay material (bentonite) which swells when wet and impedes ion migration;
   vi. vault is further backfilled and fractures, mine drifts, holes are filled by crushed rock and cement grout/cement;
   vii. final barrier is the rock/hydrogeology system

# VI. Agriculture

## Application to the Earth & the Earth's Ability to React

a) $NO_3$ – $PO_4$ – Cl, etc. + pesticides – herbicides

b) too much $NO_3$ → can cause methemoglobinemia or "blue blood" – interferes with Fe in your blood and therefore your ability to carry $O_2$ in your system

c) extreme cases $NO_3$ → gastric cancers. But remember if you like some foods (sausages) your $NO_3$ – $NO_2$ may be high anyway. Recent studies say that natural carcinogens in food are low but may exceed your anthropogenic sources.

d) Table IV – metals in fertilizers

e) Persistence of some herbicides and pesticides is still a major problem

**Table 4.4** Concentrations of some trace elements in fertilizers added to agricultural land (mg $kg^{-1}$)

| | Phosphate fertilizer | Nitrate fertilizer | Manure | Sewage sludge |
|---|---|---|---|---|
| As | 1–1,200 | 2–120 | 3–25 | 2–30 |
| Cd | 0.1–190 | 0.05–8.5 | 0.1–0.8 | <1–3,400 |
| Cr | 66–245 | 3.2–19 | 1.1–55 | 8–41,000 |
| Cu | 1–300 | – | 2–172 | 50–8,000 |
| Hg | 0.01–2 | 0.3–3 | 0.01–0.4 | <1–55 |
| Mo | 0.1–60 | 1–7 | 0.05–3 | 1–40 |
| Ni | 7–38 | 7–34 | 2–30 | 6–5,300 |
| Pb | 4–1,000 | 2–27 | 11–27 | 30–3,600 |
| Se | 0.5–25 | – | 0.2–2.4 | 1–10 |
| U | 20–300 | – | – | <2–5 |
| V | 2–1,600 | – | – | – |
| Zn | 50–1,450 | 1–42 | 15–570 | 90–50,000 |

Data from several sources but predominantly from Alloway (1995)

Selinus *et al.* 2013

# VI. Agriculture

## Application to the Earth & the Earth's Ability to React

<u>For example</u>, San Joaquin and central valley, California:

i. use a lot of water so you lower the natural river/stream delivery (you have slowed down or turned off the dilution effect at the outlet);

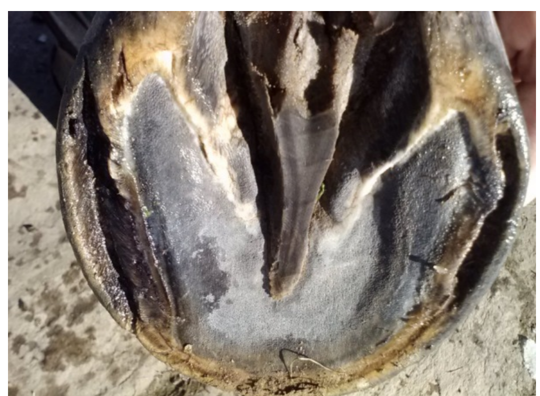

ucce.ucdavis.edu/

# VI. Agriculture

## Application to the Earth & the Earth's Ability to React

<u>For example</u>, San Joaquin, California:

ii. Also irrigation practices: the water on irrigated land- evaporates (concentrates), but also leaches ions from the soil. In this case the worst was selenium. The selenium rich groundwaters found their way to the rivers and to outlet (bird sanctuary) and delivered one hundred times more Se than normal. (Like the horses' hooves Marco Polo story – horrible deformation of birds) ,Idaho potatoes-similar



farriersforum.com/

# VII. Transportation

**Cars, planes, etc. How does geology fit this topic?**

Table V – Examples

Emission in the air: Global problems

a) $N_2$ + acid: $CO_2$ – CO: + particulates
b) How old is the vehicle? Where on the planet (Pb in gas)?
c) $NO_2$ + ozone
d) <u>Time frame</u>. At the edge of every road or junkyard you have the leftovers, Pb, steel, oil.
e) Where you are on earth and the soil type, microbiology community, redox-pH, wet-dry, etc. determine how quickly the problem accumulates or remediates.

**Table 4.5** Vehicular sources of metals

| Metal | Source |
|---|---|
| Lead | Gasoline |
| Manganese | Gasoline |
| Nickel | Diesel + alloys |
| Vanadium | Diesel + alloys |
| Zinc | Tires + galvanized items |
| Cadmium | Tires + lubricating oils (minor amounts) |
| Chromium | Chrome plating, brake linings, etc. |
| Copper | Electrical wiring, thrust bearings, etc. |
| Platinum groupmetals | Catalytic converters |

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**Table 4.6** Metals in the urban environment—Birmingham, England

| Urban area—street dust | Range (mg $kg^{-1}$) |
|---|---|
| Cadmium | 0.4–25 |
| Chromium | 9–228 |
| Copper | 36–3,160 |
| Lead | 32–4,820 |
| Nickel | 11–683 |
| Tin | 3–332 |
| Zinc | 79–5,210 |
| *Urban area—soil* | |
| Cadmium | 0.7–1.6 |
| Copper | 38–715 |
| Lead | 75–350 |
| Zinc | 53–450 |
| *Rural area—soil* | |
| Cadmium | 0.2–0.5 |
| Copper | 5–57 |
| Lead | 14–74 |
| Zinc | 10–180 |

Data for street dust are from Brothwood (2001) and data for soils are from Davies and Houghton (1984)

*Note*: Data for dust was obtained with a strong acid attack and represents a virtually total extraction of metals. Soil data is for a weak acid attack and represents metals which are easily extractable

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# VIII. Atmosphere

- We will discuss this in the next lecture.
- Example: effect of one volcano vs. many steel plants. Dust and earth emissions.


http://volcanoes.usgs.gov/

# IX. Urban Environments

- Cities are mostly dirty : dry-dust; wet – lots of geochemical issues, dogs, mold, fungus,litter

greencompanyeffect.com/

# X. Your Water System

a) Big cities – pipes – geology does not affect you unless, like in Finland, your water flows through rock tunnels (F and solubility and minerals)

www.euarchives.org/

www.lifesourcewater.com/

b) You are on a well – , hope your geological medium does not have any excess ions, eg. F, As, organics, etc. or contaminants.

Table VII: Elements and your health

**Table 4.7** Important anthropogenic sources of some elements known to have detrimental effects on the biosphere

| Element | Sources |
|---|---|
| Antimony | Mining, smelting, fossil fuel combustion |
| Arsenic | Mining, smelting, steel making, fossil fuel combustion, geothermal energy production, phosphate fertilizer, pesticides |
| Cadmium | Mining, smelting, fossil fuel combustion, incineration, phosphate fertilizer, sewage sludge, motor vehicles |
| Chromium | Smelting, steel making, fossil fuel combustion, phosphate fertilizer, sewage sludge |
| Cobalt | Mining, smelting, fossil fuel combustion |
| Copper | Mining, smelting, fossil fuel combustion, manure, sewage sludge, pesticides |
| Fluorine | Mining, aluminum refining, steel making, fossil fuel combustion, brick making, glass and ceramic manufacture, phosphate fertilizer |
| Lead | Mining, smelting, fossil fuel combustion, sewage sludge, pesticides, motor vehicles |
| Mercury | Smelting, fossil fuel combustion, incineration, sewage sludge |
| Nickel | Mining, smelting, steel making, fossil fuel combustion, oil refining, sewage sludge, motor vehicles |
| Selenium | Smelting, fossil fuel combustion |
| Thallium | Smelting, fossil fuel combustion |
| Uranium | Fossil fuel combustion, phosphate fertilizer |
| Vanadium | Steel making, fossil fuel combustion, oil refining |
| Zinc | Mining, smelting, steel making, fossil fuel combustion, phosphate fertilizer, manure, sewage sludge, pesticides, motor vehicles, galvanized metal |

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