

Mineralogy and Human Welfare: Applications in Geology, Petrology, Environmental Science and Industry; Catalog of Crystal Structures.

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Introduction

A few personal words to give context.

I lived for 17 years at Barn Close Farm, Fritchley, Derbyshire, England, UK at the southern end of the Pennine Chain. I retired on 9/30/05 as Professor of Physical Sciences at the University of Chicago, Illinois USA, but am still responsible for various duties including working on environmental matters. I sold my home in Indiana, and moved my records to Brookline next to Boston MA.

Most of my scientific research has related to mineralogy. At the intellectual level of pure science, I have had a wonderful time studying minerals selected from rocks from the Earth and the Moon, and on meteorites, including one from Mars. On a practical level, I have worked on mineral-related catalysts that have truly revolutionized the chemical and petroleum industries, but even here I have been able to relate modern structural chemistry to pure mathematics going back to Plato, Archimedes and Kepler. Furthermore, I have been able to teach students from around the World about the physics, chemistry, biology and mathematics of minerals, and have been able to profit from their diverse backgrounds.

On the negative side, I have been forced to consider how certain minerals can be bad for human health. In Derbyshire, I saw and still see the medical effects of lead poisoning and of drinking water low in iodine and fluorine, together with bronchitis induced by dirty industrial air. In the Chicago region, I see the effects of air and water pollution from intense industrial and agricultural activities. Fortunately, these medical problems are being recognized in the developed World; detailed scientific studies are followed by legal and political actions [e.g. **T Blair** 2003 *Meeting the sustainable development challenge*, Environment 45 19-25 (8974); **B Clinton** 2004 *My Life*, Borzoi/Knopf]. The overall success in the USA of the Environmental Protection Agency sets an example for other countries. However, traveling around the World, I have seen the growing evidence of dangers to human health from poor air, water and food, typically aggravated in slums resulting from the growth and movement of people desperately seeking a better life.

On the positive side, I have helped industrial scientists triple the yield of gasoline (petrol) from oil, and described the first new mineral on the Moon, while on the negative side I have been truly appalled at the development of dangerous useless nuclear/rocket weapons, and the sheer waste of energy and money (trillions of dollars) on so many vicious military and civil conflicts. The people of the World have yet to take sensible steps to guard against impacts from asteroids and comets, let alone the problems caused by earthquakes, volcanoes, landslides, coastal erosion, and other major geological hazards. **Jvs** 2000 *Natural hazards: Geology, engineering, agriculture, and sociopolitical/humanitarian considerations for the twenty-first century*, International Geological Review 42 617-56.

At the National Academy of Sciences Colloquium on *Geology, Mineralogy and Human Welfare* in 1998 (**Jvs** 1999 Proc Nat Acad Sci 96 3348-9, like all other attendees, I was appalled at the growing problems of chemical poisons that seriously affect one-fifth of the people around the World, and am haunted by what to do to alleviate the medical problems from the viewpoint of mineralogy and geochemistry (*senso lato*). Perhaps the best that can be done by a scientist like me is to present accurate factual observations and sober interpretations for ultimate social evaluation by human beings with appropriate managerial/political skills. It is easy to get depressed and think that people will continue to produce too many children who will continue to be subject to negative environments, and end up in early death either from wars or pandemics.

However, I am optimistic enough to believe that the problems will be recognized as facing the entire human race, and that ultimately there will be assignment of the correct actions by and for nearly everyone. Ultimately, physical scientists will be forced to develop a Hippocratic Oath for their behavior, but it will not be easy, as shown by the history for practitioners of medicine (**SH Miles** 2004 *The Hippocratic Oath and the Ethics of Medicine*, R724.5 M54). The “tragedy of the commons” need not occur if positive steps are taken in the context of scientific research and government: Science 302 1906-29 (9512). So here is a background for mineralogists & geochemists!

This database began as a card file in 1948 merely as a support for directing my research now amount to over 4,000 species. In 1990, I began a computer database. It is now expanded to cover biological properties and medical applications. Although it is highly technical, brief statements are added for less experienced readers. You will be able to find references to arsenic in Bengal; zeolite molecular sieve catalysts in the petroleum industry; bacteria and soil minerals; applications in art and archaeology, to give just a few examples.

This detailed database is designed for research workers, who may wish to consult: **HD Holland KK Turekian ed** 2003 *Treatise on Geochemistry*, 0-08-043751-6.

The first section INTRO stands by itself as a guide to how important mineralogy is to human welfare. It is followed by papers divided into AB, CD to U-Z for convenience. However, it is important to search all sections for a particular chemistry and mineral.

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- Abbreviations	
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The following abbreviations are used:

AAAS	atomic absorption spectroscopy
aq	water: from aqua
AEM	analytical electron microscopy
AFM	atomic force microscopy
DDT	a pesticide
EDXA	energy-dispersive X-ray analysis
EM	electron microscopy
EMP[A]	electron microprobe analysis
EPR	electron paramagnetic resonance
EXAFS	extended X-ray absorption fine structure
FT	Fourier transform
GPa	GigaPascal = unit of P
IR	infra red spectroscopy, often with FT
kybp	kilo year before present
K	Kelvin [degree of temperature] = 273 + degree Celsius
LM	light microscopy
Mössbauer	Mössbauer gamma-ray spectroscopy
ND	neutron diffraction
NMR	nuclear magnetic resonance: [MAS- = magic angle spinning]: see QD96.N8M28 2002.
P	pressure
P	powder, as in NPD & XRPD

ppm[w]	part per million [weight]
Raman	Raman spectroscopy: see QC454.R36 F47 2003
SAXS	small-angle X-ray scattering
SC	single crystal, as in SC-ND & -XD
S[T]EM	scanning [transmission] electron microscopy
SIMS	scanning isotope mass spectrometry
T	temperature
XANES	X-ray absorption near-edge spectroscopy
XAS	X-ray absorption spectroscopy
XRD	X-ray diffraction
UV	ultra-violet spectroscopy

Technical details

The database is based on systematic reading of journals. Because the early computers had little memory, a very concise format was used. Some recent references are given now in full, except that the number of authors is restricted.

Although, the latest computers have almost infinite memory, conciseness is still a virtue. Most entries are confined to a single line, longer ones being compressed by use of 8 or 9 point type instead of the usual 10 point. Subscripts and superscripts are mostly enlarged to at least 14 point to making visibility better.

I read all the journals up to Sept 2005, then just the important ones since then. I shall try to find time to catch up, so that the database is fully up-to-date by Oct 2006.

Publication was delayed by three major operations in Feb and May 2006, from which I am close to recovery in June 2006. I am also working on "Living Safely" in which problems of an environmental nature are related to mineralogy and geochemistry,

Literature Review:

Selected to give coverage on mineralogy and crystal structures; chemistry and physics related to industry and engineering; biology; evolution; ecology, general geoscience; natural hazards; agriculture & food; and general human welfare. Public affairs were checked in the New York Times and Chicago Tribune newspapers, plus occasional scanning of foreign newspapers in the University of Chicago Regenstein Library.

Technical Books

Incoming technical books were checked at the University of Chicago Crerar Library, the Michigan City, IN, Library, and the Seminary Coop Bookstore, Hyde Park, Chicago.

List of Journals read Systematically

In addition to these journals read regularly in Crerar Library, scanning of other journals was done when time permitted. Because of my operations and rehab, I have not done thorough reading since Sept 2005. I will try to catch up if I visit Chicago in summer 2006.

The following code is used:

Code	Journal
Au	Audubon
AA	Advances in Agronomy
AAPGB	American Association of Petroleum Geologists Bulletin
AnC	Analytical Chemistry

AnCh	Angewandte Chemie [International Edition]	
ACA	Acta Crystallographica A	
ACB	Acta Crystallographica B Structural Science	
ACC	Acta Crystallographica C	
ACD	Acta Crystallographica D	
ACR	Accounts Chemical Research	
ACSc	Acta Chemica Scandinavia	
ACSB	American Ceramic Society Bulletin	
AEE	Agricultural Ecosystem & Environment	
AE(I)	Atmospheric Environment (International)	
AEM	Applied and Environmental Microbiology	
AG	Applied Geochemistry	
AGH	Acta Geologica Hispanica	
AJES	Australian Journal of Earth Science	
AJS	American Journal of Science	
AdM	Advanced Materials	
AM	American Mineralogist	up to date 06/06
ARB	Annual Review of Biochemistry	
ARBBS	Annual Review of Biophysics and Biomolecular Structure	
AREE	Annual Review of Energy and Environment	
	Became ARER Annual Review of Environment and Resources	
AREPS	Annual Review of Earth and Planetary Sciences	
AS	American Scientist	
AuS	Australasian Science	
AWST	Aviation Week and Space Technology	
AWWAJ	American Water Works Association Journal	
Bi	Biochemistry	
Bo	Bone	
Br	The Bridge	
BAMS	Bulletin of the American Meteorological Society	
BGSAR	British Geological Survey Annual Report	
BGSD	Bulletin of the Geological Society of Denmark	
BGSF	Bulletin Geol Soc Finlande	
BM	Bulletin de Mineralogie:	
	Earlier: <i>BSFMC</i> Bulletin de Societé française Mineralogie et Cristallographie	
BMJ	British Medical Journal	
BSGF	Bulletin de la Societé Géologique de France	
BSSA	Bulletin Seismological Society of America	
BV	Bulletin of Volcanology	
BWHO	Bulletin World Health Organization	
BWMO	Bulletin [World Meteorological Organization]	
CB	Chemistry in Britain	
ChC	Chemical Communications	
	Earlier: <i>JCSCC</i> Journal of the Chemical Society, Chemical Communications	
CIC	Climatic Change	
CICIM	Clays and Clay Minerals	
CEn	Civil Engineering	
CEr	Chemie der Erde	
CEJ	Chemistry a European Journal	
CEN	Chemical and Engineering News	
CaG	California Geology	
ChG	Chemical Geology	
CrGD	Crystal Growth and Design	
CI	Chemistry and Industry	

CIWYB	Carnegie Institution of Washington Year Book	
CM	Canadian Mineralogist	up to date 06/06
ChM	Chemistry of Materials	
CIM	Clay Minerals	
CoMP	Contributions on Mineralogy and Petrology	
ChR	Chemical Reviews	
CrR	Crystallography Reports [translated from Russian Kristallografiya]	
CREST	Critical Reviews in Environmental Sciences and Technology	
CRG	Compte Rendus Geoscience	
	Earlier: <i>CRASP</i> Compte Rendus Academie Science Paris – geoscience subsection	
CRPS	Critical Reviews in Plant Science	
CIS	Clay Science	
CrS	Crop Science	
CuS	Current Science	
D	Discover	
DAN	Doklady Akad Nauk [Russian]	
DES	Doklady Earth Science	
Ec	Ecology	
EI	Elements	
End	Endeavour	
Env	Environment	
Eos	Eos, Transactions, American Geophysical Union	up to date 06/06
Ep	Episodes	
ECSS	Estuarine Coastal and Shelf Science	
EnF	Energy and Fuels	
EcG	Economic Geology	
EnG	Engineering Geology	
EHP	Environmental Health Perspectives	
EJIC	European Journal of Inorganic Chemistry	
EJM	European Journal of Mineralogy	
EJSS	European Journal of Soil Science	
EcM	Ecological Monographs	
EMM	Environmental and Molecular Mutagenesis	
ENR	Engineering News-Record	
EnPo	Environmental Pollution	
EnPr	Environmental Progress	
EPIEPA	Environmental Progress, Illinois EPA	
EPSL	Earth and Planetary Science Letters	
ER	Environmental Research A	
ESR	Earth-Science Review	
EST	Environmental Science and Technology	
F	Fuel	
G	Geology	up to date 06/06
Gd	Geoderma	
Gt	Geotimes	up to date 06/06
GBC	Global Biogeochemical Cycles	
GC	Green Chemistry	
GCA	Geochimica Cosmochimica Acta	
GG	Gems & Gemology	
GGSB	Geology of Greenland Survey Bulletin	
GI	Geochemistry International	
GcJ	Geochemical Journal	
GIJ	Geological Journal	
GM	Geological Magazine	

GPC	Global & Planetary Change	
GRL	Geophysical Research Letters	up to date 06/06
GSAB	Geological Society of America Bulletin	
GSAT	GSA Today	
GT	Geology Today	
IC	Inorganic Chemistry	
IGBPS	International Geosphere and Biosphere Program and Science	
IGR	International Geological Review	
IMa	Inorganic Materials	
IST	Issues in Science and Technology	up to date 06/06
JACHS	Journal of the American Chemical Society	
JACeS	Journal of the American Ceramics Society	
JalCo	Journal of Alloys and Compounds	
JACr	Journal of Applied Crystallography	
JAfES	Journal of African Earth Sciences	
JAsES	Journal of Asian Earth Sciences	
JAgFC	Journal of Agricultural and Food Chemistry	
JAMA	Journal of the American Medical Association	
JB	Journal of Bacteriology	
JBC	[The] Journal of Biological Chemistry	
JCa	Journal of Catalysis	
JCG	Journal of Crystal Growth	
JCIS	Journal of Colloid and Interface Science	
JCP	Journal of Chemical Physics	
JCSD	Journal of the Chemical Society Dalton Transactions	
	Became DT Dalton Transactions	
JCSF	Journal of the Chemical Society Faraday Transactions	
JEc	Journal of Ecology	
JEE	Journal of Environmental Engineering	
JEQ	Journal of Environmental Quality	
JESH[A/B/C]	Journal of Environmental Science and Health A & B & C	
JG	Journal of Geology	up to date 06/06
JGeEd	Journal of Geoscience Education	
JGGE	Journal of Geotechnical and Geoenvironmental Engineering	
JGR	Journal of Geophysical Research B	
JGSC	Journal of the Geological Society of China	
JGSL	Journal of the Geological Society of London	up to date 06/06
JHE	Journal of Human Evolution	
JMa	Journal of Mammalogy	
JMC	Journal of Materials Chemistry	
JME	Journal of Molecular Evolution	
JMG	Journal of Metamorphic Geology	
JMPS	Journal of Mineralogical and Petrological Sciences	
	Successor to MJJ in 2003	
JMR	Journal of Materials Research	
JMS	Journal of Materials Science	
JMSL	Journal of Materials Science Letters	
JNCS	Journal of Non-Crystalline Solids	
JP	Journal of Petrology	
JPC[A & B]	[The] Journal of Physical Chemistry [A & B after v 100]	
JPCS	Journal of Physics Chemistry Solids	
JSAmES	Journal of South American Earth Sciences	
JSFA	Journal of the Science of Food and Agriculture	
JSeG	Journal of Sedimentary Geology	

JStG	Journal of Structural Geology	
JSR	Journal of Sedimentary Research	
JSSC	Journal of Solid State Chemistry	
JVGR	Journal of Volcanology and Geothermal Research	
Kr	Kristallografiya	
La	Langmuir	
Li	Lithos	
Lt	[The] Lancet	
LE	[The] Leading Edge	
M	Meteoritics <i>became</i> MPS	
MA	Mineralogical Abstracts	
MBE	Molecular Biology and Evolution	
MD	Mineralogica Deposita	
ME	Mining Engineering	
MG	Marine Geology	
MJJ	Mineral Journal Japan	
	Became JMPS in 2003	
MM	Mineralogical Magazine	up to date 06/06
MiMa	Microporous Materials	
MMi	Microscopy & Microanalysis	
MMM	Microporous and Mesoporous Materials	
MP	Mineralogy and Petrology	
MPA	Mineralogica et Petrographica Acta	
MPS	Meteoritics and Planetary Sciences	
MR	The Mineralogical Record	up to date 06/06
MRB	Materials Research Bulletin	
N	Nature	
Nw	Naturwissenschaften	
NEJM	[The] New England Journal of Medicine	
NHi	Natural History	
NHR	Natural Hazards Review	
NIMPR	Nuclear Instruments & Methods in Physics Research	
NJMA	Neues Jahrbuch Mineralogie Abhandlungen	
NJMM	Neues Jahrbuch Mineralogie Monatshefte	
NS	New Scientist	
NYRB	New York Review of Books	up to date 06/06
NYT	New York Times	up to date 06/06
OGJ	Oil and Gas Journal	
OLEB	Origin of Life and Evolution of the Biosphere	
P	Primates	
PAC	Pure & Applied Chemistry	
PCCP	Physical Chemistry Chemical Physics	
PCE	Physics and Chemistry of the Earth A	
PCM	Physics and Chemistry of Minerals	
PD	Powder Diffraction	
PEPI	Physics and Chemistry of Planetary Interiors	
PF	Prairie Farmer	
PM	Periodico di Mineralogia	
PN	Pugwash Newsletter	
PNAS	Proceedings of the National Academy of Science	
PR	Precambrian Research	
PRB	Physical Review B	
PRL	Physical Review Letters	
PRSL	Proceedings Royal Society of London, Mathematical, Physical & Engineering	

	Sciences	
PS	Plant and Soil	
PT	Physics Today	
PW	Physics World	
QR	Quaternary Research	
QRB	Quarterly Reviews of Biology	
R	[La] Recherches	
REG	Reviews in Economic Geology	
RG	Reviews of Geophysics	
RGI	Railway Gazette International	
ReM[G]	Reviews in Mineralogy [and Geochemistry]	
RoM	Rocks and Minerals	
RMG	Rocky Mountain Geologist	
RSI	Reviews of Scientific Instruments	
S	Science	up to date 06/06
Se	Sedimentology	
SA	Scientific American	up to date 06/06
SAJG	South African Journal of Geology	
SBB	Soil Biology and Biochemistry	
SCD	Science in China D	
SoE	Solar Energy	
SG	Sedimentary Geology	
SMPM	Schweizerische Mineralogische und Petrographische Mitteilungen	
SPC	Soviet Physics Crystallography	
SoS	Soil Science	
SuS	Surface Science	
SSSAJ	Soil Science Society of America Journal	
STR	Science and Technology Review	
T	Tectonics	
Tr	Trains	up to date 06/06
TiBS	Trends in Biochemical Sciences	
TiCB	Trends in Cell Biology	
TiEE	Trends in Ecology and Evolution	
TMPM	Tschermak's Mineralogica Petrologica Mitteilungen	
TiPS	Trends in Plant Science	
TR	Technology Review	
TRSE	Transactions of the Royal Society of Edinburgh Earth Sciences	
W	Weather	
We	Weatherwise	
WASP	Water, Air & Soil Pollution	
WER	Water Environment Research	
WET	Water Environmental Technology	
WO	World Oil	
WR	Water Research	
Z	Zeolites	[ended; became MMM]
ZaaC	Zeitschrift für anorganische und allgemeine Chemie	
ZK[NCS]	Zeitschrift für Kristallographie [New Crystal Structures]	
ZN	Zeitschrift für Naturforschung B	
ZPC	Zeitschrift für physikalische Chemie	
ZVMO	[Zapiski Vserossiiskogo Mineralogicheskogo Obs.]	

Erratic format occurred upon change from Mac to PC in 1998, and PC to Mac in 2005: some diacritical symbols were lost.

Please consult primary references to check for accurate transcription.

No guarantee of accuracy. Notification of errors & omissions gratefully received at smith.joseph@comcast.net.

Bracketed number is filing code in **jvs Research Collection of Mineral Papers**. This is freely available at the University of Chicago, though most readers will wish to pull articles directly onto their computer screen. Changed from alphabetical sequence to pure number in 1996. In 2005, the numerical coding was stopped because so many journals are now on the web.

Some references are to abstracts in *American Mineralogist* (AM), *Chemical Abstracts* (CA), *Mineralogical Abstracts* (MA), *Mineralogical Magazine* (MM) or *Structure Reports* (SR): such a secondary reference is omitted if the primary reference is easily available.

The *Powder Diffraction File* (PDF) 2005-6 from the International Centre for Diffraction Data contains >477k entries, including 17.8 k for minerals.

History behind the literature review

I obtained my doctorate in physics at Cambridge University in 1951 with a thesis on the *Crystal Structures of Calcium Carbonate Silicate Minerals*. I worked at the Geophysical Laboratory of the Carnegie Institution of Washington, 1951-4; the Department of Mineralogy and Petrology at Cambridge University, 1954-6; the College of Earth Sciences at Pennsylvania State University, 1956-60; and since then at the Department of Geophysical Sciences in the University of Chicago. I was fortunate to work with scientists skilled in essentially all types of mineralogy, using essentially all techniques, particularly X-ray diffraction (with Joseph Pluth). In the 1960's, I helped to develop the application of the electron microprobe for microanalysis of minerals, particularly ones in lunar rocks, meteorites and in xenoliths from the upper mantle (with Barry Dawson), and Ian Steele carries this area forward. Very instructive has been interactions with industrial scientists, particularly on zeolite molecular-sieve catalysts, at Union Carbide Corporation, UOP & Exxon/Mobil & Dow Corporations. Study of zeolites with neutron techniques at the High Flux Beam Reactor at Brookhaven National Laboratory (with Åke Kvik) allowed understanding of water bonding.

In 1985, my research began to concentrate on new directions opened up with second-generation synchrotron X-ray sources. An NSF-EAR grant enabled completion of Sector 19 as a general user facility for X-ray fluorescence microanalysis at the National Synchrotron Light Source at Brookhaven National Laboratory in association with Keith Jones. As a member of the National Academy of Sciences Seitz-Eastman Committee on Major Materials Facilities, I became involved in the planning of the third-generation sources, including the Advanced Photon Source at Argonne National Laboratory. As a faculty member of the University of Chicago, I became Executive Director of the Center for Advanced Radiation Sources (CARS) covering both physical and biological sciences. Highly skilled scientists (including the next Director, Keith Moffat, and Mark Rivers, Stephen Sutton & Jim Viccaro) and engineers constructed a facility at the APS to serve about 1000 users at Sector 13 (Geo-Soil-Enviro-), Sector 14 (Bio-) and Sector 15 (Chem-Mat-). I encouraged the organization of Sector 16 (High Pressure), but CARS was unable to manage it because of participation by organizations funded by nuclear weapons agencies. I was engaged with Stephen Sutton in planning for a new sector devoted to Enviro/Human Welfare-Sciences, but funding has not yet been attained.

In 1993, I decided to focus my own research on advances in crystal-structure determination that became possible with the new synchrotron X-ray sources, while watching the other new areas. The increasing brightness allows structure determination on a few-micrometer-equivalent crystal, as achieved with a needle of *raite* in 1998 at the European Synchrotron Research Facility, thus opening up new understanding of fine-grained minerals. This is of particular interest to me as an ex-farmer because soil minerals are fine-grained. Availability of high-energy X-rays permits accurate electron-density determination of structures containing heavy elements as well as light elements. This is important for human welfare because most heavy elements are toxic to people, and the electron distribution is a key to their physical chemistry. Tuning through X-ray absorption edges allows pinpointing of certain individual

elements in mixed sites whether crystalline or not: this is particularly important for determining valence state and chemical bonding in amorphous and poorly-crystallized materials.

To take advantage of these new opportunities, a complementary catalog of minerals lacking a satisfactory structure determination was prepared in July 1998. A compendium of current projects at the University of Chicago, with details of specimens, crystal selection, reconnaissance X-ray data, etc., was kept up to date for UofC staff and collaborators.

The present compendium of crystal structure papers on minerals and related synthetic materials was based initially on the literature review made by me since 1948 using the mineralogy, petrology and geochemistry journals that I bought plus regular scanning of Mineralogical Abstracts and reading of chemistry, crystallography and physics journals at university libraries. My main interests were the rock-forming minerals and zeolites used in teaching and research. I had noted many minerals of potential interest to industrial chemists and environmental scientists, but had not made a systematic study. To flesh out the catalog, I began in 1994 to read systematically the main chemistry, physics and biology journals in Crerar Library. A copy was made of important articles or the abstracts for quick reference when working at home. I concentrated on the Russian journals.

I make a special effort to find papers on synthetic analogs or related materials to spark off new ideas for synthesis of useful materials with environmental and industrial interest.

High-pressure analogs were originally reported in the CARS Weekly Literature Review that went out weekly by fax, and have been transferred to this database with expanded coverage. This is important for human welfare because dangerous volcanoes are fed by melts produced at high pressure, and impact craters leave a signature of high-pressure metamorphism.

Because many major advances in mineralogy and geochemistry now involve environmental and ecological matters related to human welfare, appropriate references are being incorporated systematically. This provides a firm mineralogical/geochemical database for planning of the *International Geoscience and Human Welfare* Project that developed from the NAS Colloquium and planning by Gordon Brown, and particularly for the *Environment Sciences Center* that links faculty at the University of Chicago with staff at the Argonne National Laboratory and at other universities. Many of these references go outside the strict realm of classical mineralogy, but are an important key to understanding the human significance.

In June 2002, references involving art and science plus museum conservation were added. These provide a basis for planning of a project by the University of Chicago and the Field Museum of Natural History to take advantage of new techniques in surface chemistry and materials science.

Currently in progress is an upgrade of the references in 1988 '*Feldspar Minerals*'. New references are being added here as time permits, and full coverage is planned for 2007 in preparation for completion of vol. 2.

To scientists receiving a copy of this database, I offer no assurance of absolute accuracy or completeness. However it is a convenient record for thinking about new research studies. I would be glad to discuss plans for new studies with any mineralogist/geochemist. Please use the Web for searches to complement what you find here. Please let me know of errors & omissions, and of ideas for improvement.

Techniques

XAS/XRF/XRPD are now done mainly with synchrotron X-ray sources: see QD96.X2.C48 for chemical applications

XAS EXAFS/XANES

X-ray absorption spectroscopy

XRF

X-ray fluorescence analysis

XR[P]D

X-ray [powder] diffraction:

Rietveld = profile refinement of crystal structure.

For reference, see:

G Amsel WA Lanford 1984 *Nuclear reaction techniques in materials analysis*, Ann Rev Nucl Particle Sci 34 435-60 (8873).

MW Anderson & 5 others 2004 *Modern microscopy methods for the study of porous materials*, ChC 907-16 (10294).

A Beran E Libowitsky ed 2004 *Spectroscopic Methods in Mineralogy*, European Mineralogical Union Notes in Mineralogy 6.

TG Fawcett & 4 others 2004 *Evaluating experimental methods and techniques in X-ray diffraction using 280 000 data sets in the Powder Diffraction File*, PD 19 20-5 (10156).

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C Giacobozzo & 7 others 2002 *Fundamentals of Crystallography*, 2nd ed, QD905.2.F86.

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PL King MS Ramsey GA Swayze 2004 *Infrared Spectroscopy in Geochemistry, Exploration Geochemistry, and Remote Sensing*, Min Assoc Canada Short Course v. 33 (10710).

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Applications in art & archaeology

In 2006, I emphasize literature covering glass because of interest by scientists at the University of Chicago and the Field Museum of Natural History in use of synchrotron X-ray techniques at the Advanced Photon Source in determining the chemical composition of glass beads some of which are corroding. Also I emphasize metals and alloys, and rocks. Because corrosion in museums may depend on air quality, particularly from organic and inorganic compounds released by decaying plastics, etc., some references refer to this theme. Mineral pigments are also of interest, because many modern art objects are losing color because of breakdown of organic dyes.

Some general references in archaeology are listed. In principle, provenance can be determined from chemistry and mineralogy: in practice, this can work fairly well for stone, but not for metal. Copper and gold objects have been melted and mixed together thus wiping out the original chemical information.

A brief comment is given in square brackets. See individual minerals for further references.

Thanks to Ben Bronson and Deborah Stokes for provision of some references.

General

P Acquafredda A Paglionico 2004 *SEM-EDS microanalysis of microphenocrysts of Mediterranean obsidians: a preliminary approach to source discrimination*, EJM 16 419-29 (10479).

R Alaimo & 3 others 1998 *Le officine ceramiche di Solunto e Mozia (VII-III secolo a.C.): un primo confronto tra materie prime, fabric e chimismo dei prodotti finiti*, MPA 41 287-306. [Phoenician pottery workshops in Sicily.]

R Alaimo G Montana G Polizzi 1998 *Caratteristiche mineralogico-petrografiche delle calcareniti in opera nei complessi monumentali della Sicilia Occidentale*, MPA 41 243-266. [Biocalcarenite: 4 local types.]

- L Allemand** 2003 *Qui sauvera Lascaux?* R Apr 26-33 (8856). [Bad cave environment.]
- G Allen J Beavis** 1996 *Building on the past*, CB Sep 24-30 (1030). [Conservation of ancient buildings: water leaching, acid rain, air pollution, rock cleaning, metal corrosion, resin injection.]
- M Ambrosi & 4 others** 2001 *Colloidal particles used for restoration of frescoes*, La 17 4251-5 (2951). [Synthesis of nanometer plates. Dispersed in propan-1-ol & aq to fix loose paint in Firenze duomo.]
- NS Baer S Fitz RA Livingston** ed 1998 *Conservation of Historic Brick Structures*, Donhead, Shaftesbury, Dorset UK. (1036). [40 articles.]
- M Balter** 1999 *Restorers reveal 28,000-year-old artworks*, S 283 1835 (1174). [Grande Grotte, Arcy-sur-Cure, Burgundy. Up to 4 mm calcite removed.]
- M Balter** 2000 *Archaeology in the Holy Land*, S 287 28-35 (4998). [Tensions with biblical scholars & fundamentalists. Correctness of Bible? Meggiddo & Tel Rehov. Etc.]
- M Balter** 2001 *Did plaster hold neolithic society together?* S 294 2278-81 (3867). [9 kybp village of Catalhoyuk, Anatolia, in wetland used lime-clay.]
- GM Bargossi G Di Battistini M Zanolli** 1998 *L'Arenaria Macigno di Fivizzano (Massa Carrara) Eredita storico-culturale ed attuale georisora della Lunigiana*, MPA 41 267-85. [Massive lithic arkose with low porosity has undergone only minor exfoliation over centuries.]
- G Barone** 2002 *Preliminary archaeometric analysis on amphorae in VI and V centuries B. C., from excavations at Gela (Sicily)*, PM 71 273-87. [XRD reveals quartz/calcite/plagioclase/hematite/K-feldspar/diopside/gehlenite/illite/kaolinite/chlorite/montmorillonite.]
- D Benavente & 3 others** 1999 *Thermodynamic modeling of changes induced by salt pressure crystallization in porous media of stone*, JCG 204 168-178. [Experiments with 4M Na₂SO₄ solution to test model.]
- S Best & 3 others** 1993 *A bible laid open*, CB Feb 118-22 (887). [Raman of pigments in Lucka bible: white lead, vermilion, red lead, lapis lazuli, azurite, orpiment, minor realgar & orpiment.]
- C Biever** 2002 *St Luke's new coat*, N 417 219-20 (7220). [ter Brughen used 'smalt' = K-Si-As-Co glass powder that turned from deep blue to dull grey, instead of *ultramarine*. Neutron radiography allows virtual reconstruction.]
- RL Bishop MJ Blackman** 2002 *Instrumental neutron analysis of archaeological ceramics: care and interpretation*, ACR 35 603-10. [Analyses for Leilan, Syria; Hopi AZ; "Greater Nicoya".]
- F Blazquez & 4 others** 1997 *Microstromatolitic deposits on granitic monuments: development and decay*, EJM 9 889-901 (890). [Mica granite columns & house wall in Delos island & Seu d'Urgell Romanesque cathedral in Catalan Pyrenees. Type I patina in unsheltered areas interpreted as leaching of iron oxide/hydroxides from mica; also gypsum with actinomyces (Spain) and NaCl from sea spray (Delos). Type 2 is 10-600 micrometer crust containing calcite, weddellite, whewellite & apatite. Outer layer is broken gypsum with fungal remains plus quartz & silicate dust; inner layers, complex details. Two types of decay: grain disaggregation where wet; plaques and fissures colonized by fungal hyphae. Etc.]
- E Blinman** 1993 *Anasazi pottery*, Expedition 35 14-22 (1159). [Predominant gray-white-red, coil-and-scrap assembly. Alluvial clays with high Fe. Red hematite & Mn powder for red glaze. Lead glaze. Carbonized C-based syrup.]
- KL Brown RJH Clark** 2002 *Analysis of pigmentary materials on the Vinland Map and Tartar Relation by Raman microprobe spectroscopy*, AnC 74 3658-61 (7883). [Black C ink overlay on yellow line with anatase: latter not medieval. TR OK.]
- L Buffone & 3 others** 2003 *The millstones of ancient Pompeii: A petro-archaeometric study*, EJM 15 207-15 (9122).
- F Burrigato P Pensabene P Tucci** ed 2002 *Archaeometry and Classical Heritage*, PM LXXI special issue 1-263 (9347). [20 papers on: provenance of stones/ceramics/bricks; alteration; binder of "Roman concrete"; marble; pottery; axes; etc.]
- D Cam** 2000 *Antique Chinese paintings studied by LM, SEM and microanalysis*, The Americas Microscopy and Analysis Sep 7-8 (875). [Primary red lead & hematite; kaolin white background; emerald-green copper aceto-arsenite, etc interpreted as repair of primary.]

A Camprubi & 8 others 2003 *Mining and geological knowledge during the Neolithic: a geological study on the variscite mines at Gavà, Catalonia*, Ep 26 295 (9799).

Canadian J Earth Sci 2004 *Applications of earth science techniques to archaeological problems*, 41(6) (10502). [Special issue covering pottery, burnt stones, lead beads, basalt vessels, lithic artifacts, etc.]

E Cantisani & 5 others 2000 *Relationships between microstructures and physical properties of white Apuan marbles: inferences on weathering durability*, PM 69 257-68 (6326). [Granoblastic texture weathers worse than xenoblastic.]

AA Cantu 1991 *Analytical methods for detecting fraudulent documents*, AnC 63 A847-54 (8880). [XRF is one of tools for characterizing paper and ink.]

M Castillejo & 11 others 2002 *Analytical study of the chemical and physical changes induced by KrF laser cleaning of tempera paints*, AnC 74 4662-71. [Must keep some varnish to shield pigments from discoloration.]

C Chataigner JL Poidevin NO Arnaud 1998 *Turkish occurrences of obsidian and use by prehistoric peoples in the Near East from 14,000 to 6,000 BP*, JVGR 85 517-37 (1157). [Mineral-chemical provenances.]

O Ciferri P Tiano G Mastromei ed 2000 *Of Microbes and Art. The Role of Microbial Communities in the Degradation and Protection of Cultural Heritage*, Kluwer, 0-306-46377-6 (8000). [16 contributions.]

RJH Clark PJ Gibbs 1998 *Raman microscopy of a 13th-century illuminated text*, AnC 70 A99-104 (889). [Table 1 compares with XRD, EDXA, XRF, PIXE, IR, UV & optical. Found lead white, cinnabar, lazurite, orpiment, realgar & pararealgar (perhaps light-induced), PbS (? induced by London smog).]

P Costagliola & 4 others 2000 *Pb-isotope signatures of Italian alabasters: possible application to provenance studies of works of art*, EJM 13 421-8 (1809). [Complex reaction with water.]

UM Cowgill GE Hutchison 1969 *A chemical and mineralogical examination of the ceramic sequence from Tikal, El Peten, Guatemala*, AJS 267 465-77. [Last paper of series on Late Mayan potsherds. Si/Al still high. Calcite lower than before. Low-Sr limestone added as temper in earlier ceramics, but not later. K increases and Rb/K decreases as move to wood ash K. Probably used montmorillonite. Details of 21 elements, presence of feldspar, probable firing temperature.]

PT Craddock 1997 *The detection of fake and forged antiquities*, CI 7 Jul 515-519 (870). [Many details.]

V Daniels 1997 *Conservation and the chemical industry*, CI 15 Dec 987-990 (883). [Bronze disease. Acrylic polymer. ZnO pellets. Flush with nitrogen. Oxygen-adsorbing cachets. Details.]

PS Dahl BM Harkness GC Maurath 1990 *Trace-element analysis of Maya obsidian blades from Yucatan and Campeche Provinces, Mexico*, CG 88 163-7 (1155). [ICPES for Ca Fe K Ba La Mn Sr Ti Zn Zr; AAAS for Rb.]

M del Monte 1991 *Trajan's column: lichens don't live here any more*, End 15 86-93 (1037). [The brownish patina *scialbatura* is patchy and vari-colored; contains *whewellite* & *weddellite* produced by crustose lichens. On top are patches of *gypsum* formed from atmospheric sulfuric acid & wind-blown silicate minerals. Acid rainwater dissolved marble to give pits concentrated in areas damaged by sculptor's tools. Modern air pollution killed lichens allowing acid rain to ravish the column & many other monuments in Europe.]

J Dubarry de Lasalle 2000 *Identifying Marble*, TN967.L377 (8324).

H Edwards 1998 *Another view of the world*, CI 6 Apr 261-4 (891). [Raman of lichens, pigments in wall painting, resin, bone, teeth, ivory. Lichens colonizing Renaissance frescoes generate Ca oxalate monohydrate from the marble. Red pigment is pure *cinnabar* at Sherborne Abbey, but adulterated with iron ochre at Winchester cathedral. Lichens survive in Arctic by colonizing holes in sandstone generating four zones: top, light orange, *hematite* + *quartz*; dark lichen; white, Ca oxalate mono- & -dihydrate; bottom, *hematite*.]

LR Ember 1984 *Science in the service of art*, C&EN Dec 3 14-23 (895). [Getty Conservation Institute, Smithsonian Conservation & Analytical Laboratory, etc. Techniques. Details.]

do 2001 *Chemistry and art*, C&EN 7/30 51-9 (3655). [Synthetic varnish. New paints. Unstable high-K, low-Pb glass. False modern brass mimicks bronze. Pt photo print developed in Hg. Watered-corroded bronze sealed in wax. Techniques.]

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RA Eppler 1992 *Colorants for Ceramics*, Kirk-Othmer Encyclopedia of Chemical Technology, Wiley-Interscience, v. 6, p. 877-892 (1040) TP9.E6850.

F Farges 1998 *Mineralogy of the Louvres Merovingian garnet cloisonné jewelry: Origins of the gems of the first kings of France*, AM 83 323-30. [PIXE reveals 3 types of garnet: rhodolite, pyrope & Cr-rich pyrope.]

F Min & 3 others 2004 *Study of Ru imperial ware and its imitations*, NJMM 104-16 (10213). [Ru contains *anorthite*, but not imitations.]

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NC Flemming 2004 *Submarine prehistoric archaeology of the Indian continental shelf*, CuS 86 1225-? (10285).

M Franzini 1995 *Stones in monuments: natural and anthropogenic deterioration of marble artifacts*, EJM 7 735-43 (892). ["cooked marble" decay.]

M Franzini & 3 others 1999 *On the binder of some ancient mortars*, MP 67 59-69 (23). [90 mortars from Pisa are pozzolanic. Details.]

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E Galan F Zezza ed 2000 *Protection and Conservation of the Cultural Heritage of the Mediterranean Cities*, TA 426.158 (8045). [Conference proceedings.]

M Garcia-Valles & 3 others 1997 *Coloured mineral coatings on monument surfaces as a result of biomineralization: the case of the Tarragona cathedral (Catalonia)*, AG 12 255-66. [Microflora generated films and mats on and within successive biomineral surface coatings of limestone & marbles. Colors may be organic pigments embedded within the mineral coatings & Fe/Mn organics remaining from bioactivity.]

EG Garrison 2003 *Techniques in Archaeological Geology*, 3-540-43822-X. [Compressed compendium.]

W Gerwin R Baumhauer 2000 *Effect of soil parameters on the corrosion of archaeological metal finds*, Gd 96 63-80 (1035). [Heaviest corrosion of iron in sandy acid soils & urban ones.]

G Giorgetti E Gliozzo I Memmi 2004 *Tuscan black glosses: A mineralogical characterization by high resolution techniques*, EJM 16 493-503 (10480). [Hematite, hercynite, magnetite, spinels.]

MD Glascock 2002 *Obsidian provenance research in the Americas*, ACR 35 611-7. [Mesoamerica provenance.]

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DC Grove 1992 *The Olmec legacy*, National Geographical Research and Exploration 8(2) 148-65 (1158). [Jade celts & jewelery, *serpentine* mosaics, basalts, etc.]

N Guskos & 11 others 2002 *Photoacoustic, EPR and electrical conductivity investigations of three synthetic mineral pigments: hematite, goethite and magnetite*, MRB 37 1051-61 (7438). [Synthesized from by-product of titanium dioxide plant.]

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AL Hetherington 1937 *Chinese Ceramic Glazes*, Cambridge University Press, London, NK4165.H38c. [Useful details.]

C Henshilwood & 4 others 2004 *Middle Stone Age shell beads from South Africa*, S 304 404 (10196).

K Hinsch G Guelker 2001 *Lasers in art conservation*, PW Nov 37-41 (3416).

H Hoag 2004 *Biology for art's sake*, N 428 886-7 (10211). [Ar kills bacteria.]

C Holden 2002 *Cave paintings in jeopardy*, S 297 47 (7624). [Altamira. *Actinobacteria* degrade hematite pigment.]

B Hubbard & 4 others 2003 *Structural study of Maya Blue: textural, thermal and solid-state multinuclear magnetic resonance characterization of the palygorskite-indigo and sepiolite-indigo adducts*, CICIM 51 318-26.

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M Jansen HP Letschert 2000 *Inorganic yellow-red pigments without toxic metals*, N 404 980-2 (5728). [Cd-ones toxic. New (Ca,La)Ta(O,N)₃ perovskite ones are brilliant tunable yellow-red.]

M Jose-Yacamán & 3 others 1996 *Maya blue paint: An ancient nanostructured material*, S 273 223-5 (1171). [Very resistant. Indigo dye (from anil) protected inside *palygorskite* needles. SEM/EELS/TEM/EMPA. Also need metallic and oxide nanoparticles on an amorphous substrate. Reproduced by heating Sacalum mine Fe-bearing clay & anil.]

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DRC Kempe AP Harvey 1983 *The Petrology of Archaeological Artefacts*, Clarendon, Oxford UK. GN72.P38.

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R Kunzig 2000 *Vanishing act*, D Dec 34-36 (1439). [Examples of degradation of plastics in museums, including moon suits & Barbie dolls. Cellulose nitrate (celluloid, nitrocellulose) is brittle, but the softener camphor escapes: tends to catch fire. Cellulose acetate is fire resistant, but residual acetic acetate turns into acetic acid with vinegar smell. Polyvinyl chloride (PVC) is brittle and its softener phthalate ester escapes, and might mimic estrogen - the female sex hormone. Some later ones more stable: acrylonitrile butadiene styrene (ABS); polyethylene terephthalate (PET). Smithsonian has *Save America's Treasures* grant for conservation of Apollo space suits.]

Y Kusano & 8 others 2004 *Microstructure and formation process of the characteristic reddish color pattern Hidasuki on Bizen stoneware: reactions involving rice straw*, ChM 16 3641-6 (10644). [Mullite replaced by corundum & hematite.]

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- A Lawler** 2002 *Afghanistan's challenge*, S 298 1195-204 (8373).
- M Leslie** 2002 *Digging up Britannia's past*, S 297 1243 (7908). [Archaeology Data Service clearing house of web services: ads.ahds.ac.uk.]
- LM Mallory-Greenough MP Gorton JD Greenough** 2002 *The source of basalt vessels in ancient Egyptian archaeological sites: A mineralogical approach*, CM 40 1025-45. [All from Haddadin lava flow in north near Cairo using plagioclase, pyroxene & olivine analyses.]
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- L Maritan** 2004 *Archaeometric study of Etruscan-Padan type pottery from the Veneto region: petrographic, mineralogical and geochemical-physical characterization*, EJM 16 297-307 (10296).
- A Meharg** 2003 *The arsenic green*, N 423 688 (9051). [William Morris used green pigments in wallpaper & used income from Devon Great Consols the largest As mine producer. He decried human damage from industrialization.]
- B Moroni G Poli** 2000 *Provenance of materials employed in the construction of Orvieto Cathedral (Umbria, Italy)*, PM 69(2) 143-163 (1232). [3 types of basaltina & 3 types of travertine.]
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- L Nasdala & 3 others** 2001 *Laser Raman micro-spectroscopy in mineralogical research*, The Americas Microscopy and Analysis March 7-9 (1439). [Uses notch filter-based systems excited by 488-785 nm, lateral resolution <3 micrometer depth ~2. Azurite pigment on wood sculpture of Saint Anne; spinel inclusion in corundum, heat-treatment of emerald; radiation damage in zoned zircon from Yilgarn craton.]
- M Obstler** 2000 *Out of the Earth into the Fire: A Course in Ceramic Materials for the Studio Potter*, The American Ceramic Society, Westerville OH, 1-57498-078-5.
- RE Ogilvie** 2001 *A few examples of electron microanalysis of art objects at the Boston Museum of Fine Arts*, MMi 7 193-9 (1974). [Forgery with modern Ti paint; natural weathering of old marble; different parts of 4ky Anatolian bronze, including As-rich coating, done in 1973; Egyptian gold leaf with high Ag; depletion gilding of Pre-Columbian Muisca Tunjos.]
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- M Ortega & 5 others** 2001 *Analysis of prehispanic pigments from "Templo Mayor" of Mexico City*, JMS 36 751-6 (1196). [EMPA, SEM, TEM & XRPD reveal hematite (red), goethite (ocher), palygorskite (blue) & Mn-dioxide (black) plus clays, feldspars, carbonates.]
- M Ortega-Aviles & 4 others** 2001 *Characterization of mural paintings from Cacaxtla*, JMS 36 2227-36 (1974). [See above.]
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- R Průkryl & 3 others** 2004 *Anthropogenic origin of salt crusts on sandstone sculptures of Prague's Charles Bridge (Czech Republic): Evidence of mineralogy and stable isotope geochemistry*, EJM 16 609-18 (10608). [Gypsum & K/ammonium/Mg/Zn-sulfates.]
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- G Rapp** 2002 *Archaeomineralogy*, 3-540-42579-9.
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- I Reiche & 8 others** 2001 *From mastodon ivory to gemstone: The origin of turquoise color in odontolite*, AM 86 1519-24. [Heated mastodon ivory contains Mn-fluorapatite not vivianite.]
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- P Reina** 2001 *Soil extraction saves teetering Tower of Pisa*, ENR 4/30 68-71 (4897). [Straightened half degree.]
- D Reinen P Kohl C Muller** 2004 *The nature of the colour centres in 'Maya Blue' – the incorporation of organic pigment molecules into the palygorskite lattice*, ZaaC 630 97-103 (9669).
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- C Rist** 1999 *How to heal a masterpiece*, D Apr 72-79 (869). [Pigment, oil, tempera.]
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- SC Stinson** 1996 *Chemists learn to preserve historical polymers while probing their nature*, CEN Sep 9 34-7 (893).
- do** 1998 *Chemistry in the service of art*, CEN Sep 7 31-7(894). [Polyesters. Pyroxylin. Linseed oil. Film storage. Cellulose nitrate. Rubber.]
- DA Stocks** 2003 *Experiments in Egyptian Archaeology: Stoneworking Technology in ancient Egypt*, Routledge.
- EC Stone & 4 others** 1998 *From shifting silt to solid stone: The manufacture of synthetic basalt in ancient Mesopotamia*, S 280 2091-3 (1163). [Mashkan-Shapir, 4 kybp. Deliberate melting of alluvial silt to make grinders.]
- AW Stupart** 1993 *Water repellent treatments for brickwork*, CI 18 Oct 809-11 (886). [Silane and siloxane hydrophobic products to block wind-blown rain penetration.]
- F Surmely & 4 others** 1998 *Flint characterization by microfacies analysis applied to the prehistoric settlement of Auvergne (France)*, CRASP 326 595-601 (1162). ['Blond flint' from s. Paris basin.]
- G Szakmány Z Kasztovsky** 2004 *Prompt Gamma Activation Analysis, a new method in the archaeological study of polished stone tools and their raw materials*, EJM 16 285-95 (10297).
- WS Taft & 4 others** 2000 *The Science of Paintings*, 0-387-9822-3.
- NH Tennent ed ed** *The Conservation of Glass and Ceramics. Research Practice and Training*, James & James, London, 1-873936-18-4.
- P Tropper A recheis J Konzett** 2004 *Pyrometamorphic formation of phosphorus-rich olivines in partially molten metapelitic gneisses from a prehistoric burial site (Ötz Valley, Tyrol, Austria)*, EJM 16 631-40 (10624).
- RH Tykot** 2002 *Chemical fingerprinting and source tracing of obsidian: The Central Mediterranean trade in black gold*, ACR 35 618-27. [Details for obsidian.]
- S Valls del Barrio M Garcia-Valles M Vendrell-Saz** 2000 *Mineralogical decay processes in stones: the case of Lleida Cathedral*, EJM 12 653-659 (1040). [Grain disintegration, joint mortar loss, flaking & efflorescence vs. rock type.]
- P Walter & 7 others** 1999 *Making make-up in ancient Egypt*, N 397 483-4 (877). [Cosmetics contain galena, cerussite, laurionite & phosgenite.]
- T Weiss B Leiss H Oppermann S Siegesmund** 1999 *Microfabric of fresh and weathered marbles: Implications and consequences for the reconstruction of the Marmor-Palais Potsdam*, Z dt geol Ges 150 313-322 (1038). [Many types with characteristic weathering.]
- U Weser Y & 4 others** 1998 *Embalming in the Old Kingdom of Pharaonic Egypt*, AnC 511-6A (W919). [Importance of suppression of bacterial decay by Zn-Mg enzyme.]
- GS Wheeler** 1992 *Preserving our heritage in stone*, AnC 64 A347-355 (873). [Barium methyl sulfate introduced & hydrolyzed to Ba sulfate: Ba hydroxide plus urea makes Ba carbonate. Tetraoxysilane etc. crack during polymerization into gel - hence added alcohol solvents.]
- CJ Wilkins & 3 others** 2003 *Spectroscopic and related evidence on the coloring and constitution of New Zealand jade*, AM 88 1336-44. [Maori pounamu.]
- L Wilson AM Pollard** 2002 *Here today, gone tomorrow? Integrated experimentation and geochemical modeling in studies of archaeological diagenetic change*, ACR 35 644-51. [Hydroxyapatite in bone to hydroxypyromorphite from Pb in nitrate fluid.]
- EM Winkler** 1994 *Stone in Architecture. Properties, Durability*, Springer, Berlin, 3-540-57626-6. [Treatise.]
- do** 1998 *The complexity of urban stone decay*, Gt Sep 25-29 (888). [Details including salt weathering.]
- L Wittmers Jr & 3 others** *Archaeological contributions of skeletal lead analysis*, 2002 ACR 35 669-75. [Review.]

N Wood 1978 *Oriental Glazes. Their Chemistry, Origins and Re-creation*, Watson-Guption, New York NY, 0-8230-385-6.

RAJ Wuerst J McLane 2000 *Rock deterioration in the Royal Tomb of Seti I, Valley of the Kings, Luxor, Egypt*, EnG 58 163-190 (631). [Shale & marl.]

Y Xie & 3 others 2004 *Texture analysis of ancient coins with TOF neutron diffraction*, JMS 39 3329-37 (10410).

H Yamei & 8 others 2000 *Mid-Pleistocene Acheulean-like stone technology of the Bose Basin, South China*, S 287 1622-6 & News 1565 (5001). [Tektite airfall & forest burning.]

P Young 1996 *Mouldering monuments*, NS 2 Nov 36-8 (1040).

Glass

This section covers glass, mainly in the form of beads. Synchrotron XRF analyses of beads from the Field Museum show that the beads with low alkali are stable and ones with high alkali are unstable. In addition, certain colored beads contain large amounts of toxic elements.

J Adeduntan 1985 *Early glass bead technology of Ife-Ife*, West African J Archeology 15 165-71.

LM Angus-Butterworth 1958 *Glass*. In **S Singer EJ Holmyard AR Hall TI Williams** *A History of Technology, volume IV, The Industrial Revolution c. 1750 - c. 1850*, Oxford Univ Press, NY, 358-378. [p 364 tubing and rod. Tube made by blowing hole in spherical blob, and pulling. 373 color.]

NP Bansal RH Doremus 1986 *Handbook of Glass Properties*, TA450.B270.

HC Beck 1981 *Classification and Nomenclature of Beads and Pendants*, George Shumway, York PA, 0-87387-061-1. [Very detailed.]

R Bertonecello & 5 others 2002 *Chemistry of cultural glasses: the early medieval glasses of Montselice's hill (Padova, Italy)*, JNCS 306 249-62 (7910). [VI-VII century. SEM-EDS, XPS, SIMS, Mössbauer. Fragments of 6 flat window glasses & 5 pale-green & yellow chalices. Flat glass has surface *vaterite* overlying *calcite*. Many details of Ca-enrichment. Fe(II)/total Fe is 8% for yellow glass & ~60 for green.]

F Branda G Laudisio A Costantino C Piccioli 1999 *Weathering of a Roman glass. A new hypothesis for pit formation on glass surfaces*, Glass Technol 40 89-91. [Baia, Italy. Pits and crusts attributed to multilayer surface coating formed by hydrolysis and condensation reactions producing Si-rich gel, that ages into pores to relieve stress.]

RH Brill 1999 *Chemical Analyses of Early Glasses. Volume 1 The Catalogue. Volume 2 The Tables*, Corning Museum of Glass, Corning NY, QD139.G5 B75. [~6 k specimens. About 30 elements analyzed. Many details.]

RW Cahn P Haasen EJ Kramer ed 1991 *Materials Science and Technology. A Comprehensive Treatment. J Zarzycki ed Volume 9. Glasses and Amorphous Materials*, VCH, Weinheim. [History. 19 Typical glass compositions. 42 Melting T vs. Na/Si. Section 4 Models. 294 alkali silicate glass. 302 borate glass. Section 12 Optical properties. 13 Mechanical properties.]

M Carey 1986 *Beads and Beadwork of East and South Africa*, Shire Books, Aylesbury, UK, GN646.C8.C27b.

do 1991 *Beads and Beadwork of West and Central Africa*, Shire Books, Aylesbury, UK. GN646.C8.C276, (1443). [33 Cameroon Grasslands. Two types: cylinder & round. Cylinders 5mm diameter 10-15 long; dark blue (night, bond between ancestors and present), dull terracotta red (blood & life) and white. Probably 19C Bohemia imported by Hausa & Fulani traders. Leopard (royalty symbol). Beads strung on raphia or burlap in 'lazy stitch'. Thrones kept in treasure house. German collectors obtained gifts 1902-14.]

RJ Charleston LM Angus-Butterworth 1957 In **S Singer EJ Holmyard AR Hall TI Williams**, *A History of Technology, volume III, From the Renaissance to the Industrial Revolution, c. 1500 - c. 1750*, Oxford Univ Press, New York, 206-244. [North and South. North used K from ash. 218 colors. 1673 George Ravenscroft invented lead glass. Germany & Bohemia potash-lime crystal with chalk and Mn. 240 stained glass windows.]

DE Clark CG Pantano LL Hench 1979 *Corrosion of Glass*, Books for Industry, NY.

[The] **Corning Museum of Glass** 2001 *A Guide to the Collections*, 0-87290-152-1.

K Cummings 2002 *A History of Glassforming*, 0-8122-3647-5 (7783).

C Davison 1972 *Glass beads in African archaeology: Results of neutron activation analysis, supplemented by results of X-ray fluorescence analysis*, LRL report, Berkeley CA.

BHWS de Jong 1985 *Glass*, Ullmann's Encyclopedia of Industrial Chemistry, v. A12, p. 366-440 (1043).

RW Douglas 1958 *Glass technology*. In **S Singer EJ Holmyard AR Hall TI Williams**, *A History of Technology, volume V, The Late Nineteenth Century c.1850 to c. 1900*, Oxford Univ Press, New York, 671-682. [Until early 19C K and Na confused. Dumas 1830 found that glass most stable to water with both Na/K & Ca about one-sixth of Si. Benrath 1875 proposed Na₂O 12.9 CaO 11.7 SiO₂ 75.4 wt.% as in modern window glass. Lead glass is 55 SiO₂ 32 PbO 12 K₂O.]

HJ Drewal J Mason 1997 *Beads, Body and Soul: Art and Soul in the Yoruba Universe*, UCLA Fowler Museum of Cultural History, Los Angeles CA, 0-939741-62-5. [Cosmos and color. p. 41 & 215-7 Royal foot cushions. Most in good condition with a few having lost fiber and beads. Appear to be younger than Field Museum Natural History stools.]

LS Dubin 1987 *The History of Beads from 30,000 BC to the Present*, Thames and Hudson, London. [Excellent, but not technical.]

RA Eppler DA Eppler 2000 *Glazes and Glass Coatings*, American Ceramic Association, Westville OH. (1034).

W Fagg ed 1980 *Yoruba Beadwork: Art of Nigeria*, Pace & Rizzoli, NY.

P Francis Jr 1979 *The Story of Venetian Beads*, Lapis Route Books, Lake Placid.

S Frank 1982 *Glass and Archaeology*, Academic, London. GN762.F72. [History. Many references. (1442).]

P Francis Jr 1988 *The Glass Trade Beads of Europe*, Lapis Route Books, Lake Placid.

do 1992 *West African perspective. The early bead trade*, Ornament 16 98-101. [Study only beginning. No evidence for Roman beads. First glass beads were Arab. Early Portuguese had no trade beads. Later European dominance over continuing Arab supply.]

do 1994 *Beads of the World*, A Collector's Guide with Price Reference, 0-88740-559-2. [Nice color: no chemistry.]

M Garcia-Valles & 3 others 2003 *Medieval stained glass in a Mediterranean climate: Typology, weathering and glass decay, and associated biomineralization processes and products*, AM 88 1996-2006. [Bixbyite/calcite/gypsum/syngenite/weddellite/whewellite]

A Gasparetto 1962 *Glass. Encyclopedia of World Art. vol. VI*. McGraw-Hill, New York. [Art history. Mentions beads - oldest glass.]

CM Geary 1994 *The Voyage of King Njoya's Gift: A Beaded Sculpture from the Bamum Kingdom, Cameroon*, Smithsonian Press, 94-38694. [Mainly art history.]

AF Gordon L Kahan 1976 *The Tribal Bead: A Handbook of African Trade Beads*, Tribal Arts Gallery, New York.

DB Harden 1956 *Glasses and Glazes*. In **S Singer EJ Holmyard AR Hall TI Williams** *A History of Technology, volume II, The Mediterranean Civilizations and the Middle Ages c. 700 B. C. to c. A. D. 1500*, Oxford Univ Press, New York, 311-346. [312 & 314 colors. 313 table of compositions. K melts lower T than Na. 333 Weathering = any time-change degradation. Covers surface dulling, frosting, strain-cracking, enamel-like & iridescence. Many causes. 336 Beads using first a central metal wire dipped in glass or wound inside a glass streamer, then in late Roman times cut from blown tube.]

RGV Hancock A Chafe I Kenyon 1994 *Neutron activation analysis of sixteenth- and seventeenth European glass beads from the eastern Great Lakes*, Archaeometry 36 253-66.

P Harter 1992 *The Beads of Cameroon*, J Society of Bead Researchers 4 5-20.

J Henderson 2002 *Tradition and experiment in first millenium A. D. glass production - The emergence of early Islamic glass technology in late antiquity*, ACR 35 594-602. [Mg/K distinguishes low-Fe/K Iron Age glass from low Mg/high K Bronze Age from high Mg/low K Bronze Age. Egypt: pre 845 AD, low Mg/K natron glass; post, high plant ash. Analyses show range of input over time at one site, & between sites.]

FW Hodkin A Cousen 1925 *A Textbook of Glass Technology*, Clarendon, Oxford UK. TP857.H63. [Thorough, industrial. As: decolorizer? Chapter XXXVI: Manufacture of rod/tubing.]

- S Jargsdorf** 1991 *Glass in Jewellery. Hidden Artistry in Glass*, Schiffer Publishing, Atglen PA, 0-88740-295-X. [Useful photos and history.]
- do** 1995 *Glass Beads from Europe: with Value Guide*, Schiffer Publishing, Atglen PA, 0-88740-839-7. [Serious scholarly history. Trade from Bohemia & Murano to Africa.]
- K Karklins** 1985 *Early Amsterdam trade beads*, *Ornament* 9(2) 36-42. [~1580-1680. Many types. ? match with USA/Canada.]
- KE Kidd** 1979 *Glass Bead-Making from the Middle Ages to the Early 19th Century*, *History & Archaeology* 30, 0-660-10445-8. [Focuses on Venice.]
- I Kenyon RGV Hancock S Aufreiter** 1995 *Neutron activation analysis of AD 1600-1930 European trade beads from Ontario, Canada*, *Archeometry* 37 323-37.
- S Loughheed J Shaw** 1985 *The deterioration of glass beads on ethnographic objects*, *The Bead Forum* 7 10-2.
- AL Marlins AC Bonnano** 2001 *Jewelry and Gems. The Buying Guide*. 4th ed, Gemstone Press, TS756.M28. [Useful reading list.]
- B Messiga MP Riccardi** 2001 *A petrological approach to the study of ancient glass*, *PM* 70 (1) 57-70 (1975). [Glasses from Lomello (AD I-IV C) & Val Gargassa (late XII). Unmelted minerals, banded textures, phase separation, etc. EMPA, optical microscopy.]
- R Newton S Davidson** 1997 *Conservation of Glass*, Butterworth-Heinemann Series in Conservation and Museology, Linacre House, Oxford UK.
- PT Nicholson I Shaw** ed 2000 *Ancient Egyptian Materials and Technology*. Cambridge Univ Press, Cambridge UK (1277). [177 Egyptian faience = glazed non-clay ceramic. 195 Glass. Deliberate production in 18th dynasty. High-status product. Possible remelting of foreign glass. Beads, amulets, sculpture & vessels. Co, Mn, Cu, Sn, Sb, etc colorants. Speculations on manufacture: grinding powder; fritting furnace to boil off gases; melting in crucibles; ingots; ?shaping with a hot flame; pouring into mould; annealing in embers; Egyptian blue frit; at least 5 composition groups; opacifiers based on Sb, crystals of Ca and Pb antimonate identified by XRD; occasional Sn is impurity; Cu(II) gives *turquoise*, Cu(I) brown-red; also Pb in red-brown; EMP analyses of 18C colored glass show Na₂O 13-22 MgO 3-6 Al₂O₃ 0.5-3.4 SiO₂ 56-65 P₂O₅ 0.-0.3 SO₃ 0.1-0.7 Cl .4-1.8 K₂O 0.7-4.2 CaO 4.7-12.8 most 6-9 MnO most 0.03-0.07 Fe₂O₃ most 0.3-1.1 CoO most bd but up to 0.21 CuO nd to 1.5 As₂O₃ nd to 0.4 SnO₂ most nd Sb₂O₃ most 0.4-3 PbO up to 7, most low. Alkalis from salt plants; silica from sand; Co in blue glass, Cu in translucent *turquoise*, Mn in purple, Ca & Sb in opaque white, etc; probable deliberate addition of MnO₂; melting temperature ~ 1150-1330 K.]
- T Northern** 1975 *The Sign of the Leopard: Beaded Art of Cameroon*, University of Connecticut, Storrs CT, 75-29588. [Exhibition catalog of Linden Museum, Stuttgart.]
- T Northern** 1984 *The Art of Cameroon*, Smithsonian Inst. Press, DC.
- MV Orna** 1996 *Archaeological Chemistry*, Am Chem Soc Symp Ser 625, American Chemical Society, Washington DC, CC79.C5A73. [31 papers. Thai glass. Quebec blue beads. Cu-based medieval blue pigments. Trace elements in bone. Diagenetic alteration of bone.]
- J Picard R Picard** 1986a *Chevron Beads from the West African Trade*; b *Tabular Beads from the West African Trade*; 1987 *Fancy Beads from the West African Trade*, Carmel, Picard African Imports.
- S Quartieri & 4 others** 2002 *Fe and Mn K-edge XANES study of ancient Roman glasses*, *EJM* 14 749-56.
- T Rehren EB Pusch** 2005 *Late Bronze Age glass production at Qantir-Pirameses-Egypt*, *S* 308 1756-8, *Commentary*, 1750-1.
- JM Rincon M Romero** ed 1999 *Characterization Techniques of Glasses and Ceramics*, Springer, Berlin, TP810.C473.
- C Roesch & 4 others** 1997 *Electron microprobe analysis and X-ray diffraction methods in archaeometry: Investigations on ancient beads from the Sultanate of Oman and from Sri Lanka*, *EJM* 9 763-83 (1166). [EMPA & XRPD. Garnet (almandine-pyrope), *silver-gold*, Egyptian Blue & synthetic *enstatite*. Glass beads: reddish-brown Oman, Na-rich colored with Cu in matrix; opaque red Sri Lanka, K-rich with *cuprite* drops in matrix; blue-white-blue & brown-white-brown sandwich

beads from both areas. Many details. Alteration to *smectite-saponite* retaining metals. Analogy with nuclear waste & C-T impact glasses.]

LD Sciamia J B Eicher eds 1998 *Beads and Bead Makers: Gender, Material Culture and Meaning*, Oxford Univ Press, New York. GT2250.B43. [Most African beads from Venice (Murano island), Bohemia & Netherlands.]

JE Shelby 1997 *Introduction to Glass Science and Technology*. The Royal Society of Chemistry, Cambridge UK. [172 Chemical durability relates to interaction with liquid. Weathering is interaction with water vapor. Na ion reacts with water to generate NaOH that reacts with carbon dioxide. Leached layer can expand or contract with heat and cold. Deduction of alkali concentration by treatment with sulfur dioxide improves resistance. 187 Glass is strengthened by removing flaws by chemical etching and by mechanical or flame polishing. A surface can be ion-exchanged with larger ion. 202 Ligand field color. 209 IR.]

PJ Sirois 1999 *The deterioration of glass trade beads from Canadian ethnographic and textile collections*, in **NH Tennent** ed *The Conservation of Glass and Ceramics. Research Practice and Training*, James & James, London, 84-94 (8012). [Drawn, wire-wound & moulded. Generally 60-75% silica; alkalis & earths; colorants, opacifiers, refiners & cullet (broken waste). Stable glasses have 7-13 % CaO & 6-22% soda. Cracked & broken, sticky, waxy, weeping white powdery & crizzled surfaces. Stereo-optics of surface; pH paper & distilled water; XRPD; SEM; EMP mounts made dry; EDS analyses; FTIR. Na lower at crizzled surface. Most common is hydrolysis. Cu(I) & Mn(III) used for black color; pH 9; for pH <9 get alkali extraction leaving silica enrichment, >9 get dissolution of silica. Type II silica-rich surface is stable; IV is unstable. etc. Store with relative humidity <30%.]

JF Stebbins PF McMillan DB Dingwell ed 1995 *Structure, Dynamics and Properties of Silicate Melts*, ReM 32, 1-616.

D Stokes 1999 *Rediscovered treasures. African beadwork at the Field Museum, Chicago*, African Arts, Autumn, UCLA James S. Coleman African Studies Center (1444). [100 S. African examples in Fuller Bequest collected from 1843 onward, donated after Columbian Exposition. Etc. Now totals 1,000 examples.]

M Tite A Shortland S Paynter 2002 *The beginnings of vitreous materials in the Near East and Egypt*, ACR 35 585-93. [First ones 6kybp were Cu-alkali-lime glazed *quartz* & steatite and faience = glazed *quartz* powder. 5 to 3.5 made glass, and generated new colors - Co blue, CaSb white, PbSb yellow. Analyses show K from ash. Glass first in Mesopotamia ~3.5 then Egypt at 1373-1473 K. Details.]

FE Wagner & 5 others 2000 *Before striking gold in gold-ruby glass*, N 407 691-2 (876). [Mössbauer reveals Au (I) linearly bonded in colorless glass.]

MM Wright ed 2001 *Ethnographic Beadwork. Aspects of Manufacture, Use and Construction*, Archetype, London, 1-873132-87-5. [13 articles:

2. **IC Glover** *Differential decay of buried Iron Age Thai glass in a uniform environment*, 15-26. Table 2.2 has EMP analyses of 13 good beads with potash 15-18%, Table 2.3 5 beads with potash 3-5 & soda 10-12. Degraded beads not reliable analyses.

3. **S Carroll K McHugh** *Material characterisation of glass disease on beaded ethnographic artefacts from the collection of the National Museum of the Ancient Indian*, 27-38. Quotation from Werner: 'This "glass disease" is thus due to a constitutional defect in the glass which renders it susceptible to the slow destructive action of water vapour and carbon dioxide'. Two broad types: powdery/crystalline & waxy/crusty. Alkalis leach to the surface and Na/K hydroxide solution forms carbonates. Tests for carbonate & chloride. Oil - origins? Kaolin.

7. **T Seddon S Watts** *Examination and conservation of a beaded throne from Cameroon*, 79-101. 1916 gift to King George V. Wood good; fabric patchy loss; beads partly lost and broken. SEM-EDS of 7 beads & encrustations. #1127 red contains Fe & Cu; 1132 opaque white As, Pb; 1129 dark blue Co; etc.]

8. **M Carey** *Potential hazards in caring for ethnographic beadwork*, 103-12. Insects, leather & sinew, threads, danger from cellulose nitrate.

10. **S Doyal** *Cleaning historic beadwork*, 117-22. Vacuum cleaning. Swabbing.

13. **M Keatings** *An introduction to stone beads*, 133-40. Details of origins & best way to clean.]

Metals

Metals corrode over time generating a range of secondary minerals that can be characterized by synchrotron XRD analysis.

R Balasubramaniam 2002 *CuS* 82 1357-65 (7617). [1.6 ky P-rich wrought-iron pillar of Gupta dynasty, Delhi, is coated with 0.0n mm *misamite* a Fe-O-H protectant.]

do & 2 others 2003 *Characterization of rust on ancient Indian iron*, *CuS* 85 1546-55 (9651)>

DK Chakrabarti N Lahiri 1995 *Copper and its Alloys in Ancient India*, Munshiram Manoharlal, TS565.C43.

T Clarke 2004 *Organ failure*, *N* 427 8-9 (9516). [Pb pipes in European organs are corroding from acetic acid from new oak wood generating Pb/OH/carbonate/acetate. British organs OK probably because of 20 % Sn.]

JR Craig & 3 others 2002 *Corrosion mineralogy of an 1800 Spanish Piece of Eight*, *CM* 40 585-94. [*Acanthite, atacamite, covellite, jalpaite, mckinstryite, silver, stromeyerite.*]

SE Dunkle & 3 others 2003 *Romarchite, hydromarchite, and abhurite formed during the corrosion of pewter artifacts from the Queen Anne's Revenge*, *CM* 41 659-69.

ME Essington JE Foss Y Roh 2004 *The soil mineralogy of lead at Horace's Villa*, *SSSAJ* 68 979-93 (10295). [*Cerussite, hydrocerussite, litharge.*]

JN Fang LP Tan E Huang 2003 *Modes and textures of secondary minerals on Chinese coins of different ages*, *MM* 67 23-30. [796 coins; 80% *malachite*, 39 *cerussite*, 12 *cuprite*, 9 *azurite.*]

NH Gale ZA Stos-Gale 1982 *Bronze Age copper sources in the Mediterranean: A new approach*, *S* 216 11-9 (1167). [Metals do not give characterization of sources because of variability. Pb isotopes show Laurion, Greece, may be more important than Cyprus for Late Bronze Age Crete.]

R Gottschalk 2001 *Material provenance of late-Roman lead coffins in the Rheinland*, *EJM* 13 197-205 (8002). [Byproduct of Roman silver?]

RB Heimann & 9 others 1998 *Archaeometallurgical investigations into the iron production technology in Upper Lusatia, Saxony, from the Early Iron Age (Billendorf period) to the 12th century A.D.*, *EJM* 10 1015-35 (H1373). [Two types of bog ore used in bloomeries distinguished by Mn/Ba.]

D Hosler A Macfarlane 1996 *Copper sources, metal production, and metals trade in Late Postclassic Mesoamerica*, *S* 273 1819-24 (1170). [8 minerals/Pb isotopes/15 ores/171 artifacts.]

D Klemm R Klemm A Murr 2001 *Gold of the Pharaohs - 6000 years of gold mining in Egypt and Nubia*, *African Earth Sciences* 33 643-59 (7538). [Details of mining geology.]

A Manasse M Mellini C Viti 2001 *The copper slags of the Capattoli valley, Campiglia Marittima, Italy*, *EJM* 13 949-60 (4223). [Etruscan to Middle Ages.]

W Martens RL Frost PA Williams 2003 *Raman and infrared spectroscopic study of the basic copper chloride minerals – implications for the study of the copper and brass corrosion and "bronze disease"*, *NJMA* 197-215 (8927). [*Atacamite/clinoatacamite/paratacamite.* Use Raman during restoration of old paintings.]

B Newbury & 6 others 2004 *Synchrotron applications in archaeometallurgy: Analysis of high zinc brass astrolabes*, *PD* 19 12-5 (10155).

AG Nord E Mattson K Tronner 1996 *Mineral phases on corroded archaeological bronze artefacts excavated in Sweden*, *NJMM* 265-77 (N492). [SEM/EDS and XRPD. *Cuprite, malachite* ubiquitous. *Brochantite, atacamite/paratacamite* common, plus >10 other Cu minerals. General relation to soil chemistry.]

R Sáez & 4 others 2003 *The extractive metallurgy of copper from Cabezo Juré, Huelva, Spain: chemical and mineralogical study of slags dated to the third millennium B. C.*, *CM* 41 627-38..

DA Scott 1991 *Metallography and Microstructure of Ancient and Historic Metals*, Getty Publications, Los Angeles CA.

do 2002 *Copper and Bronze in Art: Corrosion, Colorants, Conservation*, Getty Publications, Los Angeles CA, 0-89236-638-9. [Comprehensive with sections on *cuprite/tenorite/spertiniite* (= Cu (II) hydroxide)/*malachite/azurite/brochantite/atacamite/chalconatrite/turquoise/chrysocolla/verdigris/cuprorivaite* (= Egyptian blue synthetic pigment) etc. = ~ 170 mineral types; arsenic & lead patinas; etc.]

PR Schmidt 1997 *Iron Technology in East Africa. Symbolism, Science and Archaeology*, 0-253-33255-9 (4997).

V Tripathi ed 1998 *Archaeometallurgy in India*, TN645.I4A73 (4998).

TA Wertime 1973 *The beginnings of metallurgy: a new look*, S 182 875-88 (W897).

[Comprehensive listing of known Sn and As sources in Middle East.]

KA Yener & 4 others 1989 *An Early Bronze Age source of tin ore in the Tauris Mountains, Turkey*, S 244 200-3 (8003).

Bioin mineralogy and soil mineralogy

This area of mineralogy is growing explosively, as new techniques of chemical microscopy permit characterization of bacteria and larger organisms. Both organic and inorganic chemistry are involved. Important elements for industry including uranium concentrate in the outer surfaces of bacteria, and may generate ore deposits. Bacteria have a major effect on the quality of water and air, including ones in mine drainage and industrial waste sites. Bacteria are growing in importance for industry. Tooth and bone mineralogy is covered under **Medical**. The International Geosphere-Biosphere Programme started in 1986 under the International Council of Science has several programs involving bacteria. Biominerals are summarized in **HCW Skinner** 2005 *Biominerals*, MM 69 621-41. Abiogenic vs biogenic decomposition are reviewed in **GA Krinari**
AA Shinkarev KG Giniyatullin ZVMO 134 18-33.

Applications in paleontology, bacteria, etc.

L Addadi S Weiner 1997 *A pavement of pearl*, N 389 912-3 (963).

J Aizenberg & 3 others 1996 *Stabilization of amorphous calcium carbonate by specialized macromolecules in biological and synthetic precipitates*, AdM 8 222-6 (972).

J Aizenberg & 3 others 2002 *Factors involved in the formation of amorphous and crystalline calcium carbonate: A study of an Ascidian skeleton*, JACHS 124 32-9 (3915). [*Aragonite, calcite*.]

J Aizenberg & 5 others 2005 *Skeleton of Euplectella sp.: Structural hierarchy from the nanoscale to the macroscale*, S 309 275-8; Perspectives 253-4.

JPAmend KJ Edwards TW Lyons ed 2004 *Sulfur Biogeochemistry: Past and Present*, GSA Spec Paper 379.

P Anadon R Utrilla A Vazquez 2002 *Mineralogy and Sr-Mg geochemistry of charophyte carbonates: a new tool for paleontological research*, EPSL 197 205-14 (7201). [*Calcite & aragonite* in same cell of *Chara* plants. Mg/Ca/Sr varies.]

B Arato & 6 others 2005 *Crystal-size and shape distributions of magnetite from uncultured magnetotactic bacteria as a potential biomarker*, AM 90 1233-40.

BJ Baker JF Banfield 2003 *Microbial communities in acid mine drainage*, FEMS Microbiology Ecology 44 139-52 (8945). [Review.]

SK Barik JK Jena KJ Ram 2004 *CaCO₃ crystallization in primary culture of mantle epithelial cells of freshwater pearl mussel*, CuS 86 730-2 (10092). [*Aragonite*.]

DA Bazylinski & 3 others 1993 *FeO and FeS in a bacterium*, N 366 218 (962).

A Becker & 6 others 2003 *Structural characterization of X-ray amorphous calcium carbonate (ACC) in sternal deposits of the crustacean Porcellio scaber*, JCSD 551-5 (9008).

D Bidle F Azam 1999 *Accelerated dissolution of diatom silica by marine bacterial assemblages*, N 397 508-10.

CE Blank SL Cady NR Pace 2002 *Microbial composition of near-boiling silica-depositing thermal springs throughout Yellowstone National Park*, AEM 68 5123-35. [Mainly H oxidizers in *Aquificales*, but many more. Details.]

CK Boyce & 5 others 2002 *Organic chemical differentiation within fossil plant cell walls detected with X-ray spectromicroscopy*, G 30 1039-42 (8278). [C 1s XANES. Modern red cedar; Eocene conifer; stem lycopod from Devonian Rhynie chert.]

O Braissant & 3 others 2003 *Bacterially induced mineralization of calcium carbonate in terrestrial environments: The role of exopolysaccharides and amino acids*, JSR 73 485-90 (8938). [Change of shape from needle to spherical in vaterite, & to rhombohedral in calcite.]

DA Brown & 3 others 1999 *Precipitation of iron minerals by a natural microbial consortium*, GCA 63 2163-9 (B1942).

TG Chasteen R Bentley 2003 *Biomethylation of selenium and tellurium: microorganisms and plants*, ChR 103 1-22 (8642).

X Chatellier & 4 others 2001 *Effect of the presence of bacterial surfaces during the synthesis of Fe oxides by oxidation of ferrous ions*, EJM 13 705-14 (3425). [*Lepidocrocite*.]

SJ Clemett & 11 others 2002 *Crystal morphology of MV-1 magnetite*, AM 87 1727-30. [Magnetotactic bacterium. TEM.]

SA Corr & 4 others 2004 *Magnetite nanocrystals from a single source metallorganic precursor: metallorganic chemistry vs. biogeneric bacteria*, JMC 14 944-6 (10203). [Synthesis via Fe(II)-tert-butoxide.]

LR Croal & 3 others 2004 *The genetics of geochemistry*, Ann Rev Genet 38 175-202 (10983). [Bacteria vs energy use/ As/Fe reduction.]

TC Crusberg 2004 *Biomineralization of copper by a fungus revealed by SEM*, Microscopy & Analysis 18(1) 5-7 (9642). [*Penicillium ochro-chloron*; Cu oxalate & phosphate precipitate.]

T Danelian D Moreira 2004 *Paleontological and molecular arguments for the origin of silica-secreting organisms*, C R Palevol 3 229-36 (10547).

BT De Gregorio TG Sharp 2006 *The structure and distribution of carbon in 3.5 GPa Apex chert: Implications for the biogenicity of Earth's oldest putative microfossils*, AM 91 784-9.

E DiMasi M Sarikaya 2004 *Synchrotron x-ray microbeam diffraction from abalone shell*, JMR 19 1471-8 (10254). [*Aragonite/calcite*.]

HT Dinh & 5 others 2004 *Iron corrosion by novel anaerobic microorganisms*, N 427 829-32 (10067). [Marine sulfate-reducing bacteria.]

S Dixit P Van Cappellen 2002 *Surface chemistry and reactivity of biogenic silica*, GCA 66 2559-68 (7669). [Cultured diatoms vs diatom shells in Southern Ocean sediments shows loss of reactivity of latter.]

P Dominguez AG Jacobson RPS Jefferies 2002 *Paired gill slits in a fossil with a calcite skeleton*, N 417 841-4 (7420). [X-ray tomography of *Jaekelocarpus*.]

JJM Donners & 4 others 2002 *Control over calcium phase formation by dendrimer/surfactant templates*, CEJ 8 2561-72 (7607). [Synthetic.]

PM Dove JJ De Yoreo S Weiner ed 2003 *Biomineralization*, RMG 54 1-379 (10344). [12 chapters: overview; principles; bacteria-induced; foraminifera; coral; calcite in coccoliths; prokaryotes; silica; evolutionary history; global biogeochemical cycles.]

M Dubiel & 4 others 2002 *Microbial iron respiration can protect steel from corrosion*, AEM 68 1440-5 (7189). [Biofilms with Fe-respiring bacteria may reduce corrosion by Fe(III) to (II).]

SC Dufour H Felbeck 2003 *Sulphide mining by the superextensible foot of symbiotic thyrasirid bivalves*, N 426 65-7 (9612).

RE Dunin-Borkowski & 5 others 1998 *Magnetic microstructure of magnetotactic bacteria by electron holography*, S 282 1868-70 (968).

RE Dunin-Borkowski & 5 others 2001 *Off-axis electron holography of magnetotactic bacteria: magnetic microstructure of strains MV-1 and MS-1*, EJM 13 671-84 (3423). [*Magnetite*.]

HL Ehrlich 2001 *Geomicrobiology*, 4th ed., 0-8247-0764-8. [Contains: origin of life, interactions of microbes with Si Al P N As Sb Hg Fe Mn Cr Mo V U Po S Se Te; fossil fuels.]

CS Evans C Bucke 1998 *Biomediation by fungi*, CI 16 Feb 134-7 (5544). [Compost & mushrooms use fungi for waste degradation. *Basidiomycetes* can eat wood; main focus of bioremediation. Can degrade PCB, DDT, etc. Many details.]

G Falini & 4 others 2005 *Influence on the formation of aragonite or vaterite by otolith macromolecules*, EJIC 162-7 (10987).

M Farina DMS Esquivel HGP Lins de Barros 1990 *Magnetic iron-sulphur crystals from a magnetotactic microorganism*. N 343 256-8 (961).

M Fayek & 7 others 2005 *The application of HRTEM techniques and NanoSIMS to chemically and isoopically characterize Geobacter sulfurreducens surfaces* CM 43 1631-41. [Reduction of U^{6+} to uraninite.]

AA Finch N Allison 2003 *Strontium in coral aragonite: 2. Sr coordination and the long-term stability of coral environmental records*, GCA 67 4519-27 (9526).

SA Fish & 3 others 2002 *Recovery of 16S ribosomal RNA gene fragments from ancient halite*, N 417 432-6 (7225). [11 to 425 My.]

CA Francis BM Tebo 2002 *Enzymatic manganese (II) oxidation by metabolically dormant spores of diverse Bacillus species*, AEM 68 874-80 (7188).

CG Friedrich & 4 others 2001 *Oxidation of reduced inorganic sulfur compounds by bacteria: Emergence of a common mechanism?* AEB Jul 2873-82 (4873).

S Frisia & 4 others 2002 *Aragonite-calcite relationships in speleothems (Grotte de Clamouse, France): Environment, fabrics, and carbonate geochemistry*, JSR 72 687-99 (7954).

M Gajdardziska & 4 others 2001 *Discovery of nanocrystalline botanical magnetite*, EJM 13 863-70 (3471). [Grass cells. Mostly cuboctahedra.]

M Gehlen & 5 others 2002 *Unraveling the atomic structure of biogenic silica: Evidence of the structural association of Al and Si in diatom frustules*, GCA 66 1601-9 (7163). [XAS shows tetrahedral Al in cultured diatoms, and both tetra and octa in marine.]

A Geptner & 3 others 2002 *Biogenic saponite from an active submarine hot spring, Iceland*, CICIM 50 174-85 (7138).

S Glasauer S Langley TJ Beveridge 2002 *Intracellular iron minerals in a dissimilatory iron-reducing bacterium*. S 295 117-119 (3887). [Magnetite/greigite/ferrihydrite.]

S Glasauer & 3 others 2003 *Controls on Fe reduction and mineral formation by a subsurface bacterium*, GCA 67 1277-88. [Goethite/green rust/hematite/magnetite / vivianite. Depends on nutrient availability.]

RB Gregor NE Pingitore Jr FW Lytle 1997 *Strontianite in coral skeletal aragonite*. S 275 1452-4 (973).

ST Grimes & 7 others 2002 *Fossil plants from the Eocene London Clay: the use of pyrite textures to determine the mechanism of pyritization*, JGSL 159 493-501 (7983). [SEM shows framboids, polycrystals, sub- to euhedral- & microcrystals. Get rapid nucleation of microcrystals, cell infilling with framboids or octahedra, overgrowth of latter with radial or massive polycrystals, overgrowth on plant axes & through fractures.]

Y Hu & 7 others 2004 *Three-dimensional network photonic crystals via cyclic size reduction/infiltration of sea urchin exoskeleton*, Adv Mater 16 1091-4 (10534).

SR Hall H Bolger S Mann 2003 *Morphosynthesis of complex inorganic forms using pollen grain templates*, ChC 2784-5 (9529).

CM Hansel & 5 others 2003 *Secondary mineralization pathways induced by dissimilarity reduction of ferrihydrite under advective flow*, GCA 67 2977-92 (9561). [Shewanella putrefaciens. Makes goethite/green rust/magnetite.]

SK Haslett ed 2002 *Quaternary Environmental Micropaleontology*, Oxford U P, 0-340-76197-0. [11 chapters covering benthic & intertidal foraminifera, ostracoda, diatoms, etc.]

K Henriksen & 3 others 2003 *Tailoring calcite: Nanoscale AFM of coccolith biocrystals*, AM 88 2040-4.

VC Hover LM Walker DR Peacor 2001 *Early marine diagenesis of biogenic aragonite and Mg-calcite: new constraints from high-resolution STEM and AEM analyses of modern platform carbonates*, CG 175 221-48 (2063).

J Jørgensen & 5 others *The structure of the manganese oxide on the sheath of the bacterium Leptothorix discophora: an EXAFS study*, 2004 AM 89 1110-8. [Na-birnessite.]

K Kashefi & 3 others 2001 *Reductive precipitation of gold by dissimilatory Fe(III)-reducing Bacteria and Archaea*, AEM 3275-79 (4874).

H Kim & 3 others 2003 *Nanocrystalline todorokite-like mangnaous oxide produced by bacterial catalysis*, JSChS 125 14284-5 (9531).

J Kim & 4 others 2004 *Role of microbes in the smectite-to-illite reaction*, S 303 830-2 (10056).

KO Konhauser & 6 others 2002 *Could bacteria have formed the Precambrian banded iron formations*, G 30 1079-82 (8442). [Yes, as in Hamersley, W Australia.]

JE Kostka & 4 others 2002 *Growth of iron(III)-reducing bacteria on clay minerals as the sole electron acceptor and comparison of growth yields on a variety of oxidized iron forms*, AEM 6256-62 (8376).

U Kuhn & 4 others 2000 *Field measurements on the exchange of carbonyl sulfide between lichens and the atmosphere*, AE 34 4867-78 (3380).

RK Kukkadapu & 5 others 2005 *Ferrous hydroxyl carbonate is a stable transformation product of biogenic magnetite*, AM 90 510-55. [akaganeite/ferrihydrite/magnetite/rosasite.]

BD Lanoil & 4 others 2001 *Bacteria and Archaea associated with Gulf of Mexico gas hydrates*, AEM 67 5143-53 (3515).

M Ledin 2000 *Accumulation of metals by microorganisms – processes and importance for soil systems*, ESR 51 1-31 (4052).

C Li X Zhang Z Cao 2005 *Triangular and Fibonacci number patterns driven by stress on core/shell microstructures*, S 309 909-10.

M Li B Lebeau S Mann 2003 *Synthesis of aragonite nanofilament networks by mesoscale self-assembly and transformation in reverse microemulsions*, AdM 15 2032-5. [Doughnut-shaped.]

HC Lichtenegger & 4 others 2002 *High abrasion resistance with sparse mineralization: copper biomineral in worm jaws*, S 298 389-92, perspectives 375-6. [Atacamite.]

A Lux & 4 others 2003 *Silicification of bamboo (Phyllostachys hetrocycla Mitf.) root and leaf*, PS 255 86-91 (9538).

J Macalady JF Banfield 2003 *Molecular geomicrobiology: genes and geochemical cycling*, EPSL 209 1-17 (8861). [Frontiers.]

MR McCartney & 4 others 2001 *Magnetic microstructure of bacterial magnetite by electron holography*, EJM 13 685-9 (3424).

RG McClean & 6 others 2001 *Botanical iron minerals: correlation between nanocrystal structure and modes of biological self-assembly*, EJM 13 1235-42 (3810). [Phytoferritin occurs as magnetite, epsilon-Fe₂O₃ & hematite: also calcium ferrate hexahydrate possible.]

C Macilwain 2004 *Organic: Is it the future of farming?* N 428 792-3 (10204). [Probably not entirely, but groing.]

U Magdams H Gies 2004 *Single crystal structure analysis of sea urchin spine calcites: Systematic investigations of the Ca/Mg distribution as a function of habitat of the sea urchin and the sample location in the spine*, EJM 16 261-8 (10249).

JM McIntosh LA Groat ed 1997 *Biological-Mineralogical Interactions*, Min Assoc Canada Short Course Series 25 (3523). [10 contributions.]

AJ Milligan FMM Morel 2002 *A proton buffering role for silica in diatoms*, S 297 1848-50 (7995). [Biosilica of diatoms is effective pH buffer enabling enzymatic conversion of bicarbonate to CO₂; important in deep sea.]

PA Maurice & 4 others 2002 *Direct observation of aluminosilicate weathering in the hyporheic zone of an Antarctic Dry Valley stream*, GCA 66 1335-47 (7154). [Biofilm on muscovite with alpha-Proteobacteria.]

JW Moreau RI Webb JF Banfield 2004 *Ultrastructure, aggregation-state, and crystal growth of biogenic nanocrystalline sphalerite and wurtzite*, AM 89 950-60.

SB Mukkamala AK Powell 2004 *Biomimetic assembly of calcite microtrumpets: crystal tectonics in action*, ChC 918-9 (10298). [Uses a polycarboxylate.]

WL Murphy DJ Mooney 2002 *Bioinspired growth of crystalline carbonate apatite on biodegradable polymer substrata*, JACHS 124 1910-7 (6210).

National Research Council 2003 *Bioavailability of Contaminants in Soils and Sediments. Processes, Tools, and Applications*, TD878.2.B56.

R Navarro-Gonzalez & 11 others 2003 *Mars-like soils in the Atacama Desert, Chile, and the dry limit of microbial life*, S 302 1019-21 (9599).

RS Oremland & 5 others 2002 *Anaerobic oxidation of arsenite in Mono Lake water and by a facultative, arsenite-oxidizing chemoautotroph, strain MLHE-1*, AEM 68 4795-802. [Expts aimed at biological oxidation of As(III) to (V).]

RJ Park FC Meldrum 2002 *Synthesis of single crystals of calcite with complex morphologies*, AdM 14 1167-9. [Use polymer membrane. Get porous aggregate similar to sea urchin.]

E Pennisi 2001 *Shale-eating microbes recycle global carbon*, S 292 1043 (6222).

VR Phoenix DG Adams KO Konhauser 2000 *Cyanobacterial viability during hydrothermal biomineralisation*, ChG 169 329-38 (4954).

VG Phoenix & 3 others 2005 *Bacterial S-layer preservation and rare arsenic-antimony-sulphide bioimmobilization in siliceous sediments from Champagne Pool hot spring, Waiotapu, New Zealand*, JGSL 101 323-31 (10912).

Y Politi & 4 others 2004 *Sea urchin spine calcite forms via a transient amorphous calcium carbonate phase*, S 306 1161-4 (10799).

M Posfai & 6 others 2001 *Crystal-size distributions and possible biogenic origin of Fe sulfides*, EJM 13 691-703 (3428). [Greigite.]

D Rautaray A Ahmad M Sastry 2003 *Biosynthesis of CaCO₃ crystals of complex morphology using a fungus and an actinomycete*, JACHS 125 14656-7 (9520).

D Rautaray & 4 others 2004 *Biological synthesis of strontium carbonate crystals using the fungus Fusarium oxysporum*, La 20 6827-33 (10530).

C Rathgeber & 4 others 2002 *Isolation of tellurite- and selenite-resistant bacteria from hydrothermal vents of the Juan de Fuca Ridge in the Pacific Ocean*, AEM 68 4613-22. [Reduce to metallic selenium & tellurium.]

JA Roberts & 4 others 2004 *Microbial precipitation of dolomite in methanogenic groundwater*, G 32 277-80 (10157).

S Roberts JW Murray 1995 *Characterization of cement mineralogy in agglutinated foraminifera (Protista) by Raman spectroscopy* JGSL 152 7-9 (958).

KD Rogers 1997 *Initial Rietveld characterization of biological calcifications*, PD 12 175-9 (1320).

Y Roh & 5 others 2003 *Biochemical and environmental factors in Fe biomineralization: magnetite and siderite formation*, CICIM 51 83-95 (8608). [Akaganeite reduced by various bacteria.]

RA Royer & 5 others 2002 *Enhancement of hematite bioreduction by natural organic matter*, EST 36 2897-904 (7474). [Electron shuttling & complexation; natural organic matter, ferrozine & anthraquinone-2,6-disulfonate interact with *Shewanella putrefaciens* CN32.]

I Safarik M Safarikova 2002 *Magnetic nanoparticles and biosciences*, Monat Chem 133 737-59 (7664).

WW Schmahl & 5 others 2004 *The microstructure of the fibrous layer of terebratulite brachiopod shell calcite*, EJM 16 693-7 (10606).

KG Schulz & 5 others 2004 *Effect of trace metal availability on coccolithophorid calcification*, N 430 673-6 (10562).

AC Scott ME Collinson 2003 *Non-destructive multiple approaches to interpret the preservation of plant fossils: Implications for calcium-rich permineralizations*, JGSL 160 857-62 (9615).

I Sthmann & 3 others 2005 *Observation of nano-clustered calcite growth via a transient phase mediated by organic polyanions: A close match for biomineralization*, AM 90 1213-7.

BY Smith SJ Turner KA Rodgers 2003 *Opal-A and associated microbes from Wairakei, New Zealand*, MM 67 563-70.

JV Smith 1998 *Biochemical evolution: I. Polymerization on internal organophilic silica surfaces of dealuminated zeolites and feldspars*, PNAS 95 3370-5. **I Parsons MR Lee jvs II.** *Origin of life in tubular microstructures on weathered feldspar surfaces*, 15173-76.

JT Staley A Reysenbach 2002 *Biodiversity of Microbial Life*, Wiley, QR100.B55 (4317). [16 articles.]

- X Su & 5 others** 2002 *Structural and microstructural characterization of the growth lines and prismatic microarchitecture of abalone "flat pearls"*, ChM 14 3106-17 (7721). [Aragonite.]
- K Tazaki** 1997 *Biomineralization of layer silicates and hydrated Fe/Mn oxides in microbial mats: an electron microscopical study*, CICIM 45 203-12 (979).
- KL Thomas-Keprta & 8 others** 2002 *Magnetofossils from ancient Mars: a robust biosignature in the Martian meteorite ALH84001*, AEM 68 3663-72. [Magnetite.]
- H Tiemann & 5 others** 2002 *Calcium sulfate hemihydrate in statoliths of deep-sea medusae*, JCS D 1266-8 (7068). [Bassanite.]
- AM Travaille & 6 others** 2003 *Highly oriented self-assembled monolayers as templates for epitaxial calcite growth*, JACHS 125 11571-7 (9516).
- A Vairavamurthy DS Wang** 2002 *Organic nitrogen in geomacromolecules: Insights on speciation and transformation with K-edge XANES spectroscopy*, EST 36 3050-6 (7634). [Humic substances have dominant amide N and one-quarter pyridinic. Details.]
- Y Van Lith & 3 others** 2003 *Microbial fossilization in carbonate sediments: a result of the bacterial surface involvement in dolomite precipitation*, Se 50 237-45 (8946). [Bacteria brought in Mg.]
- M Villalobos & 4 others** 2006 *Structural model for the biogenic Mn oxide produced by Pseudomonas putida*, AM 91 489-502.
- EG Vrieling & 5 others** 2004 *Ultrasmall, small, and wide angle X-ray scattering analysis of diatom biosilica: interspecific differences in fractal properties*, JMC 14 2970-5 (10531).
- J Wang & 7 others** 2003 *Morphology and crystalline characterization of abalone shell and mimetic mineralization*, JCG 252 367-71 (8863). [Soluble proteins accelerate vaterite to calcite.]
- A Warén & 3 others** 2003 *A hot-vent gastropod with iron sulfide dermal schlerites*, S 302 1007 (9838). [Greigite & pyrite.]
- LA Warren ME Kaufman** 2003 *Microbial geoengineers*, S 299 1027-9 (8759).
- GE Webb JE Sorauf** 2002 *Zigzag microstructures in rugose corals: A possible indicator of relative seawater Mg/Ca ratios*, G 30 415-8 (7167). [High-Mg calcite may change to zig-zag low-Mg calcite during diagenesis.]
- SM Webb BM Tebo JR Bargar** 2005 *Structural characterization of biogenic Mn oxides produced in seawater by the marine bacillus sp. Strain SG-1*, AM 90 1342-57. [Birnessite & todorokite.]
- M Winkhofer & 4 others** 2001 *Clusters of paramagnetic magnetite particles in the upper-beak skin of homing pigeons: evidence of a magnetoreceptor?* EJM 13 659-69 (3476).
- DW Wolfe** 2001 *Tales from the Underground. A Natural History of Subterranean Life*, Perseus, 0-7382-0128-6; **J Grisham** Review, CEN Sep10 47-8 (5552). [Soil bacteria.]
- T Yamanaka & 8 others** 2002 *Corrosion by bacteria of concrete in sewerage systems and inhibitory effects of formates on their growth*, WR 36 2636-42 (7566). [S-oxidizing & acidophilic Fe-oxidizing bacteria stopped by Ca formate at >50 mM.]
- N Yee & 4 others** 2003 *The effect of cyanobacteria on silica precipitation at neutral pH: implications for bacterial silicification in geothermal hot springs*, ChG 199 83-90 (9068). [None when supersaturated.]
- T Yoshida K Hayashi H Ohmoto** 2002 *Dissolution of iron hydroxides by marine bacterial siderophore*, ChG 184 1-9 (7027). [Most of Fe utilized by phytoplankton "may be liberated from ferric hydroxides in aeolian particles by siderophores generated by marine bacteria." Goethite.]
- M Zbinden & 4 others** 2001 *Zinc-iron sulphide mineralization in tubes of hydrothermal vent worms*, EJM 13 655-8 (3422). [Sphalerite/wurtzite.]
- J Zhang & 7 others** 1999 *Use of self-assembled monolayers as substrates for atomic force imaging of hydroxyapatite crystals from mammalian skeletal tissues*, La 15 8178-83 (1057).

Applications in soils, rocks, plants & agriculture

Soil is very important for agriculture and food supply. Most soil comes ultimately from weathering of rocks, and is changed by both natural and human factors. Currently, human actions are moving as much soil as does wind and rain. Soil chemistry is affected by ground water, acid rain and various environmental factors. Toxic elements may change valence state in soils, and may

enter food. Although most papers listed here do not involve mineralogy directly, the biogeochemical aspect is important. Certain plants can be used to extract toxic metals from soils. Pesticides and various other Br/Cl-organic compounds may cause problems in being resistant to breakdown, and building up in the food chain, and are covered separately.

DR Baker & 4 others ed 2002 *Synthesis and Chemistry of Agrochemicals VI*, TP248.P47S96 (7049).

H Eswaran & 3 others 2003 *Soil Classification. A Global Desk Reference*, CRC Press.

TE Loynachan & 5 others 2005 *Soils, Society, and the Environment*, 0-922152-74-8.

AS Mayer & 4 others ed 2005 *Soil and Groundwater Contamination*, 0-87590-321-7.

S599. various: *Soil Survey of NNN County, MM, US Department of Agriculture; Natural Resources Conservation Service*. [Reports for counties.]

W Amelung K Kaiser G Kammerer G Sauer 2002 *Organic carbon at soil particle surfaces - evidence from X-ray photoelectron spectroscopy and surface abrasion*, SSSAJ 66 1526-30 (7967).

R Amundson 2000 *Are soils endangered?* CaG Jul/Aug 4-13 (3183). [Argues that we are paving over much land & moving so much soil that historical record going away.]

R Athar M Ahmad 2002 *Heavy metal toxicity: effect on plant growth and metal uptake by wheat, and on free living Azobacter*, WASP 138 165-80 (7777). [Cd>Cu>Ni>Zn>Pb>Cr.]

GU Balcke & 5 others 2002 *Adsorption of humic substances onto kaolin clay related to their structural features*, SSSAJ 66 1805-12 (8035). [11 humic substances adsorbed positive with aromaticity & negative with polarity.]

SG Benner & 4 others 2002 *Reductive dissolution and biomineralization of iron hydroxide under dynamic flow conditions*, EST 36 1705-11 (7077). [Ferrihydrite in sand goes to magnetite & goethite.]

K Benzerara & 4 others 2005 *Nanoscale environments associated with bioweathering of a Mg-Fe-pyroxene*, PNAS 102 879-82. [Amorphous Al-rich layer overlying Ca-carbonates associated with polysaccharides next to microorganism. STXRM & NEXAFS]

RB Brown JH Huddleston JL Anderson ed 2000 *Managing Soils in an Urban Environment*, Agronomy 39, S405.A28 (5526). [10 chapters on human influence, waste management, wildlife, erosion, construction, radon risk, etc.]

RR Brooks ed 1998 *Plants that Hyperaccumulate Heavy Metals*, CAB International, QK753.H4 (5559). [15 chapters on phytochemistry, geobotany, biogeochemistry, seaweeds, algae, phytoarchaeology, revegetation of mine dumps, etc.]

ID Bull & 4 others 2000 *Detection and classification of atmospheric methane oxidizing bacteria in soil*, N 405 175-8 (3177).

D Chamberlain J Vickery 2002 *Declining farmland birds :evidence from large-scale monitoring studies in the UK*, British Birds June 300-10 (7390).

FS Chapin III 1995 *New cog in the nitrogen cycle*, N 377 199-200 (5530).

CE Clapp et al. ed 2001 *Humic Substances and Chemical Contaminants*, S592.8.H84 (8329). [Workshop.]

C Cobbett et al 2003 *Special issue: Heavy metals and plants*, New Phytologist 159 289-530.

LR Cooperband LW Good 2002 *Biogenic phosphate minerals in manure: Implications for phosphorus loss to surface waters*, EST 36 5076-82 (8466). [Poultry manure has more insoluble minerals than cow manure. SEM & EDS.]

G Davies EA Ghabbour 1999 *Understanding life and death*, CI Jun 426-30 (5527). [Humic acid; metal binding.]

J Deckers E Steinnes 2004 *State of the art on soil-related geo-medical issues in the World*, AA 84 2-37. [Covers food chain; geophagia; problems of deficiency/excess of mineral elements in animal nutrition; contaminated land; Al/As/B/Ca/Cd/Ce/Ch/Cl/Cu/F/Fe/Hg /I/K/Mn/Mo/Mg/N/Na/P/Pb/Se/Zn.]

O Dequincey & 5 others 2002 *Chemical mobilizations in laterites: Evidence from trace elements and ²³⁸U-²³⁴U-²³⁰Th disequilibria*, GCA 66 1197-210 (6991). [Complex weathering sequence.]

- E Derbyshire** ed 2001 *Recent research on loess and palaeosols, pure and applied*, ESR 54 1-157 (5553). [>10 articles in special issue.]
- KS Dhillon SK Dhillon** 2003 *Distribution and management of seleniferous soils*, Advances in Agronomy 79 120-176 (9102). [Soil minerals, toxicity, etc.]
- JB Dixon DG Schulze** ed 2002 *Soil mineralogy with Environmental Applications*, Soil Science Society of America, 2002100258 (8712). [28 chapters covering carbonates & evaporates, sulfides & sulfates, aluminumhydroxides, *allophane* & *imogolite*, iron oxides, Mn oxides, *kaolin-serpentine* minerals, *pyrophyllite-talc* minerals, *micas*, *smectites*, *vermiculites*, *chlorites*, *palygorskite* & *sepiolite*, *zeolites*, silica minerals, phosphate minerals, Ti & Zr minerals, geographic distribution, radioactive contamination, pesticides, enzyme interactions, charcoal.]
- L Ember** 2001 *Acid rain is still a menace*, CEN Apr2 11 (5539).
- NK Fageria VC Baligar RB Clark** 2002 *Micronutrients in crop production*, Advances in Agronomy 77 185-? (7094).
- SE Fendorf DL Sparks GM Lamble MJ Kelly** 1994 *Applications of X-ray absorption fine structure spectroscopy to soils*, SSSAJ 58 1583-95 (5536). [Review.]
- K Fischer H Bipp** 2002 *Removal of heavy metals from soil components and soils by natural chelating agents. Part II. Soil extraction by sugar acids*, WASP 138271-88 (7740).
- P Fookes** ed 1997 *Tropical Residual Soils*, Geol Soc London, 1-897799-38-1 (5545). [For engineers.]
- JK Fredrickson M Fletcher** ed 2001, *Subsurface Microbiology and Biochemistry*, Wiley, 0-471-31577-X (4884). [11 chapters: includes Fe reduction & humics, microbial S cycling, bioremediation, etc.]
- C Freeman CD Evans DT Monteith** 2001 *Export of organic carbon from peat soils*, N 412 785 (5549).
- JN Galloway** 2001 *Acidification of the world: Natural and anthropogenic*, WASP 130 17-24 (5555).
- LAJ Garvie** 2003 *Decay-induced biomineralization of the saguaro cactus (Carnegiea gigantea)*, AM 88 1879-88. [*Weddellite* to *lansfordite/nesquehonite/glushkinite/calcite/vaterite*, etc.]
- MJ Gherardi Z Rengel** 2001 *Bauxite residue sand has the capacity to rapidly decrease availability of added manganese*, PS 234 143-51 (9040).
- CP Giardina MG Ryan** 2000, *Soil warming and organic carbon content*, N 408 789-90 (5541).
- AV Gorbunov & 5 others** 2003 *Heavy and toxic metals in staple foodstuffs and agriproduct from contaminated soils*, JESH B38 181-92 (8845). [Data for Cr/Fe/Ni/Cu/Zn/As/Cd/Sb/Hg/Pb for Zn plant area in Astrakhan region, Russia & at Helwan, Egypt where sewage from industrial area is used for irrigation.]
- KL Grogan RJ Gilkes BG Lottermoser** 2003 *Maghemite formation in burnt plant litter at East Trinity, North Queensland, Australia*, CICIM 51 390-6 (9265). [From *goethite*.]
- K Hama & 8 others** 2001 *Influence of bacteria on rock-water interaction and clay-mineral formation in subsurface granitic environments*, CIM 36 599-613 (3993). [Aspo diorite, Sweden, alters faster when bacteria present.]
- RD Hart & 3 others** 2002 *The nature of soil kaolins from Indonesia and Western Australia*, CICIM 50 198-207 (7140). [*Kaolinite* plates vs *halloysite* tubes.]
- LE Hersman JH Forsythe LO Ticknor PA Maurice** 2001 *Growth of Pseudomonas mendocina on Fe(III) (hydr)oxides*, AEM 67 4448-53 (3517). [Aerobic growth on *goethite*>*hematite*>*ferrhydrite*.]
- ME Hodson** 2002 *Variation in element release rate from different mineral size fractions from the B horizon of a granitic podzol*, CG 190 91-112 (7916). [*Quartz*, *feldspars*, *biotite* & *chlorite*. Most of element release from fine fraction 53-2 micrometer. Details.]
- PM Huang N Senesi J Buffle** ed 1998 *Structure and Surface Reactions of Soil Particles*, Wiley, 0-471-95936-7 (5540). [12 chapters: minerals-organics-microbes, SEM/TEM/NMR/ESR, etc.]
- BS Hutchinson AP Greider** ed 2002 *Using the Agricultural, Environmental, and Food Literature*, Hutchinson, S494.5.A39U75.]

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By USA Congressional mandate, the **Agency for Toxic Substances and Disease Registry** produces "toxological profiles" for hazardous substances found at **National Priorities List** sites. Contact ATSDR by phone (1-882-422-8737), or e-mail (ATSDRIC@cdc.gov). Each profile describes the potential dangers and recommendations for protection.

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- CB Cox PD Moore** 2005 *Biogeography. An Ecological and Evolutionary Approach*, 7th ed, QH84.C65.
- LD De Lacerda & 3 others** 2004 *Environmental Geochemistry in Tropical and Subtropical Environments*, QE516.4.E579.
- PA Fenter ML Rivers NC Sturchio SR Sutton** ed 2002 *Applications of synchrotron radiation in low-temperature geochemistry and environmental science*, RMG 49 1-579. [This volume based on a short course illustrates the remarkable advances brought about by the development of synchrotron X-ray techniques. 9 chapters reviewing X-ray reflectivity/standing wave/grazing-incidence absorption/micro-fluorescence & -radiography/ soft spectroscopy. Covers ions in soil & water: Al/As/Au/Bi/C/Ca/Cd/Co/Cl/Cr/Cu/Fe/Ga/Hg/I/In/La/Mg/Mn/Na/Ni/Np/O/Pb/Pd/Pt/Pu/Rb/S/Sb/Sc/Se/Si/Tc/Ti/Th/Tl/U/Y/Zn/Zr; micro- & nano-particles & surfaces of *akaganeite/allophane/anatase/apatite/aragonite/barite/biotite/birnessite/boehmite/buserite/calcite/chalcophyrite/chlorite/copper/corundum/cryptomelane/diamond/diaspore/ettringite/feldspars/ferrihydrite/galena/gibbsite/goethite/greenrust/hectorite/hematite/hollandite/hydrobiotite/hydrotalcite/illite/imogolite/jarosite/kaolinite/lithiophorite/mackinawite/magnetite/manganite/molybdenite/montmorillonite/muscovite/nontronite/phlogopite/pyrolusite/pyromorphite/pyrophyllite/quartz/ramsdellite/rutile/schwertmannite/sepiolite/smectite/sphalerite/stannite/stishovite/talc/todorokite/vermiculite/zeolites & bacteria, glasses/humic acids & organic molecules & complexes. Covers industrial waste & remediation.]*
- MI Greenberg & 3 others** ed 2003 *Occupational, Industrial, and Environmental Toxicology*, 2nd ed, RA1229.O277. [Directed to medical personnel. Covers all types of toxics.]
- B Halford** 2005 *Nanodatabase*, CEN 10/17 33. [Data base on environmental and health impacts of nanomaterials.]
- PK Harvey & 3 others** ed 2005 *Petrophysical Properties of Crystalline Rocks*, Geol Soc London. [25 articles on fracturing & deformation; permeability. Relevant to boreholes for waste disposal.]
- AV Hirner H Emons** ed 2004 *Organic Metal and Metalloid Species in the Environment*, TD196.O76.O75.
- JL Jambor M Raudsepp K Mountjoy** 2005 *Mineralogy of permeable reactive barriers for the attenuation of subsurface contaminants*, CM 43 2117-40.
- WG Landis M Yu** 2004 *Introduction to Environmental Toxicology*, 3rd ed, QH545.A1L35.
- SC McCutcheon JL Schnoor** ed 2003 *Phytoremediation. Transformation and Control of Contaminants*, TD 192.75.M38.

Atmospheric dust & gas

Atmospheric dust has both positive and negative effects on human welfare. On the positive side is the generation of agricultural soil from desert particles blown by high winds. On the negative side is the medical hazard to lungs from ingested dust. Currently, much dust results from human actions & some contains toxic elements & bacteria. Some dust is from outer space, and the record of spherule layers from impacts of bolides implies that dust was also involved. This database concentrates on the mineralogic context. Briefly mentioned are dust and gases emitted from volcanic eruptions.

The data are relevant to climate change because clouds are involved with dust and aerosols : **DD Houghton** 2002 *Introduction to Climate Change: Lecture Notes for Meteorologists*, WMO 926, 92-63-10926-5.

Also listed are some papers on dust in cities and in homes – see also specific localities.

H Akimoto 2003 *Global air quality and pollution*, S 302 1716-23 (9610).

JR Anderson & 3 others 1996 *Characterization of the Bermuda tropospheric aerosol by combined individual-particle and bulk-aerosol analysis*, AE 30 319-38 (9186).

TL Anderson & 6 others 2003 *Climate forcing by aerosols - a hazy picture*, S 300 1103-4 (8977). [Emphasizes uncertainty.]

MO Andreae & 6 others 2004 *Smoking rain clouds over the Amazon*, S303 1337-42; **I Koren & 3 others** 2004 *Measurement of the effect of Amazon smoke on inhibition of cloud formation*, 1342-5 (10011).

KA Berubé & 3 others 2004 *The respiratory toxicity of airborne volcanic ash from the Soufrière volcano, Montserrat*, MM 68 47-60.

AJ Bory PE Biscaye A Svensson FE Grousset 2002 *Seasonal variability in the origin of recent atmospheric mineral dust at NorthGRIP, Greenland*, EPSL 196 123-34 (7091). [Major summer deposition from Takla Makan desert of nw China. Other deserts including Gobi.]

PR Buseck & 4 others 2003 *Minerals in the air: an environmental perspective*, Frontiers in Geochemistry: Global Inorganic Geochemistry, I, 106-24.

PR Buseck M Pósfai 1999 *Airborne minerals and related aerosol particles: effects on climate and the environment*, PNAS 96 3372-9.

A Caracausi & 6 others 2003 *Mount Etna: Geochemical signals of magma ascent and unusually extensive plumbing system*, GRL 30(2) 1057. [200 tons/day of gas.]

WL Chameides M Bergin 2002 *Soot takes center stage*, S 297 2214-5 (8029). [Black C may absorb solar radiation as much as carbon dioxide. **Menon et al** paper discussed.]

SM Charlesworth IDL Foster 2005 *Gamma-emitting radionuclides and metallic elements in urban dusts and sediments, Coventry, UK: implications of dosages for dispersal and disposal*, MM 69 759-67.

M Chiaradia F Cupelin 2000 *Gas-to-particle conversion of mercury, arsenic and selenium through reaction with traffic-related compounds (Geneva). Indications from lead isotopes*, AE 34 327-32 (3332).

LW Dalton 2003 *Chemical analysis of a disaster*, C&EN 10/20 26-30 (9640). [World Trade Center, NYC.]

T de Garidel-Thoron & 3 others 2004 *Evidence for large methane releases to the atmosphere from deep-sea gas-hydrate dissociation during the last glacial episode*, PNAS 101 9187-92 (10408).

E Derbyshire ed 2003 *Loess, and the dust indicators and records on terrestrial and marine palaeoenvironments (DIRTMAP database)*, Quaternary Sci Rev 22 1813-2052 (9569). [10 papers covering the World.]

BT Draine 2003 *Interstellar dust grains*, Ann Rev Astron Astrophys 41 241-89 (9602).

G Etiope & 3 others 2004 *Methane emission from mud volcanoes in eastern Azerbaijan*, G 32 466-8 (10432).

M Ezzatl DM Kammen 2002 *Household energy, indoor air pollution, and health in developing countries*, AREE 27 233-70. [Biomass is burned by 3 billion people.]

DW Fahey & 26 others 2001 *The detection of large HNO₃ particles in the winter Arctic stratosphere*, S 291 1026-30 (5741).

F Fang & 4 others 2001 *Atmospheric particulate mercury in Changchun City, China*, AE 35 4265-72 (6037).

L Frazer 2003 *Down with road dust*, EHP 111 A893-5 (9650). [3M miles of US unpaved roads emit 10 M tons of dust/y, including allergens. Dust Stop made from starch possibly viable.]

DM Gaiero & 4 others 2003 *Iron and other transition metals in Patagonian riverborne and windborne materials: Geochemical control and transport to the southern South Atlantic Ocean*, GCA 67 3603-23 (9558).

V Gauci & 6 others 2004 *Sulfur pollution suppression of the wetland methane source in the 20th and 21st centuries*, PNAS 101 12583-7 (10668). [Via sulfate. 8% reduction.]

WJ Gauderman & 12 others 2004 *The effect of air pollution on lung development from 10 to 18 years of age*, NEJM 351 1057-67 (19613).

DW Griffin & 3 others 2002 *The global transport of dust*, AS 90 228-35 (7093). [2 billion tons of dust lifted by wind per year. Microbes and pesticides carried across oceans.]

SK Guttikunda & 4 others 2003 *The contribution of megacities to regional air pollution in Asia*, AE 37 11-22 (9126). [Bad even if population & energy use do not increase.]

J Hansen & 6 others 2004 *Carbonaceous aerosols in the industrial era*, Eos 85 241 & 244 (10392).

K He H Huo Q Zhang 2002 *Urban air pollution in China*, AREE 27 397-431. [Complex details of particles and acid-rain gases. Control measures. Bad air expected for many years.]

D Jaffe J Snow 2003 *The 2001 Asian dust events: Transport and impact on surface aerosol concentrations in the U.S.*, Eos 84 501 & 507 (9623).

S Lee & 7 others 2003 *Particle formation by ion nucleation in the upper troposphere and lower stratosphere*, S 301 1887-9 (9348). [Sub-micrometer.]

M Lippmann & 23 others 2003 *The U. S. Environmental Protection Agency particulate matter health effects research centers program: A midcourse report of status, progress, and plans*, EHP 111 1074-92.

X Liu & 4 others 2000 *Biomass burning in southern Africa: Individual particle characterization of atmospheric aerosols and savannah fire samples*, JAC 36 135-55 (3189). [EMPA. 2-10 micrometer, mainly Al-silicates & sea salts; <2 K-S & S-only; KCl common in savannah.]

ST Martin & 4 others 2003 *Crystallization of atmospheric sulfate-nitrate-ammonium particles*, GRL 30 2102 (9646).

N Meskhidze 2003 *Iron mobilization in mineral dust: Can anthropogenic SO₂ emissions affect ocean productivity?* GRL 30 2085 (9647).

N Moussiopolis ed 2003 *Air Quality in Cities*, TD883.A5765.

K Nagashima & 2 others 2004 *Stardust silicates from primitive meteorites*, N 428 921-4, news & views 903-4 (10210).

JH Obenholzner & 3 others 2003 *Particles from the plume of Popocatepetl volcano, Mexico – the FESEM/EDS approach*, Geol Soc London Spec Publ 213 123-48. [Wollastonite & hercynite.]

JMC Plane & 3 others 2004 *Removal of meteoric iron on polar mesospheric clouds*, S 304 426-8, Perspectives 395-6 (10197).

CA Pope III 2004 *Air pollution nad health-good news and bad*, NEJM 351 1132-4 (10614).

M Pósfai & 4 others 1994 *Constituents of a remote Pacific marine aerosol: A TEM study*, AE 28 1747-56 (9191). [NaCl/KCl/sulfates/kaolinite/rutile.]

M Pósfai & 3 others 1995 *Compositional variations of sea-salt-mode aerosol particles from the North Atlantic*, JGR 100 23063-74 (9189).

JM Prospero 1999 *Long-range transport of mineral dust in the global atmosphere: impact of African dust on the environment of the southeastern United States*, 96 3396-403.

JM Prospero PJ Lamb 2003 *African droughts and dust transport to the Caribbean: Climate change implications*, S 2003 1024-7 (9599). [Droughts & dust lower before 1970.]

JM Prospero & 4 others 2002 *Environmental characterization of global sources of atmospheric soil dust identified with the Nimbus 7 Total Oxide Mapping Spectrometer (TOMS) absorbing aerosol product*, RG 40 1002 (9140). [Main belt from west North Africa to China.]

AR Ravishnakara ed 2003 *Atmospheric chemistry: long-term issues*, ChR 103 4505-5266 (9617). [~ 35 articles.]

D Rosenfeld R Lahav A Khain M Pinsky 2002 *The role of sea spray in cleansing air pollution over ocean via cloud processes*, S 297 1667-70 (7920). [Particulate air pollution strongly suppresses precipitation over land, but less at sea because myriad salt spray nuclei start rain drops which sweep out particles.]

D Rumble 2005 *A mineralogical and geochemical record of atmospheric photochemistry* AM 90 918-30. [Barite/gypsum/nitratine/pyrite retain isotopic records in surface deposits in arid regions.]

BG Shelton & 3 others 2002 *Profiles of airborne fungi in buildings and outdoor environment in the United States*, AEM 68 1743-53 (7194). [Indoor lower than outdoor; highest in fall & summer; highest in south; *Cladosporium*, *Penicillium*, *Aspergillus* & nonsporulating types common.]

BM Simonson BP Glass 2004 *Spherule layers – records of ancient impacts*, AREPS 32 319-61 (10355).

CW Spicer & 4 others 2002 *Hazardous Air Pollution Handbook*, Lewis.

MM Saward C Bégin M Parent 2002 *Are industrial emissions reducing CO₂ uptake by the boreal forest?* G 30 403-6 (7166). [SO₂ from Horne copper smelter, Quebec, Canada. C isotopes of tree rings say yes.]

EA Shinn DW Griffin DS Seba 2003 *Atmospheric transport of mold spores in clouds of desert dust*, Arch Env Health 38 498-510 (10427).

J Srinivasan S Gadgil 2002 *Asian Brown Cloud - fact and fantasy*, CuS 83 586-92 (8018). [UNEP report exaggerated. Haze occurs only in Jan-Mar. Expect trivial effect on rice production.]

T Takahashi 2004 *The fate of industrial carbon dioxide*, S 305 352-3 (10489). [Role of transfer into oceans.]

K Tomeoka & 4 others 2003 *Interplanetary dust from the explosive dispersal of hydrated asteroids by impacts*, N 423 60-2 (8949).

CR Usher AE Michel VH Grassian 2003 *Reactions on mineral dust*, ChR 103 4883-939 (9867). [Includes mineral composition & distribution, & reactions with nitrogen & sulfur dioxides, ozone & organics.]

V Vinoj SK Satheesh 2004 *Direct and indirect radiative effects of sea-salt aerosols over Arabian Sea*, CuS 86 1381-7 (10394).

General

This section contains a rag-bag of papers & books that are being sub-classified when time becomes available.

Landfill

WH Albright & 5 others 2003 *Examining the alternatives*, CEn May 70-5 (8975). [USA-EPA tests whether fine soil with vegetation is better cover to landfill than clay. Depends on rainfall.]

A Allen 2001 *Containment landfills: the myth of sustainability*, EnG 60 3-19 (4559). [Advocates careful choice of hydrogeologic sites using "dilute & disperse" strategy to employ ion-exchange & sorption properties of clay minerals (jvs: also zeolites in altered volcanic ash). Use permeable cap to let in rain water, and leachate trap.]

Y Kim S Park S Kim 2003 *Treatment of landfill leachate by white rot fungus in combination with zeolite filters*, JESH A38 671-83. [Pretreatment with *clinoptilolite* removed substantial ammonia allowing fungus to work.]

DAC Manning 2000 *Carbonates and oxalates in sediments and landfill: monitors of death and decay in natural and artificial systems*, JGSL 157 229-38 (4081). [Weddelite/whewellite.]

DAC Manning 2001 *Calcite precipitation in landfills: an essential product of waste stabilization*. MM 65 603-10.

R Metcalfe CA Rochelle ed 1999 *Chemical Containment of Waste in the Geosphere*, GS Spec Pub 1-86239-040-1 157 1-281 (4059).

DH Phillips & 5 others 2000 *Performance evaluation of a zerovalent iron reactive barrier: Mineralogical characteristics*, EST 34 4169-76 (4696).

Phytoremediation

AJM Baker & 3 others ed 2003 *Advances in phytoremediation*, Plant & Soil 249 1-236. [24 articles covering Cd, Cr, Cs, Ni, Se, Tl, Zn, radionuclides.]

A Kayser & 6 others 2000 *Enhancement of phytoextraction of Zn, Cd, and Cu from calcareous soil: the use of NTA and sulfur amendments*, EST 34 1778-83 (4069). [Even best plants would not clean up Dornach brass smelter waste in 10 years.]

AS Moffat 1995 *Plants proving their worth in toxic metal cleanup*, S 269 302-3 (4640). [News report on phytoremediation.]

AJ Pollard & 3 others 2002 *The genetic basis of metal hyperaccumulation in plants*, Critical Reviews in Plant Sciences 21 539-66 (8379).

I Raskin BD Ensley ed. 2000 *Phytoremediation of Toxic Metals: Using Plants to Clean up the Environment*, 0-471-19254 6 (4073). **S McGrath** 2000 *Plants to improve the environment*, review of above, CI Jul 437 (4037).

Sewage sludge

- A Artola M Martin MD Balaguer M Rigola** 2000 *Isotherm model analysis for the adsorption of Cd(II), Cu(II), Ni(II), and Zn(II) on anaerobically designed sludge*, JCS D 232 64-70 (4674).
- A Bagreev S Bashkova DC Locke TJ Badosz** 2001 *Sewage sludge-derived materials as efficient adsorbents for removal of hydrogen sulfide*, EST 35 1537-43 (4645). [Heat to 1223 K to make mineral catalyst rich in Fe/Cu/Zn. Twice as effective as coconut-shell activated C.]
- M Burke** 2002 *Phosphates go full cycle*, CB Mar 46-8 (6775). [European Union. Problem with people scared about putting sewage sludge on fields. "With phosphate rock used by the fertiliser and detergent industries likely to run out in 100 years, the prospect of recycling phosphates can only become more attractive." Many details of commercial possibilities. Problem with *struvite* blocking pipes.]
- M Fang JWC Wong** 2000 *Changes in thermophilic bacteria populations and diversity during composting of coal fly ash and sewage sludge*, WASP 124 333-43 (4663).
- DL Lewis DK Gattie** 2002 *Pathogen risks from applying sewage sludge to land*, EST 287-93A (7471). ["Despite complaints of related illnesses, little is known about the dangers of spreading biosolids on land."]
- AT Lombardi O Garcia Jr** 2002 *Biological leaching of Mn, Al, Zn, Cu and Ti in an anaerobic sewage sludge effectuated by Thiobacillus ferrooxidans and its effect on metal partitioning*, WR 16 3193-202 (7836). [Details.]
- MB McBride CE Martinez E Topp L Evans** 2000 *Trace metal solubility and speciation in a calcareous soil 18 years after no-till sludge application*, SoS 165 646-55 (4698). [Complex details. In general, strong metal-organic bonding for high-lime soils. Cd may associate with S.]
- DC Su JWC Wong** 2002 *The growth of corn seedlings in alkaline coal fly ash stabilized sewage sludge*, WASP 133 1-13 (6706). [5-10% optimal.]
- S Yoshizaki T Tomida** 2000 *Principle and process of heavy metal removal from sewage sludge*, EST 34 1572-5 (4082).

Slag

- H Ecke** 2001 *Effect of electric arc vitrification of bottom ash on the mobility and fate of metals*, EST 35 1531-6 (4644). [Metals Cr/Cu/Zn/Pb separated from slag in electric arc furnace used in Japan. Complex details.]
- M Enders M Spiegel** 1999 *Mineralogical and microchemical study of high-temperature reactions in fly-ash scale from a waste incineration plant*, EJM 11 763-74 (4631). [Corrosion problem from S & Cl. See next paper.]
- M Enders M Spiegel J Albrecht A Putnis** 2000 *Mineralogical problems in advanced power systems: The contribution of slag and gaseous chemical species to the fly ash*, EJM 12 639-50 (4060). [Ca-, KCa- & KNa-sulfates; spinels; etc.]
- V Ettler Z Johan** 2003 *Mineralogy of metallic phases in sulphide mattes from primary lead smelting*, CRG 335 1005-12 (9876).
- V Ettler Z Johan D Hradil** 2003 *Natural alteration products of sulphide mattes from primary lead smelting*, CRG 335 1013-20 (9877).
- V Ettler O Legendre F Bodenan J Touray** 2001 *Primary phases and natural weathering of old lead-zinc pyrometallurgical slag*, CM 39 873-88.
- DM Proctor & 9 others** 2000 *Physical and chemical characteristics of blast furnace, basic oxygen furnace, and electric arc furnace steel industry slags*, EST 34 1576-82 (4068).
- D Trauber UK Mäder U Eggenberger** 2002 *Petrology and geochemistry of a municipal solid waste incinerator residue treated at high temperature*, SMPM 82 1-14 (7250). [Basalt-like with melilite, anorthite, calcite, lime, corundum, quartz, depending on bulk CaO/SiO₂. Pb & half of Cu in minute metals, Zn bound to silicate minerals & glass.]

Unclassified

PK Abraitis & 3 others 2004 *Acid leaching and dissolution of major sulphide ore minerals: processes and galvanic effects in complex systems*, MM 68 343-51. [Chalcopyrite/galena/pyrite/sphalerite.]

DC Adriano JM Bollag WT Frankenberger Jr RC Sims 1999 *Bioremediation of Contaminated Soils*, Agronomy 37 S405.A28 (4065). [Systematic coverage arranged by societies.]

R Begley 1997 *Resurrecting brownfields*, EST 31 226-30A (4633).

PM Bertsch JC Seaman 1999 *Characterization of complex mineral assemblages: implications for contaminant transport and environmental remediation*, PNAS 96 3350-7.

ST Bosso J Enzweiler 2002 *Evaluation of heavy metal removal from aqueous solution onto scolecite*, WR 36 4795-800 (8339). [High affinity for Cu; moderate for Zn, Pb, Ni, Co, Cd. Available as quarry tailing in S. American basalt.]

P Brimblecombe ed 2003 *The Effects of Air Pollution on the Built Environment*, TD883.E36. [13 chapters.]

GE Brown Jr 2001 *How minerals react with water*, S 294 67-9 (3503). [Overview with references to periclase, corundum, calcite, barite, orthoclase, calcite, hematite, clay minerals in soils. Biofilms, surface metal complexes, etc studied by various chemical microscopes. Application to toxic metal contamination.]

GE Brown Jr AL Foster JD Ostergren 1999 *Mineral surfaces and bioavailability of heavy metals: a molecular-scale perspective*, PNAS 96 3388-95.

DJ Burke JS Weis P Weis 2000 *Release of metals by the leaves of the salt marsh grasses Spartina alterniflora and Phragmites australis*, ECSS 51 153-9 (4695). [Cr/Cu/Zn/Pb.]

Y Cai OC Braids 2002 *Biogeochemistry of Environmentally Important Trace Elements*, ACS Symp Ser 835 (QH344.B5723). [26 articles, many on As, Pb, Hg.]

R Celis MC Hermosín J Cornejo 2000 *Heavy metal adsorption by functionalized clays*, EST 34 4593-4599 (4093). [Montmorillonite & sepiolite. Hg/Pb/Zn (II).]

J Chorover MK Amistadi 2001 *Reaction of forest floor organic matter at goethite, birnessite and smectite surfaces*, GCA 65 95-109 (940).

S Clemens MG Palmgren U Kramer 2002 *A long way ahead: understanding and engineering plant metal accumulation*, TPS 7 309-12 (7524).

JD Cotter-Howells LS Campbell E Valsami-Jones M Batchelder eds 2000 *Environmental Mineralogy: Microbial Interactions, Anthropogenic Influences, Contaminated Land and Waste Management*, 0-903056-20-8. [19 contributions.]

BE Davies 1988 *Trace metals in soil*, ChB Feb 149-54 (4020). [Pb, Cd, Hg, Cu, Mo, S, Zn, etc.]

M Davranche J-C Bollinger 2000 *Heavy metals desorption from synthesized and natural iron and manganese oxyhydroxides: Effect of reductive conditions*, JCIS 227 531-9 (4076).

WK Dodds 2002 *Freshwater Ecology. Concepts and Environmental Applications*, Academic, QH541.5.F7. [23 chapters. Includes: 12 C; 13 N/S/P etc; 14 Toxic chemicals.]

C Driscoll & 11 others 2003 *Nitrogen pollution: Sources and consequences in the U.S. Northeast*, Env 45(7) 10-22 (9215). [Complex details of worsening.]

L Ebdon & 5 others ed 2001 *Trace Element Speciation for Environment, Food and Health*, Royal Society of Chemistry, QD139.T7.T73. [25 chapters: includes 7 Hg; 8 Organotin; 9 Pt group; 11 As; 18 Se; 20 Ni; 21 Metal aerosols; 22 Cr].

KJ Edwards PL Bond TM Gihring JF Banfield 2000 *An Archaeal iron-oxidizing extreme acidophile important in mine drainage*, S 287 1796-8 (4063). [Iron Mountain CA. pH ~ 0.]

J Emsley 2001 *Nature's Building Blocks. An A-Z Guide to the Elements*, Oxford Univ Press, 0-19-850341-5. [Guide to 115 chemical elements: sections, e. g. Arsenic - Human element, Medical element, Element of History, Element of War, Economic Element, Environmental Element, Chemical Element, Element of Surprise. Recommended to citizens & research scientists.]

AL Foster GE Brown Jr GA Parks 2003 *X-ray absorption fine structure study of As(V) and Se(IV) sorption complexes on hydrous Mn oxides*, GCA 67 1937-53 (9141). [K-birnessite/vernadite.]

CP Ferrari & 10 others 2001 *Heavy metals in ancient tropical ice: initial results*, AEI 35 5809-15 (4094).

GM Gadd ed 2001 *Fungi in Bioremediation*, Cambridge U P, TD192.72.F86.

JL Gardea-Torresdey & 4 others 2000 *Reduction and accumulation of gold(III) by Medicago sativa alfalfa biomass: X-ray absorption spectroscopy, pH, and temperature dependence*, EST 34 4392-6 (4040). [Trying to find way to get rid of cyanide process.]

J Garty 2001 *Biomonitoring atmospheric heavy metals with lichens: theory and application*, Critical Reviews in Plant Sciences 20 309-71 (4089). [Review.]

MM Häggblom ID Bossert ed 2003 *Dehalogenation. Microbial Processes and Environmental Applications*, QR97.S3.D45. [18 contributions.]

CM Hansel S Fendorf S Sutton M Newville 2001 *Characterization of Fe plaque and associated metals on the roots of mine-waste impacted aquatic plants*. EST 35 3863-8 (3141). [63% ferrihydrite, 32% goethite, 5% siderite in Fe-plaque on *Phalaris arundinacea*. Pb organic complex consistent with bacterial biofilms. Mn/Zn in rhodochrosite/hydrozincite nodules on root surface.]

DL Harris BG *Phosphate stabilization of polymineralic mine wastes*, 2006 MM 70 1-13.
[KH₂PO₄.H₂O₂ solution is best for inhibiting Pb/Cu/Zn release but not for As/Sb leaching from tetrahedrite/arsenopyrite.]

J Harte C Holdren R Schneider C Shirley 1991 *Toxics A to Z. A Guide to Everyday Pollution Hazards*, U California Press, Berkeley, 520-07724-3. [Covers air, water, food & consumer products; metals, petrochemicals, pesticides, radiation. Guide to ~ 120 toxics under introduction, physical & chemical properties, exposure & distribution, health effects, protection & prevention, regulatory status, further reading.]

B Hileman 2002 *Electronic waste*, C&EN 7/1 15-7 (7622). [Each cathode ray tube contains 2 to 4 kg Pb plus toxic Cd Be Hg etc.]

MF Hochella Jr 2002 *Sustaining Earth: Thoughts on the present and future roles of mineralogy in environmental science*, MM 66 627-52. [IMA plenary lecture.]

ME Hodson E Valsami-Jones JD Cotter-Howells 2000 *Bonemeal additions as a remediation treatment for metal contaminated soil*, EST 34 3501-7 (4712). [Acidic soils high in Cu/Zn/Cd/Pb successfully remediated. Pb/Zn linked to P, XRPD shows peaks for metal phosphates. Details.]

D Holmes 1999 *Miners in miniature*, CI 4 Jan 20-4 (969).

CJ Hurst & 4 others 2002 *Manual of Environmental Microbiology*, QR100.M36 (6748).

P Huttenloch KE Roehl K Czurda 2001 *Sorption of nonpolar aromatic contaminants by chlorosilane surface modified natural materials*, EST 35 4260-4 (3680). [Diatomite & clinoptilolite.]

V Illera & 3 others 2004 *Immobilization of the heavy metals Cd, Cu and Pb in an acid soil amended with gypsum-and lime-rich industrial by-products*, EJSS 55 135-45 (10033). [Anglesite/laurionite minerals made.]

PR Ineson 1986 *Geoveterinary aspects of Pb, Zn, Cu, and Cd concentrations in parts of the Pennines*, In *Geology in the Real World - The Kingsley Dunham vol ed.* **RW Nesbitt I Nichol**, Institution of Mining and Metallurgy, London 207-16 (5189).

BP Jackson & 5 others 2003 *Trace element speciation in poultry litter*, JEQ 32 535-40.

JL Jambor DW Blowes AIM Ritchie ed 2003 *Environmental Aspects of Mine Wastes*, Min Assoc Canada Short Course 31, 0-921294-x. [20 articles covering mineralogy, geology, hydrology, geochemistry, microbiology.]

JL Jambor JE Dutrizac 1998 *Occurrence and constitution of natural and synthetic ferrihydrite, a widespread iron oxyhydroxide*, ChR 98 2549-85 (4078). [Detailed review.]

EJJG Janssen RA van Santen ed 1999 *Environmental Catalysis*, Imperial College Press, London, TD192.3.E58. [15 articles on fuel cells, high-quality fuel, synthesis gas, nitrate from water, etc.]

GY Jeong BY Lee 2003 *Secondary mineralogy and microtextures of weathered sulfides and manganese carbonates in mine waste-rock dumps*, AM 88 1933-42.
[Anglesite/arsenopyrite/galena/hydrohetaerolite/plumbojarosite/pyrite/pyrrhotite/rhodochrosite/smithsonite/sphalerite.]

JK Jerz JD Rimstidt 2003 *Efflorescent iron sulfate minerals: Paragenesis, relative stability, and environmental impact*, AM 88 1919-32. [Copiapite/fibroferrite/halotrichite/melanterite/rozenite etc.]

J Jolivet C Chaneac E Tronc 2004 *Iron oxide chemistry. From molecular clusters to extended solid networks*, CC 481-7 (10158).

BE Johnsen 2003 *The Dirty Dozen Toxic Chemicals and the Earth's Future*, TD196.C5.J65.

CP Jordao 5 others 2002 *Removal of Cu, Cr, Ni, Zn, and Cd from electroplating wastes and synthetic solutions by vermicompost of cattle manure*, JESH A37 875-92 (7295). [

M Kawano K Tomita 2001 *Geochemical modeling of bacterially induced mineralization of schwertmannite and jarosite in sulfuric acid spring water*, AM 86 1156-65.

BE Kalinowski LJ Liermann S Givens SL Brantley 2000 *Rates of bacteria-promoted solubilization of Fe from minerals: a review of problems and approaches*, ChG 169 357-70 (4041).

S Klimmek & 4 others 2001 *Comparative analysis of the biosorption of cadmium, lead, nickel, and zinc by algae*, EST 35 4283-8 (4092). [Details for 30 algae.]

H Koren M Bisesi 2003 *Handbook of Environmental Health Vol 1 Biological, Chemical, and Physical Agents of Environmentally Related Disease, Vol II, 4th ed*, Lewis (RA565.K67). [Covers: food, insect & rodent control, pesticides, indoor /recreational/institutional environments, waste management, swimming, plumbing, sewage, water pollution, terrorism.]

S Kumar KK Singh P Ramachandrarao 2000 *Synthesis of cordierite from fly ash and its refractory properties*, JMSL 19 1263-5 (4262). [Good for refractory.]

S Kvech M Edwards 2001 *Role of aluminosilicate deposits in lead and copper erosion*, AWWAJ Nov 104-9 (4093). [pH most important.]

IL Lagadic MK Mitchell BD Payne 2001 *Highly effective adsorption of heavy metal ions by a thiol-functionalized magnesium phyllosilicate clay*, EST 35 984-90 (4033). [Smectite. Adsorbs Hg/Pb/Co(II).]

M Ledin 2000 *Accumulation of metals by microorganisms- processes and importance for soil systems*, ESR 51 1-31 (4052).

PJ Leggo B Ledesert 2001 *Use of organo-zeolitic fertilizer to sustain plant growth and stabilize metallurgical and mine-waste sites*. MM 65 563-70. [Lille. Uptake of Pb/Zn/Cu from wheat grown with Z-mix = composted 2 chicken manure & 1 clinoptilolite tuff.]

M Lehmann AI Zouboulis KA Matis 2001 *Modeling the sorption of metals from aqueous solutions on goethite fixed-beds*, EnPo 113 121-8 (4026).

C Liu & 4 others 2001 *Microbial reduction of Fe(III) and sorption/precipitation of Fe(II) on Shewanella putrefaciens strain CN 32*, EST 35 1385-93 (4027).

J Locat & 3 others ed 2003 *Contaminated Sediments: Characterization, Evaluation, Mitigation, restoration, and Management Strategy Performance*, TD878.I48. [23 contributions.]

DR Lovley ed 2000 *Environmental Microbe-Metal Interactions*, Am Soc Microbiology, 1-55581-195-7 (4675). [15 chapters covering oxidation/reduction of Fe/Mn during biogeochemical recycling & biomineralization/remediation of As/Cr/Hg.]

R Macdonald D Mackay B Hickie 2002 *Contaminant amplification in the environment*, EST 12/1 456-62 (8458). [Bioconcentration, -magnification & -accumulation from solvent switching & depletion. Details.]

CE Martínez A Jacobson MB McBride 2001 *Thermally induced changes in metal solubility of contaminated soils is linked to mineral recrystallization and organic matter transformations*, EST 35 908-16 (6071).

MM Matlock BS Howerton DA Atwood 2002 *Chemical precipitation of heavy metals from acid mine drainage*, WR 36 4757-64 (8340). [1,3-benzenediamidoethanediol = BDET = commercial MetX is very effective at metal precipitation at pH 4.5. XRPD, proton NMR, IR.]

K Matsuoka A Abe Y Suzuki A Tomita 2002 *Effectiveness of hydrothermal treatment of coal with lime for removal of trace elements*, EnF 16 920-4 (7662). [Removes most minerals except little clay & pyrite. However, organic survives.]

W Matthes FT Madsen G Kahr 1999 *Sorption of heavy-metal cations by Al and Zr-hydroxy-intercalated and pillared bentonite*, CICIM 47 617-29 (4079).

MM McGuire KJ Edwards JF Banfield RJ Hamers 2001 *Kinetics, surface chemistry, and structural evolution of microbially mediated sulfide mineral dissolution*, GCA 65 1243-58 (4646). [Arsenopyrite, marcasite & pyrite exposed to Fe-/S-oxidizing isolates & mixed ones 3 weeks at

309 K pH 1.5. Raman/SEM. Need Fe-oxidizing microbes to get higher dissolution. Suggest *sulfur* formed at surface during oxidative dissolution but did not passivate mineral surface.]

M Minamisawa & 3 others 2004 *Adsorption behavior of heavy metals on biomaterials*, JAgFC 52 5606-11 (10612). [Cd/Pb(II) at pH 2-7. Tea/activated carbon/zeolite. Very promising.]

Molecular Mechanisms of Metal Toxicity and Carcinogenicity, EHP 110 suppl 5 687-890 (8448). [Special issue with 42 articles: metal transport; chemistry & biochemistry of metals; arsenic, chromate & nickel carcinogenesis; mutagenic & epigenetic mechanisms of carcinogenesis; signal transduction and effects of gene expression; neurotoxicity and immunotoxicity; environmental toxicity & treatment. Includes: **RA Yokel** *Brain uptake, retention, and efflux of aluminum and manganese*, 699-704.]

N Moreno & 5 others 2001 *Potential environmental applications of pure zeolitic material synthesized from fly ash*, JEE 127 994-1002 (3591).

T Munn ed 2002 *Encyclopedia of Global Environmental Change*, 0-471-97796-9. [Review: **H Günter** 2003 Nw 90 282-8.]

E Murad P Rojik 2003 *Iron-rich precipitates in a mine drainage environment: Influence of pH on mineralogy*, AM 88 1915-8. [*Ferrihydrite/schwertmannite*.]

National Research Council 2000, *Waste Incineration & Public Health*, 0-309-06371-X (4653).

DK Nordstrom 2000 *Advances in the hydrogeochemistry and microbiology of acid mine waters*, IGR 42 499-515 (4077).

HT Odum ed 2000 *Heavy Metals in the Environment. Using Wetlands for their Removal*, TD196.M4 (7181). [Focus on Pb removal in cypress-gum swamp, Florida, & Pb & Zn in Biala river, Poland.]

SR Palumbi 2001 *Humans as the world's greatest evolutionary force*, S 293 1786-90 (5141).

D Peak JT Sims DL Sparks 2002 *Solid-state speciation of natural and alum-amended poultry litter using XANES spectroscopy*, EST 36 4253-61 (8150). [No evidence for Al-phosphate. However, XANES indicates precipitation of amorphous Al-tri-OH which might react with P locking it up.]

MR Perrow AJ Davy 2002 *Handbook of Ecological Restoration. Volume 1. Principles of Restoration, 2. Restoration in Practice*, Cambridge U P, QH541.15.R45H36 (8937). [41 chapters cover the World, biomes.]

KP Prodromou 1999 *Zinc and copper adsorption by aluminium hydroxides*, NJMM 7 311-21 (4088). [*Bayerite/gibbsite/nordstrandite/pseudoboehmite*.]

A Raab J Feldmann 2004 *Microbial transformation of metals and metalloids*, Sci Progr 86 179-202 (10382).

S Rauch & 4 others 2000 *Elemental association and fingerprinting of traffic-related metals in road sediments*, EST 34 3119-23 (4061). [Pb & platinum group elements.]

R Romero RD Rawlings JM Rincón 2000 *Crystal nucleation and growth in glasses from inorganic wastes from urban incineration*, JNCS 271 106-18 (4055). *Akermanite*.]

T Ressler J Wong J Roos IL Smith 2000, *Quantitative speciation of Mn-bearing particulates emitted from autos burning (methylcyclopentadienyl)manganese tricarbonyl-added gasolines using XANES spectroscopy*, EST 34 950-8 (4058).

JA Rodrigue JA Burger 2004 *Forest soil productivity of mined land in the Midwestern and Eastern Coalfields regions*, SSSAJ 68 833-44 (10300).

JA Salvato NL Nemerow FJ Agardy 2003 *Environmental Engineering*, 5th ed, TD145.S2397.

L Samsoe-Petersen EH Larsen PB Larsen P Bruun 2002 *Uptake of trace elements and PAHs by fruit and vegetables from contaminated soils*, EST 36 3057-63 (7645). [As/Pb/Cd/Cr/Cu/Hg/Ni/Zn benzopyrene dibenzanthracene. Fruits were low uncorrelated with soil chemistry. Vegetables complex.]

B Sarkar ed 2002 *Heavy Metals in the Environment*, RA1231.M52.H436.

CW Schmidt 2003 *The Earth's Open Wounds. Abandoned and Orphaned Mines*, EHP 111 A155-62 (8936). [~100-500 k mines in USA.]

PW Scott CM Bristow ed 2002 *Industrial Minerals and Extractive Industry Geology*, TN260.I53 (8916). [54 contributions to conference.]

G Schwedt 2001 *The Essential Guide to Environmental Chemistry*, Wiley, TD193.S3813.
[Pocket atlas trans from German.]

R Sheikholeslami 1999 *Composite fouling - Inorganic and biological: a review*, EnPr 18 113-? (6330). [Desalination systems, cooling towers, heat exchangers, salinity power plants. Composite fouling ignored.]

L Shuker P Harrison S Poole 1997 *Fibrous Materials in the Environment. A Review of Asbestos and Man-made Mineral Fibres*, 1 89911017 8 (4960).

FR Siegel 2002 *Environmental Geochemistry of Potentially Toxic Metals*, Springer, 3-540-42030-4.

SL Simpson SC Apte GE Batley 2000 *Effect of short-term resuspension events on the oxidation of cadmium, lead, and zinc sulfide phases in anoxic estuarine sediments*, EST 34 4533-7 (4042).

E Sokol & 4 others 2002 *Fayalite and kirschsteinite solid solutions in melt from burned spoil-heaps, South Urals*, EJM 14 795-808.

MA Sørensen & 5 others 2000 *Aging of iron (hydr)oxides by heat treatment and effects on heavy metal binding*, EST 34 3991-4000 4051).

MA Sørensen CB Koch 2001 *Thermally induced transformations of Fe oxide-stabilized residues from waste incineration*. MM 65 635-43. [Ferrox process generates ferrihydrite.]

JG Speight 1996 *Environmental Technology Handbook*, Taylor & Francis, 1-56032-315-9 (4647). [12 chapters. Includes ecosystems, chemical waste & management, and regulations.]

IF Spellerberg 2002 *Ecological Effects of Roads*, 1-57808-198-X.

JD Spengler JM Samet JF McCarthy eds 2001 *Indoor Air Quality Handbook*, McGraw-Hill, 0-07-445549-4. [71 chapters. Includes 37 Fibers; 38 Asbestos;

A Srinivasan MW Grutzeck 1999 *The adsorption of SO₂ by zeolites synthesized from fly ash*, EST 1464-9 (4565). [Suggest turning fly ash into zeolites to be used to sorb acid gases from coal power stations. Synthesized Linde X & Y (FAU), Na-P1, analcime & sodalite using NaOH.]

V Sucha & 6 others 2001 *Weathering of smectite and illite-smectite under temperate climatic conditions*. CIM 36 403-19 (3070).

B Sun FJ Zhao E Lombi SP McGrath 2001 *Leaching of heavy metals from contaminated soils using EDTA*, EP 113 111-20 (4025).

GA Swayze & 10 others 2000 *Using imaging spectroscopy to map acidic mine waste*, EST 34 47-54 (4670). [Map pyrite oxidation zones.]

A Tahani & 4 others 1999 *Adsorption of a cationic surfactant on Na-montmorillonite: Inspection of adsorption layer by X-ray and fluorescence spectroscopies*, JCIS 216 242-9 (4080).

H Tammemagi 1999 *The Waste Crisis. Landfills, Incinerators, and the Search for a Sustainable Future*, TD794.2.T36.

JM Thomas R Raja G Sankar RG Bell 2001 *Molecular sieve catalysts for the regioselective and shape-selective oxyfunctionalization of alkanes in air*, ACR 34 191-200 (1428). [AlPO-5, -18, -31, -34, -36 with Co/Fe/Mn substitution.]

RK Tiwary 2001 *Environmental impact of coal mining on water regime and its management*. WASP 132 185-99 (3429). [Pyrite.]

SJ Traina V Laperche 1999 *Contaminant bioavailability in soils, sediments, and aquatic environments*, PNAS 96 3365-71.

PG Tratnyek 1996 *Putting corrosion to use: remediating contaminated groundwater with zero-valent metals*, CI 1Jul 499-503 (4573). [Fe metal to rust is generally good. Combinations of Fe with Mg, Sn, Zn & Pd being tested. Details.]

S Triantafyllou E Christodoulou P Neou-Syngouna 1999 *Removal of nickel and cobalt from aqueous solutions by Na-activated bentonite*, CIM 47 567-72 (4075).

E Valsami-Jones 2001 *Mineralogical controls on phosphorus recovery from wastewaters*. MM 65 611-20. [Potential for P recovery via Ca phosphates.]

DJ Vaughan RAD Patrick RA Wogelius 2002 *Minerals, metals and molecules: ore and environmental mineralogy in the new millenium*, MM 66 653-76. [IMA plenary lecture.]

DJ Vaughan RA Wogelius ed 2000 *Environmental Mineralogy*, EMU Notes in Mineralogy 2, 1-433.

FJ von Willert RC Stehouwer 2003 *Compost, limestone, and gypsum effects on calcium and aluminum transport in acidic minespoil*, SSSAJ 67 778-86 (8982). [Jurbanite buffers Al, & no treatment decreases phytotoxicity of pH 2.5 minespoil.]

DL Wise & 7 others ed 2000 *Bioremediation of Contaminated Soils*, Dekker, TD878.B55.5573. [48 chapters.]

World Resources 2000-2001 *People and Ecosystems. The Fraying Web of Life*, World Resources Institute, Washington DC, 1-56973-443-7. [Millennial ed focuses on 5 ecosystems and gives overview of population, food, water, energy use, climate change. Collaboration from UN Development Program, UN Environmental Program & World Bank. Excellent color maps.]

RT Wright BJ Nebel 2002 *Environmental Science. Towards a Sustainable Future*, 8th ed, GE105.W75.

PL Younger NS Robins ed 2002 *Mine Water Hydrogeology and Geochemistry*, TN318.M56 (9111). [26 contributions..]

GJ Zagary R Samson L Deschênes 2003 *Occurrence of metals in soil and ground water near chromated copper arsenate-treated utility poles*, JEQ 32 507-14.

SF Zakrewski 2002 *Environmental Toxicology*, RA1126.Z35.

C Zhu G Anderson 2002 *Environmental Applications of Geochemical Modeling*, Cambridge U P, QE516.4.Z48. [Nuclear waste, mining, landfill, deep well injection, artificial recharge of aquifers.]

JC Zwonitzer GM Pierzynski GM Hettiarachchi 2003 *Effects of phosphorus addition on lead, cadmium, and zinc bioavailabilities in a metal-contaminated soil*, WASP 143 193-209 (8930).

Geographic location

This section picks out a few papers that illustrate problems around the World. See also individual elements.

Africa

JO Agbenin AM Atin 2003 *Copper sorption characteristics and activity in acid soil from Nigeria*, WASP 150 43-58.

CB Barrett E Place AA Aboud ed 2002 *Natural Resources Management in African Agriculture. Understanding and Improving Current Practices*, S472.A1.N38.

N Burgess & 3 others 2004 *Terrestrial Ecosystems of Africa and Madagascar. A Conservation Assessment*, QH77.A35T47.

GRC Cooper 2002 *Oxidation and toxicity of chromium in ultramafic soils in Zimbabwe*, AG 17 981-6 = MA 02M/3898. [Cr oxidized by reducible Mn in Fe-Mn concretions, becoming toxic to maize.]

AJ Dietz R Ruben A Verhagen 2004 *The Impact of Climate Change on Drylands with a Focus on West Africa*, QC991.A44 I46.

AA Duker EJM Carranza M Hale 2005 *Spatial relationship between arsenic in drinking water and Mycobacterium ulcerans infection in the Amansie West district, Ghana*, MM 69 707-17.

International Metallogenic Map of Africa at a Scale of 1:5 000 000, Ep 26 115-6.

L Jonker & 4 others ed 2002 *Integrated water resources management: Theory, practices, cases*, PCE 27 719-1010. [Conference proceedings ~40 papers, including on Malawi, South Africa & Zimbabwe.]

H Karlsson & 10 others 2000 *Persistent chlorinated pesticides in air, water, and precipitation from the Lake Malawi area, southern Africa*, EST 34 4490-5 (6435).

X Liu & 4 others 2000 *Biomass burning in southern Africa: Individual particle characterization of atmospheric aerosols and savanna fire samples*, J Atmos Chem 36 135-55 (3189). [EMPA. 2-10 micrometer, mainly Al-silicates & sea salts; <2 K-S & S-only; KCl common in savannah.]

WI Mortada & 3 others 2002 *Reference intervals of cadmium, lead, and mercury in blood, urine, hair, and nails among residents in Mansoura city, Nile Delta, Egypt*, ER A90 104-10 (8755). [68 males higher in blood Pb than 25 females. Blood Cd & Pb and hair Pb higher for tobacco smokers. Hg in blood & urine higher for dental amalgam fillings.]

D Niemeijer V Mazzucato *Soil degradation in the West African Sahel*, 2002 *Env Mar* 20-31. [Complex: bad & good locally.]

JO Onyatta PM Huang 2003 *Kinetics of cadmium release from selected tropical soils from Kenya by low-molecular-weight organic acids*, *SoS* 168 234-52. [Complex but in general Cd released from soil.]

CM O'Reilly & 4 others 2003 *Climate change decreases aquatic ecosystem productivity of Lake Tanganyika, Africa*, *N* 424 765-8 (9197).

K Sassen & 3 others 2003 *Saharan dust storms and indirect aerosol effects on clouds: CRYSTAL-FACE results*, *GRL* 30 35.

YW Shaghude KO Wannas 2000 *Mineralogical and biogenic composition of the Zanzibar Channel sediments, Tanzania*, *ECSS* 51 477-89 (246).

M Shahin 2002 *Hydrology and Water Resources of Africa*, GB800.S52. [Detailed physical but not chemical/mineralogic.]

P Sobiech 2002 *Water for people and USEPA - Creating healthy partnerships with Africa's urban poor*, *AWWAJ* 94 46-51 (7872). [Kibera slum in Nairobi, Kenya.]

SSSA Special Publication 58 2001 *Sustaining Soil Fertility in West Africa*, S596.7.S87.

J Stanley & 3 others 2004 *Submergence of ancient Greek cities off Egypt's Nile Delta – A cautionary tale*, *GSA Today* 14 4-10 (9674). [8m deep Heraakleion & Eastern Canopus. Built on unprotected sediment.]

P Sutton J Maskall I Thornton 2002 *Concentrations of major and trace elements in soil and grass of Shimba Hills National Reserve, Kenya*, *AG* 17 1003-16.

N Yassaa 2001 *Organic aerosols in urban and waste landfill of Algiers metropolitan area: Occurrence and sources*, *EST* 35 306-11 (6445).

Asia including Russia, & Middle East

General

GR Carmichael & 6 others 2002 *Changing trends in sulfur emissions in Asia: Implications for acid deposition, air pollution, and climate*, *EST* 36 4707-13 (8081). [China reduction on coal S emission. Details.]

Y Harashima 2000 *Effects of economic growth on environmental policies in Northeast Asia*, *Env* 42 28-41 (6532). [Japan: late 19C concerns; 1949, Tokyo Pref. Ordinance for Factory Pollution Control; 1956 Minamata Hg disease; 1957 ouch-ouch Cd disease; hence laws on water quality; 1960s, chronic lung disease near petrochemical complexes; hence 1962 Smoke Regulation law; etc.; Korea: political problems; many problems remain in spite of major legislation; China: Mao ignored problems; 1970s First National Conf. Enviro Protection; etc. Detailed comparison of efforts in JKC.]

H Kato K Wakita JC Bandibas 2003 *Eastern Asia Geological Hazards Map: Paper and Digital Versions*, *J Natural Disaster Science* 25 65-74 (10504).

Sustainable Use of Natural Resources of Central Asia, Environmental problems of the Aral Sea and surrounding areas, 1998, S946.34.A7.S87 (6452). [~60 papers international conference.]

JF Tremblay 2000 *Littering in Asia*, *C&EN* Jul 10 26-8 (6546). [Terrible.]

XY Zhang & 6 others 2003 *Characterization and temporal variation of Asian dust aerosol from a site in the northern Chinese deserts*, *J Atmos Chem* 44 241-57 (8926).

Bangladesh & West Bengal

The control of As is perhaps the most immediate problem. What is needed is the equivalent of a teabag that can be put in water to remove As. An oxidant is needed to convert the As to the 5-valent state that can then be absorbed.

M Bae & 6 others 2002 *Arsenic in cooked rice in Bangladesh*, Lt 360 1839-40 (8444). [In Bengal, rice retains 2/3rds of As in water. Details.]

AG Gault & 6 others 2005 *Microcosm depth profiles of arsenic release in a shallow aquifer, West Bengal*, MM 69 855-63.

CF Harvey & 15 others 2002 *Arsenic mobility and groundwater extraction in Bangladesh*, S 298 1602-6 (8393). [Importance of young C-rich surface water.]

MR Islam & 3 others 2002 *Mineralogical changes during intense chemical weathering of sedimentary rocks in Bangladesh*, JAsES 20 889-901 (8389).

MR Islam & 5 others 2002 *Potential role of the Fe(III)-reducing bacteria Geobacter and Geothrix in controlling arsenic solubility in Bengal delta sediments*, MM 69 865-75.

M Jakariya & 6 others 2003 *Sustainable community-based safe water options to mitigate the Bangladesh arsenic catastrophe – An experience from two upazilas*, CuS 85 141-6.
[Recommends detailed measurement of As in tube wells using better analysis; optimum use of surface rain water.]

R Kaiser & 7 others 2001 *Blood lead levels of primary school children in Dhaka, Bangladesh*, EHP 109 563-6 (4232).

DG Kinniburgh PL Smedley ed 2001 *Arsenic Contamination of Groundwater in Bangladesh*, Vol 1: Summary, British Geological Survey Tech Report WC/00/19, TD427.A77A78.

KM Lokuge 2004 *The effect of arsenic mitigation interventions on disease burden in Bangladesh*, EHP 112 1172 (10590).

A Mushtaque R Chowdhury M Jakariya 1999 *Testing of water for arsenic in Bangladesh*, S 284 1622 (4111). [12k water samples from 156 villages tested with cheap Asian Arsenic Network kit: 90% have high As. Kit reduces As(V) with KCl & Sn(II) chloride; As(III) turned into As gas with Zn & HCl turning bromide paper light-yellow to red-brown.]

B Nath & 5 others 2005 *Characterization of aquifers conducting groundwaters with low and high arsenic concentrations: a comparative case study from West Bengal, India*, MM 69 841-54.

AL Rowland & 3 others 2005 *Preservation and XANES determination of the oxidation state of solid-state arsenic in shallow sedimentary aquifers in Bengal and Camdodia*, MM 69 825-39.

China

China has many problems, including man-made ones. Water contains toxic elements, air contains particles from burning coal, etc. Industrial activity is increasing, and pollution is growing in general. Farmers get angry about slowness in environmental controls.

G Agoramoorthy MJ Hsu 2000 *Taiwan pays the price for growth, in toxic pollution*, N 408 905 (6446). [18 Mt of technologic solid waste per year: 1.5 considered hazardous; only 0.6 treated. 0.1 Mt of Hg waste accumulated by 1989.]

K Brown 2000 *A billion and counting: China's tricky census*, S 290 1289-9 (6518). [?accuracy of 1.18 male/female child ratio. How many migrants?]

LY Chan WS Kwok 2000 *Vertical dispersion of suspended particulates in urban area of Hong Kong*, AE I3 4403-12 (6519). [Bad air at street level falls vertically depending on wind.]

D Chen 1999 *Engineering geological problems in the Three Gorges project on the Yangtze, China*, EnG 51 183-93 (6520). [No serious challenges expected from faults and earthquakes.]

JC Chen 2004 *Goundwater maintains dune landscape*, N 432 459 (10816). [Badain Jaran desert has very high dunes maintained by groundwater. In danger from possible water diversion.]

L Chen J Wang B Fu Y Qui 2001 *Land-use change in a small catchment of northern Loess Plateau, China*, Agric Ecosystems Enviro 86 163-72 (6521). [New "household responsibility system" implemented since ~1980 resulted in decrease of terrace & slope farmland, sparse woodland & bushland, and increase of dense woodland, orchard and sparse wild grassland. Etc.]

Q Chen & 6 others 2002 *Soil organic matter turnover in the subtropical mountainous region of South China*, SoS 167 401-15 (7368).

R Clay 2002 *China. The next environmental super power?* EHP 110(9) 524-7 (8556).

D Cyranoski 2003 *China plans clean sweep on dust storms*, N 421 101 (9036). [Dust storms becoming more intense.]

E Derbyshire X Meng TA Dijkstra ed 2000 *Landslides in the Thick Loess Terrain of North-West China*, 0-471-97349-1 (6524). [8 chapters covering geology, climate, land use, loess, rain & water, earthquakes, amelioration & mitigation. Landslide scars cover _ of loess area.] **J Knill** 2000 *Review*, *Geoscientist* 11 17 (6526).

Z Ding & 7 others 2001 *Geological and geochemical characteristics of high arsenic coals from endemic arsenosis areas of southwestern Guizhou Province, China*, AG 16 1333-60 = MA 02M/0276. [Details of As(III & V).]

ZL Ding & 5 others 2002 *The loess record in southern Tajikistan and correlation with Chinese loess*, *EPSL* 200 387-400 (7377).

ZL Ding SL Yang JM Sun TS Liu 2001 *Iron geochemistry of loess and red clay deposits in the Chinese Loess Plateau and implications for long-term Asian monsoon evolution in the last 7.0 Ma*, *EPSL* 185 99-109 (6527). [Monsoon prime near 4.8-4.1 Ma attributed to uplift of Tibetan Plateau.]

R Edwards 2001 *Don't drink the water....it's radioactive*, NS 13Jan 20 (6529). [Fujian Province has high radon in water, causing high cancer. Answer: bubble air through water.]

M Elvin 2004 *The Retreat of the Elephants. An Environmental History of China*, 0-300-10111-2 (10506).

F Fang & 4 others 2001 *Atmospheric particulate mercury in Changchung City, China*, AE 35 4265-72 (6037). [Coal heating increases Hg over wind-blown dust.]

X Feng Y Hong 1999 *Models of occurrence of mercury in coals from Guizhou, People's Republic of China*, F 78 1181-8 (6038).

RB Finkelman HE Belkin B Zheng 1999 *Health effects of domestic coal use in China*, *PNAS* 99 3427-31.

FM Fordyce Z Guangdi K Green L Xinping 2000 *Soil, grain and water chemistry in relation to human selenium-responsive diseases in Enshi District, China*, AG 15 117-32 = MA 00M/1561. [5 villages have low-Se rocks & Se-deficient diet, 5 have high-Se rocks and no diet problems, and 5 have high-Se rocks and Se-toxic disease. Se bioavailability is controlled by total soil Se, pH & sorption on organic and Fe-oxyhydroxides. Se is higher in maize & vegetables than rice.]

Q Gao M Yu X Yang 2000 *An analysis of sensitivity of terrestrial ecosystems in China to climatic change using spatial simulation*, *CIC* 47 373-400 (7003). [Detailed predictions.]

W Gao & 7 others 2001 *Blood levels among children aged 1 to 5 years in Wuzi City, China*, ER A87 11-9 (4300).

ZT Guo & 9 others 2002 *Onset of Asian desertification by 22 Myr ago inferred from loess deposits in China*, N 416 159-63 (6742).

J Hao D He Y Wu L Fu K He 2000 *A study of the emission and concentration distribution of vehicular pollutants in the urban area of Beijing*, AEI 34 453-65 (6531). [Details.]

KB He & 9 others 2004 *Concentration level of fine airborne lead in Beijing, People's Republic of China*, *Bull Environ Contam Toxicol* 72 133-9 (9921).

X He K Tang J Tian JA Matthews 2002 *Paleopedological investigation of three agricultural loess soils on the Loess Plateau of China*, *SoS* 167 478-91 (7685).

YT Hong & 9 others 2001 *A 6000-year record of changes in drought and precipitation in northeastern China based on a ¹³C time series from peat cellulose*, *EPSL* 185 111-9 (6533).

D Jabowski CL Henry Z Aheng X Zhang 2001 *Mining impacts on trace metal content of water, soil, and stream sediments in the Hei River basin, China*, *WASP* 131 261-73 (4862).

D Kar 2000 *Review of RH Grove V Damodaran S Sangwan eds* 1998 *The Environment History of South and South-east Asia: Nature and the Orient*, *CuS* 79 248-9 (6449).

C Karasov 2002 *Reviving China's ruined rivers*, *EHP* 110(9) A510-1 (8556).

X Li C Poon PS Liu 2001 *Heavy metal contamination of urban soils and street dusts in Hong Kong*, AG 16 1361-8. [High Cd/Cu/Pb/Zn from traffic emissions and industry; perhaps also Cd from fertilizer.]

- C Lin Z Hseu Z Chen** 2002 *Clay mineralogy of Spodosols with high clay content in the subalpine forests of Taiwan*, CICIM 50 726-35 (8656). [Vermiculite & illite.]
- ML Lin FS Jeng** 2000 *Characteristics of hazards induced by extremely heavy rainfall in Central Taiwan - Typhoon Herb*, EnG 58 191-207 (6450). [1315 landslides; 73 dead; 1B US\$ damage.]
- C Liu M Wang PJiao** 1999 *Hydrogen, oxygen, strontium, and sulphur isotopic geochemistry and potash-forming material sources of Lop Salt Lake, Xinjiang*, MD 18 268-75 (6537). [Details.]
- J Liu & 6 others** 2002 *Chronic arsenic poisoning from burning high-arsenic-containing coal in Guizhou, China*, EHP 110 119-22 (7594). [Details.]
- JW Longworth GJ Williamson** 1993 *China's Pastoral Region. Sheep and Wool, Minority Nationalities, Rangeland Degradation and Sustainable Development*, 0-85198-890-3 (6538).
- A Lu & 4 others** 2003 *Application of vermiculite and limestone to desulphurization and to the removal of dust during briquette combustion*, MM 67 1243-51. [Relevant to air pollution from cooking stoves.]
- D MacKenzie** 2000 *Agents of death*, NS 27May 5 (6539). [2M Japanese drums & munitions with mustard gas etc. in China; slow progress in destruction; by 2007?]
- X Meng E Derbyshire Y Du** 2000 *Landslide hazards in the eastern part of Gansu Province*, Z dt.geol.Ges 151 31-47 (6540). [Heavy monsoon rain & earthquakes; human steepening of slopes.]
- M Mitsuno & 6 others** 2001 *Influence of coal ash on micro-organisms and applicability of coal ash to remediate desertified soil – in the case of desertified land in inner Mongolia, China*, Clay Sci 11 503-15. [Both coal ash & Yellow River sediment increase bacterial activity.]
- B Müller & 4 others** 2002 *P, As, Sb, Mo, and other elements in sedimentary Fe/Mn layers of Lake Baikal*, EST 36 411-20 (5896). [P/As concentrate in Fe crusts & Mo in Mn layer. Sb slight enrichment in both. Cd prefers Mn.]
- Z Nan & 4 others** 2002 *Relations between soil properties and selected heavy metal concentrations in spring wheat (*Triticum aestivum* L.) grown in contaminated soils*, WASP 133 204-13 (6709). [Grain/soil Cd & Pb predictable, but not Cu & Zn.]
- S Nayaka & 3 others** 2003 *Distribution pattern and heavy metal accumulation in lichens of Bangalore city with special reference to Lalbagh garden*, CuS 84 674-80. [Cr/Fe/Cu/Zn/Pb. Measure of increasing air pollution.]
- S Nicholson** 2000 *Land surface and processes and Sahel climate*, RG 38 117-39 (6451). [jvs Relevant to N. China.]
- S Peng W Wang J Chen** 2003 *Partitioning of trace metals in suspended sediments from Huanghe and Changjiang rivers in eastern China*, WASP 148 243-58 (9411). [Cd/Cr/Zn.]
- Proceedings of International Scientific Conference Sep 9-11, 1997** 1998 *Sustainable Use of Natural Resources of Central Asia, Environmental Problems of the Aral Sea and Surrounding Areas*, S946.34.A7S87 (6452).
- Y Qian** 2000, *The appropriate technologies for municipal wastewater treatment in China*, JESH A35 1749-60 (6535). [Part of special issue on *Environmental simulation and Pollution Control in China*, 24 other papers including on Beijing drinking water, municipal waste, VOC emissions.]
- CW Schmidt** 2002 *Economy and environment. China seeks a balance*, EHP 110 A517-22 (8556).
- KC Seto RK Kaufmann CE Woodcock** 2000 *Landsat reveals China's farmland reserves, but they're vanishing fast*, N 406 121 (6542). [Farmers underreport 2-fold.]
- CL Shah & 4 others** 2002 *Sulphur reduction evaluation of selected high-sulphur Chinese coals*, F 81 519-29 (7184). [Can remove half by latest methods.]
- DG Streets ST Waldhoff** 2000 *Present and future emissions of air pollutants in China: SO₂, NO_x and CO*, AE 34 363-74 (6544). [CHINA-MAP program. Details.]
- DG Streets & 7 others** 2001 *Recent reductions in China's greenhouse gas emissions*, S 294 1835-7 (6545). [1996 peak year.]
- S Sugimoto & 7 others** 2003 *Record heavy Asian dust in Beijing in 2002: Observations and model analysis of recent events*, GRL 30 42.
- F Tao Z Feng** 2000 *Critical loads of SO₂ dry deposition and their exceedance in South China*, WASP 124 429-38 (6455). [Details.]

- J Tremblay** 2005 *Tempers flare in China*, CEN 9/26 21-8.
- C Vita-Finzi** 2000 *Deformation and seismicity of Taiwan*, PNAS 97 11176-80 (6548).
- Q Wang W Shen Z Ma** 2000 *Estimation of mercury emission from coal combustion in China*, EST 34 2711-3 (6105).
- Q Wang & 4 others** 2003 *Soil contamination and plant uptake of heavy metals at polluted sites in China*, JESH A38 823-38 (9256). [Dangerous levels. Rice grains risk to human health from paddies contaminated with Cd/Cr/Zn. *Polygonum hydropiper* & *Rumex acetosa* L potential for phytoremediation of Zn. *Platanus acerifolia* excluded most toxic elements. Pb/Zn/Cd fell exponentially with distance from metal smelter.]
- R Wang S Bryant** 2003 *The Three Gorges Dam*, WET 15(11) 28-33.
- TJ Wang LS Jin ZK Li KS Lam** 2000 *A modeling study on acid rain and recommended emission control strategies in China*, AE 34 4467-77 (6549).
- W Wei** 2002 *Beijing inundated by the sea within the past 80 k.y.: Nannofossil evidence*, G 30 379-81 (7026).
- SC Wong & 4 others** 2002 *Heavy metals in agricultural soils of the Pearl River Delta, South China*, EnPo 119 33-44 (7765). [Cd/Co/Cu/Mn/Pb/Zn.]
- AG Wright** 2004 *Power's on, final segment's underway as the Three Gorges forges ahead*, ENR Aug 23 20-3 (10568).
- J Wu & 4 others** 2003 *Three-Gorges dam – experiment in habitat fragmentation*, S 300 1239-41 (9014).
- S Wu & 6 others** 2001 *Zonation of the landslide hazards in the forereservoir region of the Three Gorges Project on the Yangtze River*, EnG 59 51-8 (6550).
- HR Zhang Q Zhang** 2003 *Developing sustainable water supplies*, WET 15(11) 34-7.
- Q Zhou T Sun** 2002 *Effects of chromium (VI) on extractability and plant uptake of fluorine in agricultural soils of Zhejiang Province, China*, WASP 133 145-60 (6708).
- G Xu LJ Peel ed** 1991 *The Agriculture of China*, Oxford Univ Press, 0-19-859208-6.
- J Xu & 6 others** 2002 *Measurement of aerosol chemical, physical and radiative properties in the Yangtze delta region of China*, AE 36 161-173 (5901). [Comparable to dirty city.]
- SZ Yang N Blum** 1999 *Arsenic as an indicator element for gold exploration in the region of the Xiangxi Au-Sb-W deposit, NW Hunan, PR China*, J Geochem Exploration 66 441-456 (6551).
- ZF Yang & 4 others** 2001 *Engineering geomechanical analysis and monitoring-control in design and construction of the Wuqiangxi ship lock slope, China*, EnG 59 59-72 (6552).
- D Yuan D Yang TL Wade Y Qian** 2001 *Status of persistent organic pollutants in the sediment from several estuaries in China*, EnPo 114 101-11 (6553).
- J Zhang & 9 others** 2000 *Greenhouse gases and other airborne pollutants from household stoves in China: A database for emission factors*, AE 34 4537-49 (6554). [28 fuel/stove combinations; higher emission for solid than liquid/gas fuel; details.]
- Z Zhang SK Friedlander** 2000 *A comparative study of chemical databases for fine particle Chinese aerosols*, EST 34 4687-94 (6556). [High silica from burning rice straw and coal; Ca/Al/Mn/Ti/Fe higher in Beijing than Los Angeles, Cu/Pb/Zn/Cr/Ni lower.]
- XP Zhang W Deng XM Yang** 2002 *The background concentrations of 13 soil trace elements and their relationships to parent materials and vegetation in Xizang (Tibet), China*, JAS ES 21 167-74 (8549). [As/Cd/Co/Cr/Cu/F/Hg/Mn/Ni/Pb/Se/V.]
- L Zhou & 7 others** 2004 *Evidence for a significant urbanization effect on climate in China*, PNAS 101 9540-4 (10483).
- Q Zhou T Sun** 2002 *Effects of chromium (VI) on extractability and plant uptake of fluorine in agricultural soils of Zhejiang Province, China*, WASP 133 145-60 (6708).

India

India has dirty air and water in most cities, and many people suffer from toxic elements. A few representative papers:

AA Ansari IB Singh 2000 *Importance of geomorphology and sedimentation processes for metal dispersion in sediments and soils of the Ganga Plain: Identification of geochemical domains*, ChG 162 245-66 (6481). [Kanpur-Unnao industrial region heavily polluted. Details.]

SK Acharyya 2002 *Arsenic contamination in groundwater affecting major parts of southern West Bengal and parts of western Chattisgarh: Source and mobilization process*, CuS 82 740-3 (7031). Also see: N 395 338 & 401 545-7 (4113). [Weathered acid magmatic rocks. As released by biomediated reductive dissolution of Fe-oxyhydroxides.]

K Bandhu & 9 others 2000 *Elemental composition and sources of air pollution in the city of Chandigarh, India, using EDXRF and PIXE techniques*, NIMPR B160 129-38 (6483). [Soil dust dominates. Detail]

SK Gupta RD Deshpande 2004 *Water for India in 2050: first-order assessment of available options*, CuS 86 1216-? (10284).

MK Deb M Thankur RK Mishra N Bodhankar 2002 *Assessment of atmospheric arsenic levels in airborne dust particulates of an urban city of central India*, WASP 140 57-71 (8108). [Raipur.]

MK Ghose SR Majee 2000 *Assessment of the impact on the air environment due to opencast coal mining – an Indian case study*, AEI 34 2791-6 (6489). [Jharia coalfield, Bihar. Need dust control.]

CK Jain MK Sharma 2002 *Adsorption of cadmium on bed sediments of River Hindon: Adsorption models and kinetics*, WASP 137 1-19 (7496). [West Uttar Pradesh. pH increases Cd adsorption.]

KS Jayaraman 2003 *India pledges deluge of funds to water plan*, N 422 790 (8954). [Plan to link 37 rivers with 30 canals 12,000 kilometer.]

CS Jha CBS Dut KS Bawa 2000 *Deforestation and land use changes in Western Ghats, India*, CuS 79 231-7 (6491). [One-quarter lost from 1973 to 1995.]

N Kochupillai 2000 *Clinical endocrinology in India*, CuS 79 1061-7 (6493). [~108 M people, mainly poor, need immunoassay. Details.]

T Pal PK Mukherjee S Sengupta 2002 *Nature of arsenic pollution in groundwater of Bengal basin - A case study from Baruipur area, West Bengal, India*, CuS 82 554-61 (6995). [Clay 2-31 ppm, peat 9-40, silt 2-6, sand 1-7. Sand contains coated FeOOH & magnetite & ilmenite 14-112; illite 10-40; FeOH-coated sand grains 30; chlorite 5-31, biotite 9; siderite concretions 7-9: these store most of As for pollution.]

R Ramesh & 4 others 2000 *Distribution of rare earth elements and heavy metals in surficial sediments of the Himalayan river system*, GcJ 34 295-319 (6496). [Physical weathering main contributor.]

MS Reddy C Venjataraman 2000 *Atmospheric optical and radiative effects of anthropogenic aerosol constituents from India*, AE 34 4511-23 (6497). [Details.]

MS Reisch 2004 *Twenty years after Bhopal*, CEN Jun 7 19-23 (10342).

KR Smith 2000 *National burden of disease in India from indoor air pollution*, PNAS 87 13286-93 (6453). [Attribute 500 k premature deaths to biomass fuels = 5% of India's disease burden.]

J Tremblay 2000 *Vapi, India*, CEN May 15 27-8 (6500). [Heavy industrial pollution, with some local improvement.]

Indonesia

B Langmann HF Graf 2003 *Indonesian smoke aerosols from peat fires and the contribution from volcanic sulfur emissions*, GRL 30-11 1547.

Japan

M Sakata K Marumoto 2001 *Formation of atmospheric particulate mercury in the Tokyo metropolitan area*, AEI 36 239-46 (5902).

M Sakamoto A Nakano H Akagi 2001 *Declining Minamata male birth ratio associated with increased male death due to heavy methylmercury pollution*, ER 87 92-8 (6090).

KE Wilkening 2004 *Acid Rain Science and Politics in Japan*, QC926.57.J3.

Korea

KH Kim MY Kim 2001 *The temporal distribution characteristics of total gaseous mercury at an urban monitoring site in Seoul during 1999-2000*, AE 35 4235-63 (6058).

Middle East

This region is mainly arid, & available water is maldistributed & mainly polluted. Aquifers are being mined.

Y Ebel & 4 others 2001 *Lead concentrations and isotopic ratios in the sediments of the Sea of Galilee*, EST 35 292-8 (4268).

RE Kohn 2003 *Israel's need to import freshwater*, WASP 143 257-770 (8928).

A Lawler 2005 *Reviving Iraq's wetlands*, S 307 1186-9 (10937).

E Masood 2002 *Blooms in the desert*, N 416 120-2 (6740). [Arab world trying to recover from neglect of science.]

A Nishri & 4 others 1999 *Lake Kinneret (The Sea of Galilee): the effects of diversion of external salinity sources and the probable chemical composition of the internal salinity sources*, ChG 158 37-52 (6541). [Details.]

C Read 2000 *Sharing water in the West Bank*, Gt Dec 6 (6466). [Maldistribution.]

Pakistan

MH Rahbar & 4 others 2002 *Factors associated with elevated blood lead concentrations in children in Karachi, Pakistan*, Bull World Health Organization 80 769-74. [Most children likely to have some intellectual impairment. Living near main city center, application of surma to eyes, father's exposure at work, and hand-to-mouth transfer seem important. Petrol should be made Pb-free.]

OV Rattigan & 6 others 2002 *Aerosol sulfate and trace elements in urban fog*, EnF 16 640-6 (7340). [Intense disruptive fog for 2 months in winter, severe health risk to 7M people. S/Se/As/Sb/Pb/Cu/Zn,etc.]

Russia

The Stalinist regime had complete control of information, and the administrators got way with severe contamination. Huge areas are uninhabitable because of radioactive contamination.

D Gregurek & 4 others 1999 *Mineralogy and mineral chemistry of snow filter residues in the vicinity of the nickel-copper processing industry*, MP 65 87-111 (6572). [Kola Peninsula. Sulfides & oxides characteristic of emitter.]

T Haugland E Steinnes MV Frontasyena 2002 *Trace metals in soil and plants subjected to chemical pollution*, WASP 137 343-53 (7751). [Monchegorsk Cu-Ni smelter. Ag/As/Co/Cs/Fe/Ir/Ni/Rb/Sb/Sc.]

FS Kot LA Matyushkina 2003 *Mercury speciation in urban soils: Industrial centers of the middle Amur region*, GI 41 599-602. [2 to 6 higher. Hotspots from use of waste deposit as soil fertilizer.]

AG Lapenis & 7 others 2000 *Scientists unearth clues to soil contamination by comparing old and new soil samples*, Eos 81(6) 59-60 (6578). [5 sites from near St Petersburg towards Caspian Sea from mixed forest to steppe. 1895 soils have higher pH and lower exchangeable base cations than modern ones.]

IN Malikova & 5 others 2000 *On irregular distributions of mercury in the upper soil horizon: A case study of the Altai region*, GI 38 1212-20 (6070).

GG Matishov NI Golubeva LV Burtseva 2002 *Study of the gaseous mercury concentration in the atmosphere over the Barents and Kara Seas*, DES 383 163-5 (7195). [Details.]

H Mukai & 4 others 2000 *Lead isotope ratios in the urban air of eastern and central Russia*, AE 35 2783-94 (4251).

OW Purvis & 6 others 2003 *Lichen monitoring near Karabash Smelter Town, Ural Mountains, Russia, one of the most polluted areas in the world*, PRSL B 271 221-6 (10013).

C Reimann D Banks P De Caritat 2000 *Impacts of airborne contamination on regional soil and water quality: The Kola Peninsula, Russia*, EST 34 2927-32 (4067). [Source contamination of Ag/Cu/S mainly local from the smelters in the 190,000 square kilometer area.]

NV Sidenko & 4 others 2005 *Geochemical and mineralogical zoning of high-sulfide mine-waste at the Berikul mine-site, Kemerovo region, Russia*, CM 43 1141-56.

R Stone 2002 *Caspian ecology teeters on the brink*, S 295 430-3 (6579).

TR Walker SD Young PD Crittenden H Zhang 2003 *Anthropogenic metal enrichment of snow and soil in north-eastern European Russia*, EnPo 121 11-21 (8010). [Evidence for elements associated with alkaline combustion ash around coal mining towns of Vorkuta & Inta. No evidence for deposition around gas/oil town of Usinsk.]

P Webster 2004 *Study finds heavy contamination across vast Russian Arctic*, S 306 1875 (10905).

EG Yazikov & 4 others 2004 *Mineral composition of dust-aerosol fallouts in snow cover of the Tomsk industrial agglomeration*, ZVMO 53-62.

Singapore

RG Burkard 2000 *Solid ground*, CEn Sep 44-7 (6448). [Singapore is putting municipal waste into tropical atoll.]

Sri Lanka

C Dissanayake 2005 *Of stones and health: Medical geology in Sri Lanka*, S 309 883-5.

Vietnam

M Berg HC Tran TC Nugyen HV Pham R Schertenleib W Giger 2001 *Arsenic contamination of groundwater and drinking water in Vietnam: A human health threat*, EST 35 2621-25 (4098). [As may be associated with Fe oxyhydroxides, and released by reduction of Fe.]

Australia & New Zealand

PM Ashley BG Lottermoser 1999 *Arsenic contamination at the Mole River mine, northern New South Wales*, AJES 46 861-74 (6459). [Arsenopyrite ore processed in the 1920/30's. Waste has 3-27% As, soils 1%, stream sediments 60 ppm to 27%.]

GF Birch SE Taylor 2000 *Distribution and possible sources of organochlorine residues in sediments of a large urban estuary, Port Jackson, Sydney*, AJES 47 749-56 (6457).

D Craw 2000 *Water-rock interactions and acid neutralization in a large schist debris dam, Otago, New Zealand*, ChG 171 17-32 (6564). [Macraes mine tailings.]

MJ Dilworth RP Tiwari WG Reeve AR Glenn 2000 *Legume root nodule bacteria and acid pH*, Sci Prog 83 357-89 (5756). [Research at Murdoch Univ, Australia.]

MJR Halstead RG Cunninghame KA Hunter 2000 *Wet deposition of trace metals to a remote site in Fiordland, New Zealand*, AE 34 665-76 (3331).

BG Lottermoser 2002 *Mobilization of heavy metals from historical smelting slag dumps, north Queensland, Australia*, MM 66 475-90.

S Luntz 2000 *Audit predicts grim salinity future*, AuS Jan/Feb 23-5 (6465). [Adelaide's water may become unfit to drink.]

SS Mann AW Rate RJ Glikes 2002 *Cadmium accumulation in agricultural soils in Western Australia*, WASP 141 281-97 (8555). [Details of increase in Cd from fertilizer.]

JC Ng SM Kratzmann L Qi H Crawley B Chiswell MR Moore 1998 *Speciation and absolute bioavailability: risk assessment of arsenic-contaminated sites in a residential suburb in Canberra*, Analyst 123 889-92. [Plunge dip for arsenical pesticide, now in suburb of Canberra, has soil As 32-1600 mg/kg. However, little is bioavailable.]

P Pockley 2000 *Legacy of Maralinga lingers*, AuS Apr 20-2 (6468). [Nuclear weapons aftermath.]

B Robinson & 3 others 2002 *Cadmium adsorption by rhizobacteria: implications for New Zealand pastureland*, AEE 87 315-23. [Details.]

HM Shivaramaiah & 3 others 2002 *Mapping the distribution of DDT residues as DDE in the soils of the irrigated regions of northern New South Wales, Australia using ELISA and GIS*, JAgFC 50 5360-7 (7968).

R Sullivan I Woods 2000 *Using emission factors to characterise heavy metal emissions from sewage sludge incinerators in Australia*, AE 24 4571-7 (6472).

Europe including UK & Turkey

General

C Alewell R Manderscheid H Meesenburg J Bittersohl 2000 *Is acidification still an ecological threat?* N 407 856-7 (5542). [Argues that soils still acidic in Europe though deposition of industrial dust is going down.]

M Burke 2000 *Assessing the environmental health of Europe*, EST Feb1 76-80A.

G Carrera & 3 others 2000 *Persistent organic pollutants in snow from European high mountain areas*, AE 35 245-54 (5499).

European Environmental Agency 2000, *Down to Earth: Soil Degradation and Sustainable Development in Europe*, S625.E85D69 (5528). [Major problems: urbanization, erosion, slope instability, hot spots of contamination, acidification. Maps. Policy.]

European Environmental Agency 2002 *Water and health in Europe*, RA594.A1W38. [Joint report with World Health Organization.]

European Environmental Agency 2003 *Hazardous substances in the European marine environment: Trends in metals and persistent organic pollutants*, 92-9167-628-4.

DS Lee E Nemitz D Fowler RD Kingdon 2001 *Modelling atmospheric mercury transport and deposition across Europe and the UK*, AE 35 5455-66 (6062).

G Rheinheimer 1998 *Pollution in the Baltic Sea*, Nw 85 318-29 (4583). [Improving since 1974 agreement by Helsinki Commission.]

KF Schmidt 2001 *A true-blue vision for the Danube*, S 294 1444-7 (6829).

P Szefer 2002 *Minerals, Metalloids and Radionuclides in the Baltic Sea Ecosystem*, GC1271.S94.

D Van der Lelie & 4 others 2001 *Assessing phytoremediation's progress*, EST Nov1 446-52A (4720). [Review of successful European projects for Cd/Cu/Pb/Zn.]

WHO, Air Quality Guidelines for Europe 1987 TD883.7.A57.

HJ Winkels & 5 others 1998 *Geochronology of priority pollutants in sedimentation zones of the Volga and Danube deltas in comparison with the Rhine delta*, AG 13 581-91. [Details since the 1930's. Volga low; Danube maximum ~ 1987; heavy metals except Cu & Zn, PAH & PCB highest in Rhine.]

Belgium

W Adriaensen & 4 others 2000 *Soil geochemistry in and around the town of Marche-en-Famenne (Wallonia, S-Belgium)*, Geologica Belgica 3 309-30 = MA 02M/2645. [Many details for this rural area.]

V Debacker & 3 others 2000 *Heavy metals contamination and body condition of wintering guillemots (Uria aalge) at the Belgian coast from 1993 to 1998*, ER A84 310-7 (4037).

Cyprus

KA Hudson-Edwards SJ Edwards 2005 *Mineralogical controls on storage of As,Cu,Pb and Zn at the abandoned Mathiatis massive sulphide mine, Cyprus*, MM 69 695-706.

Czech Republic

Very industrialized for 2 centuries, with heavy pollution especially in the Black Triangles.

V Ettler & 3 others 2000 *Zinc partitioning between glass and silicate phases in historical and modern lead-zinc metallurgical slags from the Prábram district, Czech Republic*, CRASP-STP 331 245-50 (6804).

J Sejkora P Berlepsch E Makovicky T Balic-Zunic 2001 *Natural SnGeS₃ from Radvanice (Czech Republic): its description, crystal structure refinement and solid solution with PbGeS₃*. EJM 13 791-800 (3426). [Burning coal mine dump.]

I Suchara J Sucharova 2002 *Distribution of sulphur and heavy metals in forest floor humus of the Czech Republic*, WASP 136 289-316 (7774). [Al/As/Cd/Co/Cr/Cu/Fe/Hg/Mo/Ni/Pb/S/V.]

Finland

R Sundstrom M Astrom P Osterholm 2002 *Comparison of the metal content in acid sulfate soil runoff and industrial effluents in Finland*, EST 36 4269-72 (8152). [AS soils supply much Al/Cd/Co/Mn/Ni/Zn through agricultural ditching & should be controlled. Details.]

France

L'Environnement en France, GE160.F8 E55 2002, covers the whole caboodle.

A Courtin-Nomade C Neel H Bril M Davranche 2002 *Trapping and mobilisation of arsenic and lead in former mine tailings. Environmental conditions effects*, BSGF 173 479-85. [Cf 2 sites in Massif Central. *Beudantite, goethite, hematite, jarosite, scorodite*. Details.]

G Dagallier D Grgic F Homand 2002 *Mineralogical and microtextural characterisation of the anthropic-origin ageing of iron ore in Lorraine (France)*, CRG 334 455-62 (8133). [Abandoned mine pillars show collapse from diagenetic alteration by bacterial flora into *siderite & berthierine*, and encrusting by *goethite-hematite*.]

L Denaix RM Semlali F Douay 2001 *Dissolved and colloidal transport of Cd, Pb, and Zn in a silt loam soil affected by atmospheric industrial deposition*, EnPo 113 29-38 (4022). [North France.]

C Grosbois & 3 others 2000 *Dissolved load of the Loire River: chemical and isotopic characterization*, ChG 170 179-201 (6809).

P Ildefonse & 6 others 1990 *Weathering of a Pb-mineralized sandstone, Ardeche, France: Lead speciation*, In *Geochemistry of Earth's Surface*, 90-5809-073-6. [*Plumbogummite* constant in depth profile; Mn-(hydr)oxide surface complexes replaced by organic ones.]

C Latrille F Elsass F van Oort L Denaix 2001 *Physical speciation of trace metals in Fe-Mn concretions from a rendzic lithosol developed on Sinemurian limestones (France)*, Gd 100 127-46 (5533). [Quartz/feldspar/kaolinite/mica/goethite/Ti-oxide; Cr/Co/Ni/Cu/Zn/Pb. Pb/Fe/P correlation. Other elements correlate with Mn.]

P Michel B Boutier J Chiffoleau 2000 *Net fluxes of dissolved arsenic, cadmium, copper, zinc, nitrogen and phosphorus from the Gironde estuary (France): Seasonal variations and trends*, ECSS 51 451-62 (4677). [French Network for Quality of the Marine Environment. Worry about oyster & mussel quality from high contamination. 2 decades of study show major changes from month to month.]

W Rocher & 6 others 2004 *Hydrocarbons and metals in atmospheric deposition and roof runoff in central Paris*, WASP 159 57-86.

T Sterckeman & 4 others 2002 *Assessment of the contamination of cultivated soils by eighteen trace elements around smelters in the north of France*, WASP 135 13-94 (7073).

[Ag/As/Bi/Cd/Co/Cr/Cu/Hg/In/Ni/Pb/Sb/Se/Sn/Tl/Th/U/Zn. Pb/Zn production plants at Noyelles-Godault & Aubry. Complex details.]

M Thiry S Huet-Taillanter J Schmitt 2002 *The industrial waste land of Mortagne-du-Nord (59) – I – Assessment, composition of the slags, hydrochemistry, hydrology and estimates of the outfluxes*, BSGF 173 369-81 (8234). **JS SH MT** *II – Oxidizing alteration of the slags, hydrochemistry, geochemical modeling and remediation proposal*, 383-93. [30 Zn/Pb/Cd/Cu minerals.]

CM Tseng & 5 others 2001 *Speciation of mercury in a fluid mud profile of a highly turbid macrotidal estuary (Gironde, France)*, EST 35 2627-33 (6099).

E van Hullebusch & 7 others 2003 *Copper accumulation in a reservoir ecosystem following copper sulfate treatment (St. Germain les Belles, France)*, WASP 150 3-22.

A Veyseyre & 8 others 2001 *Heavy metals in fresh snow collected at different altitudes in the Chamonix and Maurienne valleys, French Alps: initial results*, AE 35 415-25 (4036). [Very low.]

Germany

M Anke & 6 others 2000 *Intake of chromium in Germany: risk or normality?* J Trace & Microprobe Techniques 18 541-8 (4211). [Complex; intake lower in 1996 than 1988.]

T Faus-Kessler & 3 others 2001 *Correlation patterns of metals in the epiphytic moss Hypnum cupressiforme in Bavaria*, AE 35 427-39 (4035).

M Frei U Bielert H Heinrichs 2000 *Effects of pH, alkalinity and bedrock chemistry on metal concentrations of springs in an acidified catchment (Ecker Dam, Harz Mountains, FRG)*, ChG 170 221-42 (6806).

J Gattermann W Wittke C Ericksen 2001, *Modelling water uptake in highly compacted bentonite in environmental sealing barriers*. CIM 36 435-46. [For German nuclear waste repository.]

Hungary

I Csalagovits 1992 *Arsenic-bearing artesian waters of Hungary*, Ann Rep Geol Inst Hungary 1992-1993/II 85-92 = MA 00M/1576. [6500 wells show mostly 1-10 microgram/liter with some anomalies >200 in southeast. As enriched by adsorption on colloidal Fe oxy/hydroxides, and remobilized by bacteria.]

L Juhasz & 3 others 2002 *Radon exhalation studies for the remediation of uranium tailings ponds in Hungary*, MA 03M/2665.

Italy

S Beaubien & 2 others 2003 *Carbon dioxide and radon hazard in the Alban Hills area (central Italy)*, JVGR 123 63-80.

ML Carapezza & 3 others 2003 *Gas hazard assessment in a densely inhabited area of Colli Albani Volcano (Cava dei Selci, Roma)*, JVGR 123 81-94.

A Annunziatelli & 3 others 2003 *Short- and long-term gas hazard: the release of toxic gases in the Alban Hills volcanic area (central Italy)*, MA 03M/2660. [High radon, carbon dioxide etc.]

S Caliro & 3 others 1998 *Lead pollution in roadside soils of Napoli-Salerno motorways*, MPA 41 109-17 (6794).

P Censi & 7 others 2002 *Trace element distributions in the Strait of Sicily (Central Mediterranean Sea). I. Evidence of rock-water interaction and pollution*, PM 71 255-72. [V/Cr/Fe/Co/Ni/Cu/Zn/Y/Cd/Ba/La/Ce/Nd/Pb. Complex details.]

JW Day Jr & 5 others 1999 *Soil accretionary dynamics, sea-level rise and the survival of wetlands in Venice Lagoon: A field and modeling approach*, ECSS 49 607-28 (3187).

E Dinelli S Gallerani G Cortecchi M Greco 1997 *Mineralogia e geochimica dei sedimenti della Darsena Citta (Canale Candiano, Ravenna)*, MPA 40 227-39 = MA 99M/0312. [High Pb 540 ppm Cu 200 Zn 600 compared to Adriatic coast 28 24 106. As 60 top 190 bottom of core also high. Mainly related to *pyrite* and organic matter.]

G Dongarra D Varrica G Sabatino 2003 *Occurrence of platinum, palladium and gold in pine needles of Pinus pinea L. from the city of Palermo (Italy)*, AG 18 109-16 = MA 03M/1466.

D Fabbri & 5 others 2001 *Distribution of mercury and other heavy metals in core sediments of the northern Adriatic Sea*, WASP 129 143-53 (6036). [Cr/Mn/Fe/Cu/Ni. High surface values due to Po River.]

F Frau C Ardau 2004 *Mineralogical controls on arsenic mobility in the Baccu Locci stream catchment (Sardinia, Italy) affected by past mining*, MM 68 15-30. [Arsenopyrite/ferrihydrite/scorodite.]

A Lombini E Dinelli C Ferrari A Simoni 1998 *Plant-soil relationships in the serpentinite screes of Mt. Prinzera (northern Apennines, Italy)*, J Geochem Expl 64 19-33.

P Mantovi G Bonazzi E Maestri N Marmiroli 2003 *Accumulation of copper and zinc from liquid manure in agricultural soils and crop plants*, PS 250 249-57 (8940). [No danger from repeated use of liquid slurry in N Italy.]

I Mascaro & 8 others 1999 *Environmental study of waste dumps at the Pb-Ag Bottino mine, Apuane Alps, Italy*, in ISBN 90-5809-073-6, p 203-6 (4286).

V Minganti & 6 others 2003 *Biomonitoring of trace metals by different species of lichens (Parmelia) in north-west Italy*, J Atmos Chem 45 219-29. [Cd/Cu/Mn/Pb/V/Zn.]

N Nosengo 2003 *Save our city*, N 424 608-9 (9207). [Will massive barriers protect Venice?]

B Palumbo A Bellanca R Neri MJ Roe 2001, *Trace metals partitioning in Fe-Mn nodules from Sicilian soils, Italy*, ChG 173 257-69 (5538).

G Protano F Riccobono 1997, *Antimony and arsenic contents in fresh waters and stream sediments of the Monti Romani area (southern Tuscany, Italy)*, MPA 40 213-26 = MA 99M/0311. [Highest levels from leaching of mine dumps, and from *stibnite*-mineralized carbonate rocks.]

Netherlands

DJ Huisman & 5 others 1997 *A geological interpretation of heavy metal concentrations in soils and sediments in the southern Netherlands*, J Geoch Expl 59 163-74 = MA 98M/3650. [Linear with Al. Anomalous enrichment from *glauconite* (As/Cr/Ni/Pb/Zn), *pyrite* (As) & Fe-oxides (As/Ba/Ni/Zn).]

H Middlekoop 2000 *Heavy-metal pollution of the river Rhine and Meuse floodplains in the Netherlands*, Netherlands J Geosci 79 411-28 (4657). [Highest levels in low-level areas: 30-130 mg/kg Cu, 170-1450 Zn & 70-490 Pb. During flood get highest deposition near levees.]

RSJ Tol A Langen 2000 *A concise history of Dutch river floods*, CIC 46 357-69 (6835).

Poland

J Falandysz & 4 others 2002 *Mercury in mushrooms and soil from the Wielunska Upland in south-central Poland*, JESH A37 140-20 (8060). [Details: highest Hg in Parasol & Horse mushrooms: ~4500 ng/g.]

M Jablonska & 2 others 2003 *Seasonal changes in the mineral compositions of tropospheric dust in the industrial region of Upper Silesia, Poland*, MM 67 1231-41.

C Kabala L Szerszen 2002 *Profile distributions of lead, zinc, and copper in Dystric Cambisols developed from granite and gneiss of the Sudetes Mountains, Poland*, WASP 138 307-17 (7741).

J Pempkowiak J Chiffolleau A Staniszewski 2000 *The vertical and horizontal distribution of selected trace metals in the Baltic Sea off Poland*, ECSS 51 115-25 (6821).

Romania

G Vogel 2003 *Unexpected riches from a fabled gold mine*, S 300 890-1 (8967). [Rosia Montana gold mine, Romania, has Roman archaeology. Should Gabriel Resources from Toronto be banned from cyanide treatment expected to destroy relics?]

Slovenia

H Biester M Gosar S Covelli 2000 *Mercury speciation in sediments affected by dumped mining residues in the drainage area of the Idrija mercury mine, Slovenia*, EST 34 3330-6 (6024).

I Falnoga M Tus'ek-Z'nidaric M Horvat P Stegnar 2000 *Mercury, selenium, and cadmium in human autopsy samples from Idrija residents and mercury mine workers*, ER A84 211-218 (4189).

A Gnamus' AR Byrne M Horvat 2000 *Mercury in the soil-plant-deer-predator food chain of a temperate forest in Slovenia*, EST 34 3337-45 (6046).

ME Hines & 9 others 2000 *Mercury biogeochemistry in the Idrija River, Slovenia, from above the mine into the Gulf of Trieste*, ER A83 129-39 (6049).

Spain

J Aguilar & 6 others 2004 *Remediation of Pb-contaminated soils in the Guadiamar River basin, (SW Spain)*, WASP 151 323-33 (10067).

M Leblanc & 3 others 2000 *4,500-year mining pollution in southwestern Spain: long-term implications for modern mining pollution*, EG 95 655-62.

MJ Martínez & 6 others 2001 *Distribution of the metals lead, cadmium, copper, and zinc in the top soil of Cartagena, Spain*, WASP 131 329-47 (5556).

N Moreno & 4 others 2001 *Utilization of zeolites synthesized from coal fly ash for the purification of acid mine waters*, EST 35 3526-34 (4556). [2 pilot plants in Spain. Na-P1 zeolite dominant. Tetsed on 3 mine wastes for reduction of heavy metals.]

S Moreno-Grau & 5 others 2000 *Particulate matter and heavy metals in the atmospheric aerosol from Cartagena, Spain*, AE 34 5161-7 (6817).

S Moreno-Grau & 7 others 2002 *Relationships between levels of lead, cadmium, zinc, and copper in soil and settleable particulate matter in Cartagena (Spain)*, WASP 137 365-83 (7752). [Roman Pb/Ag mines. 19th C industrialization. Details.]

A Navas J Machin 2002 *Spatial distribution of heavy metals and arsenic in soils of Aragon (northeast Spain): controlling factors and environmental implications*, AG 17 961-73 = MA 02M/3896. [Al/As/Ba/Cd/Co/Cr/Cu/Fe/Hg/Ni/Pb/Sn/Zn. Gypisol & calcisol on sediments have lowest; leptosol on metamorphic/igneous highest.]

R Prego A Gobelo-Garcia 2003 *Twentieth century overview of heavy metals in the Galician Rias (NW Iberian Peninsula)*, EnPo 121 425-52 (8637). [40% European seafood from these river estuaries. Need more data because of potential local enrichment of Co/Cr/Cu/Mn/Ni/Pb/Zn, but possibly OK for present.]

Sweden

MER Gustafsson EH Larsson 2000 *Spatial and temporal patterns of chlorine deposition in southern Sweden*, WASP 124 345-69 (6810).

A Loren & 3 others 2001 *Determination and distribution of diesel components in igneous rock surrounding underground diesel storage facilities in Sweden*, EST 35 374-8 (6820).

I Renberg MW Persson O Emteryd 1994 *Pre-industrial atmospheric lead contamination detected in Swedish lake sediments*, N 368 323-7 (5163). [At least as much from 600 BC to AD 1800 as from 1800 on.]

J Sternbeck Å Sjödin K Andréasson 2002 *Metal emissions from road traffic and the influence of resuspension – results from two tunnel studies*, AE 36 4735-44 (8227). [Gothenburg. Cu/Zn/Cd/Sb/Ba/Pb from wear rather than combustion. Particles resuspended.]

Switzerland

AP Aldrich D Kistler L Sigg 2002 *Speciation of Cu and Zn in drainage water from agricultural soils*, EST 36 4824-30 (8012). [Switzerland. Fungicides, fertilizers & feed additives cause up to 0.3 micromolar Cu & 0.26 Zn in drainage water during rain. However Cu is organically complexed & Zn is half complexed & half electrochemically labile, suggesting little bioavailability.]

M Chiaradia F Cupelin 2000 *Gas-to-particle conversion of mercury, arsenic and selenium through reactions with traffic-related compounds (Geneva). Indications from lead isotopes*, AE 34 327-32 (3332). [10/1996 – 9/1997. Gasoline, incinerated waste & coal (winter only). Pb/Cu (summer) & Cu/Zn (winter) correlate with Pb isotope of incinerator. Volatile Hg/As/Se correlate with traffic lead possibly because go from vapor to solid on particulates.]

HR von Gunten C Lienert 1993 *Decreased metal concentrations in ground waste caused by controls of phosphate emissions*, N 364 220-2 (4593). [12-year study of Glatt river, Switzerland shows reduction of Cd/Mn as P removed from detergent.]

Turkey

B Bayat 2002 *Combined removal of zinc (II) and cadmium (II) from aqueous solutions by adsorption onto high-calcium Turkish fly ash*, WASP 136 69-92 (772). [As good as activated C.]

M Çolak U Gemici G Tarkan 2003 *The effects of colemanite deposits on the arsenic concentrations of soil and ground water in Igdekoy-Emet, Kutahya, Turkey*, WASP 149 127-43 (9566). [Realgar & orpiment.]

L De Capitani D Basso S Lacerenza 2000 *Distribution of heavy metals in the sediments of Iskenderun Bay (Turkey)*, CEr 60 200-30 (4038). [Cr/Cu/ZnCd/Pb. Moderate pollution from urban & industrial sources.]

UK

MR Al-Agha SD Burley CD Curtis J Esson 1995 *Complex cementation textures and authigenic mineral assemblages from the Lincolnshire Wash (east coast, UK) driven by Fe(0) to Fe(III) oxidation*, JGSL 152 157-71 (1321).

WG Burgess L Pinto 2005 *Preliminary observations on the release of arsenic to groundwater in the presence of hydrocarbon contaminants in UK aquifers*, MM 69 887-96.

J Crowther D Kay MD Wyer 2002 *Faecal-indicator concentrations in water draining lowland pastoral catchments in the UK: relationships with land use and farming practices*, WR 36 1725-34 (7263).

M Doyle S Dorling 2002 *Visibility trends in the UK 1950-1997*, AE 36 3161-72 (7455).

C Hutton & 6 others 2005 *Aqueous and solid-state speciation of arsenic in Cornish soils*, MM 69 577-989.

DJ Large & 4 others 2001 *Petrographic observations of iron, copper, and zinc sulfides in freshwater canal sediment*, JSR 71 61-9 (4214). [Ashby canal, UK. Biofilms. Greigite to pyrite framboids. Chalcopyrite surface nucleants. Variable Zn/Fe sulfide.]

SV Lee AB Cundy 2001 *Heavy metal contamination and mixing processes in sediments from the Humber estuary, eastern England*, ECSS 53 619-36 (6124). [High Pb/Zn/Cu/Mn/Fe. Little intermixing. Cu/Pb/Zn peaked in mid-20th century. Details.]

A Milton JA Cooke MS Johnson 2004 *A comparison of cadmium in ecosystems on metalliferous mine tailings in Wales and*, WASP 153 157-72 (10198).

RJ Peart & 3 others 2003 *Eye in the sky*, Geoscientist 13(7) 4-7 (9120). ["High Resolution Airborne Geophysics can help locate and map environmental hazards in the UK."]

M Romero RD Rawlings JMA Rincón 2000 *Crystal nucleation and growth in glasses from inorganic wastes from urban incineration*, JNCS 271 106-18 (4055). [Birmingham UK. Crystals of akermanite, TiO & TiS₂.]

B Singh & 4 others 1999 *Mineralogy and chemistry of ochre sediments from an acid mine drainage near a disused mine in Cornwall, UK*, CIM 34 301-17 (6515). [?Goethite to ferrihydrite via algae.]

MA Sutton U Dragosits YS Tang D Fowler 2000 *Ammonia emissions form non-agricultural sources in the UK*, AE 34 855-869 (3186). [Complex & still uncertain.]

A Turner 2000 *Trace metals contamination in sediments from U.K. estuaries: An empirical evaluation of the role of hydrous iron and manganese oxides*, ECSS 50 355-71 (4087).

CD Vincent AJ Lawlor E Tipping 2001 *Accumulation of Al, Mn, Fe, Cu, Zn, Cd and Pb by the bryophyte Scapania undulata in three upland waters of different pH*, EnPo 114 93-100 (4021). [Lake District. Uptake greater with higher pH for 5.3/5.8/7.3. Plants/water: Fe highest/Al/Pb/Mn/Cu/Cd/Zn lowest. Details.]

N Woodcock 1994 *Geology and Environment in Britain*, UCL Press, 1-85728-05407. [Compact text.]

North America

Canada

P Adamo S Dudka MJ Wilson WJ Mchardy 2002 *Distribution of trace elements in soils from the Sudbury smelting area (Ontario, Canada)*, WASP 137 95-116 (7747). [Cu/Ni/Fe/Zn/Pb/Cr/Cd. Terrible desolation around smelters. Details of fallout and remobilization.]

LJJ Catalan KC Buset G Yin 2002 *Reactivity of oxidized sulfidic mine tailings during lime treatment*, EST 36 2766-71 (7397). [Kam Kotia mine, Timmins Ontario. K,Na,H-jarosites & schwertmannite go to Fe-OOH's (including goethite) & gypsum.]

H Coward AJ Weaver ed 2004 *Hard Choices. Climate Change in Canada*, QC981.8.C5.H37 (10670).

I Koch & 4 others 2000 *The predominance of inorganic arsenic species in plants from Yellowknife, Northwest Territories, Canada*, EST 34 22-6 (4156).

AD Paktunc NK Dave 2002 *Formation of secondary pyrite and carbonate minerals in the Lower Williams Lake tailings basin, Elliot Lake, Ontario, Canada*, AM 87 593-602. [U-milling.]

L Poissant M Amyot M Pilote D Lean 2000 *Mercury water-air exchange over the St Lawrence River and Lake Ontario*, EST 34 3069-78 (6081).

SR Walker & 4 others 2005 *The speciation of arsenic in iron oxides in mine wastes from the Giant gold mine, N.W.T.: Application of micro-XRD and micro-XANES at the grain scale*, CM 43 1205-24. [Maghemite/hematite.]

X Yan R Kerrich MJ Hendry 2000 *Distribution of arsenic(III), arsenic(V) and total inorganic arsenic in porewaters from a thick till and clay rich aquitard sequence, Saskatchewan, Canada*, GCA 62 2637-48 (4152).

Mexico

A Aragón Pin˘a & 3 others 2002 *Scanning and transmission electron microscope of suspended lead-rich particles in the air of San Luis Potosi, Mexico*, AE 36 5255-43 (8029). [Match Cu smelter.]

J Flores LA Albert 2004 *Environmental lead in Mexico, 1990-2002*, Rev Environ Contam Toxicol 181 37-109 (10197).

FG Lattore & 6 others 2003 *Relationship of blood and bone lead to menopause and bone mineral density among middle class women in Mexico City*, EHP 111 631-6 (8931). [Bone density did not match Pb. Pb released during menopause.]

LT Molina MJ Molina ed 2002 *Air Quality in the Mexico Megacity*, TD883.7.M62M682.

T Ogura & 6 others 2003 *Zacatecas (Mexico) companies extract Hg from surface soil contaminated by ancient mining industries*, WASP 148 167-77 (9409).

AA Pina & 4 others 2000 *Scanning electron microscope and statistical analysis of suspended heavy metal particles in San Luis Potosi, Mexico*, AE 34 4100-12 (6786). [As/Cd/Cu/Fe/Mn/Ni/Pb. Arsenolite/barite/bismuth/bornite/cassiterite/chalcocite/chalcopyrite/copper/covellite/galena / ilmenite/pyrite/pyrrhotite/sphalerite/smithsonite, etc.]

GB Raga T Castro D Baumgardner 2001 *The impact of megacity pollution on local climate and implications for the regional environment: Mexico City*, AE 35 1805-11 (6787).

CW Schmidt 2000 *Bordering on environmental disaster*, EHP 108 A309-15 (6788). [Border towns with USA.]

United States

RE Baumgardner & 3 others 2002 *Estimates of the atmospheric deposition of sulfur and nitrogen species: Clean Air Status and Trends Network, 1990-2000*, EST 36 2614-29 (7393).

EA Bestland GJ Retallack AE Rice A Mindszenty 1996 *Late Eocene detrital laterites in central Oregon: Mass balance geochemistry, depositional setting, and landscape evolution*, GSAB 108 285-302 (3196).

ME Brigham & 3 others 2002 *Methylmercury in flood-control impoundments and natural waters of northwestern Minnesota, 1997-9*, WASP 138 61-78 (7775). [Complex details, important for fish.]

D Carle 2004 *Introduction to Water in California*, TD224.C3C3723.

Central Great Lakes Mapping Coalition 1999 *Sustainable growth in America's heartland: 3D geologic maps as the foundation*, QE78.7.S87. [IL/IN/MI/OH. Free booklet covering geology & human use.]

JC Chambers JR Miller ed 2004 *Great Basin Riparian Ecosystems. Ecology, Management and Restoration*, QH104.5.G68.

RL Chan & 6 others 2002 *A winning pair. Reno hits the jackpot with its coupled biological phosphorus removal system*, WET June 43-6 (7374).

SN Chillrud & 9 others 1999 *Twentieth century atmospheric metal fluxes into Central Park Lake, New York City*, EST 33 657-63 (4677). [Pb/Zn/Sn in lake sediments shows very high deposition from late 1930s to early 1960s indicating that solid waste burning was major source of Pb not leaded gasoline.]

K Christen 2001b *Arsenic in old herbicides comes bsck to haunt Denver*, EST Sep 1 376-7A. [May be a crabgrass killer with 25% arsenic trioxide & 8% Pb arsenate. Complex details.]

K Christen 2002 *U.S. waters graded poorly*, EST Jul 1 266A (7470).

H Clausnitzer MJ Singer CA Davis 1999 *Mineralogy of agricultural source soil and respirable dust in California*, J Environ Qual 28 1619-29 (5558).

CM Cooper WB Gillespie Jr 2001 *Arsenic and mercury concentrations in major landscape components of an intensively cultivated watershed*, EnPo 111 67-74 (4046).

A Davis D Sherwin R Ditmars KA Hoenle 2001, *An analysis of soil arsenic records of decision*, EST 35 12 2401-6 (4097). [Data on 1986 EPA National Priority List.]

A Davis & 5 others 1996 *Mineralogic constraints on the bioavailability of arsenic in smelter-impacted soils*, EST 30 392-9 (D649). [Proposes that Anaconda MT contaminated soil and dust is hardly toxic because the As is bound into oxides and phosphates.]

J Dunn C Russell A Morrissey 1999 *Remediating historic mine sites in Colorado*, ME Aug 32-5 (6597). [2,000 Ag/Au/Pb/Zn mines affect Animas River 160 km downstream. Leadville/Climax mines affect Upper Arkansas. EPA & collaborators working on best plans.]

MA Engle MS Gustin H Zhang 2001 *Quantifying natural source mercury emissions from the Ivanhoe Mining District, north-central Nevada, USA*, AE 35 3987-97 (6035). [Lithology, soil concentration and distance to nearest fault are important.]

AR Flegal JO Nriagu S Niemeyer KH Coale 1989 *Isotopic tracers of lead contamination in the Great Lakes*, N 339 455-8 (5164). [64% Pb is industrial. Rapidly scavenged.]

NL Gale & 4 others 2002 *Lead concentrations in fish and river sediments in the Old Lead belt of Missouri*, EST 36 4262-8 (8151). [Mining stopped 1968, but tailings leak. Some sediment & bottom fish above WHO guideline; bass OK.]

W Galke & 8 others 2001 *Evaluation of the HUD lead hazard control grant program: early overall findings*, ER 86 149-56 (4301). [US Dept Health & Urban Development. Replacement of windows & old paint 2 to 4 fold lower.]

D Galloway DR Jones SE Ingerbritsen ed 1999 *Land subsidence in the United States*, US Geol Survey Circular 1182, QE600.3.U6.136 (6598).

PM Ganguli & 4 others 2000 *Mercury speciation in drainage from the New Idria mercury mine, California*, EST 34 4773-9 (6044).

PG Gerrard VL St Louis 2001 *The effects of experimental reservoir creation on the bioaccumulation of methylmercury and reproductive success of Tree Swallows (*Tachycineta bicolor*)*, EST 35 1329-38 (6045).

DJ Greeman & 4 others 1999 *Geochemistry of radium in soils of the eastern United States*, AG 14 365-85.

JW Gregg CG Jones TE Dawson 2003 *Urbanization effects on tree growth in the vicinity of New York City*, N 424 183-7 (9116). [City growth of cottonwood double rural because of lower ozone.]

JL Guentzel WM Landing GA Gill CD Pollman 2001 *Processes influencing rainfall deposition of mercury in Florida*, EST 35 863-73 (6047).

PL Gurian & 3 others 2001 *Addressing uncertainty and conflicting cost estimates in revising the arsenic MCL*, EST 35 4414-20 (3472). [Maximum Contaminant Level. Estimates of engineering costs for cutting from 50 microgram/liter to 10 pressured Bush admin to delay Clinton decision.]

KC Haering WL Daniels JM Galbraith 2004 *Appalachian mine soil morphology and properties: effects of weathering and mining method*, SSSAJ 68 1315-25 (10482).

P Hamilton 2000 *Fertile Research*, WET Feb 26-32 (4714). [Describes US Geological Survey's National Water Quality Assessment program. Insecticides higher in urban than agricultural areas. Patterns most obvious for basins. One-seventh of shallow groundwaters in agricultural & residential areas too high in nitrate. Time of year important. DDT & other early pesticides still dangerous. Etc.]

K Hayhoe & 18 others 2004 *Emissions pathways, climate change, and impacts on California*, PNAS 101 12422-7 (10667).

JC Hower RB Finkelman RF Rathbone J Goodman 2000 *Intra-and inter-unit variation in fly ash petrography and mercury adsorption: Examples from a western Kentucky power station*, EnF 14 212-6 (6052).

PF Hudak 2004 *Boron and selenium contamination in south Texas groundwater*, JESH A 39 2827-34 (10778).

D Izzo 2004 *Reengineering the Mississippi*, CEn Jul 39-119 (10465). [Delta shrinkage needs reversing.]

KL Jacobs SN Luoma KA Taylor 2003 *CALFED*, Env 45(1) 30-41 (9049). [Bay-Delta Program to help San Francisco Bay area.]

HE Jamieson & 5 others *The composition of coexisting jarosite-group minerals and water from the Richmond mine, Iron Mountain*, 2005 CM 43 1225-42.

S Jolicoeur P Ildefonse M Bouchard 2000 *Kaolinite and gibbsite weathering of biotite within saprolites and soils of central Virginia*, SSSAJ 64 1118-29 (3194). [Pseudomorphic. Topotaxy of halloysite after biotite. Details.]

WJ Kang JH Trefry TA Nelson HR Wanless 2000 *Direct atmospheric inputs versus runoff fluxes of mercury to the lower Everglades and Florida Bay*, EST 34 4058-63 (6057).

DI Kaplan AS Knox J Myers 2002 *Mercury geochemistry in wetland and its implications for in situ remediation*, JEE 128 723-32 (8062). [Savannah River, SC. Details.]

KA Katrinak JR Anderson PR Buseck 1995 *Individual particle types in the aerosol of Phoenix, Arizona*, EST 29 321-9 (9188).

M Kim J Nriagu S Haack 2002 *Arsenic species and chemistry in groundwater of southeast Michigan*, EnPo 120 379-90 (8161). [1 to 278 microg/l water, mean 29; 12% higher than standard of 50. Mostly As(III).]

T Kosatsky R Przybysz B Armstrong 2000 *Mercury exposure in Montrealers who eat St Lawrence river sportfish*, ER A84 36-43 (6059).

PE Kneebone PA O'Day N Jones JG Hering 2002, *Deposition and fate of arsenic in iron-and arsenic-enriched reservoir sediments*, EST 36 381-6 (5894). [Haiwee Reservoir, Olancho CA. Ferric chloride & cationic polymer added to manage As for Los Angeles water. XAS shows As(III) associated with Fe oxyhydroxide at depth with As(V) only in upper 2 cm.]

PE Kneebone JF Hering 2000, *Behavior of arsenic and other redox-sensitive elements in Crowley lake, CA: A reservoir in the Los Angeles aqueduct system*, EST 34 4307-12 (4138). [As in sediments appears sequestered by sulfides.]

F Kreith ed 1994 *Handbook of Solid State Management*, TD 791.K74 (4636). [Of >200 million tons of USA garbage only 30% recycled & composted. 70% into landfill, of which only 17% is burnt with energy recovery. 8% of greenhouse gases. 0.1 Megatons Pb from auto batteries. Dry batteries hard to recover. Etc.]

DE Kupel 2003 *Fuel for Growth. Water and Arizona's Urban Environment*, 0-8165-2169-7; review in S 300 1238-9 (9015).

R Lal & 3 others 2004 *Soil Degradation in the United States*, S624.A1S63 (10653).

MS Landis AF Vette GJ Keeler 2002 *Atmospheric mercury in the Lake Michigan basin: Influence of the Chicago/Gary urban area*, EST 36 4508-17 (8357). [Hg in rain twice & particulate 6-fold higher for C/G, & high concentration 19 km N of Gary. C/G emission affects entire basin.]

MS Landis GJ Keller 2002 *Atmospheric mercury deposition to Lake Michigan during the Lake Michigan Mass Balance Study*, EST 36 4518-24 (8356). [Atmospheric deposition 84% of 1400 kilogram total Hg. Chicago/Gary area contributes 127 kg.]

JR Larison GE Likens JW Fitzpatrick JG Crock 2000 *Cadmium toxicity among wildlife in the Colorado Rocky Mountains*, N 406 181-3 (4182).

X Lee G Benoit X Hu 2000 *Total gaseous mercury concentration and flux over a coastal saltmarsh vegetation in Connecticut, USA*, AE 34 4205-13 (6063).

X Lee OR Bullock Jr RJ Andres 2001 *Anthropogenic emission of mercury to the atmosphere in the northeast United States*, GRL 28 1231-4 (6064).

CM Lytle CZ McKinnon BN Smith 1994 *Manganese accumulation in roadside soil and plants*, Nw 81 509-10 (5548). [Utah. Gasoline MMT antiknock. Mn higher than Pb; toxic level in places.]

M Marvin-Dipasquale & 6 others 2000 *Methyl-mercury degradation pathways: A comparison among three mercury-impacted eco-systems*, EST 34 4908-16 (6072). [Everglades, FL; Carson River NV; San Carlos Creek CA. Microbial – complex details.]

YY Naumova & 14 others 2002 *Polycyclic aromatic hydrocarbons in the indoor and outdoor air of three cities in the US*, EST 36 2552-9 (7392). [Total PAHs nanogram/cubic meter: Los Angeles, outdoor 4-64, indoor 16-220; Houston, 10-160, 21-310; Elizabeth NJ 12-110, 22-350. Details for n-ring individual PAH.]

DL Nordstrom CN Alpers CJ Ptacek DW Blowes 2000 *Negative pH and extremely acidic mine waters from Iron Mountain, California*, EST 34 254-8 (4085).

DJ Novak DE Crane 2002 *Carbon storage and sequestration by urban trees in the USA*, EnPo 116 381-9 (6117). [700 million tons C total; 23 per year.]

JD Ostergren & 3others 1999 *Quantitative speciation of lead in selected mine tailings from Leadville, CO*, EST 33 1627-36 (4257). [Highly variable. Pb occurs in number of phases not amenable to classical techniques.]

SC Peters & 3 others 1998 *Arsenic occurrence in New Hampshire drinking water*, EST 33 1328-33 (8892). [992 random samples show <0.0003 to 180 microgram/liter As. Water from deep wells had higher As than shallow wells: hence most As from weathering of bedrock, with granite pegmatites highest.]

JL Pirkle & 5 others 1998 *Exposure of the U.S. population to lead, 1991-1994*, EHP 106 745-50 (4269). [890,000 children still have high Pb.]

MC Reheis JR Budahn PJ Lamothe 2002 *Geochemical evidence for diversity of dust sources in the southwestern United States*, GCA 66 1569-87 (7161). [Alluvium/playa/anthropogenic/volcanic contributions. Owens Valley yields dust 400 km east.]

J Rye S Gao RA Dahlgren RA Zierenberg 2002 *Arsenic distribution, speciation and solubility in shallow groundwater of Owens Dry Lake, California*, GCA 66 2981-4 (7978). [Dust carries toxic elements that cause health hazard. Details of arsenic (III) &(V).]

JWD Powell A Hunt JL Abraham 2002 *Anthropogenic vanadium-chromium-iron and cerium-lanthanum-iron particles in settled urban house dust: CCSEM identification and analysis*, WASP 135 207-17 (7074). [Syracuse, NY.]

R Reynolds & 4 others 2001, *Aeolian dust in Colorado plateau soils: Nutrient inputs and recent change in source*, PNAS 98 7123-7 (5524).

KR Rolffhus W F Fitzgerald 2001 *The evasion and spatial/temporal distribution of mercury species in Long Island Sound, CT-NY*, GCA 65 407-18 (5755).

MK Saiki BA Martin LD Thompson D Welsh 2001 *Copper, cadmium, and zinc concentrations in juvenile Chinook salmon and selected fish-forage organisms (aquatic insects) in the upper Sacramento river, California*, WASP 132 127-39 (4195).

KS Savage DK Bird 2000 *Legacy of the California gold rush: Environmental geochemistry of arsenic in the Southern Mother Lode gold district*, IGR 42 385-415 (4155). [Pyrite alters to goethite, jarosite & copiapite. Details of time of year.]

NV Sidenko & 3 others 2005 *Characterization of aluminum-rich phases in heap-leach pads at the Landusky gold mine, Montana, USA*, CM 43 1157-70. [Feldspar/illite/smectite.]

JB Stanley & 5 others 2002 *Mercury on the move during snowmelt in Vermont*, Eos 83 45-8 (5919).

D Strawn H Doner M Zavarin S McHugo 2002 *Microscale investigation into the geochemistry of arsenic, selenium, and iron in soil developed in pyritic shale materials*, Gd 108 235-57 (7657). [CA Coast Range. SXRF & XAS. Ferrihydrite, goethite, jarosite. As(V) in Fe-oxide. Se both (IV) & (VI), with most of latter in jarosite.]

JM Sweeten 2000 *Manure and wastewater management for cattle feedlots*, Rev Environ Contam Toxicol 167 121-53 (4661). [USA has 100 million cattle, 9% in feedlots. 18M tons/year of manure containing 0.4 N & 0.14 P. Details of management & controls; emphasis on composting, & reduction of ammonia & odors.]

D Turer JB Maynard J Sansalone 2001 *Heavy metal contamination in soils of urban highways: Comparison between runoff and soil concentrations at Cincinnati, Ohio*, WASP 132 293-314 (4095). [Cr/Cu/Ni/Pb/Zn.]

US Geological Survey Prof Paper 1648 *Geochemical landscapes of the conterminous United States – New map presentations for 22 elements* (7096). [As/Pb/Hg/Se/Zn, etc; related to bed rock and human activities.]

DA Van Ry & 5 others 2002 *Wet deposition of polychlorinated biphenyls in urban and background areas of the Mid-Atlantic States*, EST 36 3201-5 (7804). [New Jersey Atmospheric Deposition Network.]

AF Vette MS Landis GJ Keeler 2002 *Deposition and emission of gaseous mercury to and from Lake Michigan during the Lake Michigan Mass Balance Study (July, 1944 – October, 1995)*. EST 36 4525-32 (8355). [LM supersaturated with dissolved gaseous Hg, and releases to atmosphere.]

RD Walloch AA Kerr A Bachrach 2000 *Beach town cleanup*, CEn Dec 62-5 (4658). [Avila Beach CA. 80k cubic meter of soil contaminated with petroleum: removed, infrastructure demolished & rebuilt.]

RE Warner SL Etter LM David PC Mankin 2000 *Annual set-aside programs: a long-term perspective of habitat quality in Illinois and the Midwest*, Wildlife Society Bulletin 28 347-54 (6603). [Need to expand preservation of grass vs root crops.]

CJ Watras & 4 others 2000 *Decreasing mercury in Northern Wisconsin: temporal patterns in bulk precipitation and a precipitation-dominated lake*, EST 34 4051-5 (6107).

H Zhang SE Lindberg 2002 *Trends in dissolved gaseous mercury in the Tahquamenon River watershed and nearshore waters of Whitefish Bay in the Michigan Upper Peninsula*, WASP 133 379-89 (6711).

Y Zhang 2003 *100 years of Pb deposition and transport in soils in Champaign, Illinois, U.S.A.*, WASP 146 197-210 (9251). [Most Pb probably from residential coal burning. Half input lost in 50 years.]

South America

- J Archer & 4 others** 2005 *Aqueous exposure and uptake of arsenic by riverside communities affected by mining contamination in the Rio Pilcomayo basin, Bolivia*, MM 69 719-36.
- P Artaxo & 7 others** 2000 *Large scale mercury and trace element measurements in the Amazon basin*, AEI 34 4085-96 (6473). [Gold mining. Hg released by biomass burning.]
- C Bilos & 3 others** 2001 *Sources, distribution and variability of airborne trace metals in La Plata City area, Argentina*, EnPo 111 149-58 (6590). [Mg/Ca/Cr/Mn/Fe/Cu/Ni/Zn/Cd/Pb. Automobile exhaust important for Pb/Zn/Cd/Cu. Soil responsible for others.]
- DM Bonotto EG da Silveira** 2003 *Preference ratios for mercury and other chemical elements in the Madeira River, Brazil*, JSAmES 15 911-23 (9020).
- J Bussi & 3 others** 2002 *Photocatalytic removal of Hg from solid wastes of chlor-alkali plant*, JEE 128 733-9 (8063). [San Jose, Uruguay. Acid attack, UV in presence of Ti dioxide & citric acid precipitated 9% reduced Hg.]
- P Crompton & 5 others** 2002 *Assessment of mercury exposure and malaria in a Brazilian Amazon riverine community*, ER A90 69-75 (8253). [Alluvial Au mining releases hundreds of tons Hg/year. For Jacareacangs, hair contains 0.3 to 83 mean 9 microg/g with correlation to fish consumption & low income.]
- E da Silva Brabo & 4 others** 2000 *Mercury contamination of fish and exposures of an indigenous community in Pará State, Brazil*, ER A84 197-203 (6025).
- SMB de Oliveira & 5 others** 2001 *Soils as an important sink for mercury in the Amazon*, WASP 26 321-37 (6033).
- AP de Souza Lima & 6 others** 2000 *Mercury contamination in fish from Santarém, Pará, Brazil*, ERS 83 117-22 (6034).
- P Freyssinet AS Farah** 2000 *Geochemical mass balance and weathering rates of ultramafic schists in Amazonia*, CG 179 133-51 (6591). [Weathering rate: calcite >biotite >chlorite> serpentine>tacl. Profile deepens at 3 meter per million years.]
- SR Guevara & 4 others** 2002 *Heavy metal contamination in sediments of Lake Nahuel Huapi, Nahuel Huapi National Park, northern Patagonia, Argentina*, WASP 137 21-44 (7492). [Ag/As/Br/Co/Cr/Cs/Hg/RE/Sc.]
- S Hacon & 7 others** 2000 *Exposure to mercury in pregnant women from Alta Floresta - Amazon Basin, Brazil*, ER A84 204-10 (6048).
- J Lilienfein & 5 others** 2000 *Chemical fractionation of phosphorus, sulphur, and molybdenum in Brazilian savannah Oxisols under different land use*, Gd 96 31-46 (3173). [Nutrient-poor Oxisols have P strongly bonded to Fe oxides. Conventional-till & no-till maize-soybean; CT-sugarcane; degraded & productive pastures studied. 2 decades of land use made lower P, slightly lower S and no change in Mo.]
- W Machado & 3 others** 2002 *Mercury, zinc, and copper accumulation in mangrove sediments surrounding a large landfill in southeast Brazil*, EnPo 120 455-61 (8162).
- VF Magalhães CEV Carvalho WC Pfeiffer** 2001 *Arsenic contamination and dispersion in the Engelho inlet, Sepefiba Bay, SE Brazil*, WASP 129 83-90 (4104). [Metallurgical plant & As transport to fishing area may be dangerous.]
- D Markewitz & 4 others** 2001 *Control of cation concentrations in stream waters by surface soil processes in an Amazonian watershed*, N 410 802-5 (5531).
- J Matschullat & 5 others** 2000 *Human and environmental contamination in the Iron Quadrangle, Brazil*, AG 15 181-90 (6479). [High As from Au mining.]
- CC Muggler JJ Van Loef P Buurman JDJ van Doesburg** 2001 *Mineralogical and (sub)microscopic aspects of iron oxides in polygenic Oxisols from Minas Gerais, Brazil*, Gd 100
- S Richard & 4 others** 2000 *Mercury levels of soils, sediments and fish in French Guiana, South America*, WASP 124 221-44 (6085).
- M Roulet JD Guimarães M Lucotte** 2001 *Methylmercury production and accumulation in sediments and soils of an Amazonian floodplain - effect of seasonal inundation*, WASP 128 41-60 (6087).

M Roulet & 7 others 2000 *Increase in mercury contamination recorded in lacustrine sediments following deforestation in the Central Amazon*, CG 165 243-66 (6088).

ECO Santoz & 11 others 2002 *A contribution to the establishment of reference values for total mercury levels in hair and fish in Amazonia*, ERA 90 6-11 (8159). [4 communities: no gold mining, high fish consumption; 4-9 ppm hair, .006-2.53 carnivore fish, .008-.87 non-carnivore.]

C Warren WG Burgess MG Garcia 2005 *Hydrochemical associations and depth profiles of arsenic and fluoride in Quaternary loess aquifers of northern Argentina*, MM 69 877-86.

Metals and waste

This section covers toxic metals and waste. See alphabetical section for specific localities.

LW Chang ed 1996 *Toxicology of Metals*, RA1231.M52.

D Pakune RF Martin 2000 *Metals in the environment and mine wastes*, CM 2005 43 1129-30. [Introduction to theme issue with 9 papers.]

Ammonia & ammonium

High concentrations of ammonium in drinking water are dangerous for human health, particularly for babies.

A Hedstruem 2001 *Ion exchange of ammonium in zeolite: A literature review*, JEE Aug 673-81 (2970). [For waste water treatment.]

C Liu KV Lo 2001 *Ammonia removal from compost leachate using zeolite. II. A study using continuous flow packed columns*, JESH B36 667-75 (3651).

Antimony (Sb)

N Belzile Y Chen Z Wang 2001 *Oxidation of antimony (III) by amorphous iron and manganese oxyhydroxides*, CG 174 379-87 (4366).

M Filella N Belzile Y Chen 2002 *Antimony in the environment: a review focused on natural waters I. Occurrence, II. Relevant solution chemistry*, ESR 57 125-76 & 59 265-85 (7764, 8386). [420 papers reviewed. Sb(V) when oxic, rare Sb(III). Many details.]

AG Leyva J Marrero P Smichowski D Cicerone 2001 *Sorption of antimony onto hydroxyapatite*, EST 35 3669-75 (4364).

Arsenic

<http://www.arsenic.org>

Arsenic was well known as a poison administered to the victim in mystery novels, and in the past two decades has become recognized as a medical problem for a considerable fraction of the human population, leading towards cancer of the bladder, liver & skin. Arsenic occurs in volcanic rocks and becomes concentrated into certain sediments. Most groundwater in volcanic areas has slightly more than the recommended safe value of a few parts per million. In some regions the groundwater contains very high levels of As. As occurs as As(0), (III) and (V): metal, arsenite and arsenate. In principle, As can be removed from water by determining the valence state and using the appropriate selective adsorbent. In practice, a simple cheap system has not yet been commercialized routinely. Oxidation of any As(III) to As(V) followed by coagulation on Fe(III) chloride/sulfate/alum looks promising.

The special issue of *Elements* 2006 2-2 on Arsenic provides an excellent introduction to the research in this area, and reading it should be mandatory for all scientists and public administrators. It covers: chemistry and mineralogy; microbial transformations; As in groundwater of southern Asia; As in soils, mine tailings & former industrial sites; As in drinking water & impact on health.

See above localities for many references to As.

Special issue on arsenic: *Environmental and Health Aspects with Special Reference to Groundwater in South Asia*: JESH A38 1-306 (9598). [18 articles, on Bangladesh, West Bengal, Nepal, Taiwan, Thailand & Australia.]

<http://co.water.usgs.gov/trace/arsenic/> covers As in ground water of USA.

National Academy Press 1977 *Arsenic: Medical and Biological Effects of Environmental Pollutants*. 1999 *Arsenic in Drinking Water*, 0-309-06333-7.

National Resources Defense Council 2000 *A Scientific and Public Health Analysis of Arsenic Occurrences in Drinking Water, its Health Effects, and EPA's Outdated Arsenic Tap Water Standard*.

WT Frankenberger Jr ed 2001 *Environmental Chemistry of Arsenic*, Marcel Dekker, 0-8247-0676-5. [16 articles; history of As poisoning to chemistry, bacterial oxidation & volatilization.]

AH Welch KG Stollenwerk ed 2003 *Arsenic in Groundwater. Geochemistry and Occurrence*, TD427.A77.A75 (9125). [15 chapters on many important toxic sites around World.]

A Meharg 2005 *A Venomous Earth. How Arsenic caused the World's Worst Mass Poisoning*, Macmillan.

[Popular account.]

K Farzana & 3 others 2005 *Arsenic speciation and toxicity in biological systems*, Rev Environ Contam Toxicol 184 97-149.

MDJ Abedin & 4 others 2002 *Arsenic accumulation and metabolism in rice (Oryza sativa L.)* EST 36 962-8 (6619).

CAJ Appelo MJJ Van der Weiden C Tournassat I Charlet 2002 *Surface complexation of ferrous iron and carbonate on ferrihydrite and the mobilization of arsenic*, EST 36 3096-103 (7638). [Carbonate reduces sorption of As on ferrihydrite. In Bangladesh, high-As sediments release As to water when exposed to high-carbonate water.]

J Bates A Hanson F Cadena B Thompson M Johnson D Heil A Bristol 1998 *Technologies for the removal of arsenic from drinking water in New Mexico*, New Mexico J Science 38 333-47 (4157). [Difficult because high sulfate is bad for ion exchange.]

AJ Bednar JR Garbarino JF Ranville TR Wildeman 2002 *Preserving the distribution of inorganic arsenic species in groundwater and acid mine drainage samples*, EST 36 2213-8 (7232). [EDTA works best.]

D Bhattacharyya & 3 others 2004 *Arsenic-polluted groundwater in West Bengal: A cost-effective remedy*, CuS 86 1206 (10283). [Use clay-candle filter to remove As adsorbed on Fe(III) O(OH).]

T Bianchelli ed 2003 *Arsenic Removal from Drinking Water*, TD427.A77.A767. [3 chapters covering EPA regulations; removal by ion exchange & activated alumina; regulations on disposal of As residuals.]

BC Bostick S Fendorf GE Brown Jr 2005 *In situ analysis of thioarsenite complexes in neutral to alkaline arsenic sulphide solutions*, MM 69 781-95.

J Calderón & 7 others 2001, *Exposure to arsenic and lead and neurophysical development in Mexican children*, ER A 85 69-76 (4128). [As & chronic malnutrition.]

L Carlson & 4 others 2002 *Scavenging of As from acid mine drainage by schwertmannite and ferrihydrite: A comparison with synthetic analogues*, EST 36 1712-9 (7078). [Many details of degradation of sch. & fer. by arsenate sorption perhaps as FeOHAs surface phase.]

WR Chappell & 3 others ed 2002 *Arsenic Exposure and Health Effects V*, RA1231.A7I56 (10301). [Proceedings of 5th international conference with 50 contributions covering India, Nepal, NWT Canada, Bangladesh, Fox River Valley WI, Vietnam, Chile; epidemiology; biomarkers and animal models; mode of action; intervention & medical treatment; water treatment & remediation; USA EPA & NIEHS programs.]

ASC Chen KA Fields TJ Sorg L Wang 2002 *Field evaluation of As removal by conventional means*, AWWAJ Sep 64-8 (7955). [2 coagulation-filtration plants got As below 10 microgram/liter; Fe-removal & lime-softening did not.]

CY Chen CL Folt 2000 *Bioaccumulation and diminution of arsenic and lead in a freshwater food web*, EST 34 3878-84 (4145). [Despite high levels of As in zooplankton, As in fish low.]

K Christen 2001a *The arsenic threat worsens*, EST Jul 1 286-292 (4099). ["In Vietnam & other developing countries, As contamination of groundwaters is becoming the key environmental health problem of the 21st century."]

VST Ciminelli PG Weidler AY Ramos 2003 *Arsenic sorption onto soils enriched in Mn and Fe minerals*, CICIM 51 197-204.

S Cornu & 3 others 2003 *The influence of pH, electrolyte type, and surface coating on arsenic(V) adsorption onto kaolinites*, SSSAJ 67 1127-32 (9153).

A Coutin-Nomade & 3 others 2003 *Arsenic in iron cements developed within tailings of a former metalliferous mine – Enguialès, Aveyron, France*, AG 18 395-408. [Amorphous material 17% wt % As goes to jarosite with <6 wt % & scorodite/goethite/hematite to release of As.]

L Dambies T Vincent E Guibal 2002 *Treatment of arsenic-containing solutions using chitosan derivatives: uptake mechanisms and sorption performances*, WR 36 3699-710 (8061). [OK for As(V) in acid solution, but poor for As(III) in alkaline.]

CC Davis WB Knocke M Edwards 2001 *Implications of aqueous silica sorption to iron hydroxide: Mobilization of iron colloids and interference with sorption of arsenate and humic substances*, EST 35 15 3158-62 (4167).

V Devesa & 5 others 2001a, *Kinetic study of transformations of arsenic species during heat treatment*, JAFC 49 2267-71 (4820).

V Devesa & 5 others 2001b, *Effect of cooking temperatures on chemical changes in species of organic arsenic in seafood*, JAFC 49 2272-6 (4821).

BE Erickson 2003 *Field kits to provide accurate measure of arsenic in groundwater*, EST 35A (8668). [Describes report by **Chakraborti** 2002 EST 5365-94 that test kits give 50% warning on good water, and 7% miss on bad water.]

ML Farquhar JM Charnock FR Livens DJ Vaughan 2002 *Mechanisms of arsenic uptake from aqueous solution by interaction with goethite, lepidocrocite, mackinawite, and pyrite: An X-ray absorption spectroscopy study*, EST 36 1757-62 (7080). [EXAFS & XANES show surface complexes with As(V) bonded to 4 O. Details.]

J Farrell J Wang P O'Day M Conklin 2001 *Electrochemical and spectroscopic study of arsenate removal from water using zero-valent iron media*, EST 35 2026-32 (4096).

RG Ford 2002 *Rates of hydrous ferric oxide crystallization and the influence of coprecipitated arsenate*, EST 36 2459-63 (7334). [Made hematite & goethite at 313 K & pH 6. Details.]

AL Foster GE Brown Jr TN Tingle GA Parks 1998 *Quantitative arsenic speciation in mine tailings using X-ray absorption spectroscopy*, AM 83 553-68. [As(V) more toxic than (III). Data for Ruth, Argonaut & Spenceville mines in CA. Important details.]

DL Gallup 2002 *Removing arsenic from the water*, C&EN Jan 28 9 (4363). [Recommends coprecipitation with ferric hydroxide. Fix in cement.]

S Gao & 3 others 2004 *Evaluation of adsorbed arsenic and potential contribution to shallow groundwater in Tulare Lake bed area, Tulare Basin, California*, SSSAJ 68 89-95 (9796).

A Garcia-Sanchez E Alvarez-Ayuso F Rodriguez-Martin 2002 *Sorption of As(V) by some oxyhydroxides and clay minerals. Application to its immobilization in two polluted mining soils*, CIM 37 187-94 (6986). [Best with synthetic Al(OH)₃ & FeOOH.]

TW Gebel 1999 *Arsenic & drinking water contamination*, S 283 148-9 (4108). [Should check for synergy between As & Sb.]

AE Geiszinger W Goessler KA Francesconi 2002 *Biotransformation of arsenate to the tetramethylarsonium ion in the marine Polychaetes Nereis diversicolor and Nereis virens*, EST 36 2905-10 (7475). [Details of organic compounds in marine animals, including methyl complexes & arsenosugars.]

TM Gihring GK Druschel RB McClesky RJ Hamers JF Banfield 2001 *Rapid arsenite oxidation by Thermus aquaticus and Thermus thermophilus: Field and laboratory investigations*, EST 35 19 3857-62 (3140).

S Goldberg 2002 *Competitive adsorption of arsenate and arsenite on oxides and clay minerals*, SSSAJ 66 413-21 (6625).

S Goldberg CT Johnston 2001 *Mechanisms of arsenic adsorption on amorphous oxides evaluated using macroscopic measurements, vibrational spectroscopy, and surface complexation modeling*, JCIS 234 204-16 (4130). [Al & Fe amorphous oxides.]

J Gregor 2001 *Arsenic removal during conventional aluminium-based drinking water treatment*, WR 35 1659-64 (4125).

H Guo 2002 *Cancer risk assessment for arsenic exposure through oyster consumption*, EHP 110 123-4 (7632). [Taiwan. Exaggerated newspaper report.]

FX Han & 5 others 2003 *Assessment of global industrial-age anthropogenic arsenic contamination*, Nw 90 395-401 (9568). [In 2000, total World production = 4.5 M tonnes with mining>coal>petroleum = 1.2 x in lithosphere. Suggests using substitutes in agriculture & forestry, & control emission from coal.]

JA Hingston CD Collins RJ Murphy JN Lester 2001 *Leaching of chromated copper arsenate wood preservatives: a review*, EnPo 111 53-66 (4140). [Insufficient data to estimate leaching rate.]

C Hogue 2001 *Arsenic debate: It's all about cost*, CEN Oct 15 20-1 (4169).

SJ Hug & 4 others 2001 *Solar oxidation and removal of arsenic at circumneutral pH in iron containing waters*, EST 3514-21 (4121). [Citrate or lemon juice caused Fe/As precipitation removing 45-78% As in field trials in Bangladesh.]

FE Huggins & 5 others 2002 *Combined application of XAFS spectroscopy and sequential leaching for determination of arsenic speciation in coal*, EnF 16 1167-72 (8042). [2 major types: arsenate leached by HCl, & organic arsenite, & As for S in pyrite, leached by nitric acid. Details.]

FS Islam & 6 others 2004 *Role of metal-reducing bacteria in arsenic release from Bengal delta sediments*, N 430 68-71 (10414).

PM Jayaweera PI Godakumbura KAS Pathiratne 2003 *Photocatalytic oxidation of As(III) to As(V) in aqueous solutions: A low cost re-oxidative treatment for total removal of arsenic from water*, CuS 84 541-4. [TiO₂ photocatalyst.]

F Juillot P Ildefonse G Morin G Calas AM de Kersabiec M Benedetti 1999 *Remobilization of arsenic from buried wastes at an industrial site: mineralogical and geochemical control*, AG 14 1031-48. [Runoff water pH 7.9 becomes acidic 2.2 by reaction with As-sulfides and reacts with limestone substratum to give Ca & Ca-Mg arsenates leaving water fit for human drinking.]

J Kim & 3 others 2003 *A novel ion exchange process for As removal*, AWWAJ 95(3) 77-85 (8937). [Only sulfate-rich resin in column needs regeneration.]

MF Kirk & 6 others 2004 *Bacterial sulfate reduction limits natural arsenic contamination in groundwater*, G 32 953-6 (10806).

L Kuai AA Nair MF Polz 2001 *Rapid and simple method for the most-probable-number estimation of arsenic-reducing bacteria*, AEM 67 3168-73 (4106).

ACQ Ladeira & 4 others 2001 *Mechanisms of anion retention from EXAFS and density functional calculations: Arsenic (V) adsorbed on gibbsite*, GCA 65 1211-7 (4124).

MJ La Force CM Hansel S Fendorf 2000 *Arsenic speciation, seasonal transformations and co-distribution with iron in a mine waste-influenced Palustrine emergent wetland*, EST 34 3937-43 (4144).

DC Lampkin BJ Alloway 2003 *Arsenate-induced phosphate release from soils and its effect on plant phosphorus*, WASP 144 41-56. [Experiments to test addition of As-contaminated irrigation water. P released as As added up to limit. So plant P availability OK at low As but not at high As.]

HW Langner CR Jackson TR McDermott WP Inskeep 2001 *Rapid oxidation of arsenite in a hot spring ecosystem, Yellowstone National Park*, EST 35 3302-9 (4101).

HW Langner WP Inskeep 2000 *Microbial reduction of arsenate in the presence of ferrihydrite*, EST 34 3131-6 (4151).

T Lasky & 3 others 2004 *Total arsenic concentrations in chicken 1989-2000 and estimated exposures for consumers of chicken*, EHP 112 18-21 (10104).

XC Le & 5 others 2000, *Speciation of key arsenic metabolic intermediates in human urine*, AnC 72 5172-77 (4133). [Methylation pathway.]

E Lombi RS Sletten WW Wenzel 2000, *Sequentially extracted arsenic from different size fractions of contaminated soil*, WASP 124 319-32 (4664). [5 soils in Austria. Ammonium oxalate extracted best. Most As associated with Fe.]

LQ Ma 5 others 2001 *A fern that hyperaccumulates arsenic*, N 409 579. [*Pteris vittata*. Central Florida site contaminated with chromated copper arsenate. Up to 7500 ppm in fronds.]

RE Macur JT Wheeler TR McDermott WP Inskeep 2001 *Microbial populations associated with the reduction and enhanced mobilization of arsenic in mine tailings*, EST 35 3676-82 (4172). [As(III) dominates oxic systems. Liming and algae convert (V) into (III).]

S Mahimairaja & 3 others 2005 *Arsenic contamination and its risk management in complex environmental settings*, Adv Agronomy 86 1-65.

A Manceau 1995 *The mechanism of anion adsorption on iron oxides: Evidence for the bonding of arsenate tetrahedra on free Fe(O,OH) edges*, GCA 59 3647-53. [Polemic with Waychunas.]

BA Manning SE Fendorf B Bostick DL Suarez 2002 *Arsenic (III) oxidation and arsenic (V) adsorption reactions on synthetic birnessite*, EST 36 976-81 (6620).

AA Meharg MM Rahman 2003 *Arsenic contamination of Bangladesh paddy field soils: Implications for rice contribution to arsenic consumption*, EST 37 229-34 (8835). [US/Europe rice 0.05 ppmw; Bangladesh soils up to 46 with rice up to 2.]

AA Meharg 2004 *Arsenic in rice – understanding a new disaster for South-East Asia*, Trends in Plant Science 3 1360-85 (10906).

N Melitas M Conklin J Farrell 2002 *Electrochemical study of arsenate and water reduction on iron media used for arsenic removal from potable water*, EST 36 3188-93 (7642). [Iron metal corrosion will not reduce As(V) to (III) in filters relevant to potable water treatment.]

X Meng GP Korfiatis C Christodoulatos S Bang 2001a *Treatment of arsenic in Bangladesh well water using a household co-precipitation and filtration system*, WR 35 2805-10 (4107). [Cocprecipitation with ferric hydroxide & hypochlorite salts reduced As from ~ 300 to < 50 µg/liter.]

do 2001b *Redox transformations of arsenic and iron in water treatment sludge during aging and TCLP extraction*, EST 35 3476-81 (4102). [Complex: 3 redox zones.]

KN Morales & 4 others 2000 *Risk of internal cancers from arsenic in drinking water*, EHP 108 655-61 (4136). [Recommends lowering As below 50 microgram/liter.]

JA Muñoz A Gonzalo M Valiente 2002 *Arsenic adsorption by Fe(III)-loaded open-celled cellulose sponge. Thermodynamic and selectivity aspects*, EST 36 3405-11 (7804). [Details of use of commercial sponge.]

O Muñoz & 7 others 2000 *Total and inorganic arsenic in fresh and processed fish products*, JAF 48 4369-76 (4142). [Inorganic As worse than organic. Data for Spain.]

HW Nesbitt IJ Muir 1998 *Oxidation sites and speciation of secondary products on pyrite and arsenopyrite reacted with mine waste waters and air*, MP 62 123-44. [Many details.]

A Niggemyer S Spring E Stackebrandt RF Rosenzweig 2001 *Isolation and characterization of a novel As(V)-reducing bacterium: Implications for arsenic mobilization and the Genus Desulfotobacterium*, AEM 67 5568-80 (4171).

DK Nordstrom 2002 *Worldwide occurrences of arsenic in ground water*, S 296 2143-6 (7400). [Half the world does not have adequate sanitation & one-quarter clean drinking water. 40 million people may be exposed to high-As ground water, particularly in Bengal. Sources are: black shales, some alluvial sediments, mine waste, volcanoes & some thermal springs. Closed basins & strong-reducing aquifers. Oxidation of As-pyrite & arsenopyrite. Highest US level at Fairbanks Alaska.]

PA O'Day & 3 others 2004 *The influence of sulfur and iron on dissolved arsenic concentrations in the shallow subsurface under changing redox conditions*, PNAS 101 13703-8 (10705). [Realgar.]

RS Oremland & 9 others 2000 *Bacterial dissimilatory reduction of arsenate and sulfate in meromictic Mono Lake, California*, GCA 64 3073-84 (4146).

RS Oremland & 6 others 2005 *A microbial arsenic cycle in a salt-saturated extreme environment*, S 308 1305-8 (11040). [Searles Lake CA. As(V) to As (III). Inorganic electronic donor]

C Pascua & 5 others 2005 *Arsenic-bearing smectites from the geochemical environment*, MM 69 897-906. [First report of As(III) in Japan smectite.]

T Pichler J Veizer GEM Hall 1999 *Natural input of arsenic into a coral-reef ecosystem by hydrothermal fluids and its removal by Fe(III) oxyhydroxides*, EST 33 1373-8 (4112).

T Pichler & 8 others 2006 *A natural laboratory to study arsenic geochemistry*, Eos 87 221 & 225. [Submarine shallow-water hydrothermal vents at Tutum Bay, Ambitle Island, Papua New Guinea release 1.5 kg As per day.]

DA Polya & 13 others 2005 *Arsenic hazard in shallow Cambodian groundwaters*, MM 69 807 - 23.

MM Rahman & 10 others 2002 *Effectiveness and reliability of arsenic field testing kits: Are the million dollar screening projects effective or not?* EST 36 5385-94 (8531). [~half tests are wrong.]

AD Redman DL Macalady D Ahmann 2002 *Natural organic matter affects arsenic speciation and sorption onto hematite*, EST 36 2889-96 (7473). [NOM affects arsenite desorption more than arsenate perhaps explaining greater mobility of arsenite.]

M Reisch 2002, *Getting arsenic out of wood*, CEN Feb 11 9 (6228). [Business problems in replacing chromated copper arsenate with recycled plastic or Cu-B-azole or ammoniacal copper quat.]

KC Rice KM Conko GM Hornberger 2002 *Anthropogenic sources of arsenic and copper to sediments in a suburban lake, northern Virginia*, EST 36 4962-7 (8461). [Leach from Chromate-Copper-Arsenate-treated lumber As 50% Cu 4); streamwater 50 90; atmosphere 1 3. Lake retained 70 As 20.]

EA Rochette GC Li SE Fendorf 1998 *Stability of arsenate minerals in soil under biotically generated reducing conditions*, SSSAJ 62 1530-7 (4116). [18 arsenate minerals including scorodite, caryinite & berzeliite.]

EA Rochette BC Bostick G Li S Fendorf 2000 *Kinetics of arsenate reduction by dissolved sulfide*, EST 34 4714-20 (4132).

AM Rouhi 2001 *Wrestling with the plagues of wood*, CEN 56-7 (4914). [4/5ths of wood in USA is treated with chromated copper arsenate which gives green color. Is it dangerous? Details.]

P Roy A Saha 2002 *Metabolism and toxicity of arsenic: A human carcinogen*, CuS 82 38 (5963).

DA Rubinos & 3 others 2005 *Speciation of adsorbed arsenic (V) on red mud using a sequential extraction procedure*, MM 69 5921-600.

JM Ruiz L Romero 2002 *First evidence of arsenic phytoremediation*, TiPS 7 384 (7981). [Canola with transgenic ACC-deaminase.]

PB Ryan N Huet DL Macintosh 2000 *Longitudinal investigation of exposure to arsenic, cadmium and lead in drinking water*, EHP 108 731-35 (4129). [Maryland.]

MJ Scott JJ Morgan 1995 *Reactions at oxide surfaces. I. Oxidation of As(III) by synthetic birnessite*, EST 29 1898-905 (S1873). [pH 4, As(III) depleted from solution in minutes. No effect from oxygen. Hence, oxidation of As(III) to As(V) occurs at surface of synthetic birnessite.]

DB Senn HF Hemond 2002 *Nitrate controls on iron and arsenic in an urban lake*, S 296 2373-6 (7619). [Upper Mystic Lake, MA. Oxidizes Fe(II) to (III) whose oxyhydroxides sorb As.]

M Sever 2005 *Needling out the arsenic epidemic*, Gt May 36-7 (11043). [Testing water with a needle before drilling well.]

JM Sharples AA Meharg SM Chambers JWG Cairney 2000 *Symbiotic solution to arsenic contamination*, N 404 951-2 (4161). [Plant/fungus.]

DM Sherman SR Randall 2003 *Surface complexation of arsenic(V) to iron(III) (hydr)oxides: Structural mechanism from ab initio geometries and EXAFS spectroscopy*, GCA 67 4223-30. [Ferrihydrite, goethite, hematite.]

S Simpson 2002 *Coal control*, SA Feb 20-22 (3982). [As & F in Chinese coal cause skin freckling & carcinoma & fluorosis. Program to map As in mines and to develop field test kit.]

PL Smedley DG Kinniburgh 2002 *A review of the source, behaviour and distribution of arsenic in natural waters*, AG 17 517-68.

AH Smith PA Lopipero MN Bates CM Steinmaus 2002 *Arsenic epidemiology and drinking water standards*, S 296 2145-6 (7400). [50 microgram/liter gives maximum contaminant level of ~1500 per 100,000 = 1.5%. History of moving US standard from 50 to 10.]

SD Smith M Edwards 2002 *Bench-scale evaluation of innovative arsenic-removal processes*, AWWAJ Sep 78-86 (7956). [Currently coagulation/microfiltration is best now, microsand-ballasted coagulation is promising.]

IR Sneddon H Garelick E Valsami 2005 *An investigation into arsenic (V) removal from aqueous solutions by hydroxylapatite and bone-char*, MM 69 769-80. [Bone-char is excellent adsorbent.]

C Su RW Puls 2001a,b *Arsenate and arsenite removal by zerovalent iron: Kinetics, redox transformation, and implications for in situ groundwater remediation*, EST 35 1487-92 (4123); *Effects of phosphate, silicate, carbonate, borate, sulfate, chromate, molybdate, and nitrate, relative of chloride*, 4562-8 (3473). [Details.]

MA Súñer & 7 others 2002 *Organoarsenical species contents in fresh and processed seafood products*, JAgFC 50 924-32 (5941).

OS Thirunavukkarasu T Viraraghavan KS Subramanian 2003 *Arsenic removal from drinking water using iron oxide coated sand*, WASP 142 95-111 (9783). [As(V)&(III) < 5 microgram/liter.]

S Utsunomiya & 3 others 2003 *Nanoscale mineralogy of arsenic in a region of New Hampshire with elevated As-concentrations in the groundwater*, AM 88 1844-52. [Arsenopyrite to magnetite & westerveldite.]

M Vahter 1999 *Methylation of inorganic arsenic in different mammalian species and population groups*, Science Progress 82 69-88 (4115). [Complex variation.]

CA Waltham MJ Eick 2002 *Kinetics of arsenic adsorption on goethite in the presence of sorbed silicic acid*, SSSAJ 66 818-25 (7127). [Complexity of halving arsenite adsorption on goethite.]

AH Welch KG Stollenwerk ed 2003 *Arsenic in Groundwater. Geochemistry and Occurrence*, TD427.A77.A75 (9125). [15 chapters on many important toxic sites around World.]

J Yang & 4 others 2002 *Adsorption, sequestration, and bioaccessibility of As(V) in soils*, EST 36 4562-9 (8354). [Lower pH & higher Fe oxide reduces bioaccessibility.]

T Yuan JY Hu SL Ong QF Luo WJ Ng 2002 *Arsenic removal from household drinking water by adsorption*, JESH A37 1721-36 (8217). [Fe-oxide coated sand removed >94% As(III,V) when pH adjusted. Details.]

T Yuan & 4 others 2003 *A study of arsenic removal from household drinking water*, JESH A38 1731-44 (9213). [Kaolinite & powder activated C did not enhance As removal by Fe or Al sulfate.]

J Zobrist PR Dowdle JA Davis RS Oremland 2000 *Mobilization of arsenite by dissimilatory reduction of adsorbed arsenate*, EST 34 4747-53 (4131).

Beryllium

Be is very dangerous if ingested. Most people are probably only exposed to low concentrations from coal-fired power plants. Industrial workers in nuclear sites in particular should be careful.

ES Grew ed 2003 *Beryllium. Mineralogy, Petrology, and Geochemistry*, RMG 50.

JM Kaste SA Norton CT Hess 2002 *Environmental chemistry of beryllium-7*, RMG 50 271-90.

TP Taylor & 5 others 2003 *Beryllium in the environment: A review*, JESH A38 439-69 (8769). [Little information on the dangers from this very toxic element.]

JT Vesely & 6 others 2002 *Environmental chemistry of beryllium*, RMG 50 291-318.

Cadmium

Cadmium is dangerous at a few places, principally from industrial activity such as processing of electrical batteries. Cd occurs in coal, and in phosphate fertilizer, and may be building up in soil. Details are complex.

AT Abdallah MA Moutstafa 2002 *Accumulation of lead and cadmium in the marine prosobranch Nerita saxtilis, chemical analysis, light and electron microscopy*, EnPo 116 185-91 (6121).

MK Andersen & 4 others 2002 *Content, distribution, and solubility of cadmium in arable and forest soils*, SSSAJ 66 1829-35 (8036). [11 pairs arable & forest soils in Denmark. "afforestation may lead to higher soil solution concentrations of Cd as decreasing pH and effective cation-exchange capacity diminish Cd retention & reduces Cd concentration in the forest topsoils."]

CN Aonghusa NF Gray 2002 *Laundry detergents as a source of heavy metals in Irish domestic wastewater*, JESH A37 1-6 (6702). [Cd, Cu, Zn.]

EH Bailey & 2 others 2005 *Time-dependent surface reactivity of Cd sorbed on calcite, hydroxylapatite and humic acid*, MM 69 563-75.

B Bayat 2002 *Combined removal of zinc (II) & cadmium (II) from aqueous solutions by adsorption onto high-calcium Turkish fly ash*, WASP 136 69-92 (7360). [2 h for equilibrium. Max adsorption at pH 7 to 7.5. As effective as activated C.]

B Benguela H Benaissa 2002 *Cadmium removal from aqueous solutions by chitin: kinetic and equilibrium studies*, WR 36 2463-74 (7566). [Cd-containing nodules on chitin surface. Langmuir isotherm.]

E Benineasa & 4 others 2002 *Sorption of Cd-cysteine complexes by kaolinite*, Appl Clay Sci 21 191-201 = MA 03M/2475.

L Björkman M Vahter NL Pedersen 2000 *Both the environment and genes are important for concentrations of cadmium and lead in blood*, EHP 108 719-22 (4190).

G Blackmore W Wang 2002 *Uptake and efflux of Cd and Zn by the green mussel Perna viridis after metal preexposure*, EST 36 989-95 (6621).

NS Bolan & 4 others 2003 *Immobilization and phytoavailability of cadmium in variable-charge soils. I. Effect of phosphate addition*, PS 250 83-94. [pH & surface charge very important. Details.]

BC Bostick S Fendorf BT Bowie PR Griffiths 2000 *Influence of cadmium sorption on FeS₂ oxidation*, EST 34 1494-99 (4173). [Pyrite.]

MG Burnett & 4 others 2000 *The enhanced adsorption of cadmium on hydrous aluminium (III) hydroxide by ethylenediaminetetraacetate*, PCCP 2 1273-9 (3630).

MC Camerani & 5 others 2004 *X-ray fluorescence tomography of individual municipal waste and biomass fly ash particles*, AnC 76 1586-95; **MC Camerani Pinzani & 4 others** *Microextended X-ray absorption fine structure studies of cadmium speciation within single municipal solid waste fly ash particles*, 1596-602 (10068). [Cd higher in core. Cd in both silicate & chloride crystals & amorphous.]

CW Cheung CK Chan JF Porter G McKay 2001 *Combined diffusion model for the sorption of cadmium, copper, and zinc ions onto bone char*, EST 35 1511-22 (4177).

E Coppola & 7 others 2003 *Remediation of Cd- and Pb-polluted soil by treatment with organo-zeolite conditioner*, CICIM 51 609-15.

L Croisetière L Hare A Tessier 2001 *Influence of current velocity on cadmium accumulation by an aquatic moss and the consequences for its use as a biomonitor*, EST 35 923-927 (4191).

NCC Da Rocha & 5 others 2002 *Cadmium uptake by hydroxyapatite synthesized in different conditions and submitted to thermal treatment*, EST 36 1630-5 (7040).

P Di Leo J Cuadros 2003 ¹¹³Cd, ¹H MAS NMR and FTIR analysis of Cd²⁺ adsorption on dioctahedral and trioctahedral smectite, CICIM 51 403-14 (9267).

JC Echeverria E Churio JJ Garrido 2002 *Retention mechanisms of Cd on illite*, CICIM 50 614-23 (833&7). [pH important.]

JR Evans WG Davids JD MacRae A Amirbahman 2002 *Kinetics of cadmium uptake by chitosan-based crab shells*, WR 36 3219-26 (7837).

RM Flouroi AP Davis A Torrents 2001 *Cadmium adsorption on aluminum oxide in the presence of polyacrylic acid*, EST 35 348-53 (4176).

CA Grant & 3 others 2002 *Effect of phosphate source, rate and cadmium content and use of Penicillium bilali on phosphorus, zinc and cadmium concentration in durum wheat grain*, JSFA 82 301-8 (5940).

LJ Glover II MJ Eick PV Brady 2002 *Desorption kinetics of cadmium and lead from goethite: Influence of time and organic acids*, SSSAJ 66 797-804 (7145). [pH 6, 1 & 20 week; Pb

adsorption complete in 4 hour; Cd slower. Desorption at pH 4.5 slower than sorption with salicylate > oxalate. Details.]

M Grassi M Mingazzini 2001 *Cd-NMR and fluorescence studies of the interactions between Cd(II) and extracellular organic matter released by Selenastrum capricornutum*, EST 35 4271-4276 (4196).

VK Gupta S Sharma 2002 *Removal of cadmium and zinc from aqueous solutions using red mud*, EST 36 3612-7 (7879). [Red mud from Al industry waste.]

Z Hu K Chandran D Grasso BF Smets 2002 *Effect of nickel and cadmium speciation on nitrification inhibition*, EST 36 3074-8 (7636). [Cation concentration important.]

T Izuno & 6 others 2000 *Validity of cadmium concentration in rice as the "dose" of the dose-response relationship between cadmium intake and renal dysfunction*. ER A84 275-81 (4175).

R James K Sampath 1999 *Effect of zeolite on the reduction of cadmium toxicity in water and a freshwater fish, Oreochromis mossambicus*, Environ Contam Toxicol 62 222-9 (4181).

H Jobstmann B Singh 2001 *Cadmium sorption by hydroxy-aluminum interlayered montmorillonite*, WASP 131 203-15 (4197).

C Kom SA Power JNB Bell 2003 *Effects of cadmium and soil type on mineral nutrition and carbon partitioning in seedlings of Pinus sylvestris*, WASP 145 253-66 (9249).

JH Lee JJ Doolittle 2002 *Phosphate application impacts on cadmium sorption in acidic and calcareous soils*, SoS 167 390-400 (7367). [Many details. Pre-application dipotassium phosphate sorbs best.]

X Lin RC Burns GA Lawrance 2003 *Effect of cadmium(II) and anion type on the ageing of ferrihydrite and its subsequent leaching under neutral and alkaline conditions*, WASP 143 155-77 (8931). [Goethite/hematite produced. Details.]

N Lugon-Moulin & 6 others 2004 *Critical review of the science and options for reducing cadmium in tobacco (Nicotiana tabacum L.) and other plants*, AA 83 112-81.

MJ McLaughlin BR Singh Ed 1999 *Cadmium in Soils and Plants*, 0-7923-5843-0.

Developments in Plants and Soil Sciences 85 1-269, TD879.C33, (4183).

CW Noonan & 5 others 2002 *Effects of exposure to low levels of environmental cadmium on renal biomarkers*, EHP 110 151-5 (7598). [Details. "biologic measures of cadmium exposure < 2 microg/g creatinine may produce measurable changes in kidney biomarkers.]

WH Otto WR Carper CK Larive 2001 *Measurement of cadmium(II) and calcium(II) complexation by fulvic acids using ¹¹³Cd NMR*, EST 35 1463-8 (4178).

M Panayotova B Velikov 2002 *Kinetics of heavy metal ions removal by use of natural zeolite*, JESH A37 139-47 (5951).

MCC Pinzani & 5 others 2002 *Direct determination of cadmium speciation in municipal solid waste fly ashes by synchrotron radiation induced micro-X-ray fluorescence and micro-X-ray absorption spectroscopy*, EST 36 3165-9 (7641). [Cd(II) in hot-spots up to 200 ppm.]

M Sanchez-Polo J Rivera-Utrilla 2002 *Adsorbent-adsorbate interactions in the adsorption of Cd(II) and Hg(II) on ozonized activated carbons*, EST 36 3850-4 (8021). [Details.]

R Scheifler & 4 others 2003 *"Nonavailable" soil cadmium is bioavailable to snails: Evidence from isotopic dilution experiments*, EST 37 81-6 (8664).

M O Schwartz 2000 *Cadmium in zinc deposits: Economic geology of a polluting element*, IGR 42 445-69 (4174).

KG Stanhope SD Young JH Hutchinson R Kamath 2000 *Use of isotopic dilution techniques to assess the mobilization of nonlabile Cd by chelating agents in phytoremediation*, EST 34 4123-27 (4187).

C Stouraiti A Xenidis I Paspaliaris 2002 *Reduction of Pb, Zn and Cd availability from tailings and contaminated soils by the action of lignite fly ash*, WASP 137 247-65 (7489).

Y Suwazono & 5 others 2000 *Renal effects of cadmium exposure in cadmium nonpolluted areas in Japan*, ER A 84 44-55 (4186).

BW Strobel & 4 others 2001 *Cadmium and copper release kinetics in relation to afforestation of cultivated soils*, GCA 65 1233-42 (4192).

L Tudoreanu CJC Phillips 2004 *Modeling cadmium uptake and accumulation in plants*, AA 84 122-59.

N Yee J Fein 2001 *Cd adsorption onto bacterial surfaces: A universal adsorption edge?* GCA 65 2037-42 (4180).

Y Zhang & 11 others 2004 *Effect of environmental exposure to cadmium on pregnancy outcome and fetal growth: A study of healthy pregnant women in China*, JESHA 39 2507-15 (10694).

D Zhou & 3 others 2003 *Effects of organic acids, o-phenylenediamine and pyrocatechol on cadmium adsorption and desorption in soil*, WASP 145 109-21 (9248). [Complex details.]

Chlorine

C Winder 2001, *The toxicology of chlorine*, ER 85 105-14 (4199).

Chromium

Cr occurs in the (III) and (VI) valence states. Trivalent Cr becomes locked up in the Al positions of various minerals. Hexavalent Cr is mobile in water as the hexa-hydrate ion. X-ray absorption spectroscopy allows easy characterization of the valence state. Cr(VI) causes lung cancer.

MJ Alowitz MM Scherer 2002 *Kinetics of nitrate, nitrite and Cr(VI) reduction by iron metal*, EST 36 299-303 (5891).

YM Arias BM Tebo 2003 *Cr(VI) reduction by sulfidogenic and nonsulfidogenic microbial consortia*, AEM 1847-53 (8597).

T Astrup SLS Stipp TH Christensen 2000 *Immobilization of chromate from coal fly ash leachate using an attenuating barrier containing zero-valent iron*, EST 34 4163-8 (4208).

S Avudainayagam & 5 others 2003 *Chemistry of chromium in soils with emphasis on tannery waste sites*, Reviews Environmental Contamination & Toxicology 178 53-92.

D Blowes 2002 *Tracking hexavalent Cr in groundwater*, S 295 2024-5 (7008).

MF Brigatti & 7 others 2000 *Reduction and sorption of chromium by Fe(II)-bearing phyllosilicates: Chemical treatments and X-ray absorption spectroscopy (XAS) studies*, CICIM 48 272-81 (4207).

JH Duffus 2005 *Chemical speciation terminology: chromium chemistry and cancer*, MM 69 557-62

AS Ellis TM Johnson TD Bullen 2002 *Chromium isotopes and the fate of hexavalent chromium in the environment*, S 295 2060-2 (6751).

S Fendorf BW Wielinga CM Hansel 2000 *Chromium transformations in natural environments: The role of biological and abiological processes in chromium(VI) reduction*, IGR 42 691-701 (4200).

JP Fitts GE Brown Jr GA Parks 2000 *Structural evolution of Cr(III) polymeric species at the Al_2O_3 /water interface*, EST 34 5122-8 (4204).

J Fruchter 2002 *In situ treatment of chromium-contaminated groundwater*, EST 36 464-72A (8459). [Typical pump-and-treat. In situ approaches: reduce mobile Cr(IV) to insoluble Cr(III) using permeable reactive barriers, iron particle barriers, microbes etc. Examples at Hanford WA & central CA. Uncertainties.]

JS Geelhoed & 6 others 2002 *Identification and geochemical modeling of processes controlling leaching of Cr(VI) and other major elements from chromite ore processing residue*, GCA 66 3927-42 (8008). [Millions of tons of COPR deposited at Glasgow UK, Hudson Co, NJ, etc. At Glasgow, chromite ore was roasted with alkali carbonate to oxidize (III) to (VI) for recovery by leaching. COPR contains 4 to 6% Cr in equilibrium with groundwater pH 11 to 12 containing 1.6 millimole Cr(VI), a thousand fold higher than enviro quality standard. Leaching model involves: Cr(VI)-hydrogarnet, -hydrocalumite, -ettringite, brucite, calcite, gehlenite hydrate, etc.]

UC Ghosh & 3 others 2003 *Studies on management of chromium(VI)-contaminated industrial waste effluent using hydrous titanium oxide (HTO)*, WASP 143 245-56 (8929).

SPB Kamaludeen & 4 others 2003 *Chromium-microorganism interaction in soils: Remediation implications*, Reviews Environmental Contamination & Toxicology 178 93-164.

RJ Kieber JD Willey SD Zvalaren 2002 *Chromium speciation in rainwater: Temporal variability and atmospheric deposition*, EST 36 5321-7 (8533). [All atmospheric Cr washed out at 2×10^9 mol/year. Half is dissolved with ~ equal toxic Cr(VI) and almost safe Cr(III). Details.]

C Kim & 4 others 2001 *Chromium(VI) reduction by hydrogen sulfide in aqueous media: Stoichiometry and kinetics*, EST 35 2219-25 (4193).

JG Kim JB Dixon CC Chusuei Y Deng 2002 *Oxidation of chromium (III) to (VI) by manganese oxides*, SSSAJ 66 306-15 (4994). [Birnessite, todorokite & lithiophorite in soils can oxidize Cr into mobile (VI) in soils. Lab expts.]

J Lakatos SD Brown CE Snape 2002 *Coals as sorbents for the removal and reduction of hexavalent chromium from aqueous waste streams*, F 81 691-8 (7186). [Oxidation of coal increases removal of dangerous Cr(VI).]

S Loya-Lawniczak & 4 others 2000 *Trapping of Cr by formation of ferrihydrite during the reduction of chromate ions by Fe(II) - Fe(III) hydroxysalt green rusts*, EST 34 438-43 (4056).

S Loya-Lawniczak P Lecomte JJ Ehrhardt 2001 *Behavior of hexavalent chromium in a polluted groundwater: Redox processes and immobilization in soils*, EST 35 1350-7 (4202). [High Fe(II) reduces Cr(VI) to (III) in industrial waste landfill, France.]

GN Manju MC Gigi TS Anirudhan 1999 *Hydrotalcite as adsorbent for the removal of chromium (VI) from aqueous media: equilibrium studies*, Indian J Chemical Technology 6 134-41 = MA 00M/1554. [Sorbent power drops 5-fold from pH 2 to 10.]

J McLean T Beveridge 2001 *Chromate reduction by a pseudomonad isolated from a site contaminated with chromated copper arsenate*, AEM 67 1076-84 (4203).

C Oze & 3 others 2004 *Chromium geochemistry of serpentine soils*, IGR 46 92-126 (10093).

CD Palmer 2000 *Precipitates in a Cr(VI)-contaminated concrete*, EST 34 4185-92 (4209). [Ettringite & hydrocalumite.]

M Pettine L Campanella FJ Millero 2002 *Reduction of hexavalent chromium by H_2O_2 in acidic solutions*, EST 36 901-7 (6618).

RW Puls CJ Paul RM Powell 1999 *The application of in situ permeable reactive (zero-valent iron) barrier technology for the remediation of chromium-contaminated groundwater: a field test*, AG 14 989-1000. [Cr-plating facility, Elizabeth City NC. Barrier of iron metal, sand & aquifer sediment. As Fe corrodes, pH rises, forming ferrous sulfides & oxyhydroxides. Cr(VI) changes to Cr(III).]

AS Stasinakis D Mamais NS Thomaidis TD Lekkas 2002 *Effect of chromium (VI) on bacterial kinetics of heterotrophic biomass of activated sludge*, WR 36 3341-9 (7838).

P Sylvester & 5 others 2001 *Ferrate treatment for removing chromium from high-level radioactive tank waste*, EST 35 216-21 (4205).

RW Taylor S Shen WF Bleam S Tu 2000 *Chromate removal by dithionite-reduced clays: Evidence from direct X-ray adsorption near edge spectroscopy (XANES) of chromate reduction at clay surfaces*, CIM 48 648-54 (4206). [Kaolinite/illite/montmorillonite/smectite/vermiculite.]

TK Tokunaga & 6 others 2001 *Chromium diffusion and reduction in soil aggregates*, EST 35 3169-74 (4201).

do & 9 others 2003 *Distribution of chromium contamination and microbial activity in soil aggregates*, JEQ 32 541-9.

YM Tzou MK Wang RH Loeppert 2004 *Organic ligand-enhanced photochemical reduction and immobilization of chromium (VI) on TiO_2 particles in acidic aqueous media*, SoS 169 413-22 (10381).

RM Weaver MF Hochella Jr 2003 *The reactivity of seven Mn-oxides with Cr(3+, aq): A comparative analysis of a complex environmentally important redox reaction*, AM 88 2016-27. [Birnessite/cryptomelane/hausmannite/lithiophorite/manganite/pyrolusite/romanechite.]

CH Weng & 4 others 2001 *Cr(VI) adsorption onto hydrous concrete particles from groundwater*, JEE Dec 1124-31 (4213).

AGB Williams MM Scherer 2001 *Kinetics of Cr(VI) reduction by carbonate green rust*, EST 35 3488-94 (4194).

Y Yun D Park JM Park B Volesky 2001 *Bisorption of trivalent chromium on the brown seaweed biomass*, EST 34 4353-4358 (4212).

D Zhou H Chen C Zheng C Tu 2001 *Catalytic effect of soil colloids on the reaction between Cr^{VI} and p-methoxyphenol*, EnPo 111 75-81 (4210).

Cobalt

Cobalt is probably not dangerous except at high concentration.

EJ Boyle-Wright LE Katz KF Hayes 2002 *Macroscopic studies of the effects of selenate and selenite on cobalt sorption to γ -Al₂O₃*, EST 36 1212-8 (6732); *Spectroscopic studies of the effects of selenate and selenite on cobalt sorption to γ -Al₂O₃*, 1219-25 (6731). [CHECK γ -Al₂O₃]

SM Grimes JD Donaldson AJ Chaudhary MU Hassan 2000 *Simultaneous recovery of metals and destruction of organic species: cobalt and phthalic acid*, EST 3 4128-4132 (4198).

S Rengaraj S Moon 2002 *Kinetics of adsorption of Co(II) removal from water and wastewater by ion exchange resins*, WR 36 1783-93 (7264). [Details.]

Copper

Cu occurs in the (I) and (II) valence states. Cu-herbicides (Bordeau mixture) may cause problems with grape cultivators. Cu may be dangerous in smelting places.

D Buerge-Weirich & 4 others 2002 *Adsorption of Cu, Cd, and Ni on goethite in the presence of natural groundwater ligands*, EST 36 328-36 (5892).

M Choi & 3 others 2004 *Microbial recovery of copper from printed circuit boards of waste computer by Acidithiobacillus ferrooxidans*, JESH A 39 2973-82 (10779).

L Dupont & 4 others 2002 *EXAFS and XANES studies of retention of copper and lead by a lignocellulosic material*, EST 36 5062-6 (8464). [Wheat bran residue useful for sorbing Cu from grape cultivation and Pb from battery plants. Both Cu & Pb bound by carboxylic moieties.]

JP Fitts & 5 others 1999 *Grazing-incidence XAFS investigations of Cu(II) sorption products at γ -Al₂O₃ - water and γ -SiO₂ - water interfaces*, J Synchrotron Radiat 6 627-9 (4219). [CHECK ?]

GE Lagos CA Cuadrado MV Lethelier 2001 *Aging of copper pipes by drinking water*, AWWAJ Nov 94-8 (4224). [Scales contain cuprite/tenorite/malachite/langite/atacamite/brochantite/azurite.]

GW Luther III & 5 others 2002 *Aqueous copper sulfide clusters as intermediates during copper sulfide formation*, EST 36 394-402 (5895).

MB McBride CE Martínez 2000 *Copper phytotoxicity in a contaminated soil: Remediation tests and adsorptive materials*, EST 34 4386-91 (4220).

JD Morton KF Hayes JD Semrau 2000 *Bioavailability of chelated and soil-adsorbed copper to Methylosinus trichosporium OB3b*, EST 34 4917-22 (4217).

MS Panin AB Sibirskina 2000 *Technogenic copper pollution of the catchment area of the Irtysh river on the territory of Kazakhstan*, GI 38 159-68 (4221).

C Parat & 4 others 2002 *The relationship between copper accumulated in vineyard calcareous soils and soil organic matter and iron*, Eur J Soil Sci 53 663-9 (8523). [Cu from Bordeaux mixture bound to FeOOH, except for some bonded to organic matter when Cu very high. Details.]

RAD Patrick & 6 others 1997 *The structure of amorphous copper sulfide precipitates: An X-ray absorption study*, GCA 61 2023-36 (P689). [Metastable precipitate ages to material similar to amorphous covellite.]

F Pizarro & 4 others 2001 *Gastrointestinal effects associated with soluble and insoluble copper in drinking water*, EHP 109 949-52 (4222).

O Ribolzi & 3 others 2002 *Speciation and origin of particulate copper in runoff water from a Mediterranean vineyard catchment*, EnPo 117 261-71 (5937). [Risk greatest for stony red soils.]

R Vulkan & 6 others, 2000 *Copper speciation and impacts on bacterial biosensors in the pore water of copper-contaminated soils*, EST 34 5115-21 (4216).

M Waeles RD Riso PL Corre 2005 *Seasonal variations of dissolved and particulate copper species in estuarine waters*, ECSC 62 313-23 (10918).

Y Wei Y Yang N Cheng 2001 *Study of thermally immobilized Cu in analogue minerals of contaminated soils*, EST 35 416-21 (4215).

Fluorine

Fluorine is needed for strong bones and teeth, but may become dangerous at higher concentration. Fluorosis is common in many poor countries where people rely on groundwater. In acid soils, clay minerals sorb about 5 times more than in alkaline ones.

M Agarwal K Rai R Shrivastav S Dass 2002 *A study on fluoride sorption by montmorillonite and kaolinite*, WASP 141 247-61 (8554). [Details of higher sorption in acid.]

LH Weinstein AW Davison 2004 *Fluorides in the Environment*, TD196.F44W44.

Lead

Lead Pb is poisonous to humans, particularly to babies with undeveloped immune systems. Lead occurs in ore deposits mainly as *galena* PbS together with several other species. I was born at Crich, Derbyshire, UK, which is in a lead ore district. The cupola of a Roman lead mine was in one of my grandfathers's fields. The water pipes were made of metallic Pb, but fortunately had become encrusted with a grey Pb carbonate which cut down on the interaction with drinking water. However, downwind of lead smelters, as near Holloway, certain fields had so much Pb that cattle sickened from *belland*. During retirement, my parents lived at Middleton-by-Wirksworth, just one field away from where 3 wt.% Pb was measured in a field with unusual sparse flora. The Greeks smelted Pb ore to capture silver Ag dissolved in the galena. The Romans made increasing use of Pb, and it has been suggested that drinking hot toddy from lead vessels led to madness and changed history. Lead continued to be used in Derbyshire for water pipes, hanging gates from hinges fastened by Pb into sandstone pillars, covering church roofs, and so on. White lead paint was and is particularly dangerous because it flakes off, and young children ingest it: it has a nice sweet taste. Modern white paint is based on titanium dioxide, but old buildings still carry lead paint. Typically the soil around old Pb-painted wood houses carries 1 to 3 % Pb, unless it has been treated. The introduction of tetraethyl lead in gasoline-petrol in the twentieth century led to a major health hazard that is being reduced as no-lead gasoline replaces low-lead and leaded gasoline from the advanced world to the underdeveloped world. It is difficult to be sure how much brain damage has been caused and how much will occur in the future, but numbers of affected people are high, particularly in older slum areas. Currently the atmospheric deposition, as measured in ice cores and varved sediments, went way down in the northern hemisphere over a decade ago. In northern cities, most of the concern is probably with old Pb deposits. Old lead paint should be chipped off and vacuumed up immediately. Pb from storage batteries should be recycled.

LY Alleman & 5 others 1999 *Invasion of the abyssal North Atlantic by modern anthropogenic lead*, GRL 26 1477-80 (4255).

JR Bargar & 4 others 2004 *In situ grazing-incidence extended X-ray absorption fine structure study of Pb(II) chemisorption on hematite (0001) and (1⁻102) surfaces*, La 20 267-73.

D Barry 2005 *Lead binding reexamined*, CEN 6/27 13. [Trigonal pyramidal coordination to S may be key to poisoning.]

EL Belokoneva & 4 others 2002 *Synthesis and crystal structure of new carbonate NaPb(CO₃)(OH)*, CrR 47 217-22 (7083). [Structure similar to *ewaldite*.]

CF Boutron CC Patterson 1986 *Lead concentration changes in Antarctic ice during the Wisconsin/Holocene transition*, N 323 222-5 (5161).

GR Boyd & 5 others 2001 *Selecting lead pipe rehabilitation and replacement technologies*, AWWAJ Jul 74-87 (4239). [3 million Pb lines in US, 8 in UK.]

ML Brannvall & 5 others 1999 *The medieval metal industry was the cradle of modern large-scale atmospheric lead pollution in Northern Europe*, EST 32 4391-5 (4292). [Sediments in Sweden show Pb signal for Greek & Roman times, then low Pb 400-900 AD. Then increase with peaks at 1200 & 1530 matching European production. Final peak matches Industrial Revolution.]

S Caliro M Imperato V Monetti D Stanzione 1998 *Lead pollution in roadside soils of Napoli-Salerno motorway*, MPA 41 109-17 (4291). [Great variation with distance, depth and tilt of soil from dangerous levels by motorway. Pb penetrates soil downwards at 1 cm/yr. Pb particles move 40 meter sideways and 2 m upwards.]

JR Campbell ME Moss RF Raubertas 2000 *The association between caries and childhood lead exposure*, EHP 108 1099-102 (4266). [Blood Pb of young toddler showed little association with caries.]

JR Campbell & 3 others 2004 *The association between environmental lead exposure and bone density in children*, EHP 112 1200 (10591).

X Cao & 4 others 2002 *Impacts of phosphate amendments on lead biogeochemistry at a contaminated site*, EST 36 5296-301 (8536). [Combined H_3PO_4 & phosphate rock generates stable *chloropyromorphite*. Details.]

X Cao & 4 others 2003 *Weathering of lead bullets and their environmental effects at outdoor shooting ranges*, JEQ 32 526-34.

C J Chisholme-Brause & 5 others 1990 *Spectroscopic investigation of Pb(II) complexes at the gamma- Al_2O_3 /water interface*, GCA 54 1897-1909 (4281). [Inner-sphere mainly.]

JJ Chrisholm Jr 2001 *Evolution of the management and prevention of childhood lead poisoning: dependence of advances in the determination of lead and related biochemical indicators of its toxicity*, ER 86 111-21 (4299). [History from first report in 1892 at Brisbane.]

JD Cotter-Howells PE Champness JM Charnock 1999 *Mineralogy of Pb-P grains in the roots of Agrostis capillaris L. by ATEM and EXAFS*, MM 63 777-89 (9104). [This heavy-metal-tolerant cultivar precipitates *pyromorphite*-type material in the outer cell wall of root cells.]

M Edwards LS McNeill 2002 *Effect of phosphate inhibitors on lead release from pipes*, AWWAJ Jan 79-84 (4002). [Phosphates good for reducing Fe corrosion & Ca-scale build-up; unfortunately increase release of both particulate & soluble lead.]

V Ettler & 3 others 2005 *The leaching behavior of lead metallurgical slag in high-molecular-weight (HMW) organic solutions*, MM 69 737-45. [pH vs Pb/Cu/Zn/As. Relevant to fulvic acid or peat water.]

EJ Elzinga D Peak DL Sparks 2001 *Spectroscopic studies of Pb(II)-sulfate interactions at the goethite-water interface*, GCA 65 2219-30 (4238). [Co-adsorption affects extent & mechanisms.]

EJ Elzinga DL Sparks 2002 *X-ray absorption spectroscopy study of the effects of pH and ionic strength on Pb(II) sorption to amorphous silica*, EST 36 4352-7 (8153). [Increase with pH & ionic strength, details.]

S Emmanuel Y Erel 2002 *Implications from concentrations and isotopic data for Pb partitioning process in soils*, GCA 66 2517-27 (7667). [Czech forests: affinity, Fe-oxides > organic > silicates. Semi-arid Mediterranean: Fe-oxides > carbonates > organic > silicates.]

PC English 2001 *Old Paint*, Rutgers Univ Press, 0-8135-2987-5 (6749).

EPA 1999 *The lead-based paint pre-renovation education rule*, a handbook for contractors, property managers, and maintenance personnel, EPA-747-B-99-004 (4250).

AS Ettinger & 8 others 2002 *Assessment of cleaning to control lead dust in homes of children with moderate lead poisoning: Treatment of lead-exposed children trial*, EHP 110 A773-9 (8652). [Professional cleaning helps, but not good enough.]

MR Farfel & 5 others 2003 *A study of urban housing demolitions as source of lead in ambient dust: demolition practices and exterior dust fall*, EHP 111 1228-34 (10103).

D Ferber 2002 *Overhaul of CDC Panel revives lead safety debate*, S 298 732 (8185). [Politics.]

GM Filipelli & 3 others 2005 *Urban lead poisoning and medical geology: An unfinished story*, GSAT 15 4-11(10984).

KL Florini EK Silbergeld 1993 *Getting the lead out*, IST Summer 33-9 (5180).

M Gaft H Seigel G Panczer R Reisfeld 2002 *Laser-induced time-resolved luminescence spectroscopy of Pb^{2+} in minerals*, EJM 14 1041-8 (8676). [50 K to ambient of calcite, hardystonite, hydrozincite, pyromorphite. Pb bands distinguished from Ce(III) & Eu(II) ones.]

MT Gallardo-Williams & 3 others 2002 *Accumulation and retention of lead by cattail* (*Typha domingensis*), *hydrilla* (*Hydrilla verticillata*) and *duckweed* (*Lemna obscura*), JESH A37 1399-408 (8059). [Tested at Delaney Creek, Tampa FL, at abandoned lead-acid battery site.]

C Gobeil RW Macdonald JN Smith L Beaudin 2001 *Atlantic water flow pathways revealed by lead contamination in arctic basin sediments*, S 293 1301-4 (4234).

H Greman & 3 others 2003 *Ethylenediamminedisuccinate as a new chelate for environmentally safe enhanced lead phytoextraction*, JEQ 32 500-6.

SD Grosse TD Matte J Schwartz RJ Jackson 2002 *Economic gains resulting from the reduction in children's exposure to lead in the United States*, EHP 110 563-9 (7523). [Assume ~0.2 IQ drop per 1 microgram/deciliter. Each IQ point raises worker productivity ~2%. For each year's cohort of 4M 2-year old children get \$110-319 billion based on lifetime earnings of \$720k per child.]

RH Gwiazda DR Smith 2000 *Lead isotopes as a supplementary tool in the routine evaluation of household lead hazards*, EHP 108 1091-7 (4267). [Try to distinguish source using isotope ratios.]

S Harris BL Harper 2000 *Lifestyles, diets and native American exposure factors related to possible lead exposures and toxicity*, ER 86 140-8 (4302). [Ideas.]

GM Hettiarachchi GM Pierzynski MD Ransom 2000 *In situ stabilization of soil lead using phosphorus and manganese oxide*, EST 34 4614-9 (4273). [Bioavailability of mine-waste Pb reduced by joint cryptomelane-phosphate.]

K Hwang & 5 others 2002 *Protein kinase C activity and the relations between blood lead and neurobehavioral function in lead workers*, EHP 110 133-8 (7597). [Details.]

P Johansen G Asmund F Riger 2001 *Lead contamination of seabirds harvested with lead shot - implications to human diet in Greenland*, EnPo 112 501-4 (4252). [Pb fragments give ~ 50 mg per bird = _ tolerable level.]

U Kolitsch E Tillmanns 2003 *The crystal structure of anthropogenic $Pb_2(OH)_3(NO_3)$, and a review of $Pb-(O,OH)$ clusters and lead nitrates*, MM 67 79-93. [Black Forest mine area: attributed to nitrate explosive.]

SM Kraemer J Xu KM Raymond G Sposito 2002 *Adsorption of $Pb(II)$ and $Eu(III)$ by oxide minerals in the presence of natural and synthetic hydroxamate siderophores*, EST 36 1287-91 (6729).

BP Lanphear 1998 *The paradox of lead poisoning prevention*, S 281 1617-8 (4270). [Details of paint ingestion, cost of removal etc.]

C Lin & 4 others 2004 *Determinants of bone and blood levels among minorities living in the Boston area*, EHP 112 1147 (10593).

ME Markowitz X Shen 2001 *Assessment of bone lead during pregnancy: A pilot study*, ER 85 83-9 (4265). [Details.]

CJ Matochar EJ Elzinga DL Sparks 2001 *Reactivity of $Pb(II)$ at the $Mn(III,IV)$ (oxyhydr)oxide – water interface*, EST 35 2967-72 (5321). [Birnessite/manganite.]

E Mavropoulos & 5 others 2002 *Studies on the mechanisms of lead immobilization by hydroxyapatite*, EST 36 1625-9 (7039). [XRD.]

HW Mielke 1999 *Lead in the inner cities*, AS 87 62-73 (4253). [USA. Pb paint peaked in 1920's and phased out by 1980. Gasoline lead started in 1930, peaked at 1970, and phased out by 1990. Dust and soil eaten by kids. Wood decks and sand lots help.]

HW Mielke 2005 *Lead's toxic urban legacy*, Gt May 22-6 (11044). [20% children of Cleveland have lead poisoning, Chicago 13%, New York City 2%.]

HW Mielke & 4 others 2001 *Multiple metal contamination from house paints: consequences of power sanding and paint scraping in New Orleans*, EHP A109 973-8 (4304). [Sanding of old lead paint released Pb & other metals matching old gasoline Pb. Must scrape and clean up.]

G Morin JD Ostergren F Juillot P Ildefonse G Calas GE Brown Jr 1999 *XAFS determination of the chemical form of lead in smelter-contaminated soils and mine tailings: Importance of adsorption processes*, AM 84 420-34. [XRPD, XAS and XRF demonstrate Pb sorbed on humic acids & Mn/Fe oxy/hydroxides in smelter-contaminated soils from Evin-Malmaison, Nord Pas-de-Calais. In mine tailings from Leadville CO, Pb is linked to acidity: near-neutral carbonate-buffering has about half as adsorption complexes on Fe-oxy/hydroxides, whereas sulfide-rich samples have Pb-bearing *jarosite*.]

T Nedwed DA Clifford 2000 *Feasibility of extracting lead from lead battery recycling site soil using high-concentration chloride solutions*, EnPo 19 197-202 (4272). [Chloride as good as EDTA. Meets EPA's test.]

HL Needleman 2000 *The removal of lead from gasoline: historical and personal reflections*, ER 84 20-35 (4283). [Tetraethyllead first used 1923. Workers became floridly psychotic and died. 1959 warning from Claire Patterson. Took 25 years to remove from gasoline.]

HL Needleman ed 1991 *Human Lead Exposure*, CRS Press, RC347.5H86 (4288). [Pb raises blood pressure.]

YM Nelson & 3 others 2002 *Effect of oxide formation mechanisms on lead adsorption by biogenic manganese (hydr)oxides and iron hydr(oxides), and their mixtures*, EST 36 421-5 (5897).

JO Nriagu 1984 *Lead and Lead Poisoning in Antiquity*, Wiley (5160).

SE O'Reilly MF Hochella Jr 2003 *Lead sorption efficiencies of natural and synthetic Mn and Fe oxides*, GCA 67 4471-87 (9522).

J Rose & 7 others 2000 *X-ray absorption spectroscopy study of immobilization processes for heavy metals in calcium silicate hydrates 1. Case of lead*, La 16 9900-6 (4271).

JF Rosen P Mushak 2001 *Primary prevention of childhood lead poisoning- the only solution*, NEJM 344 1470-1 (4259). [Succimer chelate reduces Pb, but damage already done. Must get lead paint removed.]

RM Semlali & 3 others 2001 *Estimating distributions of endogenous and exogenous Pb in soils by using Pb isotopic ratios*, EST 35 4180-8 (4298).

W Shoty & 4 others 2002 *New peat bog record of atmospheric lead pollution in Switzerland: Pb concentrations, enrichment factors, isotopic composition, and organolead species*, EST 36 3893-900 (8013). [Earliest organolead fits use of leaded gasoline 1947. Many details.]

DE Stangle & 4 others 2004 *Reductions in blood lead overestimate reduction in brain lead after repeated succimer regimens in a rodent model of childhood lead exposure*, EHP 112 302-8 (10160).

S Sugiyama & 5 others 2001 *Enhancement of lead-barium exchangeability of barium hydroxyapatite*, JCIS 238 183-7 (4236).

AS Templeton & 4 others 2001 *Pb(II) distributions at biofilm-metal oxide interfaces*, PNAS 98 11897-902 (3514). [*Hematite* & *corundum*. X-ray standing wave.]

N Teutsch 2001 *Distribution of natural and anthropogenic lead in Mediterranean soils*, GCA 65 2853-64 (4294).

TP Trainor & 3 others 2002 *Application of the long-period X-ray standing wave technique to the analysis of surface reactivity: Pb(II) sorption at alpha-Al₂O₃/aqueous solution interfaces in the presence and absence of Se(VI)*, La 18 5782-91 (7663).

P Van Herck & 3 others 2000 *Zinc and lead removal from blast furnace sludge with a hydrometallurgical process*, EST 34 3802-8 (4284). [Leaching & ion exchange.]

PJ Vojta & 9 others 2002 *First national survey of lead and allergens in housing: Survey design and methods for the allergen and endotoxin components*, EHP 110 527-32 (7356). [Data for 831 homes for Pb & allergens of cat/dog/rodent/mouse/fungus & endotoxin.]

H von Storch & 6 others 2002 *Reassessing past European gasoline lead policies*, Eos 83 (36) 393 & 399 (8000). [1955: 31 kilo ton from road transport; 13 from non-ferrous metal manufactory; 7 from steel production; 1 from cement; 5 from stationary engines; & 5 other; 1995: 18, 3, 2, <1, 3, 3. Pb deposition in a Danish peat bog & in the Baltic Sea peaked at 1970. In German adults, blood Pb increased from 110 microgram/liter in 1957 to 140 in 1973 and down to 40 in 1996: compares with 100 as maximum suggested in USA for children. Details.]

AS Templeton & 7 others 2003 *Sorption versus biomineralization of Pb(II) within Burkholderia cepacia biofilms*, EST 37 300-7 (8633). [This Gram-negative soil bacterium forms *pyromorphite* hotspots. EXAFS & TEM.]

VM Vulava JC Seaman 2000 *Mobilization of lead from highly weathered porous material by extracting agents*, EST 34 4828-34 (4275). [EDTA & CMCD.]

NB Vyas JW Spann GH Heinz 2001 *Lead shot toxicity to passerines*, EnPo 111 135-8 (4285). [Complex.]

J Wakefield 2002 *The lead effect?* EHP 110 A574-80 (8553). [Review of health hazardsto children.]

A Walcarius & 4 others 2001 *Recovery of lead-loaded zeolite particles by flotation*, La 17 2258-64 (4251). [X & Y faujasites and LTA.]

C Warren 2000 *Brush with Death: a Social History of Lead Poisoning*, John Hopkins University Press 384pp, review by Thomas Dormandy (4278).

J Wu EA Boyle 1997 *Lead in the western North Atlantic ocean: completed response to leaded gasoline phaseout*, GCA 61 3279083 (4252).

J Yang & 3 others 2001 *Lead immobilization using phosphoric acid in a smelter-contaminated urban soil*, EST 35 3553-9 (4293).[Chloropyromorphite.]

DJ Sterling CE Dunlap A R Flegal 2000 *New isotopic evidence for chronic lead contamination in the San Francisco Bay estuary system: implications for the persistence of past industrial lead emissions in the biosphere*, PNAS 97 11181-6 (4279).

MA Vile R K Wieder M Novak 2000 *200 years of Pb deposition throughout the Czech Republic: patterns and sources*, EST 34 12-7 (4289).

H Yang & 3 others 2002 *Mercury and lead budgets for Lochnagar, a Scottish mountain lake and its catchment*, EST 36 1383-8 (7033).

L Yiin & 7 others 2002 *Comparison of techniques to reduce residential lead dust on carpets and upholstery: The New Jersey assessment of cleaning techniques trial*, EHP 110 1233-7 (8653). [High-efficiency particulate air (HEPA) vacuum cleaner recommended by US-HUD.]

TM Young & 3 others 2002 *Resuspension of soil as a source of airborne lead near industrial facilities and highways*, EST 36 2484-90 (7335).

Manganese

Manganese is an essential element for human life, but excess Mn may be bad. Some soils have high Mn, and indeed Mn nodules may occur, as on the ocean floor. 4% Mn is used in steel. Mn is readily oxidized to the 4-valent state, being immobilized as a black oxide. Bacteria oxidize Mn in wheat and rice making it unavailable to food production, "take-all disease". Arsenic can reduce Mn as it is oxidized itself.

JR Bargar BM Tebo JE Villinski 2000 *In situ characterization of Mn(II) oxidation by spores of the marine Bacillus sp. strain SG-1* GCA 64 2775-8 (4227).

M Kitao TT Lei T Nakamura T Koike 2001 *Manganese toxicity as indicated by visible foliar symptoms of Japanese white birch (Betula platyphylla var. japonica)*, EnPo 111 89-94 (4226).

C Santos-Burgoa & 9 others 2001 *Exposure to manganese: Health effects on the general population, a pilot study in Central Mexico*, ER A85 90-104 (4225).

DT Scott DM McKnight BM Voelker DC Hrncir 2002 *Redox processes controlling manganese fate and transport in a mountain stream*, EST 36 453-9 (5898).

BM Tebo & 7 others 2004 *Biogenic manganese oxides: properties and mechanisms of formation*, AREPM 32 287-328 (10354). [Birnessite.]

C Tournassat L Charlet D Rosbach A Manceau 2002 *Arsenic(III) oxidation by birnessite and precipitation of manganese(II) arsenate*, EST 36 493-500 (5899).

Mercury

Mercury occurs either as metallic liquid or as vapor composed of organo complexes. The movement of mercury is complex and depends on soil and air chemistry. Coal power stations are a major source of Hg-bearing vapors, and no adsorbent has yet been fully tested, and routinely installed. Medical waste incineration accounts for one-tenth. Gold mining involves extraction with mercury, and mercury mines also are associated with high Hg. Mercury becomes converted to methylmercury by certain biological processes apparently involving sulfate, and is potentially dangerous medically. Old thermometers and barometers used Hg. Some homes have high Hg in the air. Hg increases as small fish are eaten by large fish. Eating fish however has not been proven to be dangerous, possibly because the methylmercury is complexed with cysteine. Nor has any danger been proven for people with mercury amalgam tooth filling. Methyl mercury is produced by organisms in soil, and Hg content is higher for acidic soils and is related to S content. Ethylmercury is the active ingredient in the vaccine preservative *thimerosal*. In general, Hg is not for worry at low concentrations, but may become more dangerous where concentrations increase from coal-fired stations.

MB Parsons JB Percival ed 2005 *Mercury. Sources, Measurements, Cycles, and Effects*, Mineral Soc Canada Short Course Vol 34.

ML Abbott & 3 others 2002 *Mercury deposition in snow near an industrial emission source in the western U.S. and comparison to ISC3 model predictions*, WASP 139 95-114 (7512). [Details.]

M Arias & 4 others 2004 *Interaction of Hg(II) with kaolin-humic acid complexes*, CIM 39 35-45 (10302).

A Amirbahman & 4 others 2002 *Association of methylmercury with dissolved humic acids*, EST 36 690-5 (6192).

CD Axtell & 8 others 2000 *Association between methylmercury exposure from fish consumption and child development at five and a half years of age in the Seychelles child development study: An evaluation of nonlinear relationships*, ER 84 71-80 (6021). [Nothing is clear.]

JM Benoit CC Gilmour RP Mason 2001 *The influence of sulfide on solid-phase mercury bioavailability for methylation by pure cultures of Desulfobulbus propionicus (1pr3)*, EST 35 127-32 (6022).

T Berg & 5 others 2001 *Atmospheric mercury species in the European Arctic: measurements and modelling*, AE 35 2569-82 (6023).

H Biester & 5 others 2002 *Elevated mercury accumulation in a peat bog of the Magellanic Moorlands, Chile (53 °S) - an anthropogenic signal from the Southern hemisphere*, EPSL 201 609-20. [3 ky. 18x increase in past century.]

do & 3 others 2003 *Effect of peat decomposition and mass loss on historic mercury records in peat bogs from Patagonia*, EST 37 32-9 (8666). [Important to adjust for peat humification.]

R Bindler 2003 *Estimating the natural background atmospheric deposition rate of mercury utilizing ombrotrophic bogs in southern Sweden*, EST 37 40-6 (8552). [Now conclude that 10-fold increase over old level.]

R Bindler & 4 others 2001 *Mercury accumulation rates and spatial patterns in lake sediments from west Greenland: A coast to ice margin transect*, EST May 173 (4029).

KA Bjornberg & 9 others 2003 *methyl mercury and inorganic mercury in Swedish pregnant women and in cord blood: Influence of fish consumption*, EHP 111 637-41 (8968). [Cord from fetus. Weak associations.]

P Blanchard & 4 others 2002 *Four years of continuous total gaseous mercury (TGM) measurements at sites in Ontario, Canada*, AE 36 3735-43 (8114).

PM Bolger BA Schwetz 2002 *Mercury and health*, NEJM 347 1735-6. [Consumption of fish should be selective to lower danger from methylmercury, especially for pregnant women: salmon & shrimp, not detected, are best; tilefish, swordfish, king mackerel & shark, 1.4 to 1.0 ppm are worst; tuna 0.3 is possibly OK. Conflicting results for relation with cardiovascular health in men.]

L Boszke A Kowalski J Siepak 2004 *Grain size partitioning of mercury in sediments of the Middle Odra River (Germany/Poland)*, WASP 159 129-38.

R Bopp 2001 *Heavy metal in Central Park*, Geoscientist 11 13 (4091).

BA Branfireun & 4 others 2001 *Mercury cycling in boreal ecosystems: The long-term effect of acid rain constituents on peatland pore water methylmercury concentrations*, GRL 28 1227-30 (6108). [Sulfate but nitrate increases Hg.]

ME Brigham & 3 others *Methylmercury in flood-control impoundments and natural waters of northwestern Minnesota, 1997-99*, WASP 138 61-78 (7482). [Advisory for Red River. Details.]

J Brown R Richer L Mercier 2000 *One-step synthesis of high capacity mesoporous Hg²⁺ adsorbents by non-ionic surfactant assembly*, MMM 37 41-8 (6026).

J Burger & 5 others 2001 *Mercury and selenium in fish from the Savannah River: Species, trophic level, and locational differences*, ERS 87 108-18 (6028).

M Burke 2002 *UNEP takes first step to control worldwide mercury releases*, EST 12/1 441-2 (8458). [Details.]

A Carpi YF Chen 2001 *Gaseous elemental mercury as an indoor air pollutant*, EST 35 4170-3 (6029). [One-tenth of New York homes have higher than outdoor.]

JM Charnock & 5 others 2003 *The structural evolution of mercury sulfide precipitate: an XAS and XRD study*, AM 88 1197-1203. [Amorphous cinnabar-like to crystalline metacinnabar.]

K Christen 2001b *Tracking mercury in landfill gas*, EST Sep 354A (6031).

TW Clarkson 2002 *The three modern faces of mercury*, EHP 110 11-23 (6772).

TW Clarkson L Magos GJ Myers 2003 *The toxicology of mercury –current exposures and clinical manifestations*, NEJM 349 1731-7 (9590). [From fish, dental amalgams & vaccines. Many details. General conclusion: keep your dental amalgam & eat fish.]

CM Cooney 2002 *Wisconsin pulls out ahead on mercury controls*, EST 12/1 440-1A (8457).

PW Davidson & 8 others 2000 *Neurodevelopmental outcomes of Seychellois children from the pilot cohort at 108 months following prenatal exposure to methylmercury from a maternal fish diet*, ER 84 1-11 (6032). [No relation found.]

RD DeLaune & 3 others 2004 *Relationship of sediment redox conditions to methyl mercury in surface sediment of Louisiana lakes*, JESHA 39 1925-33 (10537). [Oxidation reduces.]

MM Dipasquale & 6 others 2000 *Methyl-mercury degradation pathways: A comparison among three mercury-impacted ecosystems*, EST 34 4908-16 (6072).

J Domagalski 2001 *Mercury and methylmercury in water and sediment of the Sacramento River Basin, California*, AG 16 1677-91. [Highest Hg during high streamflow: jvs, presumably due to activating mine waste.]

GB Dreher LR Follmer 2004 *Mercury content of Illinois soils*, WASP 156 299-315 (10611).

RT Drexel & 4 others 2002 *Mercury(II) sorption to two Florida Everglades peats: Evidence for strong and weak binding and competition by dissolved organic matter released from the peat*, EST 36 4058-64 (8118).

R Ebinghaus & 7 others 2002 *Antarctic springtime depletion of atmospheric mercury*, EST 36 1238-44 (6730).

R Eisler 2004 *Mercury hazards from gold mining to humans, plants and animals*, Rev Environ Contam Toxicol 181 139-98 (10194).

G Ewert T Paulsen M Linscheid 2003 *Immobilization of mercury species under the influence of typical organic compounds in waste gases by the circulating fluid bed*, WASP 144 141-8. [Tried to remove Hg by using brown-coal coke & portlandite particles. Details; major problem is that worked for only 5 minutes.]

P Factor-Litvak & 8 others 2003 *Mercury derived from dental amalgams and neuropsychologic function*, EHP 111 719-23 (9103). [No clear relation.]

HR Friedli LF Radke JY Lu 2001 *Mercury in smoke from biomass fires*, GRL 28 3223-6 (6040).

M Futatsuka & 8 others 2000 *Health surveillance in the population in a methyl mercury-polluted area over a long period*, ER A83 83-92 (6041). [Minamata, Japan.]

V Goutner RW Furness G Papakostas 2001 *Mercury in feathers of Squacco heron (Ardeola ralloides) chicks in relation to age, hatching order, growth, and sampling*, EnPo 111 107-15 (6043).

RP Gambrell & 3 others 2001 *Mercury distribution in sediment profiles of six Louisiana lakes*, JESH A36 661-75 (6042).

M Haitzer GR Aiken JN Ryan 2002 *Binding of mercury(II) to dissolved organic matter: The role of the mercury-to-DOM concentration ratio*, EST 36 3564-70 (7878).

HH Harris IJ Pckering GN George 2003 *The chemical form of mercury in fish*, S 301 1203 (9272); Letters, 303 763-6 (10054). [XAS for LIII Hg. Best fit with methylmercury cysteine, less toxic than the chloride.]

D Hesterberg & 3 others 2001 *Bonding of Hg(II) to reduced organic sulfur in humic acid as affected by S/Hg ratio*, EST 35 2741-5 (6050).

JM Hightower D Moore 2003 *Mercury levels in high-end consumers of fish*, EHP 111 604-8 (8932). [San Francisco. Swordfish had highest correlation 0.71 with blood Hg; every other fish low to negative.]

H Hintelmann & 9 others 2002 *Reactivity and mobility of new and old mercury deposition in a boreal forest ecosystem during th first year of the METAALICUS study*, EST 36 5034-40 (8463). [Mercury Experiment to Assess Atmospheric Loading in Canada and the US. New Hg more reactive than old Hg, but only 8% released to air & <1% to water. Details.]

C Hogue 2001 *Assessing mercury*, CEN Feb 14 (6051). [World-wide UNEP assessment due 2003.]

JC Hower & 3 others 2000 *Mercury capture by distinct fly ash carbon forms*, EnF 14 224-6 (6053).

H Hsi & 4 others 2002 *Mercury adsorption properties of sulfur-impregnated adsorbents*, JEE 128 1080-9 (8256).

JA Jay & 6 others 2002 *Mercury methylation by Desulfivibrio desulfuricans ND132 in the presence of polysulfides*, AEM 68 5741-5. [Details.]

J Johnson 2001a *Power plants to limit mercury*, CEN Jan 1 18-9 (6055); 2001b *The mercury conundrum*, Feb 5 21-4 (5776); 2002 *Too much of a bad thing*, Jul 22-3 (7745). [What to do with thousands of tons of unneeded Hg.]; 2003 *Delay proposed for mercury cuts*, Dec 20-1 (9601). ["New EPA draft gives coal-fired power plants a decade or more."]

CJ Kennedy 2003 *Uptake and accumulation of mercury from dental enamel in the common goldfish*, Carassius auratus, EnPo 121 321-6 (8636).

JD Lalonde & 3 others 2001 *Photooxidation of Hg(0) in artificial and natural waters*, EST 35 1367-72 (6060).

JD Lalonde AJ Poulain M Amyot 2002 *The role of mercury redox reactions in snow on snow-to-air mercury transfer*, EST 36 174-8 (4339). [Photochemical?]

CH Lamborg & 3 others 2002 *A non-steady-state compartmental model of global-scale mercury biogeochemistry with interhemispheric atmospheric gradients*, GCA 66 1105-18 (6989). [Ocean to atmosphere model using particle scavenging & deep ocean burial, etc.]

MA Latif & 3 others 2001 *Effects of environmental and maternally derived methylmercury on the embryonic and larval stages of walleye (Stizosedion vitreum)*, EnPo 111 139-48 (6061).

C Lin SO Pehkonen 1999 *The chemistry of atmospheric mercury: A review*, AE 33 2067-79 (6065).

SE Lindberg & 5 others 2001 *Methylated mercury species in municipal waste landfill gas sampled in Florida, USA*, AE 35 4011-5 (6066).

M Little 2002 *Reducing mercury pollution from electric power plants*, IST Summer 27-30; Forum Fall 13-5 (7507). [464 plants produce 56% electricity, spewing downwind 48 tons Hg ~ one-third total emission. Suggest that ~60 k babies have neuro problems from Hg. NOx removal can remove half Hg. Activated C injection would be more effective and is cheap. Even cheaper methods under consideration. Hope is to remove 90% by 2007 but politics in the way.]

K Liu & 6 others 2001 *An investigation of mercury emission from FBC systems fired with high-chlorine coals*, EnF 15 1173-80 (3080).

W Liu RD Vidic TD Brown 2000 *Impact of flue gas conditions on mercury uptake by sulfur-impregnated activated carbon*, EST 34 154-9 (6067).

VLS Louis & 7 others 2001 *Importance of the forest canopy to fluxes of methyl mercury and total mercury to boreal ecosystems*, EST 35 3089-98 (6097).

JY Lu & 9 others 2001 *Magnification of atmospheric mercury deposition to polar regions in springtime: the link to tropospheric ozone depletion chemistry*, GRL 28 3219-22 (6068).

R Lutter E Irwin 2002 *Mercury in the environment. A volatile problem*, Env 44(9) 25-40 (8216). [Details of volcanic vs industrial sources. Product regulations. Proposed new standards may not be cost-effective.]

EG Malcolm GJ Keeler 2002 *Measurements of mercury in dew: atmospheric removal of mercury species to a wetted surface*, EST 36 2815-21 (7472). [Lowest 0.31 ng/m² at remote Lake Superior, highest at FL Everglades 1.4.]

MM Matlock & 4 others 2002 *Advanced mercury removal from gold leachate solutions prior to gold and silver extraction: A field study from an active gold mine in Peru*, EST 36 1636-9 (7041). [K-organic complex sorbs almost all Hg in 10 minutes.]

MA McDowell & 10 others 2004 *Hair mercury levels in U. S. children and women of childbearing age: reference range data from NHANES 1999-2000*, EHP 112 1165 (10589). [Increase with fish consumption.]

S Mendioroz & 3 others 1999 *Mercury retrieval from flue gas by monolithic adsorbents based on sulfurized sepiolite*, EST 33 1697-702 (6073).

CJ Miles & 3 others 2001 *Partitioning of monomethylmercury between freshwater algae and water*, EST 35 4277-82 (6074).

JW Miller JE Callahan JR Craig 2002 *Mercury interactions in a simulated gold placer*, AG 17 21-8 = MA 02M/2679. [Complex details.]

HA Moye & 4 others 2002 *Kinetics and uptake mechanisms for monomethylmercury between freshwater algae and water*, EST 36 3550-5 (7877).

G Muckle & 4 others 2001 *Determinants of polychlorinated biphenyls and methylmercury exposure in Inuit women of childbearing age*, EHP 109 957-63 (6075).

National Research Council 2000 *Toxicological Effects of Methylmercury*, RA1231.M5 T695 (6076).

JO Nriagu 1994 *A precious legacy*, CB Aug 650-1 (6079).

NJ O'Driscoll RD Evans 2000 *Analysis of methyl mercury binding to freshwater humic and fulvic acids by gel permeation chromatography/hydride generation ICP-MS*, EST 34 4039-43 (6078).

EG Pacyna JM Pacyna 2002 *Global emission of mercury from anthropogenic sources in 1995*, WASP 137 149-65 (7490). [World emission 1900 tonnes. Three quarters from coal combustion -China, India and Korea contribute 56%, Europe & N. America <25%. Metal gas 53%, divalent gas 37%; on particles ~10%.]

SJ Perry 2001 *Mercury minimization*, WET Sep 92-7 (3035).

ME Pichichero & 3 others 2002 *Mercury concentrations and metabolism in infants receiving vaccines containing thiomersal: a descriptive study*, La 360 1737-41 (8391). [Contains ethylmercury; probably eliminated in a few days from blood via feces.]

J Qian & 5 others 2002 *Bonding of methyl mercury to reduced sulfur groups in soil and stream organic matter as determined by X-ray absorption spectroscopy and binding affinity studies*, GCA 66 3873-85 (8005). [Complex details.]

AW Rea SE Likndberg GJ Keeler 2001 *Dry deposition and foliar leaching of mercury and selected trace elements in deciduous forest through fall*, AE 35 3453-62 (6082). [Mg/Al/V/Cr/Mn/Cu/Zn/Rb/Sr/Cd/Ba/La/Ce/Pb.]

AW Rea & 3 others 2002 *Mercury accumulation in foliage over time in two Northern mixed-hardwood forests*, WASP 133 49-67 (6707).

R Renner 2002b *Ice cores open new window on historical mercury deposition*, EST 231-2A (7329). [See Schuster.]

SG Riddle & 3 others 2002 *Field, laboratory, and X-ray absorption spectroscopic studies of mercury accumulation by water hyacinths*, EST 36 1865-70 (7177). [Could phytoremediate Hg in Bay Area CA.]

F Roos-Barracough & 3 others 2002 *A 14 500 year record of the accumulation of atmospheric mercury in peat: volcanic signals, anthropogenic influences and a correlation to bromine accumulation*, EPSL 202 435-51 (8156). [Swiss Jura mountain bog. Pre-industrial: .3-8 microgram/square meter per year; Hg/Br spikes correlate with known eruptions; industrial 15 x higher, probably from non-Swiss coal burning in early 20C, and Swiss sources thereafter.]

AM Rouhi 2001 *Where to, mercury?* CEN Sep 24 35-8 (6086).

AM Rouhi 2002 *Mercury showers*, CEN Apr 15 40 (7119). [Hg depletion from troposphere.]

A Ryaboshapo & 8 others 2002 *Comparison of mercury chemistry models*, AE 36 3881-98 (8122).

D Sarkar ME Essington KC Misra 1999 *Adsorption of mercury(II) by variable charge surfaces of quartz and gibbsite*, SSSAJ 63 1626-36 (6092).

AV Savenko 1998 *The experimental modeling of mercury desorption in estuaries*, MM 62A 1324-5 (6111).

F Scala 2001 *Simulation of mercury capture by activated carbon injection in incinerator flue gas*. 1. In-duct removal, EST 35 4367-72, 2. Fabric filter removal, 4373-8 (5114).

WH Schroeder & 5 others 1998 *Arctic springtime depletion of mercury*, N 394 331-2 (6093).

PF Schuster & 8 others 2002 *Atmospheric mercury deposition during the last 270 years: A glacial ice core record of natural and anthropogenic sources*, EST 36 2303-10 (7332). [Wyoming glacier, 1720-1993: anthropogenic 52%, volcanic 6, background 42. 1750, 3 ng/L; Tambora 15; Gold Rush 17, Krakatoa 25 1930 8; 1982 25; Mt St Helens 32; 1993 13.]

P Sellers & 3 others 1996 *Photodegradation of methylmercury in lakes*, N 380 694-7 (6095).

G Sheu RP Mason 2004 *An examination of the oxidation of elemental mercury in the presence of halide surfaces*, J Atmos Chem 48 107-30 (10637).

PL Short 2001 *Negotiating away mercury emissions*, CEN Mar 21-4 (6096).

SD Siciliano NJ O'Driscoll DRS Lean 2002 *Microbial reduction and oxidation of mercury in freshwater lakes*, EST 36 3064-8 (7635). [In morning, microbes generate dissolved gaseous Hg; photochemical H₂O₂ causes lowering after noon by oxidation.]

LFF Silva & 3 others 2003 *Mercury accumulation in sediments of a mangrove ecosystem in SE Brazil*, WASP 145 67-77 (9247). [Complex details.]

L Sonesten 2003 *Catchment area composition and water chemistry heavily affects mercury levels in perch (Perca fluviatilis L.) in circumneutral lakes*, WASP 144 117-39. [Sweden boreal lakes. Complex: in general, highest Hg for lakes fed from arable land; dissolved ions correlate negatively; etc. Even though Sweden has cut down Hg emission, lakes may be richer in Hg, possibly from atmospheric deposition from elsewhere.]

P Suer B Allard 2003 *Mercury transport and speciation during electrokinetic soil remediation*, WASP 143 99-109 (8944). [Details.]

P Suer T Lifvergren 2003 *Mercury-contaminated soil remediation by iodide and electroreclamation*, JEE 129 441-6 (8942). [After 5 days, half of Hg migrated to anode, & another quarter in water near anode.]

C Temme & 3 others 2003 *Measurements of atmospheric mercury species at a coastal site in the Antarctic and over the South Atlantic Ocean during polar summer*, EST 37 22-31 (8667). [Fast oxidation of mercury gases during summer.]

JS Tsuji & 6 others 2003 *Evaluation of mercury in urine as an indicator of exposure to low levels of mercury vapor*, EHP 111 623-30 (8930). [0.77 correlation.]

A Turner GE Millward SM Le Roux 2001 *Sediment-water partitioning of inorganic mercury in estuaries*, EST 35 4648-54 (6098).

SM Ulrich TW Tanton SA Abdrashitova 2001 *Mercury in the aquatic environment: A review of factors affecting methylation*, CREST 31 241-93 (6100).

US Geological Survey 2004 *Geological studies of mercury by the U.S. Geological Survey*, Circular 1248, QE75.A23 (9673).

JA Vandeven SL McGinnis 2005 *An assessment of mercury in the form of amalgam in dental wastewater in the United States*, WASP 1643409-666l

GM Varshal & 8 others 1999 *Complex formation of mercury with humus acids: An important stage of the biospheric mercury cycle*, GI 37 229-34 (6101).

LM Vucetich & 4 others 2001 *Mercury concentrations in deer mouse (Peromyscus maniculatus)*, EnPo 114 113-8 (6103).

I Wagner-Döbler & 4 others 2000 *Removal of mercury from chemical wastewater by microorganisms in technical scale*, EST 34 4628-34 (6104).

Q Wang W Shen Z Ma 2000 *Estimation of mercury emission from coal combustion in China*, EST 34 2711-3 (6105).

W Wang Y Huang J Liu A Peng 2002 *Effect of some environmental factors on mercury (II) reduction by suspended particulate matter associated Kluvera cryocrescens biofilms in waterbodies*, WER 74 77-81 (7030). [Reduction to Hg(0) less for biofilm than for free bacteria.]

I Wängberg & 5 others 2001 *Estimates of air-sea exchange of mercury in the Baltic Sea*, AE 35 5477-84 (6106).

SM Wilhelm 2001 *Estimate of mercury emissions to the atmosphere from petroleum*, EST 35 4704-8 (3783).

K Xia & 5 others 1999 *X-ray absorption spectroscopic evidence for the complexation of Hg(II) by reduced sulfur in soil humic substances*, EST 33 257-61 (3661).

X Xu & 4 others 2000 *A regional scale modeling study of atmospheric transport and transformation of mercury. I. Model development and evaluation*, AE 34 4933-44 (4692); *II. Simulation results for the northeast United States*, 4645-55.

H Yang & 3 others 2002 *Mercury and lead budgets for Lochnagar, a Scottish mountain lake and its catchment*, EST 36 1383-8 (7033). [Peat & sediment cores to 1860. Most Hg/Pb is anthropogenic. Peat will release Hg/Pb for many years delaying restoration.]

P Zeitz MF Orr WE Kaye 2002 *Public health consequences of mercury spills: Hazardous Substances Emergency Events Surveillance System*, EHP 110 129-32 (7593). [Details of 406 events.]

H Zhang SE Lindberg 2001 *Sunlight and iron(III)-induced photochemical production of dissolved gaseous mercury in freshwater*, EST 35 928-35 (6108).

Nickel

Nickel is toxic to plants and animals in high concentration. Only around smelting plants does there seem to be any medical problems for humans.

M Anke & 6 others 2000 *Intake of nickel in Germany: Risk or normality?* J Trace & Microprobe Tech 18 549-56 (4229).

C Kennedy DS Smith LA Warren 2004 *Surface chemistry and relative Ni sorptive capacities of synthetic hydrous Mn oxyhydroxides under variable wetting and drying regimes*, GCA 68 443-54 (9896).

A Manceau & 7 others 2002 *Deciphering Ni sequestration in soil ferromanganese nodules by combining X-ray fluorescence, absorption, and diffraction at micrometer scales of resolution*, AM 87 1494-9. [Ni substitutes for Mn(II) in lithiophorite.]

A Manceau & 6 others 2003 *Molecular-scale speciation of Zn and Ni in soil ferromanganese nodules from loess soils of the Mississippi Basin*, EST 37 75-80 (8665).

NU Yamaguchi AC Scheinost DL Sparks 2001 *Surface-induced nickel hydroxide precipitation in the presence of citrate and salicylate*, SSSAJ 65 729-36 (4228).

Nuclear

This section covers mineralogical/geochemical aspects of remediation of the military nuclear waste together with the growing problem of the material from civil nuclear power stations. Various other aspects of nuclear phenomena are covered. In the USA, there are major leaks at Hanford and other nuclear war facilities, and concern about the potential for leaks at the Yucca Mountain site (MA 02M/3945-56 = special issue of AG). For Yucca Mountain there is considerable concern about future volcanic activity over the next millenium. In Russia there are huge areas contaminated with nuclear waste, and the Ch(o/e)rnobyl nuclear-reactor disaster in the Ukraine had world-wide fall-out. Etc. A few papers set the nuclear scene in the context of military affairs and terrorism.

A Abdelouas & 4 others 1995 *Structure and chemical properties of surface layers developed on R7T7 simulated waste glass altered in brine at 190°C*, EJM 7 1101-13 (5340).

D Adams 2002 *Public body appointed to clean up UK's nuclear legacy*, N 418 117 (7429).

T Allard & 3 others 1999 *Structural chemistry of uranium associated with Si, Al, Fe gels in a granitic uranium mine*, ChG158 81-103 (5405).

T Allard & 7 others 2003 *Radiation-induced defects in dickites from the El Berrocal granite system (Spain): relation with past occurrence of natural radioelements*, EJM 15 629-40 (9321).

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H Zhao & 4 others 2004 *Alteration of kaolinite to cancrinite and sodalite by simulated Hanford tank waste and its impact on cesium retention*, CICIM 52 1-13 (10068).

Phosphorus

P-rich waters get algal blooms that stink up beaches, and reduce O needed for plants and fish. Lake Erie became a cess pool in the 1960's but has recovered greatly in the past 40 years because of careful monitoring of input of P and other elements according to mandates from the Environmental Protection Agency. Replacement of P-bearing compounds in laundry chemicals with P-free LTA-type zeolite was a major advance. However, fertilizer leaks into streams and lakes, and human sewage is rich in P: their input must be reduced.

JL Barnard CE Scruggs 2003 *Biological phosphorus removal*, WET Feb 27-30 (8731). [BPR works can work cheaply with chemical polishing. Phosphate accumulating organisms (obligate aerobes) & glycogen acc. org. need volatile fatty acids. Remove sludge.]

Y Zhang IZhu X Zeng Y Lin 2004 *The biogeochemical cycling of phosphorus in the upper ocean of the East China Sea*, ECSS 60 369-79 (10410).

Platinum

No reports of medical hazards.

C Barbante & 8 others 2001 *Greenland snow evidence of large scale atmospheric contamination for platinum, palladium, and rhodium*, EST 35 835-9 (4032).

JFW Bowles AP Gize 2005 *A preliminary study of the release of platinum and palladium from metallic particles in the surface environment by organic acids: relevance to weathering of particles from vehicle exhaust catalysts*, MM 63 687-93.

KE Jarvis SJ Parry JM Piper 2001 *Temporal and spatial studies of autocatalyst-derived platinum, rhodium, and palladium and selected vehicle-derived trace elements in the environment*, EST 35 1031-7 (4030).

Rare Earths

F Elbaz-Poulichet C Dupuy 1999 *Behaviour of rare earth elements at the freshwater-seawater interface of two acid mine rivers: the Tinto and Odiel (Andalucia, Spain)*, AG 14 1063-72.

VS Sastri & 4 others 2003 *Modern Aspects of Rare Earths and their Complexes*, QD172.R2S27.

Selenium

Se is needed in small amounts for human health, but is a poison in high concentration.

D Amouroux & 4 others 2001 *Roles of oceans as biogenic sources of selenium*, EPSL 189 277-83 (4373).

LS Balistrieri TT Chao 1990 *Adsorption of selenium by amorphous iron oxyhydroxide and manganese dioxide*, GCA 54 739-51 (5920).

A Berken & 3 others 2002 *Genetic engineering of plants to enhance selenium phytoremediation*, Critical Reviews in Plant Sciences 21 567-82 (8380). [Progress in overexpressing potentially important enzymes involved in S/Se pathways.]

TG Chasteen R Bentley 2003 *Biomethylation of selenium and tellurium: microorganisms and plants*, ChR 103 1-22 (8642).

M Chiaradia F Cupelin 2000 *Gas-to-particle conversion of mercury, arsenic and selenium through reaction with traffic-related compounds (Geneva) Indications from lead isotopes*, AE 34 327-32 (3332).

I Falnoga & 3 others 2000 *Mercury, selenium, and cadmium in human autopsy samples from Idrija residents and mercury mine workers*, ER 84 211-8.

FM Fordyce & 3 others 2000 *Soil, grain and water chemistry in relation to human selenium-responsive diseases in Enshi District, China*, AG 15 117-32. [5 villages have low-Se rocks & Se-deficient diet, 5 have high-Se rocks and no diet problems, and 5 have high-Se rocks and Se-toxic disease. Se bioavailability is controlled by total soil Se, pH & sorption on organic and Fe-oxyhydroxides. Se is higher in maize & vegetables than rice.]

WT Frankenger Jr RA Engberg ed 2001 *Environmental Chemistry of Selenium*, Marcel Dekker, 0-8247-0136-4. [32 articles ranging from Se poisoning to chemistry, bacterial reduction & supplementation in agriculture.]

S Gao & 4 others 2003 *Selenium removal from irrigation drainage water flowing through constructed wetland cells with special attention to accumulation in sediments*, WASP 144 263-84. [Tulare Lake CA. Major Se sink is metal reduced from Se(VI) by reducing bacteria & plants.]

KJ Hintze & 3 others 2002 *Selenium accumulation in beef: Effect of dietary selenium and geographic area of animal origin*, JAgFC 50 3938-42 (7449). [Details.]

G Huel & 4 others 2000 *Does selenium reduce the risk of threatened preterm delivery associated with placental cytochrome P450-A1 activity?* ER 84 228-33 (4369).

D Peak DL Sparks 2002 *Mechanisms of selenate adsorption on iron oxides and hydroxides*, EST 36 1460-6 (7037). [EXAFS & FTIR. Selenate forms inner-sphere surface complex on hematite; outer- & inner- on goethite.]

CE Schlegel & 4 others *Bioavailability of particle-associated Se to the bivalve Potamocorbula amurensis*, EST 34 4504-10 (4368).

CP Schulthess Z Hu 2001 *Impact of chloride anions on proton and selenium adsorption by an aluminium oxide*, SSSAJ 65 710-8 (4375).

N Terry & 3 others 2000 *Selenium in higher plants*, Ann Rev Plant Physiol Plant Mol Biol 51 401-32 (4367).

US Geological Survey 1999 *Areas susceptible to irrigation-induced selenium contamination of water and biota in the Western United States*, US Geol Surv Circ 1180 (4374).

Z Wang Y Gao 2001 *Biogeochemical cycling of selenium in Chinese environments*, AG 16 1345-51. [Details of leaching, etc..]

R Yan & 5 others 2001 *Fate of selenium in coal combustion: volatilization and speciation in the flue gas*, EST 35 1406-10 (4371).

HS Yee CI Measures JM Edmond 1987 *Selenium in the tributaries of the Orinoco in Venezuela*, N 326 686-9 (4372).

BA Zachara A Pilecki 2000 *Selenium concentrations in the milk of breast-feeding mothers and its geographic distribution*, EHP 108 1043- (4370).

Y Zhang ZA Zahir WT Frankenger Jr 2003 *Factors affecting reduction of selenate to elemental selenium in agricultural drainage water by Enterobacter taylorae*, JAgFC 51 7073-8.

Y Zhang & 3 others 2004 *Selenate reduction in river water by Citerobacter freundii isolated from a selenium-contaminated sediment*, JAF 52 1594-600 (10095).

Strontium

See Nuclear

Sulfur, Sulfide & Sulfate

Many metallic ores are sulfides, and industrial waste generates sulfate. Burning of coal and S-rich oil generates acid rain. S is needed biologically, and plants take up small amounts in soil. But too much S is bad.

SR Jennings DJ Dollhopf WP Inskeep 2000 *Acid production from sulphide minerals using hydrogen peroxide weathering*, AG 15 235-43. [All common sulfide minerals except galena &

chalcocite generate acidity upon oxidative weathering; sulfates do not. Hence remediation must consider specific mineralogy.]

JA Sarnat & 5 others 2002 *Using sulfur as a tracer of outdoor particulate matter*, AST 36 5305-14 (8534). [Boston homes, indoor & outdoor. Details.]

Tin

Organo-tin compounds are medical hazards.

V Borghi C Porte 2002 *Organotin pollution in deep-sea fish from the northwestern Mediterranean*, EST 36 4224-8 (8141). [Details of serious levels.]

M Bueno & 4 others 2001 *Effect of solid surface composition on the migration of tributyltin in groundwater*, EST 35 1411-9 (4377).

H Hong & 3 others 2002 *Butyltin residues in blue mussels (*Mytilus edulis*) and arkshells (*Scapharca broughtonii*) collected from Korean coastal waters*, EnPo 117 475-86 (6118).

JB Nielsen J Strand 2002 *Butyltin compounds in human liver*, ER A88 129-33 (6979).

M Ohtsubo 1999 *Organotin compounds and their adsorption behavior on sediments*, Clay Science 10 519-39 = MA 00M/2435. [Change from cations to hydroxides with higher pH. Concentration in sediments much higher than in water.]

M Reisch 2001 *Maritime dilemma*, C&EN Nov 12 16 (4995). [Tributyltin being phased out as antifoulant.]

Q Zhou G Jiang J Liu 2001 *Small-scale survey on the contamination status of butyltin compounds in seafoods collected from seven Chinese cities*, JAgFC 49 4287-91 (4376).

Vanadium

AM Shiller L Mao 2000 *Dissolved vanadium in rivers: effects of silicate weathering*, CG 165 13-22 (4378).

Zinc

One-third of the catalysts in the human body contain zinc, and many people benefit from addition of Zn gluconate to their diet. Too much may be bad.

L Bendell-Young 1999 *Contrasting the sorption of Zn by oxyhydroxides of Mn and Fe, and organic matter along a mineral-poor to mineral-rich fen gradient*, AG 14 719-34. [Greater binding of Zn by surface peat of mineral-poor fen. Metal-organic matter - Fe oxide complexes important in *Sphagnum*-dominant peat.]

D Bryce-Smith 1989 *Zinc deficiency*, CB Aug 783-6 (5172).

DC Cooper & 3 others 2000 *Zinc immobilization and magnetite formation via ferric oxide reduction by *Shewanella putrefaciens* 200*, EST 34 100-6 (4382).

P Feiffer C Carl 1978 *Zinc and Other Micro-nutrients*, Keats, New Canaan CT 242p (5173).

RB Herbert Jr 2003 *Zinc immobilization by zerovalent Fe: surface chemistry and mineralogy of reaction products*, MM 67 1285-98.

M Isuare & 8 others 2002 *Quantitative Zn speciation in a contaminated dredged sediment by micro-PIXE, micro-SXRF, EXAFS spectroscopy and principal component analysis*, GCA 66 1549-67 (7160). [Mine smelter made ship canal sediment with coarse *sphalerite*, *willemite*, Zn, Fe-oxyhydroxides & *zincite*. Weathering moved Zn to the last one.]

F Juillot & 7 others 2003 *Occurrence of Zn/Al hydrotalcite in smelter-impacted soils from northern France: Evidence from EXAFS spectroscopy and chemical extractions*, AM 88 509-26. [Lille. Also *magnetite-franklinite*, *sphalerite*, *wurtzite*.]

DB Kent & 4 others 2002 *Effect of adsorbed metal ions on the transport of Zn- and Ni-EDTA complexes in a sand and gravel aquifer*, GCA 66 3017-36 (7980).

T Korolewicz & 3 others 2001 *Speciation and removal of zinc from composted municipal solid wastes*, EST 35 810-4 (4381).

K Lock CR Janssen 2001 *Ecotoxicity of zinc in spiked artificial soils versus contaminated field soils*, EST 35 4295-300 (4387).

A Manceau & 8 others *Quantative Zn speciation in smelter-contaminated soils by EXAFS spectroscopy*, AJS 300 289-343 (4384).

C Nuttall 1999 *Cleaning zinc out of the river Nent*, Geoscientist 9 4-6 (4385).

DR Roberts AC Scheinost DL Sparks 2002 *Zinc speciation in a smelter-contaminated soil profile using bulk and microspectroscopic techniques*, EST 36 1742-50 (7079). [Palmerston PA smelter. Zn in *franklinite* & *sphalerite*. Many details.]

ML Schlegel & 3 others 2001 *Adsorption mechanisms of Zn on hectorite as a function of time, pH, and ionic strength*, AJS 301 798-830 (7197). [EXAFS.]

AC Scheinost & 3 others 2002 *Combining selective sequential extractions, X-ray absorption spectroscopy, and principal component analysis for quantitative zinc speciation in soil*, EST 36 5021-8 (8462). [Smelter soils contain at top *franklinite* & *sphalerite*. Details.]

M Sole JM Casas C Lao 2003 *Removal of Zn from aqueous solutions by low-rank coals*, WASP 144 57-65. [Leonardite coal with lots of humus removed 90% of 2 ppm Zn in 2 hours for pH 4-6.]

CE Tommaseo DM Kersten 2002 *Aqueous solubility diagrams for cementitious waste stabilization systems. 3. Mechanism of zinc immobilization by calcium silicate hydrate*, EST 36 2919-25 (7476).

TP Trainor GE Brown Jr GA Parks 2001 *Adsorption and precipitation of aqueous Zn(II) on alumina powders*, JCIS 231 359-72 (131).

P Trivedi L Axe TA Tyson 2001 *An analysis of zinc sorption to amorphous versus crystalline iron oxides using XAS*, JCIS 244 230-8 (5440).

W Wang J Qiu P Qian 1999 *Significance of trophic transfer in predicting the high concentration of zinc in barnacles*, EST 33 2905-9 (4386).

SM Webb GG Leppard JF Gaillard 2000 *Zinc speciation in a contaminated aquatic environment: Characterization of environmental particles by analytical electron microscopy*, EST 34 1926-33 (4383).

SN Whiting MP De Souza N Terry 2001 *Rhizosphere bacteria mobilize Zn for hyperaccumulation by Thlaspi caerulescens*, ESR 35 3144-50 (4380).

SN Whiting & 3 others 2001 *Hyperaccumulation of Zn by Thlaspi caerulescens can ameliorate Zn toxicity in the rhizosphere of cocropped Thlaspi arvense*, EST 35 3237-41 (4379).

MS Yoo BR James 2002 *Zinc extractability as a function of pH in organic waste-amended soils*, SoS 167 246-59 (7150). [Details.]

F Ziegler R Giere CA Johnson 2001 *Sorption mechanisms of zinc to calcium silicate hydrate: Sorption and microscopic investigations*, EST 35 4556-61 (3523). [C-S-H(I) cement phase.]

Rock weathering

Weathering of rocks has always occurred with conversion of anhydrous minerals to hydrous ones, etc. Soil is a product of rock weathering. In modern times, weathering has increased because of more acid rain. This has been particularly bad for carbonate rocks, and marble statues have been severely eroded. Granite has been much more stable, probably because the feldspar became protected by a silica film as the Ca/K/Na/Al dissolved; indeed, the feldspar and quartz weather at about the same rate. Fungi are important in weathering, but details are very complex.

EB Alexander 2004 *Serpentine soil redness, differences among peridotite and serpentinite materials, Klamath Mountains, California*, IGR 46 754-64 (10538).

SP Anderson AE Blum ed 2003 *Controls on chemical weathering*, ChG 2002 191-456 (9866). [Special issue based on Goldschmidt conference.]

JF Banfield & 3 others 1999 *Biological impact on mineral dissolution: application of the lichen model to understand weathering in the rhizosphere*, PNAS 96 3404-11.

T Bjelland IH Thorseth 2002 *Comparative studies of the lichen-rock interface of four lichens in Vingen, western Norway*, CG 192 81-98 (8456). [Details.]

EP Burford M Fomina GM Gadd 2003 *Fungal involvement in bioweathering and biotransformation of rocks and minerals*, MM 67 1127-55.

G Certini & 3 others 2002 *Rock weathering promoted by embryonic soils in surface cavities*, EJSS 53 139-46. [Top of trachyte boulders. Cyanobacteria/algae/organic acids.]

M Chigira ed 2000 *Interdisciplinary studies of rock weathering*, EnG 65 1-130 (6323). [12 articles include salt weathering of brick monuments, Thailand; deterioration of stone, Angkor, Thailand.]

RH Dott Jr 2003 *The importance of aeolian abrasion in supermature quartz sandstones and the paradox of weathering on vegetation-free landscapes*, JG 111 387-405.

GH Girty & 10 others 2003 *Assessing changes in elemental mass as a result of chemical weathering of granodiorite in a Mediterranean (hot summer) climate*, JSR 73 434-44 (8939). [Peninsular Ranges CA. Plagioclase feldspar leached faster than K-feldspar.]

M Hamer 1998 *Heavy duty. Invisible mending can help brick bridges to take the strain*, NS 5 Dec 17 (6324). [Hidden stainless steel rods.]

P Hinsiger & 4 others 2001 *Plant-induced weathering of a basaltic rock: Experimental evidence*, GCA 65 137-52 (5921). [Increased by plants at first. Both with/without plants decrease with time.]

S Hiradate S Wada 2005 *Weathering process of volcanic glass to allophane determined by ²⁷Al and ²⁹Si solid-state NMR*, CICIM 53 401-8.

LR Kump SL Brantley MA Arthur 2000 *Chemical weathering, atmospheric CO₂, and climate*, Ann Rev Earth Planet Sci 28 611-67 (6325).

F Rey & 3 others 2004 *Role of vegetation in protection against surface hydric erosion*, CRG 336 991-8 (10484).

JR Rogers PC Bennett 2004 *Mineral stimulation of subsurface microorganisms: release of limiting nutrients from silicates*, ChG 203 92-108 (9661).

C Rodriguez-Navarro & 3 others 2003 *Conservation of ornamental stone by Myxococcus xanthus-induced carbonate biomineralization*, AEM 2182-93 (8866). [Successful treatment of carbonate by infilling calcite holes.]

JR Rogers PC Bennett 2004 *Mineral stimulation of subsurface microorganisms: release of limiting nutrients from silicates*, ChG 203 91-108 (9881).

L Rowan ed 2004 *Touch and go*, S 305 793-845; news story 770-1 (10560). [12 articles on Mars Exploration Rover Spirit in Gusev crater shows hematite balls, sulfates.]

S Siegesmund A Vollbrecht T Weiss ed 2002 *Natural Stone, Weathering Phenomena, Conservation Strategies and Case Studies*, Geol Soc Spec Publ 205, 1-86239-123-8 (9119). [31 contributions including: gypsum-based mortars & products; biofilms on carbonates; weathering in Budapest/Cairo/Paris/Portugal/Saxony/Venice/Vienna/etc; marbles; granites; sandstones.]

JL Smellie MG Chapman ed 2002 *Volcano-Ice Interaction on Earth and Mars*, GSL Spec Publ 202, QE522.V63. [21 contributions including ferrihydrite/serpentine/smectite in Iceland & Hawaii; microbial alteration of basaltic glass in oceanic crust.]

JV Smith 1998 *Atmospheric weathering and silica-coated feldspar: analogy with zeolite molecular sieves, granite weathering, ornamental slabs and ceramics*, PNAS 95 3366-9.

MR Smith ed 1999 *Stone: Building Stone, Rock Fill and Armourstone in Construction*, TA426.S76. [10 chapters.]

W Stumm R Wollast 1990 *Coordination chemistry of weathering: Kinetics of the surface-controlled dissolution of oxide minerals*, RG 28 53-69 (6332). [Classical theory.]

AE Taunton SA Welch JF Banfield 2000 *Geomicrobiological controls on light rare earth element, Y and Ba distributions during granite weathering and soil formation*, JAICo 303-4 30-6 (9864).

Water

<http://water.usgs.gov/nawqa>. <http://soundwaves.usgs.gov>.

This section could be infinite, and is being restricted to papers specifically on mineralogy and geochemistry, and to a few general papers on large dams and reservoirs, plus supply and quality of groundwater. See US Department of Agriculture 2003 *National Water Quality Handbook*, TD223.U533; & US Geological Survey Circulars on *Water Quality in (various) River Basins*, QE75.A23.

HA Al-Abadleh VH Grassian 2003 *FT-IR study of water adsorption on aluminum oxide surfaces*, La 19 341-7 (8654). [Covers adsorption of nitric acid on atmospheric dust particles. For corundum 0001, get ordered water for relative humidity <10 %, increasing disorder with liquid like > 70%.]

P Aldhous ed 2003 *The world's forgotten crisis*, N 422 251-6 (8618). ["Over a billion people cannot get clean water, and things are getting worse." Maps showing access to safe water, running dry, disease burden from unsafe water, flashpoints for conflict. Bangladesh delta blues.]

WM Alley & 3 others 2002 *Flow and storage in groundwater systems*, S 296 1985-90 (7414).

WM Alley TE Reilly OL Franke 1999 *Sustainability of ground-water resources*, US Geol Survey Circ 1186 (4786).

BMR Appenzeller & 3 others 2002 *Influence of phosphate on bacterial adhesion onto iron oxyhydroxide in drinking water*, EST 36 646-52 (6191). [Decrease of 75% *E. coli* by adding phosphate. Details.]

SK Baish SD David WL Graf 2002 *The complex decisionmaking process for removing dams*, Env May 21-31 (7298).

A Becker U Grünwald 2003 *Flood risk in Central Europe*, S 300 1099 (8976). [Must keep out of flood plains.]

ES Bernhardt & 25 others 2005 *Synthesizing U. S. river restoration efforts*, S 308 636-7 (11000).

G Bitton 1999 *Wastewater Microbiology*, 2nd ed, Wiley-Liss, QR48.B53.

SH Bottrell & 5 others 2000 *Controls on bacterial sulphate reduction in a dual porosity aquifer system: The Lincolnshire Limestone aquifer, England*, ChG 169 461-70 (4764).

N Boulay M Edwards 2000 *Copper in the urban water cycle*, CREST 30 297-326 (4722).

CJ Bowser BF Jones 2002 *Mineralogic controls on the composition of natural waters dominated by silicate hydrolysis*, AJS 302 582-662 (8231). [Calculations sensitive to composition of *feldspar*, *mica*, *amphibole*, etc.]

PJ Bremer BJ Webster DB Wells 2001, *Biocorrosion of copper in potable water*, JAWWA Aug 82-91 (4799). [Possible importance of microbes.]

SS Buehler RA Hites 2002 *The Great Lakes' Integrated Atmospheric Deposition Network*, EST Sep 1 354-9A (7983). [IADN has 14 stations measuring toxic materials with time. Cities have higher PCBs than rural areas.]

M Burke 2000, *Managing China's water resources*, EST May1 218-21A (4787). [North is short, south OK. Yellow River does not reach sea for half the year. Cities need water now used for agriculture. Four-fifths of rivers too polluted for fish. Etc.]

WM Chan FT Cheng WK Chow 2002 *Susceptibility of materials to cavitation erosion in Hong Kong*, AWWAJ 94:8 76-84 (8037). [Stainless steel > brass > bronze > cast iron > copper.]

RJ Charbeneau 2000 *Groundwater Hydraulics and Pollutant Transport*, TC176.C43.

MAI Chowdhury MF Ahmed MA Gaffar 2002 *Management of nonrevenue water in four cities of Bangladesh*, AWWAJ 94:8 64-75 (7950). [Severe water leakage estimated at 1/4 to 1/2.]

G Clarke & 3 others 2003 *Superlakes, megafloods, and abrupt climate change*, S 301 922-3 (9203). [8200 ybp. Lake Agassiz.]

J Cribb 2002 *Underground movements for water banks*, AuS Nov/Dec 28-30 (8384). [Underground dams for storage and purification.]

AP Davis & 4 others 2003 *Water quality improvement through biotension: lead, copper, and zinc removal*, WER 75 73-? (8600). [Water runoff from roads etc treated using mulch, soil & plants.]

FA DiGiano & 13 others 2004 *Safe water for everyone*, WET Jun 31-6 (10334).

CB Dowling RJ Poreda AR Basu 2003 *The groundwater geochemistry of the Bengal Basin: Weathering, chemisorption, and trace metal flux to the oceans*, GCA 67 2117-36 (9110).

JD Doyle SA Parsons 2002 *Struvite formation, control and recovery*, WR 36 3925-40 (8176). [Problems with scaling.]

JD Doyle & 4 others 2003 *Chemical control of struvite precipitation*, JEE 129 419-26 (8943). [Scale inhibitors no good. EDTA was best chelator: EDTA/struvite = 2 cause dissolution.]

CE Dunlap R Bouse AR Flegal 2000, *Past leaded gasoline emissions as a nonpoint source tracer in riparian systems: A study of river inputs into San Francisco Bay*, EST 34 1211-5 (4795). [Pb isotopes indicate that half present Pb from leaded gasoline.]

SM Eberts LL George 2000, *Regional ground-water flow and geochemistry in the Midwestern basins and arches aquifer system in parts of Indiana, Ohio, Michigan, and Illinois*, 0-607-92669-4 (4734). [Maps of geology & water use.]

A Ertunc 1999 *The geological problems of the large dams constructed on the Euphrates River (Turkey)*, EnG 51 167-82 (6592). [Problems of leaks, partly reduced by grout.]

T Estrella & 11 others 1999 *Sustainable Water Use in Europe. Part 3: Extreme Hydrologic Events: Floods and Droughts*, 92-9167-306-4. [Thorough coverage.]

AI Frenkel GV Korshin AL Ankudinov 2000 *XANES study of Cu²⁺-binding sites in aquatic humic substances*, EST 34 2138-42 (4793).

G Furrer & 4 others 2002 *The origin of aluminum flocs in polluted streams*, S 297 2245-7 (8030).

T Gaiser & 3 others ed 2003 *Global Change and Regional Impacts, Water Availability and Vulnerability of Ecosystems and Society in the Semiarid Northeast of Brazil*, Springer, QC988.B8G56.

Y Gao A Mucci 2003 *Individual and competitive adsorption of phosphate and arsenate on goethite in artificial seawater*, ChG 199 91-109 (9108).

R Glazier & 4 others 2003 *Nanotechnology takes root*, CEn May 64-9 (8951). [Nanometer particles of Fe(0) coated with noble metal catalyst donate electrons, destroying pesticides in groundwater.]

PH Gleik 2003 *Global freshwater resources; soft-path solutions for the 21st century*, S 302 1524-7 (9644).

PH Gleick S Postel 2001, *Safeguarding our water. Making every drop count; Growing more food with less water*, SA Feb 38-55 (4754). [Various points: Mexico City leaks would supply Rome. Why flush toilets with potable water? Irrigation must be more widespread & less wasteful. Etc.]

W Graves ed 1993 *Water. The power, promise, and turmoil of North America's fresh water*, National Geographic Special Edition (4770).

PA Hamilton JD Stoner RJ Gilliom 2000, *Water quality, why geology matters*, Gt Jun 20-3 (4782). [Pesticides everywhere in USA.]

VMC Herzl & 3 others 2003 *Species of dissolved Cu and Ni and their adsorption kinetics in turbid riverwater*, ECSC 56 43-52.

B Hileman 2003 *Fluoride concerns surface once again*, CEN Aug 25 22-3 (9252). [New concerns about skeletal fluorosis from water meeting EPA standard to be checked by NRC committee.]

MI Hornberger & 7 others 2000, *Linkage of bioaccumulation and biological effects to changes in pollutant loads in south San Francisco Bay*, EST 34 2401-9 (4791). [Ag/Cu/Zn down at mudflat 1 km from domestic sewage treatment plant. Details.]

PK House & 3 others ed 2002 *Ancient Floods Modern Hazards*, QE39.5.P27A53.

PR Hunter M Waite E Ronchi ed 2003 *Drinking Water and Infectious Disease. Establishing the Links*, RA1216.D74.

V Ittekkot 2003 *A new story from the Ol'Man River*, S 301 56-8. [Chemical weathering in the Mississippi Valley.]

N Johnson C Revenga J Echeverria 2001, *Managing water for people and nature*, S 292 1071-2 (4741). [Use cost to make sustainable.]

B Jones RW Renaut MR Rosen 2001 *Biogenicity of gold- and silver-bearing siliceous sinters forming in hot (75 °C) anaerobic spring-waters of Champagne Pool, Waiotapu, North Island, New Zealand*, JGSL 158 895-911 (9862).

S Khagram 2003 *Neither temples or tombs*, Env 45 May 28-37 (8947). [Ecosystem plus/minus of large dams.]

K Kloor 2000, *Everglades restoration plan hits rough waters*, S 288 1166-7 (4788).

MH Kramer G Quade P Hatemann M Exner 2001 *Waterborne diseases in Europe 1986-96*, AWWAJ Jan 48-53 (4747).

J Landers 2003 *Saving the bay*, CEn Jan 54-82 (9056). [Chesapeake needs less nutrients.]

JA Leenheer J Croué 2003 *Characterizing dissolved organic matter*, EST 18-26A (8670). [Complex mixture of aliphatic/organic hydrocarbons.]

E Lydersen S Lofgren RT Arnesen 2002 *Metals in Scandinavian surface waters: Effects of acidification, liming, and potential reacidification*, CREST 32 73-295 (7193).

DA Lytle VL Snoeyink 2002 *Effect of ortho- and polyphosphates on the properties of iron particles and suspensions*, AWWAJ 94:10 87-99 (8109).

JA Macdonald 2000 *Evaluating natural attenuation for groundwater cleanup*, EST 346-53A (4768). [National Research Council report.]

I McBeth KJ Reddy QD Skinner 2003 *Chemistry of trace elements in coalbed methane product water*, WR 37 884-90 (9113). [Al/As/B/Ba/Cr/Cu/F/Fe/Mn/Mo/Se/Zn. Precipitated barite/rhodochrosite/smithsonite in holding ponds.]

LS McNeill M Edwards 2001, *Iron pipe corrosion in distribution systems*, JAWWA Jul 88-100 (4730). [Review of 300 references. Scale consists of calcite, siderite, green rust, etc. Phosphate inhibitors.]

Z Milán & 7 others 2001 *The removal of bacteria by modified natural zeolites*, JESH A36 1073-87 (4721).

SM Miller CW Sweet JV Depinto KC Hornbuckle 2000, *Atrazine and nutrients in precipitation: Results from the Lake Michigan Mass Balance study*, EST 34 55-61 (4779).

National Water-Quality Assessment (NAWQA) 2000 *Water Quality in the Central Arizona Basins, Arizona, 1995-98*, USGS Circ 1213 (4723).

National Water-Quality Assessment (NAWQA) 2000 *Water Quality in the Eastern Iowa Basins, Iowa and Minnesota, 1996-98*, USGS Circ 1210 (4724).

National Water-Quality Assessment (NAWQA) 2000 *Water Quality in South-Central Texas, Texas, 1996-98*, USGS Circ 1212 (4729).

National Water-Quality Assessment (NAWQA) 2000 *Water Quality in the Mississippi Embayment, Mississippi, Louisiana, Arkansas, Missouri, Tennessee, and Kentucky 1995-98*, USGS Circ 1208 (4731).

BN Nelson & 4 others 2003 *In situ, anaerobic, biological immobilization of uranium, molybdenum and selenium in an alluvial aquifer*, ME March 31-6 (8653). [Homestake Mine Reclamation Project. Practical success using glucose etc as C source, with orthophosphate and ammonium supplements.]

SC Nixon & 5 others 2000 *Sustainable use of Europe's water*, European Environment Agency, Environmental Assessment Ser no 7, TD255.S879.

DN Pandey AK Gupta DM Anderson 2003 *Rainwater harvesting as an adaptation to climate change*, CuS 85 46-59.

F Pearce 2003 *Replumbing the planet*, NS 178 2398 30-4. [Water from Three Georges dam to move from Yangze to Yellow river. India/Spain/Africa/Australia have similar big plans. But ecological problems with water leaks, etc.]

N Pinter 2005 *One step forward, two steps back on U. S. floodplains*, S 308 207-8 (11019).

RH Platt PK Barten MJ Pfeffer 2000, *A full, clean glass? Managing New York City's watersheds*, Env Jun 8-20 (4781).

TD Potter BR Colman 2003 *Handbook of Weather, Climate, and Water. Dynamics, Climate, Physical Meteorology, Weather Systems, and Measurements*, QC880.H34.

IDB Quintal & 4 others 2000 *Determination of cadmium and lead species in the water column of the Jose Antonio Alzate reservoir, Mexico*, WER 72 132-8 (4790).

V Ramanathan PJ Crutzen JT Kiehl D Rosenfeld 2001 *Aerosols, climate, and the hydrological cycle*, S 294 2119-23 (9057).

PA Raymond JJ Cole 2003 *Increase in the export of alkalinity from North America's largest river*, S 301 88-90 (9119).

KC Rice 1999 *Trace-element concentrations in streambed sediment across the conterminous United States*, EST 33 2499-504 (4737).

B Richter S Postel 2004 *Saving Earth's rivers*, IST Spring 31-6 (10151).

SR Roalson & 3 others 2003 *Enhanced softening: Effects of lime dose and chemical additions*, AWWAJ 95(11) 97-103 (9541).

NS Robins ed 1998 *Groundwater Pollution, Aquifer Recharge and Vulnerability*, GSL Spec Publ 130.

P Sarin & 3 others 2003 *Iron release from corroded, unlined cast-iron pipe*, AWWAJ 95(11) 85-996 (9541).

A Scheidleder & 13 others 1999 *Groundwater Quality and Quantity in Europe*, TD255.G768 (4789).

D Schulze-Makuch & 8 others 2002 *Surfactant-modified zeolite can protect drinking water from viruses and bacteria*, Eos 83(18) 193-201 (7407). [*Clinoptilolite*.]

M Sever 2004 *Western aquifers under stress*, Gt May 32-3 (10263). [Denver basin & High Plains aquifer.]

JA Smith SE Burns ed 2001 *Physicochemical Groundwater Remediation*, Kluwer, 0-306-46569-8. [15 chapters.]

P Sobiech 2002 *Water for people and USEPA - Creating healthy partnerships with Africa's urban poor*, AWWAJ 94:8 46-51 (7945). [Example is Kibera in Nairobi where ~0.6M people live in 1 square mile on <1US\$/day. Details.]

S Squire & 3 others 2002 *Decadal trends of silver and lead contamination in San Francisco Bay surface waters*, EST 36 2379-86 (7333). [Ag going down, but Pb stays up.]

AJ Stocking IH Suffet MJ McGuire MC Kavanagh 2001 *Implications of an MTBE odor study for setting drinking water standards*, JAWWA Mar 95-102 (4738).

I Stratful DM Scrimshaw JN Lester 2004 *Removal of struvite to prevent problems associated with its accumulation in wastewater treatment works*, WER 76 437-43 (10709).

P Swarzenski P Campbell 2004 *Tracking contaminants down the Mississippi*, Gt May 40-1 (10264).

GN Textor M Kothawala 2003 *Making the transition*, CEn May 58-63 (8949). [Transition Reservoir for flood water at Thornton Quarry, Chicago.]

Y Tani & 5 others 2004 *Sorptin of Co(II), Ni(II), and Zn (II) on biogenic manganese oxides produced by a Mn-oxidizing fungus, strain KR21-2*, JESHA 39 2641-60 (10712). [Relevant to cleanup of water.]

TA Thompson SJ Baedke 1997 *Strand-plain evidence for late Holocene lake-level variations in Lake Michigan*, GSA B 109 666-82 (4771). [Beach-ridge up-and-down 0.5-0.6 meter 29-38yr. jvs: linked to weather oscillations in the Atlantic Ocean?]

AH Tullo 2002 *Turning on the tap*, CEN Nov 18 37-42 (9055), [Growing industry.]; **R Mullin** *Basic materials keep a technology edge*, 44-8 [Filter-stage chemicals.]; **J Tremblay** *China changes gear*, 51-3 [Spending billions on treatment plants.]

US EPA 2002 *Onsite Wastewater Treatment Systems Manual*, TD745.O57.

US Geological Survey 2003 *Assessing Ground-Water Vulnerability to Contamination: Providing Scientifically Defensible Information for Decision Makers*, Circular 1224, QE75.A23.

US Geological Survey 2004 *Ground water in freshwater-saltwater environments of the Atlantic Coast*, Circular 1262.

H Vaux Jr 2002 *A U. S. water agenda for the twenty-first century*, Env May 32-43 (7297).

L Vigano & 14 others 2003 *Quality assessment of bed sediments of the Po River (Italy)*, WR 37 501-18 (9059).

M Vigil 2003 *Clean Water. An Introduction to Water Quality and Water Pollution Controls*, 2nd ed, TD370.V55.

CJ Vörösmarty P Green J Salisbury RB Lammers 2000 *Global water resources: Vulnerability from climate change and population growth*, S 289 284-8 (4780).

Ö Yavuz Y Altunkaynak F Güzel 2003 *Removal of copper, nickel, cobalt, and manganese from aqueous solution by kaolinite*, WR 37 948-52 (9058).

J Zhang CL Liu 2002 *Riverine composition and estuarine geochemistry of particulate metals in China - weathering features, anthropogenic impact and chemical fluxes*, ECSS 54 1051-70 (8129). [Detail. Lower than in Europe industrial rivers.]

R Zimmerman Jr 2002 *Goodbye to tea in Boston*, WET Feb 24-7 (5950). [Charles River Watershed Association. Complex details.]

General

Geological Hazards

B Hason 2005 *Learning from Natural Disasters*, S 308 1125-46.[Concentrates on the earthquake and Sumatra-Andaman 12/26/04.]

TM Kusky 2003 *Geological Hazards: A Sourcebook*, QE501.3.K795.

Population growth

Certainly, population growth continues to be a major problem for human welfare causing increased pressure on the quality of air, soil and water. In 2006, most growth is in underdeveloped countries, where sex education and contraception are inadequate. People move from rural to city life, and many try to emigrate to developed countries. Most developed countries (Japan, Italy, USA) have leveled off the population growth of their own native born citizens, mainly because women are given a fair chance to control their lives. However, some have population growth from illegal immigration, and some people have large families for religious reasons. Stricter control of immigration would help, but existing immigrants tend to have higher birth rates than the replacement level. Perhaps the best chance to minimize total growth is to fence off a large fraction of the land area, so that overcrowding will force population reduction in the occupied areas. I believe that the population of the World should be about one-half of the sustainable level as a guard against natural catastrophes. For the USA, a reduced population of about a quarter billion should be the limit. Japan & Singapore seem to going this way because of strict control on immigration. Rich people might consider buying up farmland and putting it into wilderness areas. For example for the mid-West USA, a huge prairie park would have many long-term advantages. Ideally Chicago should shrink in area by one-half, and so on. In an emergency caused by impact of a large bolide, the wilderness areas could be opened up to agriculture.

J Bongaarts RA Bulatao 2001 *Beyond Six Billion: Forecasting the World's Population*, National Academy Press. [Review: N 410 631-2 (8992). Authoritative projections.]

RP Cincotta J Wisniewski R Englema 2000, *Human population in the biodiversity hotspots*, N 404 990-2 (5729).

R Doyle 2002 *Assembling the future*, SA Feb 30 (3984). [List of immigrants per country.]

W Lutz W Sanderson S Scherbov 2001 *The end of world population growth*, N 412 543-5 (8993). [Details.]

K West 2002 *The billionaire conservationist*, SA Aug 34-5 (7907). [Ted Turner owns 1M hectares, and set up Turner Foundation & Turner Endangered Species Fund.]

High pressure mineralogy *See individual minerals also.*

The invention of the diamond-anvil cell plus multi-anvil cells together with the development of high-intensity synchrotron X-ray and neutron sources has helped to revolutionize the understanding of the interior of the Earth and other bodies in the solar system. In addition, the Periodic Table of Elements at high pressure can be exploited with about half a million new

compounds to be expected. Only materials relevant to the Earth and to industrial activities are covered here. Many papers are listed in the alphabetic section, particularly for diamond.

From the geophysical viewpoint, high shock pressure is obtained during asteroid collisions. On Earth, volcanoes have brought up samples of the lower crust and upper mantle. Mineral inclusions stored inside diamonds are of particular interest. Complex metasomatism/metamorphism has to be sorted out to get information on the crust and particularly the mantle. Selected papers on imaging from seismic waves are listed.

The following papers give an introduction to this research area. When time permits this section should be subclassified.

Diffusion and partitioning in planetary interiors, Special Issue, PEPI 139 vi. [11 papers covering diamond/ferropericlase/garnet/magnesiowustite/perovskite (10061).]

High-pressure crystallography and synthesis, ZK 219-6(10594). [11 papers including ones on quartz analogs, sillimanite & kyanite, halite, sylvite.]

An Ernst Festschrift: AM 90 777-912. [14 papers covering mineralogy & petrology of high P/T terranes, P-T-ometry (& experimental phase relations).]

DH Abbott IS Isley 2002 *Extraterrestrial influences on mantle plume activity*, EPSL 205 53-62; discussion, 425-31 (10774).

J Adam T Green 2003 *The influence of pressure, mineral composition and water on trace element partitioning between clinopyroxene, amphibole and basaltic melts*, EJM 831-42.

Y Akahama & 4 others 2000 *Structural stability and equation of state of simple-hexagonal phosphorus to 280 GPa: Phase transition at 262 GPa*, PRB 61 3139-43 (1284).

M Akaogi & 4 others 2002 *High-pressure transformations in NaAlSiO₄ and thermodynamic properties of jadeite, nepheline, and calcium-ferrite phase*, PEPI 130 49-58 (6771).

M Akaogi A Tanaka E Ito 2002 *Garnet-ilmenite-perovskite transitions in the system Mg₄Si₄O₁₂-Mg₃Al₂Si₃O₁₂ at high pressures and high temperatures: phase equilibria, calorimetry and implications for mantle structure*, PEPI 132 303-24 (8113). [19-27 GPa & 1073-1273 K.]

JA Akins & 3 others 2004 *Shock-induced melting of MgSiO₃ perovskite and implications for melts in Earth's lowermost mantle*, GRL 31 L14612 (10570).

D Alfé MJ Gillian GD Price 2003 *Thermodynamics from first principles: Temperature and composition of the Earth's core*, MM 67 113-23. [Inner core boundary 5650±600 K; 8-10% S/Si & 8% O.]

NV Alymova & 3 others 2004 *Picroilmenite from kimberlites of the Daldyn Field, Yakutia*, DES 395A 444-7 (10394).

D Andrault 2003 *Cationic substitution in MgSiO₃ perovskite*, PEPI 136 67-78.

D Andrault N Bolfan-Casanova N Guignot 2001 *Equation of state of lower mantle (Al,Fe)-MgSiO₃ perovskite*, EPSL 193 501-8 (3866).

D Andrault M Madon JP Itie A Fontaine 1992 *Compression and coordination changes in pyroxenoids: an EXAFS study of MgGeO₃ enstatite and CaGeO₃ wollastonite*, PCM 18 506-13.

Y Asahara & 8 others 2005 *Formation of metastable cubic-perovskite in high-pressure phase transformation of Ca(Mg,Fe,Al)Si₂O₆*, AM 90 457-62.

IV Ashchepkov & 7 others 2004 *Mineralogy and geochemistry of mantle inclusions and mantle column structure of the Yubileynaya kimberlite pipe, Alakit Field, Yakutia*, DES 395A 378-84 (10398).

C Aubaud EH Hauri MM Hirschmann 2004 *Hydrogen partition coefficients between nominally anhydrous minerals and basaltic melts*, GRL 31 L20611 (10823). [Olivine/pyroxenes.]

J Badro & 7 others 1999 *Magnetism in FeO at megabar pressures from X-ray emission spectroscopy*, PRL 83 4101-4 (1289).

J Badro & 6 others 2003 *Iron partitioning in Earth's mantle: Toward a deep lower mantle discontinuity*, S 300 789-91 (8947). [High/low spin change in ferropericlase at 60-70 GPa.]

J Badro & 5 others 2004 *Electronic transitions in perovskite: possible nonconvecting layers in the lower mantle*, N 305 383-6 (10485).

- YuP Barashkov WL Griffin SB Tel'nikova** 1998 *Trace element composition of sulfide inclusions in garnets from the Udachnaya kimberlite pipe*, GI 36 1147-55 (7848).
- WA Bassett** 2003 *High pressure-temperature aqueous systems in the hydrothermal diamond anvil cell (HDAC)*, EJM 773-80.
- P Beck & 4 others** 2004 *A new natural high-pressure (Na,Ca)-hexaaluminosilicate $[(Ca_xNa_{1-x})Al_{3+x}Si_{3-x}O_{11}]$ in shocked Martian meteorites*, EJM 16 10 (10639).
- D Bercovici S Karato** 2003 *Whole-mantle convection and the transition-zone filter*, N 425 39-44 (9296).
- M Bizimis VJM Salters JB Dawson** 2003 *The brevity of carbonatite sources in the mantle: evidence from isotopes*, CMP 145 281-300 (9261).
- UW Blä? & 5 others** 2004 *A new oxygen-deficient perovskite phase $Ca(Fe_{0.4}Si_{0.6})O_{2.8}$ and phase relations along the join $CaSiO_3$ - $CaFeO_{2.5}$ at transition zone conditions*, PCM 31 52-65 (10018).
- BA Blyuman** 2002 *Possibility of the impact paragenesis of diamond-bearing eclogites with gray gneiss and basalt -komatiite complexes*, DES 384 409-11 (7362).
- C Bockrath C Ballhaus A Holzheid** 2004 *Fractionation of the platinum-group elements during mantle melting*, S 305 1951-3.
- R Boehler** 2000 *High-pressure experiments and the phase diagram of lower mantle and core materials*, RG 38 221-45 (1362).
- M Boiocchi & 4 others** 2001 *Crystal-chemical reasons for the immiscibility of periclase and wüstite under lithospheric P,T conditions*, EJM 13 871-81 (3413).
- N Bolfan-Casanova H Keppler DC Rubie** 2000 *Water partitioning between nominally anhydrous minerals in the MgO - SiO_2 - H_2O system up to 24 GPa: implications for the distribution of water in the Earth's mantle*, EPSL 182 200-21 (141).
- N Bolfan-Casanova** 2005 *Water in the Earth's mantle*, MM 69 229-57.
- N Bolfan-Casanova & 4 others** 2002 *Pressure dependence of H solubility in magnesiowüstite up to 25 GPa: Implications for the storage of water in the Earth's lower mantle*, GRL 29 89 1-4. [Increases with P.]
- MA Bouhifd AP Jephcoat** 2003 *The effect of pressure on partitioning of Ni and Co between silicate and iron-rich metal liquids: a diamond-anvil cell study*, EPSL 209 245-55 (8862). [Less siderophile with higher P up to 42 GPa.]
- M Boyet RW Carlson** 2005 ^{142}Nd evidence for early(>4.53 Ga) global differentiation of the silicate earth, S 309 576-81.
- FE Brenker T Stachel JW Harris** 2002 *Exhumation of lower mantle inclusions in diamond: ATEM investigation of retrograde phase transitions, reactions and exsolution*, EPSL 198 1-9 (7275). [Kankan, Guinea. Multi-phase inclusion interpreted as $MgSiPvk + CaSiPvk$ to $MgSillm + CaSiPvk$ to *ringwoodite* + *stishovite* + $CaSiPvk$ to *cpx* + relict *ringwoodite*. Then *ringwoodite* to *wadsleyite* + tetragonal *Al-pyrope* symplectite. *Ca-carbonate*.]
- E Brizi & 3 others** 2003 *Clinopyroxenes from mantle-related xenocrysts in alkaline basalts from Hannuoba (China): augite-pigeonite exsolutions and their thermal significance*, CMP 145 578-84 (9322).
- G Bromiley N Hilaret C McCammon** 2004 *Solubility of hydrogen and ferric iron in rutile and TiO_2 (II): implications for phase assemblages during ultrahigh-pressure metamorphism and for the stability of silica polymorphs in the lower mantle*, GRL 31 L0461 (10116).
- GD Bromiley AR Pawley** 2002 *The high-pressure stability of Mg-sursassite in a model hydrous peridotite: a possible mechanism for the deep subduction of significant volumes of H_2O* , CMP 142 714-23 (6988).
- JM Brown** 2001 *The equation of state of iron to 450 GPa: Another high pressure solid phase?* GRL 28 4339-42 (3427).
- HK Brueckner DA Carswell WL Griffin** 2002 *Paleozoic diamonds within a Precambrian peridotite lens in UHP gneisses of the Norwegian Caledonides*, EPSL 203 805-16 (8025). [Suggest metasomatic introduction of C into mantle wedge.]
- E Buffetaut C Koeberl ed** 2002 *Geological and Biological Effects of Impact Events*, Springer, 3-540-42286-2. [13 papers.]

- A Carraro** 2003 *Crystal chemistry of Cr-spinels from a suite of spinel peridotite mantle xenoliths from the Predazzo Area (Dolomites, Northern Italy)*, *EJM* 15 681-8 (9332).
- DA Carswell R Companoni ed** 2004 *Ultrahigh pressure metamorphism*, *EMU Notes in Mineralogy* 5.
- P Cartigny & 3 others** 2004 *Early Proterozoic ultrahigh pressure metamorphism: evidence from microdiamonds*, *S* 304 853-5 (10247).
- NL Chabot MJ Drake** 1999 *Potassium solubility in metal: the effects of composition at 15 kbar and 1900°C on partitioning between iron alloys and silicate melts*, *EPSL* 172 323-35 (1303).
- AR Chakhmouradian RH Mitchell** 2001 *Crystal structure of novel high-pressure perovskite $KTh_{2/3}Ti_{1/3}O_3$, a possible host for Th in the upper mantle*, *AM* 86 1076-80.
- GQ Chen TJ Ahrens EM Stolper** 2002 *Shock-wave equation of state of molten and solid fayalite*, *PEPI* 134 36-52 (8030).
- J Chen & 3 others** 2002 *Effect of water on olivine-wadsleyite phase boundary in the $(Mg,Fe)_2SiO_4$ system*, *GRL* 29 22 1-4. [Transition loop to lower P & narrower.]
- do** 2001 *Observation of cation reordering during the olivine-spinel transition in fayalite by in situ synchrotron X-ray diffraction at high pressure and temperature*, *PRL* 86 4072-5 (2910).
- J Chen DJ Weidner MT Vaughan** 2002 *The strength of $Mg_{0.9}Fe_{0.1}SiO_3$ perovskite at high pressure and temperature*, *N* 419 824-6 (8246).
- M Chen & 4 others** 2003 *Natural occurrence and synthesis of two new postspinel phases of chromite*, *PNAS* 100 14651-4 (9933). [Shock vein of Suizhou L6-chondrite. Calcium ferrite type made at 12.5-20 GPa in DAC, then to calcium titanate type.]
- M Chen A El Goresy P Gillet** 2004 *Ringwoodite lamellae in olivine: Clues to olivine-ringwoodite phase transitions in shocked meteorites and subducting slabs*, *PNAS* 101 15033-7 (10847).
- NJ Chinnery AR Pawley SM Clark** 1999 *In situ observation of the formation of 10 Å phase from talc + H_2O at mantle pressures and temperatures*, *S* 286 940-2 (1288).
- C Chopin** 2003 *Ultrahigh-pressure metamorphism: tracing continental crust into the mantle*, *EPSL* 212 1-14 (9112).
- L Chudinovskii R Boehler** 2001 *High-pressure polymorphs of olivine and the 660-km seismic discontinuity*, *N* 411 574-7 (2049).
- JI Chung H Kagi** 2002 *High concentration of water in stishovite in the MORB system*, *GRL* 29 16 1-4. [10 & 15 GPa, 1473 & 1673 K. 840 ppm matching Al etc.]
- F Comodi & 3 others** 2005 *The 10 Å phase: crystal structure from single-crystal X-ray data*, *AM* 90 1012-6. [Similar to 1M-mica.]
- P Cordier & 2 others** 2004 *Mechanical instability near the stishovite- $CaCl_2$ phase transition: implications for crystal preferred orientations and seismic properties*, *EJM* 16 387-99 (10486).
- P Cordier & 3 others** 2004 *Dislocation creep in $MgSiO_3$ perovskite at conditions of the Earth's uppermost lower mantle*, *N* 428 837-40, news & views 813-4 (10193).
- A Corgne BJ Wood** 2002 *$CaSiO_3$ and $CaTiO_3$ perovskite-melt partitioning of trace elements: Implications for gross mantle differentiation*, *GRL* 29 39 1-4. [Mg/Al/Si/Ca/Sc/Ti/Rb/Sr/Y/Zr/Nb/Cs/Ba/RE/Hf/Ta/Th/U.]
- WA Crichton NL Ross** 2002 *Equation of state of dense hydrous magnesium silicate phase A, $Mg_7Si_2O_8(OH)_6$* , *AM* 87 333-8.
- do** 2005 *Equation of state of dense hydrous magnesium silicates: results from single-crystal X-ray diffraction*, *MM* 69 273-87.
- I Daniel & 3 others** 2001 *Equation of state of Al-bearing perovskite to lower mantle pressure conditions*, *GRL* 28 3789-92 (3037).
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- L Davison Y Horie T Sekine ed** 2003 *High-Pressure Shock Compression of Solids V. Shock Chemistry with Applications to Meteorite Impact*, *TA417.7.C65H44*.
- JB Dawson** 2004 *A fertile harzburgite-garnet lherzolite transition: possible inferences for the roles of strain and metasomatism in upper mantle peridotites*, *Li* 77 553-69 (10708).
- J de Wit SH Richardson LD Ashwal** 2004 *Kaapval Craton special volume: An introduction*, *SAJG* 107 1/2 1-324; 22 articles, including **DR Bell RO Moore** *Deep chemical structure of the*

southern African mantle from kimberlite megacrysts, 59-80; **SB Shirey SH Richardson JW Harris** Age, paragenesis and composition of diamonds and evolution of the Precambrian mantle lithosphere of southern Africa, 91-106; **KJ Westerlund JJ Gurney** Silicate and oxide inclusion characteristics and infra-red absorption analysis of diamonds from the Klipspringer kimberlites, South Africa, 131-46.

V Dehant & 3 others ed 2003 *Earth's Core: Dynamics, Structure, Rotation*, AGU, QE509.2.E26. [18 papers including 3 on iron.]

P Deines 2002 *The carbon isotope geochemistry of mantle xenoliths*, ESR 58 247-78 (8279). [Degassing model not viable: suggests dissolved C in minerals and Si-C bonds.]

P Dera & 3 others 2002 *Characterization of a high-pressure phase of silica from the Martian meteorite Shergotty*, AM 87 1018-23. [Scrutinyite type.]

A Deuss & 3 others 2006 *The nature of the 660-kilometer discontinuity in Earth's mantle from global seismic observations of PP precursors*, S 311 198-202. [Find multiple reflections requiring phase transitions from 640-720 km. Consistent with pyroite.]

A Dewaele & 3 others 2000 *P-V-T equation of state of periclase from synchrotron radiation measurements*, JGRB 105 2469-77 (9030).

A Dewaele & 3 others 2003 *Measurement of refractive index and equation of state in dense He₂, H₂, H₂O, and Ne under high pressure in a diamond anvil cell*, PRB 67 094112 (8940).

A Dewaele & 2 others 2004 *Equations of state of six metals above 94 GPa*, PRB 70 094112 (10991). [Au/Ta/Pt to 94, Al/Cu/w to 153 GPa.]

G Dobosi G Kurat 2002 *Trace element abundances in garnets and clinopyroxenes from diamondites - a signature of carbonatitic fluids*, MP 76 21-38 (8219). [Framesite diamonds.]

LF Dobrzhinetskaya & 3 others 2002 *Silica precipitates in omphacite from eclogite at Alpe Arami, Switzerland: evidence of deep subduction*, JMG 20 481-92 (7666). [4 stages to 7 GPa.]

DP Dobson & 4 others 2003 *The equation of state of CsCl-structured FeSi to 40 GPa: Implications for silicon in the Earth's core*, GRL 30 14-1/4 (8854). [OK for substitution.]

DP Dobson PG Meredith SA Boon 2002 *Simulation of subduction zone seismicity by dehydration of serpentine*, S 298 1407-10 (8026). [Acoustic energy emission from antigorite at 1.5-8.5 GPa & 573-1173 K.]

L Dubrovinsky & 6 others 2001 *Chemical interaction of Fe and Al₂O₃ as a source of heterogeneity at the Earth's core-mantle boundary*, N 412 527-9 (2306).

L Dubrovinsky & 4 others 2001 *Stability of (Mg_{0.5}Fe_{0.5})O and (Mg_{0.8}Fe_{0.2})O magnesiowustites in the lower mantle*, EJM 13 857-61 (3412).

LS Dubrovinsky & 7 others 2001 *The hardest known oxide*, N 410 653-4 (8872). [TiO₂ > 60 GPa; cotunnite structure type.]

KN Egorov LV Solov'eva SG Simakin 2004 *Megacrystalline cataclastic Iherzolite from the Udachnaya Pipe: Mineralogy, geochemistry and genesis*, DES 397 5 698-702 (10605).

A El Goresy & 4 others 2001 *An ultradense polymorph of rutile with seven-coordinated titanium from the Ries crater*, S 293 1467-70 (5408). [Baddeleyite type.]

A El Goresy & 5 others 2001 *A natural shock-induced dense polymorph of rutile with alpha-PbO₂ structure from the Ries crater in Germany*, EPSL 192 485-95 (3625). [Matches synthetic.]

MI Eremets RJ Hemley H Mao E Gregoryanz 2001 *Semiconducting non-molecular nitrogen up to 240 GPa and its low-pressure stability*, N 411 170-4 (2060).

D Fee K Dueker 2004 *Mantle transition zone tomography and structure beneath the Yellowstone hotspot*, GRL 31 L18603 (10743).

G Fiquet 2001 *Mineral phases of the Earth's mantle*, ZK 216 248-71 (2046).

ME Fleet X Liu 2001 *High-pressure rare earth disilicates REE₂Si₂O₇ (REE = Nd, Sm, Eu, Gd): Type K*, JSSC 161 166-72 (3624).

DJ Frost 2003a *Fe²⁺-Mg partitioning between garnet, magnesiowustite and (Mg,Fe)₂SiO₄ phases of the transition zone*, AM 88 387-97. [Grossular, majorite, olivine, ringwoodite, wadsleyite. 9-18 GPa 1673-1973 K; EMPA.]

do 2003b *The structure and sharpness of (Mg,Fe)₂SiO₄ phase transformations in the transition zone*, EPSL 216 313-28 (9534).

DJ Frost Y Fei 1999 *Static compression of the hydrous magnesium silicate phase D to 30 GPa at room temperature*, PCM 26 415-8 (7851).

DJ Frost F Langenhorst 2002 *The effect of Al_2O_3 on Fe-Mg partitioning between magnesiowustite and magnesium silicate perovskite*, EPSL 199 227-41 (7342). [Multi-anvil at 25 GPa & 1923-2173 K.]

DJ Frost & 5 others 2004 *Experimental evidence for the existence of iron-rich metal in the Earth's lower mantle*, N 428 409-12.

P Fumagalli & 3 others 2001 *The 10Å phase: a high-pressure expandable sheet silicate stable during subduction of hydrated lithosphere*, EPSL 186 125-41 (1498).

GA Gaetani & 4 others 2003 *Mineral/melt partitioning of trace elements during hydrous peridotite partial melting*, CMP 145 391-45 (9260).

T Gasparik 2002 *Experimental investigation of the origin of majoritic garnet inclusions in diamonds*, PCM 29 170-80 (7255). [Multi-anvil at 10-15 GPa & 1873-2173 K. Natural majorites have Si indicating max. depth of 410 km. Conclude that world-wide eclogite layer at 200 to 410 km from crystallization of magma ocean. No olivine in this zone? Hence 410 discontinuity may be chemical boundary.]

T Gasparik 2003 *Phase Diagrams for Geoscientists. An Atlas for the Earth's Interior*, QE515.G33.

T Gasparik YA Litvin 2002 *Experimental investigation of the effect of metasomatism by carbonatitic melt on the composition and structure of the deep mantle*, Li 60 129-43 (7282). [20-24 GPa & 1873-2273 K. Conclude that c melt could occur in entire upper mantle and at least top of lower mantle. Moves faster than solid-state convection.]

GA Gaetani 2004 *The influence of melt structure on trace element partitioning near the peridotite solvus*, CMP 147 511-27 (10549).

GA Gaetani & 4 others 2003 *Mineral/melt partitioning of trace elements during hydrous peridotite melting*, CMP 145 391-405.

EJ Garnero 2004 *A new paradigm for the Earth's core-mantle boundary*, S 304 834-6 (10249).

L Gautron RJ Angel R Miletich 1999 *Structural characterisation of the high-pressure phase $CaAl_4Si_2O_{11}$* , PCM 27 47-51 (3601).

CK Gessmann BJ Wood 2002 *Potassium in the Earth's core?*, EPSL 200 63-78 (7376). [K,Na partitioning between Fe-S-O & silicate melt measured at 2.5 to 24 GPa & 1773-2173 K. No S, all K in silicate. With S, go into Fe liquid. For deep magma ocean, highest K in core is ~250 ppm. Many details.]

SA Gilder & 3 others 2004 *Magnetic properties of single and multi-domain magnetite under pressures from 0 to 6 GPa*, GRL 31 L10612 (10404).

P Gillet & 5 others 2002 *Raman spectroscopic study of garnet inclusions in diamonds from the mantle transition zone*, AM 87 312-7. [Majorite substitution.]

VP Glazkov & 4 others 2003 *Neutron diffraction investigation of the atomic and magnetic structures of MnAs at high pressure*, CrR 48 54-7 (8785).

AF Goncharov & 3 others 2001 *Spectroscopic studies of the vibrational and electronic properties of solid hydrogen to 285 GPa*, PNAS 98 14234-7 (4329).

Z Gong & 4 others 2004 *Equation of state and phase stability of mantle perovskite up to 140 GPa shock pressure and its geophysical implications*, GRL 31 L04614 (10112).

HW Green II 2004 *Shock-induced minerals in meteorite provide prospecting tools for mineral physics*, PNAS 101 6-7 (9671). [High-P polymorph of chromite.]

HW Green II 2005 *Psychology of a changing paradigm: 40+ years of high-pressure metamorphism*, IGR 47 439-56.

M Grégoire DR Bell AP Le Roex 2003 *Garnet Iherzolites from the Kaapvaal craton (South Africa): Trace element evidence for a metasomatic history*, JP 44 629-57. [Type 1 & 2 clinopyroxene, II matches MARID.]

IE Grey & 3 others 2000 *$CaAl_{12}Si_4O_{27}$, a new high-pressure phase containing Al_6O_{19} clusters*, JSSC 153 391-7 (3626).

Y Gung M Panning B Romanowicz 2003 *Global anisotropy and the thickness of continents*, N 422 707-10; news & views, 674-5 (8843).

- JJ Gurney & 3 others** 1999 *Proc VIIth International Kimberlite Conference, JB Dawson & PH Nixon* vols, 0-7992-1864-2, 1865-0.
- J Haines & 3 others** 2001 *Crystalline post-quartz phase in silica at high pressure*, PRL 87 15503-4 (3155).
- L Haines & 6 others** 2003 *Collapsing cristobalitelike structures in silica analogues at high pressure*, PRL 91 015503(4) (9107). [B(As/PO₄).]
- AN Halliday** 2004 *Mixing, volatile loss and compositional change during impact-driven accretion of the Earth*, N 427 505-9 (11019).
- T Hammouda** 2003 *High-pressure melting of carbonated eclogite and experimental constraints on carbon recycling and storage in the mantle*, EPSL 214 357-68 (9360).
- U Häussermann** 2003 *High-pressure structural trends of Group 15 elements: Simple packed structures versus complex host-guest arrangements*, CEJ 9 1472-8 (8848).
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Materials science & industry

Much of the comfort and ease of modern life results from advances in industry fueled by research in the material sciences. Zeolite molecular sieve catalysts are covered under Zeolites and the individual minerals. Steel becomes stronger as the chemistry and mechanical working is adjusted. And so on.

Cement & concrete

Cement dates back to the Roman era at least, but only now is it possible to determine the details of the mineralogical reactions during setting. Many advances in structural strength and integrity can be expected over the next decades. The major problem of corrosion of steel bars set in concrete may be reduced by surface protection as phosphorized iron. Mixing of horse hair and plastics into concrete mixes greatly increases resistance to twisting, and would help in earthquake zones.

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Ceramics

The hardest known material remains *diamond* and tremendous progress has been made in its use in grinding etc. For cutting steel however it fails because of reaction to make Fe carbide. Synthetic BN is suitable for this important job. Most ceramics are based on oxides.

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Electric Batteries

Tremendous progress has been made in making existing lead batteries more stable. In addition, Li and other batteries have proved invaluable. Storage of electrical energy in hybrid cars requires powerful batteries.

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Energy-related

The supply of energy is critical for modern civilization. In 2006, it appears that the key thing in energy use is to minimize the use of energy that is contributing to the enhanced greenhouse effect. Population reduction and conservation are the obvious ways to go. The actual use of energy can be minimized by not driving as much, switching off lights, using efficient fixtures, and decreasing heat loss. Reduction of use in war machines would release oil for civilian aviation. Oil is just beginning to peak out right now, and natural gas is becoming tighter. Wind and tides are increasingly used. These concepts are covered in *Living Safely*.

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SJ Baines RH Worden ed 2004 *Geological Storage of Carbon Dioxide*, 1-86239-163-7. [17 articles covering injection into saline aquifers & unmineable coal seams to minimize the enhanced greenhouse effect.]

AA Bartlett 2004 *Thoughts on long-term energy supplies: Scientists and the silent lie*, PT July 53-5 (10416). [Population growth is major problem.]

CO Bauer 2003 *Developing clean coal technology*, EST 27-34A (8669). [DoE National Energy Technology Laboratory programs.]

H Bearat & 4 others 2002 *Magnesium hydroxide dehydroxylation/carbonation reaction processes: implications for carbon dioxide mineral sequestration*, JACeS 85 742-8 (7226). [Brucite.]

B Beauchamp 2004 *Natural gas hydrates: myths, facts and issues*, CRG 336 751-65 (10464).

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CE Brown 2002 *World Energy Resources*, TJ163.2.B776.

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TS Collett 2004 *Gas hydrates as a future energy resource*, Gt 49 24-7 (10986).

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SJ Friedman 2003 *Storing carbon in Earth*, Gt March 16-20; *Demonstrating carbon sequestration*, 22-3; **K Bartlett** *Oil fields: giving and receiving*, 24; **LM Pinsker** *Value added in oil seams*, 25 (8673). [Choices: saline aquifers, depleted oil and gas fields, coal seams & enhanced coalbed methane recovery, oil shales; terrestrial & oceanic. Conversion to rock slow and too expensive.]

R Gieré LE Carleton GR Lumpkin 2003 *Micro- and nanochemistry of fly ash from a coal-fired power plant*, AM 88 1853-65. [Hematite/magnetite/mullite/quartz.]

J Giles 2004 *Every last drop*, N 429 694-5 (10390). ['Can underground fires and hydrocarbon-hungry bacteria keep the oil flowing?']

F Goodarzi 2002 *Mineralogy, elemental composition and modes of occurrence of elements in Canadian feed-coals*, F 81 1199-213 (7346). [Usual igneous & clay minerals plus gorceixite.]

CG Granqvist 2003 *Solar energy materials*, AdM 15 1789-802 (9628).

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T Hibino & 5 others 2000 *A low-operating-temperature solid oxide fuel cell in hydrocarbon-air mixtures*, S 288 2031-3 (5749).

RL Hirsch & 2 others 2005 *Peaking oil production: sooner rather than later*, IST Spring 25-30 (11015).

WS Holbrook & 6 others 2002 *Escape of methane gas through sediment waves in a large methane hydrate province*, G 30 467-70 (7170). [Seismic data suggest that significant gas escapes without being trapped as hydrate.]

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M Jacoby 2003 *Fuel cells move closer to market*, CEN Jan 20 32-6 (9038).

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J Johnson 2004b *Coal-fired power may get cleaner*, CEN 9/20 36-7 (10633). [New 1000-MW integrated gasification combined-cycle plant to be built by 2010 in Florida.]

J Johnson 2004c *Power from moving water*, CEN 10/4 23-30 (10714). [Tides.]

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(see also *iron*)

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Medical mineralogy

Various inorganic elements are important in the human body for the proper functioning of metalloproteins. The most obvious features are shown by bone & teeth, where the composition of apatite reflects the chemistry of the whole body. In 2006, in the advanced world, most young people get enough Ca, F etc to have strong teeth. Older people tend to have cavities, and dentists are beginning to fill these holes with appropriate chemicals rather than metal amalgams used in the past. *Alendronate sulfate* is being used to compensate from loss of apatite in bone that tends to occur in older women and men suffering from osteoporosis. Toxic elements are dealt with above.

Bone & teeth

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Fibers & particles in lung

All of us get particles in the lungs, and some of us develop cancer or mesothelioma. Mineralogists have identified a certain type of asbestos as particularly dangerous, but even so, mostly it is tobacco smokers who tend to get lung cancer. Small fibers are dangerous, including erionite zeolite in certain places.

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Structure & Classification

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Occurrence

This section merely begins to list a few of the near-infinite number of publications.

Mineralogical Record: currently has over 200 issues, often with details of a mining area; recent examples are: Mexico I, II Ojuela, III *Los Lamentos, Fresnillo, Las Vigas, Sierra de Cruces (Lake Jaco)* 2003 34(6); China, 2005 36(1); *Cripple Creek, CO*, 36(2).

Rocks and Minerals: currently has over 300 issues: recent example is special issue on China, 2004 80 (1).

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AH Ahmed S Arai 2003 *Platinum-group minerals in podiform chromitites of the Oman ophiolite*, CM 41 597-616.

SM Aleksandrov 2003 *Genesis and composition of ore-forming magnesian borates, their analogues, and modifications*, GI 41 440-58 (9112).

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SB Castor GC Ferdock 2004 *Minerals of Nevada*, QE375.N3C37 (10262).

GE Dunning & 4 others 2005 *The Clear Creek mine, San Benito County, California: A unique mercury locality*, MR 36 337-63. [23 known & 7 new Hg-minerals.]

EA Dunworth K Bell 2003 *The Turly Massif, Kola Peninsula, Russia: mineral chemistry of an ultramafic-alkaline-carbonatite intrusion*, MM 67 423-51. [Garnet/melilite/pyroxene/mica/magnetite/ilmenite/perovskite/apatite/götzenite/stronalsite/banalsite, etc.]

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C Gillen ed 2003 *Geology and Landscapes of Scotland*, QE264.G55.

DI Groves LG Gwalani ed 2004 *Carbonatites and associated mineralization*, MP 80 123-262. [Special issue with 7 articles mainly on isotopes.]

AL Hammond RH Mitchell 2002 *Accessory mineralogy of orangeite from Swartruggens, South Africa*, MP 76 1-19 (8218). [Includes unidentified Ca-Ti-Fe silicate & Ca-RE phosphate.]

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Mineral Deposits of China, 5 vol, 1990 TN101.M5513.

TP Moore PKM Megaw 2003 *Mexico II. The Ojuela Mine, Mapimí, Durango, Mexico*, MR 34 5-91. [117 minerals.]

IV Pekov 2005 *The Palitra Pegmatite, a newly discovered hyperalkaline pegmatite in the Lovozero Massif, Kola Peninsula, Russia*, MR 36 397-420.

OV Peterson 2001 *List of all minerals identified in the Ilimaussaq alkaline complex, South Greenland*, GGSB 190 25-33 (8684). [220 of which 27 are type.]

RO Sack 2005 *Origin of high-Ag fahlores from the Galena Mine, Wallace, Idaho, U.S.A.*, AM 90 1000-7.

DF Sangster ed 2003 *Nonsulfide zinc deposits: A new look*, EG 98 683-54. [8 articles.]
ID Sasowsky J Mylroie ed 2004 *Studies of Cave Sediments*, QE471.2.S86.
NH Trewin ed 2003 *The Geology of Scotland*, 4th ed, 1-86239-105-X.
RC Wang & 6 others 2003 *Accessory minerals in the Xihuashan Y-enriched granitic complex, southern China: A record of magmatic and hydrothermal stages of evolution*, CM 41 727-48.
M Zelenski S Bortnikova 2005 *Sublimation speciation at Mutnovsky volcano, Kamchatka*, EJM 17 107-18 (11028). [Rich in Cd/Tl/I. Two new sulfosalts: $\text{Cd}_4\text{PbBi}_{12}(\text{S},\text{Se})_{23}$ & $\text{CdPb}_4\text{Bi}_6\text{S},\text{Se})_{14}$.]

This completes the initial part of the database. As web searches become more productive, readers may wish to supplement the database with specific searches. The remainder of the database consists of an alphabetical listing of the known minerals. Readers may wish to supplement reading on high pressure (say) with looking at diamond, and other high pressure minerals.

For a general view on Living Safely, readers are advised to consult a book to be published with this title. Here it is emphasized that the world should abandon military forces, cut the population, store food and oxygen, and build shelters against potential asteroid impact. It should minimize the use of energy, and prepare for local increase in sea level by 100 to 300 feet (depending on the changes in mantle strain) and big tsunamis and hurricanes.