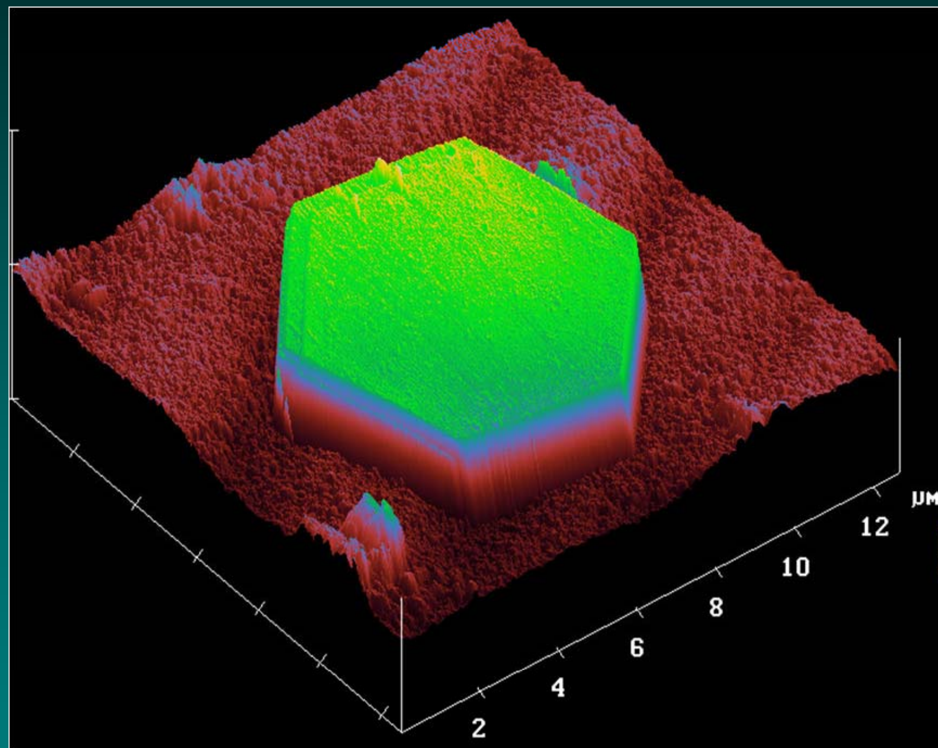
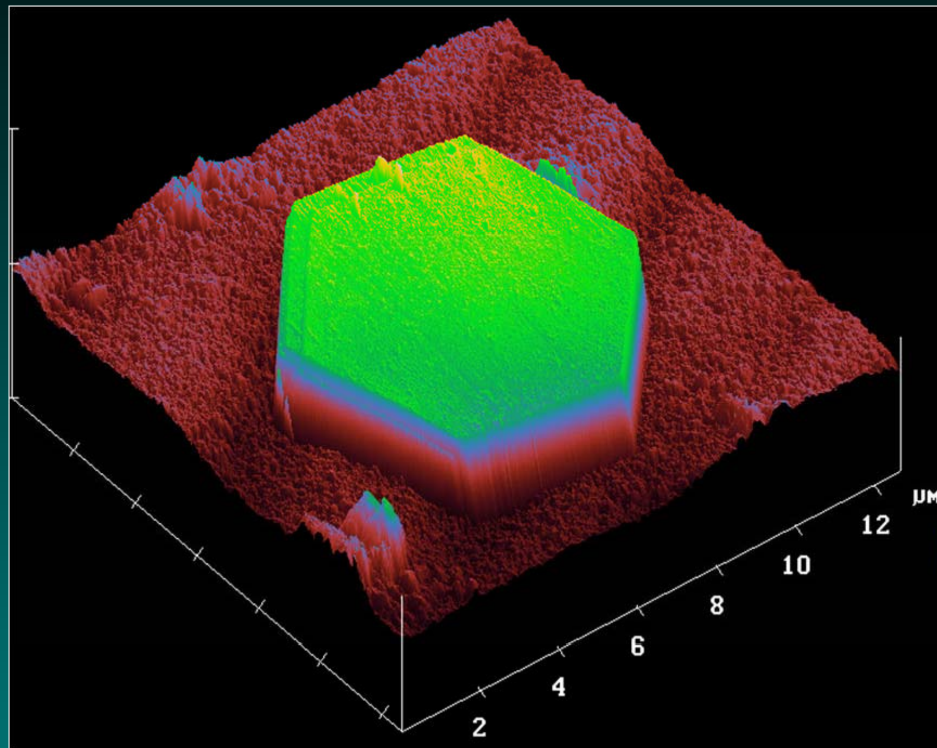
ΣΤΟΧΟΙ ΚΑΙ ΠΡΟΟΠΤΙΚΕΣ ΤΗΣ ΣΥΓΧΡΟΝΗΣ ΟΡΥΚΤΟΛΟΓΙΑΣ



PERSPECTIVES IN MODERN MINERALOGY

Dr. A. GODELITSAS, Univ. Athens - 2014



Εικόνα απο Μικροσκόπιο Ατομικής Δύναμης -Atomic Force Microscope /AFM - μικροκρυστάλλου ανθρακικού μολύβδου/$PbCO_3$ επιταξιακά ανεπτυγμένου στην επιφάνεια αραγονίτη (ορθορομβικό πολύμορφο του ανθρακικού ασβεστίου/$CaCO_3$)

GODELITSAS et al., ES&T 2003

ΟΡΥΚΤΟΛΟΓΙΑ

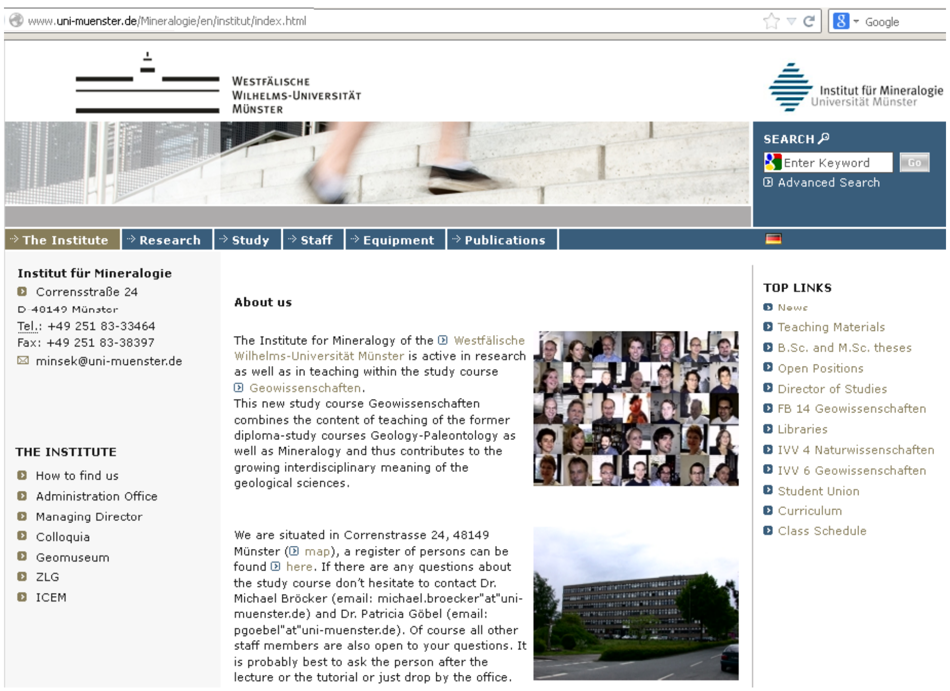
είναι ο κλάδος των Θετικών Επιστημών, που άπτεται των Μαθηματικών, της Χημείας, και της Φυσικής, και ασχολείται με την ΜΕΛΕΤΗ ΤΩΝ ΟΡΥΚΤΩΝ

Η Ορυκτολογία έχει άμεση σχέση με την Κρυσταλλογραφία (Crystallography),
την Πετρολογία (Petrology),
την Γεωχημεία (Geochemistry),
την Επιστήμη των Υλικών (Materials’ Science),
και αποτελεί βασικό και αναπόσπαστο πεδίο των Γεωλογικών και Περιβαλλοντικών Επιστημών

Η Ορυκτολογία αποτελεί επίσης σημαντικό αντικείμενο της Γεμμολογίας, της Εδαφολογίας, της Μεταλλουργίας, της Χημικής Τεχνολογίας, της Ωκεανογραφίας, της Οδοντιατρικής & Ιατρικής , της Κοσμετολογίας, της Αρχαιολογίας, της Συντήρησης Έργων Τέχνης, και των Πλανητικών Επιστημών

MINERALOGY

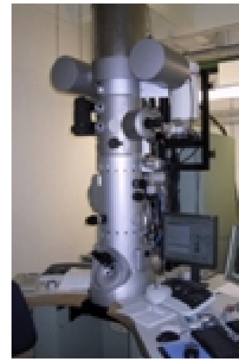
WESTFÄLISCHE WILHELMS-UNIVERSITÄT MÜNSTER



Firstly, let us state **what mineralogy is definitely NOT about:** Mineralogy is not about mineral oil, mineral water, mineral pills from the pharmacy, and mineral stands on flea markets - just like biology has nothing to do with market-gardens or pet shops. Also mineralogy is not a museum-science, which is about collecting, cataloguing, and exhibiting rocks. Since all solid parts of the universe are composed of minerals, mineralogy is a fundamental natural science with extensive meaning. The objects of research include materials that come from our earth, samples that are collected by people and machines on other planetary bodies, meteorites and stardust. Next to these natural samples, mineralogy is more and more concerned with different kinds of technical products, which have the characteristics of minerals.

WESTFÄLISCHE
WILHELMS-UNIVERSITÄT
MÜNSTER

Mineralogy today



Mineralogy has evolved from a describing science to an analytical and experimental science. Lots of analyzing methods were developed, in order to work on mineralogical questions. Examples for these methods are the microprobe, which can conduct rapid non-destructive point analyses of minerals and the mass spectrometer, which can determine isotope ratios of elements.

In order to simulate natural processes, experimental techniques were developed to produce the pressure- and temperature conditions in the lab as they occur in the earth’s interior. Furthermore, modern chemical and physical methods and procedures are adjusted to fit mineralogical issues. The newly acquired knowledge of minerals and solid materials are applicable to fields such as material science, retention and processing of natural resources, recycling and waste disposal as well as the development of new materials and analyzing procedures.

The new study course Geowissenschaften combines the content of teaching of the former diploma-study courses Geology-Paleontology as well as Mineralogy. At the Mineralogical Institute at the University of Münster the main foci are on research and teaching in the fields of petrology, geochemistry, crystallography, technical mineralogy as well as chemistry of mineral surfaces. A specialization in these fields can take place at our Institute.

Science 13 August **1999**:
Vol. 285. no. 5430, pp. 1026 - 1027

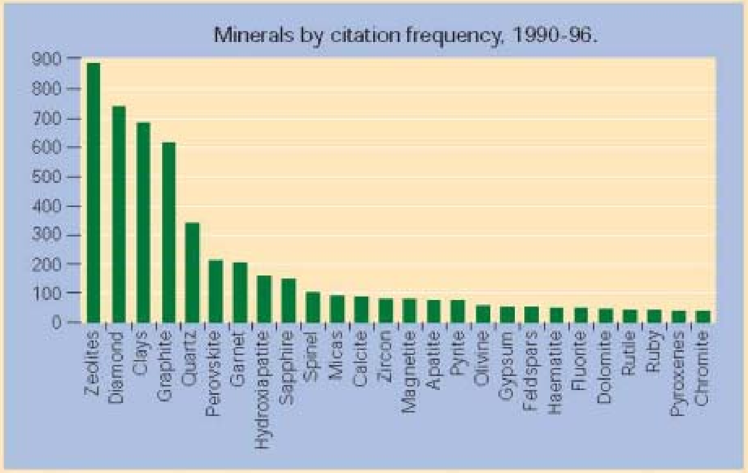
Mineralogy at a Crossroads

Russell J. Hemley, Carnegie Institution of Washington

Mineralogy, for a long time defined as the study of naturally occurring crystalline compounds formed as a results of inorganic processes, is at a crossroads. The above definition is now seen as far too restrictive, and a wider definition includes new high pressure/temperature minerals not yet found on Earth, amorphous, nano-, and mesoscopic materials and their dimensionality-dependent properties, extraterrestrial rocks, biologically precipitated minerals, and the role of minerals in the evolution of life. At the interface to technology, mineralogy is providing a stimulus both in terms of the materials studied and the tools applied to their investigation. The interdisciplinary nature of mineralogy is illustrated in an overview of recent developments in the field.

Citation analysis

Democracy on the rocks



Arguably the simplest way to review the state of a subject is not to commission an article by an expert reviewer, but just to make a statistical summary of what is going on in that field. Democracy does not have the same standing as a scientific methodology as it does as a principle for government, but would an objective summary of the subjects of published papers present a very different snapshot from an expert review?

In an article entitled "The most popular rock stars, scientifically speaking" (*Annals of Improbable Research* (5, 20; 1999)), Vidal Barrón makes a light-hearted attempt to do just this for mineralogy. Barrón analysed the titles of papers in mineralogy published from 1990 to 1996, recording the frequency of occurrence of names of minerals or mineral groups to identify the "most popular". His results are summarized in a histogram, reproduced here.

Mineralogy emerges as a subject whose remit swings rapidly from the slime to the sublime, with clays and diamond narrowly losing out to zeolites in the popularity stakes. This is an apt result because zeolites have filled both roles at different times — in the eighteenth century, fine zeolite specimens were among the most valuable minerals in the known world, but their prominence today is largely practical (for ion exchange and adsorption).

All five front-runners have important industrial applications, and clearly a high proportion of mineralogical research is being carried out in industry or at its behest. Number six, perovskite, is a curious star; this is a rare oxide that few mineralogists will have handled. The key to its popularity is that its densely packed structure is believed to be typical of mineral structures at high pressures in the mantle.

Overall, the list is dominated by industrial materials, with a smattering of gemstones and intellectually challenging exotica. The main rock-forming minerals barely figure. An obvious anomaly is that minerals that are exploited in their own right feature strongly, unlike metallic ores, which usually occur in complex assemblages and so are unlikely to be named specifically in a paper's title.

What the list tells us is that mineralogy is a mature discipline, with the emphasis on applications rather than fundamental discoveries — probably not a balance that an expert review would have reached. The academic emphasis is on minerals formed under extreme conditions in the inaccessible mantle. Considering that Earth scientists are proud of dealing with past events for which human activity is irrelevant and where hot silicates reign supreme, it is a little disconcerting to find that the top scorers are minerals rich in water or carbon — just as we are.

Bruce W. D. Yardley

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Mineralogical Society of America

www.minsocam.org

MINERALOGY: AN INCH DEEP AND A MILE WIDE?

Michael Hochella Jr.

Sure, why not. In so many important cases, the science that the world most needs is about making the right connections.

You have often heard it said, really good science is an inch wide and a mile deep. Science must have the "depth" to push the envelope of knowledge and peer into the world of the unknown. In many cases, that is certainly the case. But that was not the experience of Gerd Binnig and Heinrich Rohrer, two European physicists (German and Swiss, respectively) who in 1981 invented the scanning tunneling microscope. Their first publications on the method, in 1982, were each only a few pages long, but four years later, they were awarded the Nobel Prize for their discovery. Why? The key components of their new microscope (both instrumentation and the underlying quantum mechanics) were all known previously. However, their supreme triumph came from putting all these pieces together into a package, a package that nobody had ever imagined before them. With this microscope, they were the first to measure electron tunneling currents between a metallic tip and a semiconducting surface as a function of the tip-to-surface separation, which they could control with angstrom-level precision. Then, by adding lateral controllability of the tip, they realized that they had stumbled upon an atom-resolving microscope that required no lenses. Their astonishing achievement, with monumental consequences, resulted from thinking that was much, much broader than it was deep. And that was pure genius.

Look at some of the most influential and valued achievements of mineralogy in the past, which are, in my opinion, remarkable and positively key to the development of civilization. Yet they involved exceptionally broad thinking rather than deep probing of a single phenomenon:

- Early humans, including in all likelihood *Homo erectus* as early as several hundred thousand years ago, acquired the ability to make and utilize fire on demand by striking together a very hard mineral and an iron sulfide, like quartz and pyrite. This was certainly one of mankind's most important early inventions, allowing the development of cooking, providing protection and warmth, and permitting expansion of their livable geographic range.
- The writings of German physician Georg Bauer (Georgius Agricola) in the 16th century were the beginning of modern mineralogy and environmental science. His statements, such as "When the ores are washed, the water which has been used poisons the brooks and streams and either destroys the fish or drives them away," were extraordinarily broad and sophisticated observations and conclusions at the time.
- We have realized very recently that iron, a critical limiting nutrient of the phytoplankton of the world's oceans, can be provided by iron oxide nanominerals supplied by the weathering of continents. This process is an important factor in controlling the populations of these organisms, which in turn plays a critical role in global temperatures due to their dramatic influence on the amount of atmospheric CO_2.

Science from an integrated point of view is a vital part of the future of mineralogy. From an educational standpoint, we should change our questioning from how much mineralogy is taught in mineralogy courses to how much mineralogy is taught in an integrated Earth science curriculum, and in certain courses in the chemistry, physics, and biology curricula. But it goes further. At Virginia Tech, an undergraduate will soon be able to *major* in nanoscience, an integrated science, and in several of the courses in this four-year curriculum, these science majors of the future will learn mineralogy. This is a great example of how mineralogy is not becoming less important in higher education, but much more important, and in fact, absolutely critical. Sure, the framework has changed, but it needs to.

As I argued in my last president's letter (volume 7, page 420), MSA will align itself better with the future of science by, for example, instituting changes having to do with how we interact with other societies, how we publish and what we publish, and how we are perceived by the outside world. In my next letter, using integrated science as a key to the future, I will describe what MSA is doing to move in these critical directions, while, in part, being an inch deep and a mile wide.

Michael F. Hochella Jr. (Hochella@vt.edu), MSA President

ONE HUNDRED MINERALOGICAL QUESTIONS IMPACTING THE FUTURE OF THE EARTH, PLANETARY AND ENVIRONMENTAL SCIENCES

Richard J. Harrison[1], Michael F. Hochella Jr.[2], Kevin Murphy[3] and David J. Vaughan[4]

AN HISTORICAL PERSPECTIVE

It is arguable that mineralogy is the oldest of all the practical sciences. The early manufacture of fire that could be called upon 'at will' depended, in part, upon the sparks produced on striking minerals such as pyrite. Although anthropologists cannot be certain of the first mineral-based fire strikers, the oldest commonly accepted evidence of fire production dates to *Homo erectus* populations 500,000 years ago. *Homo sapiens* were expert fire starters 40,000 to 50,000 years ago, during the Palaeolithic period. The importance of minerals and rocks for prehistoric human development is enshrined in our use of the terms *Stone Age*, *Bronze Age* and *Iron Age*. Stone tools were fashioned by our ancestors more than 30,000 years ago from hard, fine-grained rocks such as flint and naturally occurring glass such as obsidian. By 9000 BC, clays were being fired to make pottery, leading to other ceramic

since its launch. This ensured that submissions were received from a cross section of the community (including mineralogists, petrologists and geochemists, broadly defined) working in current areas of research.

A total of 283 submissions was received. From these, the final list of 100 questions, which can be downloaded at www.elementsmagazine.org/supplements, was agreed upon and edited by the authors. Our aim was to have well-defined scientific questions of broad significance, ranging from the most fundamental to the most applied. While no such list can ever claim to be definitive, the results provide a fascinating snapshot of the mineralogical questions that scientists across a wide spectrum of the Earth sciences wish to address. It provides definitive proof, if such were needed, that mineralogy is as important now as ever, perhaps even more so given the challenges facing humanity in the 21st century.

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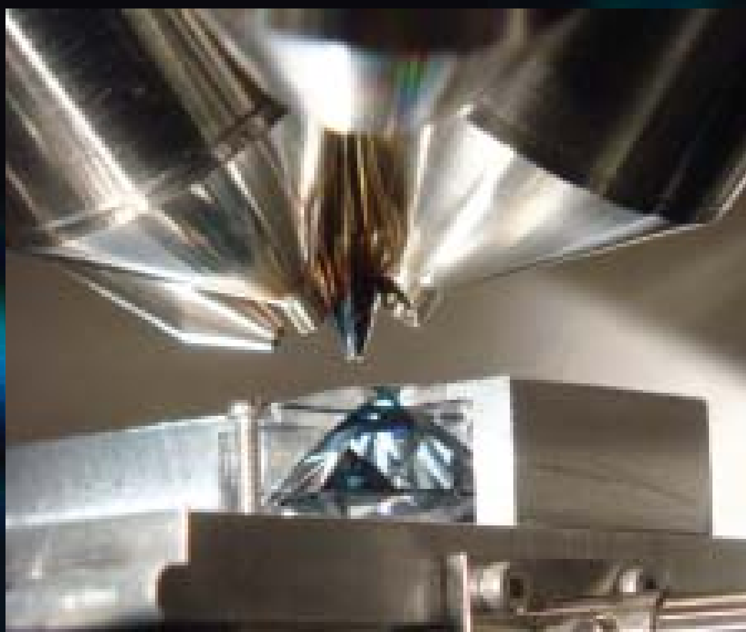
Visit **www.elementsmagazine.org/supplements** to download the final list of 100 questions.

deep carbon cycle operates and by what mechanisms minerals stabilize organic carbon in soils. The nuclear industry is associated with problems that are well known, but critical questions remain about the reactions between minerals and nuclear wastes in deep disposal facilities or about the long-term fate of man-made actinides in the environment.

Many of the questions, although fundamental, have a bearing on the behaviour of contaminants in the near-surface environment of the Earth (the so-called 'critical zone') and the remediation of that contamination. Questions are raised concerning the atomic-scale mechanisms that control the mobility of trace elements, how organic matter affects

ΓΕΜΜΟΛΟΓΙΑ

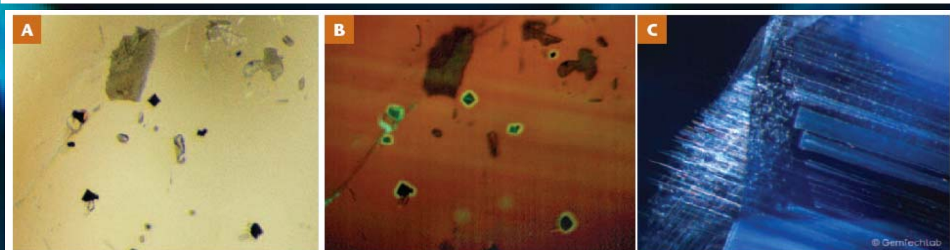


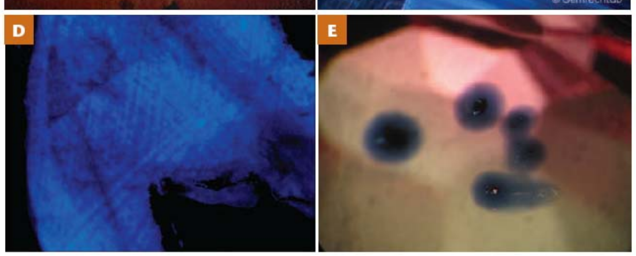

Elements
An International Magazine of Mineralogy, Geochemistry, and Petrology
June 2009
Volume 5, Number 3
ISSN 1811-5209
Gems
EMMANUEL FRITSCH and BENJAMIN RONDEAU, Guest Editors
Gemology: A Developing Science
Gem Formation, Production, and Exploration
Geochemistry of Gems
Identifying Faceted Gemstones
Synthetic Gems
Laboratory-Treated Gemstones
Pearls and Corals: "Trendy Biomineralizations"

The Identification of Faceted Gemstones: From the Naked Eye to Laboratory Techniques

Bertrand Devouard[1] and Franck Notari[2]

1811-5209/09/0005-0163$2.50 DOI: 10.2113/gselements.5.3.163





stones. Large colored stones without any inclusions or heterogeneity of color are always suspicious since they are likely to be synthetic, but on the other hand they command high value if they are natural.

From Ultraviolet to Infrared

Visible light optical spectroscopy quantifies what the eye sees as color and, in favorable cases, assists in identifying the origin of color (Fritsch and Rossman 1987, 1988; Rossman et al. 1991). UV–visible spectrom-

FIGURE 4 In modern gemology laboratories, visual observation is important. At GemTechLab (Geneva), roughly one-half of the room is occupied by binocular microscopes (A), while the other half (B) contains analytical instruments such as ED-XRF, FT-Raman, FTIR, and UV-NIR spectrometers.

The Geochemistry of Gems and Its Relevance to Gemology: Different Traces, Different Prices

George R. Rossman[1]

1811-5209/09/0005-0159$2.50 DOI: 10.2113/gselements.5.3.159

In colored gems, minor and trace chemical components commonly determine the difference between a common mineral specimen and a gemstone. Also, these components are often responsible for the color, and may provide a "fingerprint" for determining the provenance of the gemstone. The minor elements that are incorporated will depend on local geologic conditions such as temperature, redox conditions, and, particularly, chemistry.

FIGURE 4 A plot of the relative proportions of Bi, Pb, and Ga, all present as trace elements in Cu-containing tourmalines (inset), can in most cases distinguish the provenance of such tourmalines: Nigeria, Mozambique, or Brazil. These data were obtained using LA–ICP–MS. GRAPH MODIFIED FROM MICKAEL KRZEMNICKI (2007); PHOTO (INSET): WIMON MANOROTKUL, WWW.PALAGEMS.COM

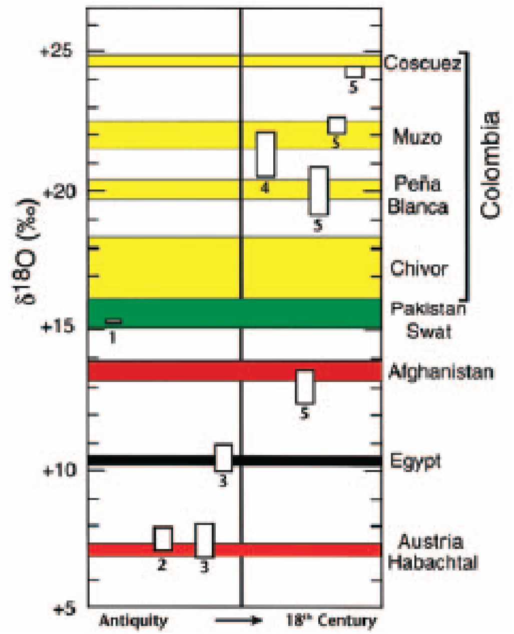


FIGURE 5 The oxygen isotope composition of emeralds varies among important gem-producing regions of historical importance. The colored bands indicate the range of composition at each locality, and the white rectangles indicate the composition of the ancient emeralds studied by Giuliani et al. (2000). 1: Gallo-Roman earring; 2: Holy Crown of France; 3: Haüy's emeralds; 4: Spanish galleon wreck; 5: "old mine" emeralds. The isotopic variations allowed these authors to trace the flow of emeralds in world commerce from antiquity to the late 18th century. GRAPH MODIFIED FROM GIULIANI ET AL. (2000)

American Mineralogist, Volume 97, pages 1–18, 2012

Boron in natural type IIb blue diamonds: Chemical and spectroscopic measurements

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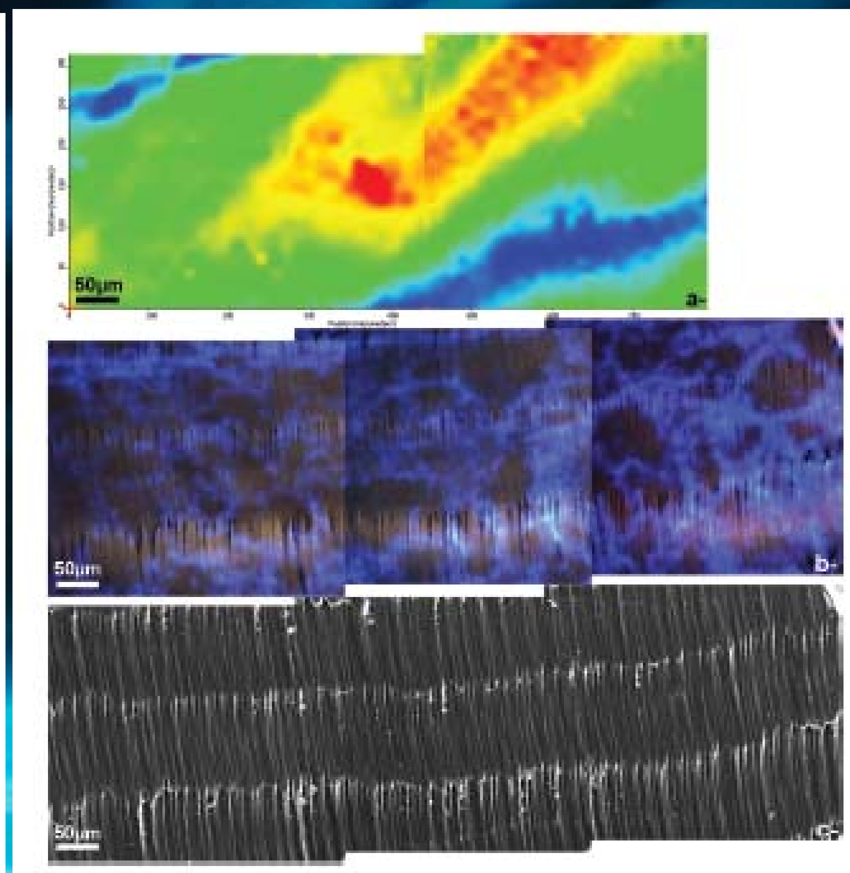

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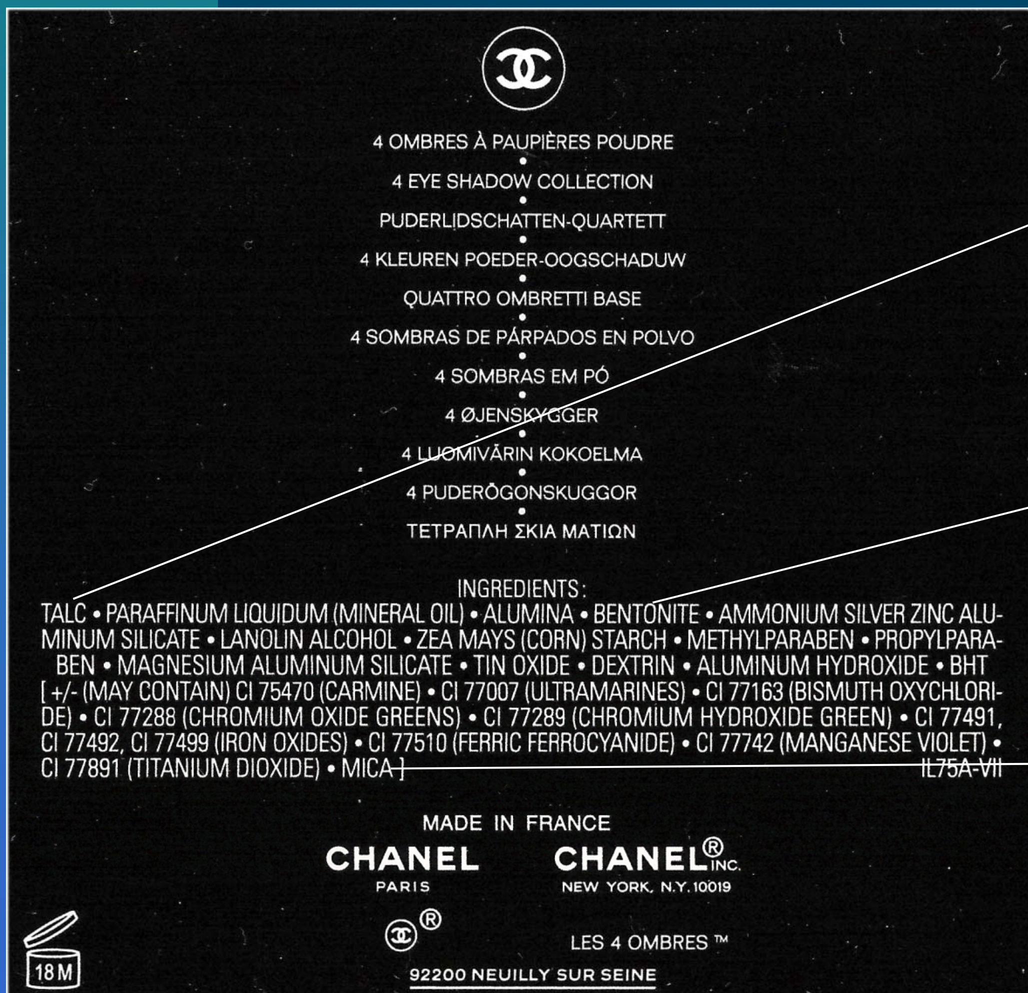

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Anal. Chem. 2010, *82*, 457–460

Letters to *Analytical Chemistry*

Finding Out Egyptian Gods' Secret Using Analytical Chemistry: Biomedical Properties of Egyptian Black Makeup Revealed by Amperometry at Single Cells

Issa Tapsoba,[†,‡] Stéphane Arbault,[†,§] Philippe Walter,[*,∥] and Christian Amatore[*,†]

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Lead-based compounds were used during antiquity as both pigments and medicines in the formulation of makeup materials. Chemical analysis of cosmetics samples found in Egyptians tombs and the reconstitution of ancient recipes as reported by Greco-Roman authors have shown that two non-natural lead chlorides (laurionite Pb(OH)Cl and phosgenite $Pb_2Cl_2CO_3$) were purposely synthesized and were used as fine powders in makeup and eye lotions. According to ancient Egyptian manuscripts, these were essential remedies for treating eye illness and skin ailments. This conclusion seems amazing because today we focus only on the well-recognized toxicity of lead salts. Here, using ultramicroelectrodes, we obtain new insights into the biochemical interactions between lead(II) ions and cells, which support the ancient medical use of sparingly soluble lead compounds. Submicromolar concentrations of Pb^{2+} ions are shown to be sufficient for eliciting specific oxidative stress responses of keratinocytes. These consist essentially of an overproduction of nitrogen monoxide (NO°). Owing to the biological role of NO° in stimulating nonspecific immunological defenses, one may argue that these lead compounds were deliberately manufactured and used in ancient Egyptian formulations to prevent and treat eye illnesses by promoting the action of immune cells.

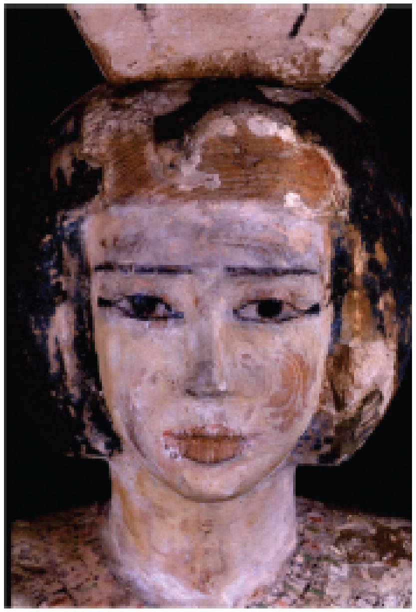
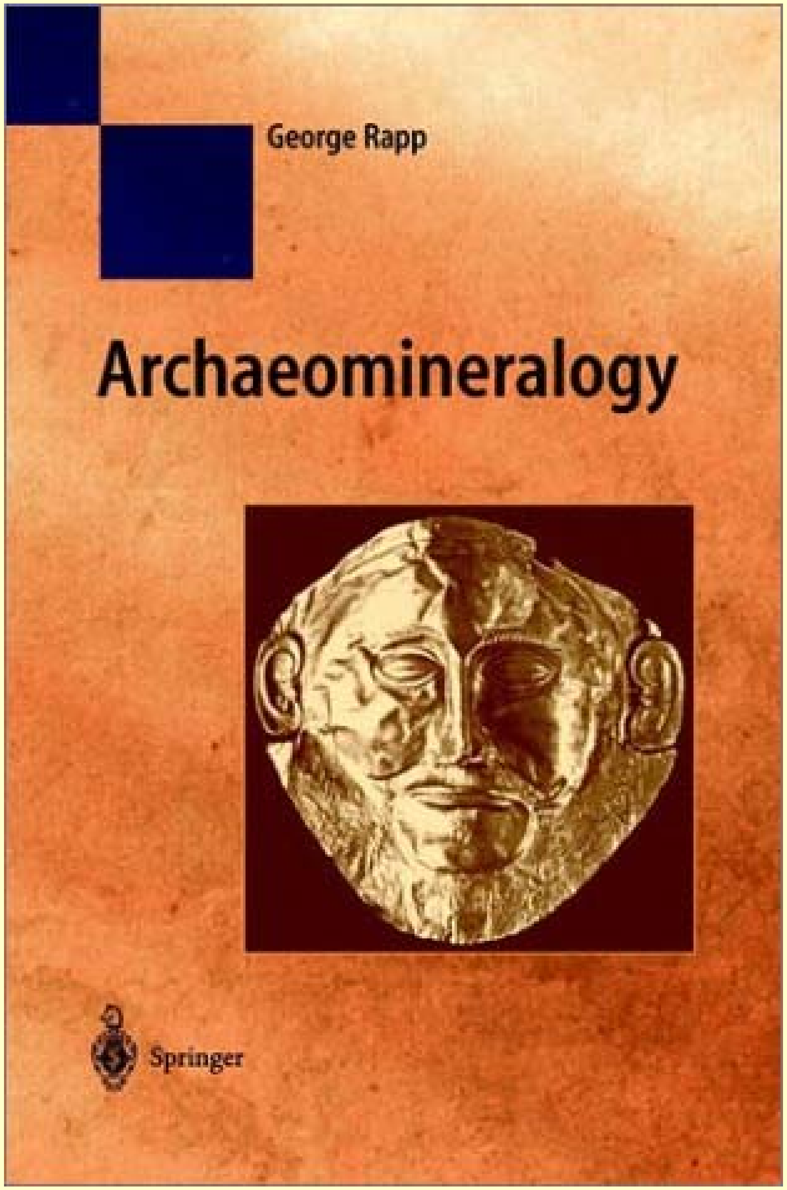


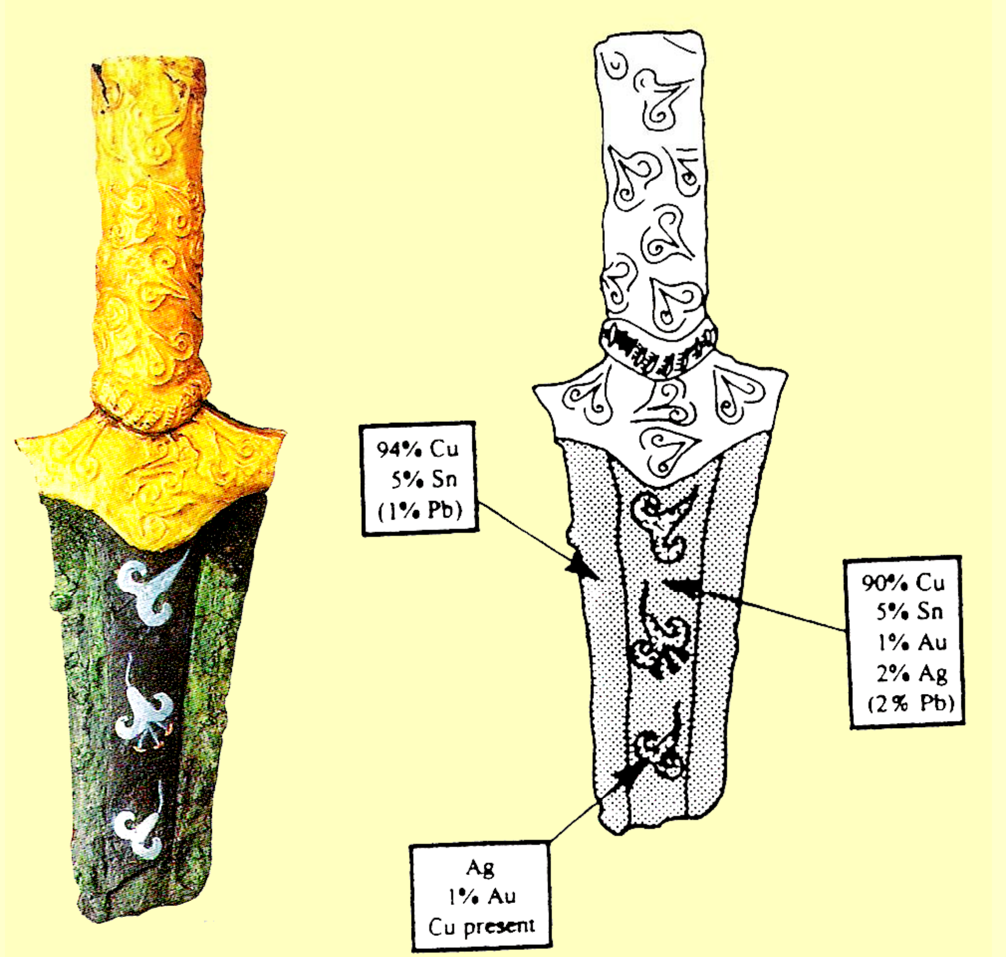
Figure 1. Water-trough carrying girl dressed with the black makeup (Polychromatic wood, ~2000 B.C. Reprinted with permission from the Louvre Museum B.C. collections, C2RMF, D. Bagault). Among many others, this representation testifies that the use of the black makeup was not restricted to the highest Egyptian classes.

ΑΡΧΑΙΟ-ΟΡΥΚΤΟΛΟΓΙΑ



ΤΟ ΠΡΟΒΛΗΜΑ ΤΟΥ ΠΡΩΙΜΟΥ ΚΑΣΣΙΤΕΡΟΥ
(Early Tin)

ΚΑΣΣΙΤΕΡΙΤΗΣ (SnO_2 - Τετραγωνικό)



ΜΥΚΗΝΕΣ, **16ος αι. π.χ.**
Εθνικό Αρχαιολογικό Μουσείο

Nuclear Instruments and Methods in Physics Research B 318 (2014) 139–144

Contents lists available at ScienceDirect

Nuclear Instruments and Methods in Physics Research B

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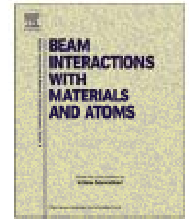

Characterization of the lapis lazuli from the Egyptian treasure of Tôd and its alteration using external μ-PIXE and μ-IBIL

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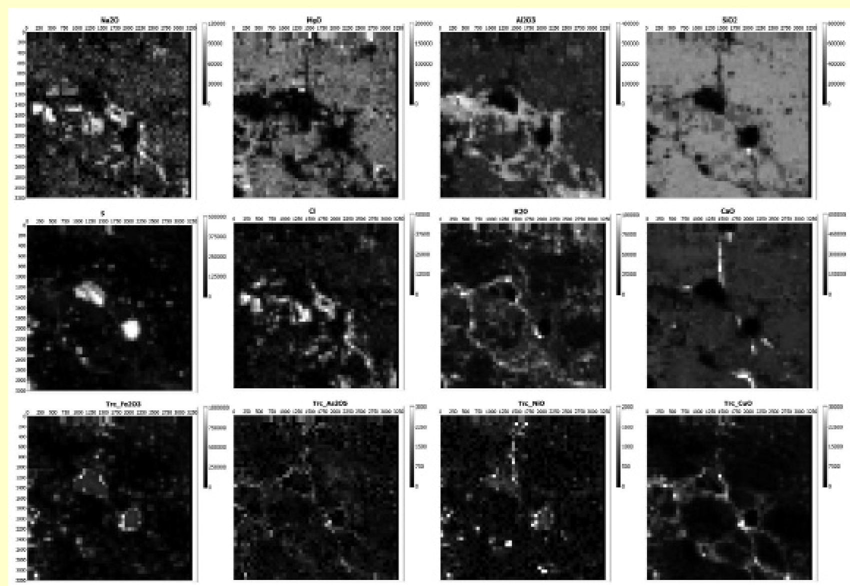
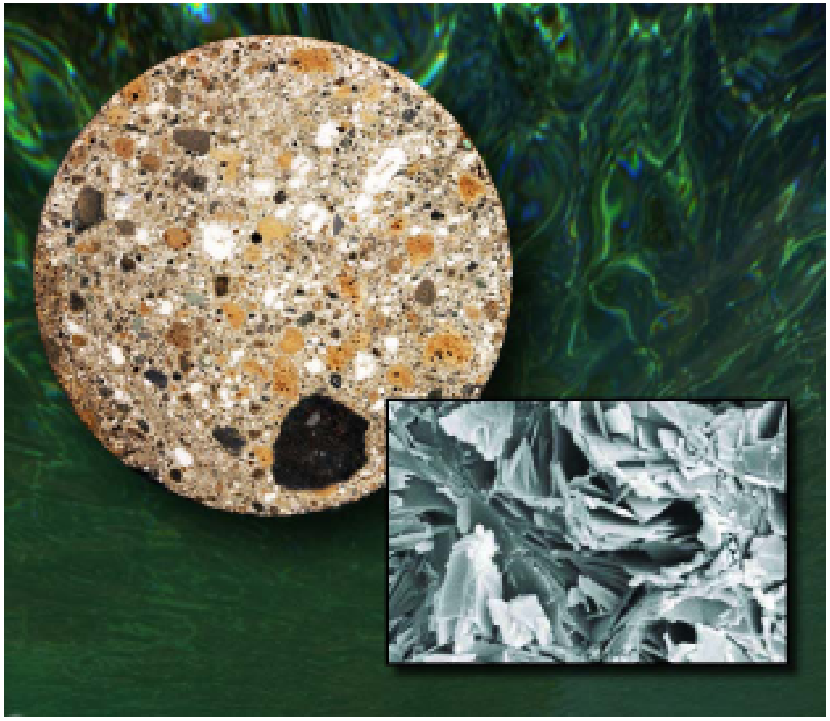


Roman Seawater Concrete Holds the Secret to Cutting Carbon Emissions

Posted By paulpreuss On June 4, 2013 @ 8:59 am In News Releases | Comments Disabled

The chemical secrets of a concrete Roman breakwater that has spent the last 2,000 years submerged in the Mediterranean Sea have been uncovered by an international team of researchers led by Paulo Monteiro of the U.S. Department of Energy's Lawrence Berkeley National Laboratory (Berkeley Lab), a professor of civil and environmental engineering at the University of California, Berkeley.



Drill core of volcanic ash-hydrated lime mortar from the ancient port of Baiae in Pozzuloi Bay. Yellowish inclusions are pumice, dark stony fragments are lava, gray areas consist of other volcanic crystalline materials, and white spots are lime. Inset is a scanning electron microscope image of the special Al-tobermorite crystals that are key to the superior quality of Roman seawater concrete. (Click on image for best resolution.)

Analysis of samples provided by team member Marie Jackson pinpointed why the best Roman concrete was superior to most modern concrete in durability, why its manufacture was less environmentally damaging – and how these improvements could be adopted in the modern world.

"It's not that modern concrete isn't good – it's so good we use 19 billion tons of it a year," says Monteiro. "The problem is that manufacturing Portland cement accounts for seven percent of the carbon dioxide that industry puts into the air."

American Mineralogist, Volume 98, pages 1669–1687, 2013

Unlocking the secrets of Al-tobermorite in Roman seawater concrete†

MARIE D. JACKSON[1], SEJUNG R. CHAE[1], SEAN R. MULCAHY[2], CAGLA MERAL[1,6], RAE TAYLOR[1], PENGHUI LI[3], ABDUL-HAMID EMWAS[4], JUHYUK MOON[1], SEYOON YOON[1,7], GABRIELE VOLA[5], HANS-RUDOLF WENK[2], AND PAULO J.M. MONTEIRO[1,*]

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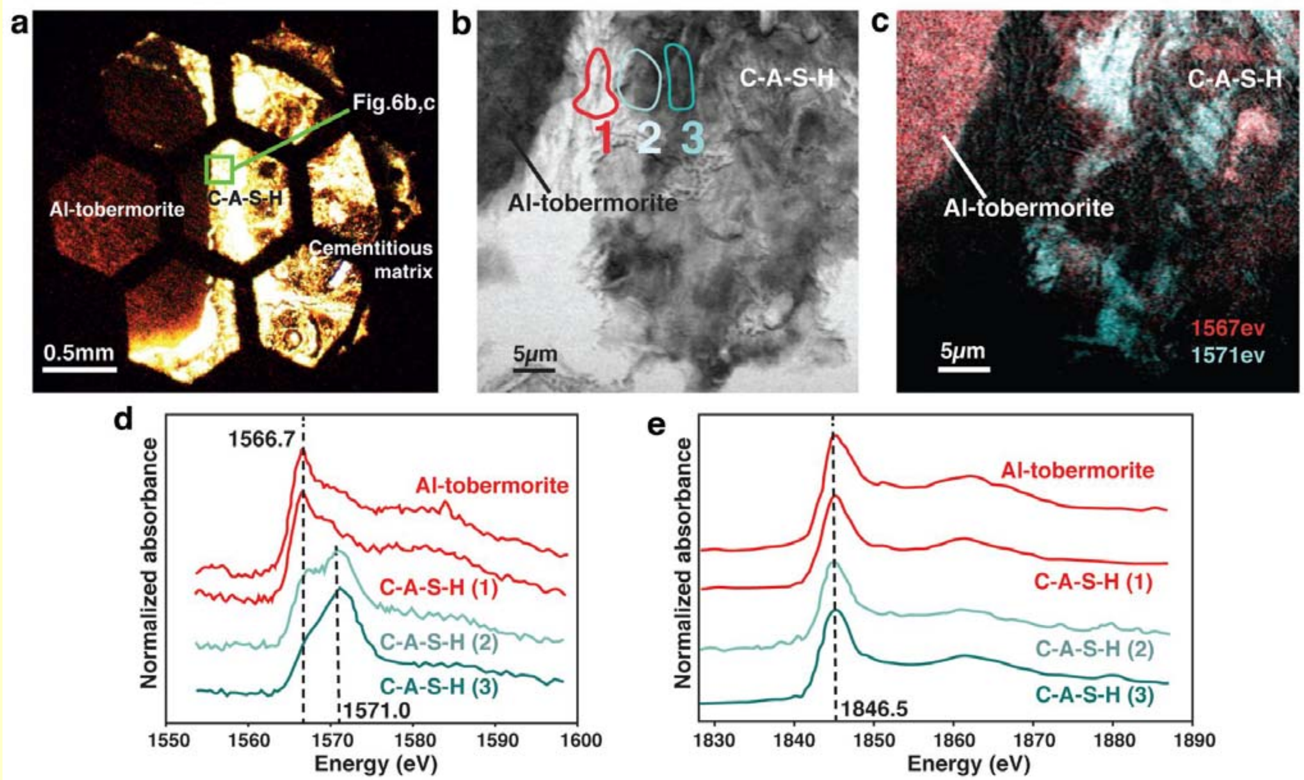
[5]Cimprogetti S.p.A., Via Pasubio 5, 24044, Dalmine, Italy
[6]Middle East Technical University, 06800, Ankara, Turkey
[7]School of Engineering, King's College, The University of Aberdeen, Aberdeen AB24 3UE, U.K.



Earth and Planetary Science Letters 382 (2013) 21–31

Contents lists available at ScienceDirect

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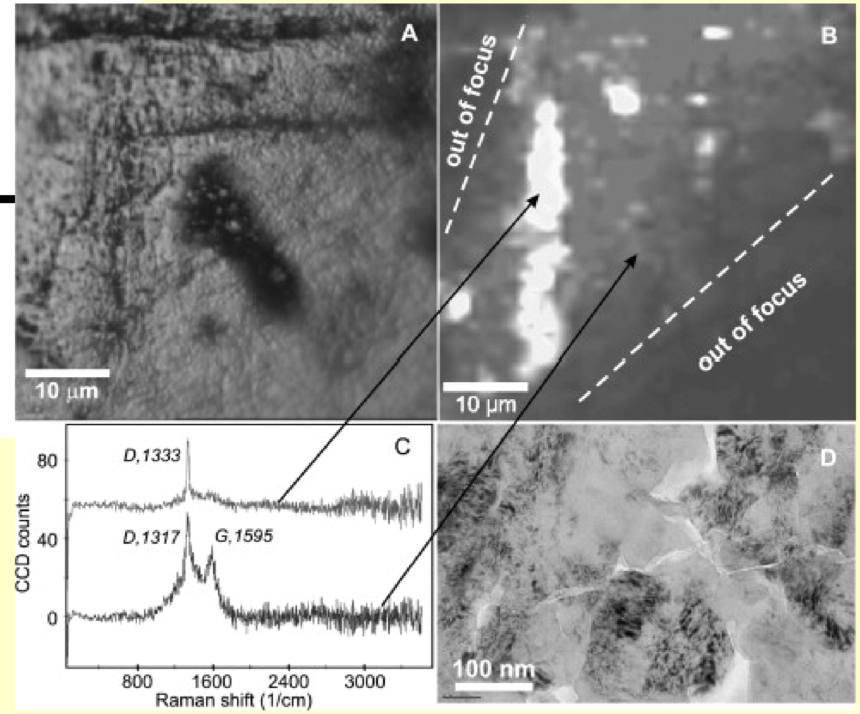
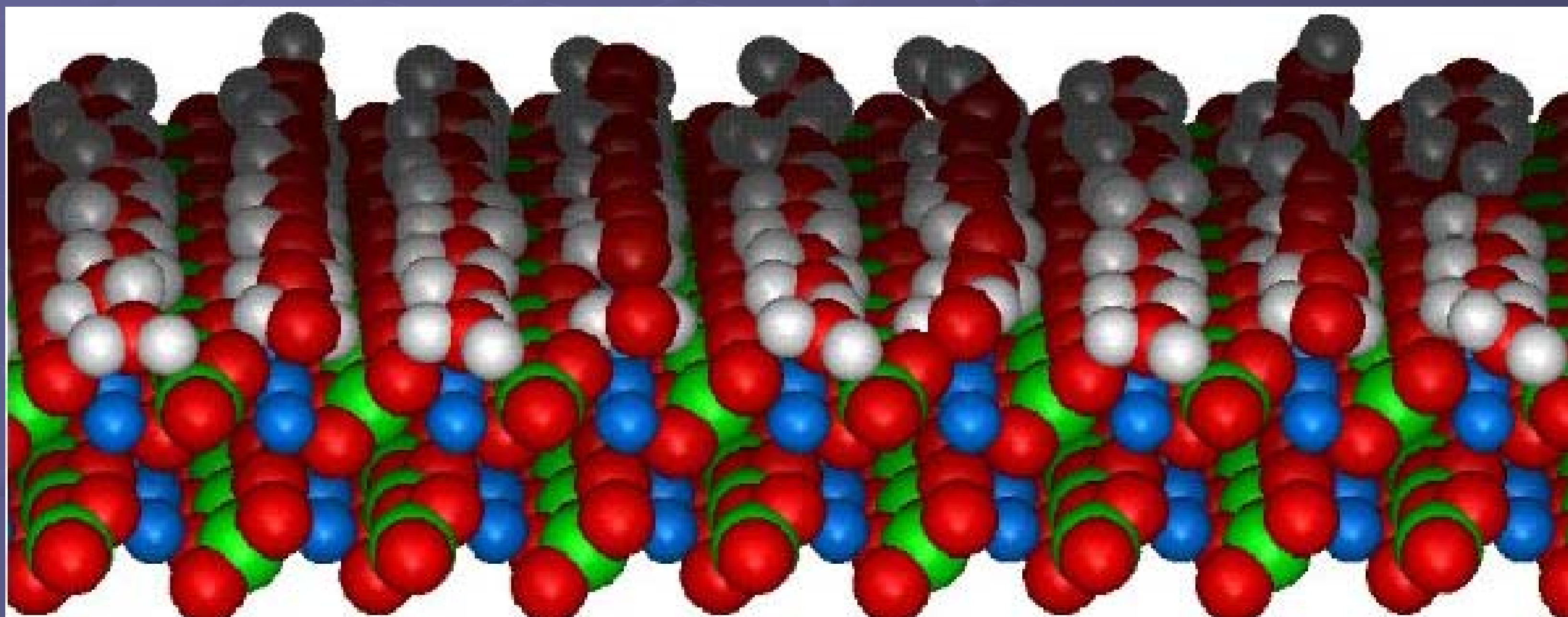
Unique chemistry of a diamond-bearing pebble from the Libyan Desert Glass strewnfield, SW Egypt: Evidence for a shocked comet fragment

Jan D. Kramers[a,*], Marco A.G. Andreoli[b,c], Maria Atanasova[d], Georgy A. Belyanin[a], David L. Block[e], Chris Franklyn[b], Chris Harris[f], Mpho Lekgoathi[b], Charles S. Montross[g], Tshepo Ntsoane[b], Vittoria Pischedda[h], Patience Segonyane[b], K.S. (Fanus) Viljoen[a], Johan E. Westraadt[g]



NANOΓΕΩΕΠΙΣΤΗΜΗ / NANO-ΟΡΥΚΤΟΛΟΓΙΑ

ΜΙΚΡΟΠΟΡΩΔΗ / NANOΠΟΡΩΔΗ ΟΡΥΚΤΑ

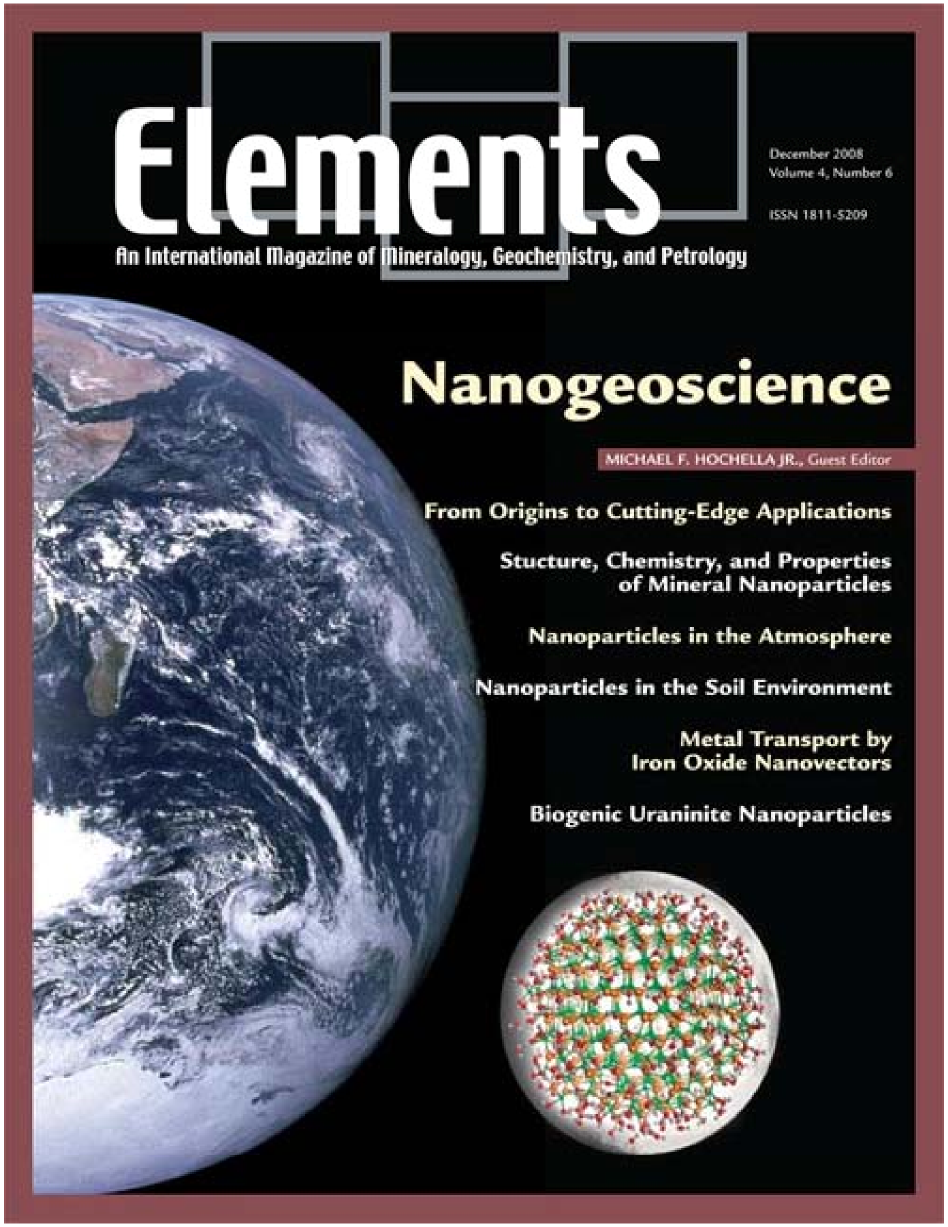


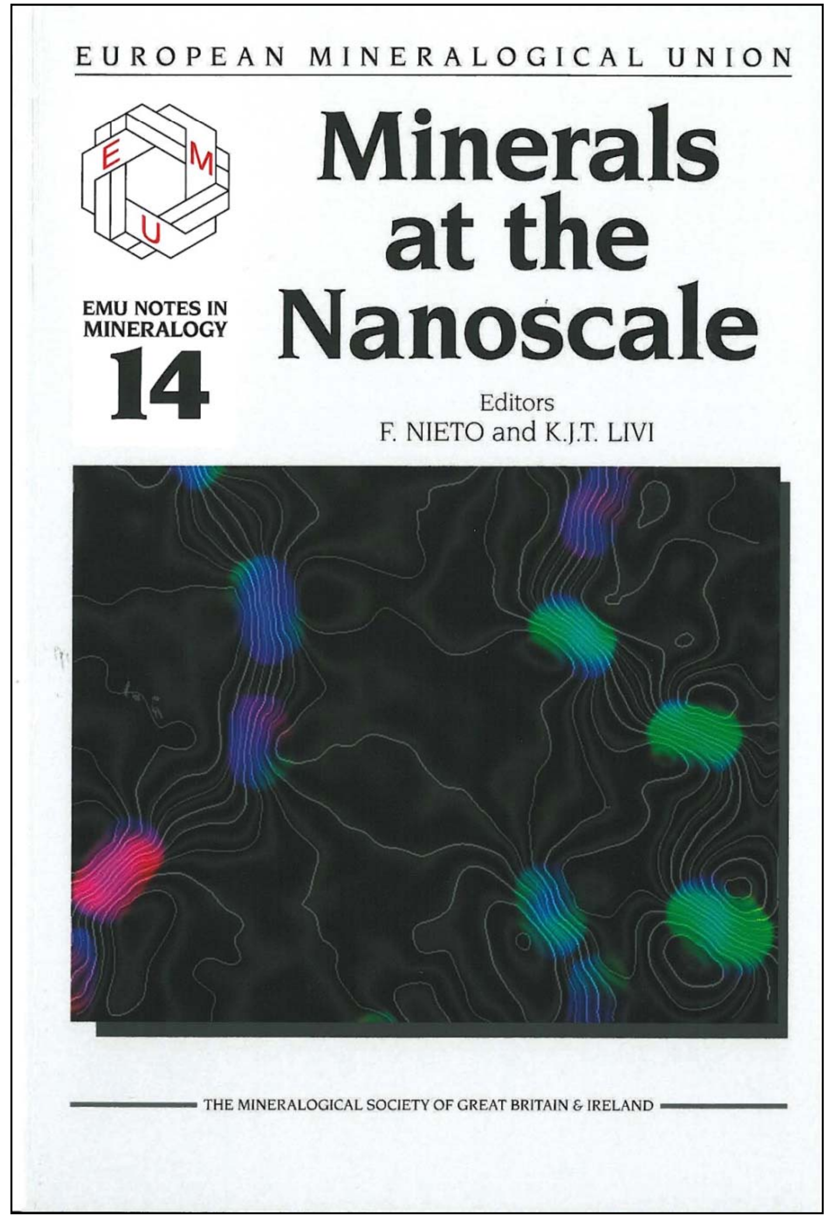
NANOGEOSCIENCE / NANOMINERALOGY

MICROPOROUS / NANOPOROUS MINERALS

Η **Νανο-Ορυκτολογία**
σχετίζεται με το **προσφάτως καθορισμένο πεδίο της Νανογεωεπιστήμης (Nanogeoscience) το οποίο αποτελεί την "επανάσταση" των Γεωεπιστημών.**

Η Νανογεωεπιστήμη ασχολείται με την διερεύνηση γεωλογικών διαδικασιών στις οποίες συμπεριλαμβάνονται νανοσωματίδια υλικών **(~1 nm/~10 Å έως ~100 nm/~1000 Å)**, και ειδικότερα με την **μελέτη φυσικών και χημικών φαινομένων τα οποία λαμβάνουν χώρα σε νανοκλίμακα κυρίως στην *επιφάνεια* αλλά και στο εσωτερικό των κρυστάλλων των ορυκτών.**


Elements
December 2008
Volume 4, Number 6
ISSN 1811-5209
An International Magazine of Mineralogy, Geochemistry, and Petrology
Nanogeoscience
MICHAEL F. HOCHELLA JR., Guest Editor
From Origins to Cutting-Edge Applications
Stucture, Chemistry, and Properties of Mineral Nanoparticles
Nanoparticles in the Atmosphere
Nanoparticles in the Soil Environment
Metal Transport by Iron Oxide Nanovectors
Biogenic Uraninite Nanoparticles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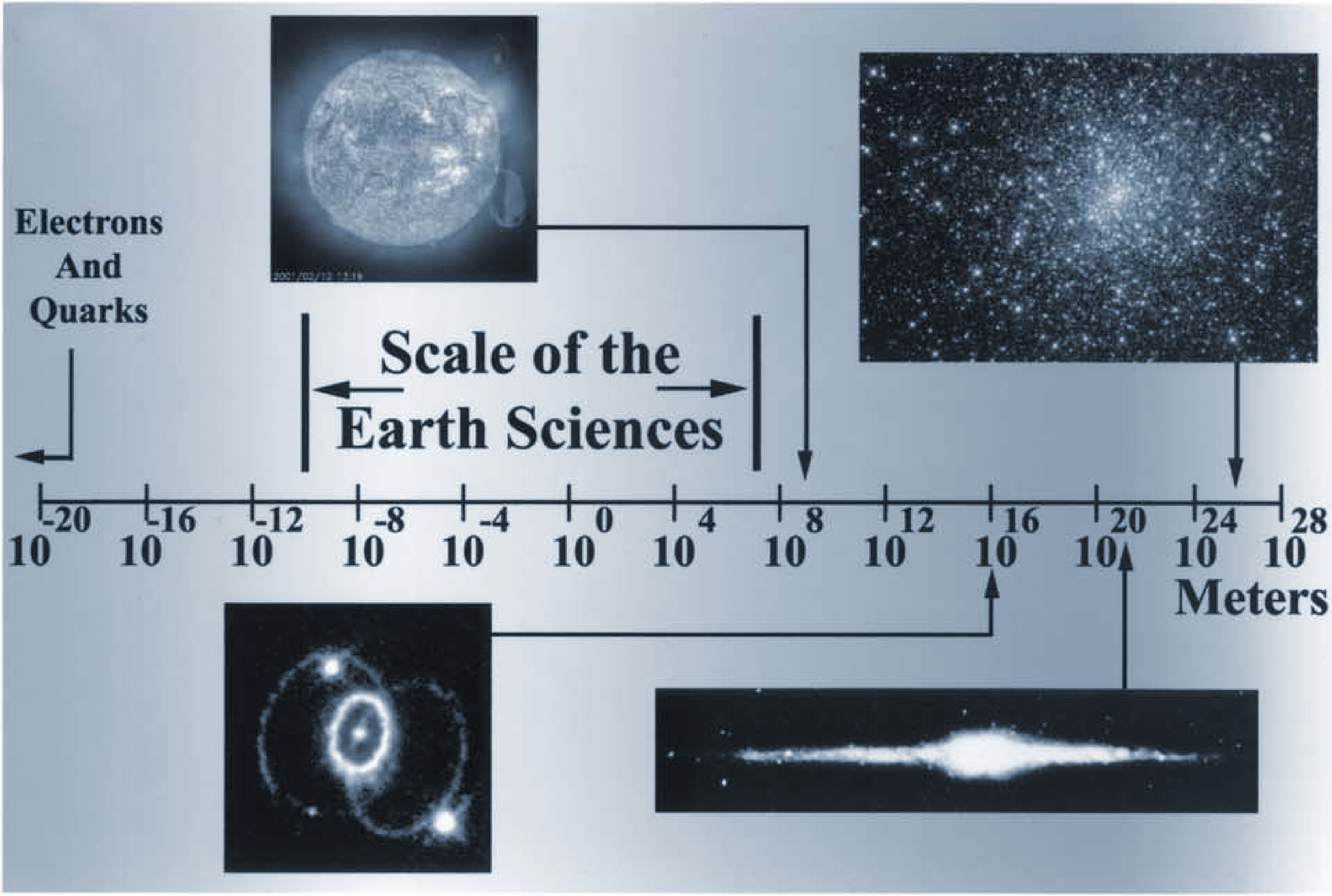
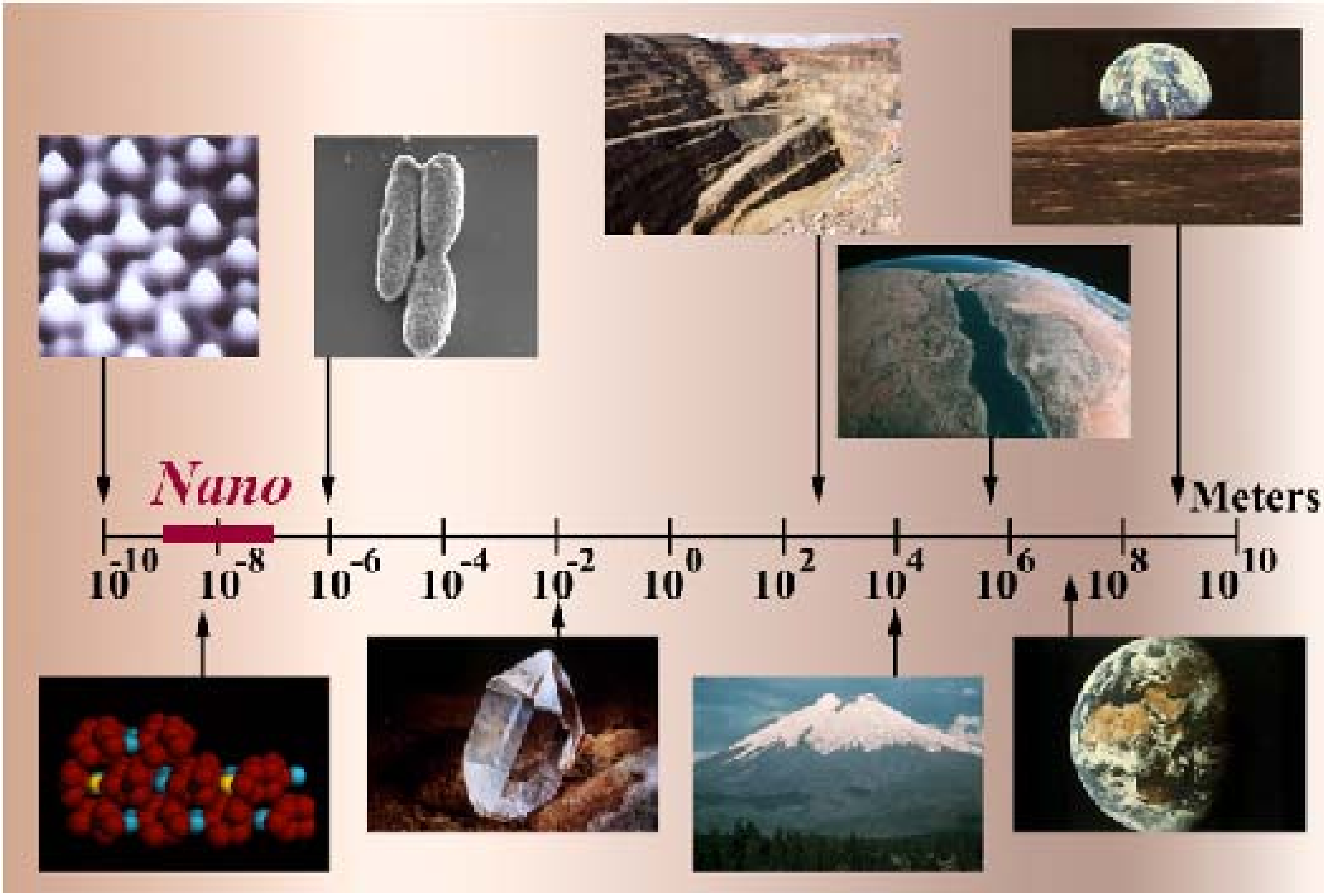
EMU
EMU NOTES IN MINERALOGY
14
Minerals at the Nanoscale
Editors
F. NIETO and K.J.T. LIVI
THE MINERALOGICAL SOCIETY OF GREAT BRITAIN & IRELAND



HOCHELLA Jr., GCA 2002



HOCHELLA Jr., GCA 2002

NANOGEOSCIENCE / NANOMINERALOGY

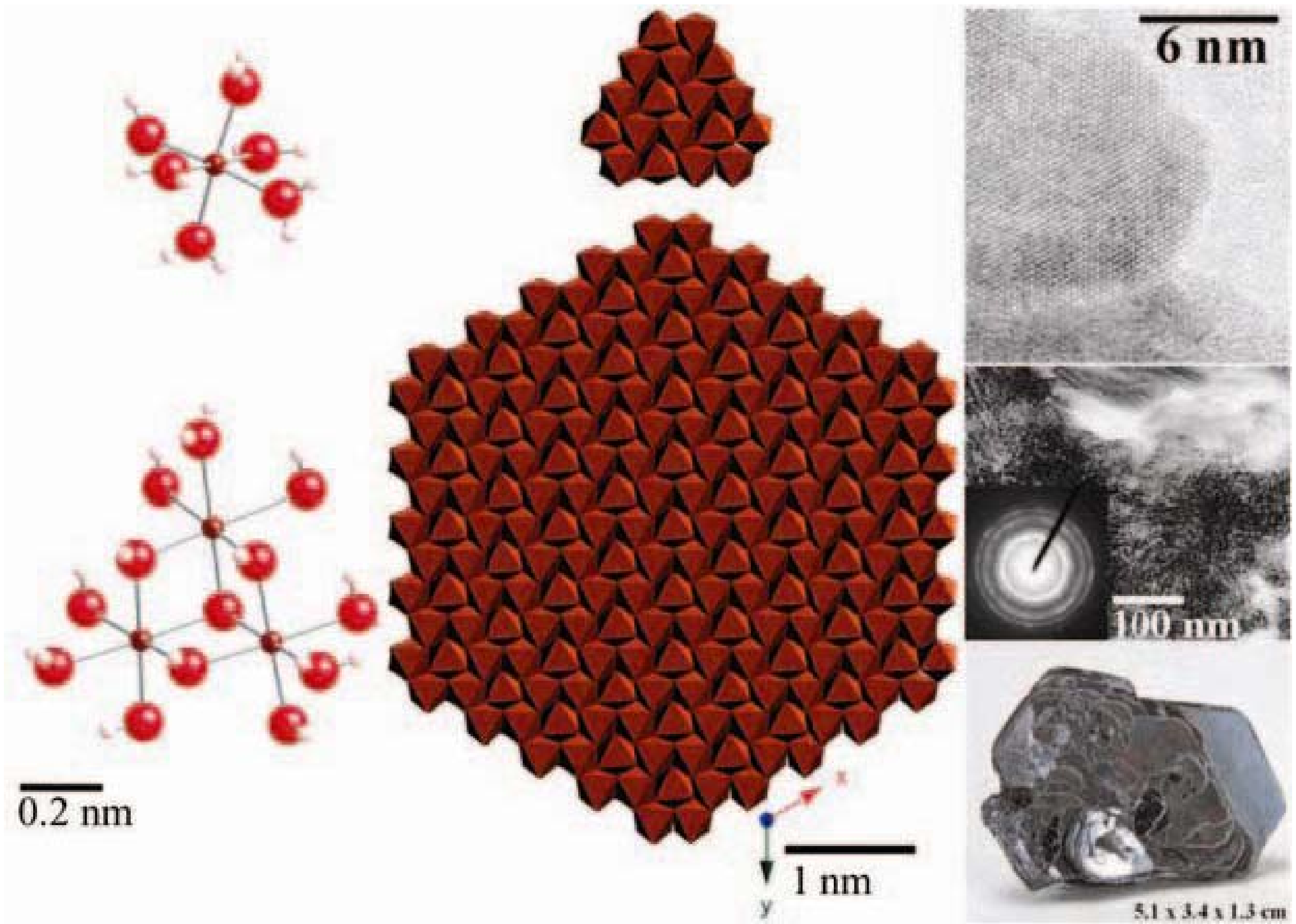
Nanoscale Mineral Classification

Mineral Nanoparticles
(They exist in the nanorange, but they can also exist in sizes that exceed the nanorange up to the largest dimensions for minerals)

Nanominerals
(Exist only as one of the three types of nanoscale minerals –**nanorods, nanosheets and nanoparticles**- and there are no bulk equivalents)

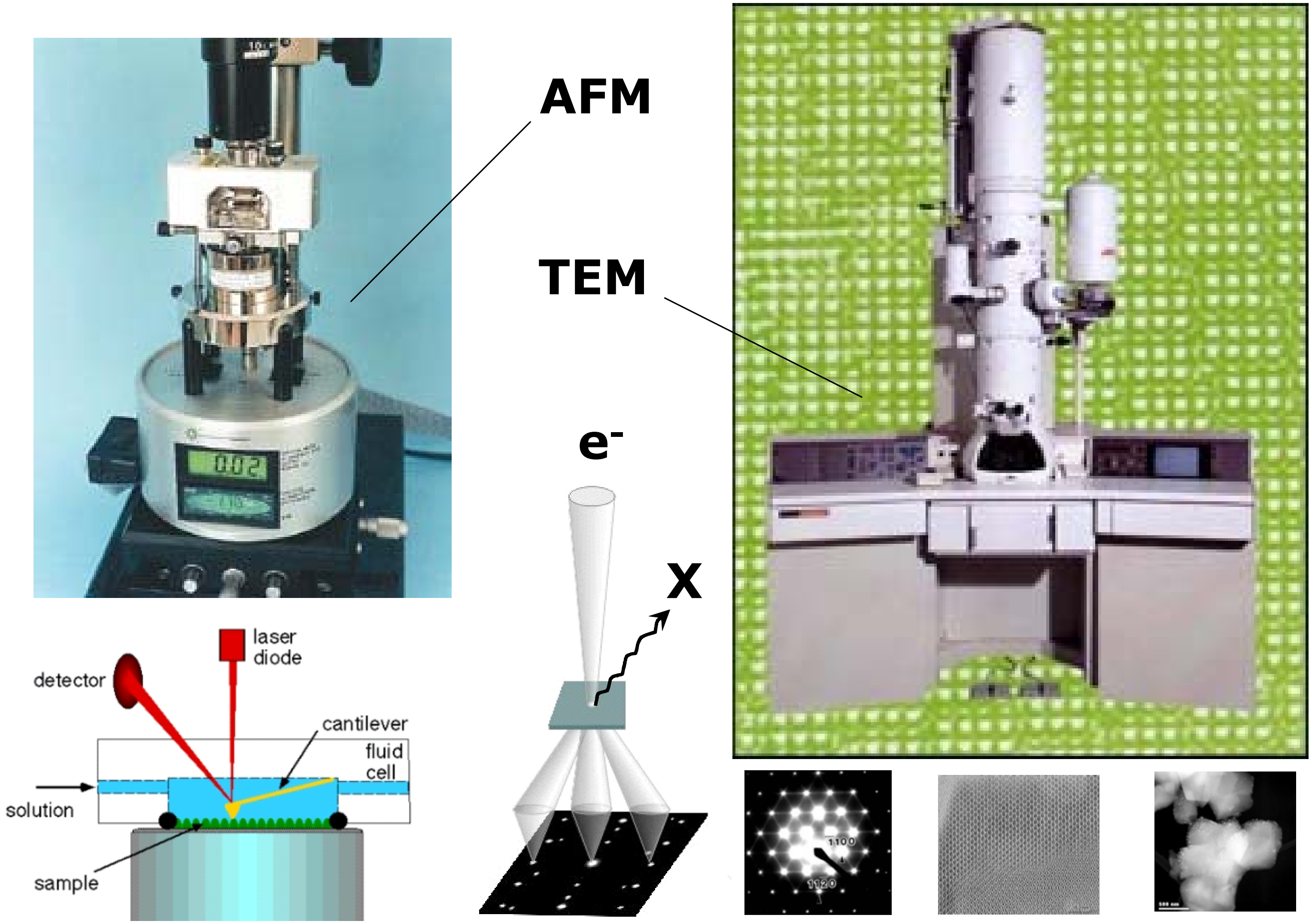
HOCHELLA Jr., Science 2008
and Elements 2008

ΟΡΥΚΤΟΛΟΓΙΑ & ΝΑΝΟ-ΟΡΥΚΤΟΛΟΓΙΑ ΤΟΥ Fe^{3+}
MINERALOGY & NANOMINERALOGY OF Fe^{3+}



HOCHELLA Jr., Science 2008

MICRO/NANOSCOPIC TOOLS (nm/Å-scale)



EUROPEAN MINERALOGICAL UNION

EMU NOTES IN MINERALOGY

8

Nanoscopic Approaches in Earth and Planetary Sciences

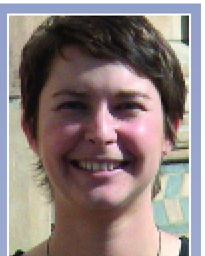
Edited by
FRANK E. BRENKER
and GUNTRAM JORDAN

THE MINERALOGICAL SOCIETY OF GREAT BRITAIN & IRELAND

New Opportunities for Nanomineralogy using FIB, STEM/EDX and TEM

Caroline L. Smith[1,3], Martin R. Lee[1] and Maureen MacKenzie[2]
1. Dept of Geographical and Earth Sciences, 2. Dept of Physics and Astronomy, University of Glasgow, UK 3. Dept of Mineralogy, The Natural History Museum, London, UK

BIOGRAPHY



Dr Caroline Smith is Meteorite Curator at the Natural History Museum in London. Formerly she was a postdoc in the Department of Earth and Geographical Sciences at Glasgow University, investigating natural weathering of silicate minerals. Her research interests are the combined mineralogical, petrologic and isotopic investigation of meteorites, terrestrial rocks and minerals.

ABSTRACT

Recent developments in focused electron- and ion-beam technologies have opened up many new avenues for the nanoscale characterisation of materials. TEM is a well-established technique, but FIB sample preparation and STEM/EDX imaging and analysis have only recently been embraced as tools for studying minerals and rocks. To demonstrate the benefits of combining these techniques we have used them to pre-

INTRODUCTION

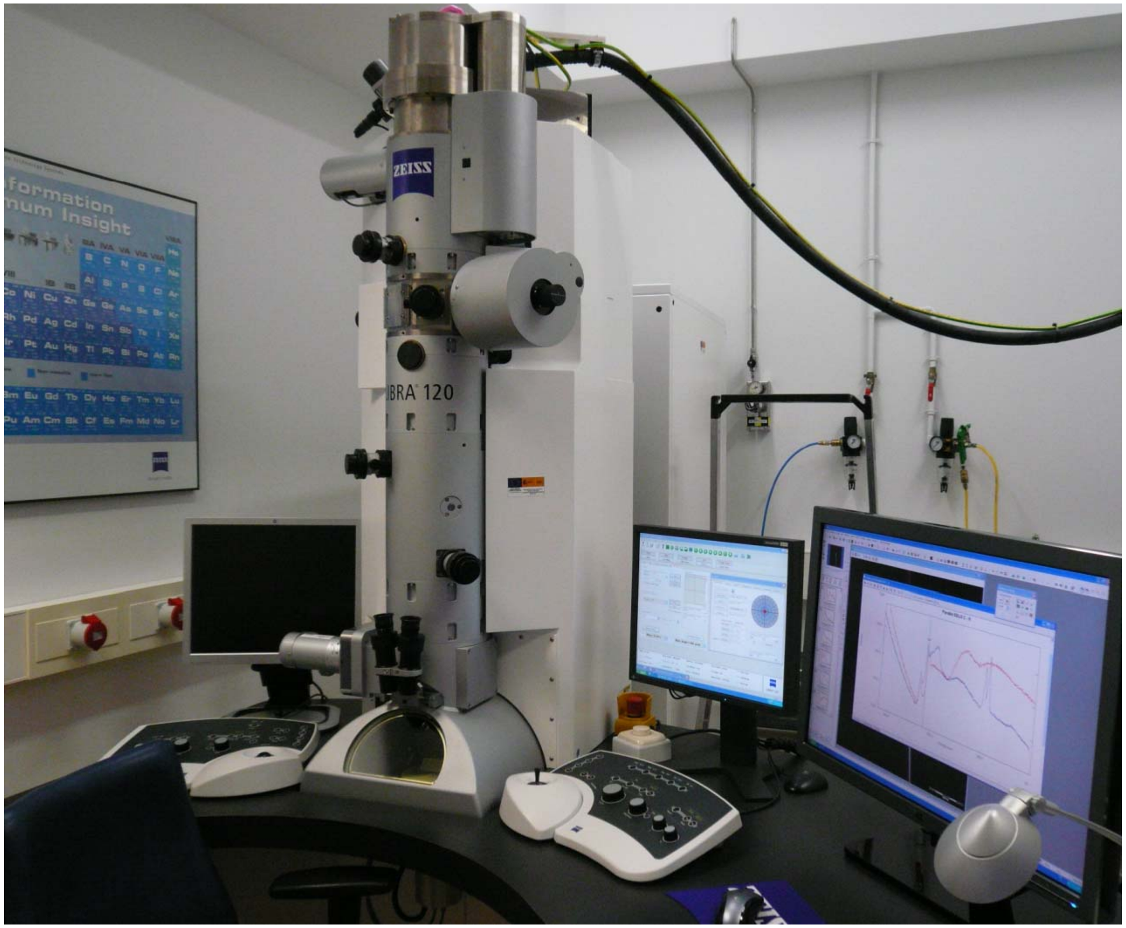
Since its development during the late 1980s and 1990s, the focused ion-beam (FIB) microscope has been used extensively for the characterisation of synthetic materials such as semiconductors [1-3]. Its utility comes from the coupling of high-resolution (~7 nm) imaging with the ability to machine the sample surface using a gallium ion beam. As FIB microscopes are becoming more readily available, and now in combination with electron guns (dual-beam instruments), they are finding a much wider range of applications including the machining of natural materials, often with the purpose of producing site-specific electron-transparent samples for subsequent investigation by transmission electron microscopy (TEM) [4-6].

We have carried out a pathfinder investigation to evaluate the use of the FIB microscope to prepare electron-transparent samples of Earth and planetary materials. These samples have been characterised by conventional high-voltage TEM imaging and also by scanning transmission electron microscopy in a scanning electron microscope (SEM-STEM, also known

an obvious technique to use in order to determine whether such amorphous layers can form naturally, the preparation of samples using conventional Ar ion milling has been very challenging. FIB techniques may provide an ideal way in which to prepare cross-sections of weathered minerals for study at the nanoscale.

The second set of samples studied were meteorites, most of which come to Earth from the asteroid belt. Many of these rocks are very finely crystalline and mineralogically heterogeneous on a micrometre to submicrometre scale and so TEM has again been extensively used in studies of their composition and origin. However as meteorites, by their very nature, are rare and precious, it is imperative that the volume of material that is damaged or destroyed during sample preparation is minimised. In addition, owing to the very fine grain size of these rocks the electron-transparent sample must be precisely located, for example within a micrometre-wide vein or a submicrometre-sized mineral grain. To date most samples for TEM have been manufac-

TRANSMISSION ELECTRON MICROSCOPE (TEM-EDS-EELS / STEM-HAADF)



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Langmuir
Received: February 7, 2013
Revised: May 14, 2013
Article
pubs.acs.org/Langmuir

Atomic-Scale Surface Roughness of Rutile and Implications for Organic Molecule Adsorption

Kenneth J. T. Livi,[*,†] Bernhard Schaffer,[‡,§,&] David Azzolini,[∥] Che R. Seabourne,[⊥] Trevor P. Hardcastle,[⊥] Andrew J. Scott,[⊥] Robert M. Hazen,[#] Jonah D. Erlebacher,[%] Rik Brydson,[⊥] and Dimitri A. Sverjensky[∥,#]

[†]HRAEM/IIC Facility, Department of Earth & Planetary Sciences, Johns Hopkins University, Baltimore, Maryland 21218, United States

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[∥]Department of Earth & Planetary Sciences, Johns Hopkins University, Baltimore, Maryland 21218, United States

[⊥]Institute for Materials Research, SPEME, University of Leeds, Leeds LS2 9JT, U.K.

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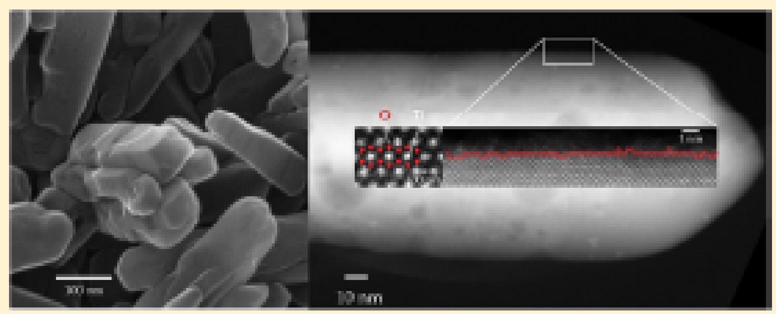
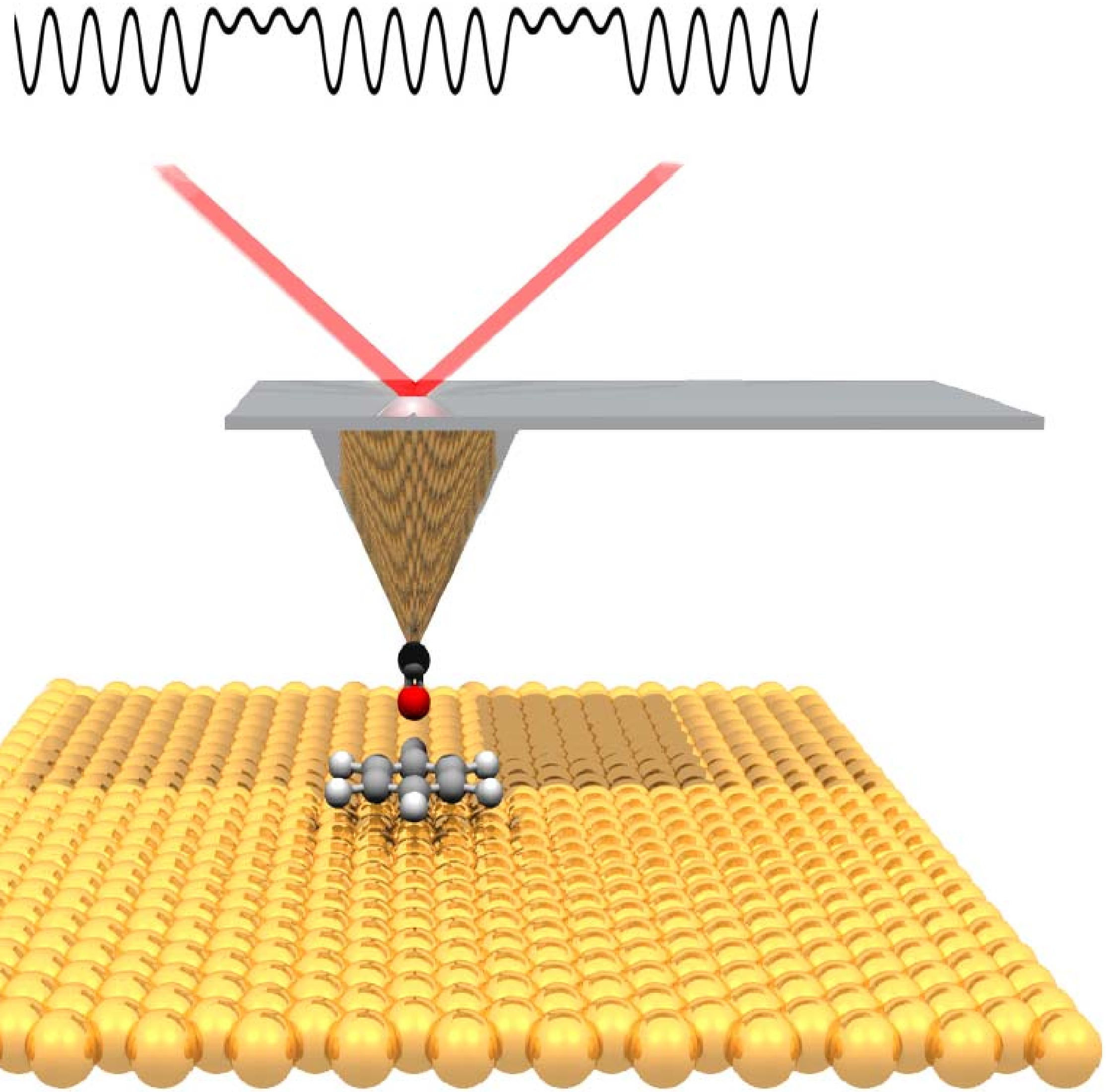
[%]Department of Materials Sciences, Johns Hopkins University, Baltimore, Maryland 21218, United States

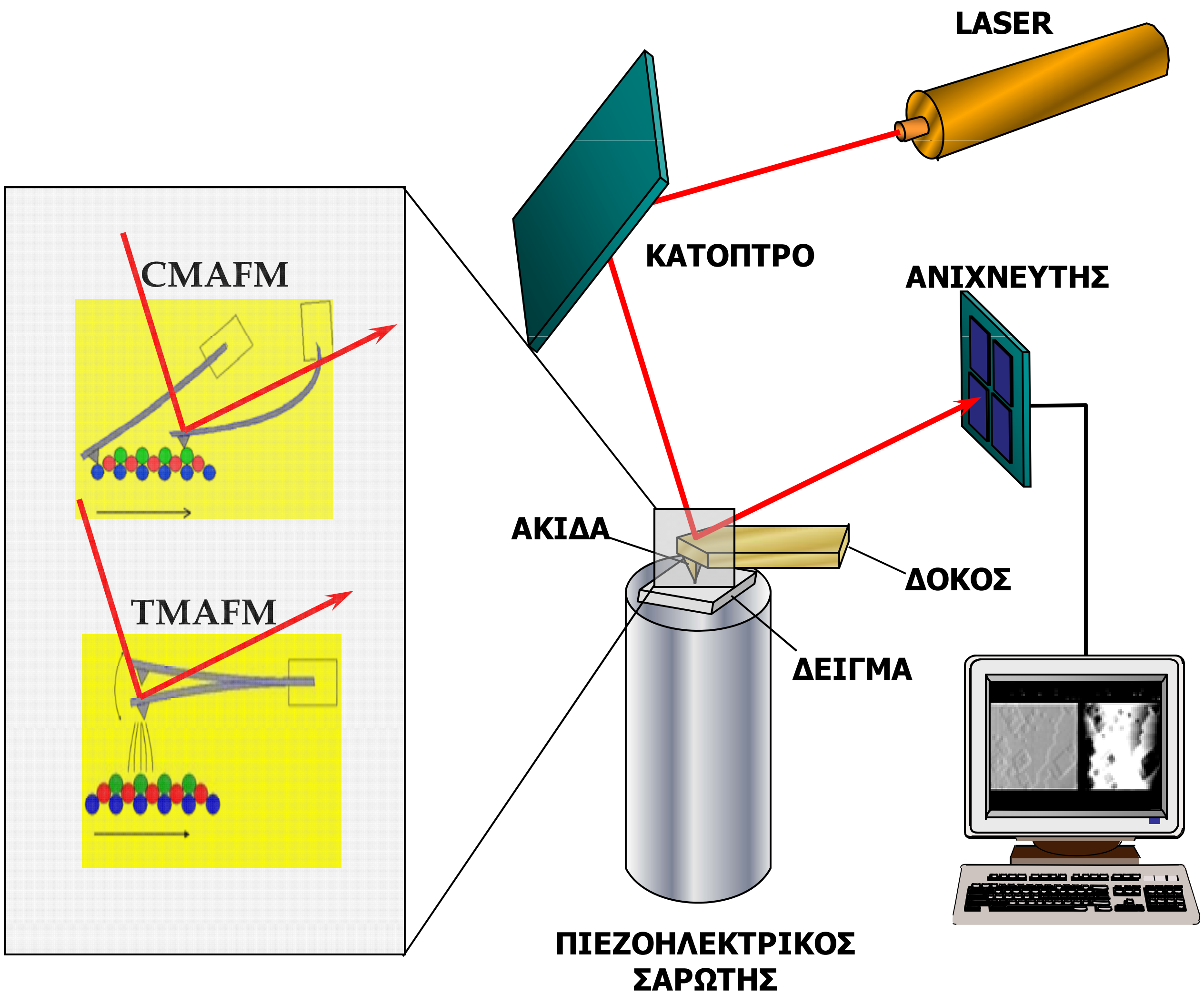
ABSTRACT: Crystal surfaces provide physical interfaces between the geosphere and biosphere. It follows that the arrangement of atoms at the surfaces of crystals profoundly influences biological components at many levels, from cells through biopolymers to single organic molecules. Many studies have focused on the crystal−molecule interface in water using large, flat single crystals. However, little is known about atomic-scale surface structures of the nanometer- to micrometer-sized crystals of simple metal oxides typically used in batch adsorption experiments under conditions relevant to



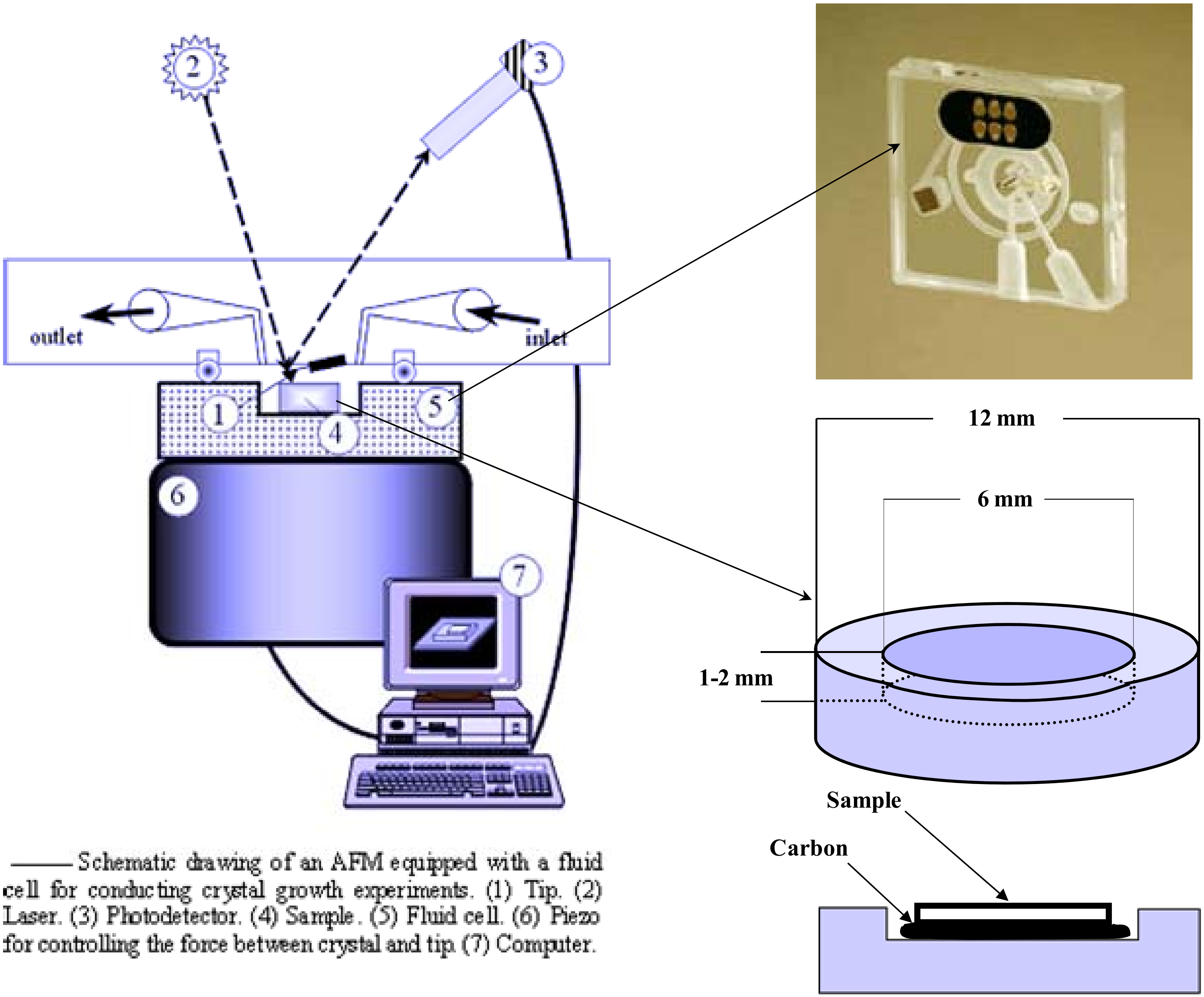
ATOMIC FORCE MICROSCOPE (AFM)



ΜΙΚΡΟΣΚΟΠΙΟ ΑΤΟΜΙΚΗΣ ΔΥΝΑΜΗΣ (AFM)

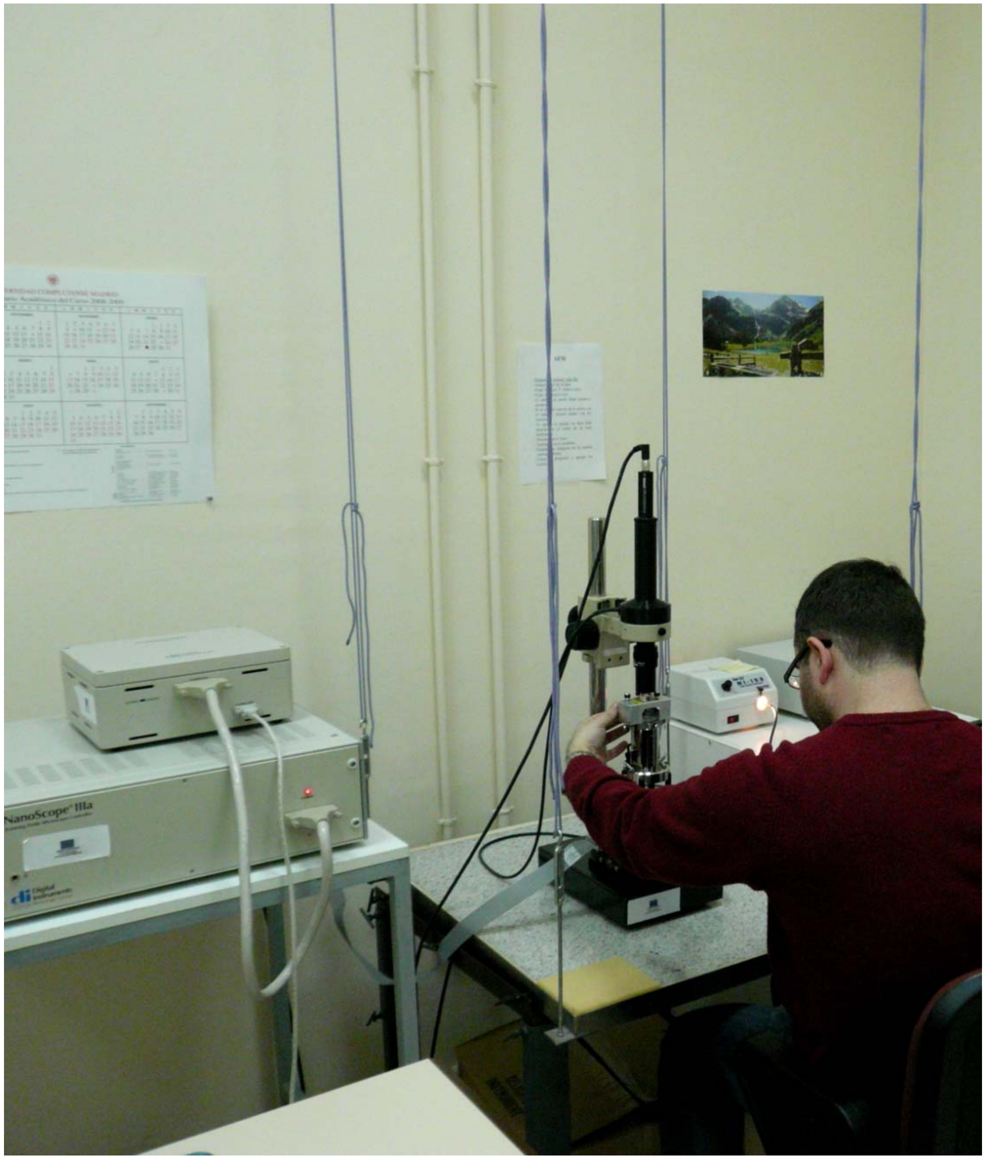


in-situ AFM

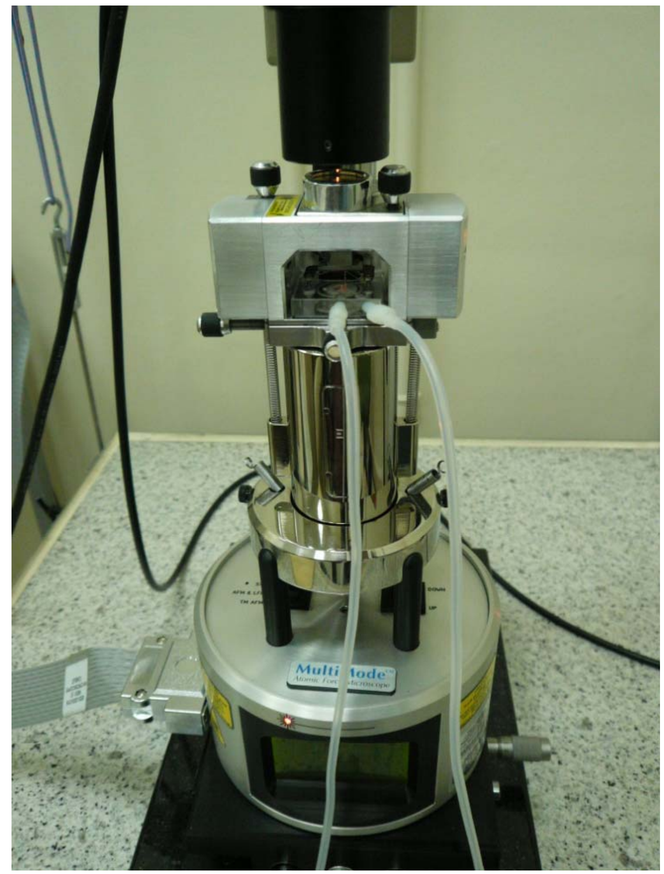


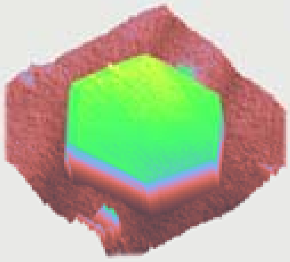
——— Schematic drawing of an AFM equipped with a fluid cell for conducting crystal growth experiments. (1) Tip. (2) Laser. (3) Photodetector. (4) Sample. (5) Fluid cell. (6) Piezo for controlling the force between crystal and tip. (7) Computer.

in-situ AFM

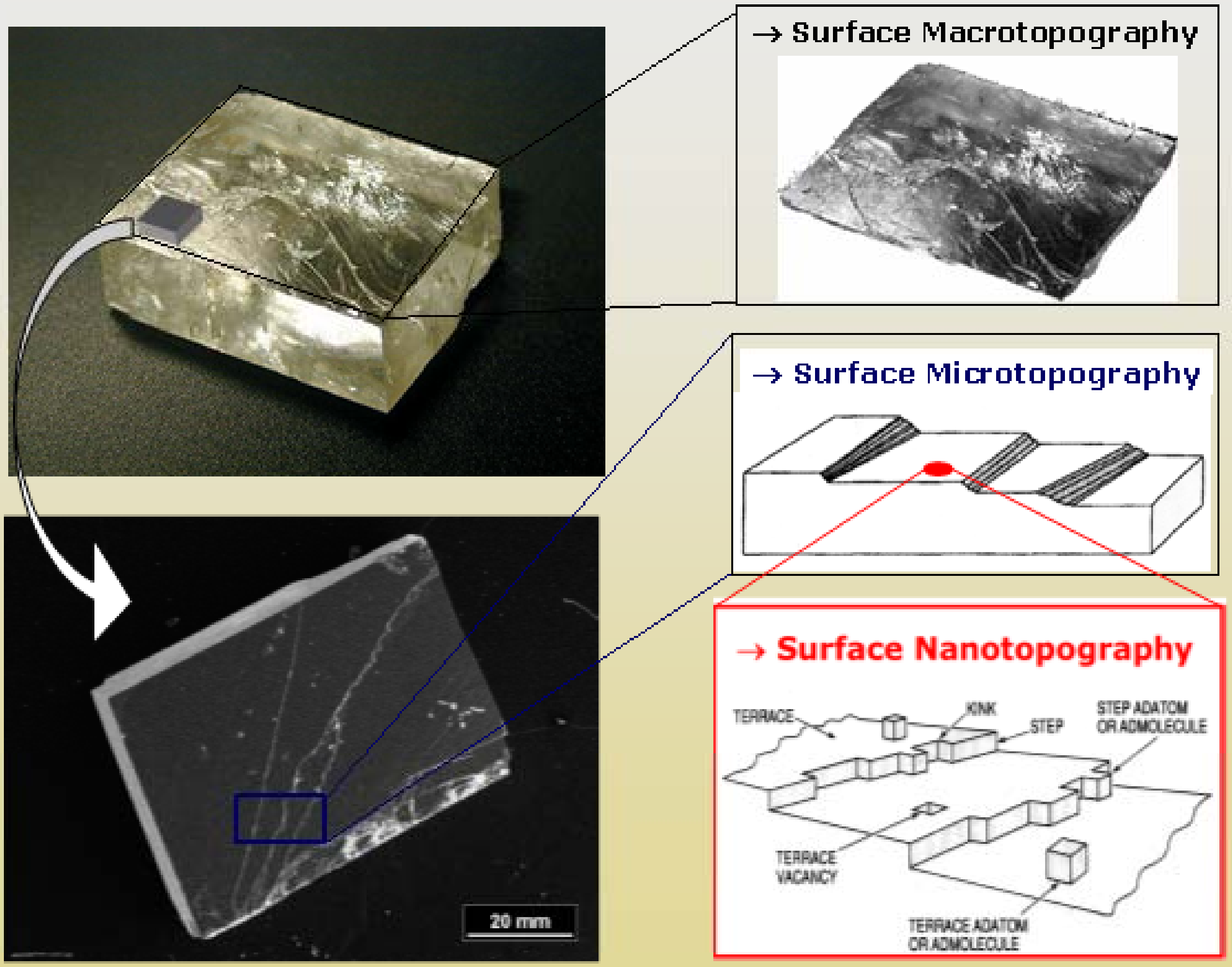

NanoScope IIIa


Universidad Complutense de Madrid
DRAGADOS
Centro de microscopia

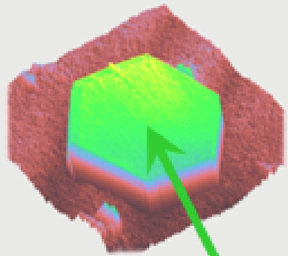

MultiMode



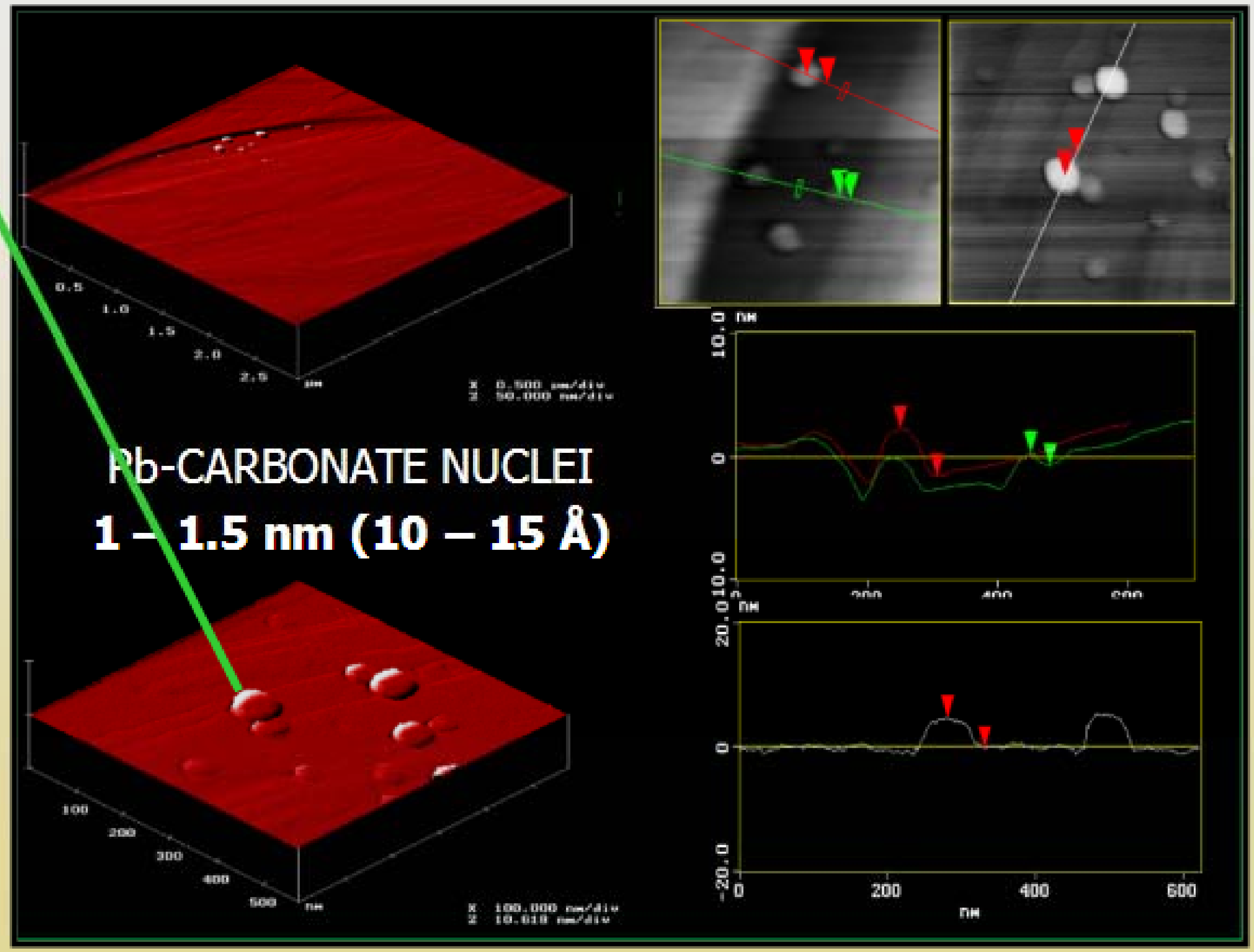
MINERAL SURFACE TOPOGRAPHY (CALCITE)



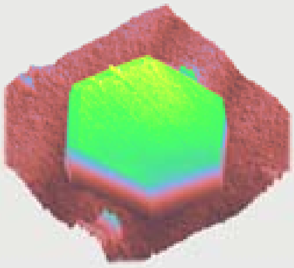
GODELITSAS & ASTILLEROS,
EMU Notes 2010



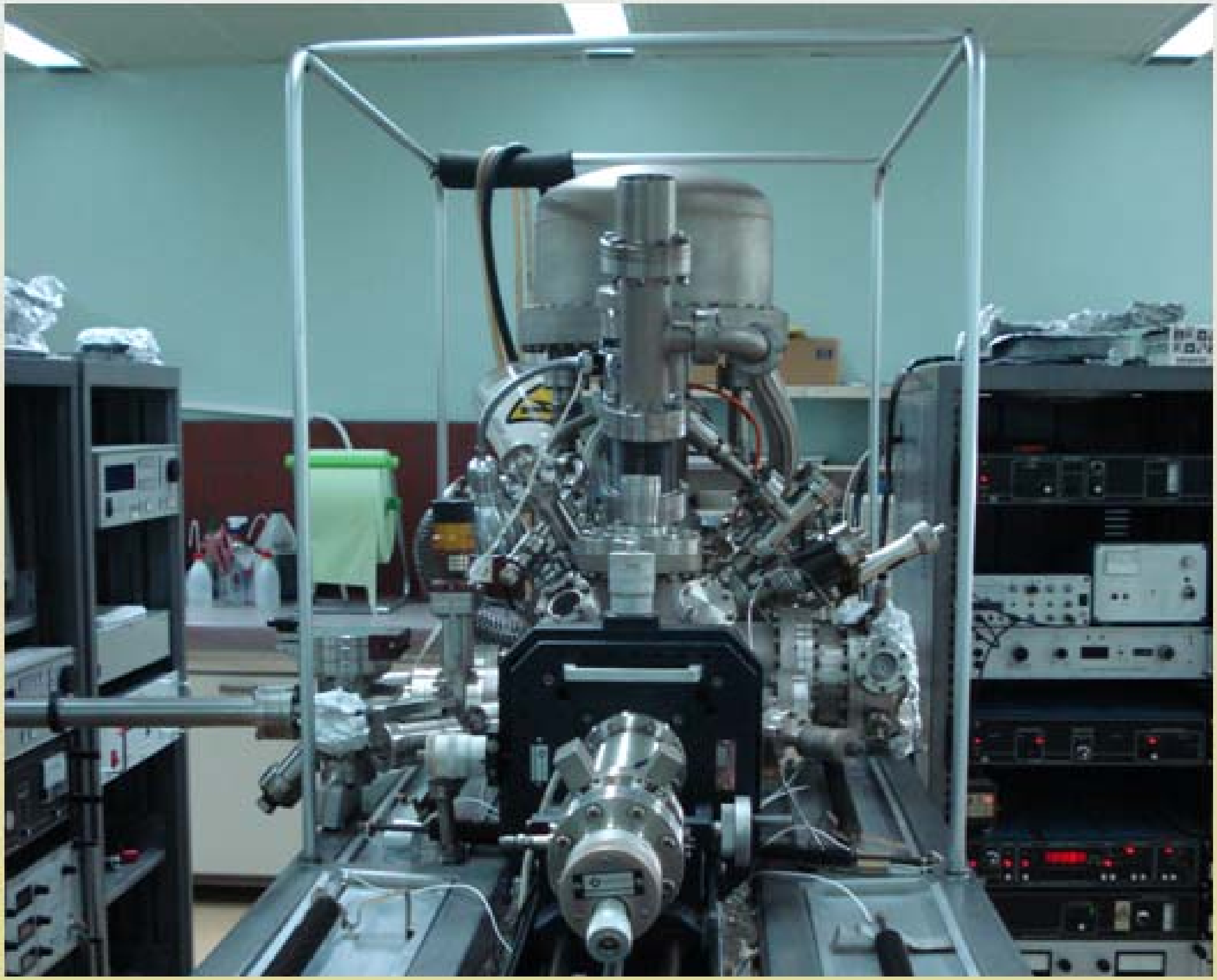
SURFACE NANOTOPOGRAPHY
in-situ AFM (CALCITE - H_2O - Pb^{2+})



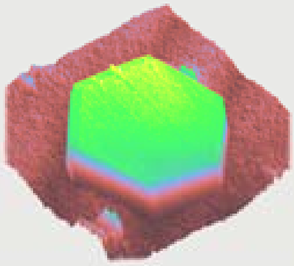
GODELITSAS et al., ES&T2003



X-RAY PHOTOELECTRON SPECTRA
(XPS)



GODELITSAS et al., ES&T2003



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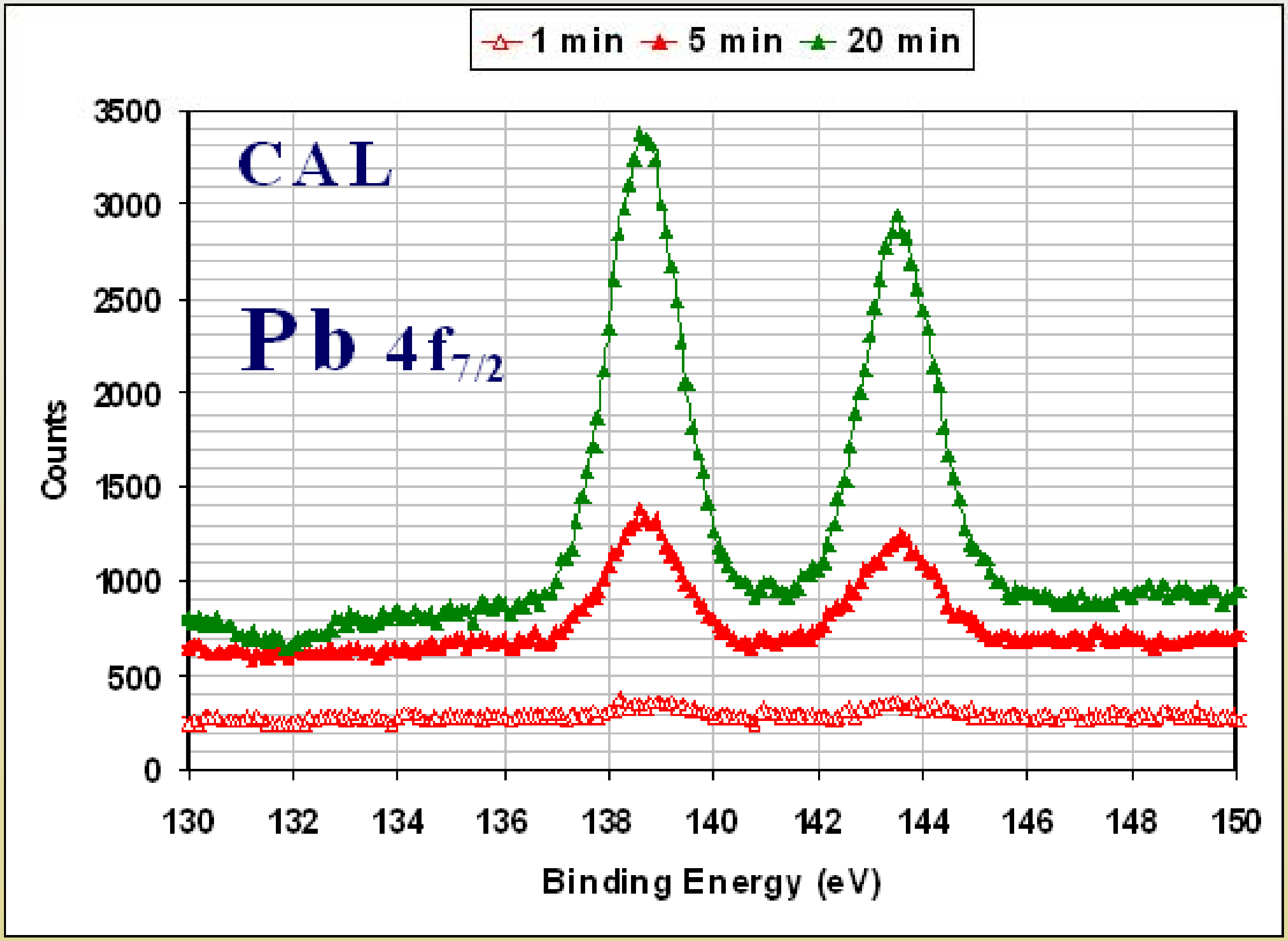
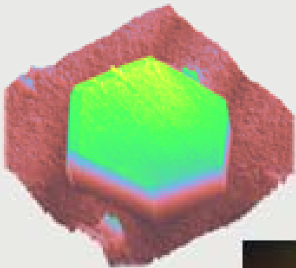
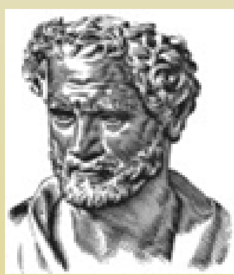
(XPS)

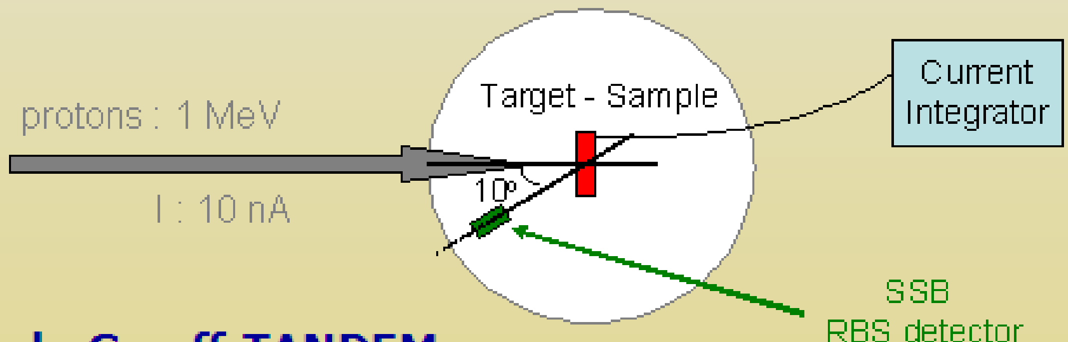


GODELITSAS et al., ES&T2003



RUTHERFOD BACKSCATTERING SPECTROSCOPY (RBS)





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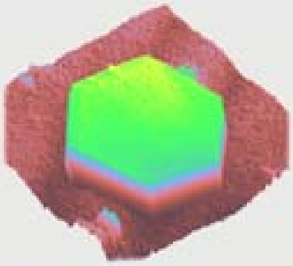
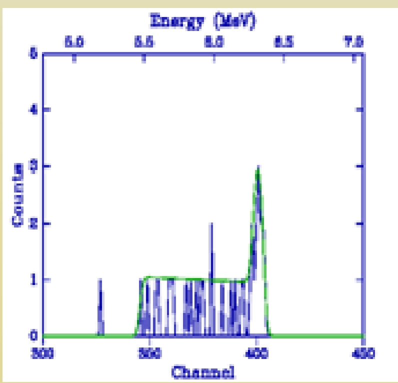
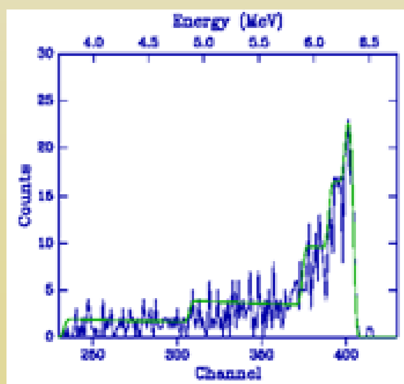
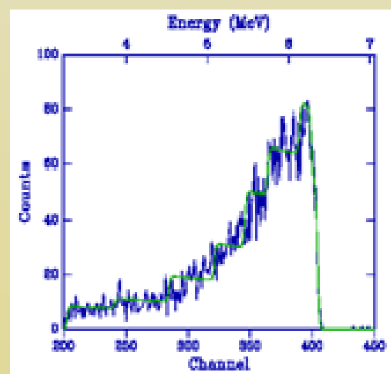
GODELITSAS et al., ES&T2003

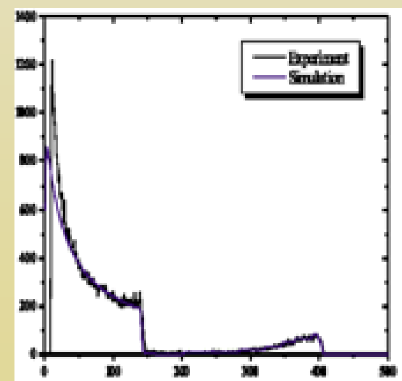


RUTHERFOD BACKSCATTERING SPECTROSCOPY
(RBS)



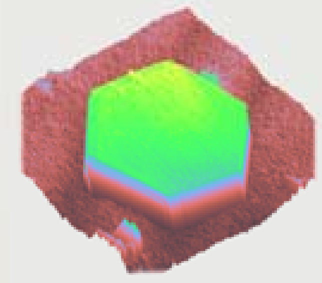




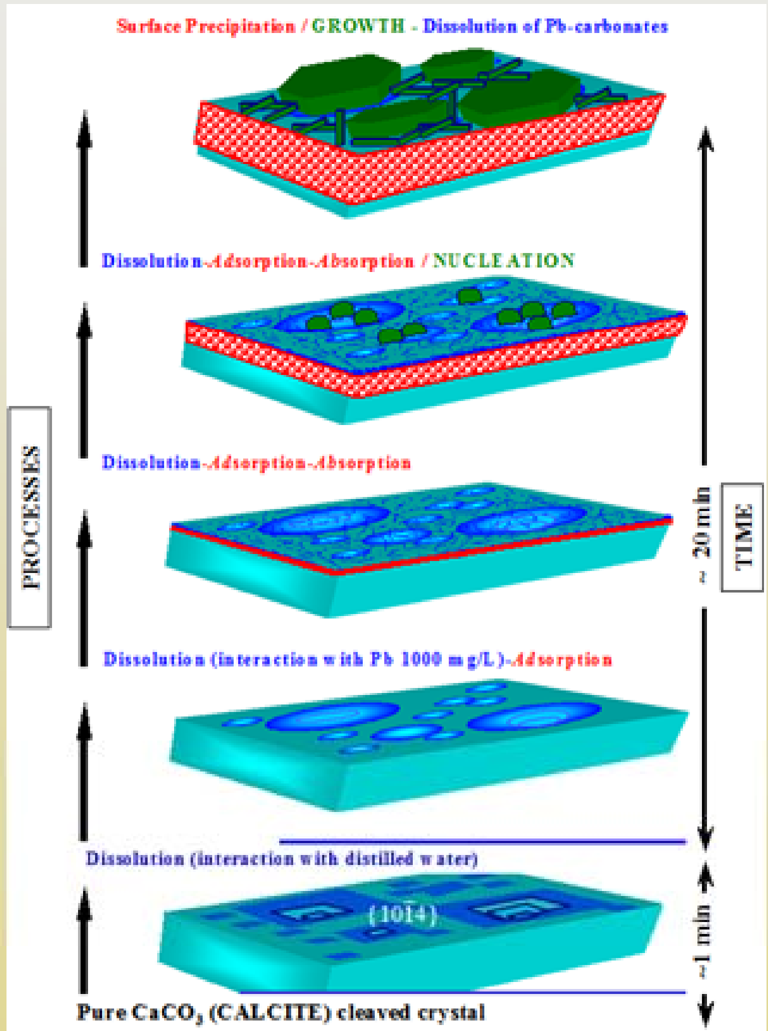


GODELITSAS et al., ES&T2003

Nanoscale processes on the basis of *in-situ* AFM / XPS / RBS data



CALCITE - H_2O - Pb^{2+}



GODELITSAS & ASTILLEROS, EMU Notes 2010

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Volume 57

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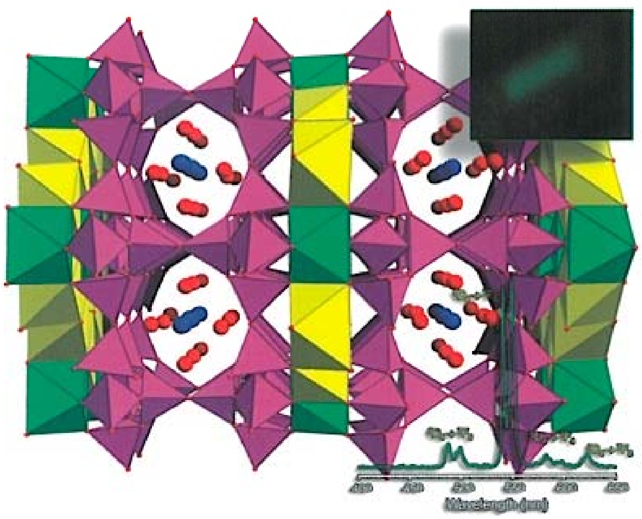
EDITORS: Giovanni Ferraris & Stefano Merlino



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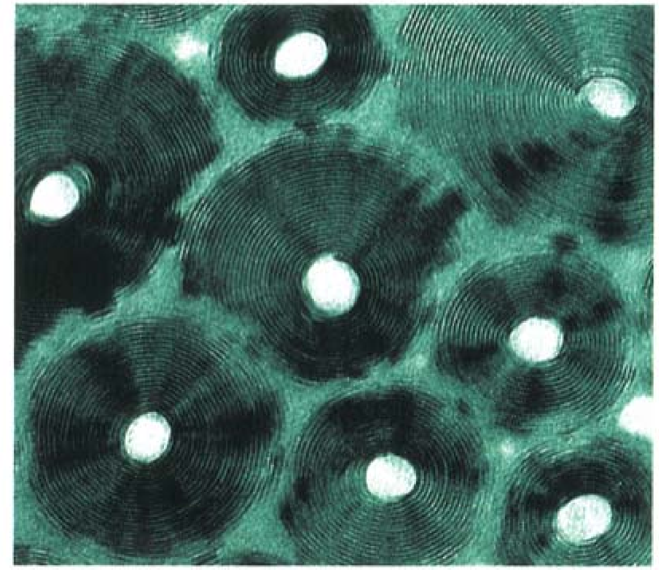

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ISBN 093995069-3
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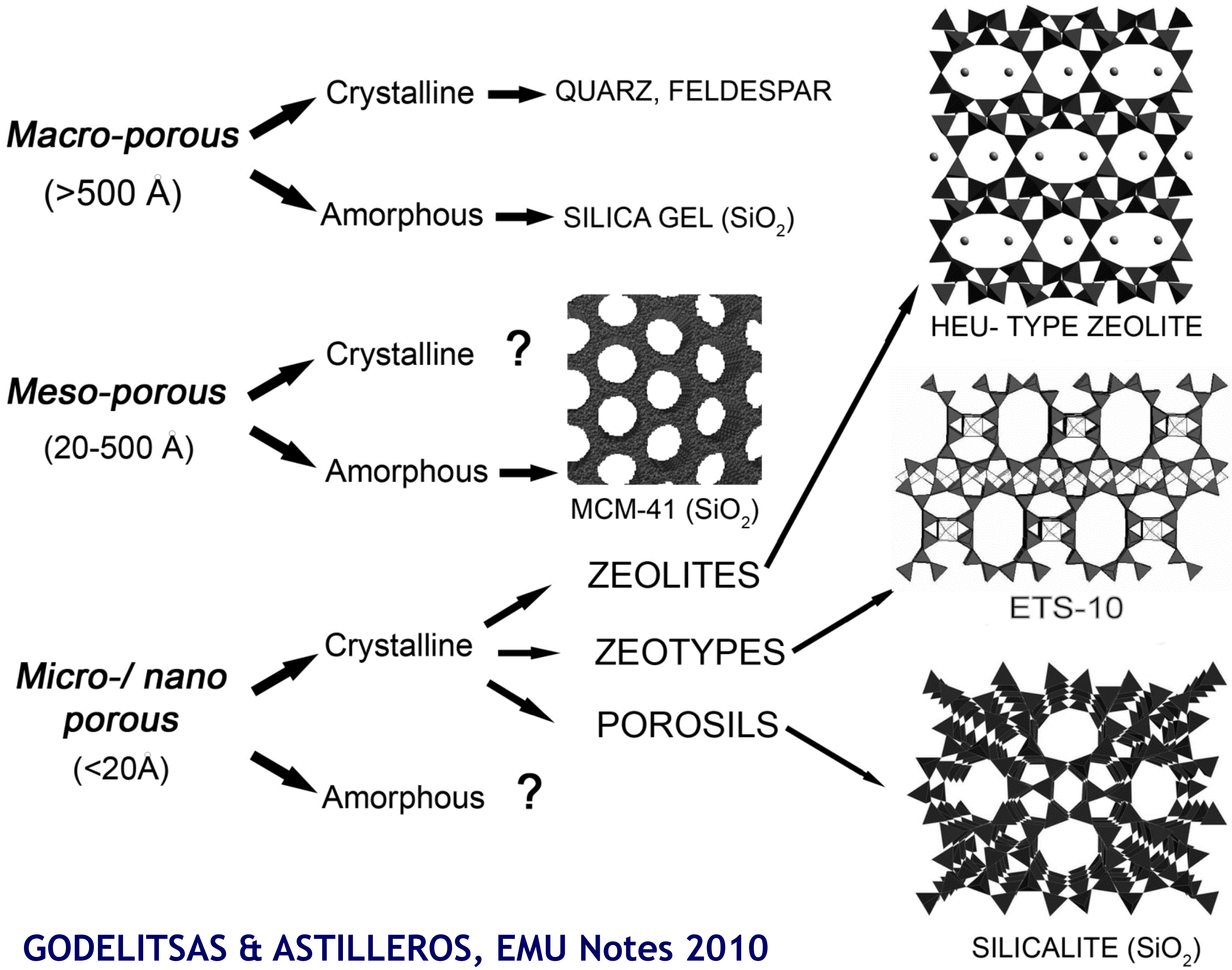

GODELITSAS & ASTILLEROS, EMU Notes 2010

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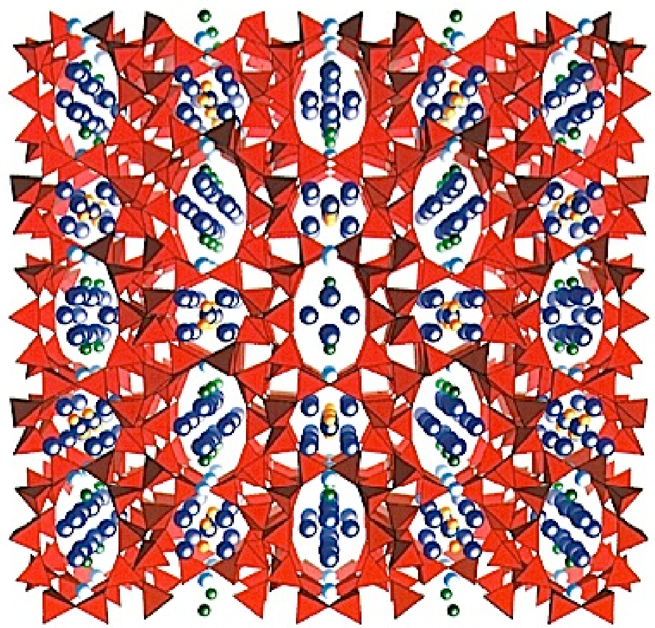
GEOCHEMISTRY
Volume 45

NATURAL ZEOLITES:

OCCURRENCE, PROPERTIES, APPLICATIONS

D. L. BISH, D. W. MING, EDITORS



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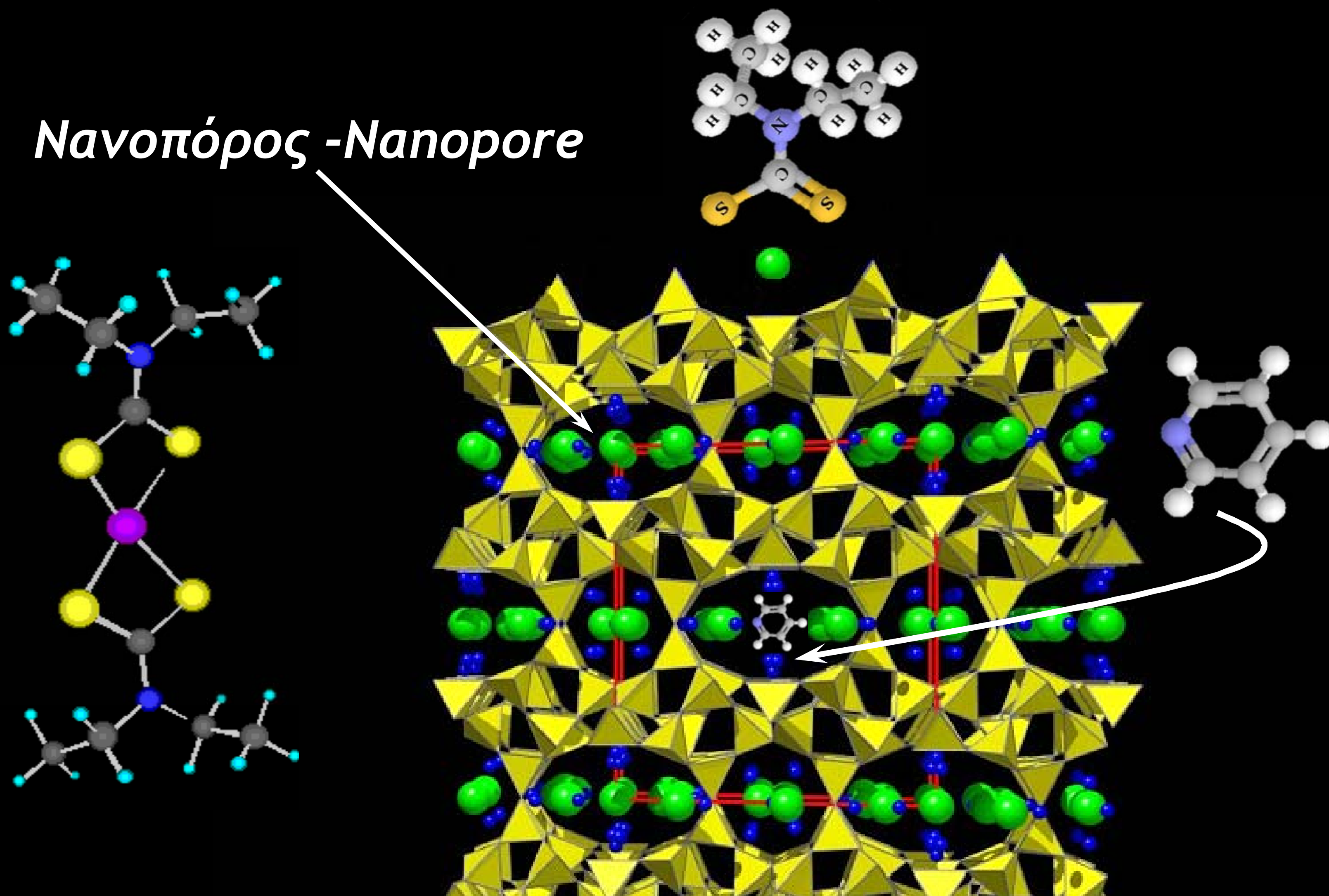
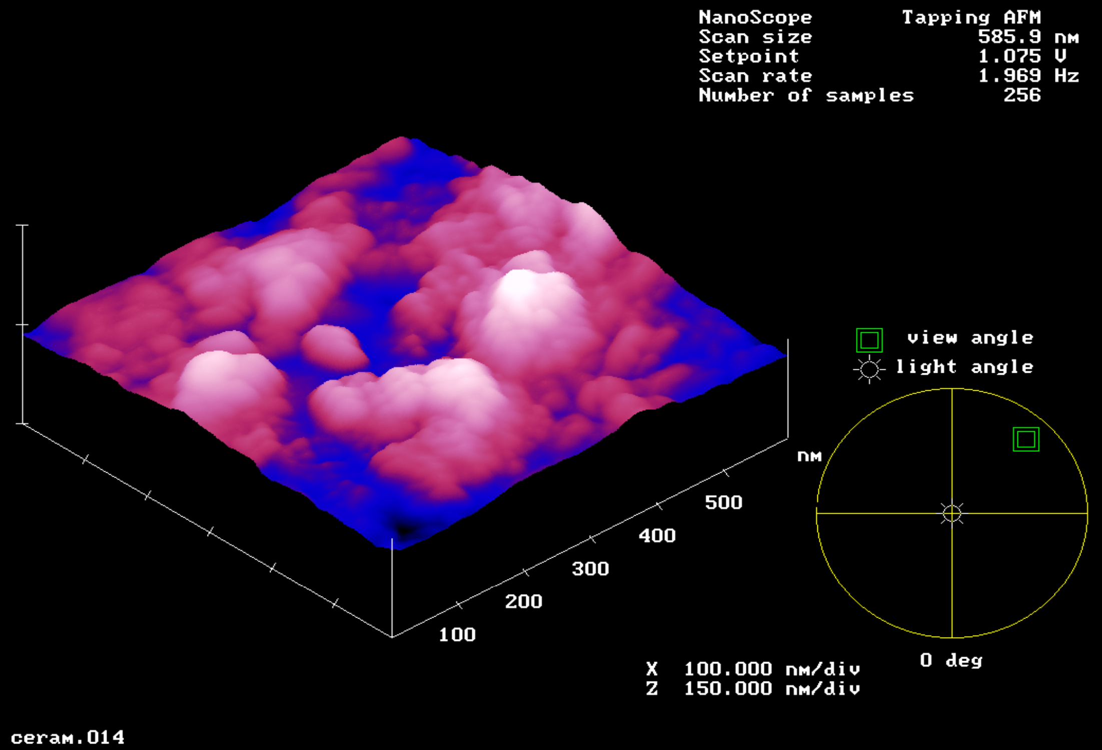
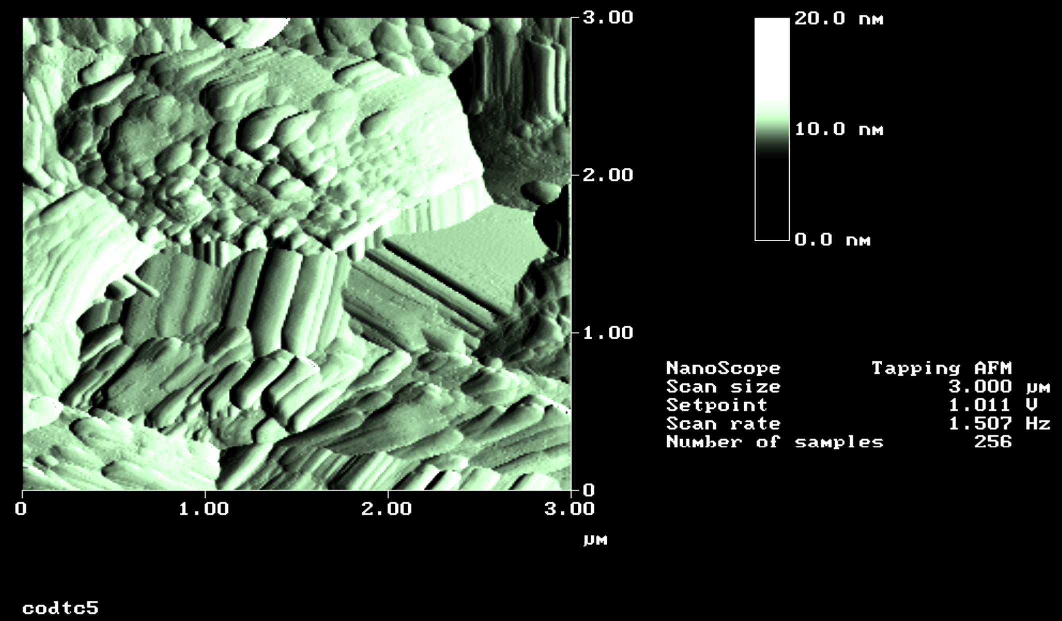


GODELITSAS et al., 1999, 2001, 2003; GODELITSAS & ARMBRUSTER, 2003

Atomic Force Microscopy (AFM)

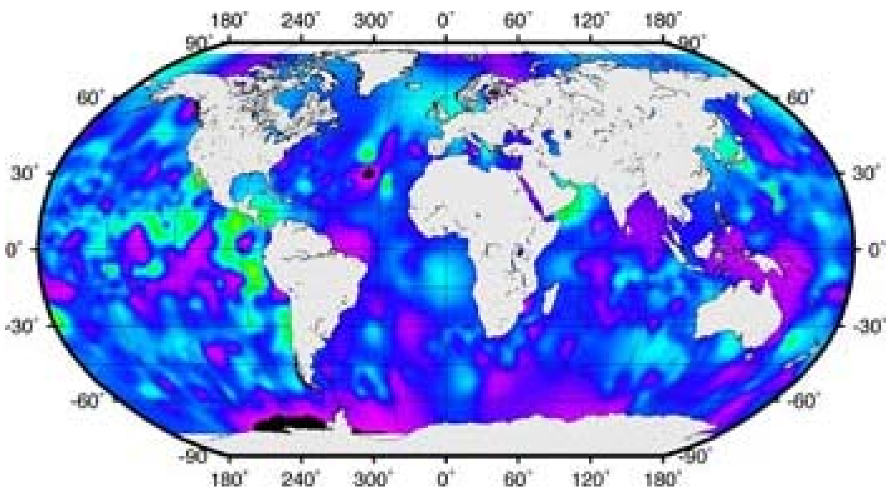




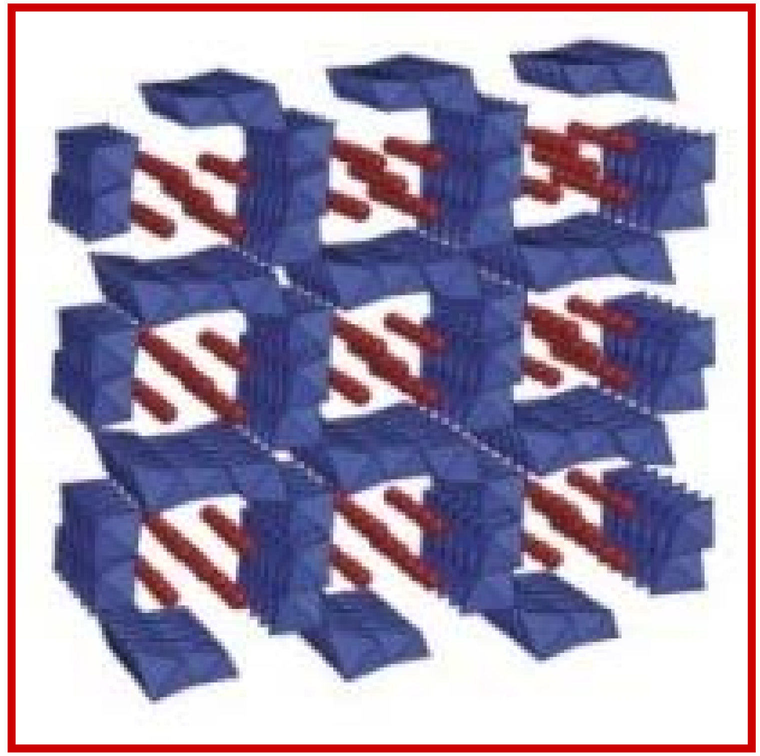
GODELITSAS et al., MMM 2003

Νανοπορώδη ορυκτά Mn – Nanoporous Mn minerals

ΚΟΝΔΥΛΟΙ ΜΑΓΓΑΝΙΟΥ



Τοντοροκίτης -Todorokite

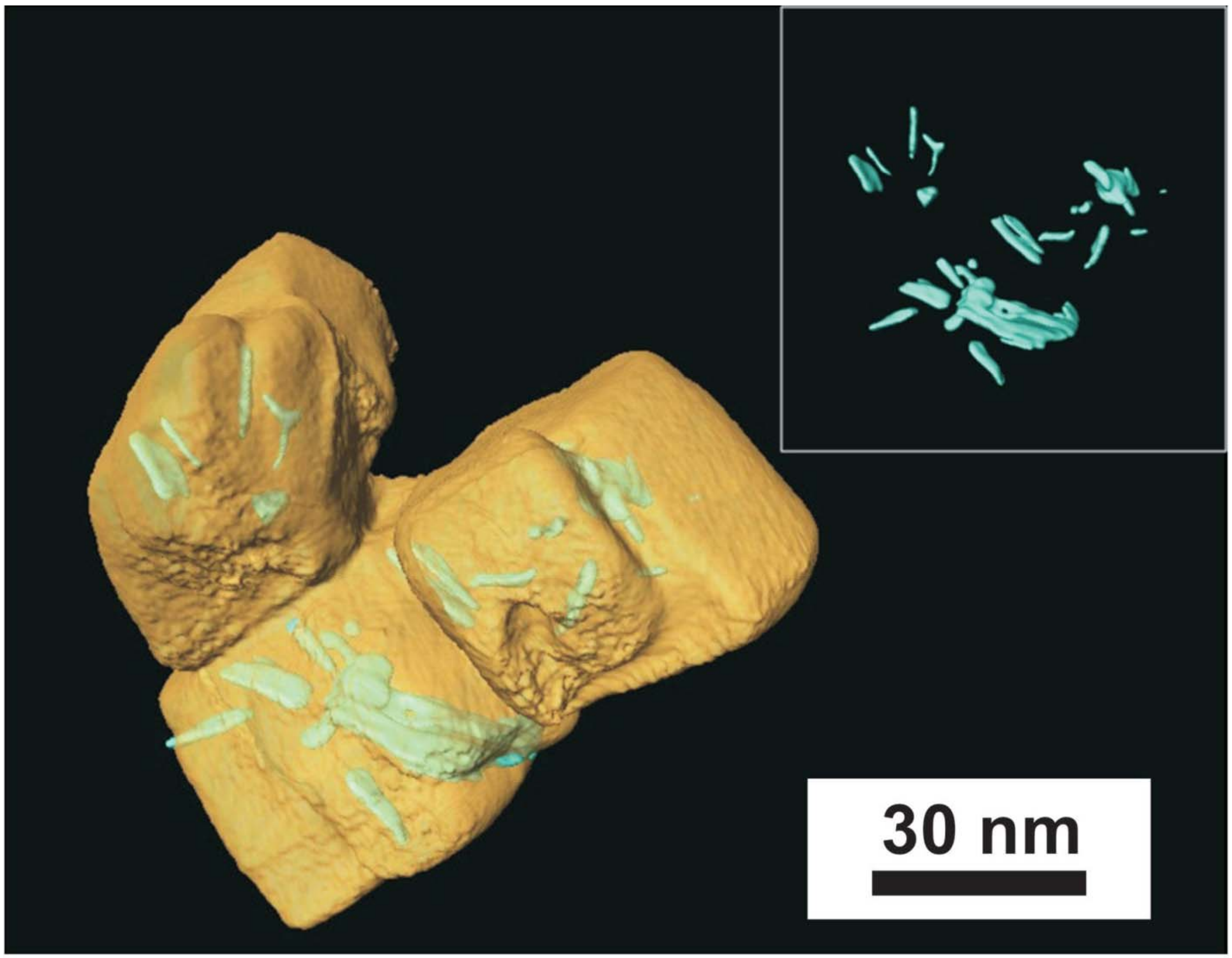


American Mineralogist, Volume 98, pages 154–162, 2013

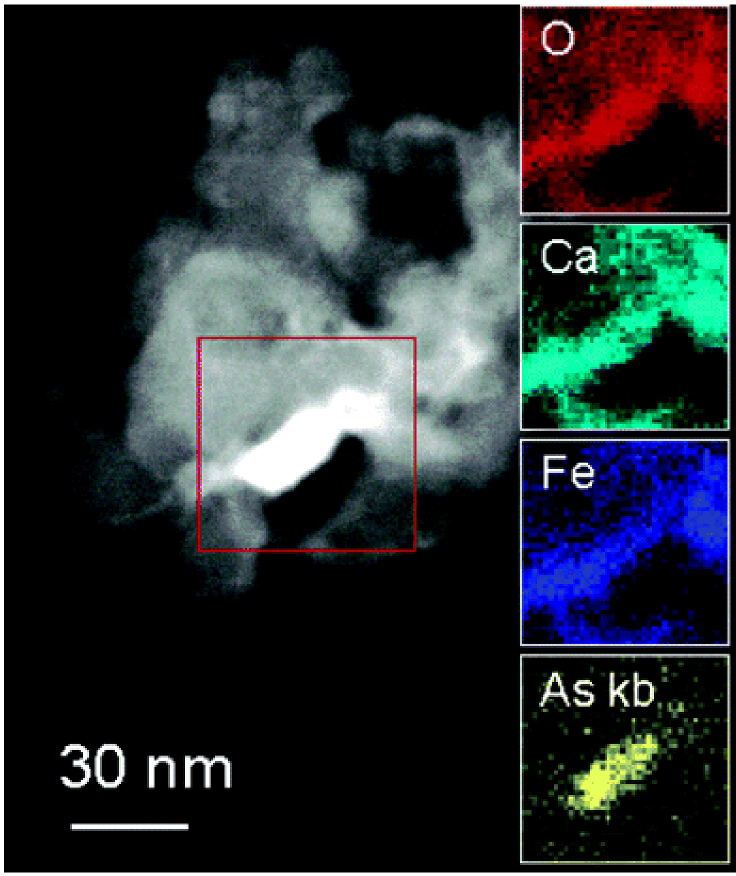
Nanopores in hematite (α-Fe_2O_3) nanocrystals observed by electron tomography

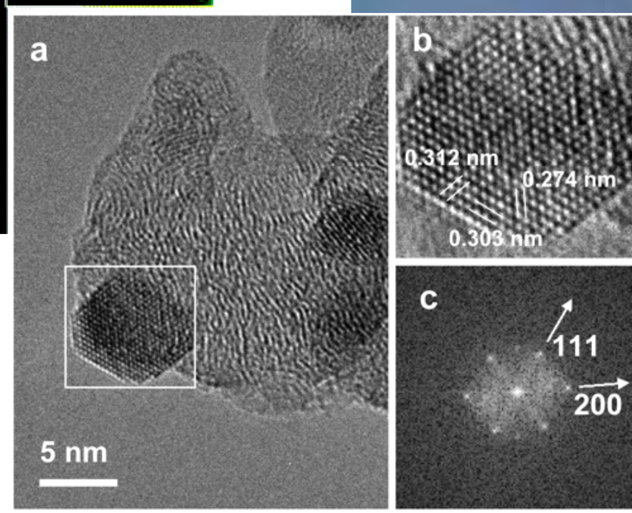
TAKUYA ECHIGO,[1,2,*] NIVEN MONSEGUE,[3,4] DEBORAH M. ARUGUETE,[1,3,†] MITSUHIRO MURAYAMA,[3,4] AND MICHAEL F. HOCHELLA JR.[1,3]

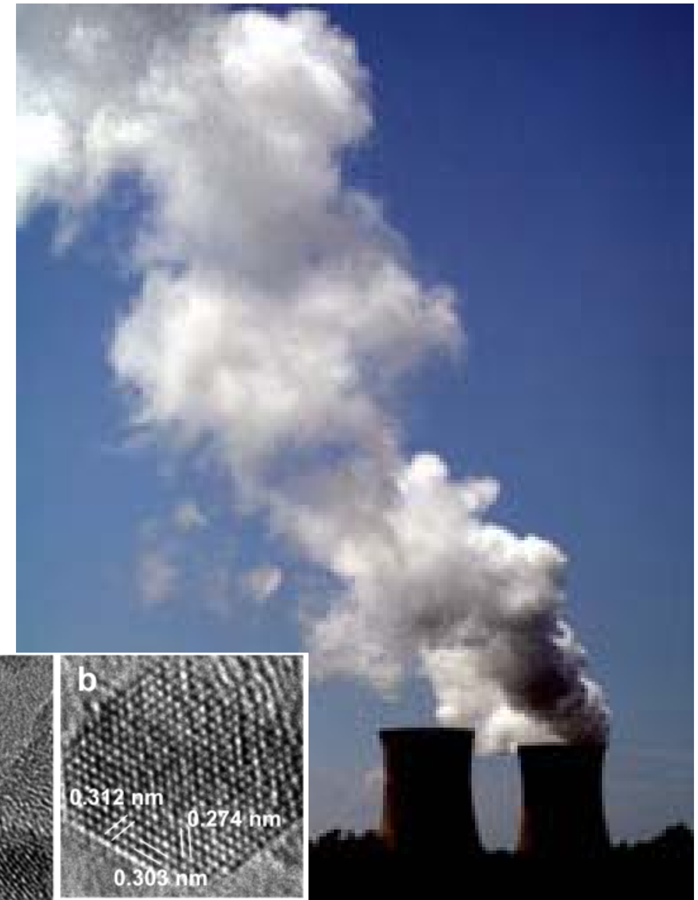
[1]Center for NanoBioEarth, Department of Geosciences, Virginia Tech, Blacksburg, Virginia 24061, U.S.A.
[2]Japan International Research Center for Agricultural Sciences, Ohwashi 1-1, Tsukuba 305-8686, Ibaraki, Japan
[3]Institute for Critical Technology and Applied Science, Virginia Tech, Blacksburg, Virginia 24061, U.S.A.
[4]Department of Materials Science and Engineering, Virginia Tech, Blacksburg, Virginia 24061, U.S.A.



Ατμοσφαιρικά Νανοσωματίδια - Atmospheric Nanoparticles

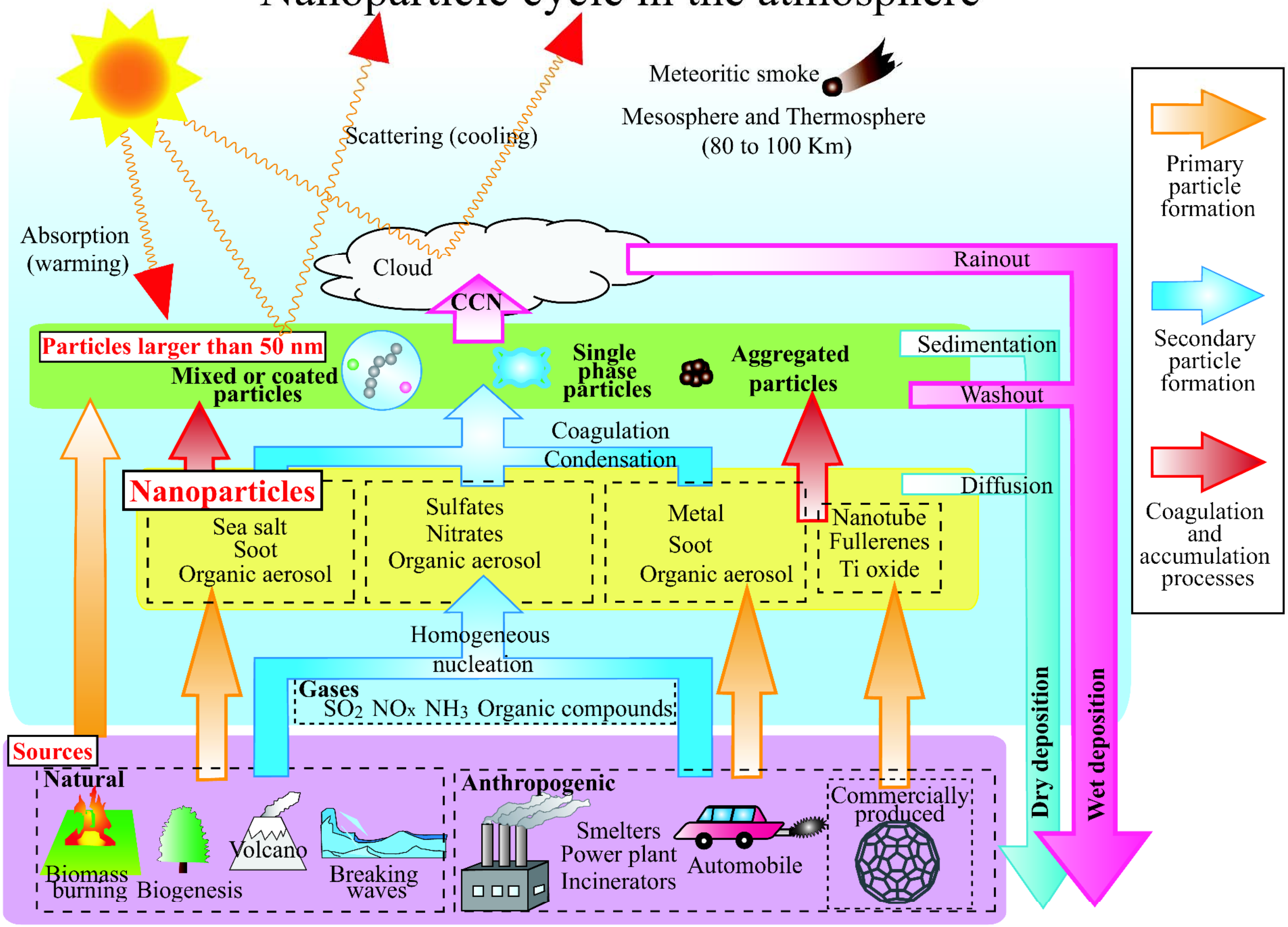






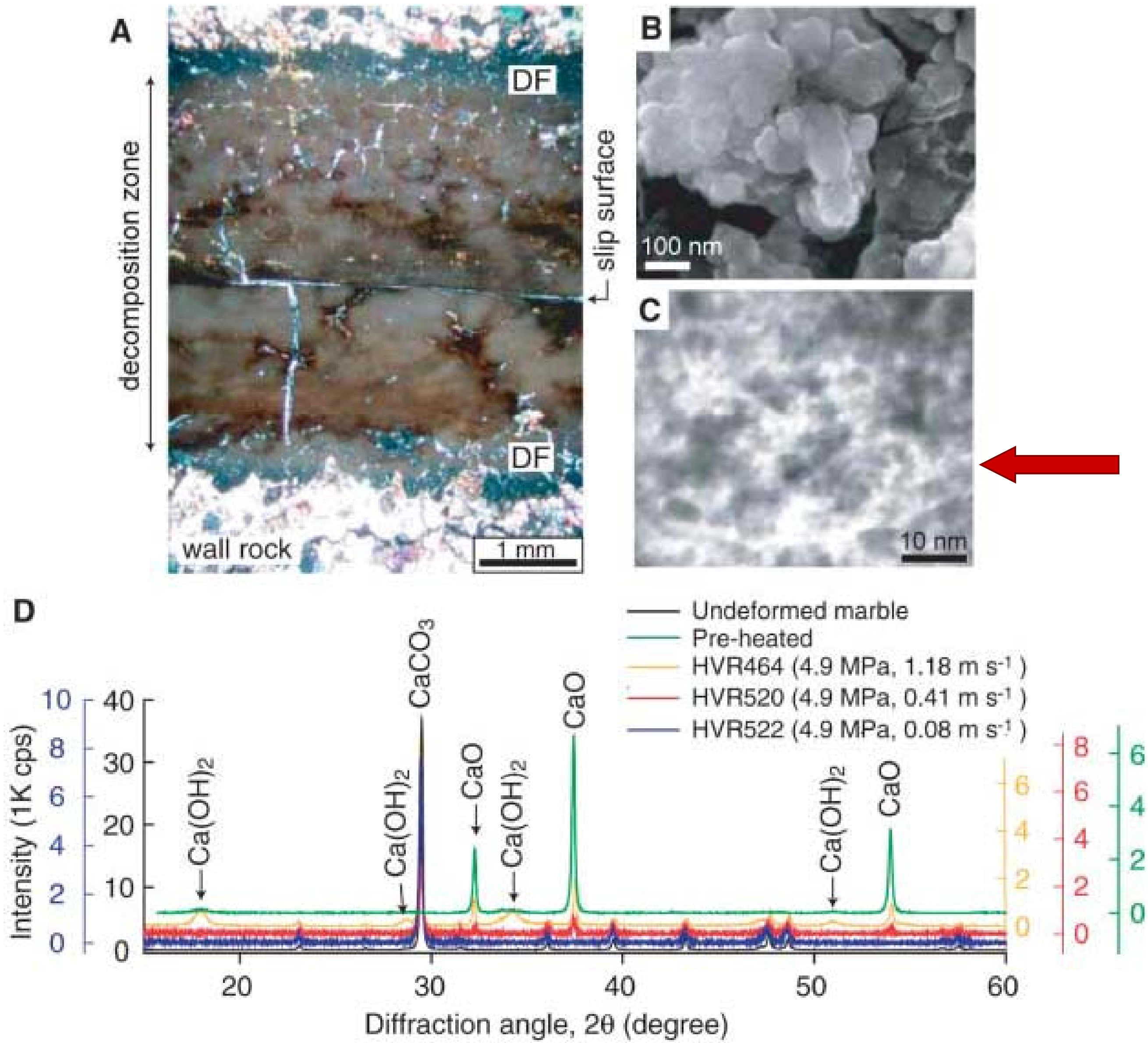
UTSUNOMIYA et al.,
ES&T 2002 and 2004

Nanoparticle cycle in the atmosphere



BUSECK & ADACHI, Elements 2008

Νανοσωματίδια σε ρήγματα - Nanoparticles in faults

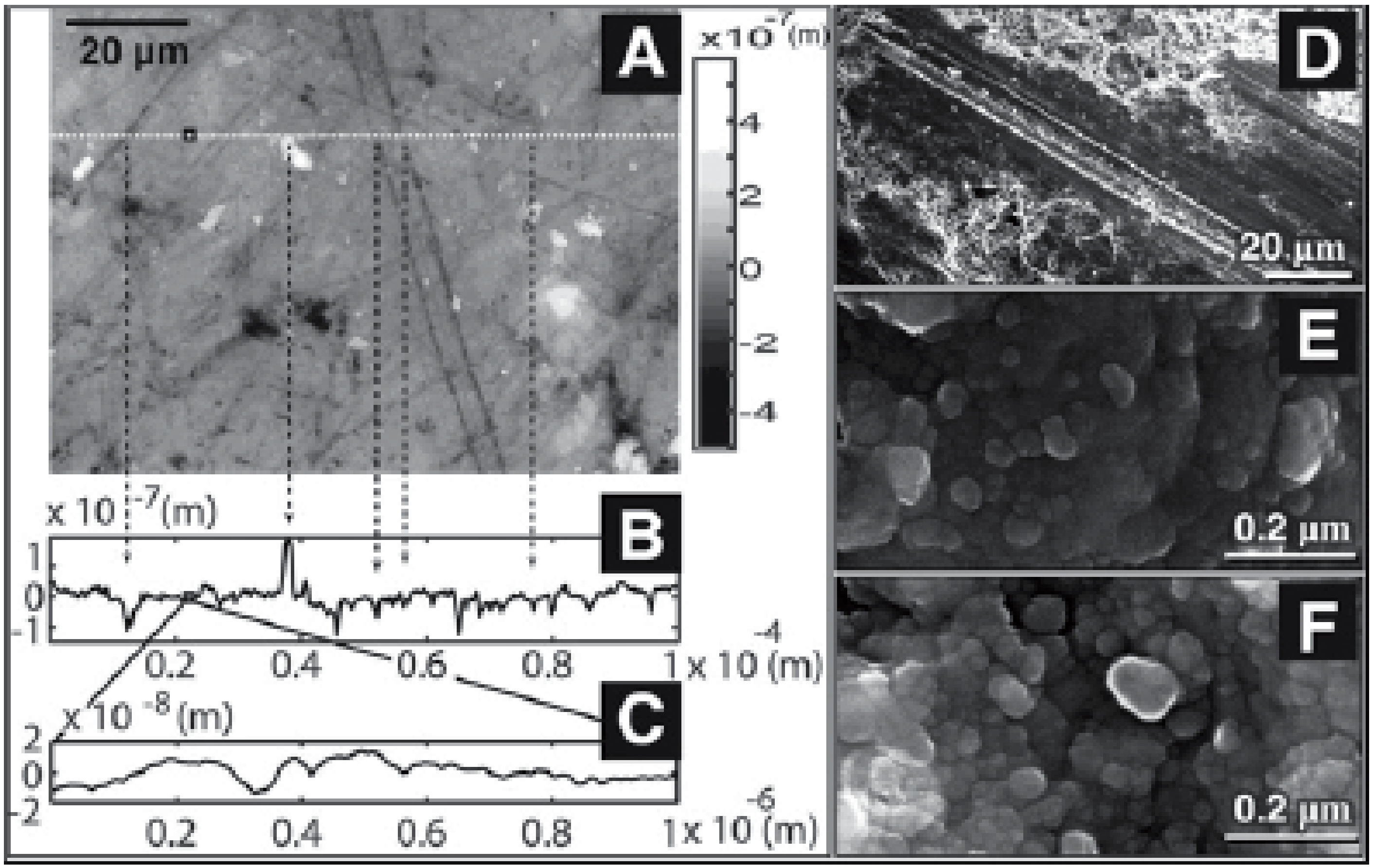


HAN et al., Science 2007

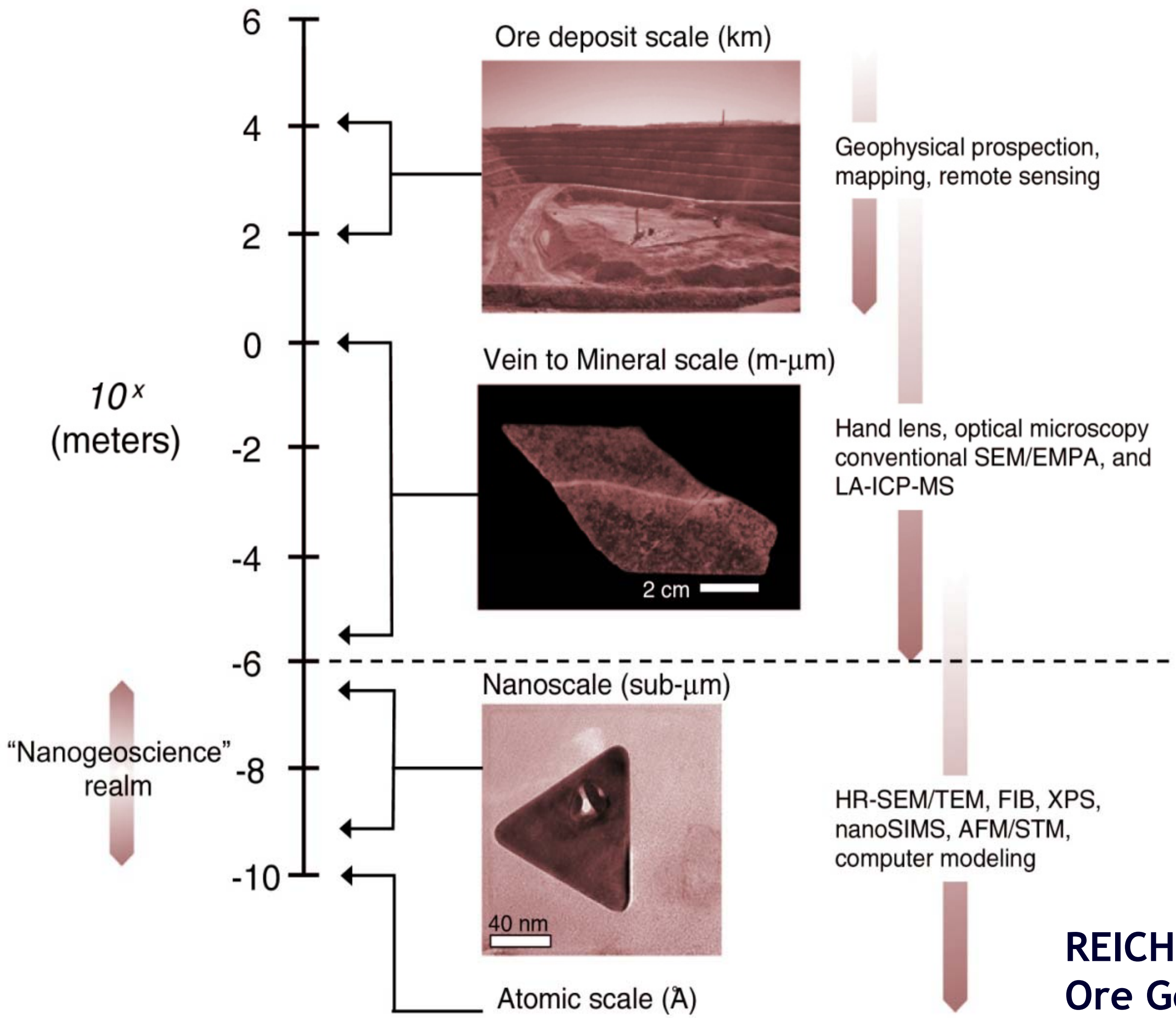
Geology, published online on 16 April 2013 as doi:10.1130/G34087.1

Nanograins form carbonate fault mirrors

Shalev Siman-Tov[1], Einat Aharonov[1], Amir Sagy[2], and Simon Emmanuel[1]
[1]Institute of Earth Sciences, The Hebrew University of Jerusalem, Jerusalem 91904, Israel
[2]Geological Survey of Israel, 30 Malkhe Israel, Jerusalem 95501, Israel



Νανογεωπιστήμη και ορυκτές πρώτες ύλες



REICH et al., Ore Geol. Rev. 2011

Ore Geology Reviews 42 (2011) 6–31

Contents lists available at ScienceDirect

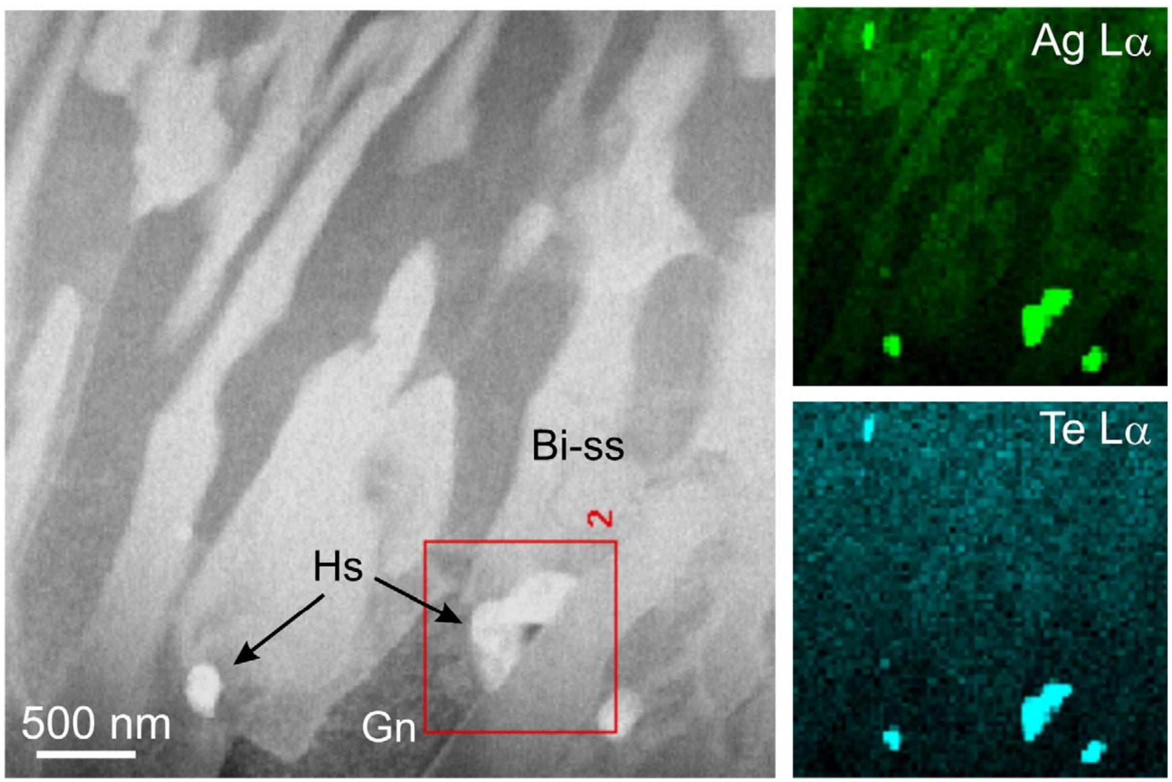
Ore Geology Reviews

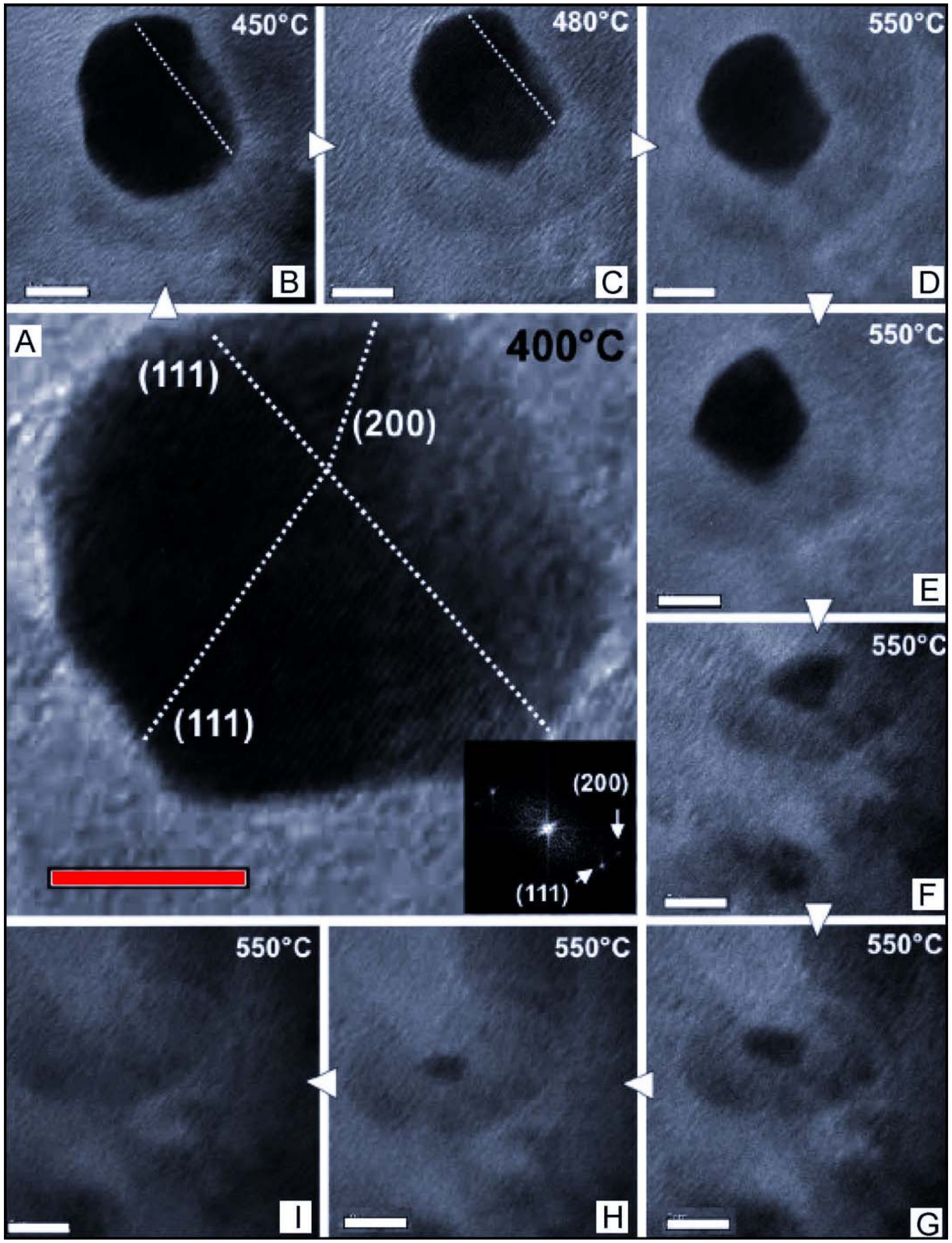
journal homepage: www.elsevier.com/locate/oregeorev

Focussed ion beam–transmission electron microscopy applications in ore mineralogy: Bridging micro- and nanoscale observations

C.L. Ciobanu [a,*], N.J. Cook [a,b], S. Utsunomiya [c], A. Pring [a,b], L. Green [d]

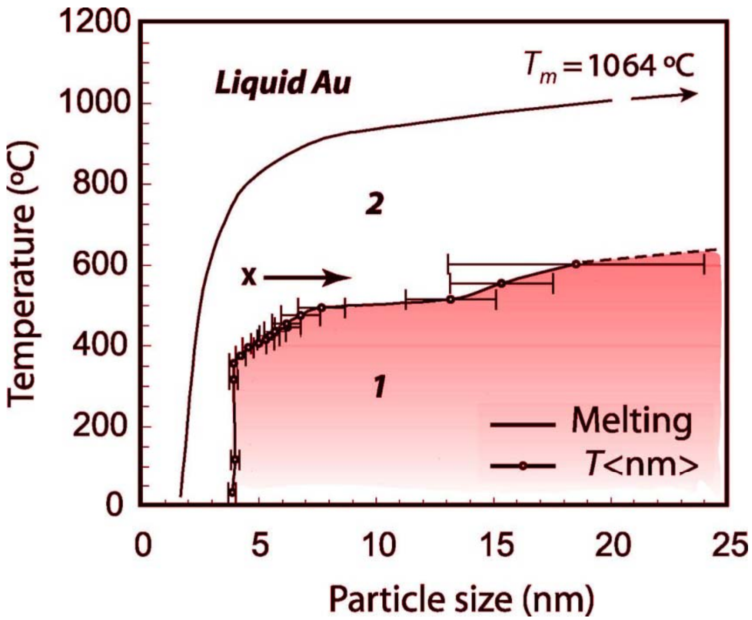
[a] Centre for Tectonics, Resources and Exploration (TRaX), School of Earth and Environmental Sciences, University of Adelaide, 5005 S.A., Australia
[b] South Australian Museum, Adelaide, 5000 S.A., Australia
[c] Department of Chemistry, Kyushu University, Fukuoka, Japan
[d] Adelaide Microscopy, University of Adelaide, 5005 S.A., Australia



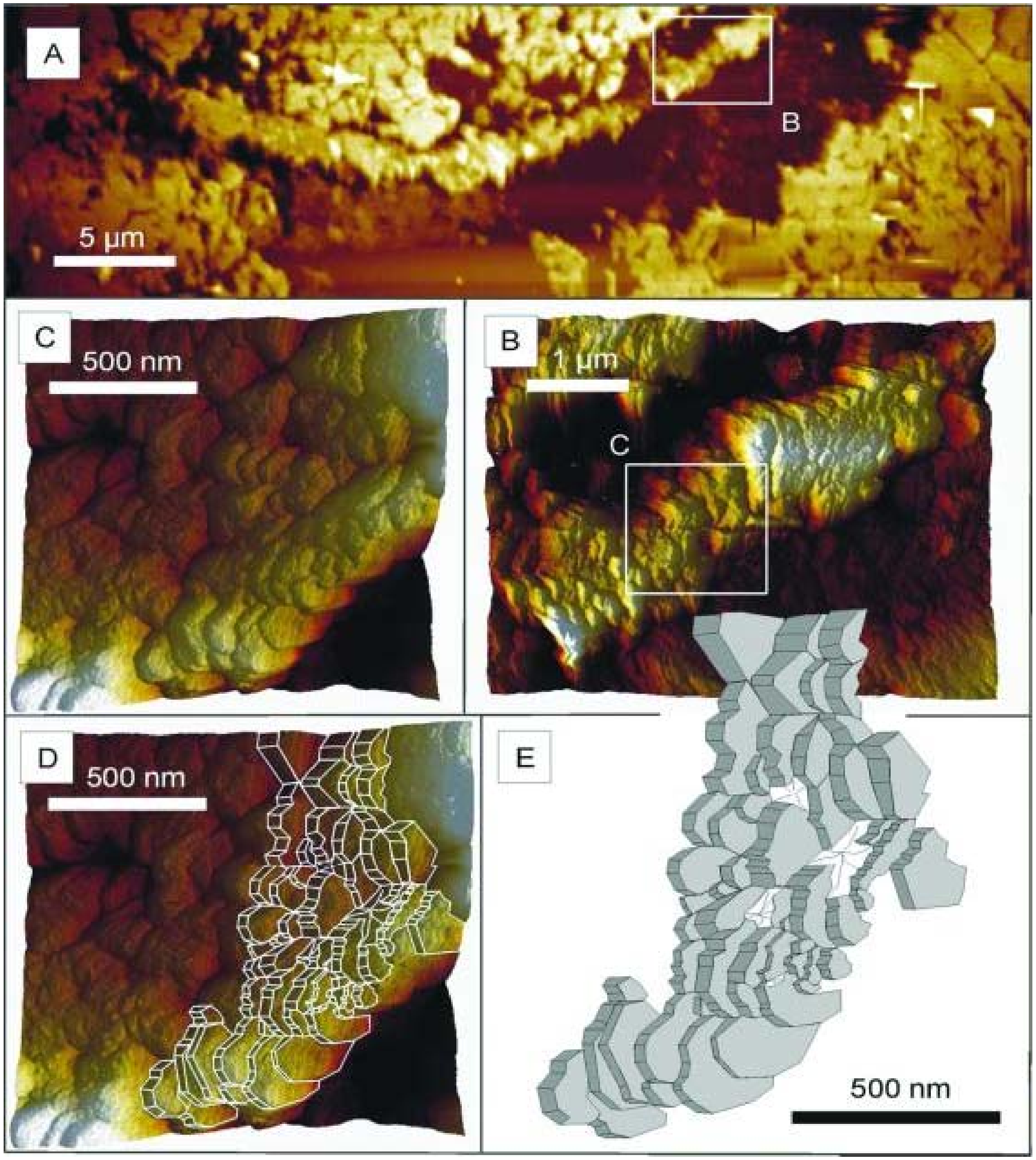


Νανοσωματίδια Au σε σουλφίδια

Κλίμακα = 5 nm

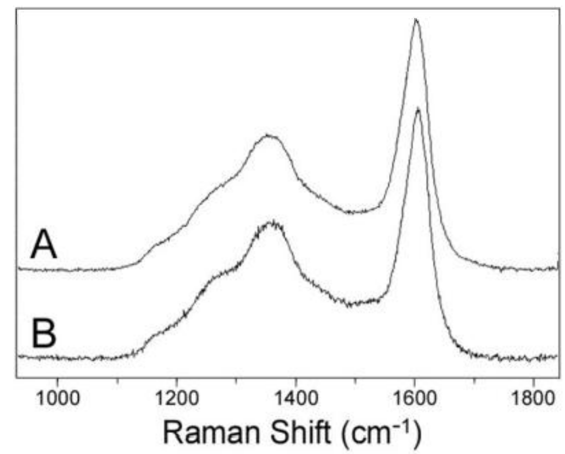


REICH et al., Geology 2006



Νανο-Απολιθώματα

Nano-fossils



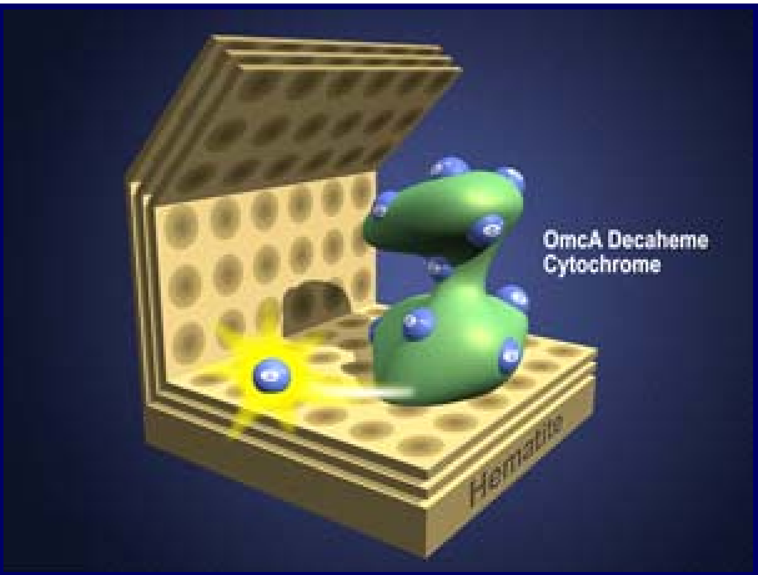
KEMPE et al., PNAS 2002

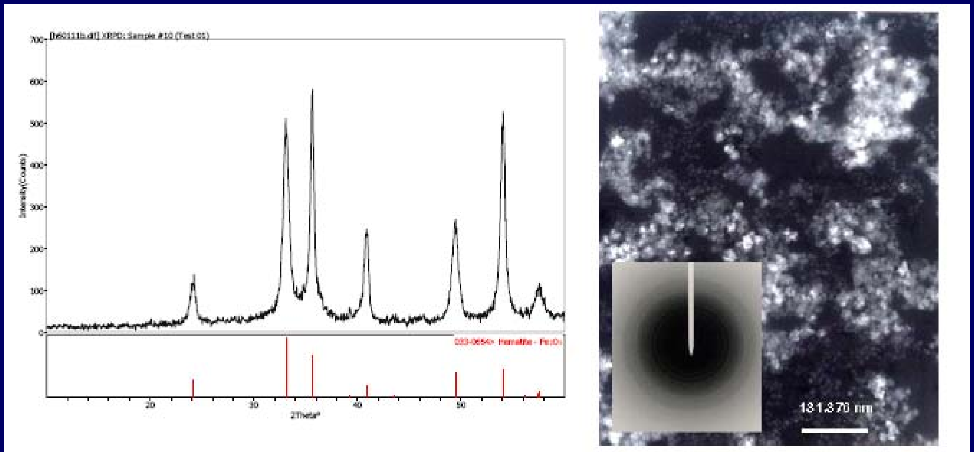
ΝΑΝΟΓΕΩΕΠΙΣΤΗΜΗ - ΝΑΝΟΤΕΧΝΟΛΟΓΙΑ

Biofuel cells

miniature bioreactor cells to power small electronic devices

Hematite nanoparticles

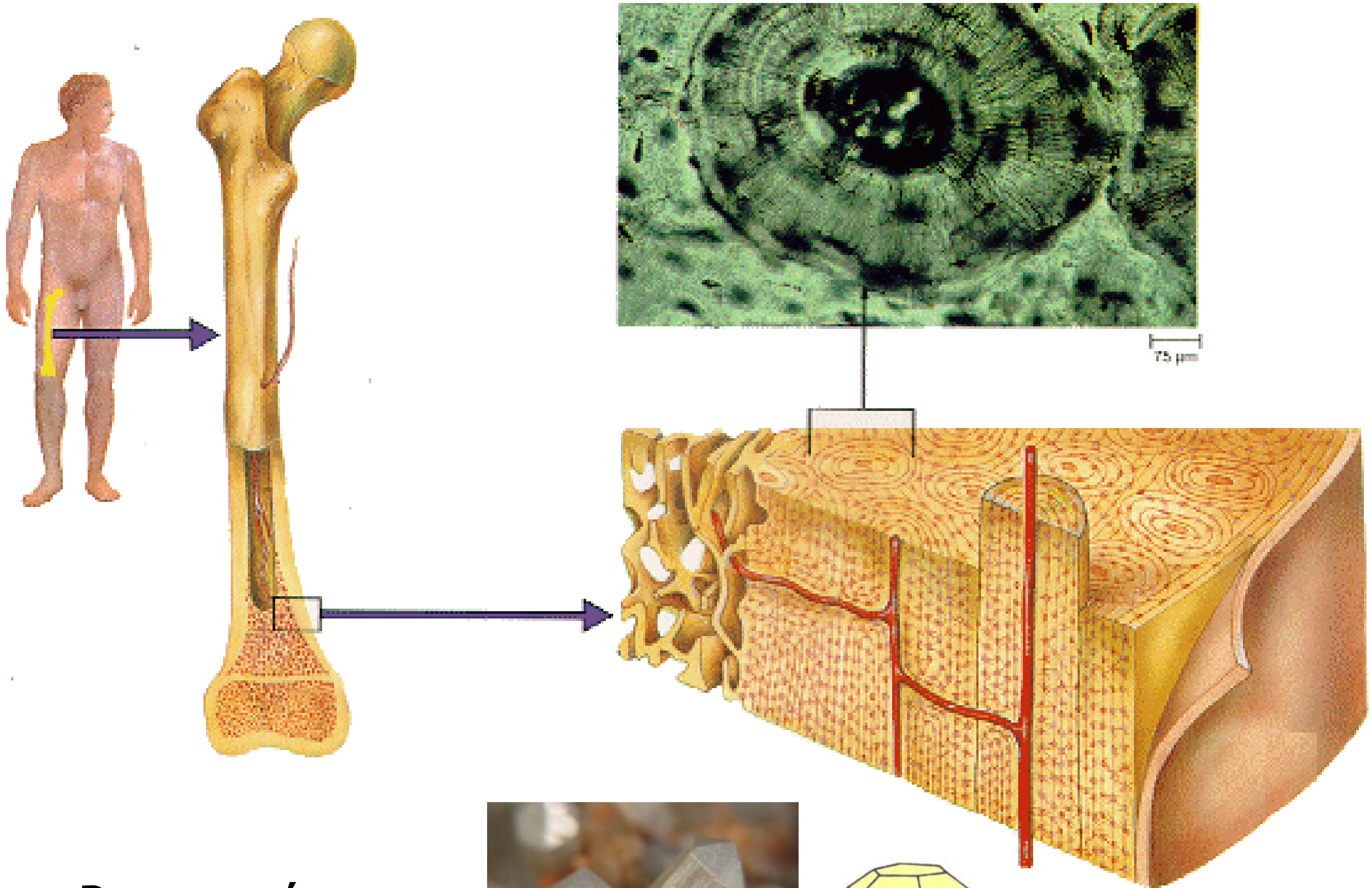




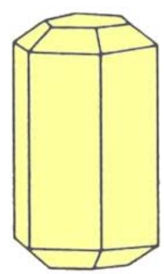
Purified proteins removed from the outer membrane of the versatile, metal-altering soil bacterium *Shewanella oneidensis*

ΒΙΟ-ΟΡΥΚΤΑ & ΒΙΟ-ΟΡΥΚΤΟΓΕΝΕΣΗ

BIOMINERALS & BIOMINERALIZATION



Βιο-απατίτης
Bio-apatite



American Mineralogist, Volume 99, pages 16–27, 2014

MINERALS IN THE HUMAN BODY

Molecular water in nominally unhydrated carbonated hydroxylapatite: The key to a better understanding of bone mineral†

JILL DILL PASTERIS[1,*], CLAUDE H. YODER[2] AND BRIGITTE WOPENKA[1]

[1]Department of Earth and Planetary Sciences, Washington University in St. Louis, St. Louis, Missouri 63130-4899, U.S.A.
[2]Department of Chemistry, Franklin and Marshall College, Lancaster, Pennsylvania 17603, U.S.A.

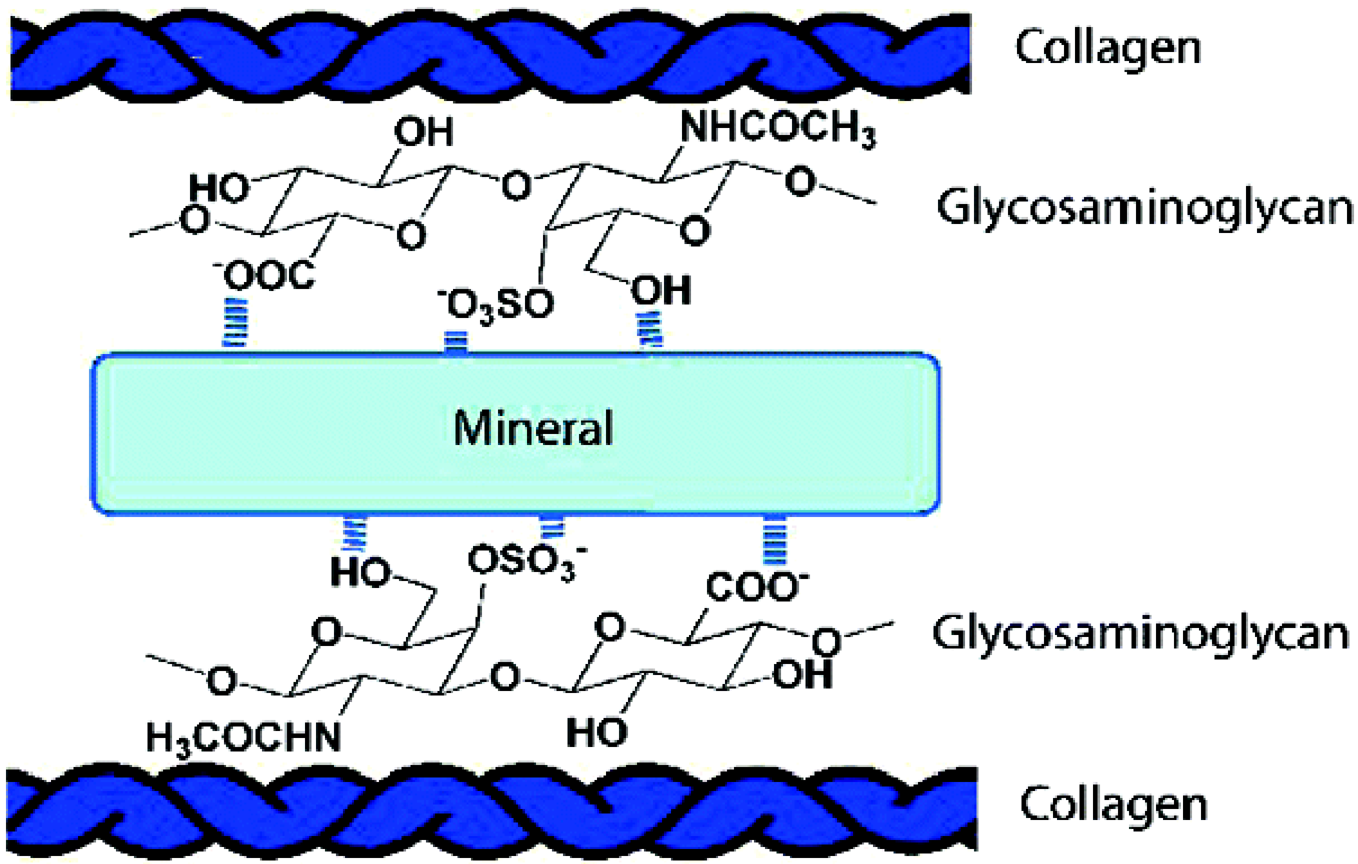
substituting for hydroxyl ions in the channels, thus regulating chemical access to the channels. As they note, their results show that *bone apatite is not a "flawed hydroxylapatite," but instead a definable mineralogical entity, a combined hydrated-hydroxylated calcium phosphate phase of the form* $Ca_{10-x}[(PO_4)_{6-x}(CO_3)_x](OH)_{2-x}\cdot nH_2O$*, where* $n \sim 1.5$*. Water is therefore not an accidental, but rather an essential, component of bone mineral and other natural and synthetic low-temperature carbonated apatite phases.*

The results of this study, published in this issue, are extremely important in many fields and will be of particular interest to those in medicine who study diseases of the bone.

The Organic−Mineral Interface in Bone Is Predominantly Polysaccharide

Erica R. Wise, Sergey Maltsev, M. Elisabeth Davies, Melinda J. Duer, Christian Jaeger, Nigel Loveridge, Rachel C. Murray, and David G. Reid

Chem. Mater., **2007**, *19* (21), pp 5055-5057
Publication Date (Web): September 25, 2007 (Communication)
DOI: 10.1021/cm702054c



Elements, Vol. 4, pp. 97–104 97 April 2008

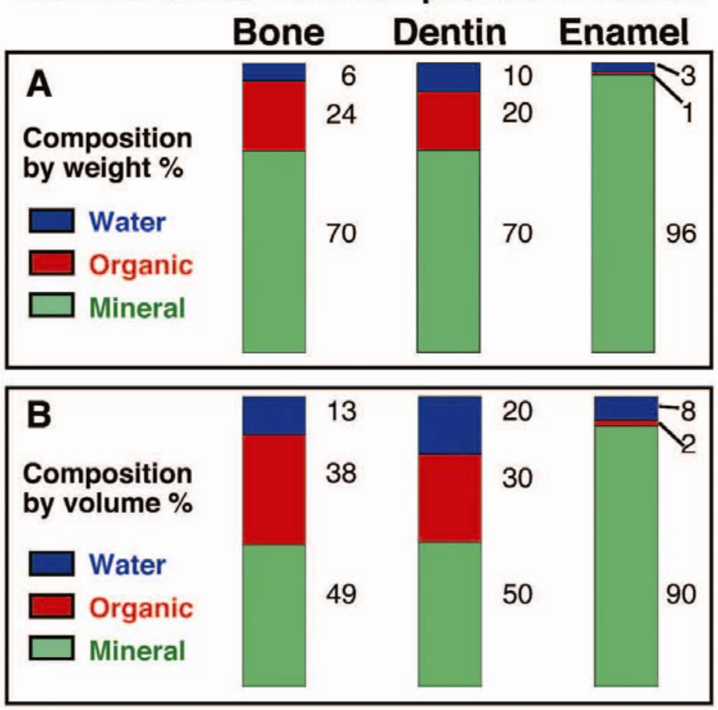
Bone and Tooth Mineralization: Why Apatite?


Skull of a modern horse

Jill D. Pasteris[1], Brigitte Wopenka[1], and Eugenia Valsami-Jones[2]

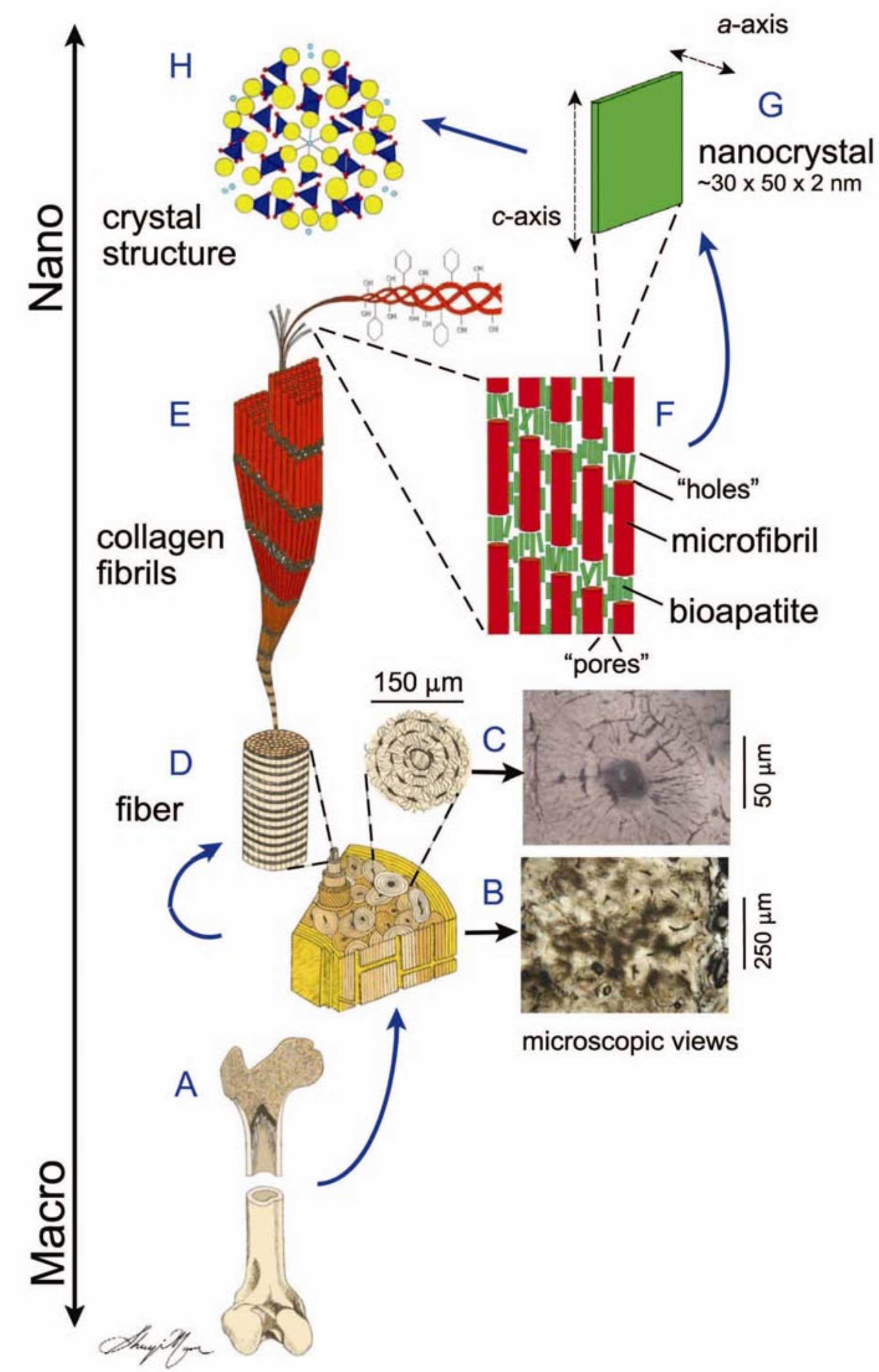
DOI: 10.2113/gselements.4.2.97

Biomineralized Nanocomposites in Human



C
Bioapatite parameters

	Bone	Dentin	Enamel
Remodeled ?	Yes	No	No
Crystallite size (nm)	**20 x 4**	**20 x 4**	**130 x 30**
[CO_3^{2-}] in wt%	6.0	5.0	3.5
[OH^-]	**Very Low**	**Low**	**High**



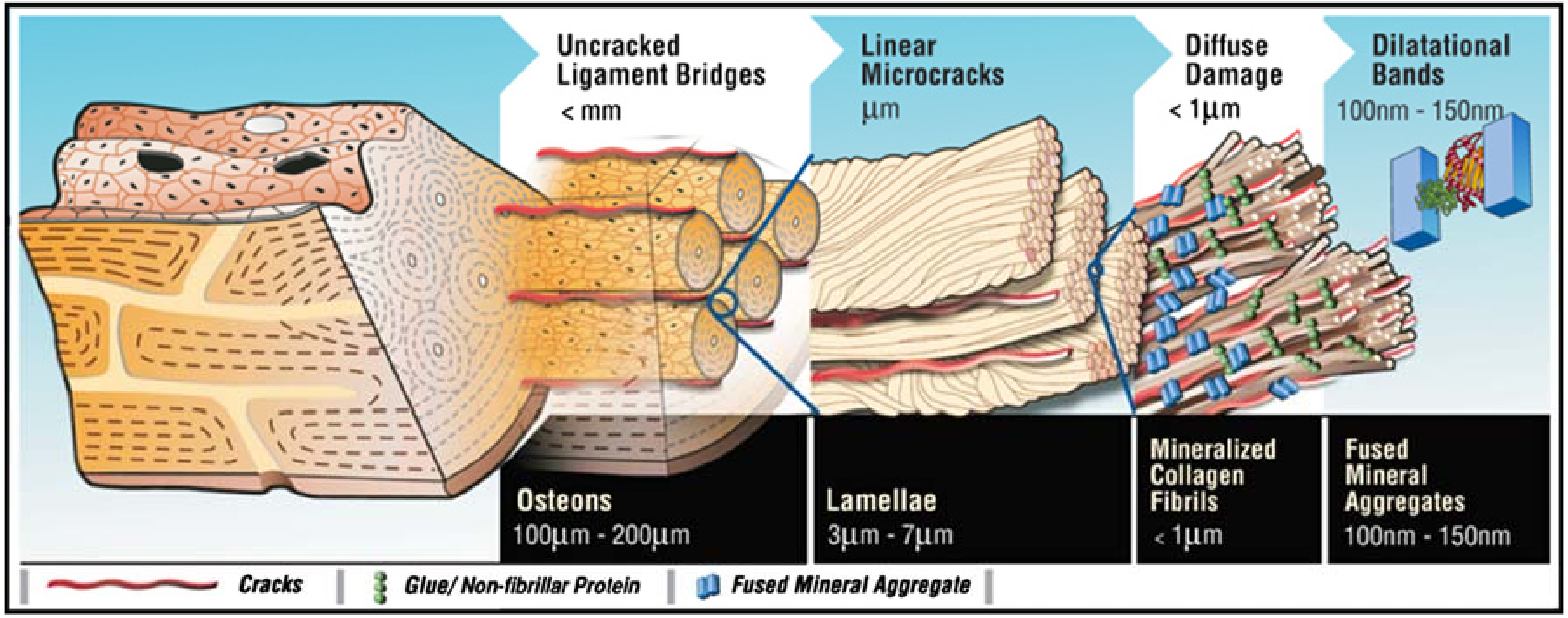
PNAS

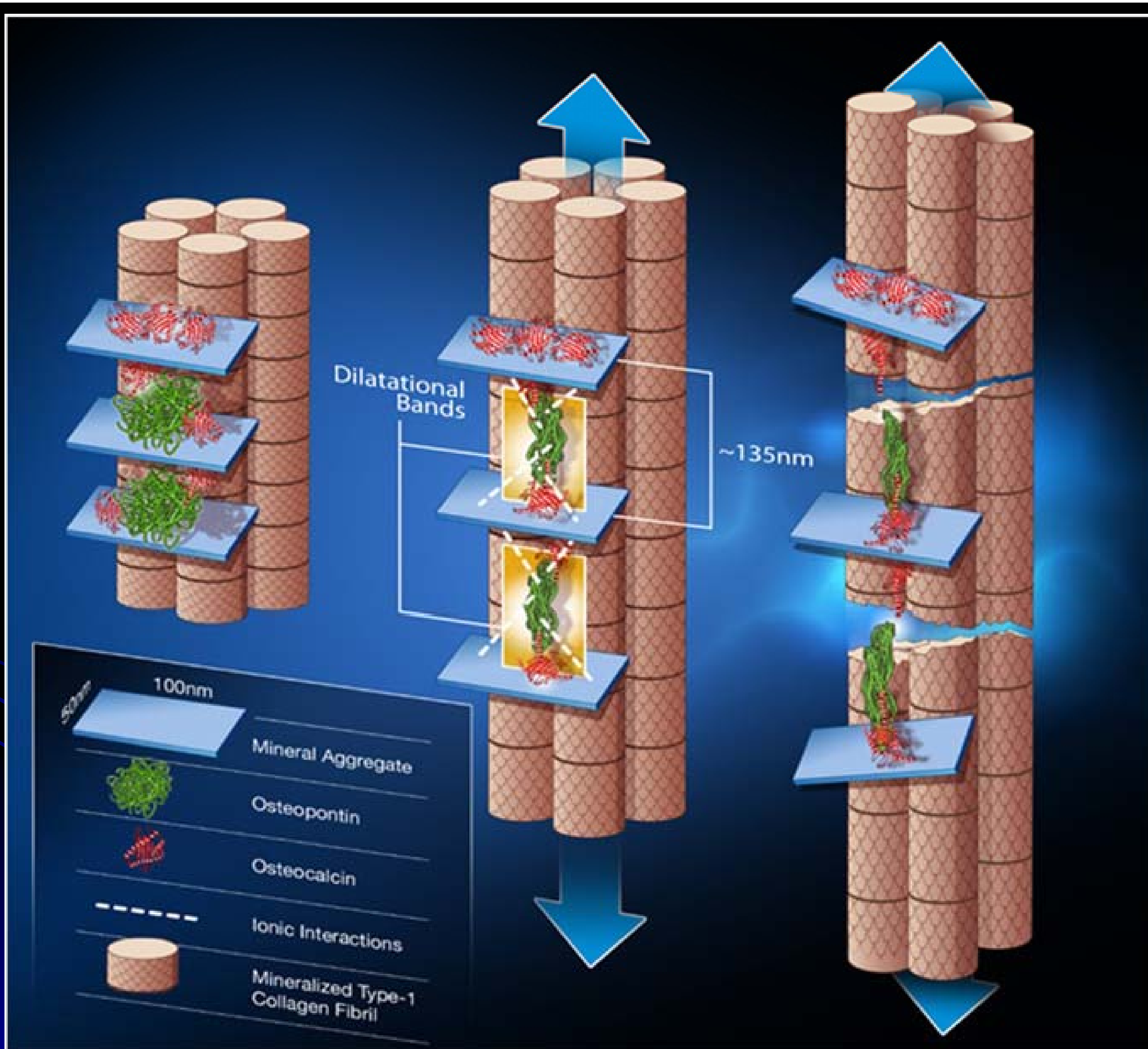
Dilatational band formation in bone

Atharva A. Poundarik[a], Tamim Diab[a], Grazyna E. Sroga[a], Ani Ural[b], Adele L. Boskey[c], Caren M. Gundberg[d], and Deepak Vashishth[a,1]

[a]Department of Biomedical Engineering, Rensselaer Polytechnic Institute, Troy, NY 12180; [b]Department of Mechanical Engineering, Villanova University, Villanova, PA 19085; [c]Musculoskeletal Integrity Program, Hospital for Special Surgery, New York, NY 10021; and [d]Department of Orthopedics and Rehabilitation, Yale University, New Haven, CT 06520

Edited by Sheldon Weinbaum, City College of New York, New York, NY, and approved October 3, 2012 (received for review January 31, 2012)




Dilatational Bands
~135nm
100nm
50nm
Mineral Aggregate
Osteopontin
Osteocalcin
Ionic Interactions
Mineralized Type-1 Collagen Fibril

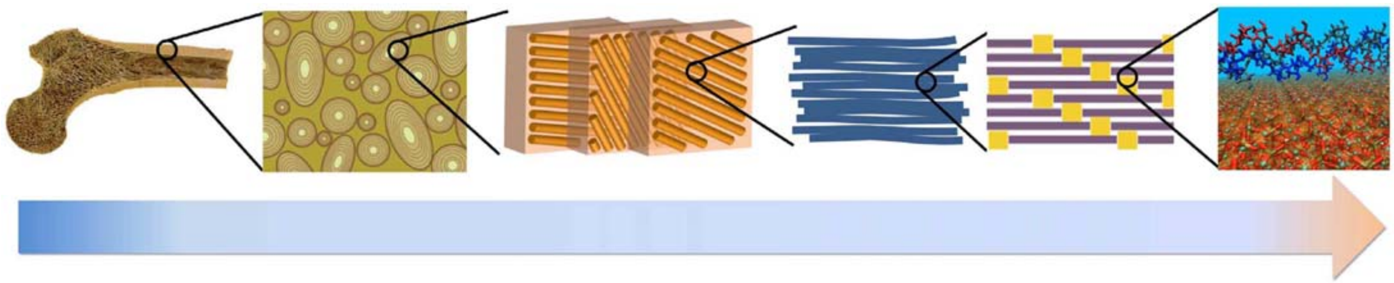
nature COMMUNICATIONS

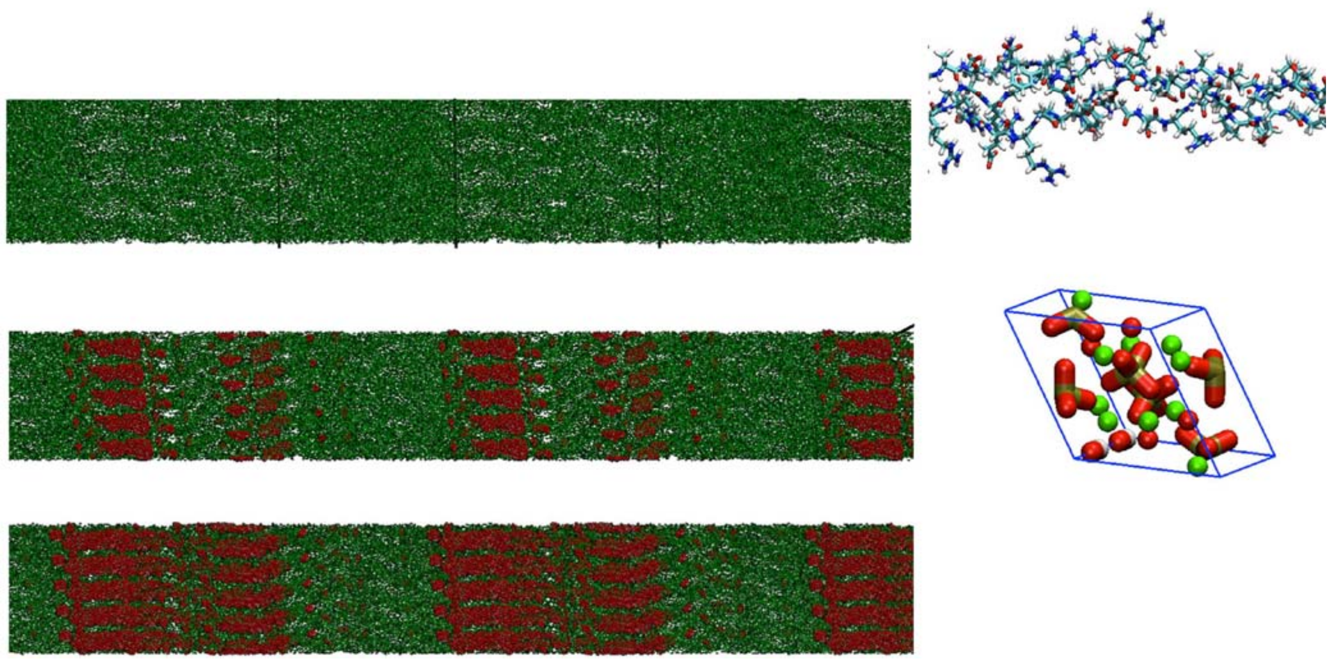
ARTICLE

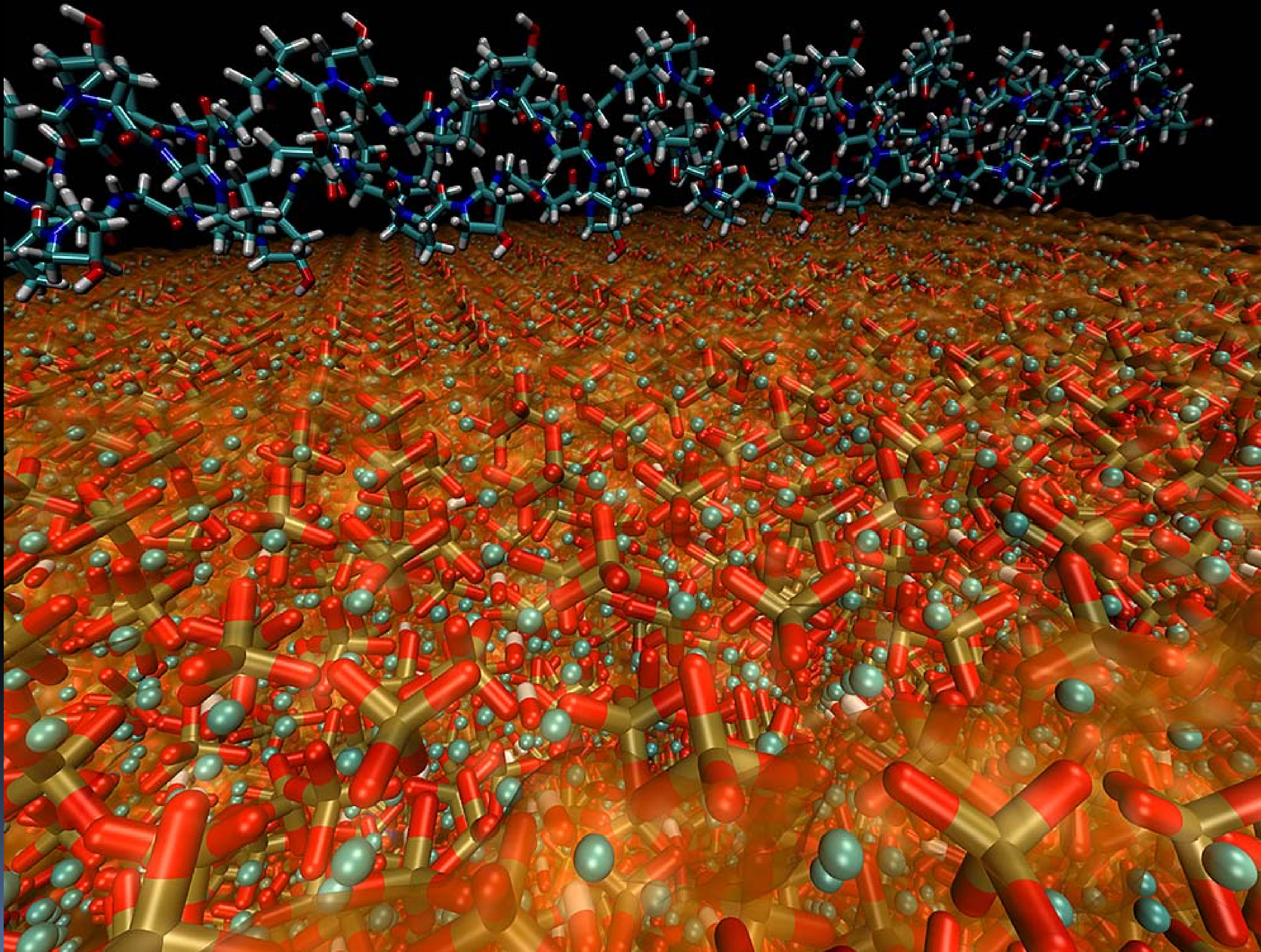
Received 23 Jul 2012 | Accepted 8 Mar 2013 | Published 16 Apr 2013 DOI: 10.1038/ncomms2720 OPEN

Molecular mechanics of mineralized collagen fibrils in bone

Arun K. Nair[1], Alfonso Gautieri[1,2], Shu-Wei Chang[1] & Markus J. Buehler[1,3,4]

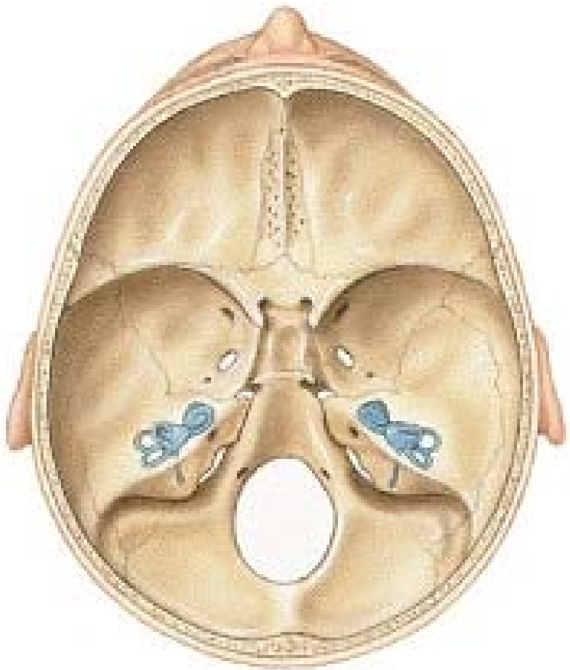


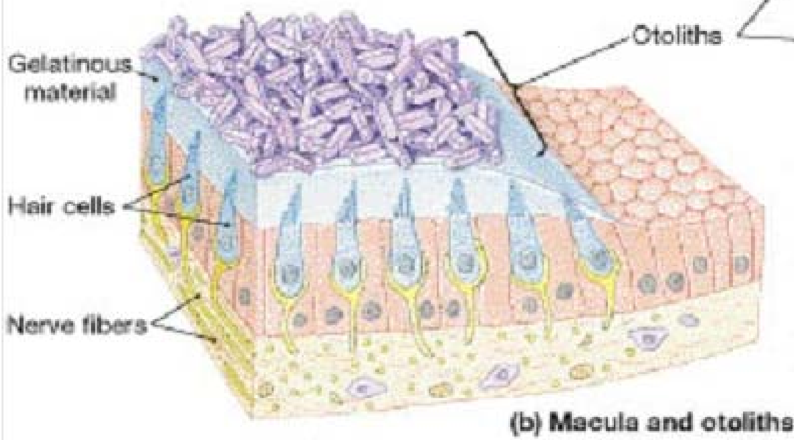


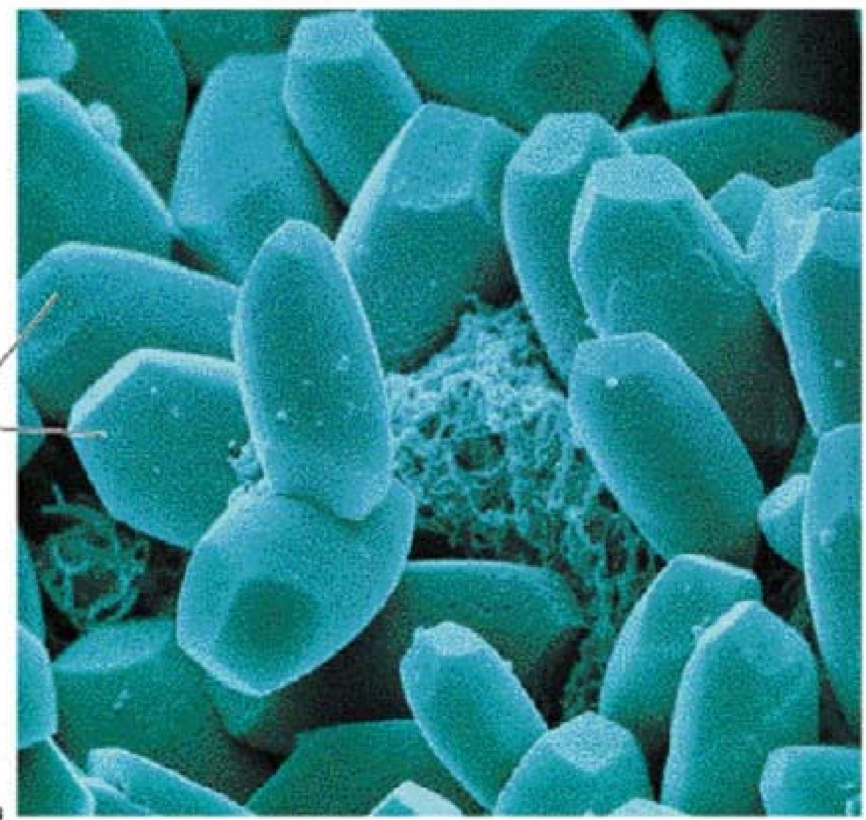


ΩΤΟΛΙΘΟΙ

Μικροκρύσταλλοι ΑΣΒΕΣΤΙΤΗ ($CaCO_3$)







CRYSTAL GROWTH & DESIGN

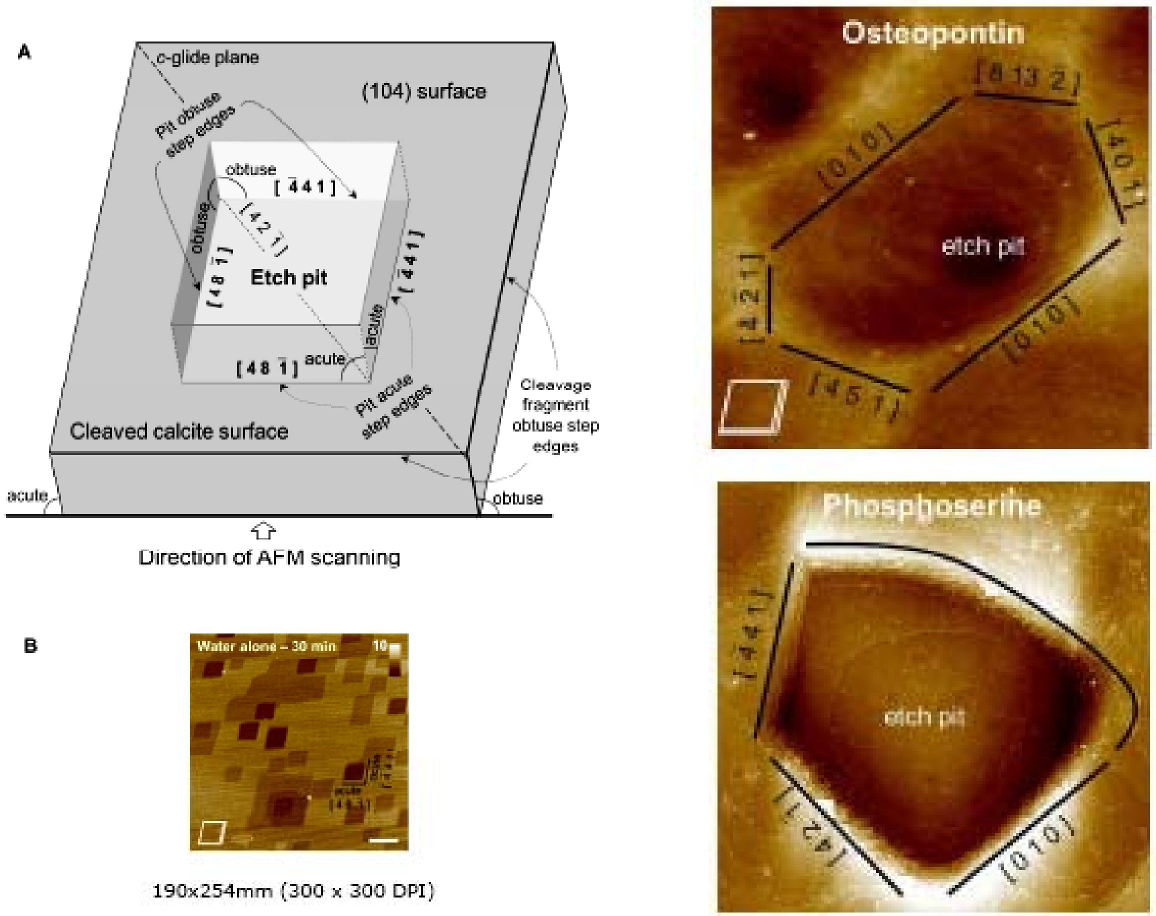
Just Accepted

Article

Effects of full-length phosphorylated osteopontin and constituent acidic peptides and amino acids on calcite dissolution

Valentin Nelea, Yung-Ching Chien, Jeanne Paquette, and Marc D McKee

Cryst. Growth Des., Just Accepted Manuscript • DOI: 10.1021/cg4012394 • Publication Date (Web): 22 Jan 2014



190x254mm (300 x 300 DPI)

analytical chemistry

Article

pubs.acs.org/ac

Strontium Randomly Substituting for Calcium in Fish Otolith Aragonite

Zoë A. Doubleday,[*,†] Hugh H. Harris,[*,‡] Christopher Izzo,[†] and Bronwyn M. Gillanders[†,§]

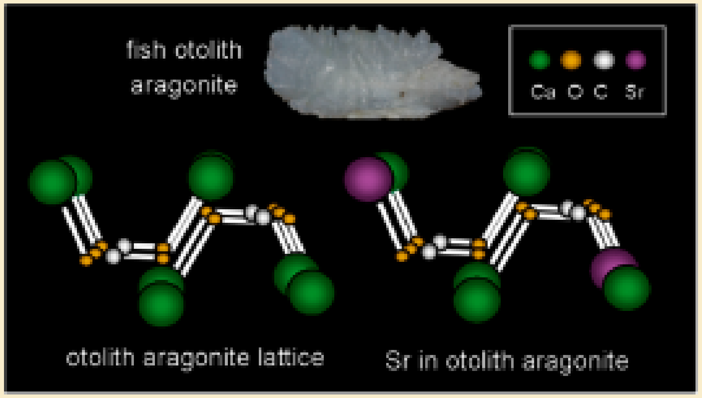
[†]Southern Seas Ecology Laboratories, DX 650 418, School of Earth and Environmental Sciences, The University of Adelaide, Adelaide, South Australia 5005, Australia

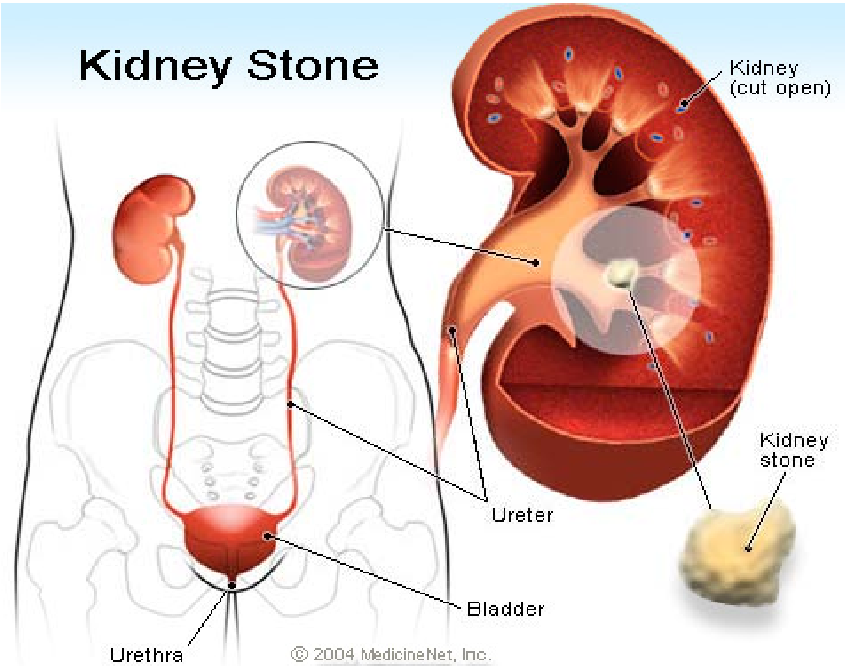
[‡]School of Chemistry and Physics, The University of Adelaide, Adelaide, South Australia 5005, Australia

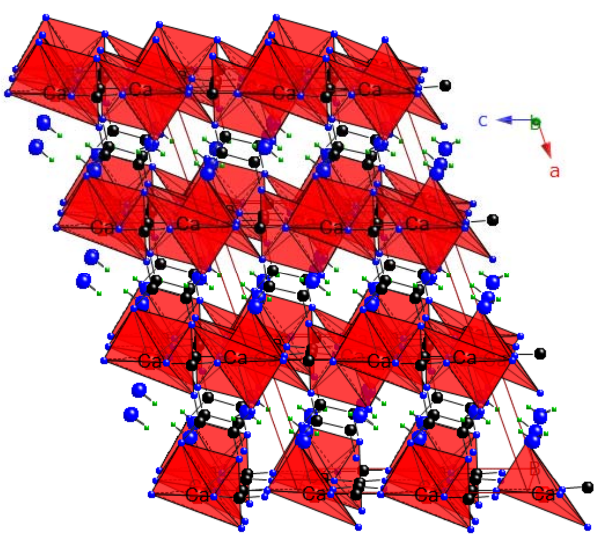
[§]Environment Institute, The University of Adelaide, Adelaide, South Australia 5005, Australia

S *Supporting Information*

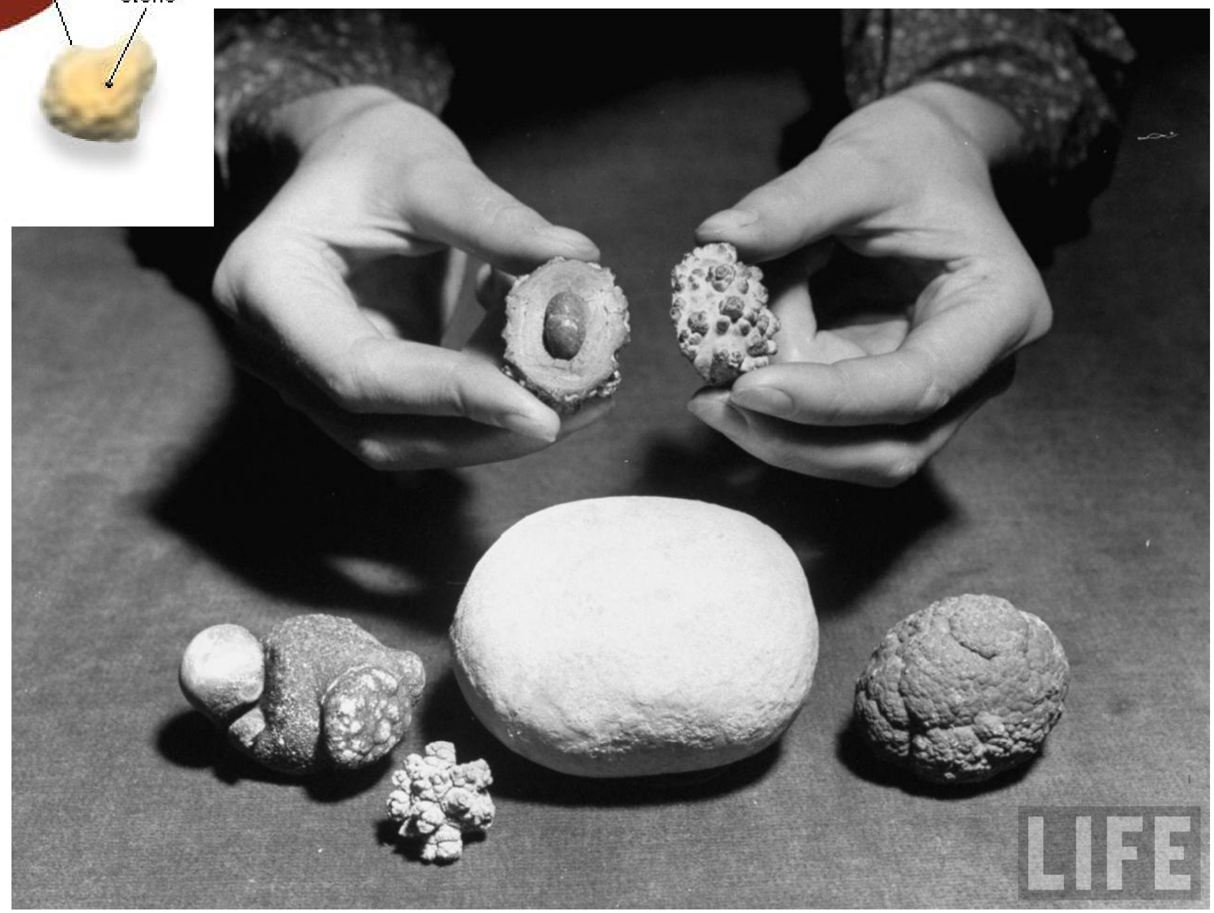
ABSTRACT: The chemistry of fish ear bones (otoliths) is used to address fundamental questions in fish ecology and fisheries science. It is assumed that strontium (Sr), the most important element used in otolith chemistry research, is bound within the aragonitic calcium carbonate lattice of otoliths via random chemical replacement of calcium; however, this has never been tested and three other alternatives exist with regard to how Sr may be incorporated. If any variation in the mode of incorporation occurs, otolith chemistry data may be misinterpreted, impacting how fish and fisheries are understood and managed. Using X-ray absorption spectroscopy (specifically, analysis of extended X-ray absorption fine structure or EXAFS), we investigated how Sr is incorporated within fish otoliths from seven species collected from a range of aquatic environments. For comparison, aragonitic structures from other aquatic taxa (cephalopods and coral) were also analyzed. The results consistently indicated for all samples that Sr randomly replaces Ca within the aragonite lattice. This research explicitly shows how Sr is bound within otoliths and validates a fundamental and long-held assumption in aquatic research.







$CaC_2O_4 \bullet H_2O$

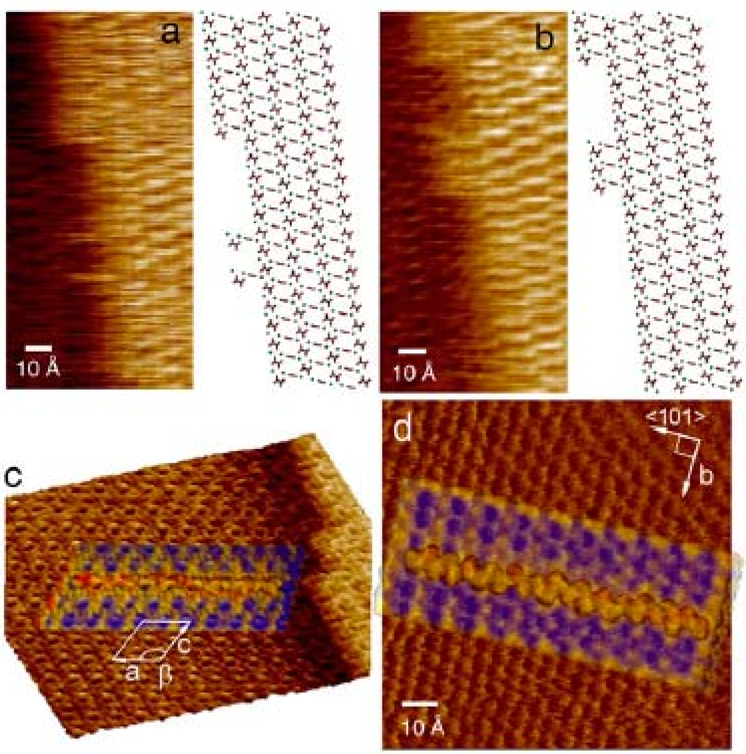


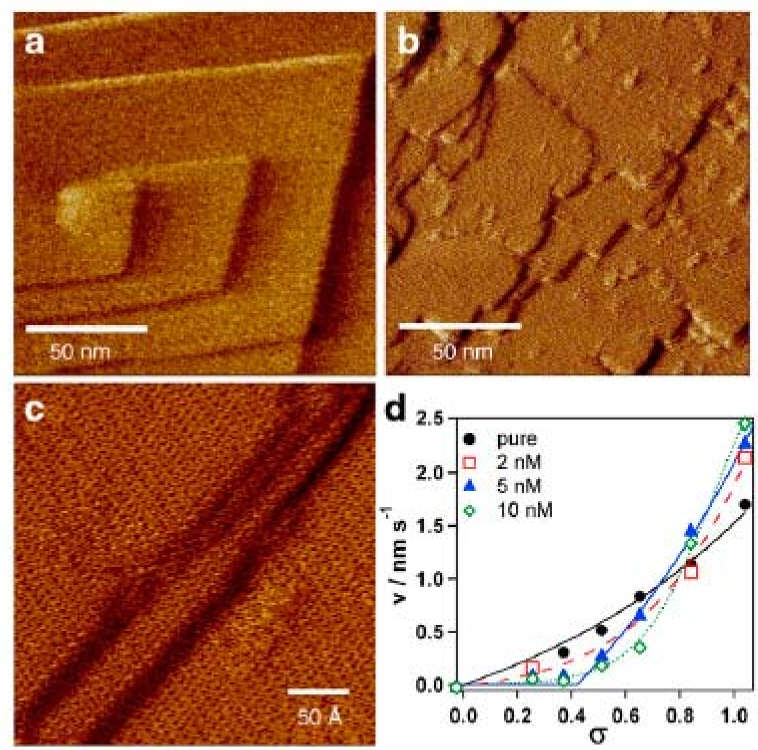
Subnanometer atomic force microscopy of peptide–mineral interactions links clustering and competition to acceleration and catastrophe

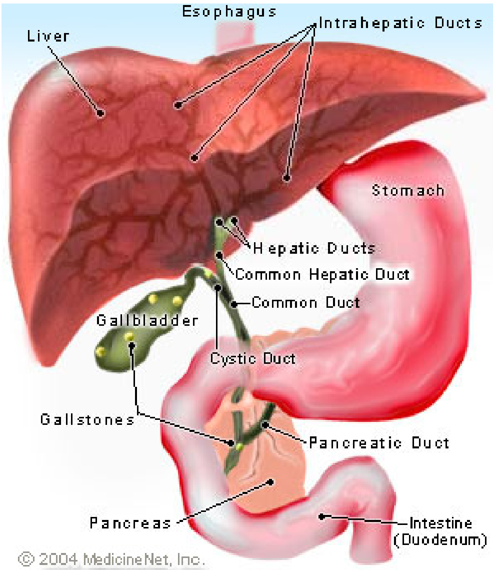
R. W. Friddle[a,b,1], M. L. Weaver[a,c,1], S. R. Qiu[a], A. Wierzbicki[d], W. H. Casey[c], and J. J. De Yoreo[b,2]

[a]Physical and Life Sciences Directorate, Lawrence Livermore National Laboratory, Livermore, CA 94551; [b]Molecular Foundry, Lawrence Berke Laboratory, Berkeley, CA 94720; [c]Departments of Chemistry and Geology, University of California, Davis, CA 95616; and [d]Department of Ch University of South Alabama, Mobile, AL 36688

Edited by Joanna Aizenberg, Harvard University, and accepted by the Editorial Board November 3, 2009 (received for review July 23, 2009)







Journal of Trace Elements in Medicine and Biology 27 (2013) 79–84

Contents lists available at SciVerse ScienceDirect

Journal of Trace Elements in Medicine and Biology

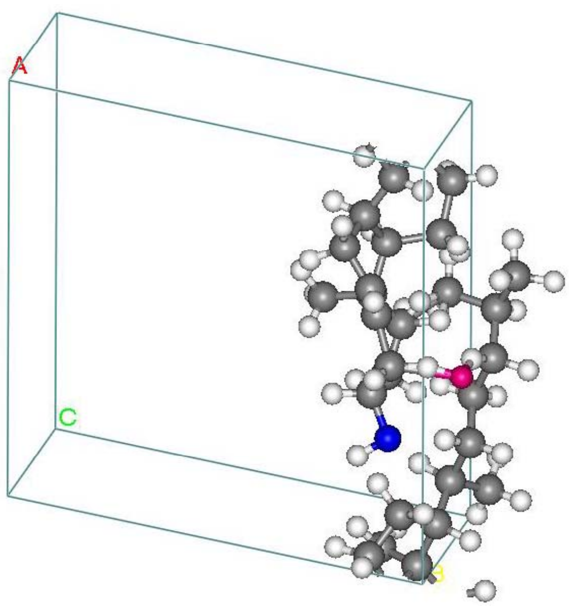
journal homepage: www.elsevier.de/jtemb

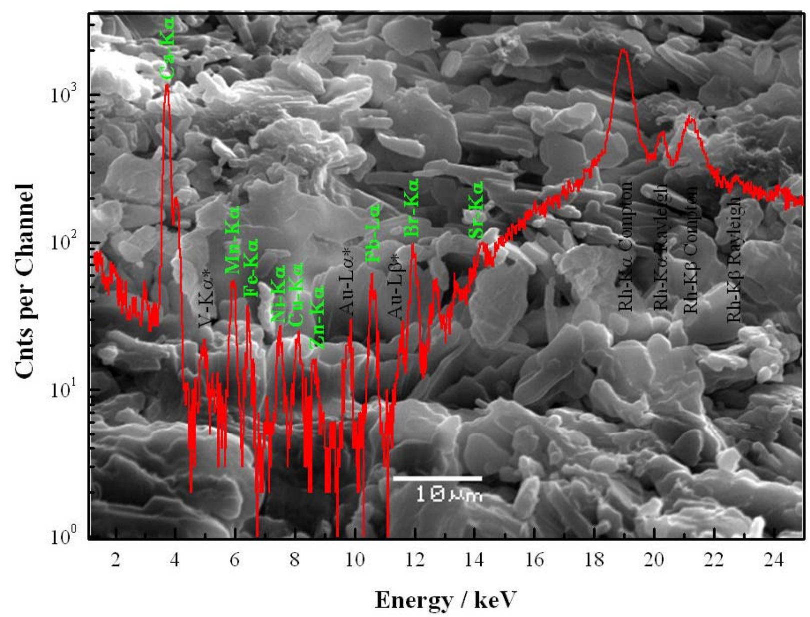
Analytical methodology

New insights into the chemical and isotopic composition of human-body biominerals. I: Cholesterol gallstones from England and Greece

Dimitra Athanasiadou[a,1], Athanasios Godelitsas[a,*], Dimosthenis Sokaras[b,2], Andreas-Germanos Karydas[c,d], Elisavet Dotsika[e], Constantinos Potamitis[f], Maria Zervou[f], Stelios Xanthos[g], Elias Chatzitheodoridis[h], Hock Chye Gooi[i], Udo Becker[j]

[a] School of Sciences, University of Athens, Panepistimioupoli Zographou, 15784 Athens, Greece
[b] Institute of Nuclear Physics, National Center for Scientific Research "Demokritos", Aghia Paraskevi, 15310 Athens, Greece
[c] Institute of Nuclear Physics, National Center for Scientific Research "Demokritos", Aghia Paraskevi, 15310 Athens, Greece
[d] International Atomic Energy Agency (IAEA), Nuclear Spectrometry and Applications Laboratory, Seibersdorf Laboratories, Austria
[e] National Center for Scientific Research "Demokritos", I.M.S., 15310 Aghia Paraskevi Attikis, Greece
[f] National Hellenic Research Foundation, Institute of Biology, Medicinal Chemistry and Biotechnology, Vas. Constantinou 48, 11635 Athens, Greece
[g] Department of Electrical and Computer Engineering, Aristotle University of Thessaloniki, GR-54124 Thessaloniki, Greece
[h] School of Mining and Metallurgical Engineering, National Technical University of Athens, 15780 Zographou, Athens, Greece
[i] Beaumont Hospital, Dublin, Ireland
[j] Department of Geological Sciences, University of Michigan, 1100 North University Ave., Ann Arbor, MI 48109, USA

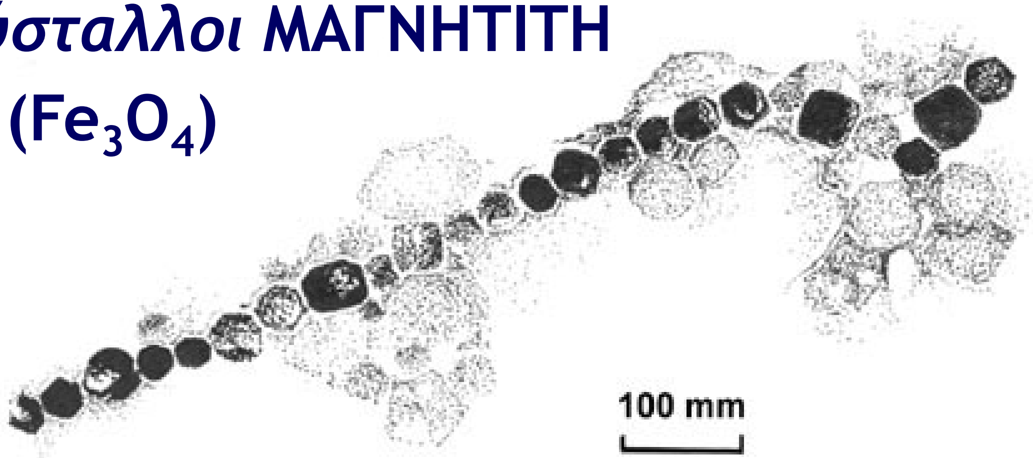


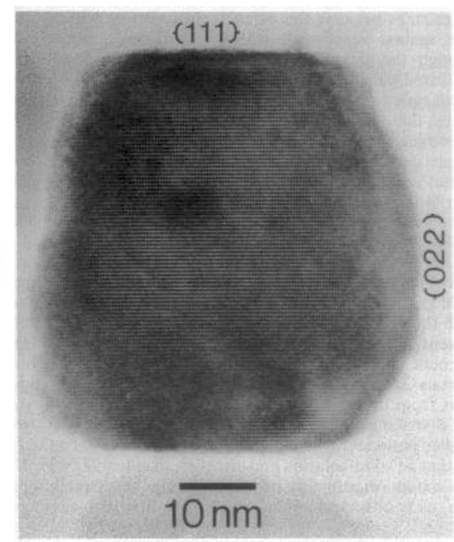


CALTECH division of Geological & Planetary Sciences

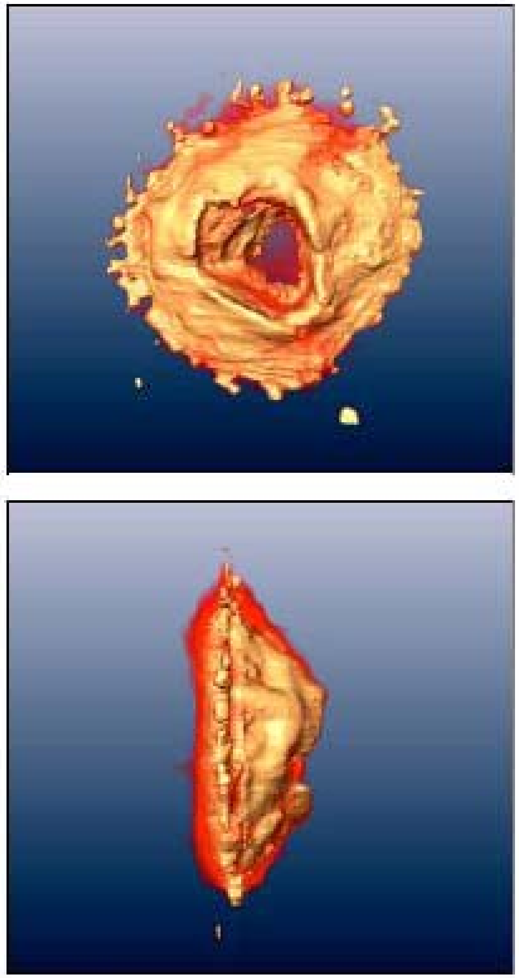
Νανοκρύσταλλοι ΜΑΓΝΗΤΙΤΗ

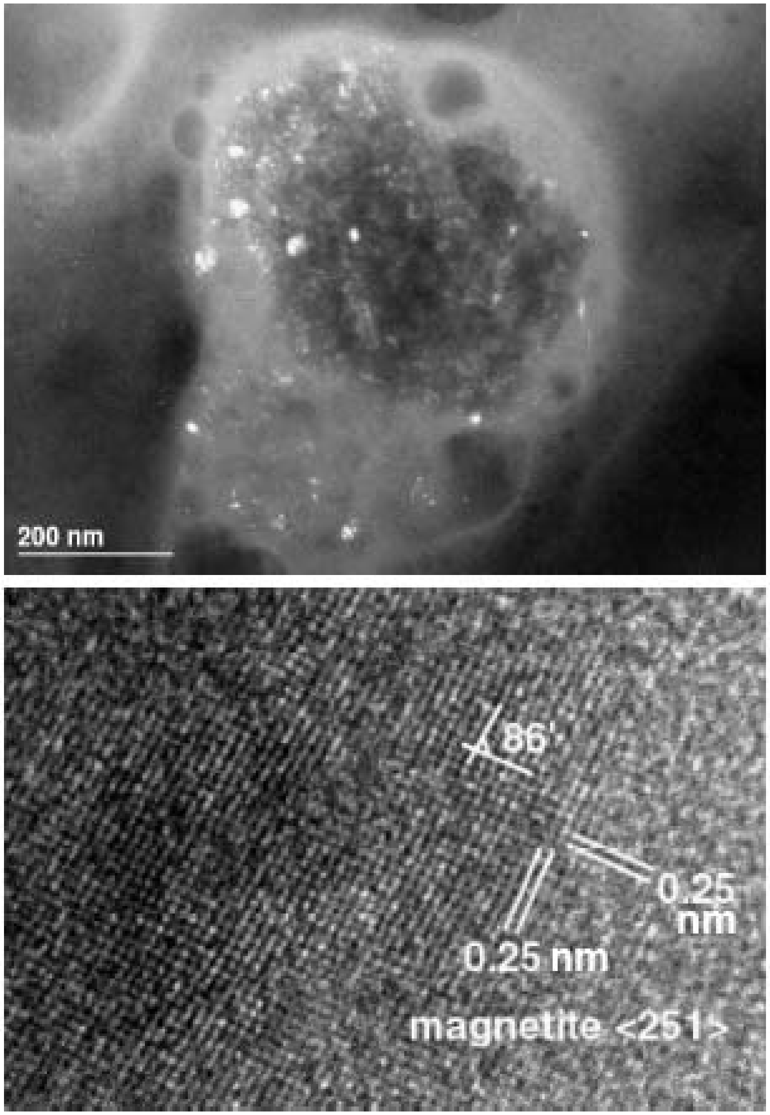
(Fe_3O_4)





Magnetite in the human brain





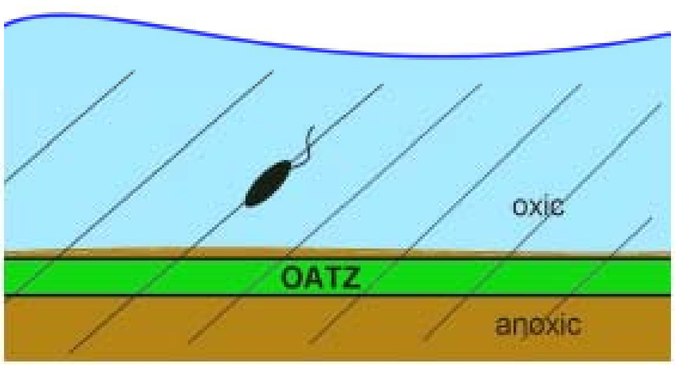
Collingwood et al. 2008 J. Alzheimer's Disease

Magnetotactic bacteria

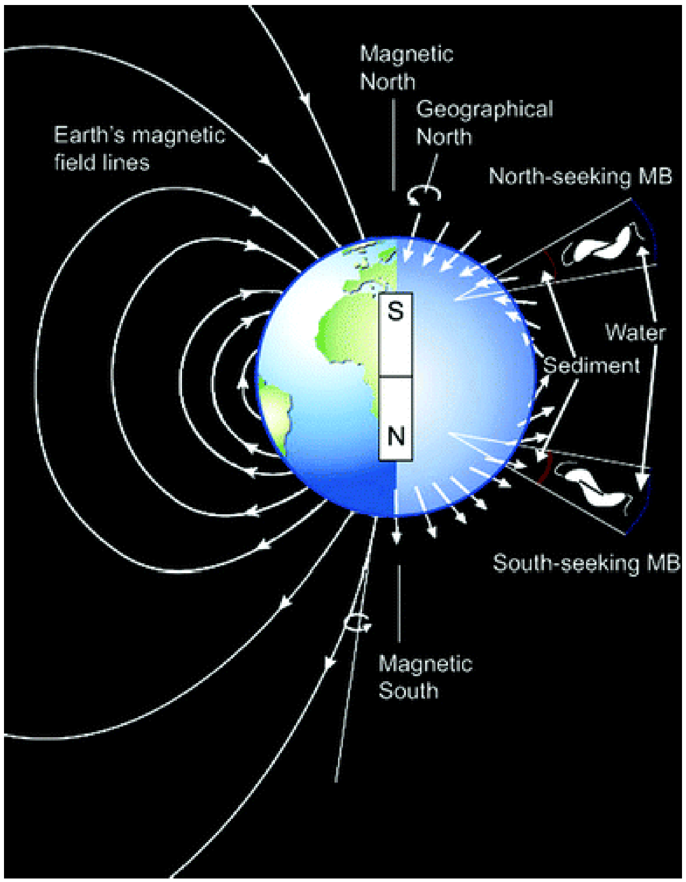
Cells contain ferrimagnetic nanocrystals of magnetite (Fe_3O_4) or greigite (Fe_3S_4)

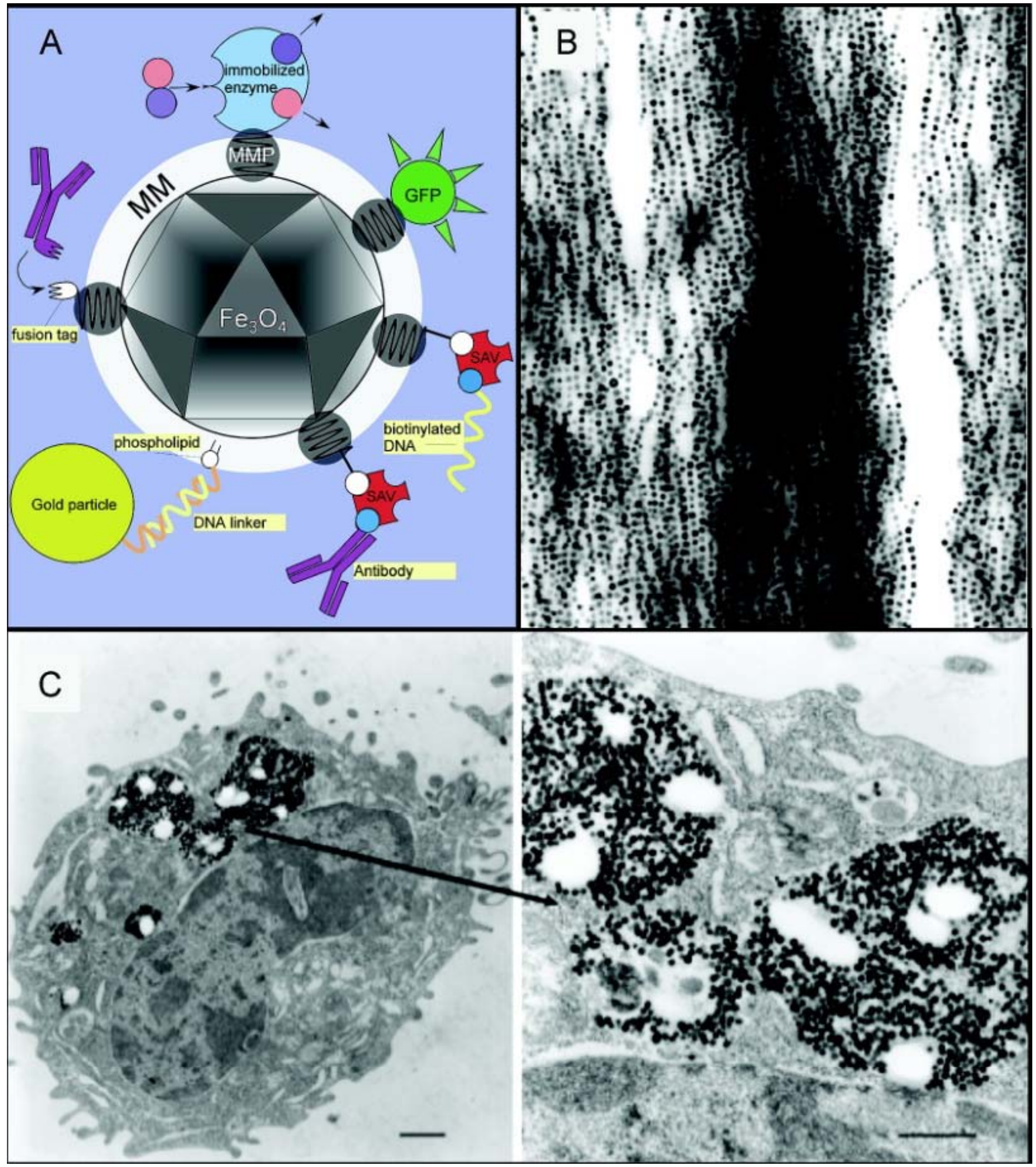
Cells are magnetotactic: they are oriented by Earth's magnetic field and actively swim along the geomagnetic field lines

Blakemore (1975) Science 190, 377



Published in: Damien Faivre; Dirk Schüler;
Chem. Rev. **2008,** 108, 4875-4898.
DOI: 10.1021/cr078258w.

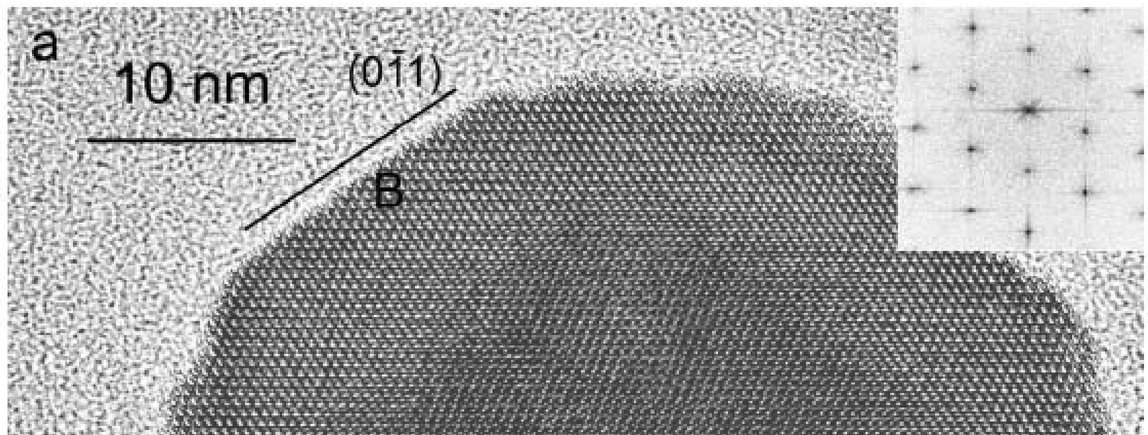


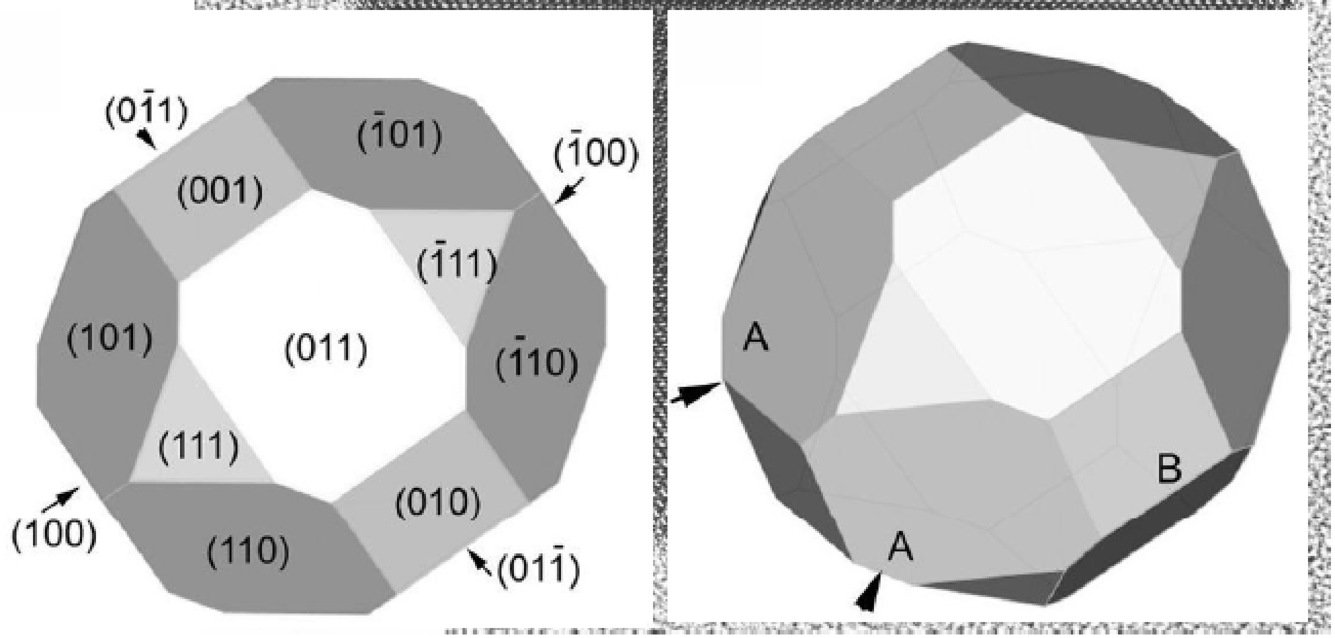


Mihály Pósfai
University of Pannonia, Veszprém, Hungary

Particle shape guessed form
HRTEM image +
SAED pattern

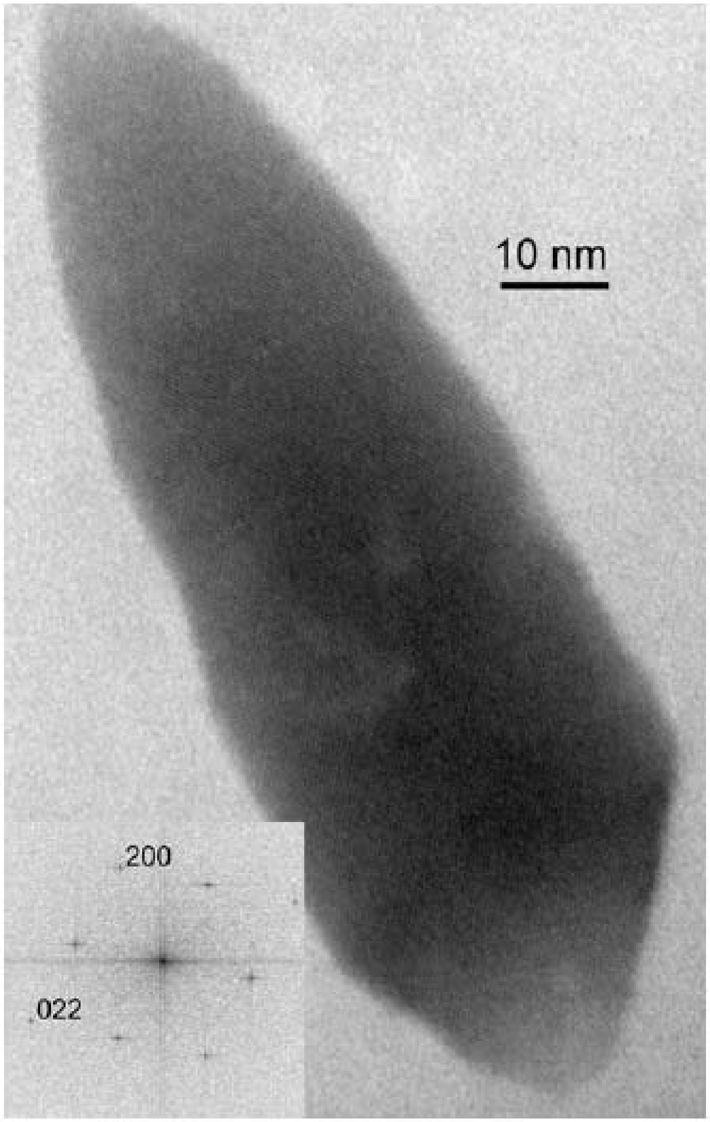
“Cubooctahedral” magnetite from M. gryph.

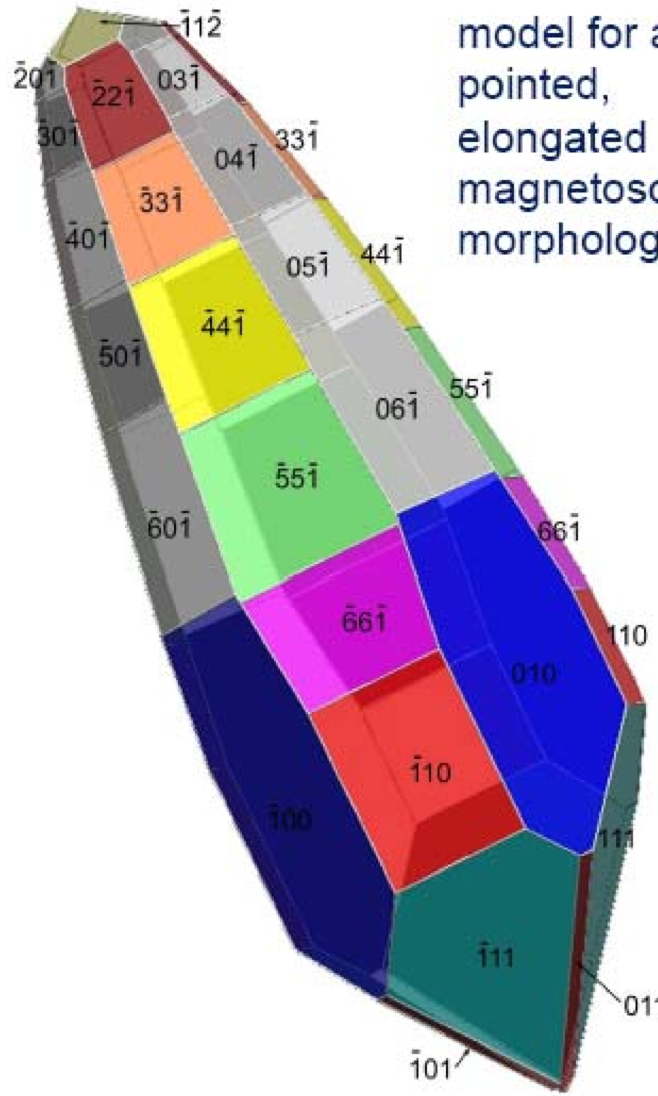




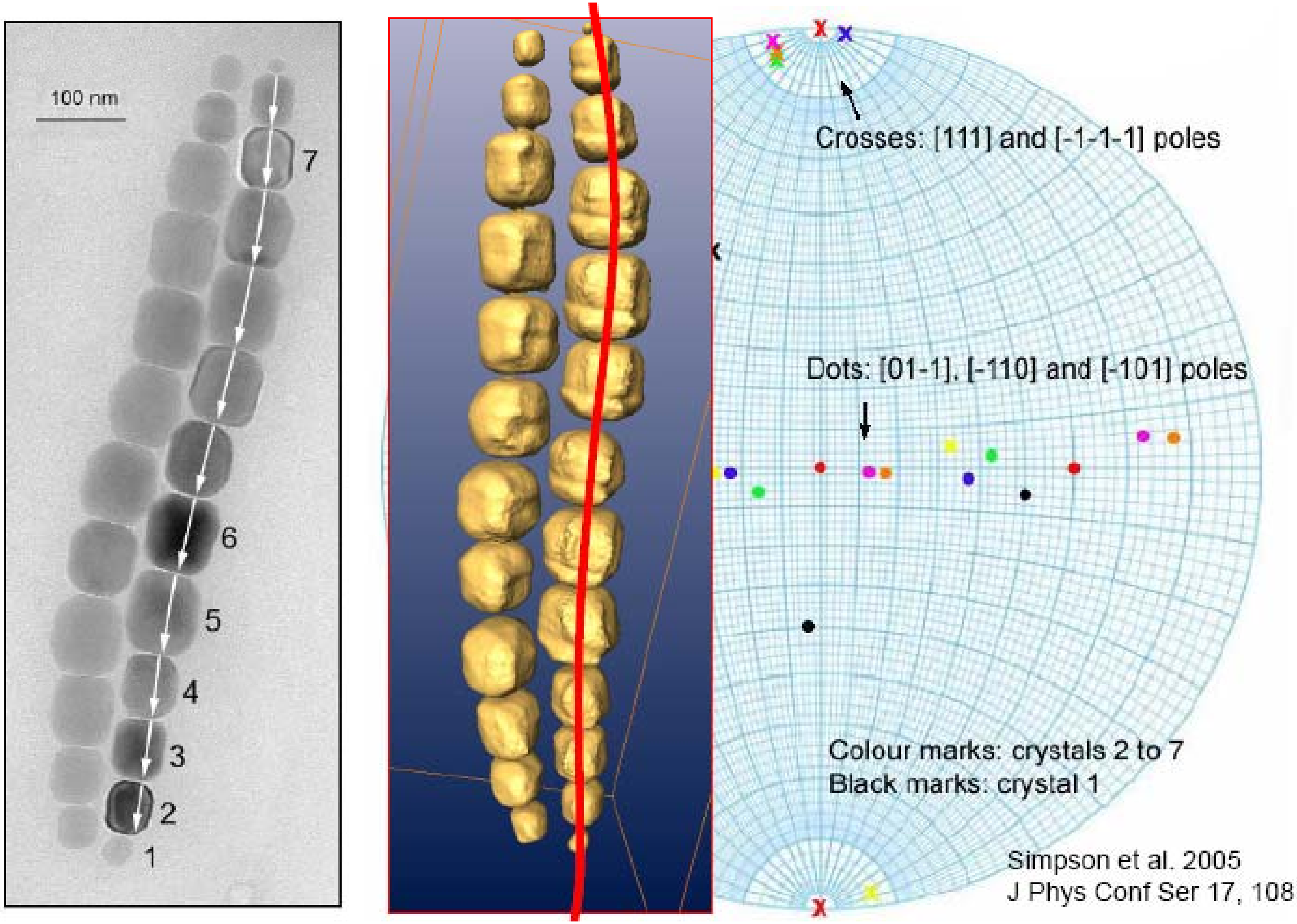
Mihály Pósfai
University of Pannonia, Veszprém, Hungary

EMU School, Granada, 3-6 June 2013





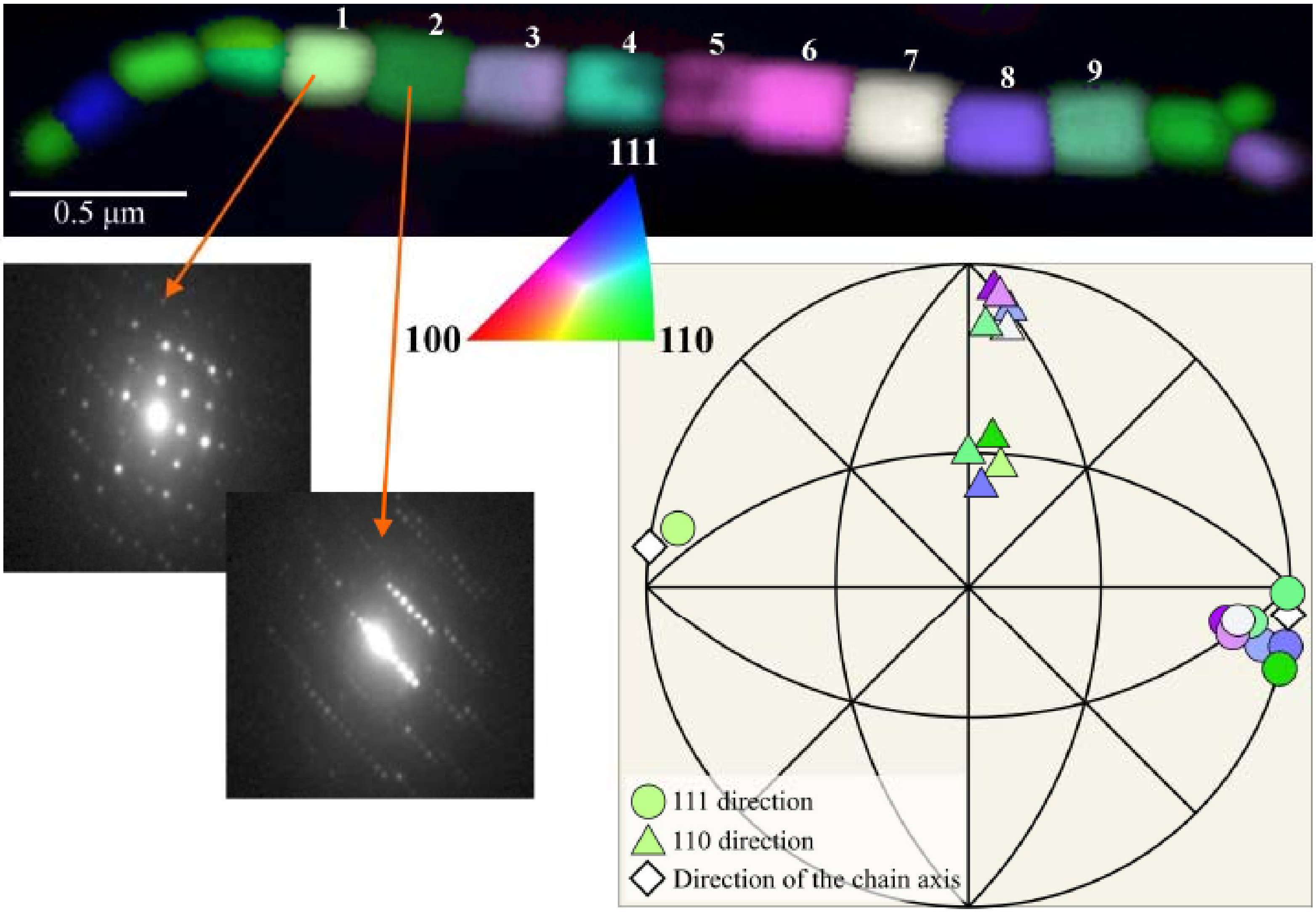
model for a pointed, elongated magnetosome morphology


100 nm
7
6
5
4
3
2
1
Crosses: [111] and [-1-1-1] poles
Dots: [01-1], [-110] and [-101] poles
Colour marks: crystals 2 to 7
Black marks: crystal 1
Simpson et al. 2005
J Phys Conf Ser 17, 108

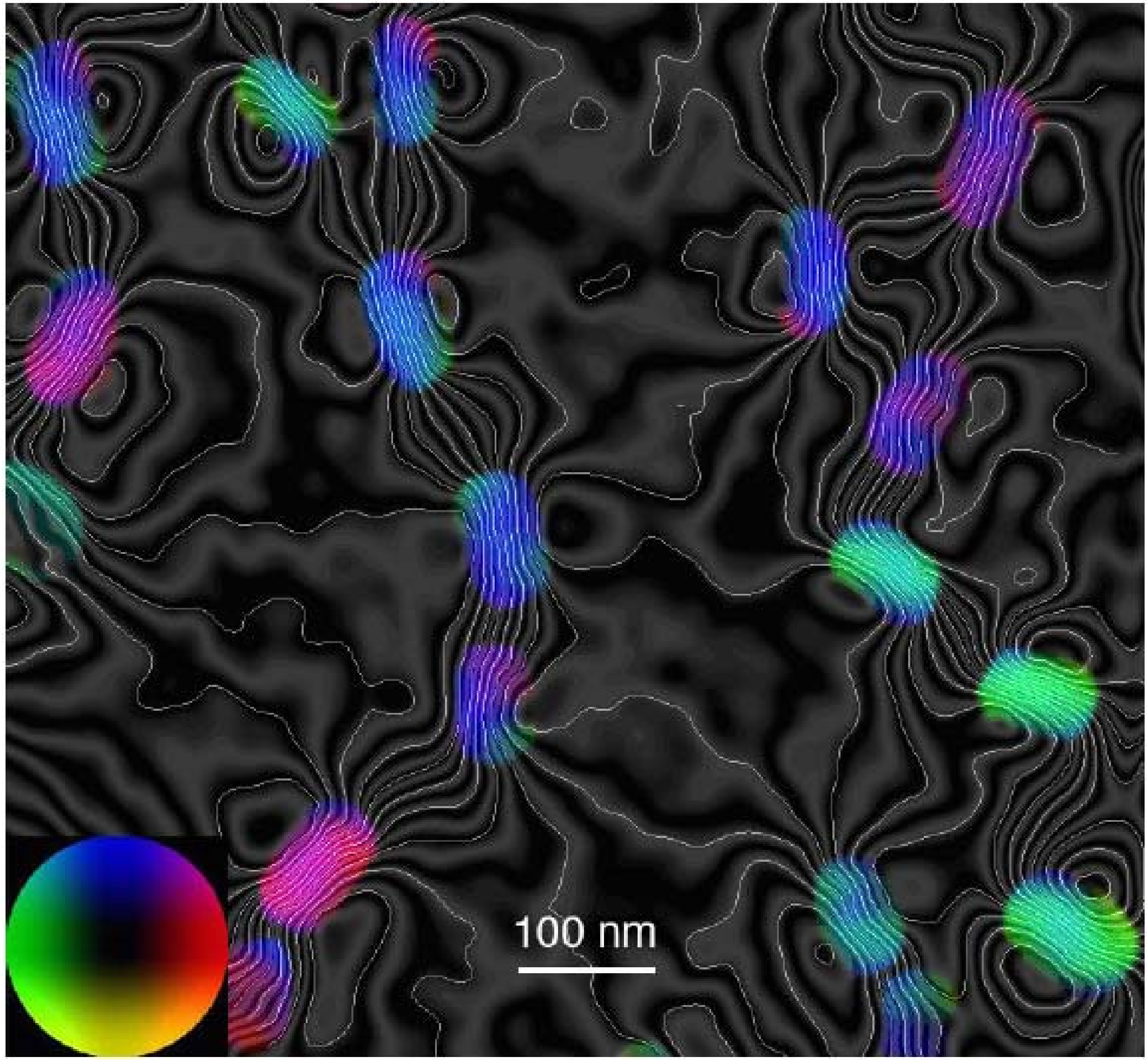
Mihály Pósfai
University of Pannonia, Veszprém, Hungary

EMU School, Granada, 3-6 June 2013

Orientation map of a chain of magnetosomes

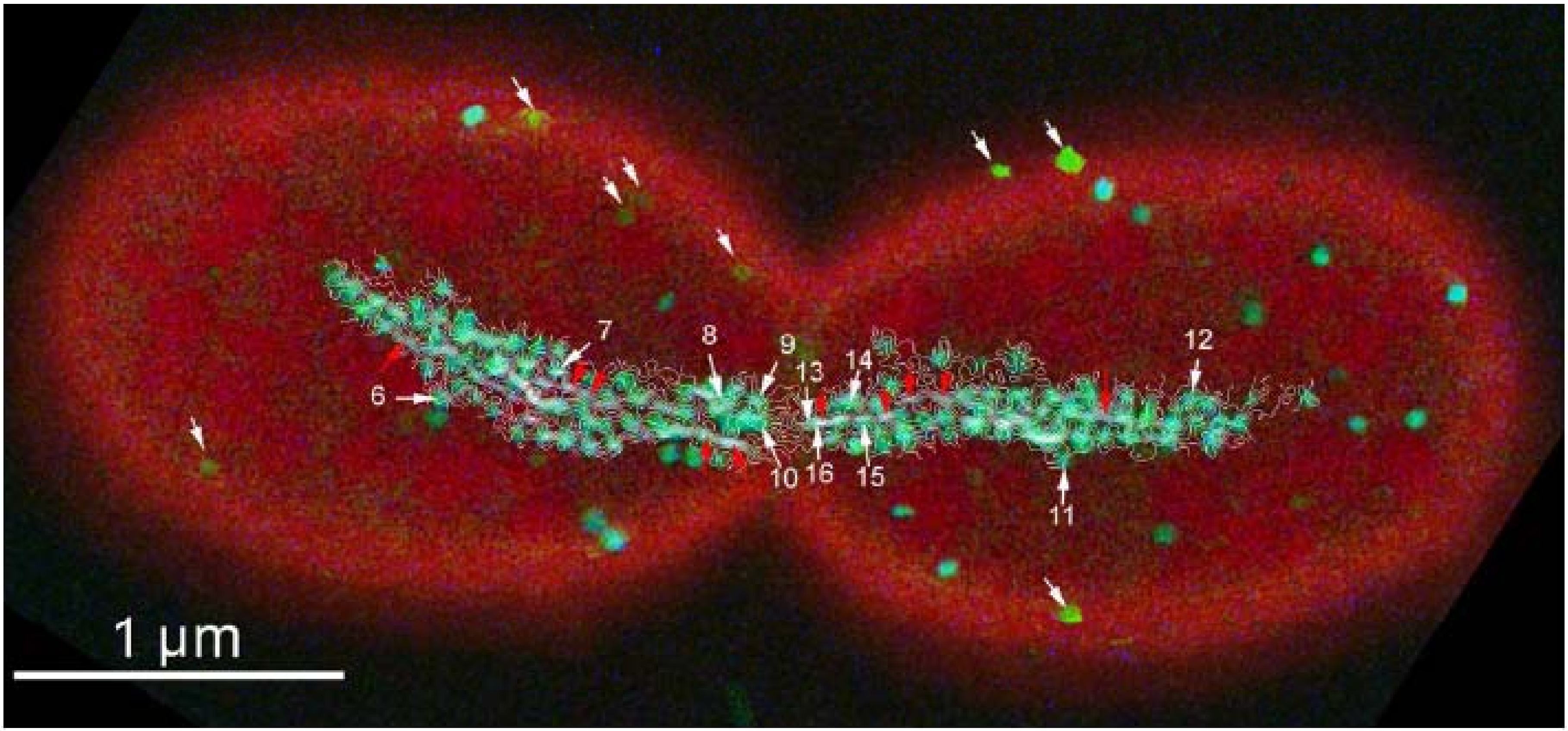


Magnetic induction map of scattered magnetite crystals in the cell of a freshwater magnetotactic *coccus*, obtained from electron holography



Pósfai and Dunin-Borkowski (2009) Elements 5, 235

A dividing cell that contains greigite (Fe_3S_4) magnetosomes



Kasama et al. Am Miner 91, 1216 (2006)

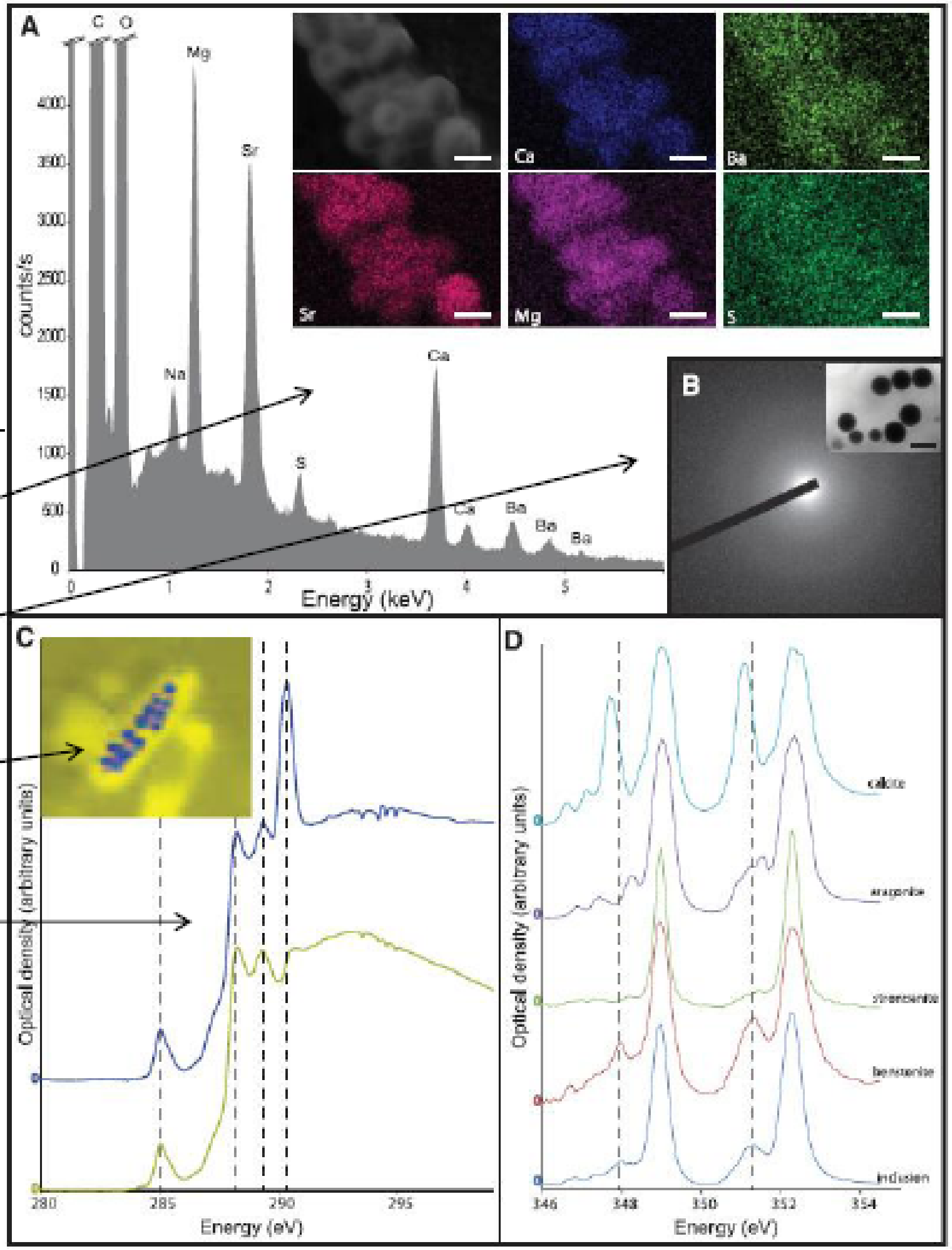
Combination of electron microscopy with scanning transmission X-ray microscopy – X-ray absorption near-edge structure spectroscopy (STXM-XANES) – amorphous carbonate inclusions in cyanobacteria

SEM-EDS

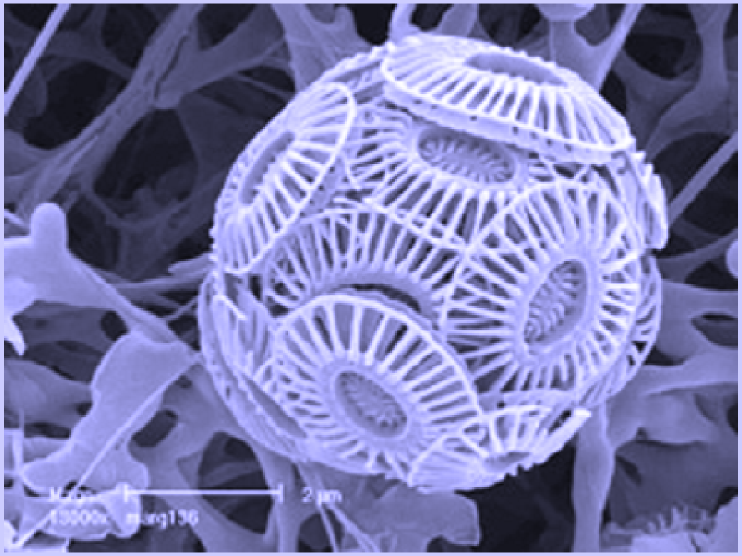
SAED

STXM

XANES

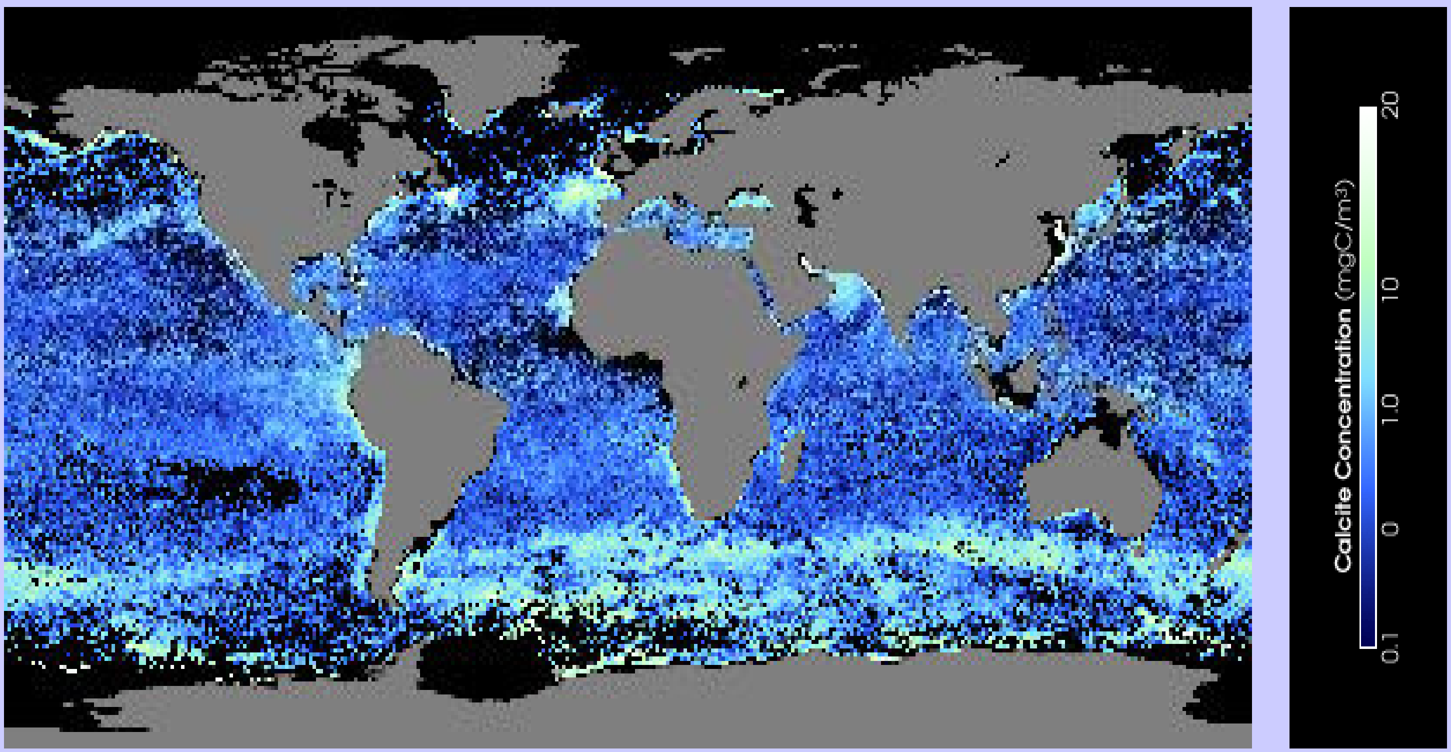


Couradeau et al., Science 336, 459 (2012)



ΚΟΚΚΟΛΙΘΟΦΟΡΑ

Coccolithophores

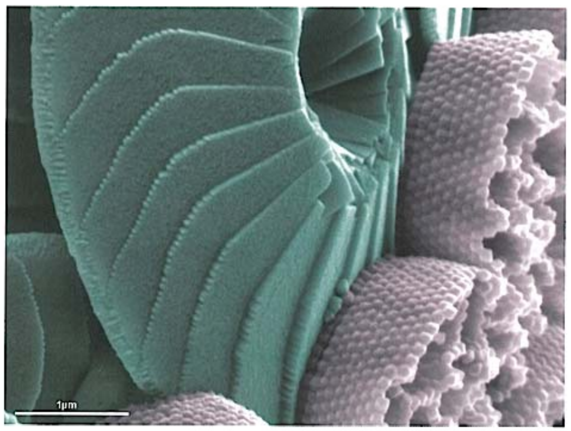


REVIEWS in MINERALOGY & GEOCHEMISTRY

Volume 54

— *BIOMINERALIZATION* —

Patricia M. Dove, James J. De Yoreo & Steve Weiner, editors



Series Editor: Jodi J. Rosso

MINERALOGICAL SOCIETY OF AMERICA

GEOCHEMICAL SOCIETY

ISSN 1529-6466

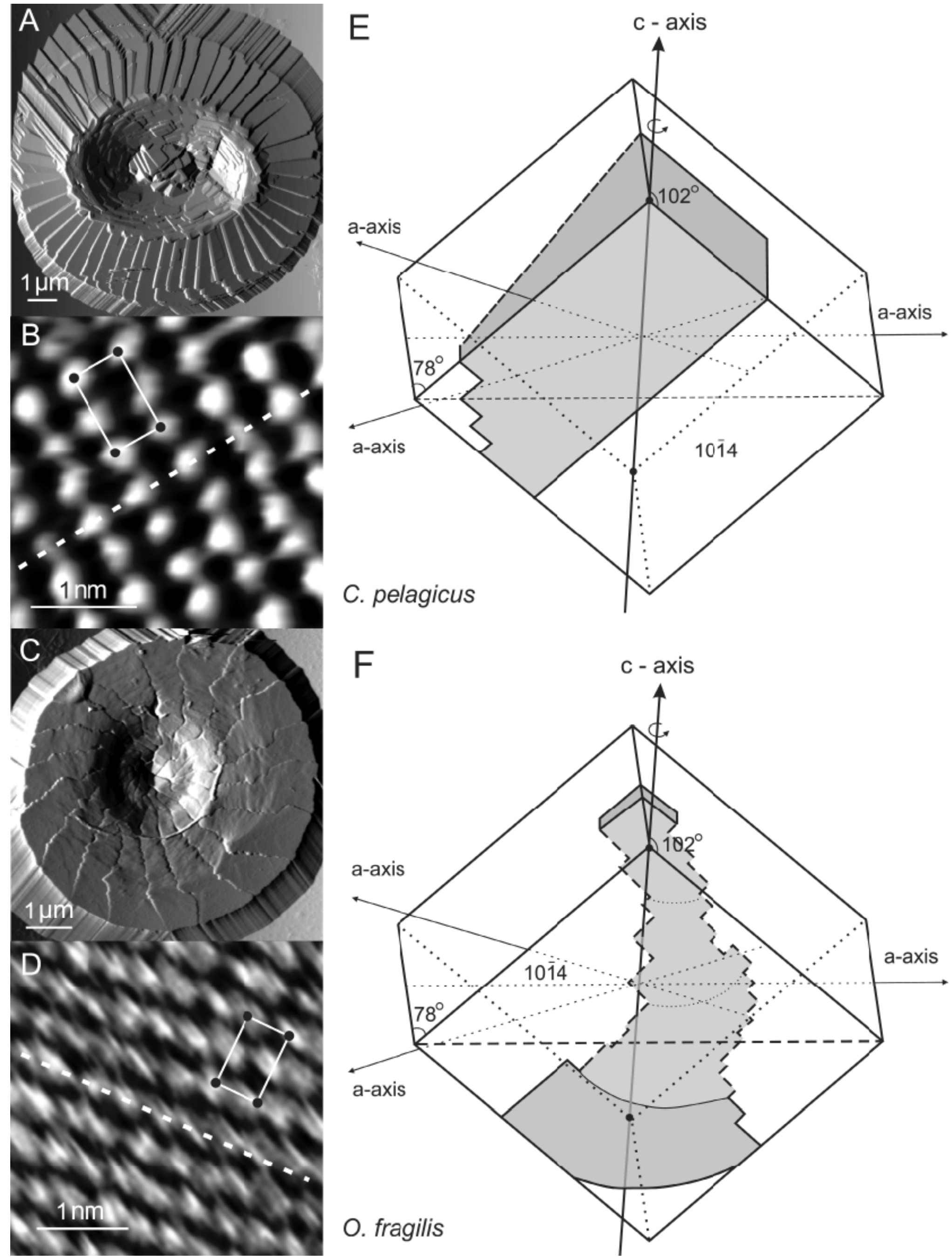
7 Biomineralization Within Vesicles: The Calcite of Coccoliths

Jeremy R. Young

Palaeontology Department
The Natural History Museum
Cromwell Road, London SW7 5BD, United Kingdom

Karen Henriksen

NanoGeoScience, Geological Institute
University of Copenhagen
Øster Voldgade 10
Dk-1350 Copenhagen K, Denmark



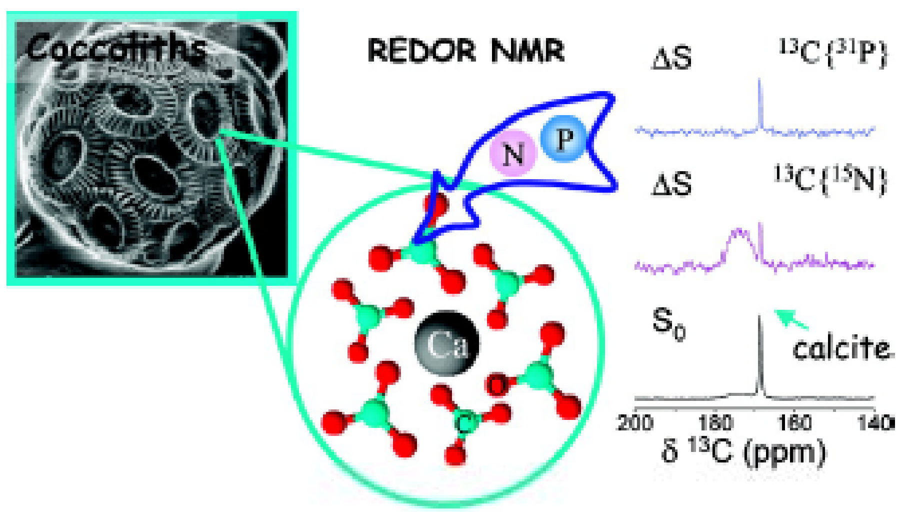
JOURNAL OF THE AMERICAN CHEMICAL SOCIETY

Article

In Situ Observation of the Internal Structure and Composition of Biomineralized *Emiliania huxleyi* Calcite by Solid-State NMR Spectroscopy

Ronen Gertman, Ira Ben Shir, Shifi Kababya, and Asher Schmidt

J. Am. Chem. Soc., 2008, 130 (40), 13425-13432• DOI: 10.1021/ja803985d • Publication Date (Web): 10 September 2008



CRYSTAL GROWTH & DESIGN

Article

pubs.acs.org/crystal

Received: December 11, 2013
Revised: February 11, 2014

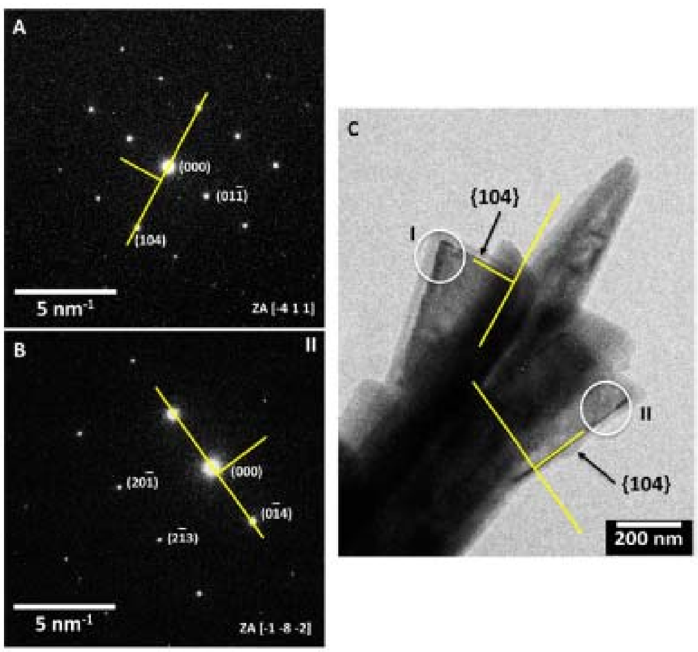
Ultrastructure and Crystallography of Nanoscale Calcite Building Blocks in *Rhabdosphaera clavigera* Coccolith Spines

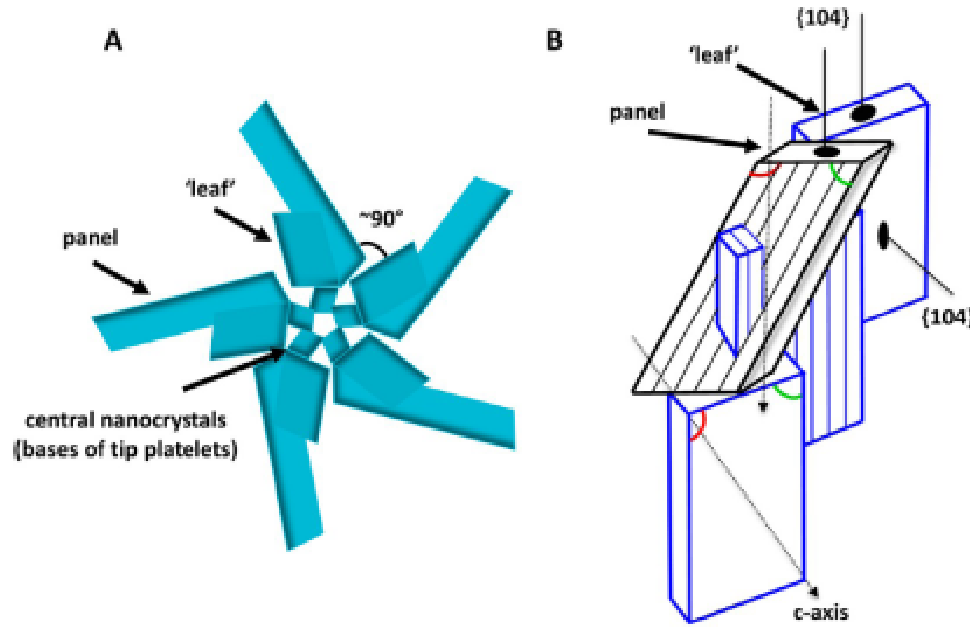
Renée van de Locht,*,† Thomas J. A. Slater,‡ Andreas Verch,† Jeremy R. Young,§ Sarah J. Haigh,‡ and Roland Kröger*,†

†Department of Physics, University of York, Heslington, York, YO10 5DD, U.K.

‡Schools of Materials, University of Manchester, Oxford Road, Manchester, M13 9PL, U.K.

§Department of Earth Sciences, University College London, Gower Street, London, WC1E 6BT, U.K.





Pearls and Corals: "Trendy Biomineralizations"

Jean-Pierre Gauthier[1] and Stefanos Karampelas[2]

1811-5209/09/0005-0179$2.50 DOI: 10.2113/gselements.5.3.179

Corals and pearls are "organic gems" produced by living beings. These esthetic "biomineralizations" are attractive for their color and the optical effects resulting from their structure.

Keywords: coral, pearl, biomineralization, cultured pearls, endangered coral species

Pearls are secreted by mollusks, such as bivalves, gastropods, and, very rarely, cephalopods (Landman et al. 2001). They were initially, and are still occasionally today, fished in nature from various saltwater bivalves (for example, *Pinctada spp.*

Materials Science and Engineering C 33 (2013) 1521–1529

Contents lists available at SciVerse ScienceDirect

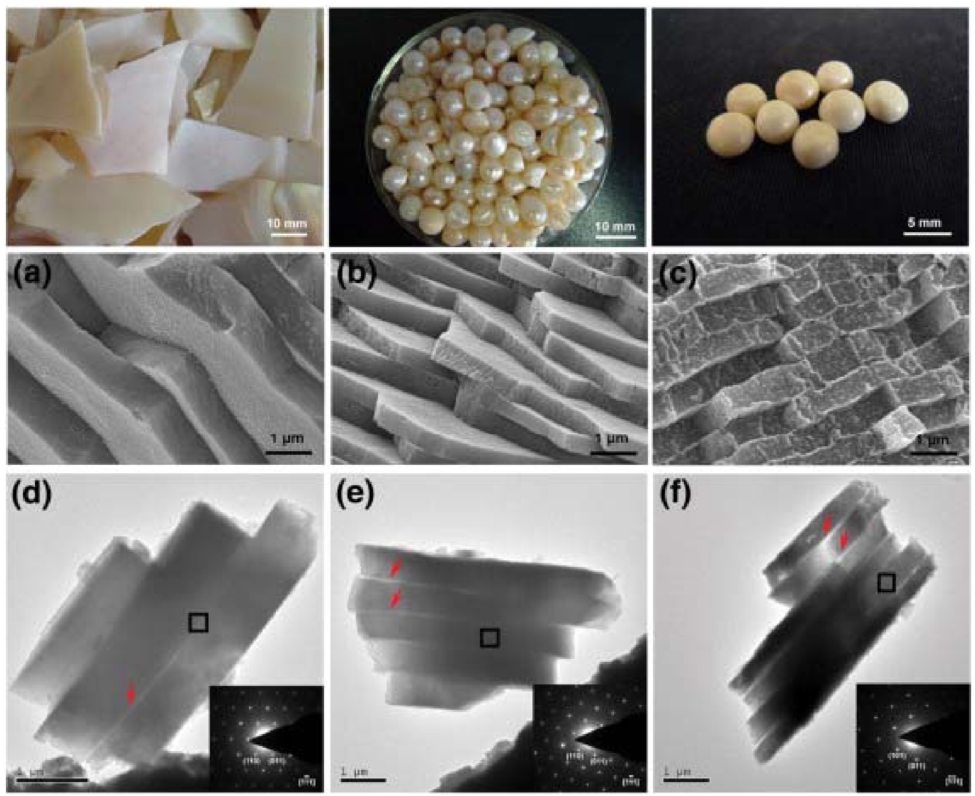
Materials Science and Engineering C

journal homepage: www.elsevier.com/locate/msec

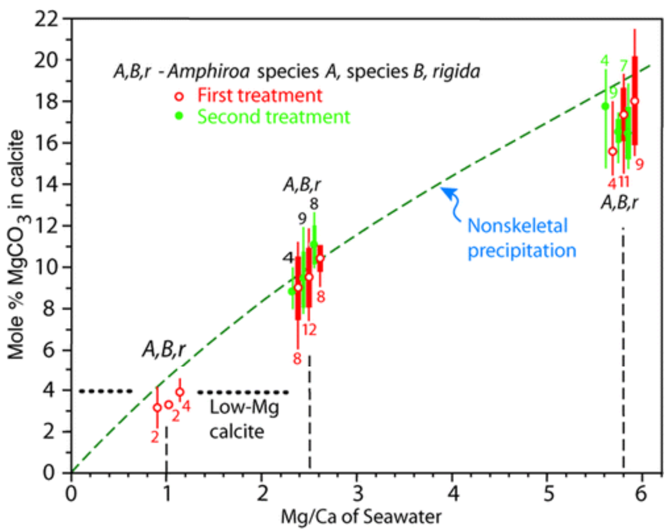
What is the difference in organic matrix of aragonite vs. vaterite polymorph in natural shell and pearl? Study of the pearl-forming freshwater bivalve mollusc *Hyriopsis cumingii*

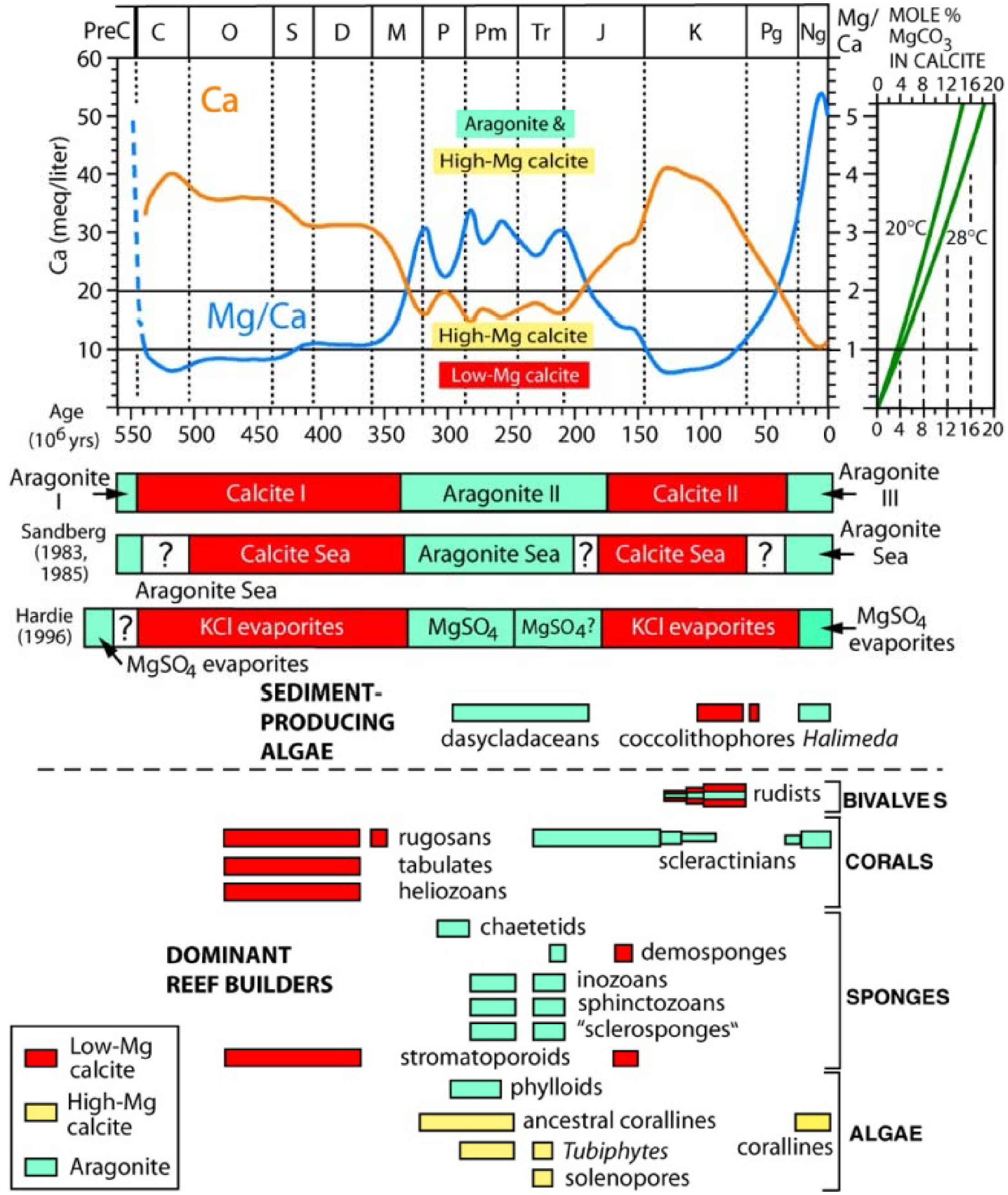
Yufei Ma [a], Sophie Berland [b], Jean-Pierre Andrieu [c], Qingling Feng [d,*], Laurent Bédouet [b]

[a] State Key Laboratory of New Ceramics and Fine Processing, Department of Materials Science and Engineering, Tsinghua University, Beijing 100084, China
[b] Muséum National d'Histoire Naturelle, UMR BOREA (Biologie des Organismes et Ecosystèmes Aquatiques), MNHN/CNRS 7208/IRD 207, CP 26, 75005 Paris, France
[c] Institut de Biologie Structurale, Groupe Réponse Immunitaire aux Pathogènes et au Soi Altéré, 41 rue Jules Horowitz, 38027 Grenoble, France
[d] Laboratory of Advanced Materials, Department of Materials Science and Engineering, Tsinghua University, Beijing 100084, China

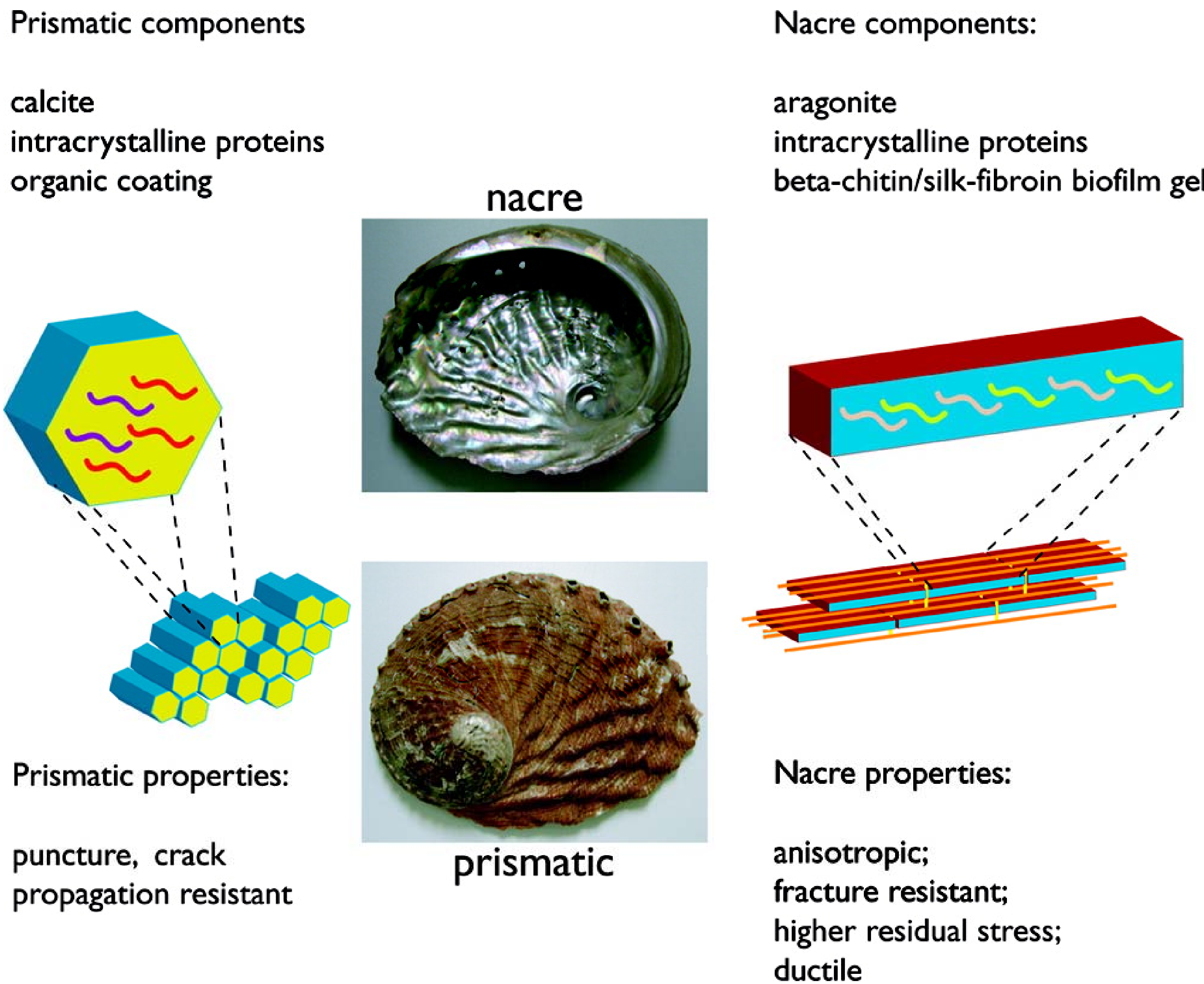


Published in: Steven M. Stanley;
Chem. Rev. **2008,** 108, 4483-4498.
DOI: 10.1021/cr800233u.





Published in: John Spencer Evans; *Chem. Rev.* **2008,** 108, 4455-4462.
DOI: 10.1021/cr078251e.



Article

Ordered Misorientations and Preferential Directions of Growth in Mesocrystalline Red Coral Sclerites

N. Floquet * and D. Vielzeuf
Aix-Marseille University, CNRS, CINaM UMR7325, 13288, Marseille, France

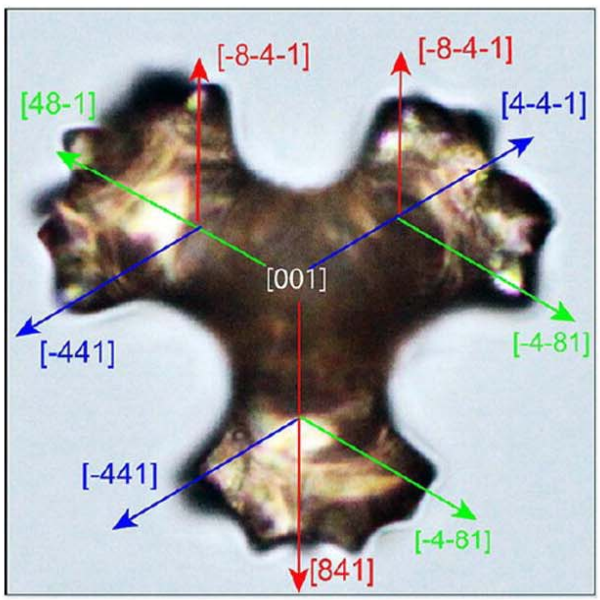
Cryst. Growth Des., **2012**, *12* (10), pp 4805-4820
DOI: 10.1021/cg300528h
Publication Date (Web): August 30, 2012

*E-mail: floquet@cinam.univ-mrs.fr

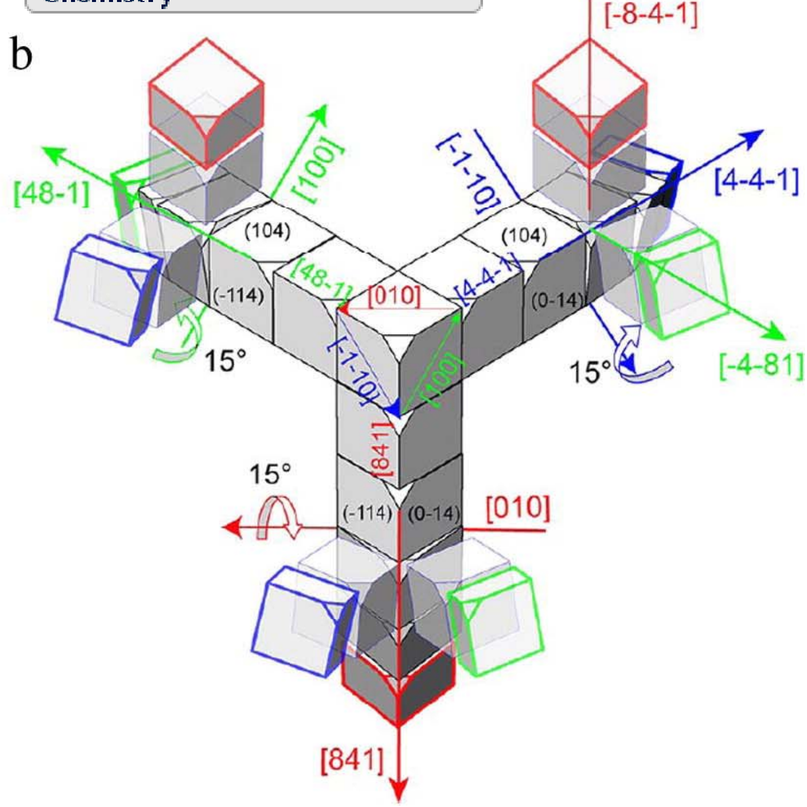
CRYSTAL GROWTH & DESIGN

CAS Section: Mineralogical and Geological Chemistry

a



b



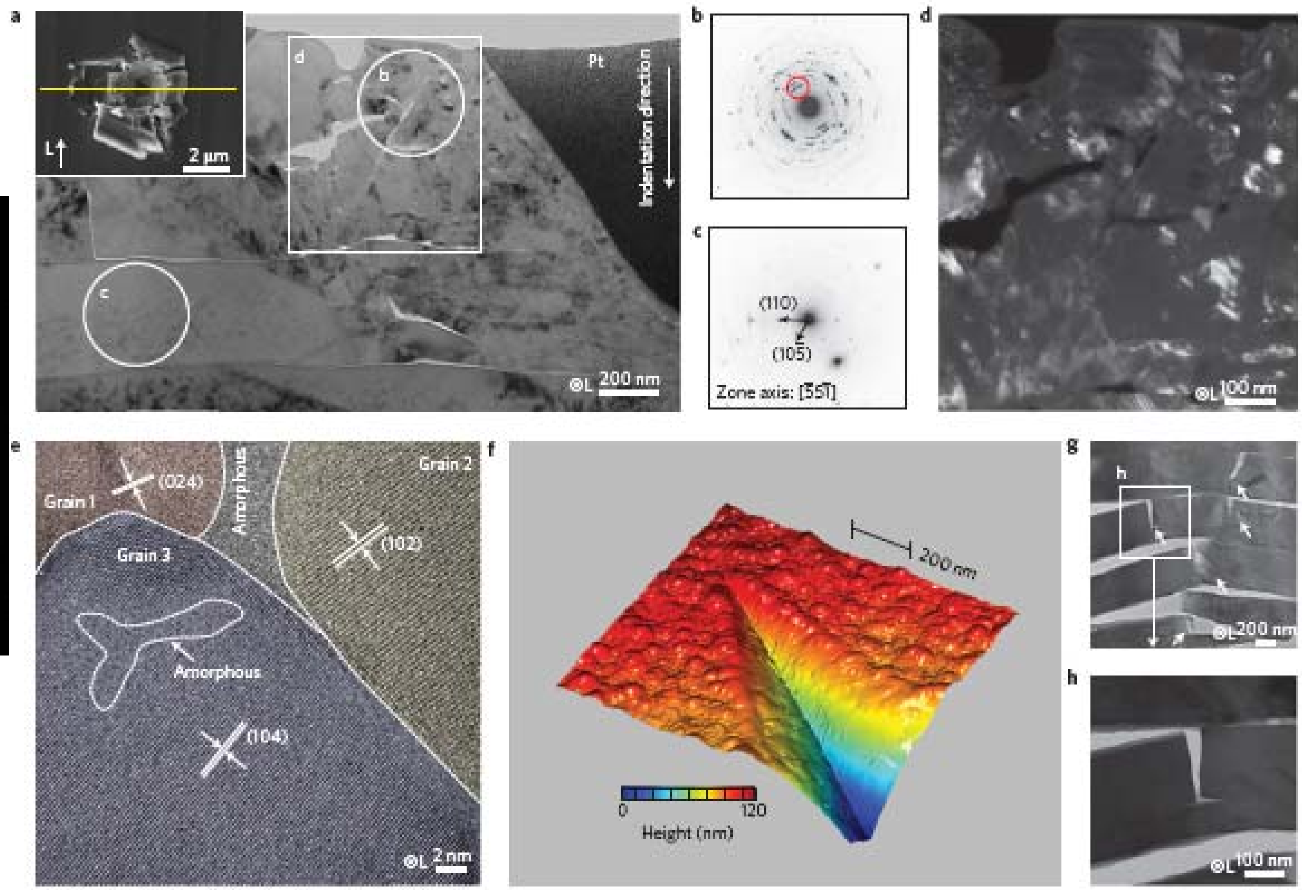
nature materials

ARTICLES

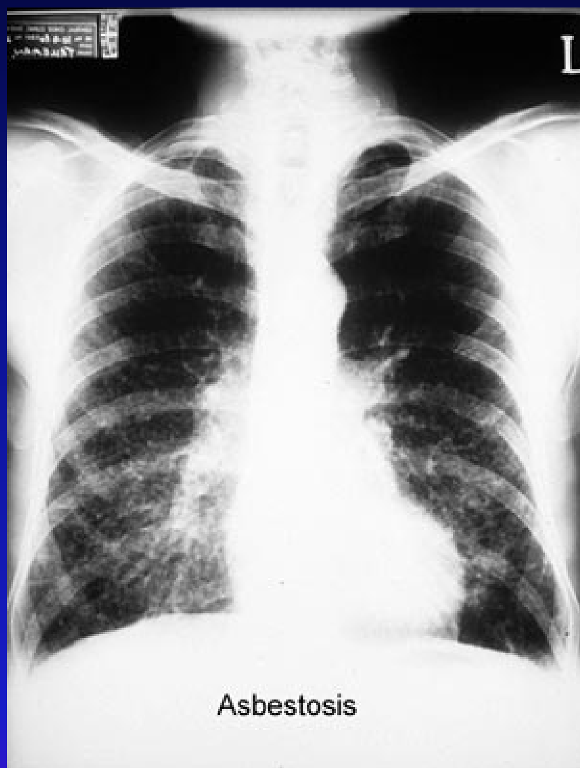
PUBLISHED ONLINE: 30 MARCH 2014 | DOI: 10.1038/NMAT3920

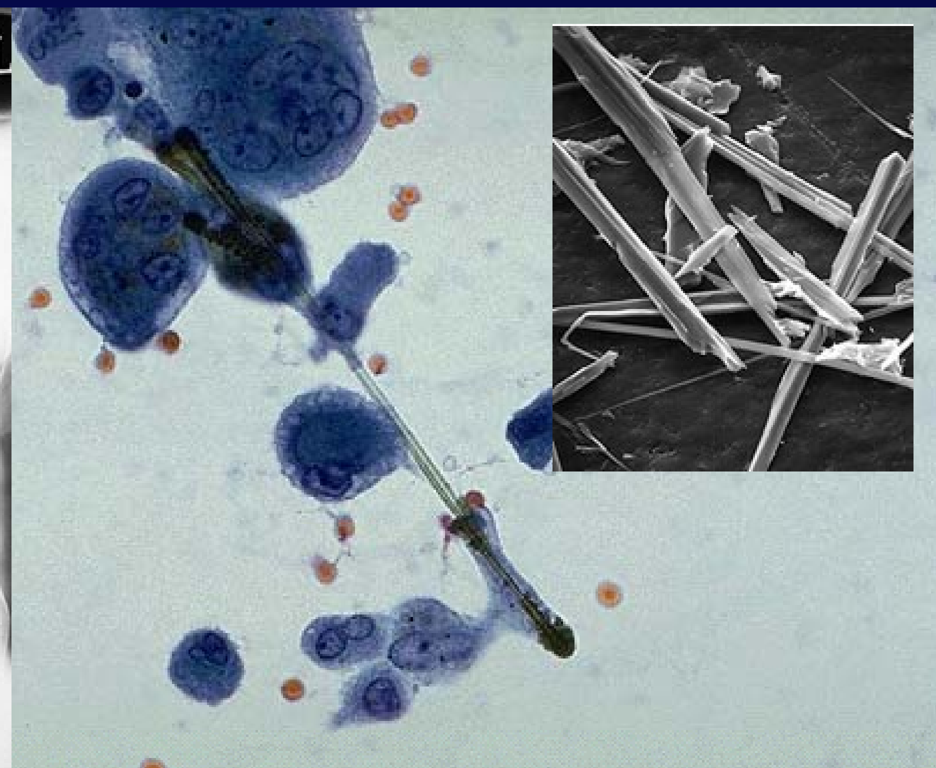
Pervasive nanoscale deformation twinning as a catalyst for efficient energy dissipation in a bioceramic armour

Ling Li and Christine Ortiz*



ΙΑΤΡΙΚΗ ΟΡΥΚΤΟΛΟΓΙΑ-ΓΕΩΛΟΓΙΑ



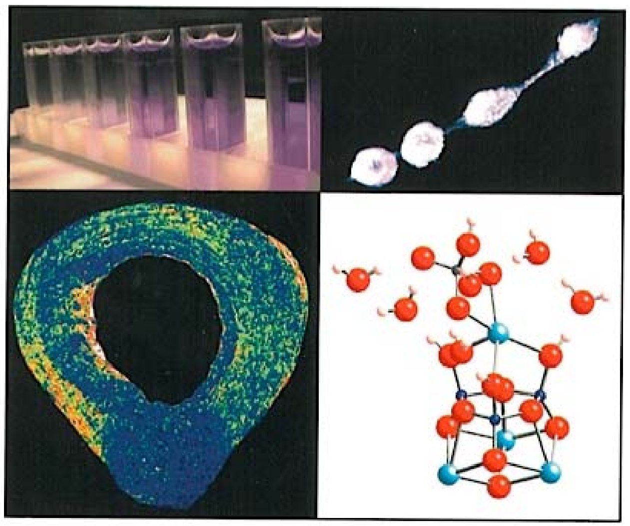


MEDICAL MINERALOGY - GEOLOGY

REVIEWS in
MINERALOGY &
GEOCHEMISTRY
Volume 64

MEDICAL MINERALOGY AND GEOCHEMISTRY

EDITORS:
Nita Sahai and Martin A.A. Schoonen



GEOCHEMICAL SOCIETY
MINERALOGICAL SOCIETY OF AMERICA

Series Editor: Jodi J. Rosso

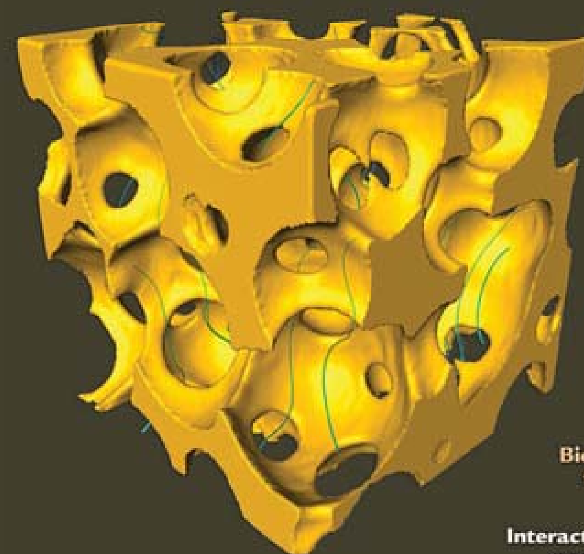
2006 *ISSN 1529-6466*

Elements

December 2007
Volume 3, Number 6
ISSN 1811-5209

An International Magazine of Mineralogy, Geochemistry, and Petrology

Medical Mineralogy and Geochemistry



An Interfacial Science

Mineralization of Bones and Teeth

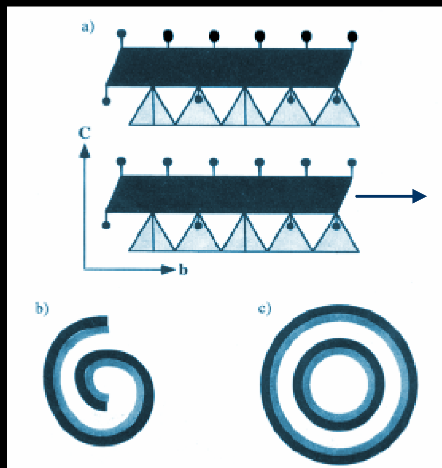
Bioactive Glass Scaffolds for Bone Regeneration

Interactions between Proteins and Soil Mineral Surfaces

Toxic Potential of Mineral Dusts

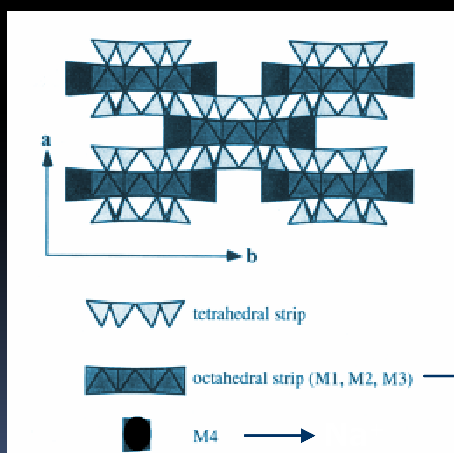
Kidney Stones

ΑΜΙΑΝΤΟΣ (ASBESTOS)

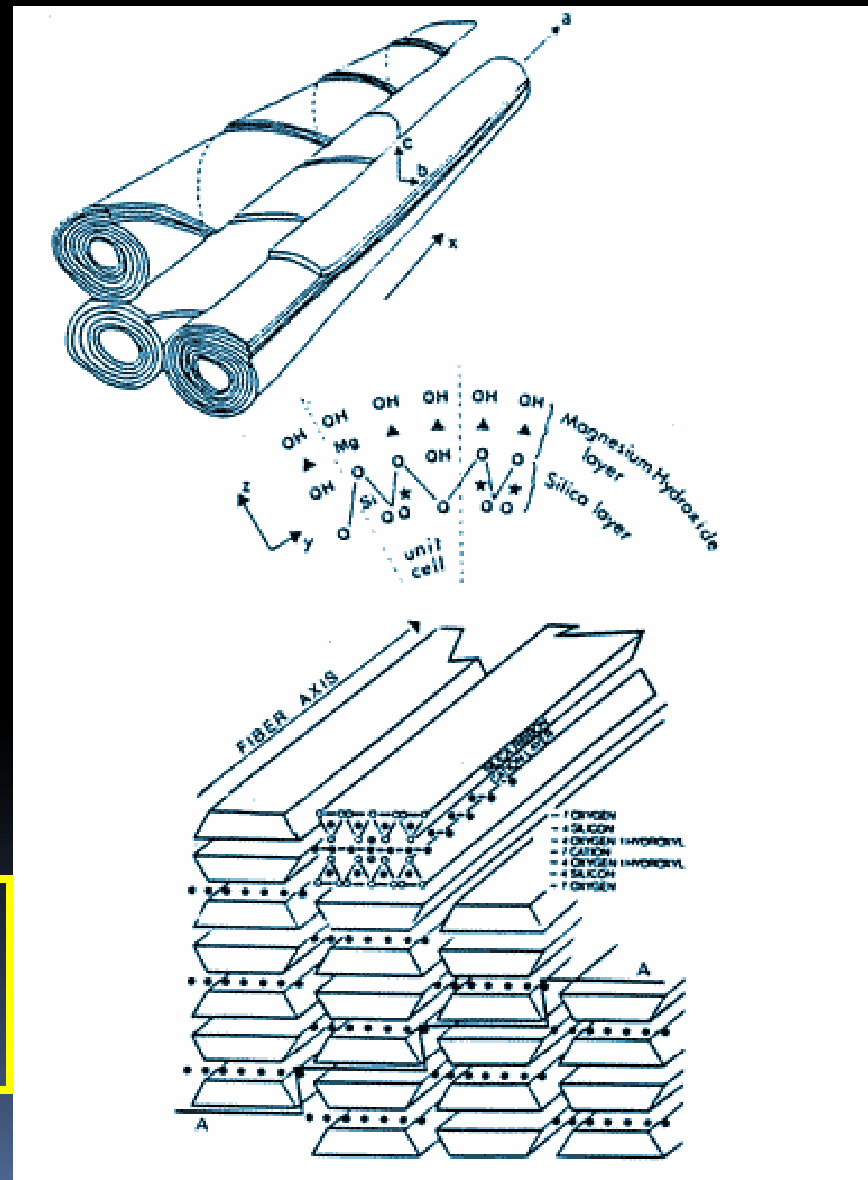


$Mg(OH)_2$

CHRYSOTILE (SERPENTINE ASBESTOS)



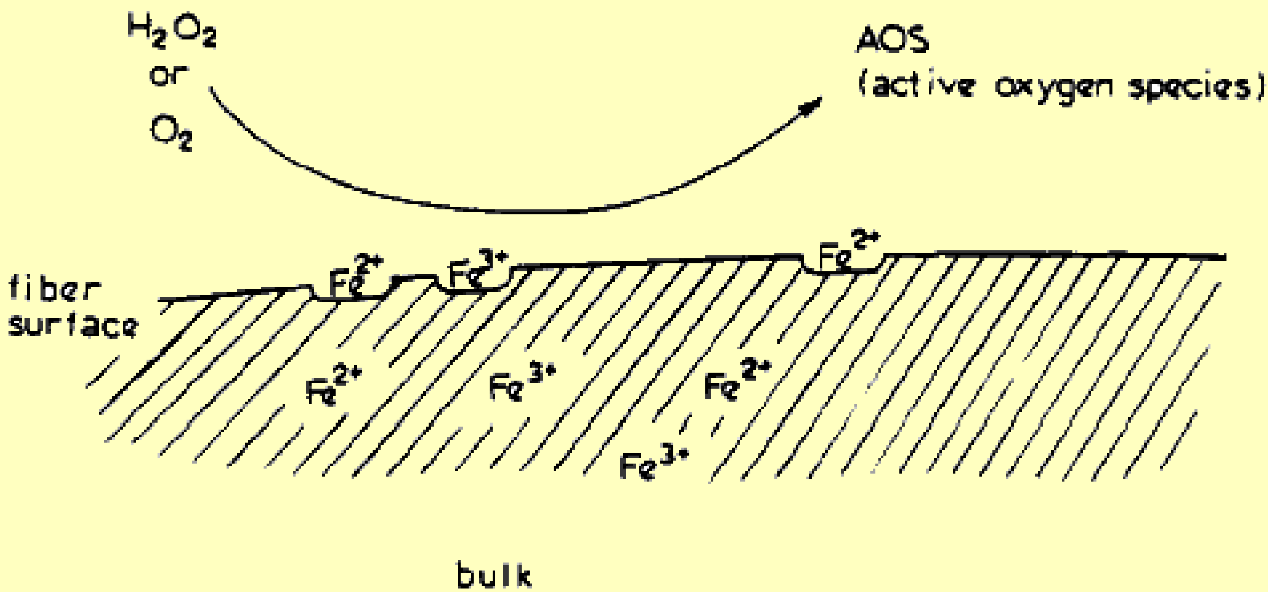
Mg^{2+}, Fe^{2+}, Fe^{3+}



CROCIDOLITE (AMPHIBOLE ASBESTOS)

Fenton Chemistry

$$Fe^{2+} + H_2O_2 \text{ ---> } Fe^{3+} + OH^- + \boxed{OH^*}$$



The surface reactivity scheme proposed by Fubini and associates depicting the occurrence of both Fe-(II) and Fe(III) on the surface and in the interior of the mineral fibers.

Hardy and Aust: Iron in Asbestos Chemistry and Carcinogenity. *Chem. Rev.* 95 (1995) 97-118.

ΥΔΡΟΓΟΝΟ & ΑΝΘΡΑΚΑΣ ΣΤΑ ΟΡΥΚΤΑ

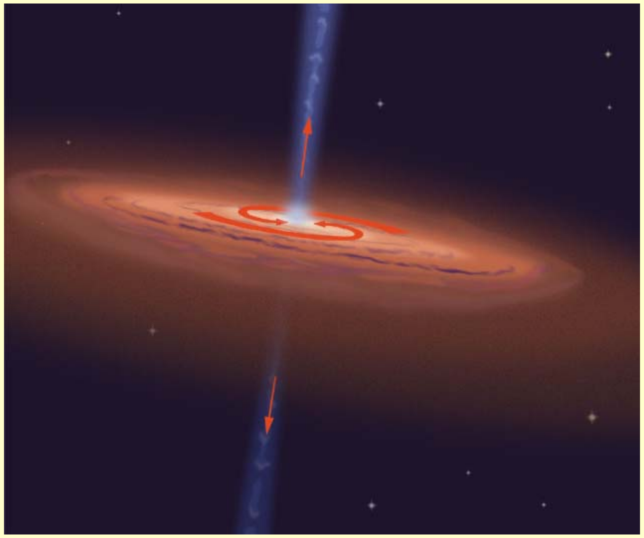
HYDROGEN & CARBON IN MINERALS

Το H είναι **το πλέον διαδεδομένο χημικό στοιχείο στο Σύμπαν** ακολουθούμενο από το He, το O, τον C, το N, το Ne, το Mg, και το Si. Αποτελεί **βασικό συστατικό του DNA όλων των έμβιων όντων** ενώ ο μέσος όρος του H στο ανθρώπινο σώμα είναι ~10 wt%. Επομένως το H είναι άφθονο στην Βιόσφαιρα, και φυσικά στην Υδρόσφαιρα (ωκεανοί, λίμνες, ποταμοί, κ.λ.π.). Στην Ατμόσφαιρα το H είναι λιγότερο διαδεδομένο (~0.53 ppm), ενώ στον **στερεό φλοιό της Γής** (ωκεάνειο και ηπειρωτικό) υπολογίζεται σε **~0.14 wt% (~1400 ppm)** κατά μέσο όρο.

Είναι φανερό ότι ενώ τεράστια ποσά H είναι διαθέσιμα στην Υδρόσφαιρα, δεν συμβαίνει το ίδιο και στην Λιθόσφαιρα όπου το H απαντά *κυρίως* στα λεγόμενα **“ένυδρα” ορυκτά** (Nominally Hydrous Minerals – **NHM**) των πετρωμάτων. Αξίζει να σημειωθεί ότι ενώ **οι ωκεανοί αποτελούν το 71% της επιφάνειας του πλανήτη αντιπροσωπεύουν μόνο το 0.025% της ολικής μάζας**, και συνεπώς πολλά ερωτήματα παραμένουν για το τι ακριβώς συμβαίνει με **το H στο υπόλοιπο 99.975% της μάζας της Γής (φλοιός-μανδύας-πυρήνας).**

ΚΟΣΜΟΧΗΜΙΚΕΣ ΠΗΓΕΣ (πιθανώς <10% συμβολή από SN)

Ηλιακό Νεφέλωμα (Solar Nebula-SN)



H_2 : 96.1 %
He : 3.8 %
CO : 0.077 %
Ne : 0.016 %
N_2 : 78 ppm
H_2O/H_2 ~ 10^{-4}

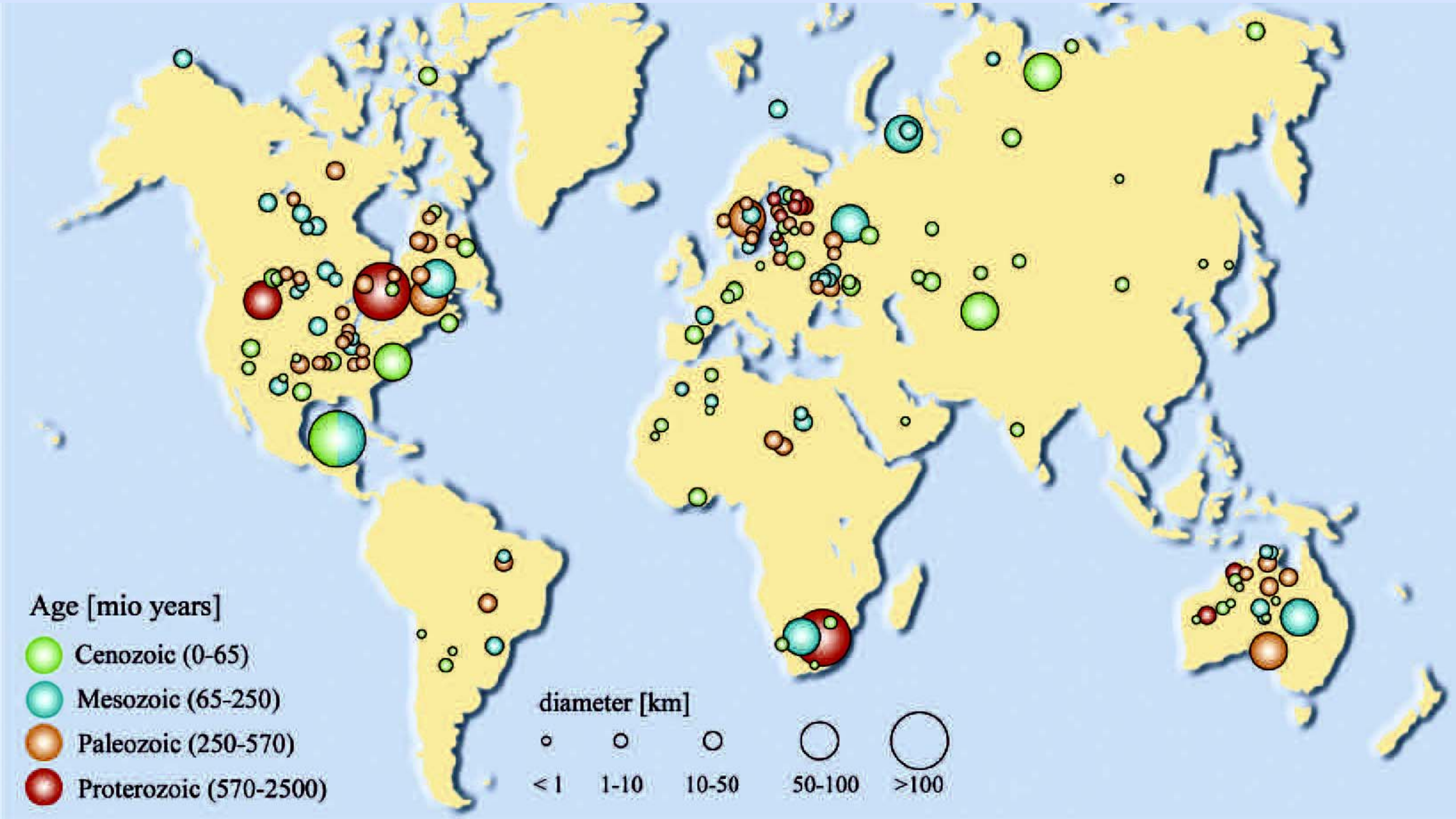
Κομήτες

έως και
50%
H_2O

Μετεωριτική Ύλη

έως και
10%
H_2O
σε ανθρακικούς
ΧΟΝΔΡΙΤΕΣ

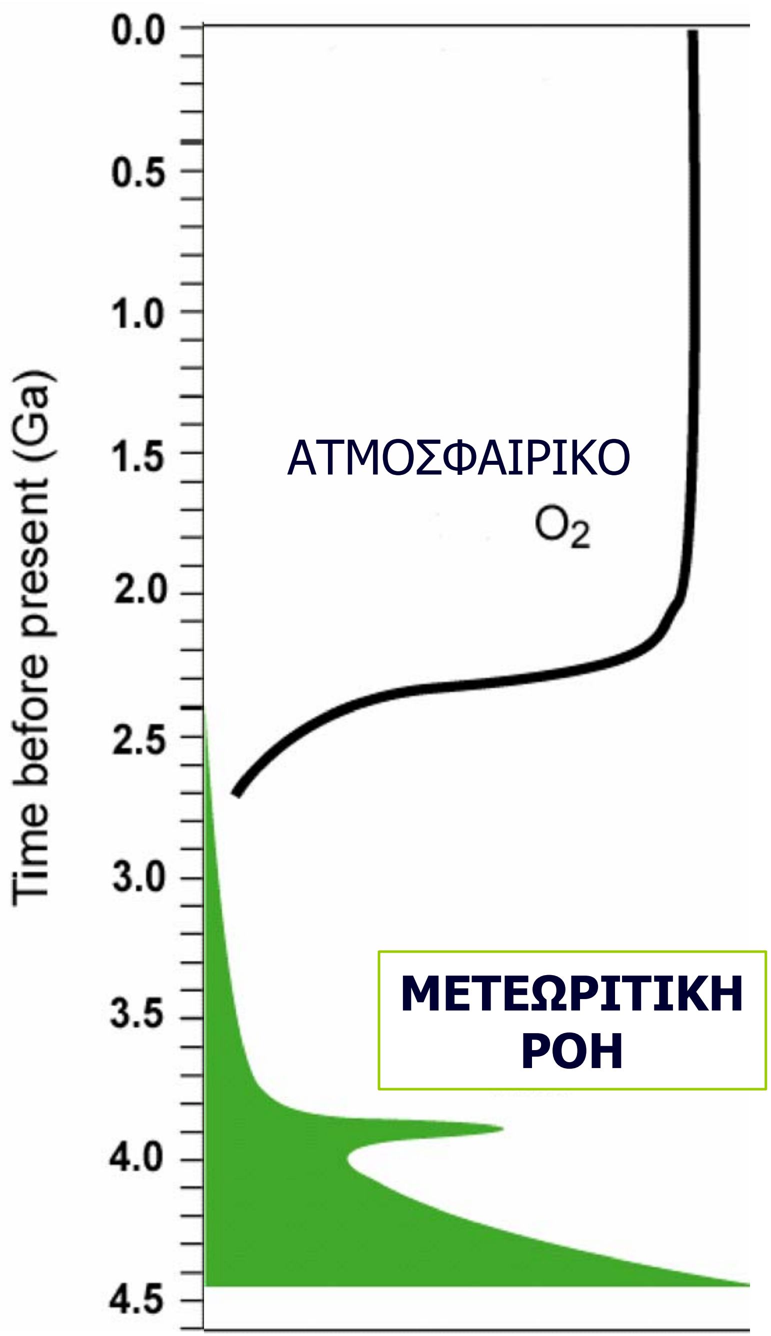
Μετεωριτικοί Κρατήρες

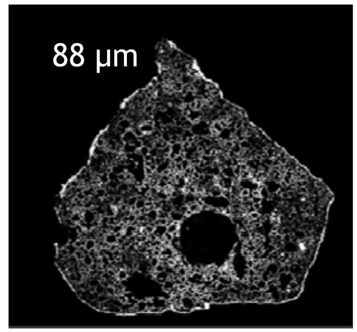


ΡΟΗ ΥΛΗΣ ΣΕ ΓΗΙΝΟΥΣ ΠΛΑΝΗΤΕΣ

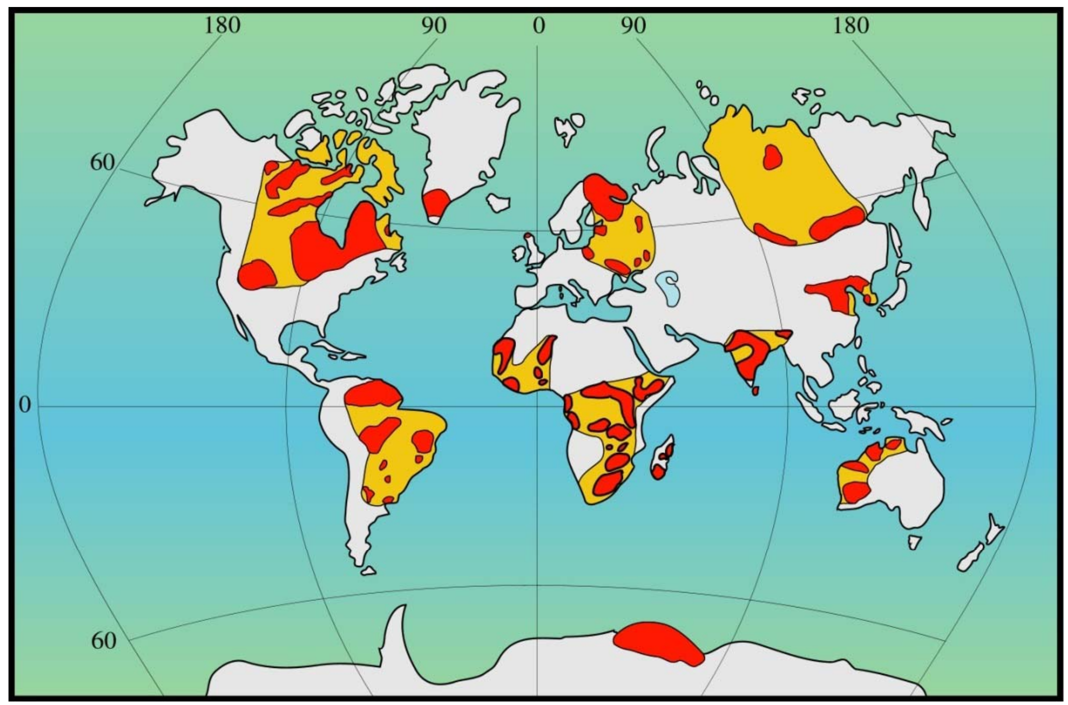
IDPs, MM : 20,000 – 40,000 tons/yr

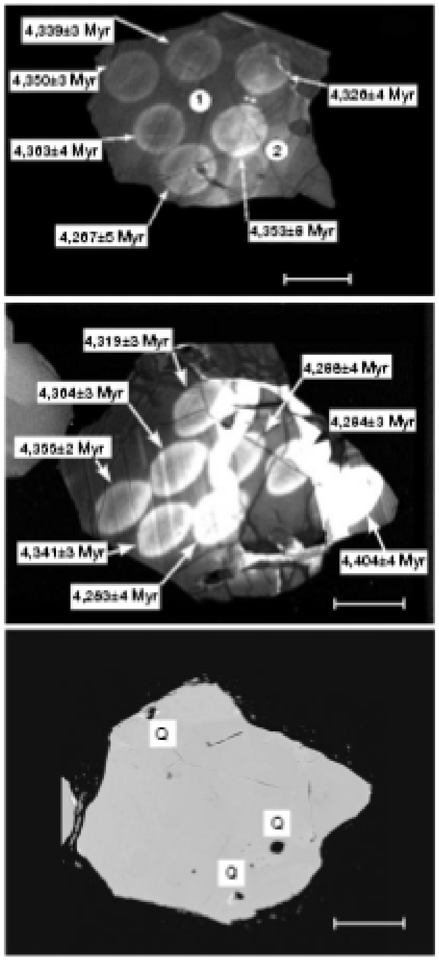
Μετεωρίτες : 10 tons/yr





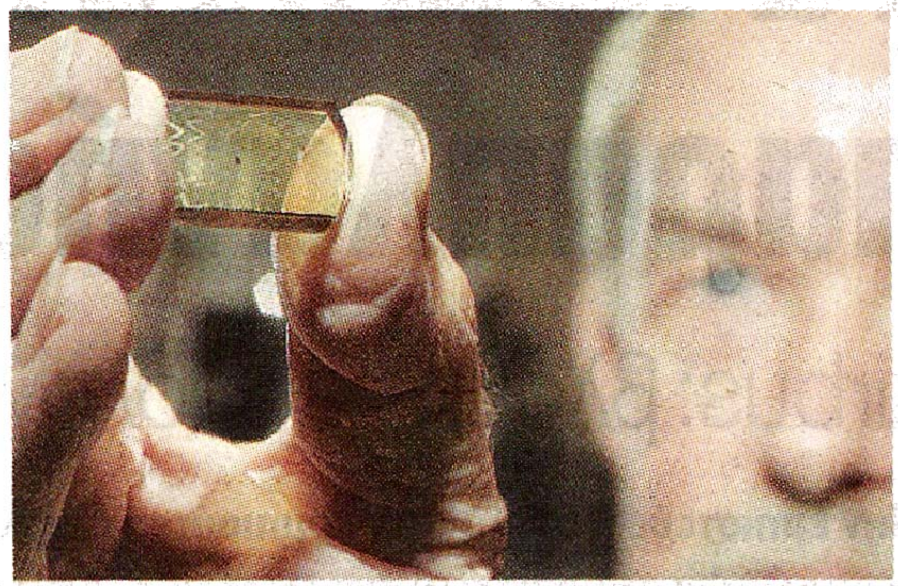
ΜΙΚΡΟ-ΜΕΤΕΩΡΙΤΕΣ
(ΜΜ)





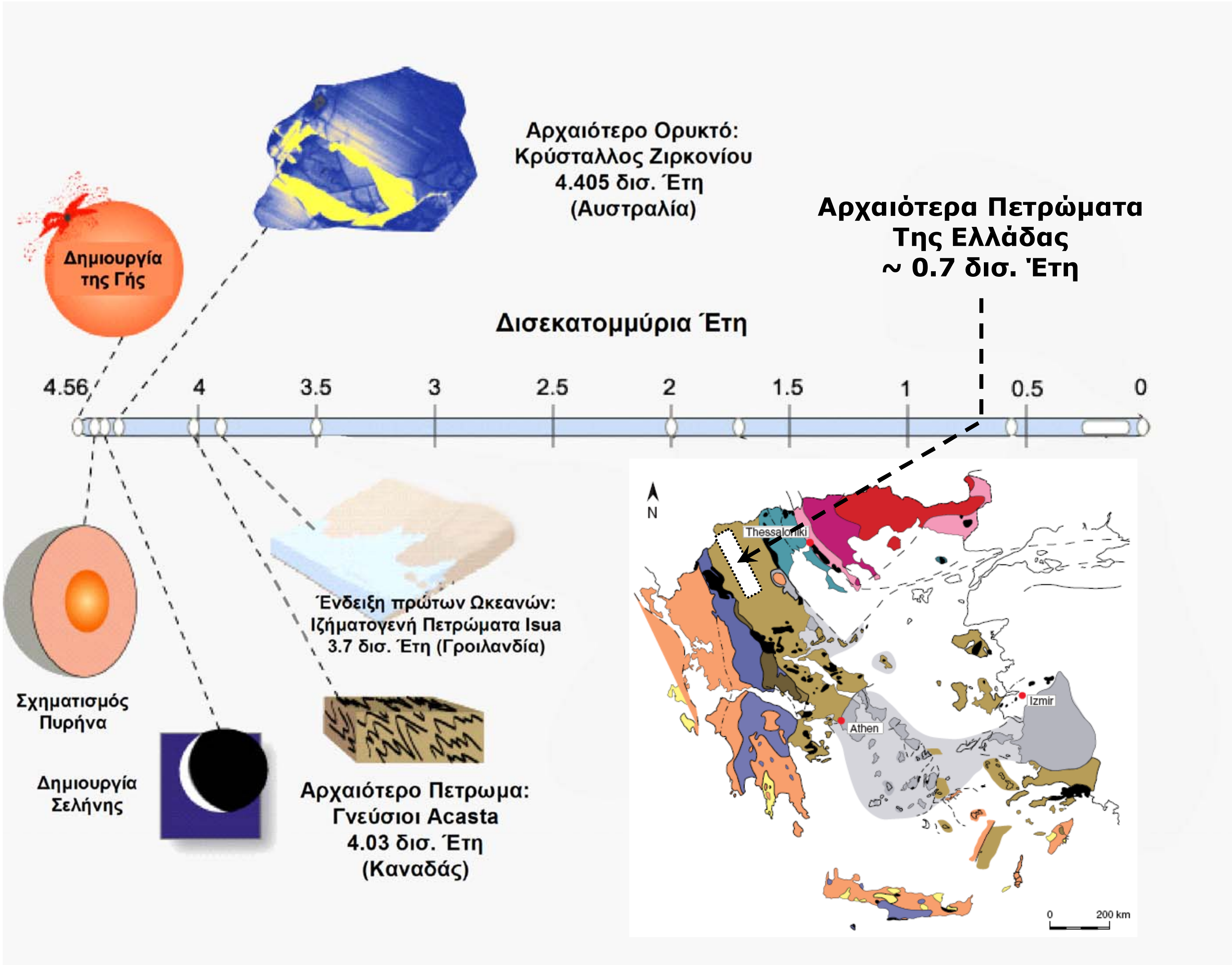
$^{207}Pb/^{206}Pb$

ΤΑ ΝΕΑ / Δευτέρα 11 Απριλίου 2005

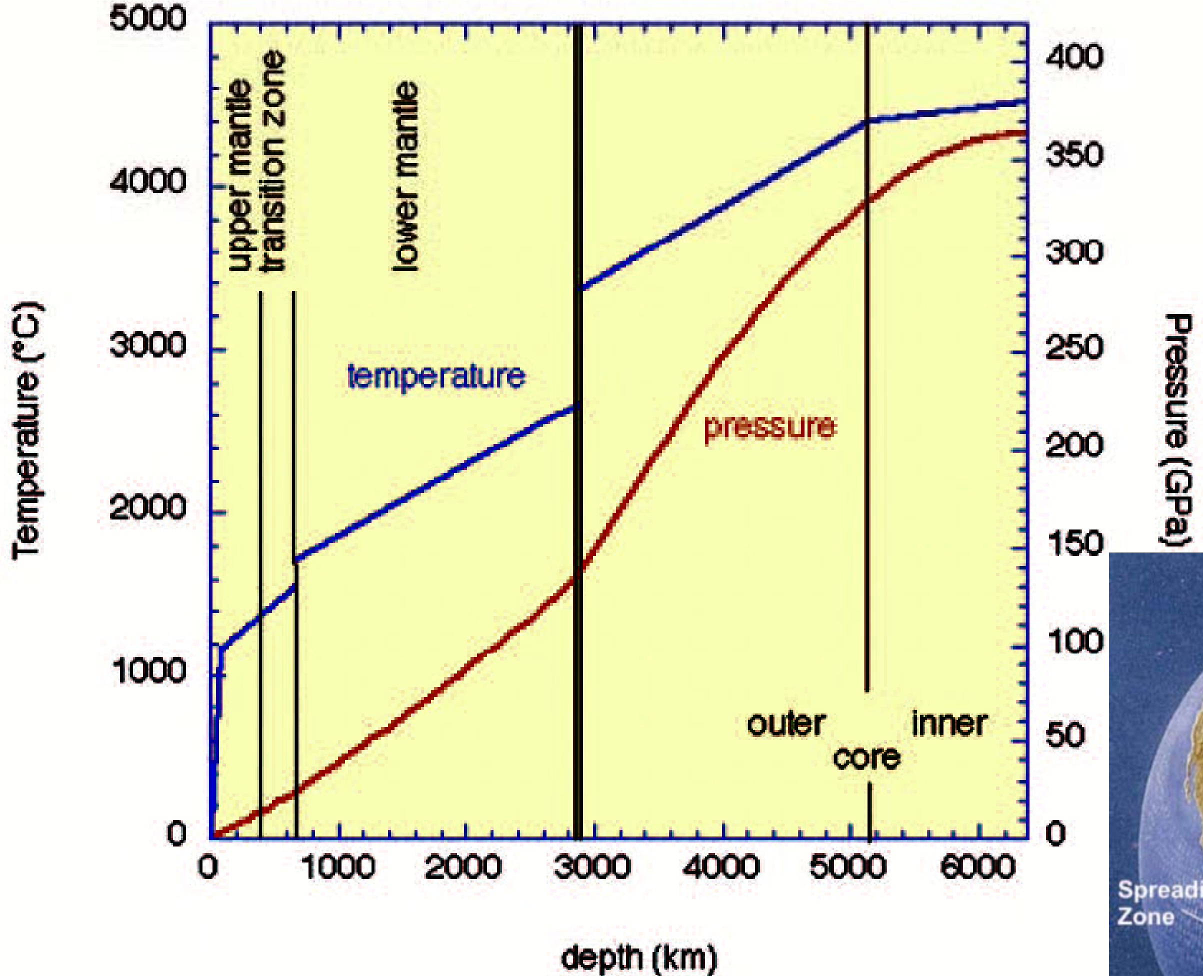


■ **Κρύσταλλος ζιρκονίου.** Έχει ηλικία 4,4 δισ. ετών

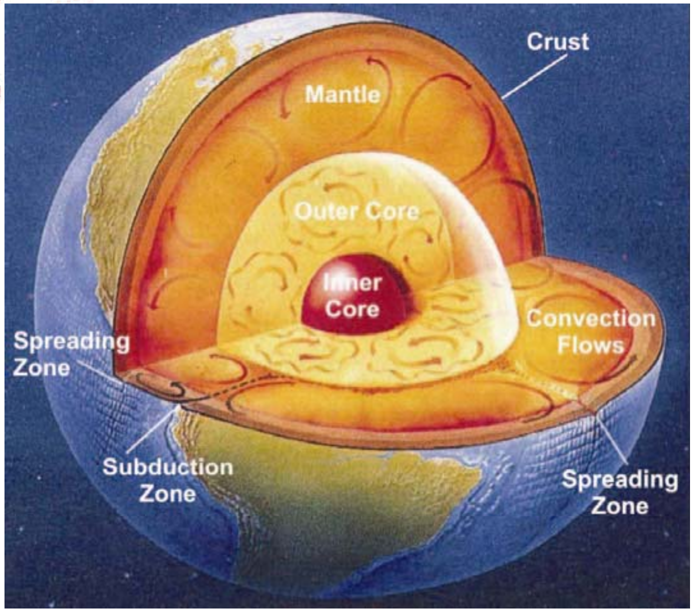
το συμπέρασμα ήταν ότι αρχικά η Γη δεν ήταν ένας συνεχώς κινούμενος ωκεανός μάγματος – όπως πιστεύαμε έως σήμερα – αλλά, αντίθετα, είχε αρκετά δροσερή ατμόσφαιρα, ώστε να δημιουργηθούν ωκεανοί και ήπειροι, προϋποθέσεις απαραίτητες για τη δημιουργία και την εμφάνιση της ζωής



Αρχαιότερο Ορυκτό:
Κρύσταλλος Ζιρκονίου
4.405 δισ. Έτη
(Αυστραλία)
Αρχαιότερα Πετρώματα
Της Ελλάδας
~ 0.7 δισ. Έτη
Δημιουργία
της Γής
Δισεκατομμύρια Έτη
4.56
4
3.5
3
2.5
2
1.5
1
0.5
0
N
Thessaloniki
Izmir
Athen
0
200 km
Ένδειξη πρώτων Ωκεανών:
Ιζήματογενή Πετρώματα Isua
3.7 δισ. Έτη (Γροιλανδία)
Σχηματισμός
Πυρήνα
Δημιουργία
Σελήνης
Αρχαιότερο Πετρωμα:
Γνεύσιοι Acasta
4.03 δισ. Έτη
(Καναδάς)

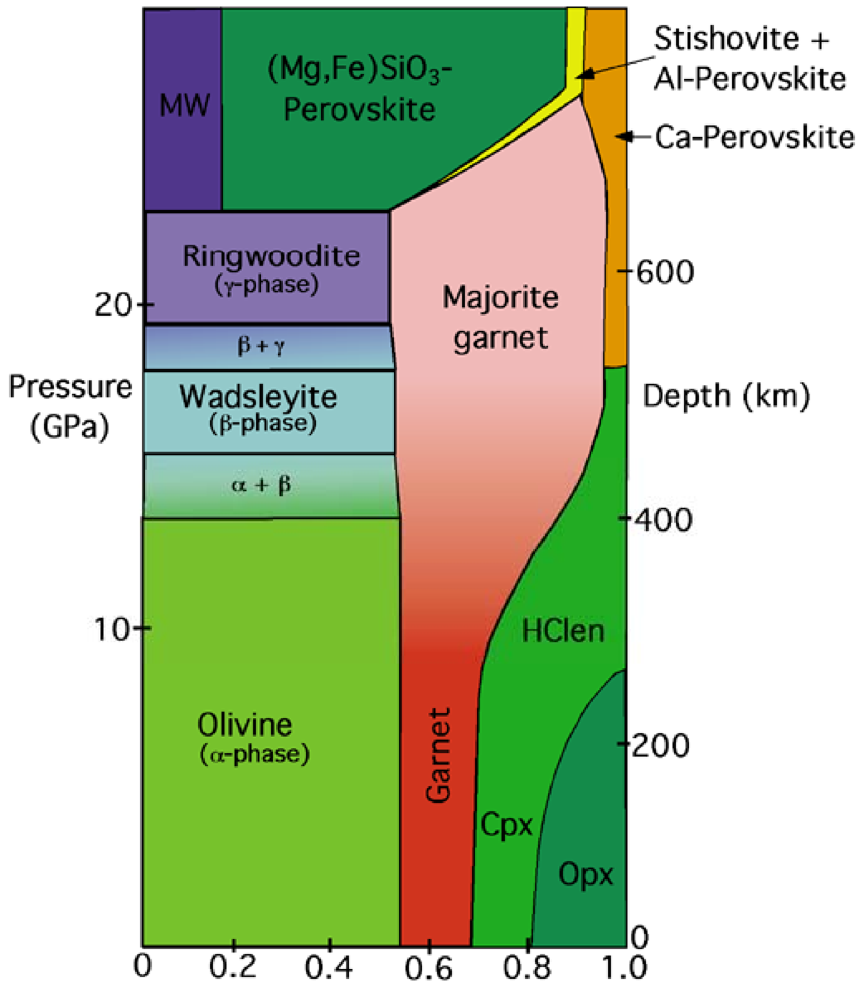


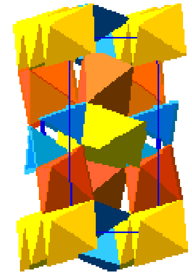
5000
4000
3000
2000
1000
0
Temperature (°C)
upper mantle
transition zone
lower mantle
temperature
pressure
outer
core
inner
0
1000
2000
3000
4000
5000
6000
depth (km)
400
350
300
250
200
150
100
50
0
Pressure (GPa)



Crust
Mantle
Outer Core
Inner Core
Convection Flows
Spreading Zone
Subduction Zone
Spreading Zone

ΠΟΛΥΜΟΡΦΙΣΜΟΣ ΤΟΥ ΟΛΙΒΙΝΗ (κατ' όνομα "άνυδρο" πυριτικό ορυκτό) ΣΤΟ ΕΣΩΤΕΡΙΚΟ ΤΗΣ ΓΗΣ

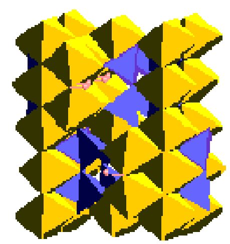




α-$(Mg,Fe)_2SiO_4$
ΡΟΜΒΙΚΟ

↓

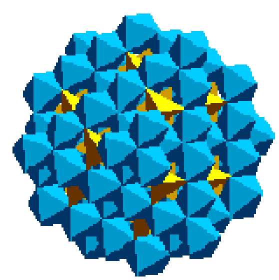
410 Km



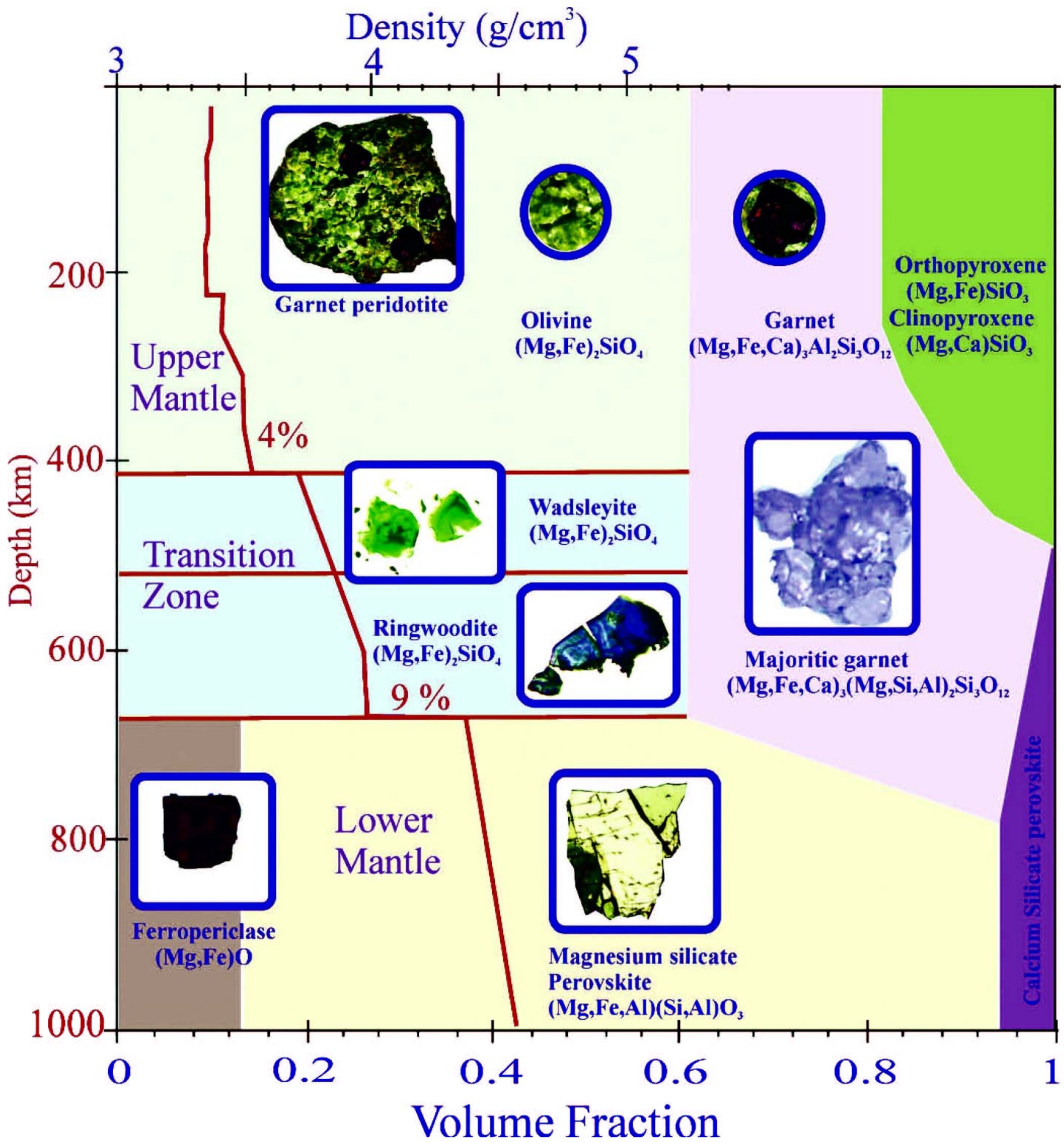
β-$(Mg,Fe)_2SiO_4$
ΡΟΜΒΙΚΟ
Γουαντσλεΐτης

↓

520 Km



γ-$(Mg,Fe)_2SiO_4$
ΚΥΒΙΚΟ
Ρινγκουντίτης



Density (g/cm^3)
3
4
5
Depth (km)
200
400
600
800
1000
Upper Mantle
4%
Transition Zone
9 %
Lower Mantle
Garnet peridotite
Olivine
(Mg,Fe)$_2$SiO$_4$
Garnet
(Mg,Fe,Ca)$_3$Al$_2$Si$_3$O$_{12}$
Orthopyroxene
(Mg,Fe)SiO$_3$
Clinopyroxene
(Mg,Ca)SiO$_3$
Wadsleyite
(Mg,Fe)$_2$SiO$_4$
Ringwoodite
(Mg,Fe)$_2$SiO$_4$
Majoritic garnet
(Mg,Fe,Ca)$_3$(Mg,Si,Al)$_2$Si$_3$O$_{12}$
Ferropericlase
(Mg,Fe)O
Magnesium silicate
Perovskite
(Mg,Fe,Al)(Si,Al)O$_3$
Calcium Silicate perovskite
0
0.2
0.4
0.6
0.8
1
Volume Fraction

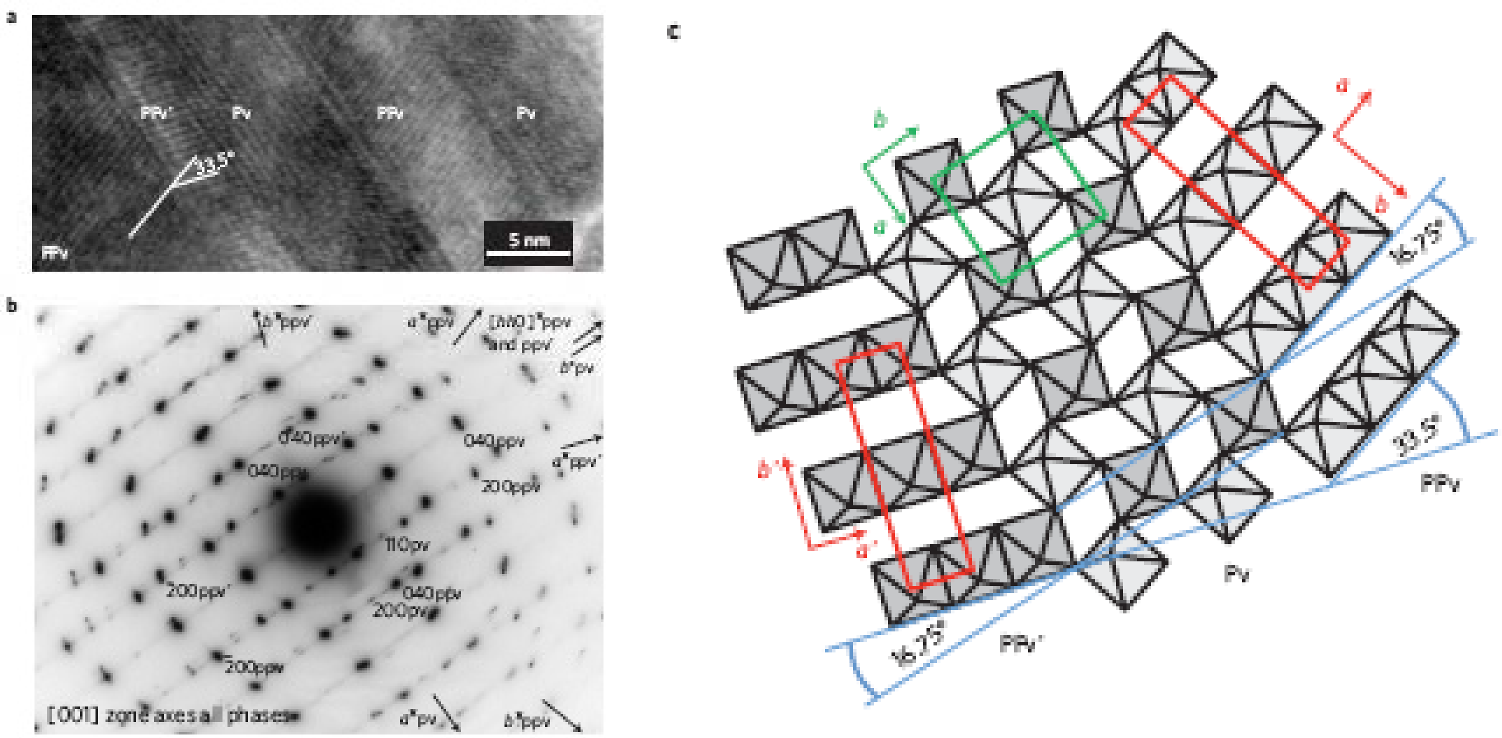
nature geoscience

LETTERS

PUBLISHED ONLINE: 16 JUNE 2013 | DOI: 10.1038/NGEO1844

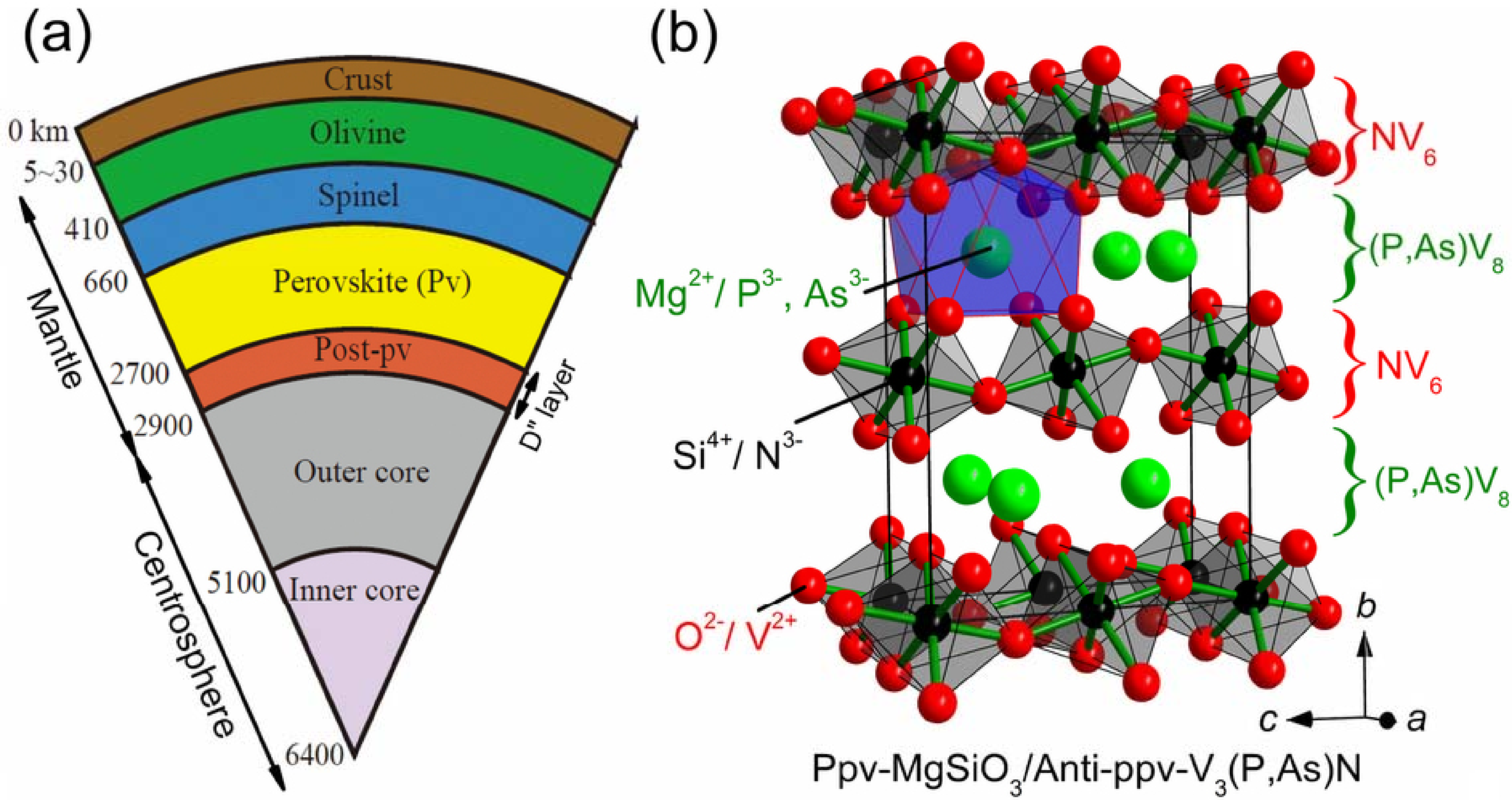
Strong inheritance of texture between perovskite and post-perovskite in the D″ layer

David P. Dobson[1,2]*, Nobuyoshi Miyajima[3], Fabrizio Nestola[4], Matteo Alvaro[4], Nicola Casati[5], Christian Liebske[2], Ian G. Wood[1] and Andrew M. Walker[6]



SCIENTIFIC REPORTS

Published
29 November 2013



DEEP EARTH SCIENCE sciencemag.org 23 MAY 2014 • VOL 344 ISSUE 6186 877

Disproportionation of (Mg,Fe)SiO_3 perovskite in Earth's deep lower mantle

Li Zhang,[1,2*] Yue Meng,[3] Wenge Yang,[1,4] Lin Wang,[1,4] Wendy L. Mao,[5,6] Qiao-Shi Zeng,[5] Jong Seok Jeong,[7] Andrew J. Wagner,[7] K. Andre Mkhoyan,[7] Wenjun Liu,[8] Ruqing Xu,[8] Ho-kwang Mao[1,3]

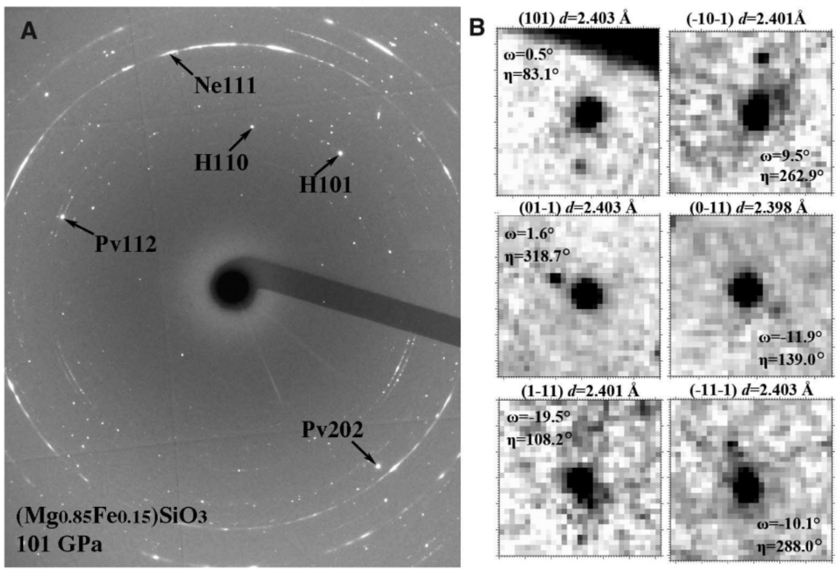


Fig. 2. Selection of $MgSiO_3$ pv and H-phase individual single crystals using the multigrain method. (**A**) A representative spotty multiple-crystal XRD pattern of the H-phase and coexisting pv in Fs15 at 101 GPa and after T quench (x-ray wavelength of 0.3738 Å), and the marked Miller indices show some of the most intense diffraction spots. (**B**) Six {101} diffraction reflections at different rotation angle ω and azimuthal angle η belonging to one selected crystallite of the H-phase at 101 GPa.

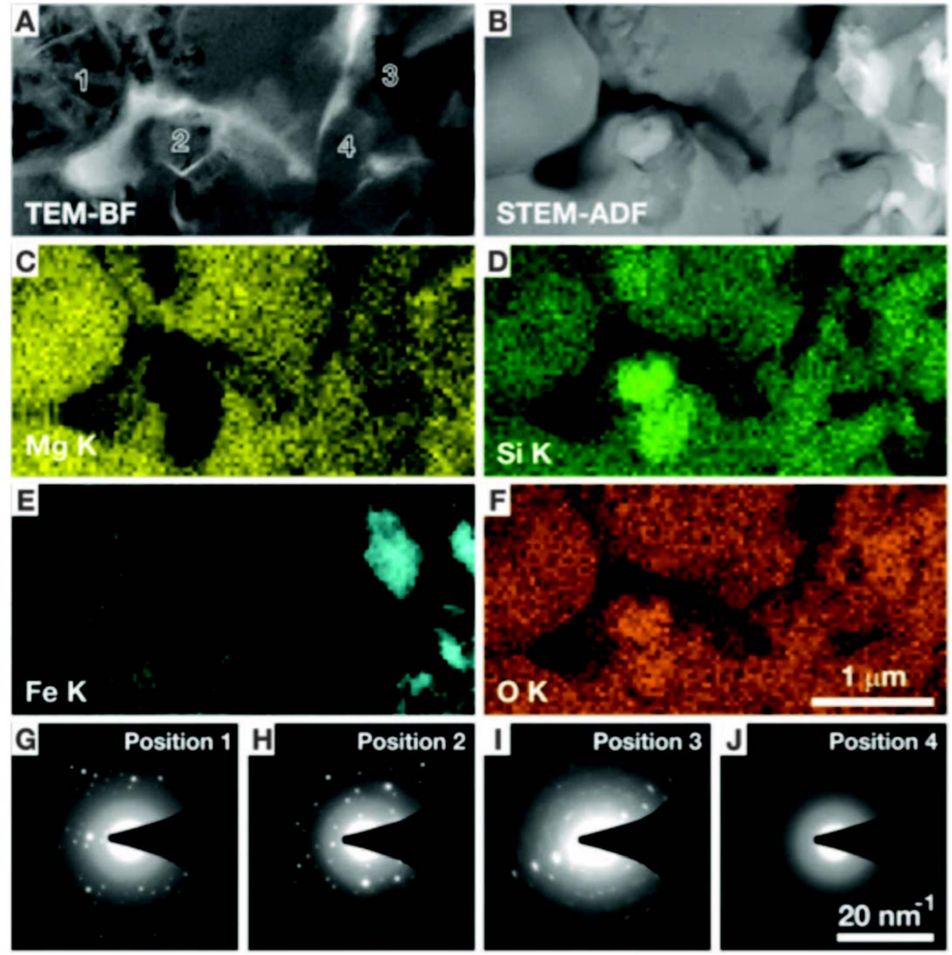


Fig. 3. STEM-EDX analysis of the recovered products. (**A**) TEM-BF image. (**B**) STEM-annular dark-field (ADF) image. (**C** to **F**) Corresponding STEM-EDX maps: (C) Mg K, (D) Si K, (E) Fe K, and (F) O K. STEM-ADF and EDX maps were obtained simultaneously. (**G** to **J**) SAED patterns obtained from the positions indicated in (A).

Μπριντγκμανίτης (bridgmanite-$MgSiO_3$)

6 JUNE 2014

Earth’s most abundant mineral finally gets a name

Posted by nbompey

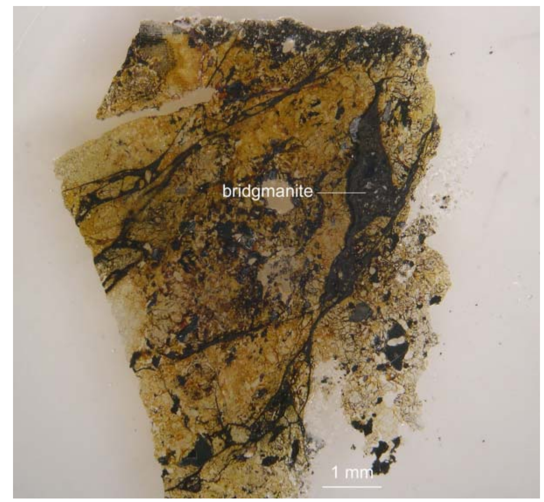
By JoAnna Wendel

The mineral said to be the most abundant of our planet, but found so deep within Earth's interior that scientists usually cannot observe it directly, now has a name.

On June 2, bridgmanite was approved as the formal name for one of the Earth's most plentiful yet elusive minerals known to exist in the Earth's lower mantle. Bridgmanite, which was formerly known simply as silicate-perovskite, is named after the 1946 Nobel Prize winning physicist Percy Bridgman.

Scientists have known for decades that bridgmanite existed in the Earth's interior, but had been unable to successfully characterize a naturally occurring sample until this year.

"This [find] fills a vexing gap in the taxonomy of minerals," Oliver Tschauner, an associate research professor at the University of Nevada-Las Vegas who characterized the mineral, said in an email.



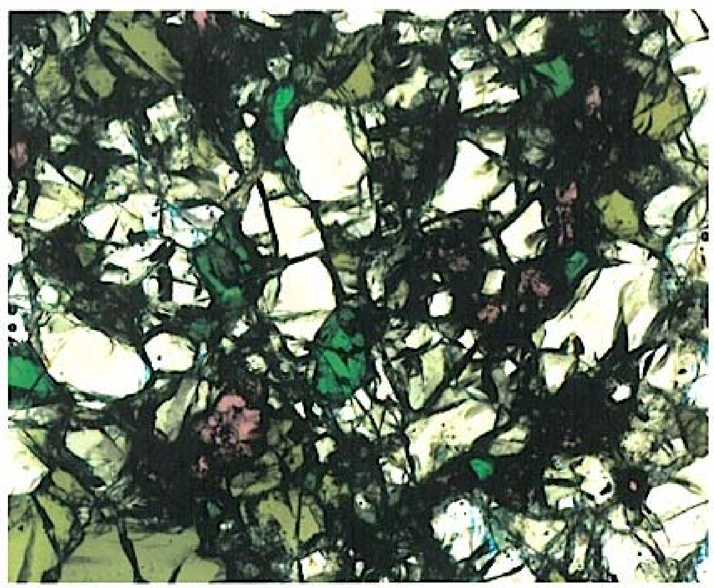
Tschauner, along with Chi Ma, a senior scientist and mineralogist at the California Institute of Technology in Pasadena, Calif., have been working to chemically and structurally characterize natural silicate-perovskite ($MgSiO_3$) since 2009.

REVIEWS in
MINERALOGY &
GEOCHEMISTRY
Volume 62

WATER IN NOMINALLY ANHYDROUS MINERALS

EDITORS

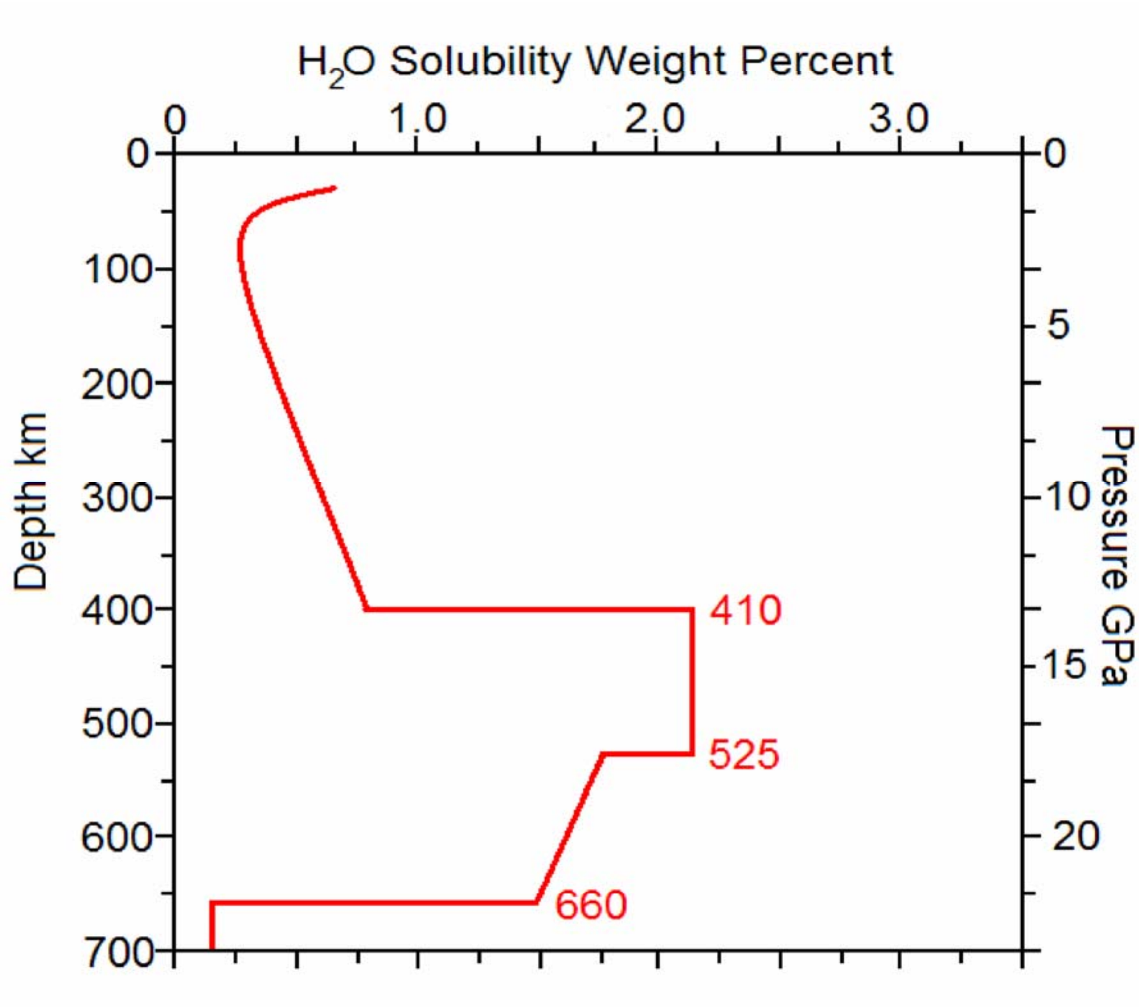
Hans Keppler and Joseph R. Smyth

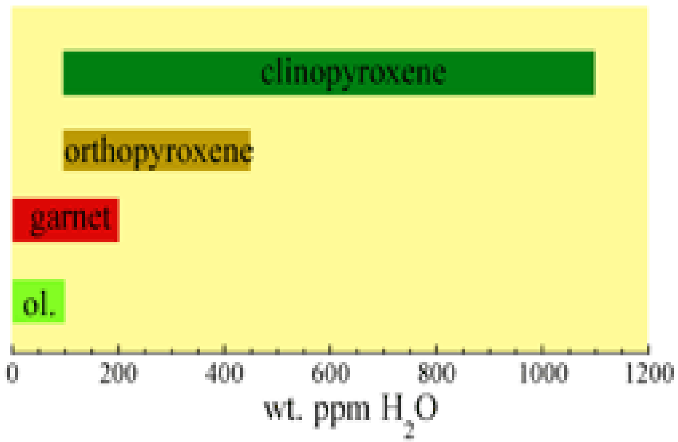


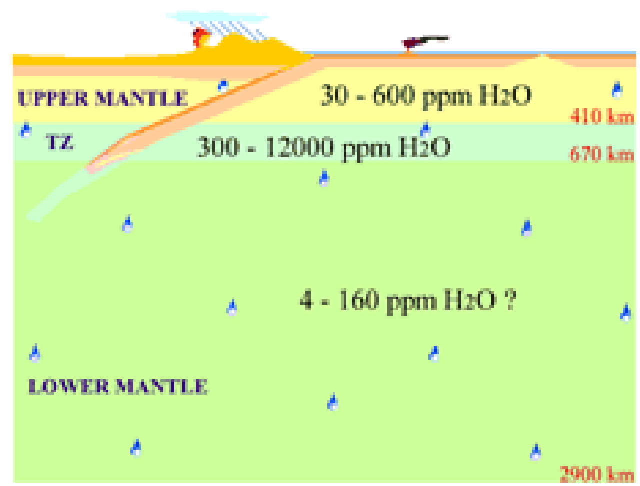
GEOCHEMICAL SOCIETY
MINERALOGICAL SOCIETY OF AMERICA
Series Editor: Jodi J. Rosso

2006 *ISSN 1529-6466*

Κατανομή του H (ως H_2O) στο εσωτερικό της Γής και σε διάφορα κατ' όνομα "άνυδρα" πυριτικά ορυκτά (Nominally Anhydrous Minerals - **NAM**)



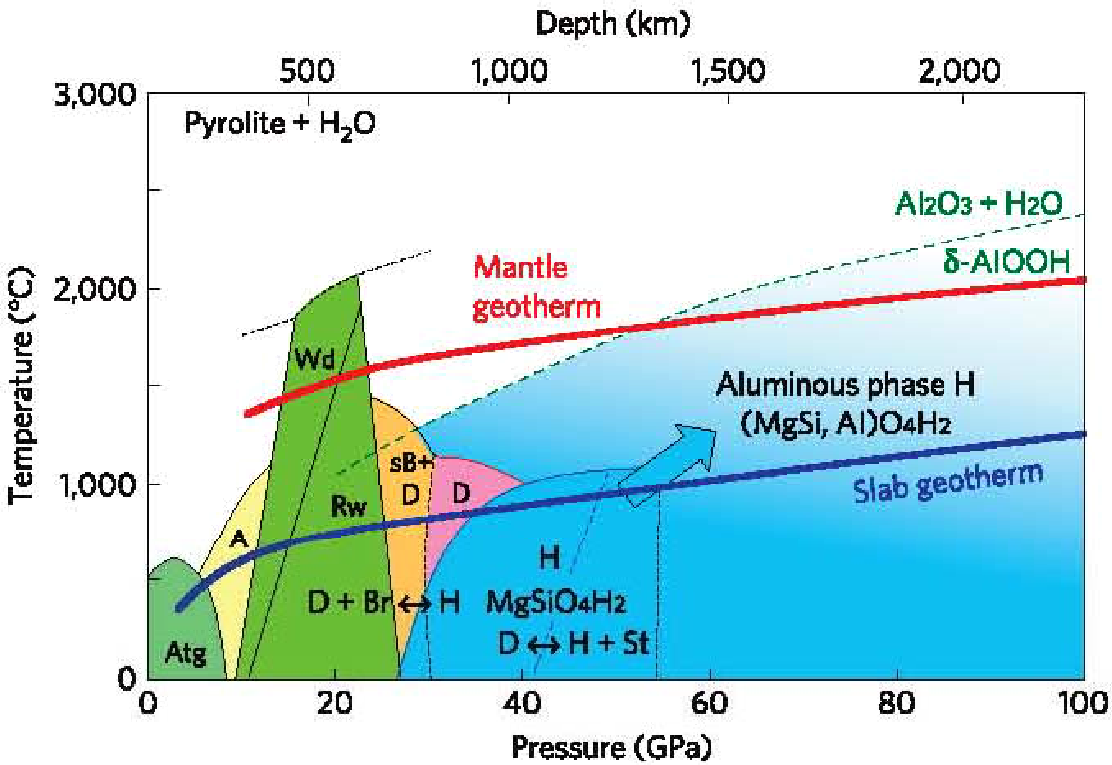




nature geoscience
LETTERS
PUBLISHED ONLINE: 2 FEBRUARY 2014 | DOI: 10.1038/NGEO2074

Stability of hydrous silicate at high pressures and water transport to the deep lower mantle

M. Nishi[1,2*], T. Irifune[1,2], J. Tsuchiya[1,2], Y. Tange[1,2], Y. Nishihara[1], K. Fujino[1] and Y. Higo[3]



Atg, antigorite; A, phase A; Wd, wadsleyite; Rw, ringwoodite; sB, superhydrous phase B; D, phase D.

Earth may have underground 'ocean' three times that on surface

Scientists say rock layer hundreds of miles down holds vast amount of water, opening up new theories on how planet formed

Melissa Davey
The Guardian, Friday 13 June 2014 04.53 BST

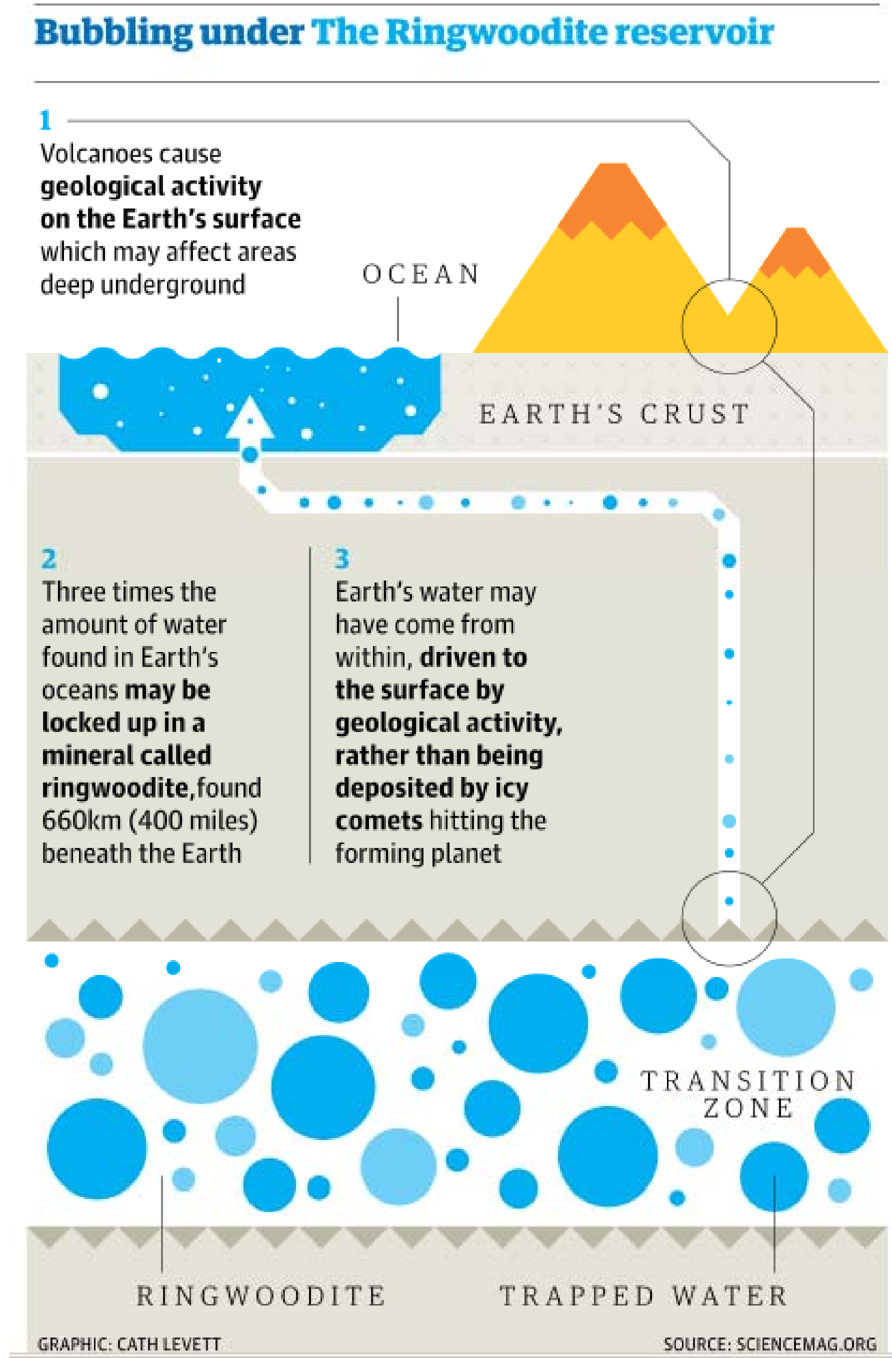
Three-quarters of the Earth's water may be locked deep underground in a layer of rock, scientists say. Photograph: Blue Line Pictures/Getty Images

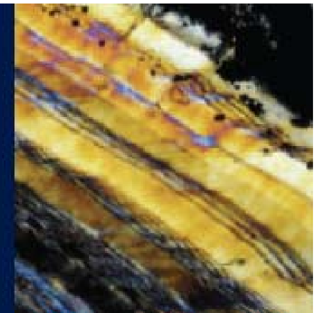
Science 13 June 2014:
Vol. 344 no. 6189 pp. 1265-1268
DOI: 10.1126/science.1253358

REPORT

Dehydration melting at the top of the lower mantle

Brandon Schmandt[1,*], Steven D. Jacobsen[2,*], Thorsten W. Becker[3], Zhenxian Liu[4], Kenneth G. Dueker[5]

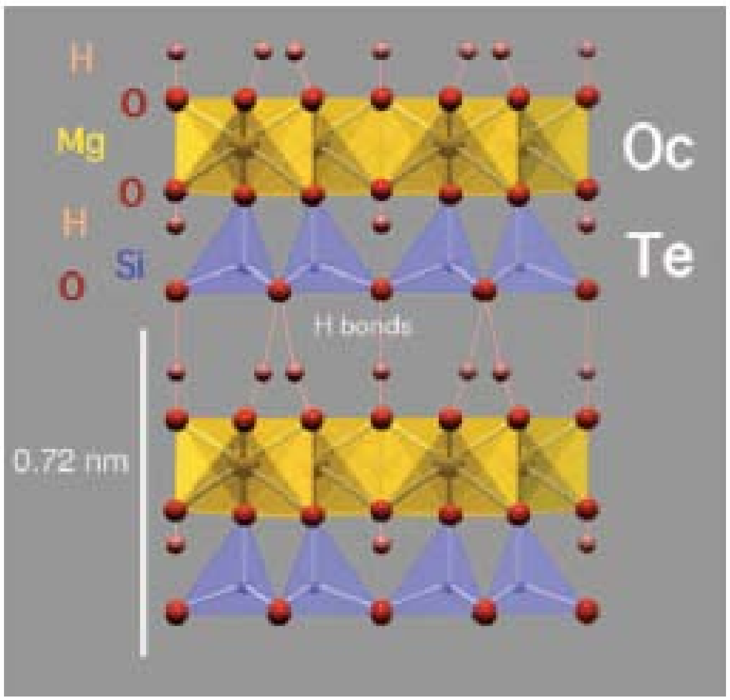


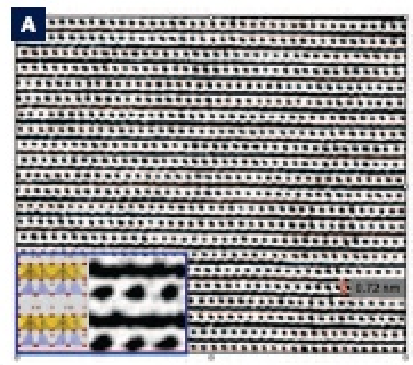


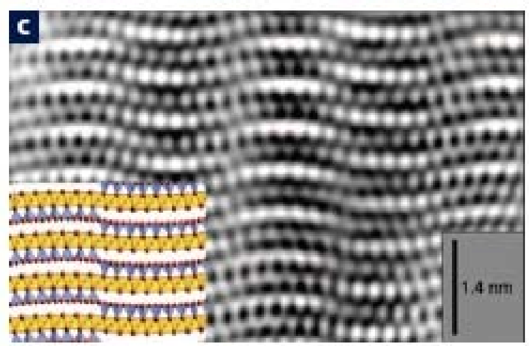
Serpentinite: What, Why, Where?

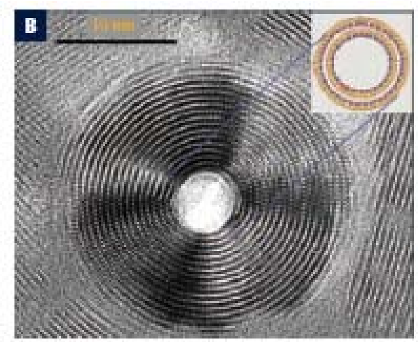
Bernard W. Evans[1], Keiko Hattori[2], and Alain Baronnet[3]

1811-5209/13/0009-99$2.50 DOI: 10.2113/gselements.9.2.99









Available online at www.sciencedirect.com

SCIENCE DIRECT

Earth and Planetary Science Letters 223 (2004) 17–34

EPSL

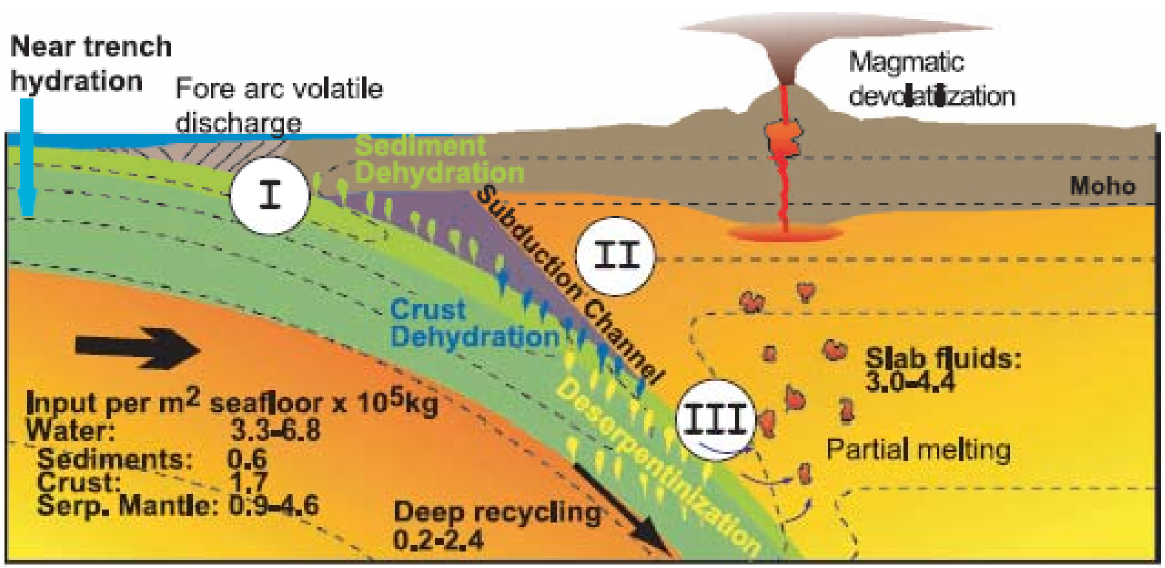
www.elsevier.com/locate/epsl

Serpentine and the subduction zone water cycle

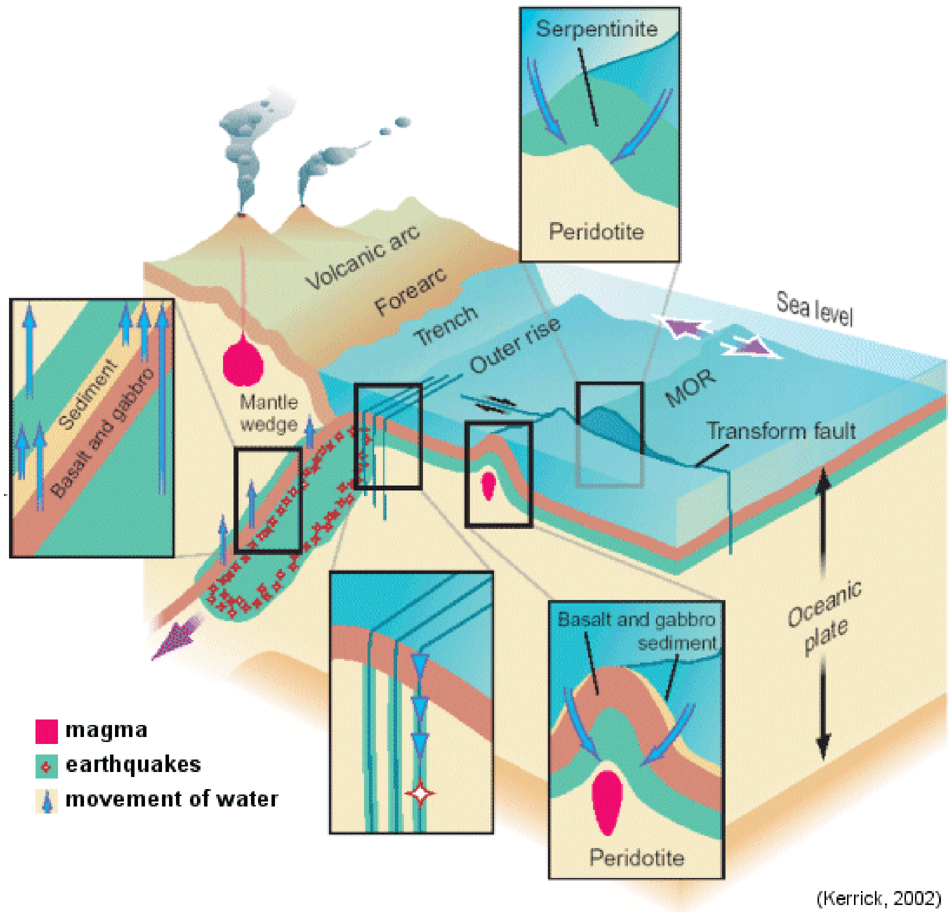
Lars H. Rüpke[a,b,*], Jason Phipps Morgan[a,b], Matthias Hort[b,c], James A.D. Connolly[d]

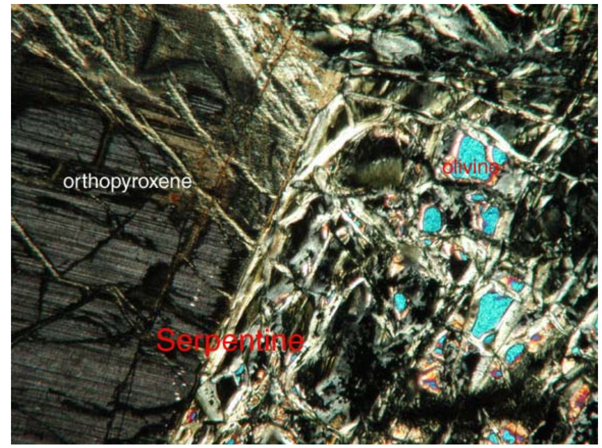
[a] IFM-GEOMAR, Dynamics of the Ocean Floor, Wischhofstr. 1-3, 24148 Kiel, Germany
[b] SFB 574, Christian-Albrechts-Universität, Kiel, Germany
[c] Institut für Geophysik, Universität Hamburg, Bundesstr. 55, D-20146 Hamburg, Germany
[d] Institut für Mineralogie und Petrographie, ETH-Zentrum, Sonneggstr. 5, CH-8082, Zürich, Switzerland

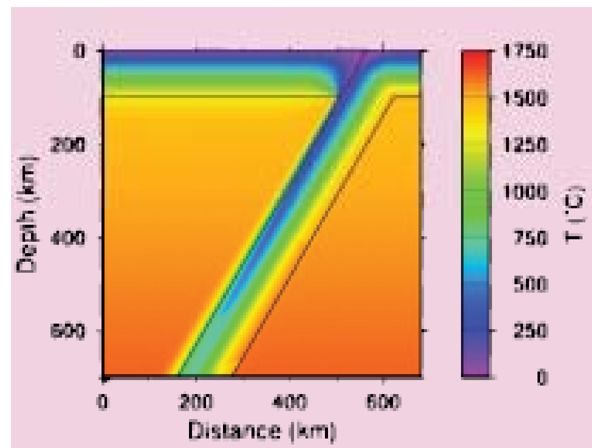
Received 24 September 2003; received in revised form 7 April 2004; accepted 13 April 2004



Ενυδάτωση και αφυδάτωση ένυδρων πυριτικών ορυκτών σε ζώνες υποβύθισης λιθοσφαιρικών πλακών (μηχανισμός δημιουργίας **ΣΕΙΣΜΩΝ**)







http://records.viu.ca/~earles/dehydration-earthquakes-nov02.htm

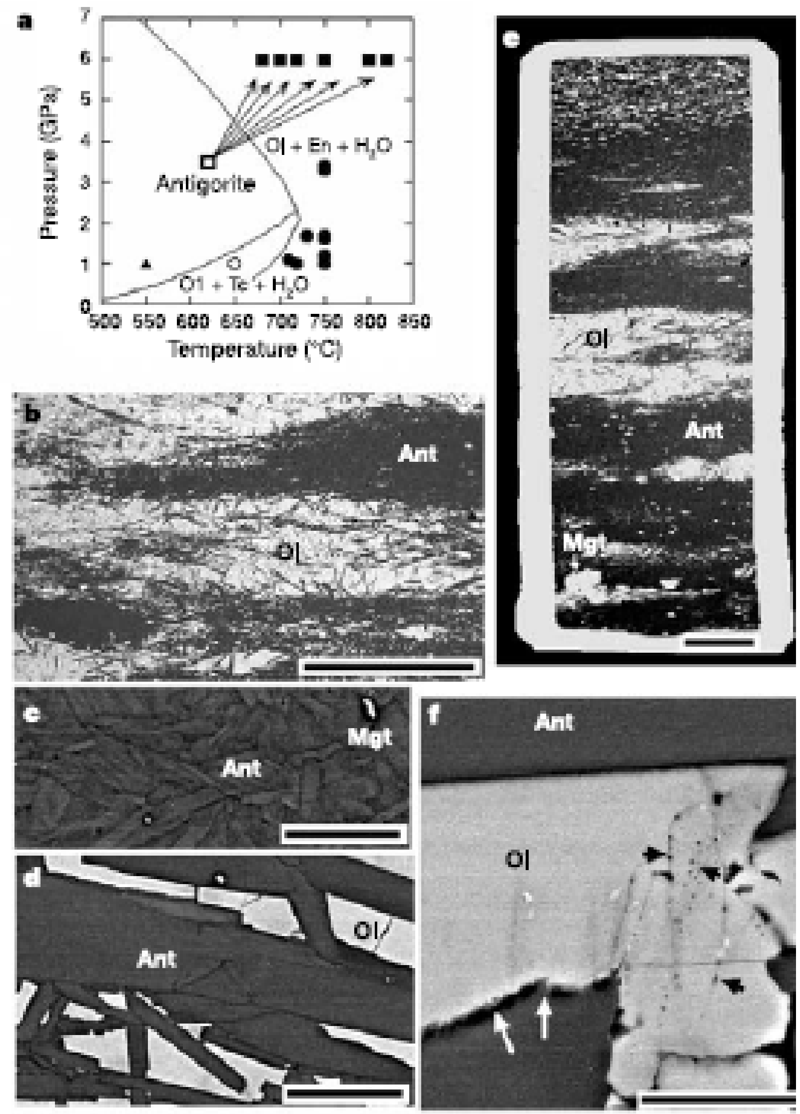
Intermediate-depth earthquake faulting by dehydration embrittlement with negative volume change

Haemyeong Jung[1], Harry W. Green II[1,2] & Larissa F. Dobrzhinetskaya[2]

[1]*Institute of Geophysics and Planetary Physics,* [2]*Department of Earth Sciences, University of California, Riverside, California 92521, USA*

Earthquakes are observed to occur in subduction zones to depths of approximately 680 km, even though unassisted brittle failure is inhibited at depths greater than about 50 km, owing to the high pressures and temperatures[1–3]. It is thought that such earthquakes (particularly those at intermediate depths of 50–300 km)

NATURE | VOL 428 | 1 APRIL 2004 | www.nature.com/nature



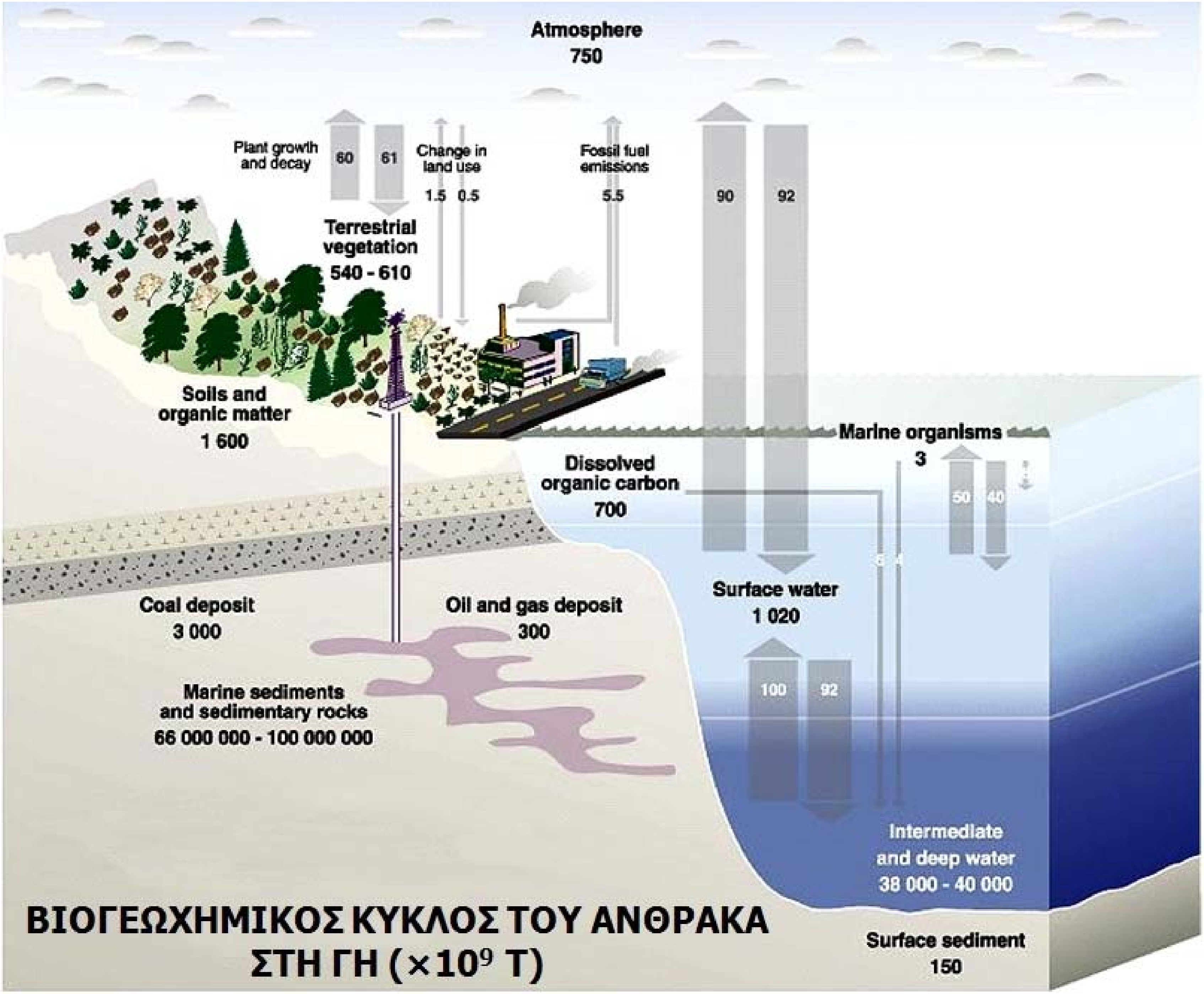
ΑΡΗΣ (MARS)
Αραιή ατμόσφαιρα
(CO_2 στο έδαφος)
Μέση θερμοκρασία: **-50 °C**

ΓΗ (EARTH)
0.03% του CO_2 στήν ατμόσφαιρα
Μέση θερμοκρασία: **+15 °C**

ΑΦΡΟΔΙΤΗ (VENUS)
Πυκνή ατμόσφαιρα με
96% CO_2
Μέση θερμοκρασία: **+420 °C**

2006: 381 ppmv (μL/L)

.... 1750: 280 ppmv (μL/L)



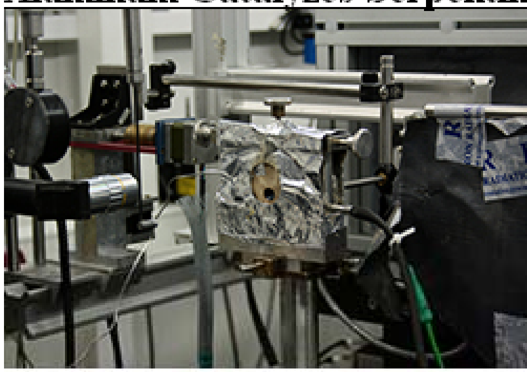
ΒΙΟΓΕΩΧΗΜΙΚΟΣ ΚΥΚΛΟΣ ΤΟΥ ΑΝΘΡΑΚΑ ΣΤΗ ΓΗ ($\times 10^9$ Τ)

deepcarbon.net/#main-content-area

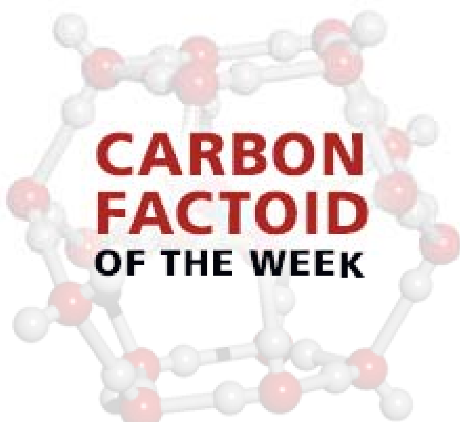
Skip to Main Content Area

DEEP CARBON OBSERVATORY

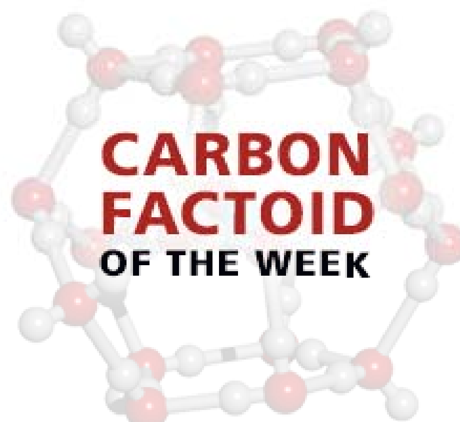
Aluminum Catalyzes Serpentinization that Fuels Deep Life



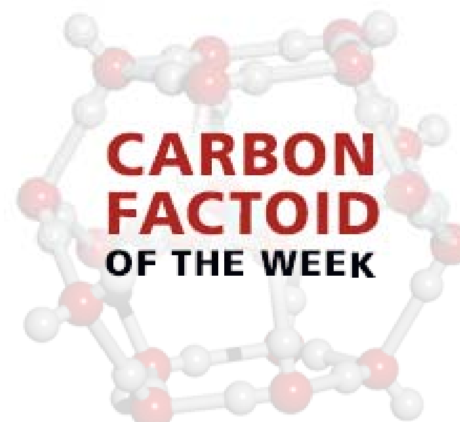
Geologic hydrogen production has long been thought to fuel deep ecosystems. Hydrogen-pro
temperatures and pressures, however,...



The word graphite comes from the Greek graphein, meaning “to write”.
More facts...



The International Mineralogy Association recognizes more than 380 carbon-bearing minerals. One of those is diamond.
More facts...



Fact: carbon is the fourth most abundant element in the universe by mass, after hydrogen, helium, and oxygen.
More facts...

REVIEWS in
MINERALOGY &
GEOCHEMISTRY
Volume 75

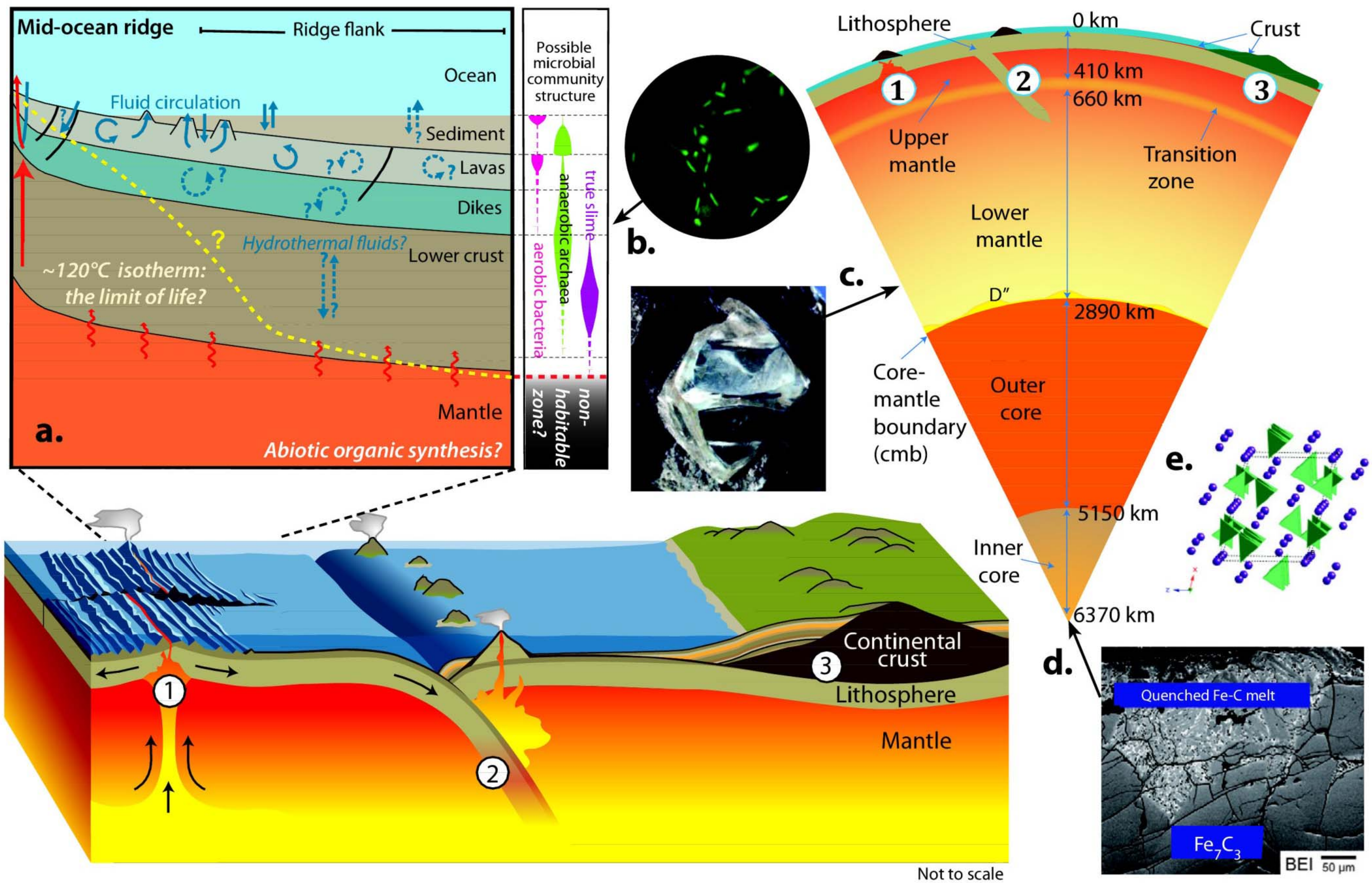
CARBON IN EARTH

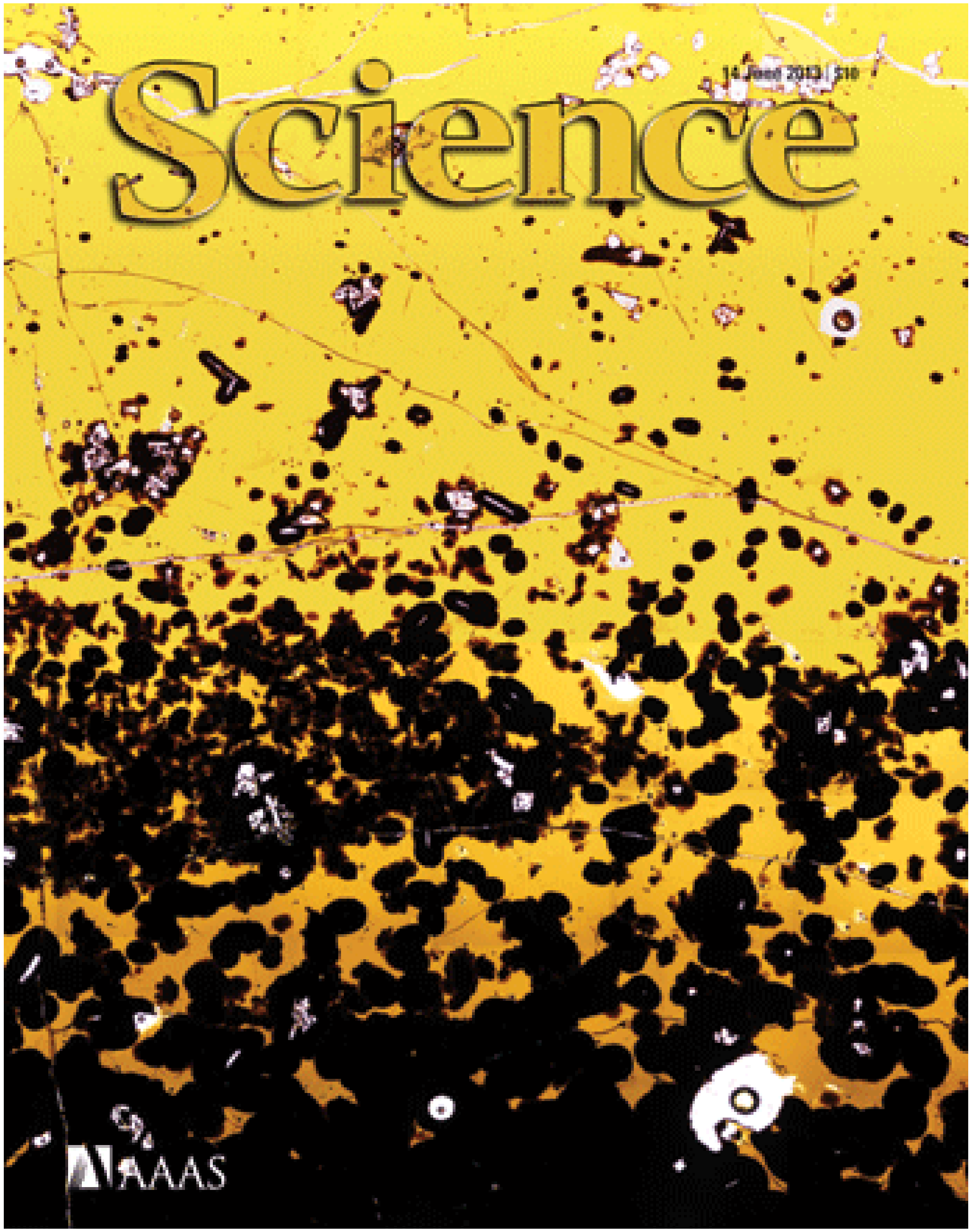
EDITORS: Robert M. Hazen, Adrian P. Jones,
and John A. Baross

MINERALOGICAL SOCIETY OF AMERICA
GEOCHEMICAL SOCIETY
Series Editor: Jodi J. Rosso

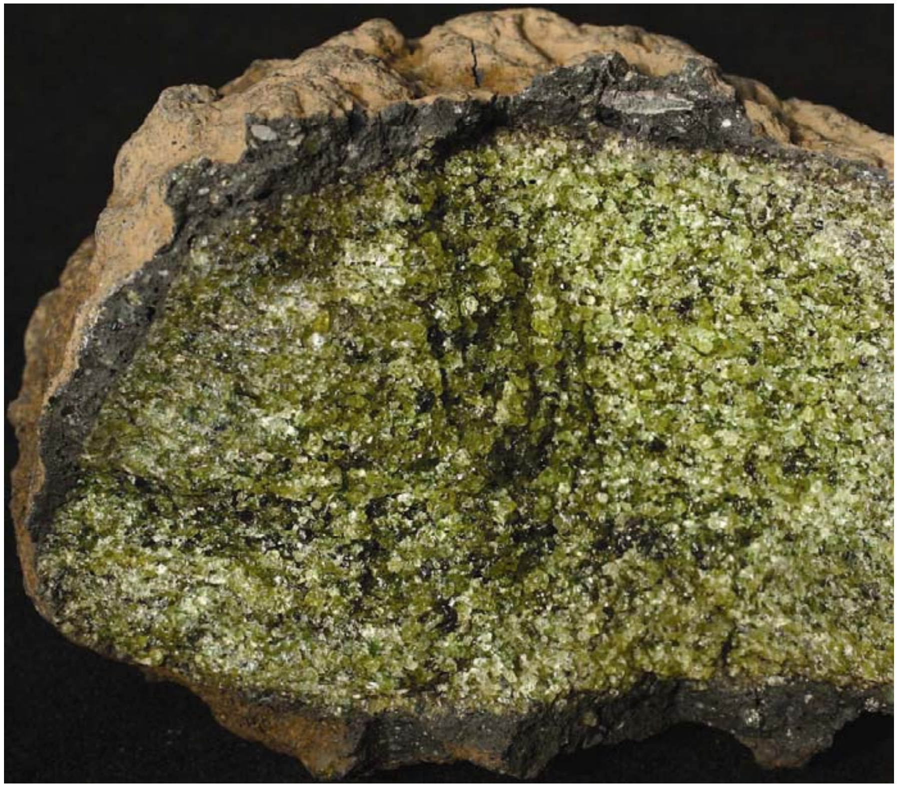
2013 ISSN 1529-6466

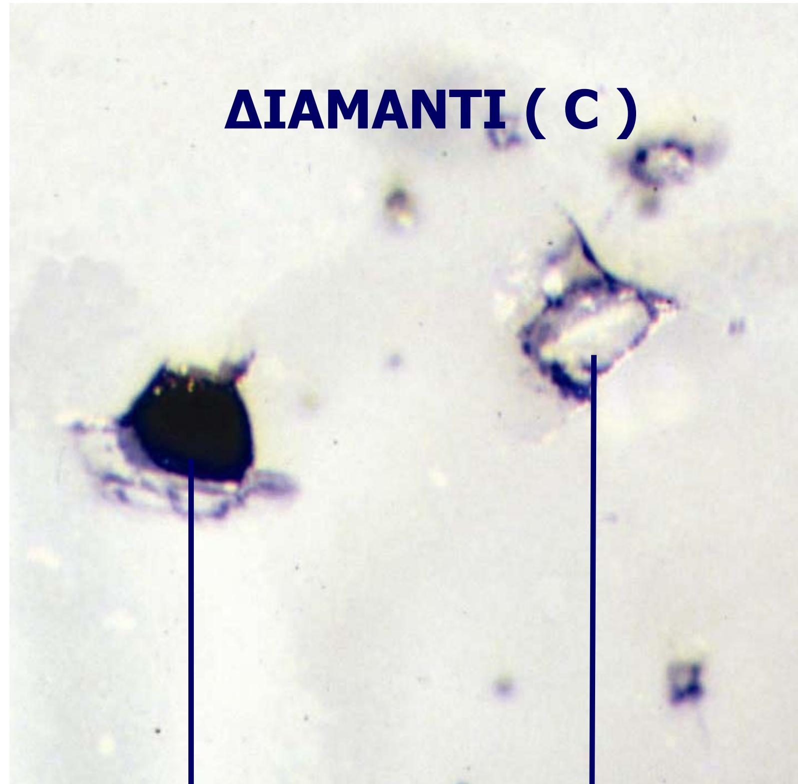
Ο άνθρακας στο εσωτερικό της Γής

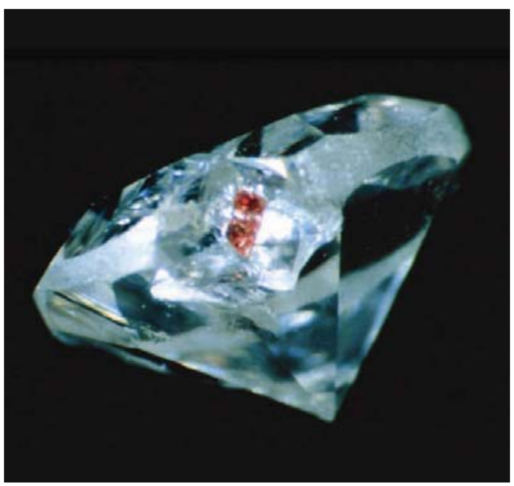




Polished thin section (70 micrometers) of volcanic glass, sample catalog number NMNH115296-3, in transmitted light (14 by 18 millimeters). Molten lava erupted onto the sea floor freezes to glass and minerals that contain clues to the lava's ancient past and origin in Earth's deep interior. Volcanic glasses such as this one may reveal a link between Earth's oxidation state and the **deep carbon cycle**. See http://www.sciencemag.org/content/340/6138/1314.short . Image: G. Macpherson, T. Gooding, and E. Cottrell







Fe-ΠΕΡΙΚΛΑΣΤΟ
(Mg,Fe)O

Πυρόξενος
από μετασχηματισμό
ΠΕΡΟΒΣΚΙΤΗ
($MgSiO_3$)

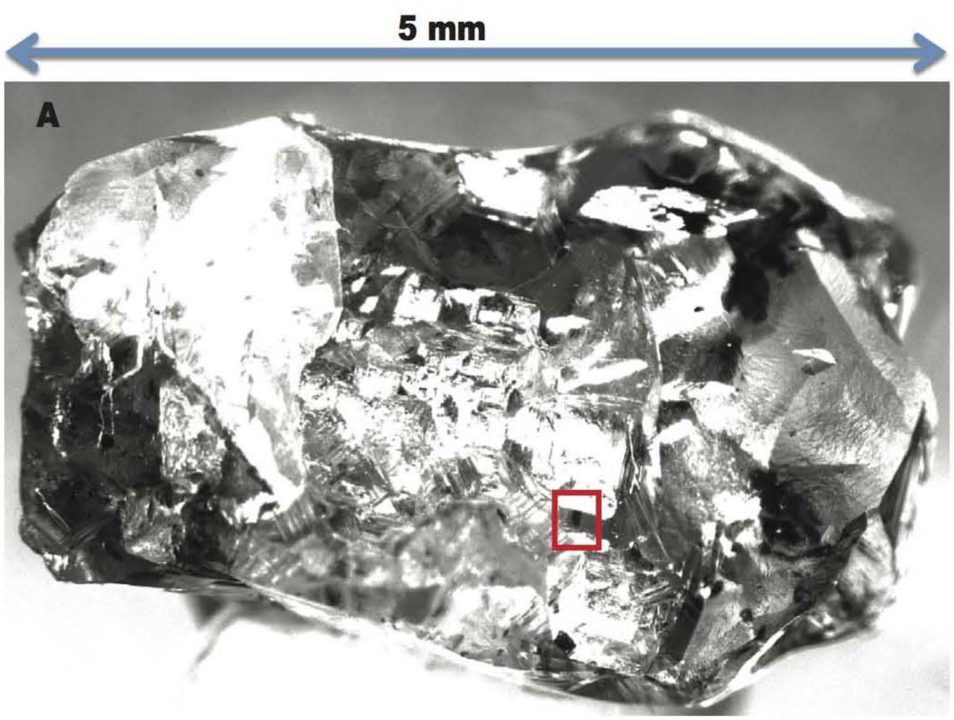
LETTER

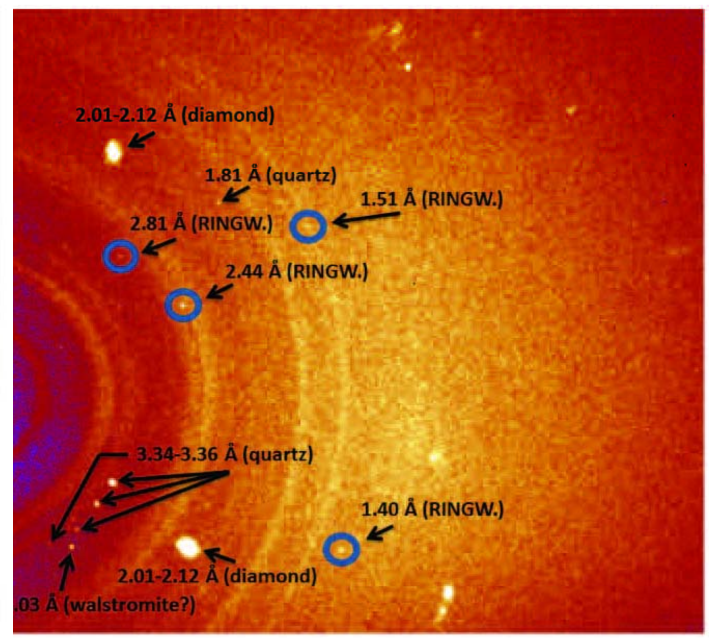
13 MARCH 2014 | VOL 507 | NATURE | 221

doi:10.1038/nature13080

Hydrous mantle transition zone indicated by ringwoodite included within diamond

D. G. Pearson[1], F. E. Brenker[2], F. Nestola[3], J. McNeill[4], L. Nasdala[5], M. T. Hutchison[6], S. Matveev[1], K. Mather[4], G. Silversmit[7], S. Schmitz[2], B. Vekemans[7] & L. Vincze[7]





PNAS

Carbon substitution for oxygen in silicates in planetary interiors

Sabyasachi Sen[a], Scarlett J. Widgeon[a,b], Alexandra Navrotsky[a,b,1], Gabriela Mera[c], Amir Tavakoli[b], Emanuel Ionescu[c], and Ralf Riedel[c]

[a]Department of Chemical Engineering and Materials Science and [b]Peter A. Rock Thermochemistry Laboratory and Nanomaterials in the Environment, Agriculture, and Technology Organized Research Unit, University of California, Davis, CA 95616; and [c]Institut für Materialwissenschaft, Technische Universität Darmstadt, D-64287 Darmstadt, Germany

Contributed by Alexandra Navrotsky, August 22, 2013 (sent for review May 4, 2013)

Significance

Carbon is an important element in the Earth and other planets, but its concentration, chemical and structural form, and dynamics throughout the crust, mantle, and core are incompletely known. Based on the thermodynamic stability of a class of synthetic materials, the polymer-derived ceramics containing Si, C, and O, and on new NMR data for such systems containing a network-modifying metal (Li), this paper suggests that the substitution of C for O (rather than C for Si) in molten, amorphous, and crystalline silicate structures may provide a hitherto hidden reservoir of carbon in planetary interiors.

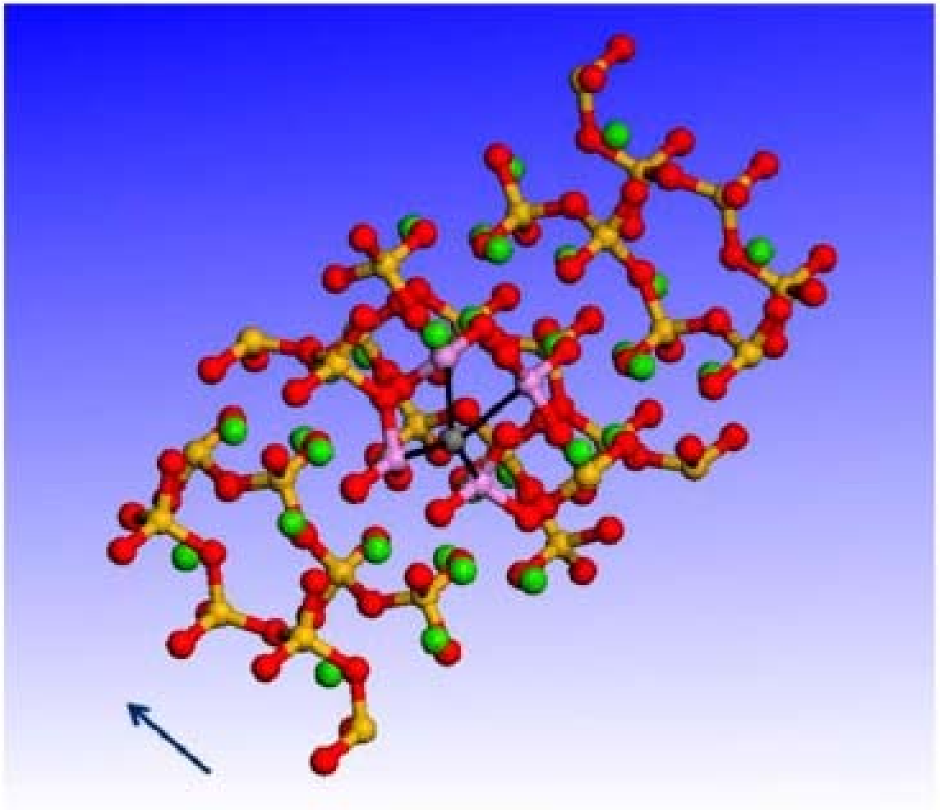


Fig. 4. Schematic representation of a "defect" created by the replacement of oxygen by carbon in the lattice of an ortho-enstatite ($MgSiO_3$) structure. The Si, O, Mg, and C atoms are shown in yellow, red, green, and dark gray, respectively. The chains of Q^2 SiO_4 tetrahedra in the structure are oriented along the crystallographic *c* axis indicated by the arrow. Two BO atoms connecting two pairs of SiO_4 tetrahedra in the neighboring chains have been substituted by the carbon atom that now bonds to four Si atoms (shown in pink) and cross-links the two chains. This substitution results in the formation of four SiO_3C tetrahedra, as shown. Although not shown here, the structure near the defect is expected to relax in response to this substitution.

nature COMMUNICATIONS

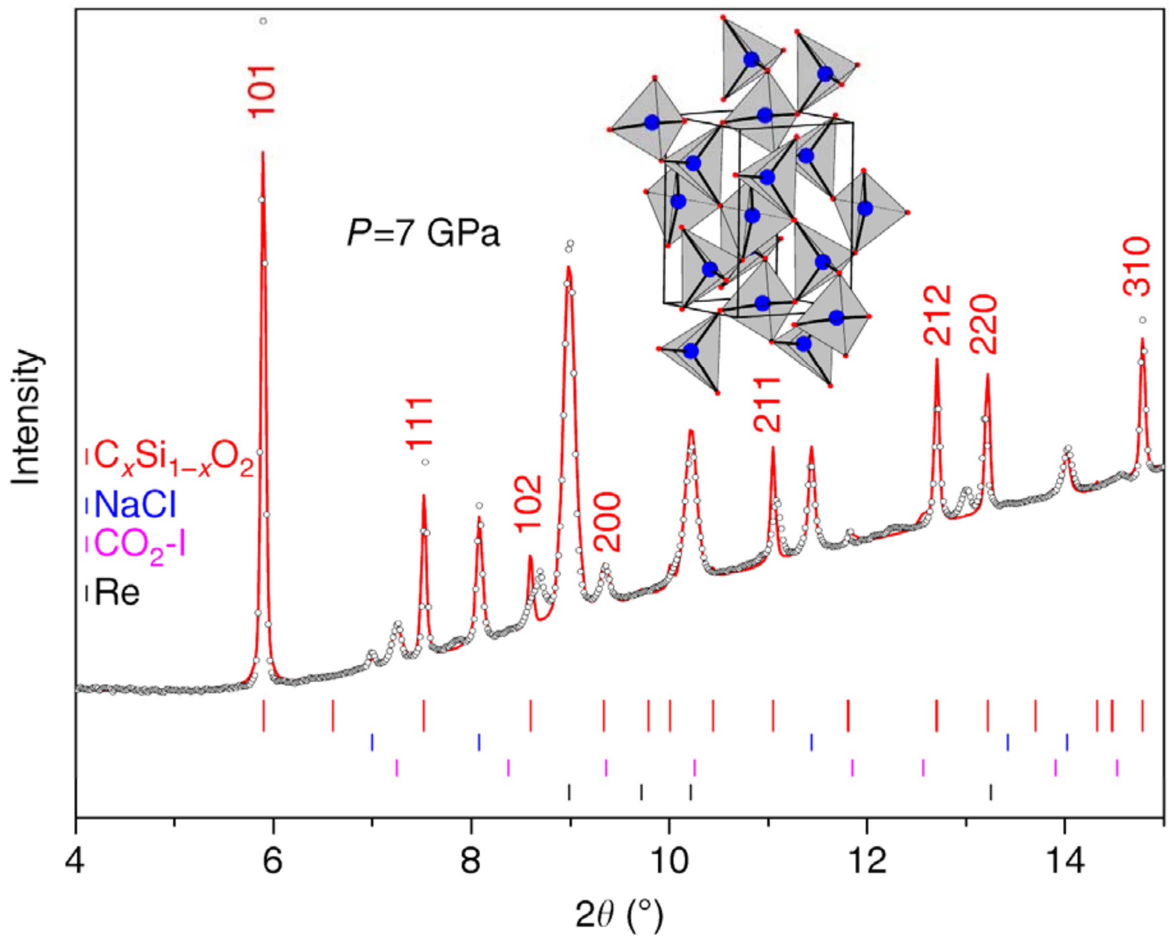
ARTICLE

Received 20 Dec 2013 | Accepted 31 Mar 2014 | Published 30 Apr 2014

DOI: 10.1038/ncomms4761

Carbon enters silica forming a cristobalite-type CO_2–SiO_2 solid solution

Mario Santoro[1,2], Federico A. Gorelli[1,2], Roberto Bini[2,3], Ashkan Salamat[4], Gaston Garbarino[4], Claire Levelut[5], Olivier Cambon[6] & Julien Haines[6]



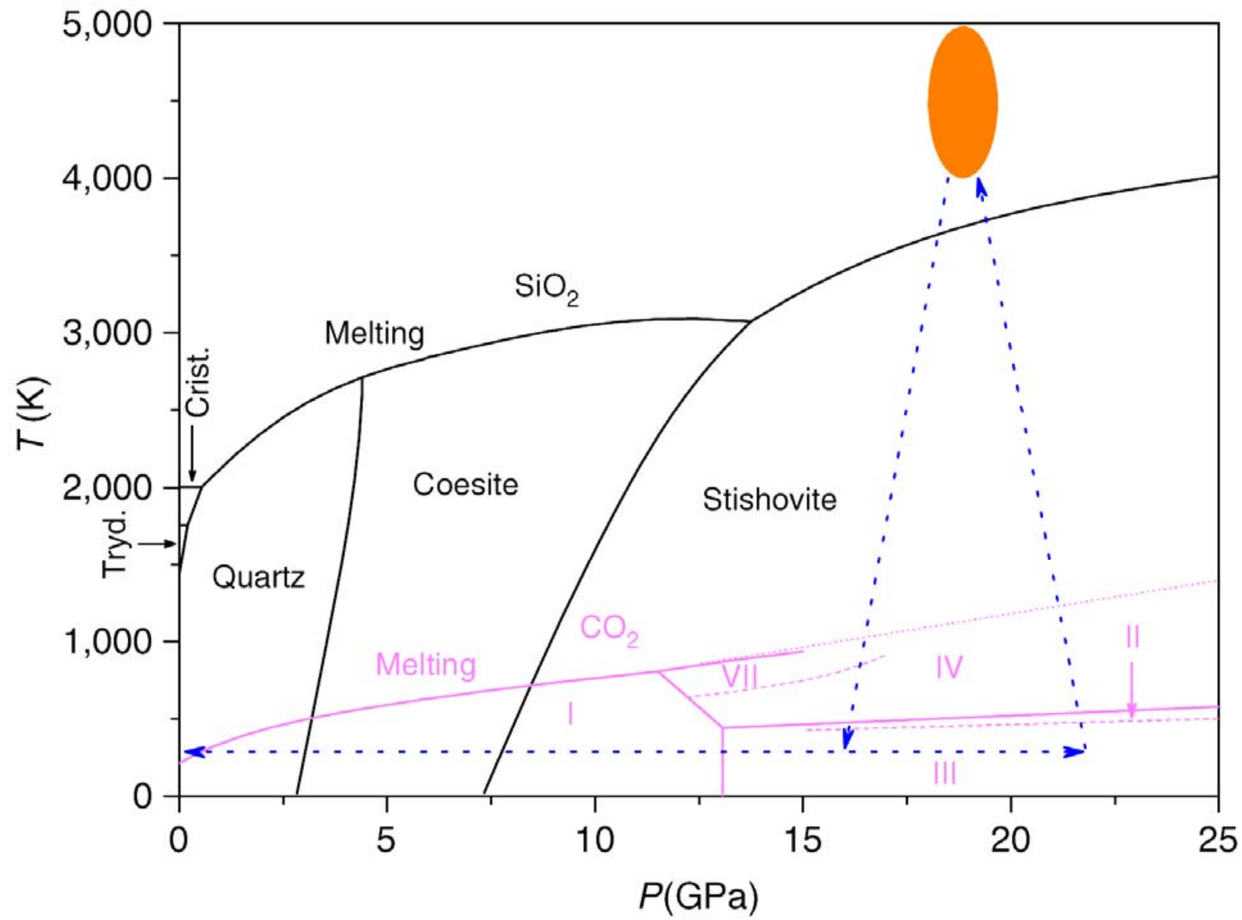


Figure 1 | Pure SiO_2 and CO_2 phase diagrams and P-T path. Black lines: SiO_2 phase boundaries[17]. Light magenta, continuous and dotted lines: CO_2 phase boundaries; light magenta, dashed lines: kinetic boundaries for CO_2[11,18–20]. Blue dashed arrows and orange ellipse: P-T path followed in this study. All five solid phases of CO_2 shown are molecular crystals. Non-molecular CO_2 phases are formed above 25–30 GPa. Crist, cristobalite; Tryd, trydimite.

DEEP CARBON OBSERVATORY

Mantle Carbon Content Influences Plate Tectonics

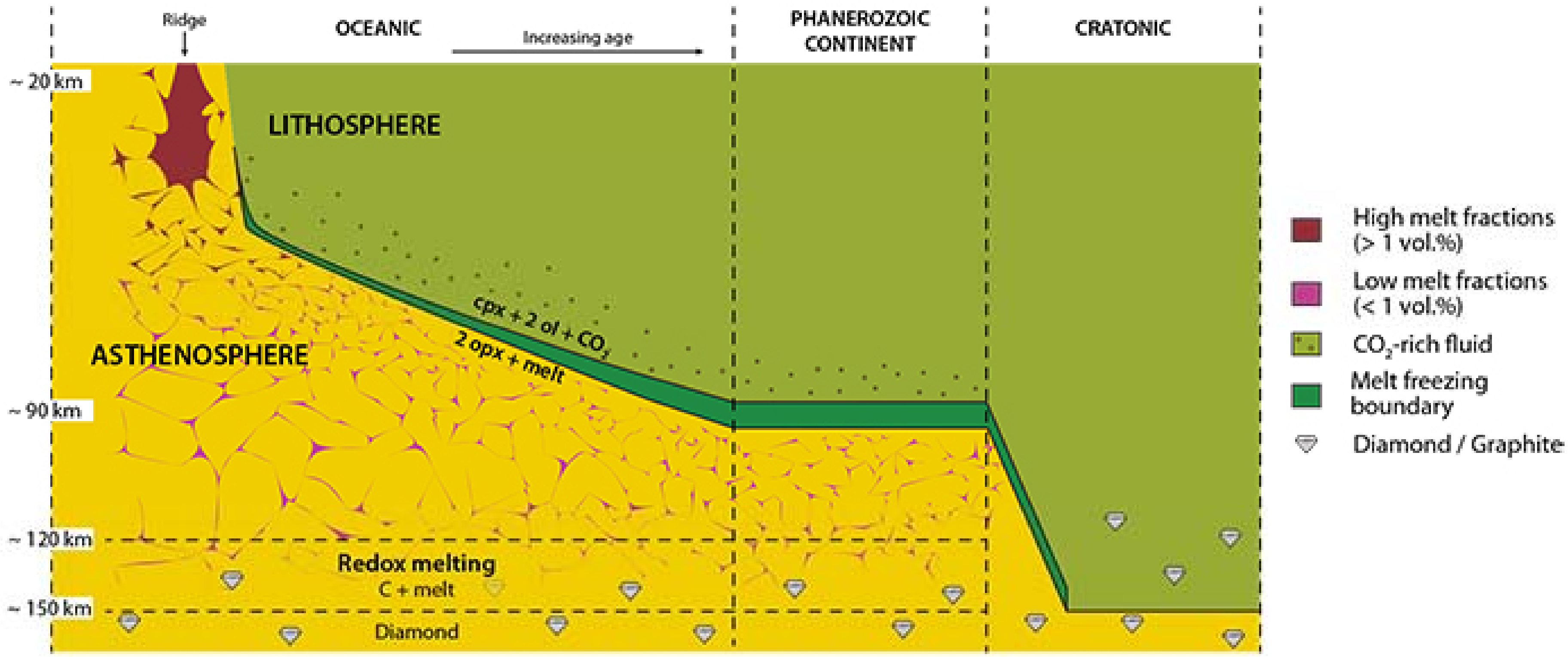


Image credit: Sifré D. (CNRS Orléans, France)

nature geoscience

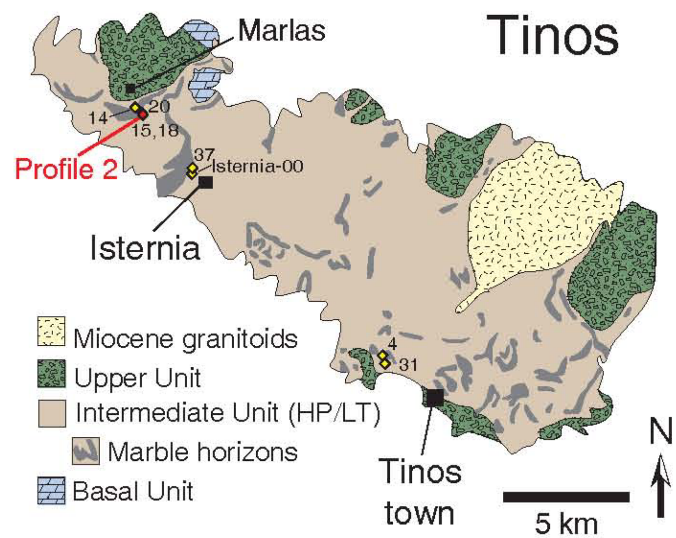
NATURE GEOSCIENCE | LETTER

Carbon dioxide released from subduction zones by fluid-mediated reactions

Jay J. Ague & Stefan Nicolescu

Affiliations | Contributions | Corresponding author

Nature Geoscience **7**, 355–360 (2014) | doi:10.1038/ngeo2143
Received 19 September 2013 | Accepted 17 March 2014 | Published online 20 April 2014



Κρύσταλλοι επιδότου στα πετρώματα της Τήνου
Crystals of epidote from a quartz vein on Tinos island, Greece

ΟΡΥΚΤΑ
ΚΑΙ ΚΑΤΑΓΩΓΗ ΤΗΣ ΖΩΗΣ

MINERALS
AND ORIGIN OF LIFE

letters to nature

Nature **381**, 59 - 61 (02 May 1996); doi:10.1038/381059a0

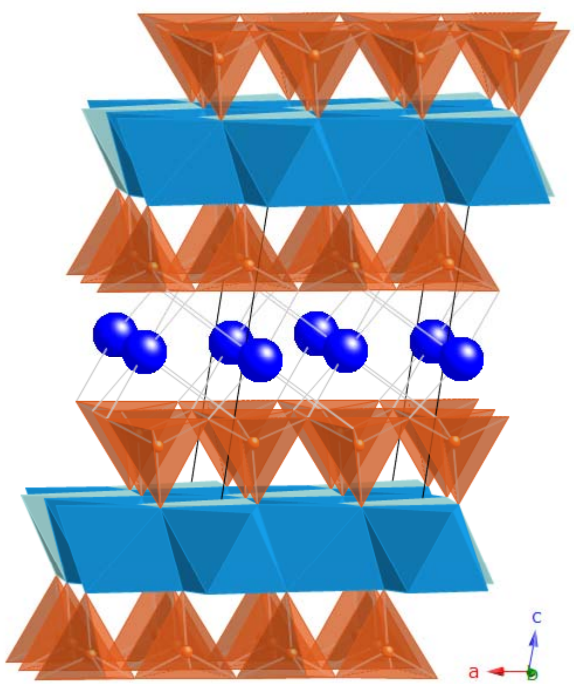
Synthesis of long prebiotic oligomers on mineral surfaces

JAMES P. FERRIS[*], AUBREY R. HILL JR, RIHE LIU[†] & LESLIE E. ORGEL[†]

[*] Department of Chemistry, Rensselaer Polytechnic Institute, Troy, New York 12180, USA

[†] The Salk Institute for Biological Studies, PO Box 85800, San Diego, California 92186, USA

MOST theories of the origin of biological organization assume that polymers with lengths in the range of 30–60 monomers are needed to make a genetic system viable[1]. But it has not proved possible to synthesize plausibly prebiotic polymers this long by condensation in aqueous solution, because hydrolysis competes with polymerization. The potential of mineral surfaces to facilitate prebiotic polymerization was pointed out long ago[2]. Here we describe a system that models prebiotic polymerization by the oligomerization of activated monomers—both nucleotides and amino acids. We find that whereas the reactions in solution produce only short oligomers (the longest typically being a 10-mer), the presence of mineral surfaces (montmorillonite for nucleotides, illite and hydroxylapatite for amino acids) induces the formation of oligomers up to 55 monomers long. These are formed by successive 'feedings' with the monomers; polymerization takes place on the mineral surfaces in a manner akin to solid-phase synthesis of biopolymers[3,4].



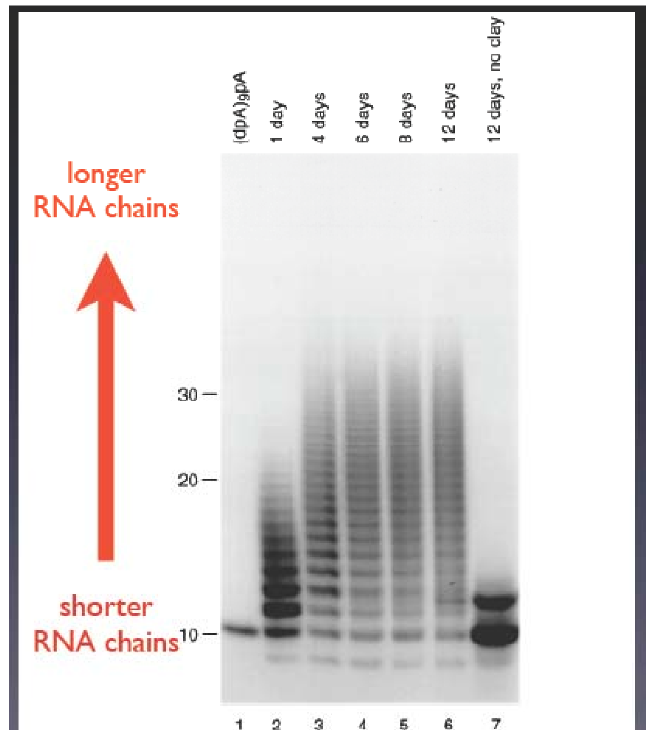


Figure 2. Gel electrophoresis of the elongation of ^{32}pdA(pdA)$_8$pA with ImpA in microcentrifuge tubes. Lane 1, ^{32}pdA(pdA)$_8$pA; lanes 2-6 elongation in the presence of montmorillonite; lane 7, elongation in the absence of montmorillonite.

Proc. Natl. Acad. Sci. USA
Vol. 95, pp. 3370–3375, March 1998
Geology

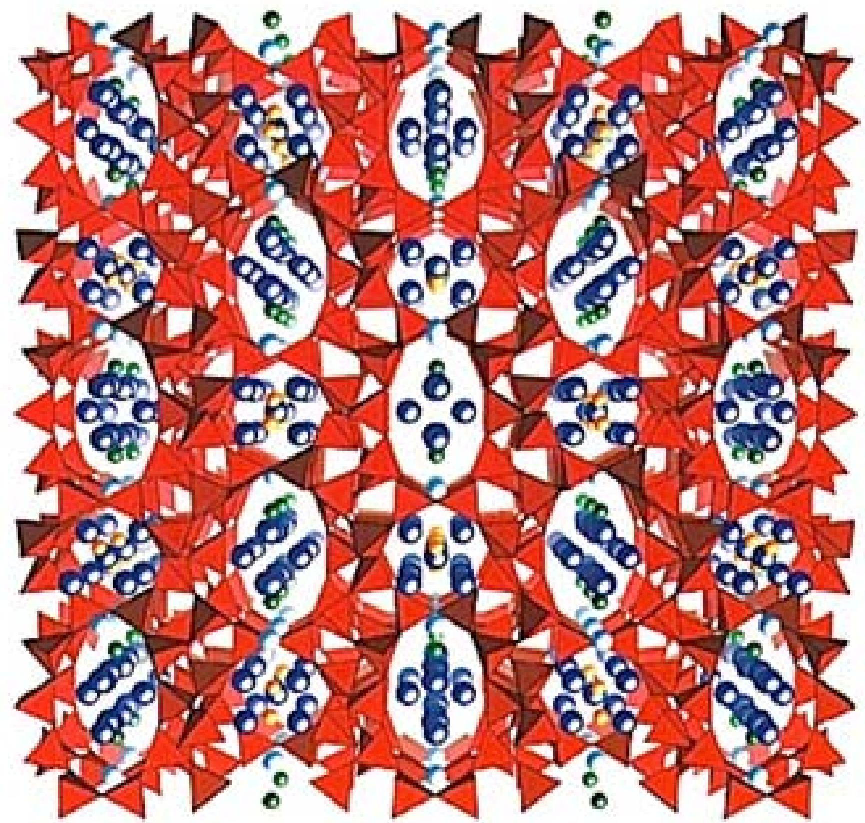
Biochemical evolution. I. Polymerization on internal, organophilic silica surfaces of dealuminated zeolites and feldspars

(biological evolution volcanic emissions)

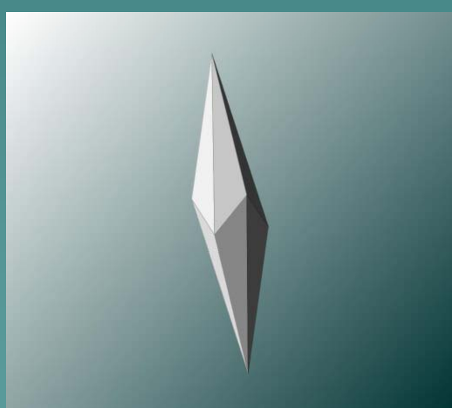
JOSEPH V. SMITH*

Department of Geophysical Sciences and Center for Advanced Radiation Sources, 5734 S. Ellis Avenue, University of Chicago, Chicago, IL 60637 and UOP Research Center, Des Plaines, IL 60017-5016

Contributed by Joseph V. Smith, December 29, 1997

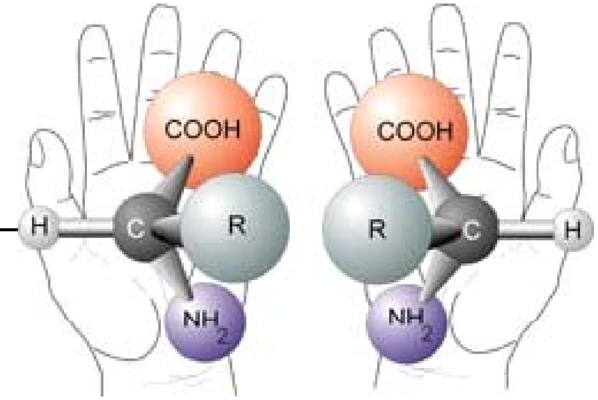


Χαλαζίας (Quartz) :
SiO_2



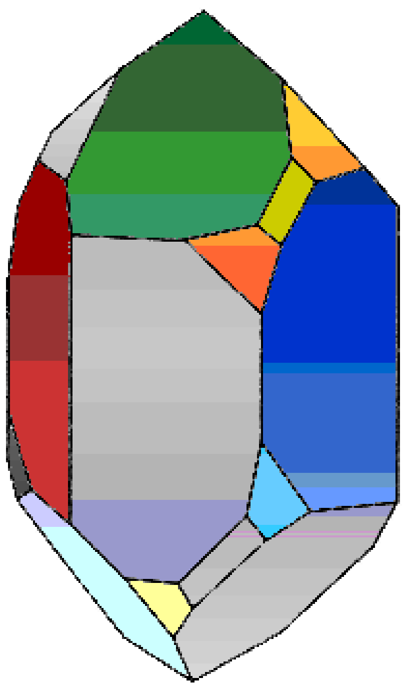
Ασβεστίτης (Calcite) :
$CaCO_3$

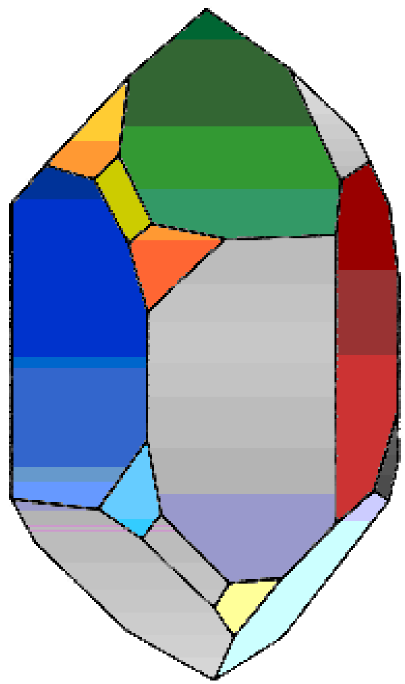
Εναντιομορφισμός (Enantiomorphism)
Χειρομορφία (Chirality)

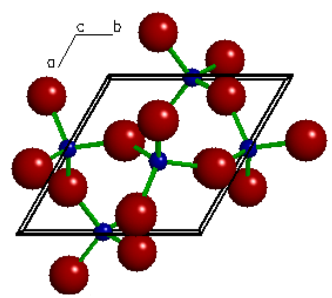


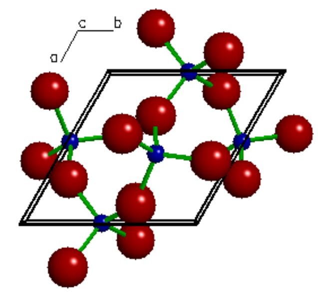
D- και L-Μορφές

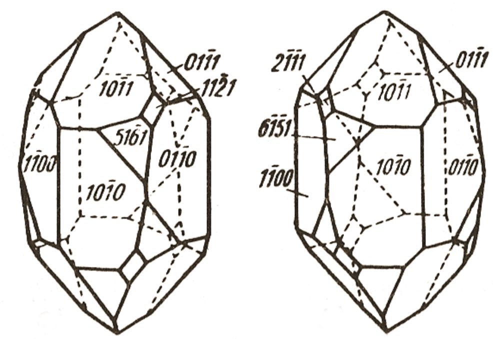
Εναντιόμορφοι κρύσταλλοι







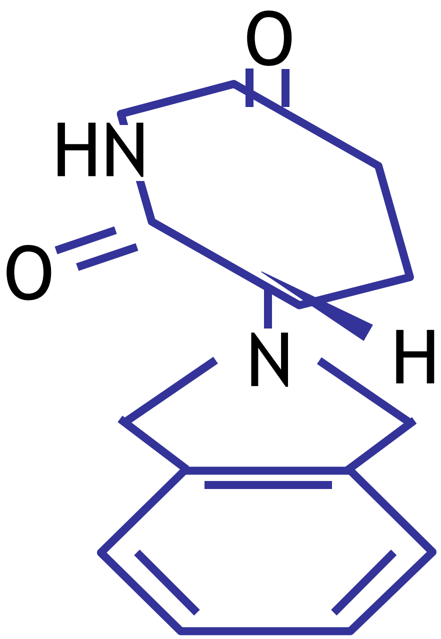




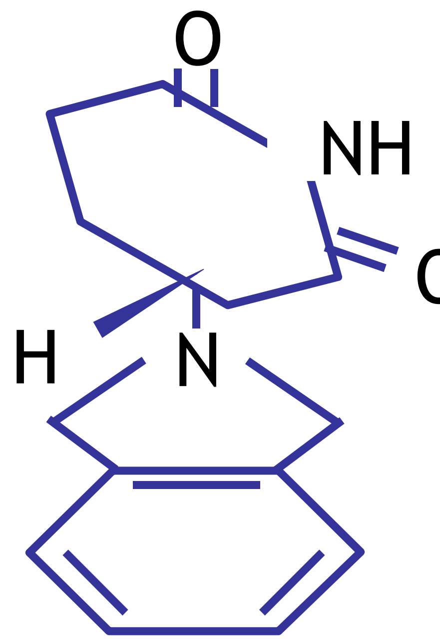
Απουσία επιπέδων συμμετρίας (P) και κέντρου συμμετρίας (C)

ΧΕΙΡΟΜΟΡΦΙΑ - ΕΝΑΝΤΙΟΜΟΡΦΙΣΜΟΣ

ΘΑΛΙΔΟΜΙΔΗ



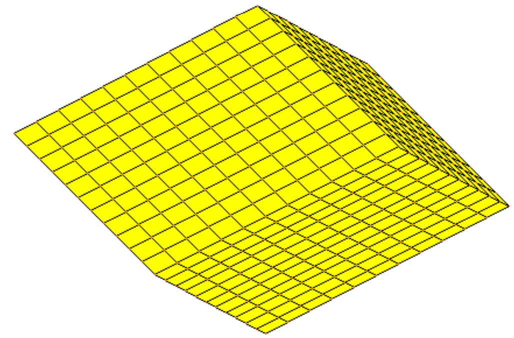
Αναλγητικό



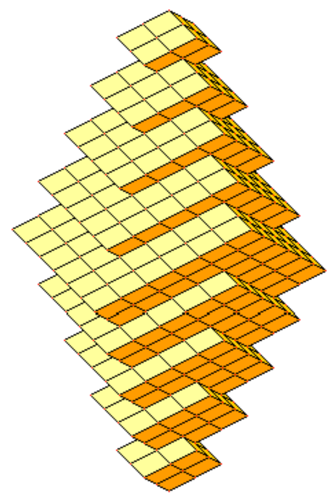
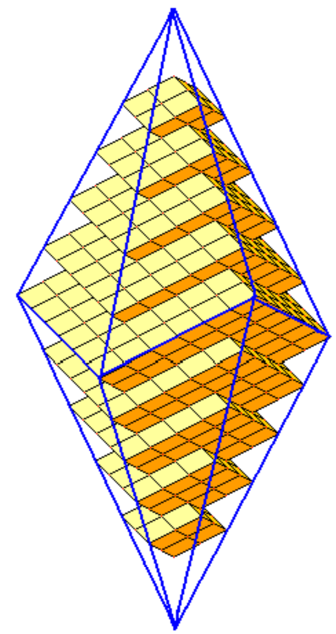
Τερατογόνα ουσία

1958

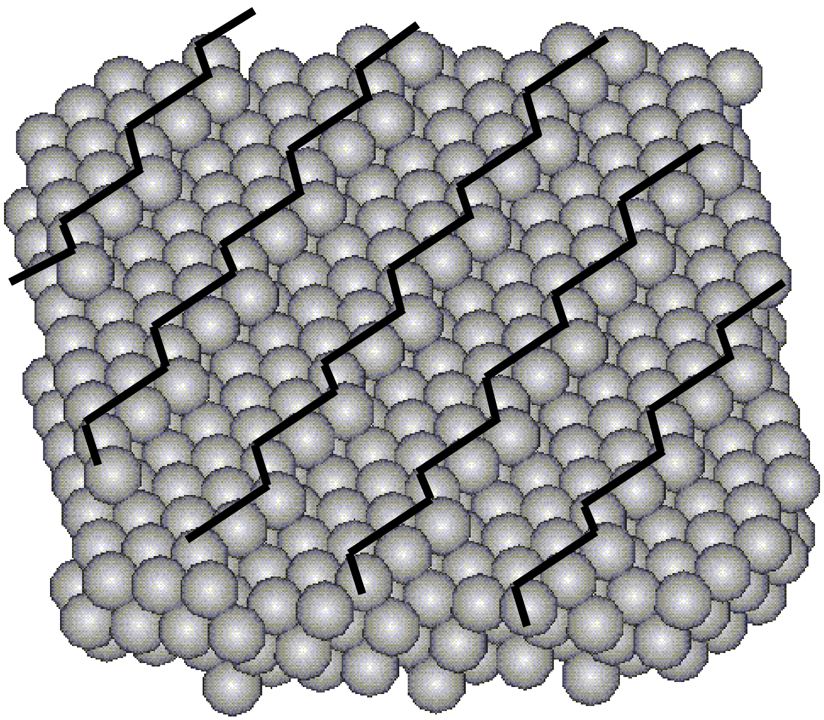


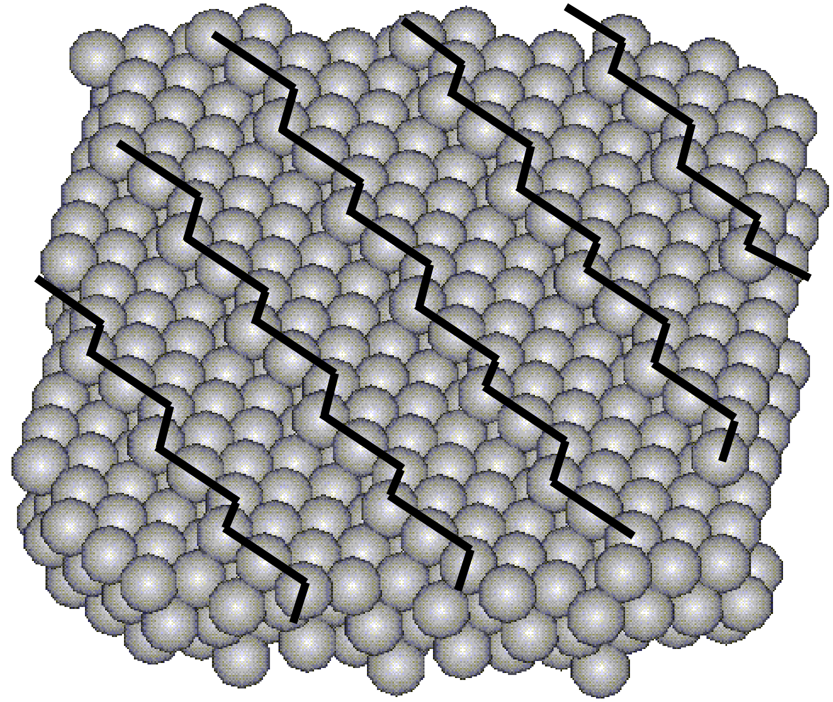


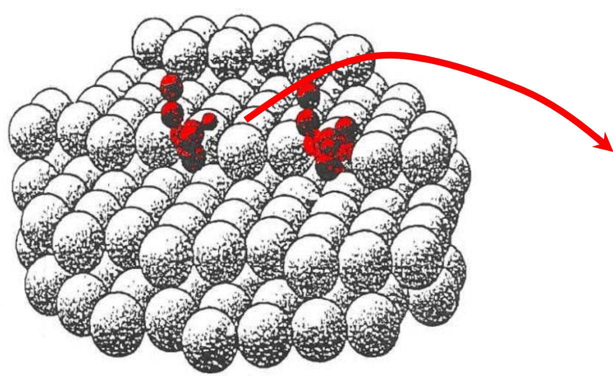

ΑΣΒΕΣΤΙΤΗΣ: $CaCO_3$

ΕΝΑΝΤΙΟΜΟΡΦΕΣ ΕΠΙΦΑΝΕΙΕΣ / ΕΔΡΕΣ

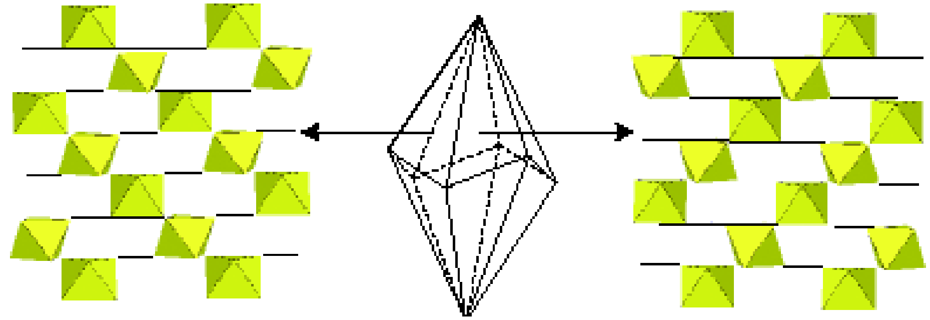


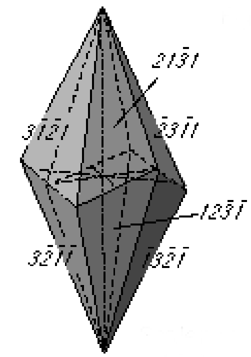


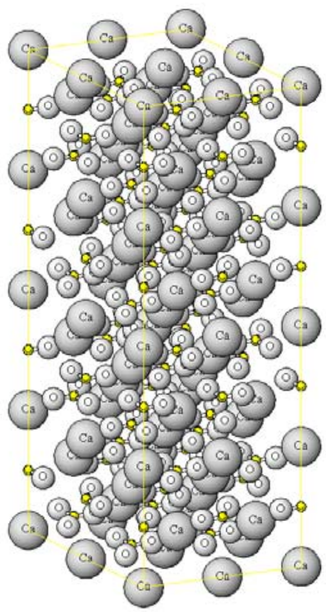


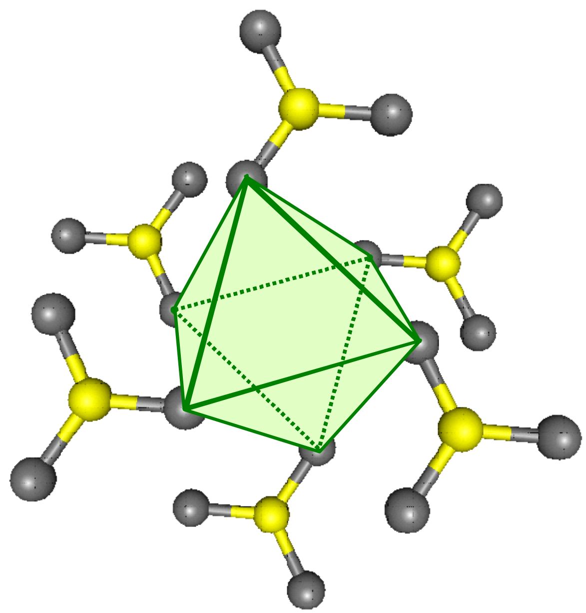
Αντίδραση Εναντιόμορφων Εδρών
με ανάλογα Εναντιόμορφα Μόρια

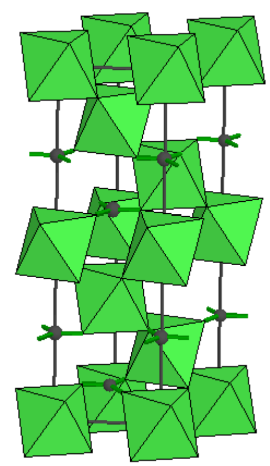
Εναντιόμορφες έδρες-Εναντιόμορφες επιφανειακές δομές





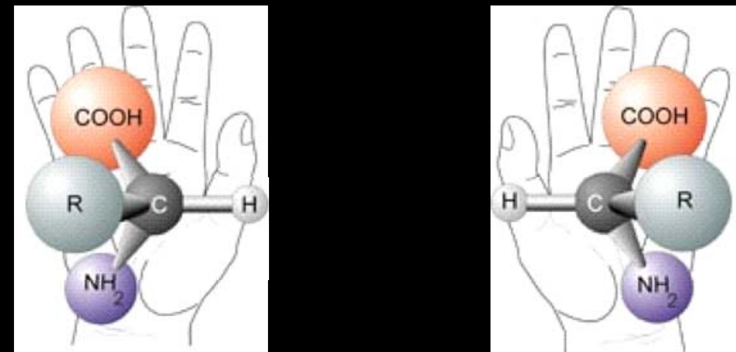






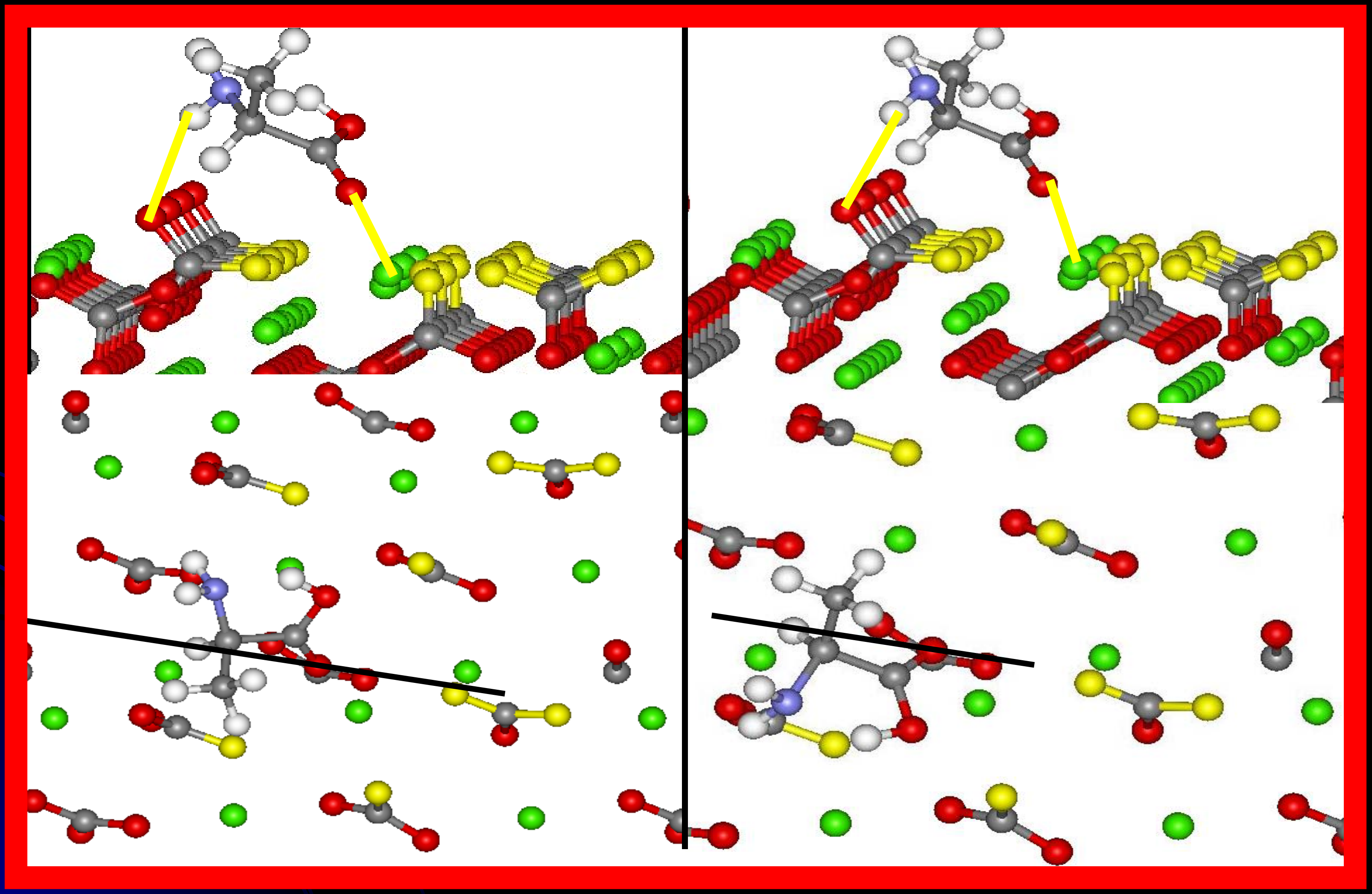
Dr. Robert M. Hazen

CARNEGIE INSTITUTION FOR SCIENCE

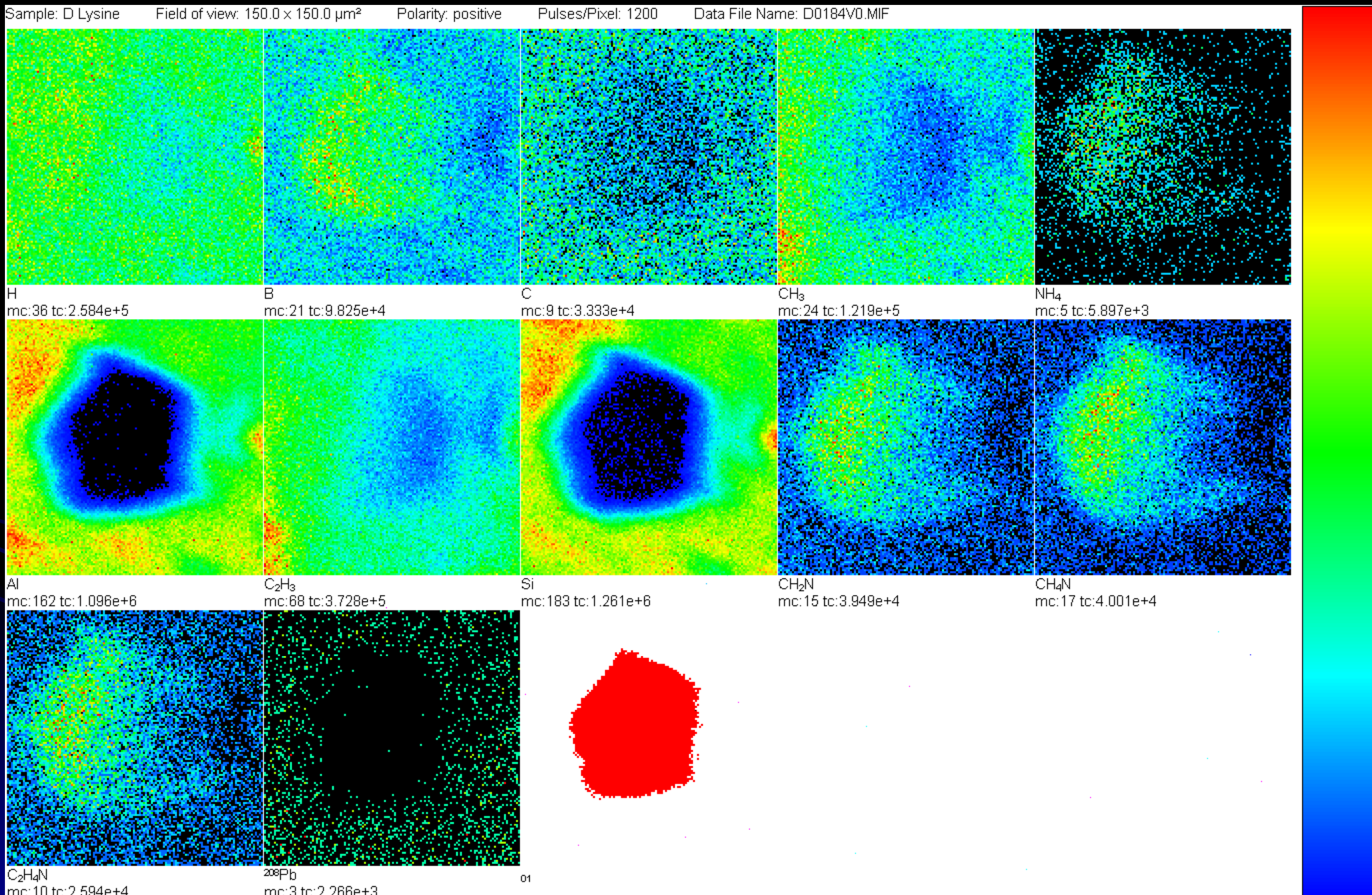


Alanine-Calcite (214) Interactions

D-alanine **L-alanine**



D-Lysine on Feldspar (010)

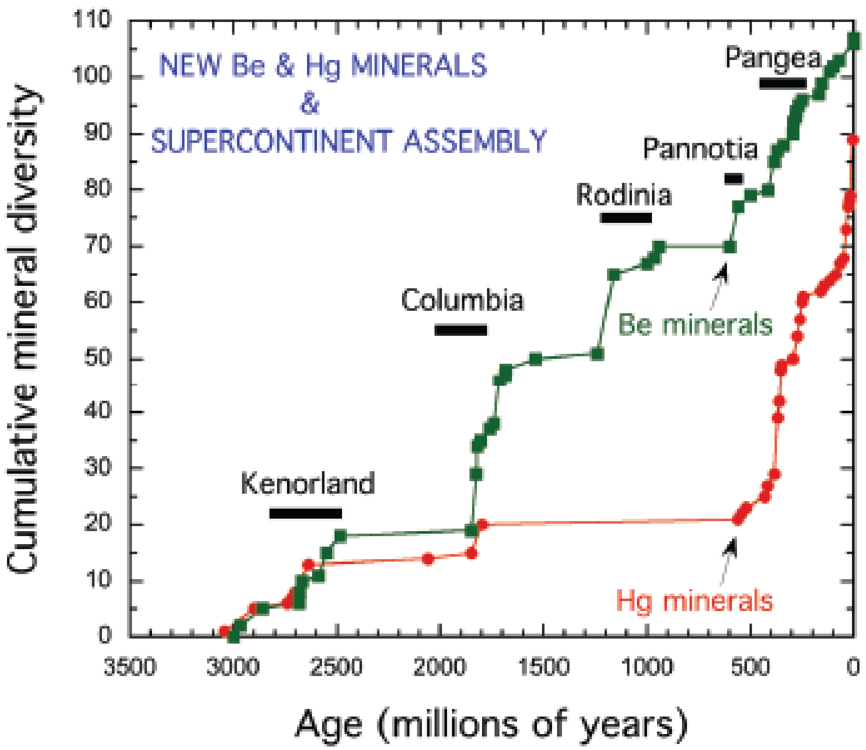


Το παράδειγμα της εξέλιξης των ορυκτών Be και Hg

American Mineralogist, Volume 97, pages 1013–1042, 2012

Mercury (Hg) mineral evolution: A mineralogical record of supercontinent assembly, changing ocean geochemistry, and the emerging terrestrial biosphere

ROBERT M. HAZEN,[1,*] JOSHUA GOLDEN,[2] ROBERT T. DOWNS,[2] GRETHE HYSTAD,[3] EDWARD S. GREW,[4] DAVID AZZOLINI,[5] AND DIMITRI A. SVERJENSKY[1,5]



Mineral Surfaces, Geochemical Complexities, and the Origins of Life

Robert M. Hazen[1] and Dimitri A. Sverjensky[2]

[1]Geophysical Laboratory, Carnegie Institution of Washington, Washington, DC 20015

[2]Department of Earth and Planetary Sciences, Johns Hopkins University, Baltimore, Maryand 21218

Correspondence: rhazen@ciw.edu

Crystalline surfaces of common rock-forming minerals are likely to have played several important roles in life's geochemical origins. Transition metal sulfides and oxides promote a variety of organic reactions, including nitrogen reduction, hydroformylation, amination, and Fischer-Tropsch-type synthesis. Fine-grained clay minerals and hydroxides facilitate lipid self-organization and condensation polymerization reactions, notably of RNA monomers. Surfaces of common rock-forming oxides, silicates, and carbonates select and concentrate specific amino acids, sugars, and other molecular species, while potentially enhancing their thermal stabilities. Chiral surfaces of these minerals also have been shown to separate left- and right-handed molecules. Thus, mineral surfaces may have contributed centrally to the linked prebiotic problems of containment and organization by promoting the transition from a dilute prebiotic "soup" to highly ordered local domains of key biomolecules.

Editors: David Deamer and Jack W. Szostak
Additional Perspectives on The Origins of Life available at www.cshperspectives.org

Advanced Online Article. Cite this article as *Cold Spring Harb Perspect Biol* doi: 10.1101/cshperspect.a002162

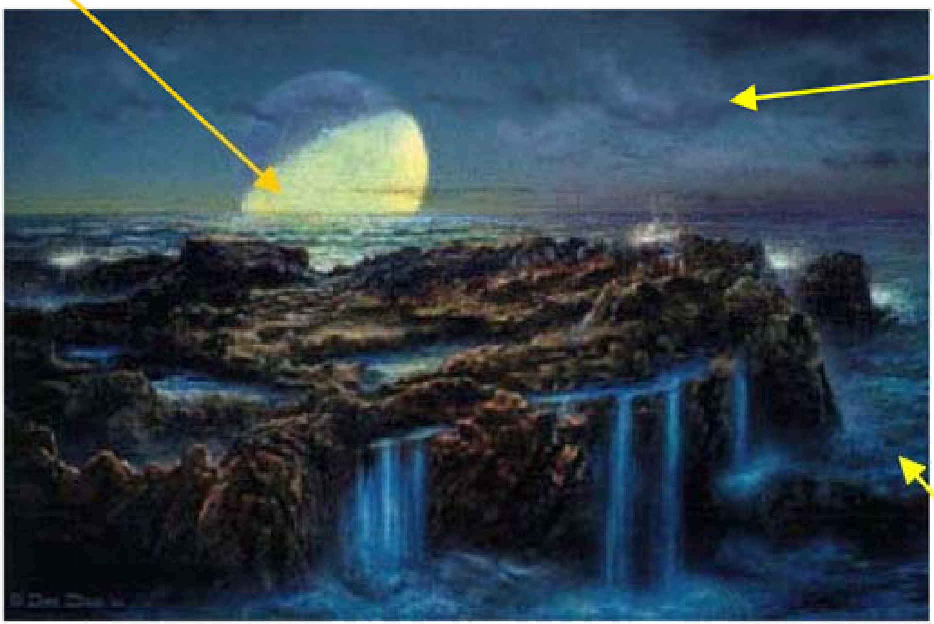
4 δισεκατομμύρια έτη πρίν...

Four Billion Years Ago...

UV radiation ($\lambda < 150$nm):
1.6×10^{-9} einsteins•cm^{-2}•sec^{-1}

Αρχική ατμόσφαιρα

Early Atmosphere:
CO_2: 1 to 10 atm
N_2, CO,
H_2S: 10^{-4} atm
CH_4: 10^{-4} atm
O_2: No



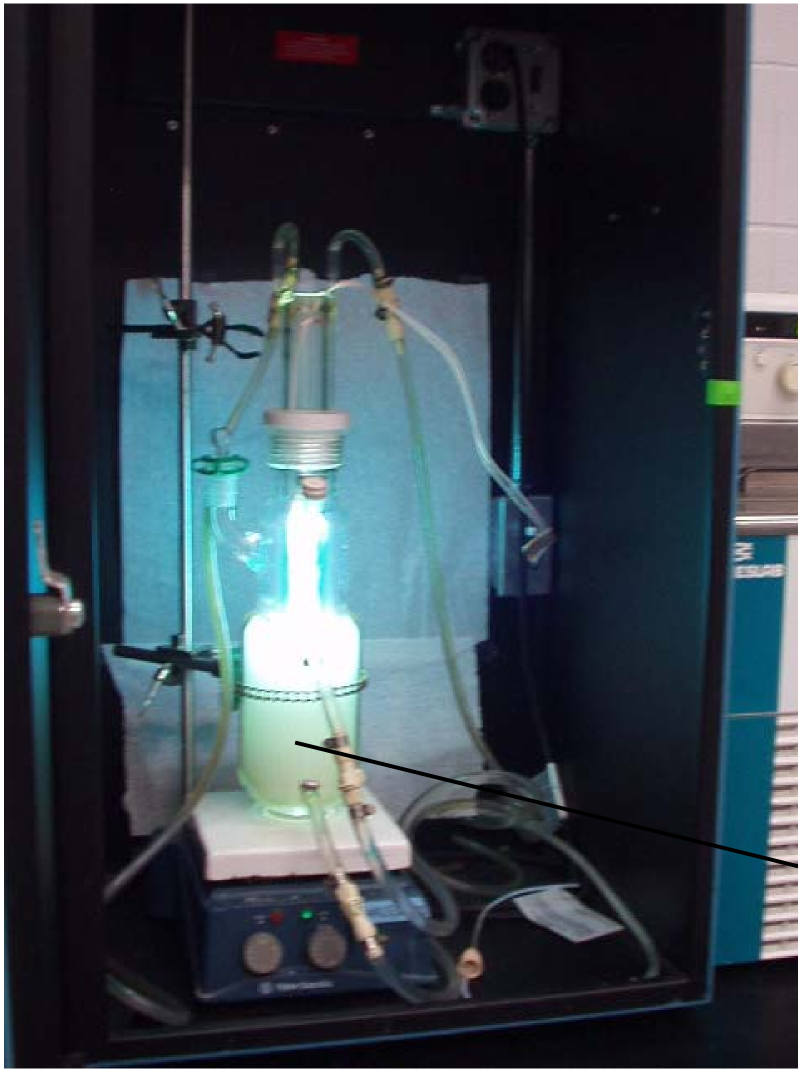
Αρχικός ωκεανός

Early Ocean:
Na^+, Mg^{2+}, Cl^-, SiO_3^{2-}, HCO_3^-,
pH = 5.5, T > 50 °C

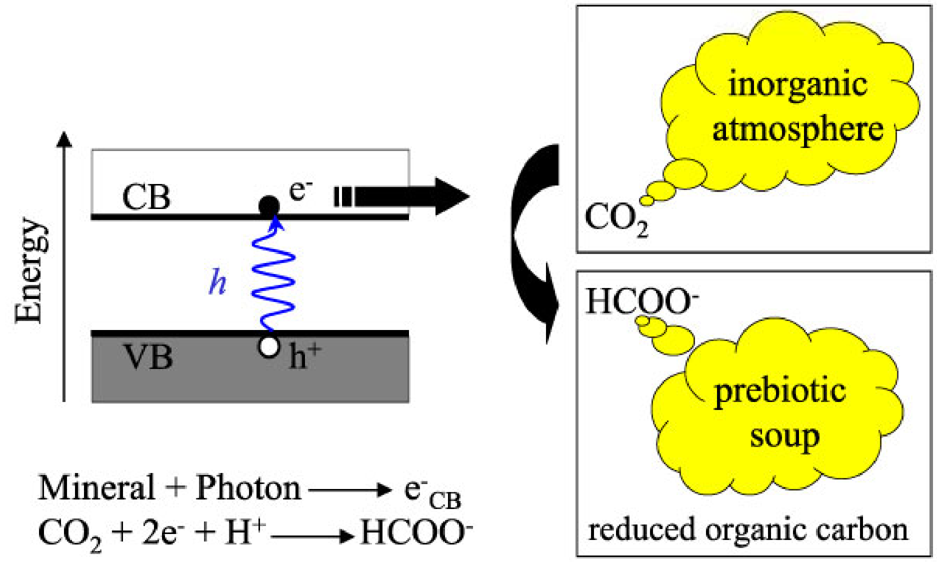
Πώς άρχισε η ζωή ;

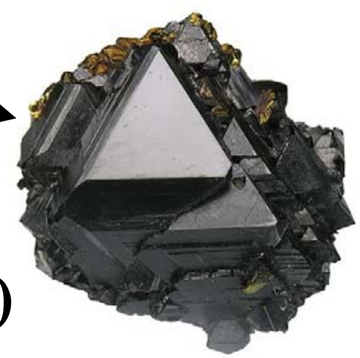
How did life begin?

ΦΩΤΟ-ΗΛΕΚΤΡΟΧΗΜΕΙΑ ΣΕ ΣΩΜΑΤΙΔΙΑ ΟΡΥΚΤΩΝ



Photoelectrochemistry on Mineral Particles





ΣΦΑΛΕΡΙΤΗΣ (ZnS)

http://www.seas.harvard.edu/environmental-chemistry/projects/prebiotic.php

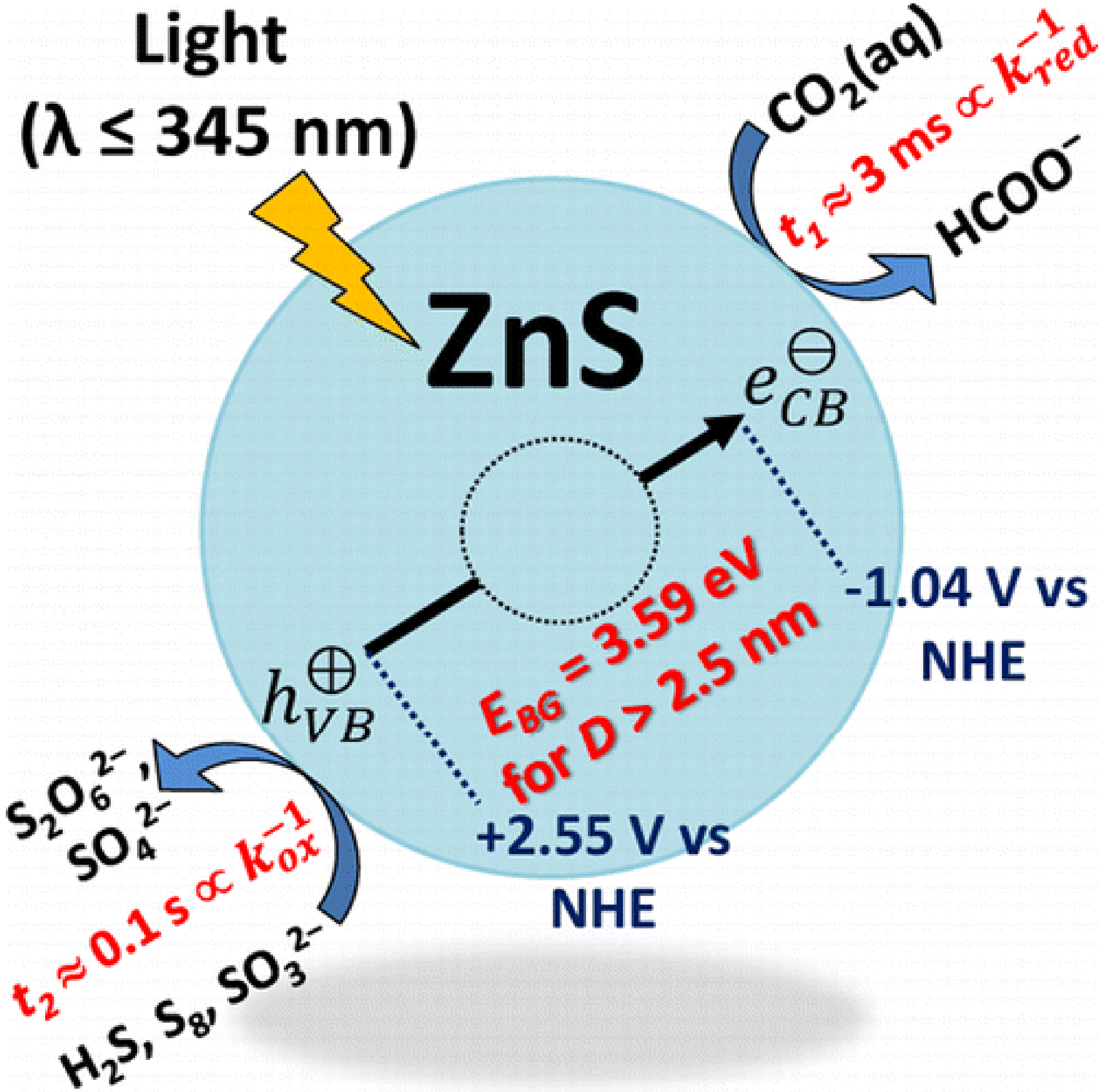
UK
UNIVERSITY OF
KENTUCKY

Guzman Laboratory

College of Arts & Sciences

Department of Chemistry

People Marcelo I. Guzman
Principal Investigator



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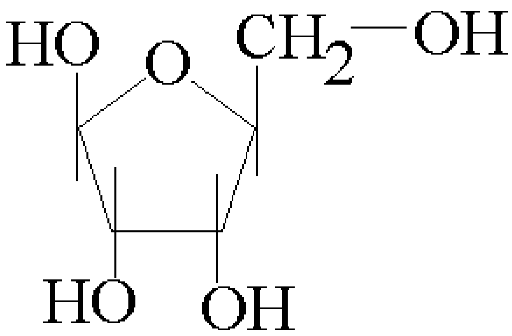
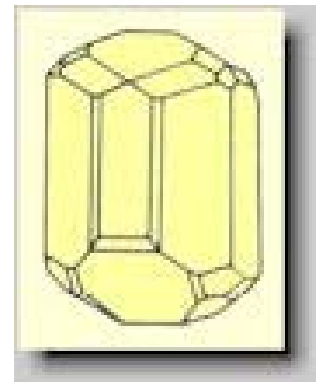
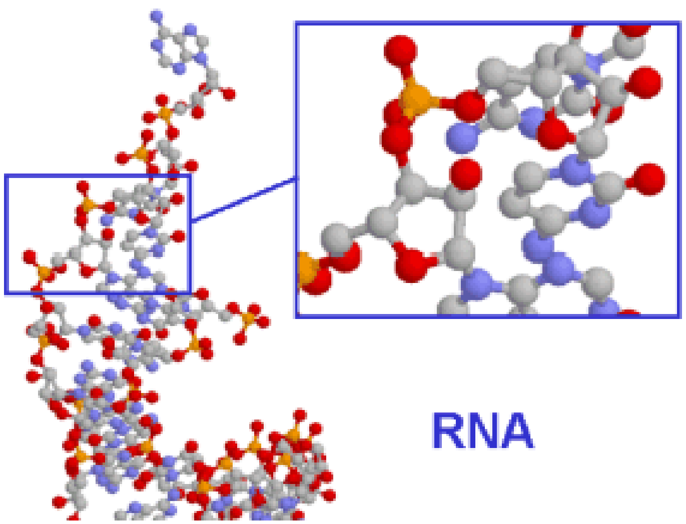
http://pubs.acs.org/doi/abs/10.1021/jp4126039

ΚΟΛΕΜΑΝΙΤΗΣ : $Ca_2B_6O_{11}\cdot 5H_2O$

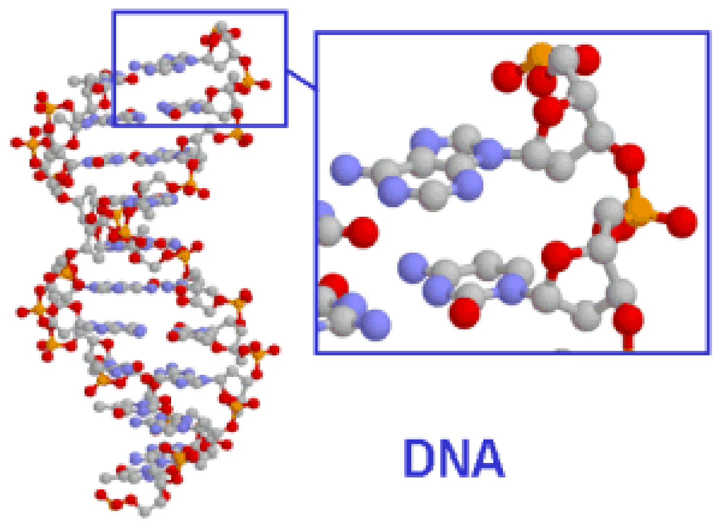


Ribose



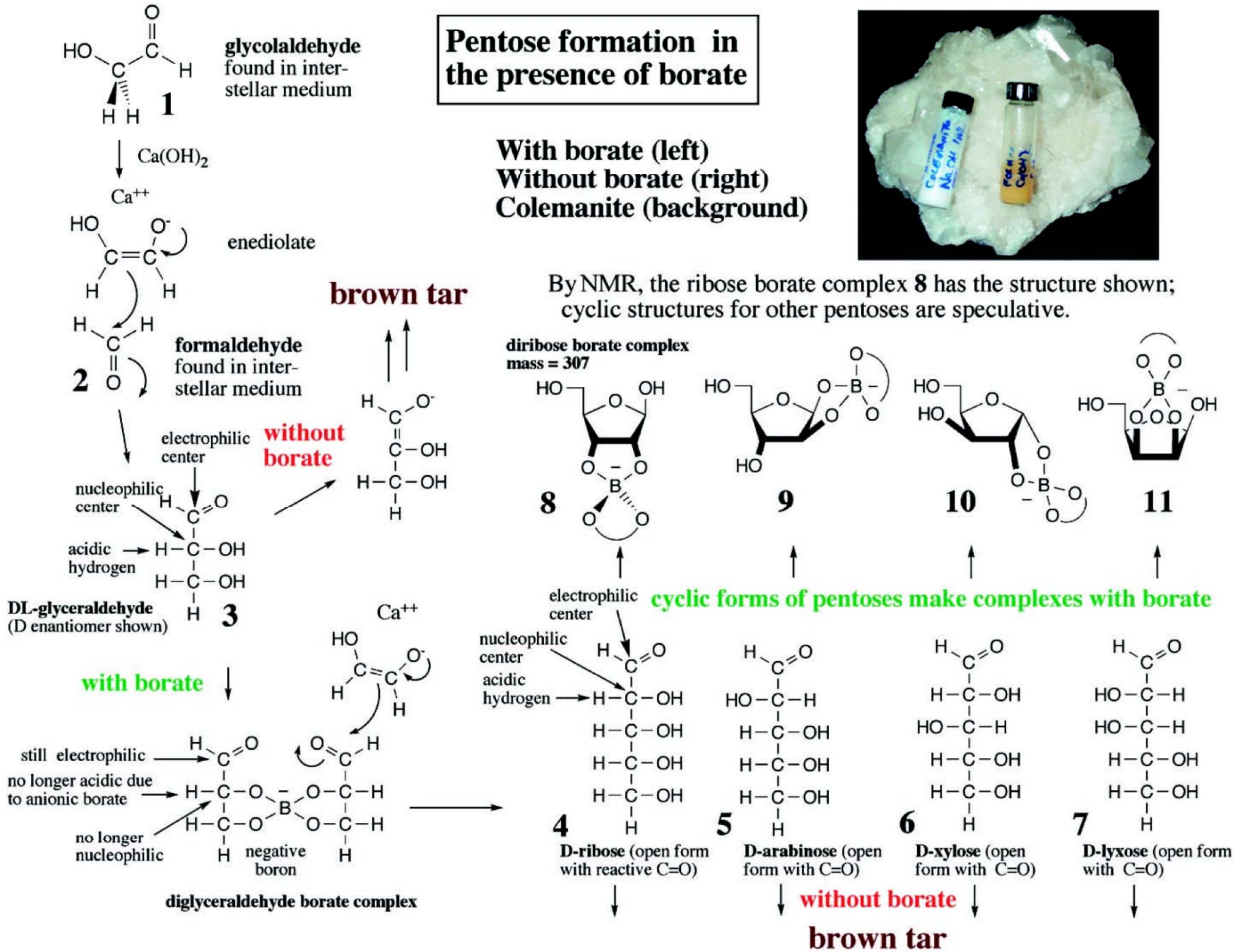


RNA



DNA

A. Ricardo,[1] M. A. Carrigan,[1] A. N. Olcott,[2] S. A. Benner* 9 JANUARY 2004 VOL 303 SCIENCE



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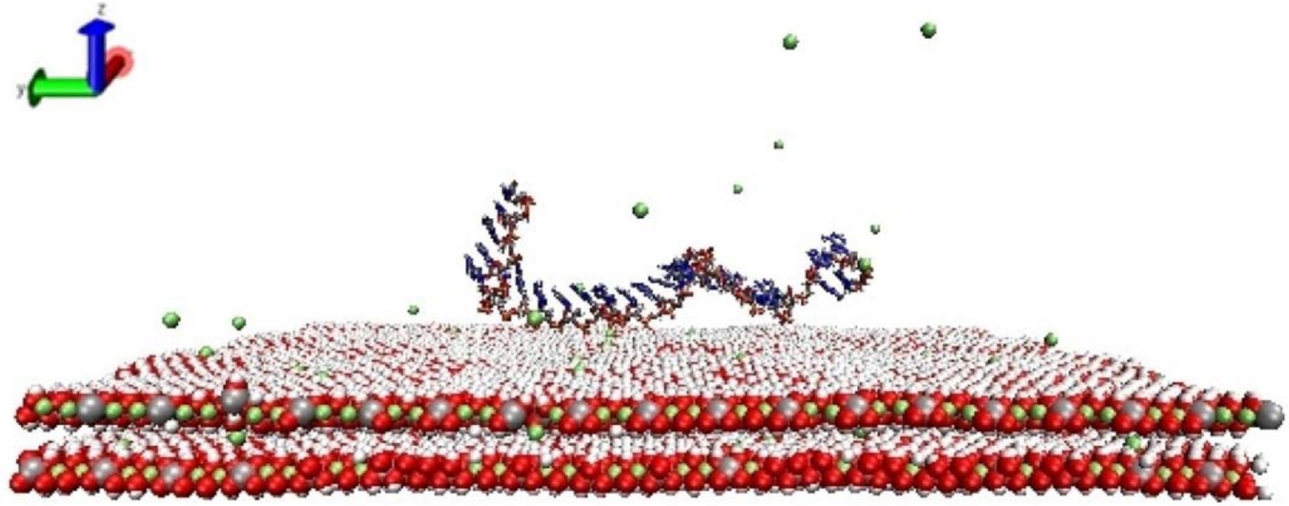
Αντίδραση RNA με επιφάνειες ορυκτών



(a)

(b)

Jacob B. Swadling; James L. Suter; H. Christopher Greenwell; Peter V. Coveney; *Langmuir* 2013, 29, 1573-1583.

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Geochimica et Cosmochimica Acta 71 (2007) 1721–1736

Geochimica et Cosmochimica Acta

www.elsevier.com/locate/gca

A radical pathway for organic phosphorylation during schreibersite corrosion with implications for the origin of life

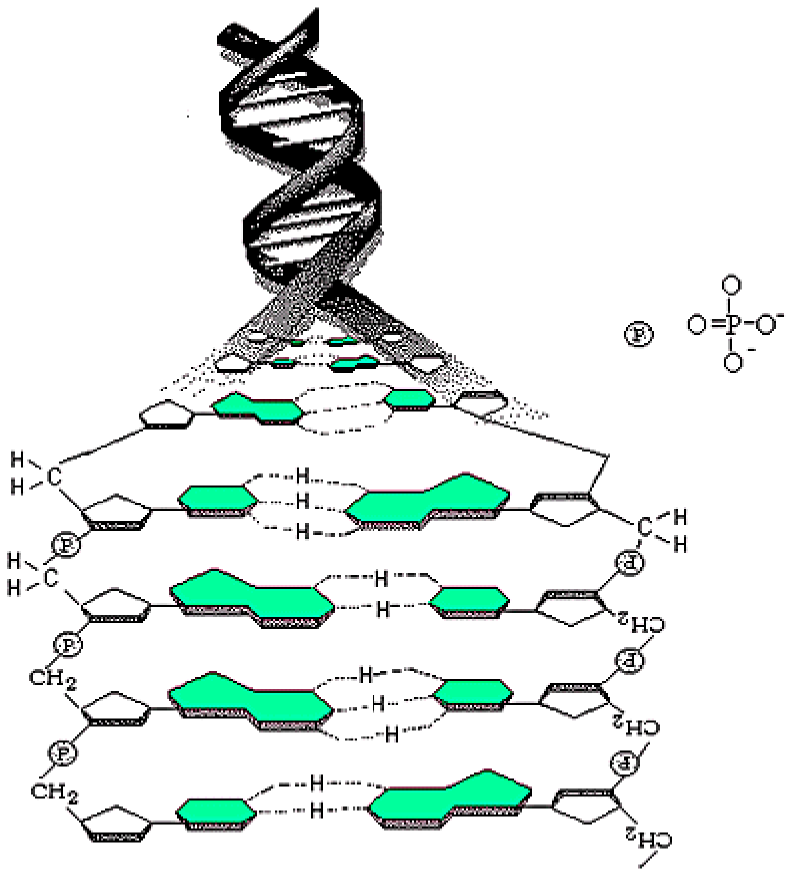
Matthew A. Pasek [a,*], Jason P. Dworkin [b], Dante S. Lauretta [c]

[a] *Steward Observatory, 1629 E. University Blvd, University of Arizona, Tucson, AZ 85721, USA*
[b] *Astrochemistry Branch, NASA Goddard Space Flight Center, Greenbelt, MD, USA*
[c] *Lunar and Planetary Laboratory, University of Arizona, Tucson, AZ, USA*

Received 29 August 2006; accepted in revised form 23 December 2006; available online 10 January 2007

ΣΡΑΪΜΠΕΡΣΙΤΗΣ: $(Fe,Ni)_3P$

Φωσφίδιο,
ορυκτό μετεωριτών



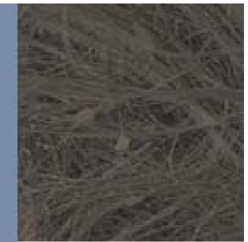
ΔΙΑΒΡΩΣΗ

$(Fe,Ni)_3P \longrightarrow -PO_3^{2-}$

ΟΡΓΑΝΙΚΗ ΦΩΣΦΟΡΥΛΙΩΣΗ

Serpentinites, Hydrogen, and Life

Thomas M. McCollom[1] and Jeffrey S. Seewald[2]



Chrysotile serpentine fibers growing on olivine

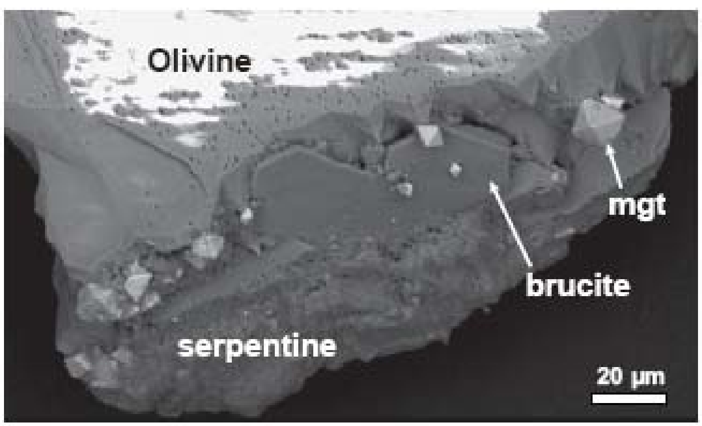
1811-5209/13/0009-129$2.50 DOI: 10.2113/gselements.9.2.129

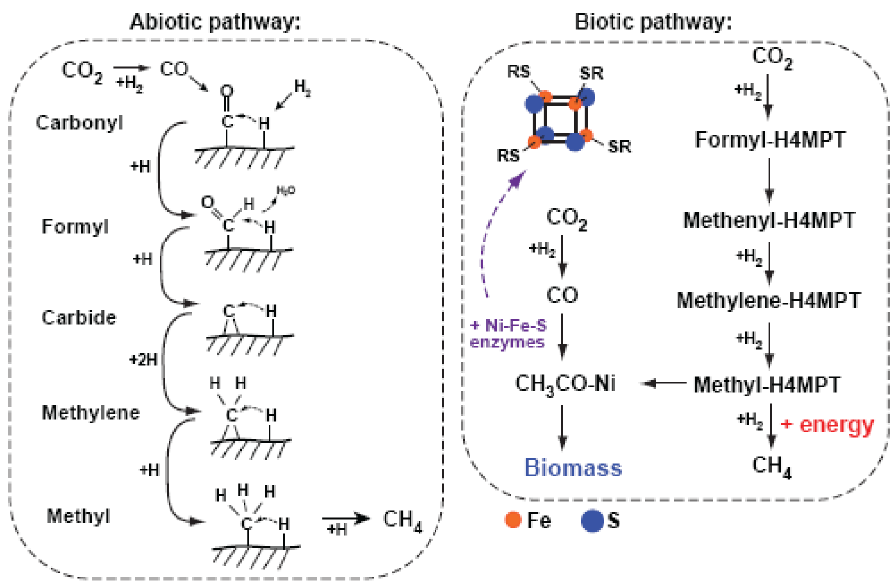
The process of serpentinization creates strongly reducing conditions and produces fluids that are highly enriched in molecular hydrogen and methane. Some microorganisms are able to exploit these compounds to gain metabolic energy and to generate biomass, leading to the development of biological communities based on chemical energy rather than photosynthesis. The abundance of chemical energy and favorable conditions for organic synthesis make serpentinites a strong candidate for the site of the origin of life on Earth, as well as a prime target in the search for life elsewhere in our Solar System.

Keywords: chemosynthesis, hydrogen metabolism, abiotic organic synthesis, early Earth, origin of life, methane

SERPENTINIZATION AND HYDROGEN GENERATION

The presence of fluids containing high levels of H_2 and CH_4 is one of the most distinctive characteristics of rocks undergoing active serpentinization (Abrajano et al. 1988; Charlou et al. 2002; Kelley et al. 2005). Serpentinites form through the aqueous alteration and hydration of rocks composed predominantly of the minerals olivine and pyroxene (i.e. ultramafic rocks), and H_2 and CH_4 are generated through the reduction





Cell

Leading Edge
Perspective

The Origin of Membrane Bioenergetics

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http://dx.doi.org/10.1016/j.cell.2012.11.050

Harnessing energy as ion gradients across membranes is as universal as the genetic code. We leverage new insights into anaerobe metabolism to propose geochemical origins that account for the ubiquity of chemiosmotic coupling, and Na^+/H^+ transporters in particular. Natural proton gradients acting across thin FeS walls within alkaline hydrothermal vents could drive carbon assimilation, leading to the emergence of protocells within vent pores. Protocell membranes that were initially leaky would eventually become less permeable, forcing cells dependent on natural H^+ gradients to pump Na^+ ions. Our hypothesis accounts for the Na^+/H^+ promiscuity of bioenergetic proteins, as well as the deep divergence between bacteria and archaea.

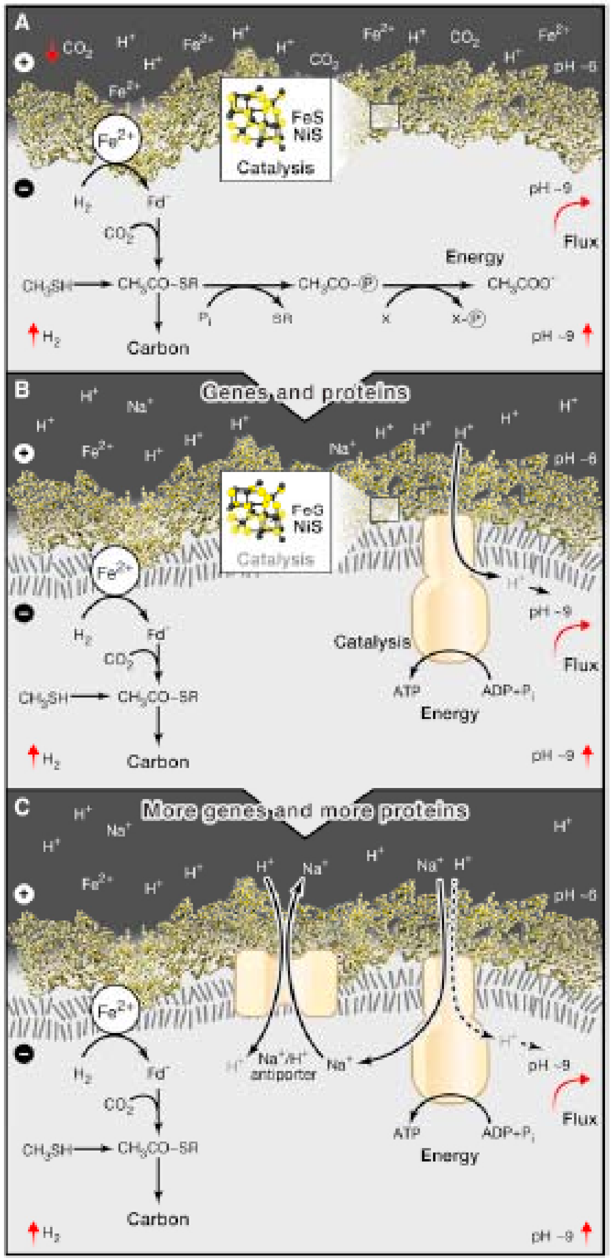
Box 1. Serpentinization

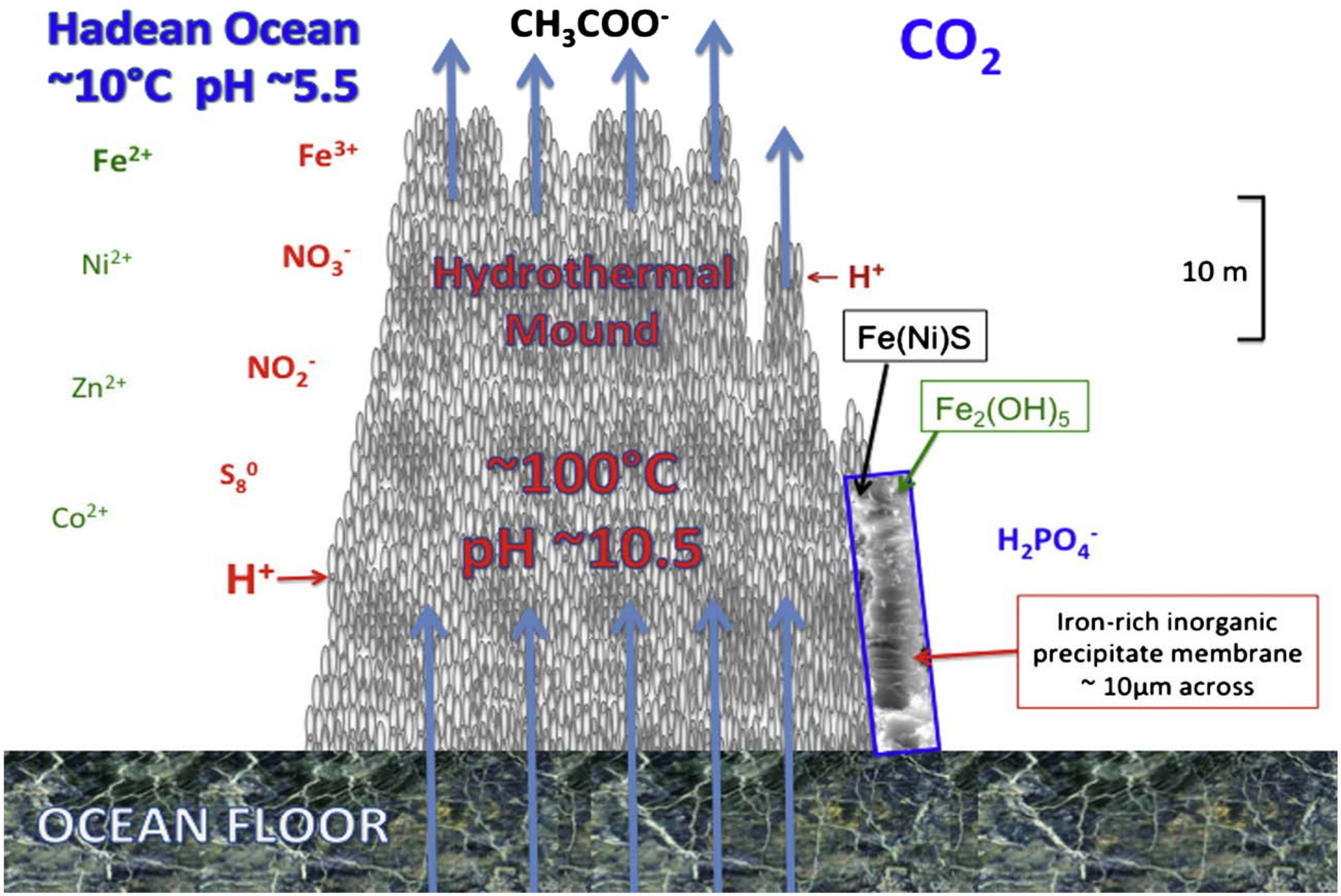
Serpentinization is important in the context of biochemical origins because it is the source of electrons for reducing CO_2 in hydrothermal systems. At the high pressures and moderately high temperatures of the deep ocean crust, minerals with low SiO_2 content such as olivine react with water to form a hydroxylated mineral, serpentinite, and 10–20 mM concentrations of H_2, dissolved in alkaline fluids (Sleep et al., 2004). Proskurowski et al. (2008) write the serpentinization reaction as:

$$6\,\underset{\text{olivine}}{(Mg_{1.5}Fe_{0.5})SiO_4} + 7H_2O \rightarrow \underset{\text{serpentinite}}{3Mg_3Si_2O_5(OH)_4} + \underset{\text{magnetite}}{Fe_3O_4} + H_2$$

Serpentinization occurs when rocks derived from the upper mantle (rich in olivine) are exposed to ocean water, which percolates down fractures several km to react with rocks beneath the sea floor. This exothermic reaction, combined with geothermal heat, warms the circulating fluid to ~150°C, generating a buoyant alkaline (pH 9–11, note magnesium hydroxide in the above equation) mineral-laden hydrothermal fluid, originally sourced from the ocean, that rises up to the sea floor and exhales at 70–90°C.

At Lost City, the exhalate precipitates into large spires (<60 m) of microporous minerals consisting of calcium magnesium carbonate (Kelley et al., 2001, 2005). The thin mineral walls thereof (100 nm to 5 µm in diameter) form osmotic barriers that separate warm H_2-rich alkaline fluids from cooler, more oxidized ocean waters (Kelley et al., 2001, 2005). Reduced, warm, alkaline fluids percolate continually through the labyrinths of micropores, sustaining thermal, redox, and pH gradients within the vents. Secondary convection in the adjacent ocean waters guarantees a steady supply of CO_2 and other solutes to the mound's margins. At the interface with Fe^{2+}-containing oceans (Arndt and Nisbet, 2012), the hydrothermal mounds on the early Earth would not have been carbonate spires as at Lost City today but would have been rich in transition metal sulfides instead.





Wolfgang Nitschke , Shawn E. McGlynn , E. James Milner-White , Michael J. Russell

On the antiquity of metalloenzymes and their substrates in bioenergetics

Biochimica et Biophysica Acta (BBA) - Bioenergetics 2013

ΠΛΑΝΗΤΙΚΗ ΟΡΥΚΤΟΛΟΓΙΑ

PLANETARY MINERALOGY

Κάποτε στον πλανήτη Αρη...

Η ύπαρξη νερού στην επιφάνειά του είναι η πρώτη από τις φετινές ανακαλύψεις

Το ερώτημα ποιες ήταν οι σημαντικότερες επιστημονικές κατακτήσεις συγκεκριμένης χρονιάς σπανίως μπορεί να απαντηθεί αν δεν μεσολαβήσει κάποια χρονική απόσταση. Παρόλα αυτά, κάθε χρόνο, η επιθεώρηση Science συντάσσει και αφήνει στην κρίση ιστορικών της επιστήμης, κατάλογο των κατακτήσεων που η επιστημονική επιτροπή τις θεωρεί σημαντικότερες. Στον κατάλογο του 2004, την πρώτη θέση κατέλαβε η ανακάλυψη της NASA ότι κάποτε στον Αρη υπήρχε νερό, το απαραίτητο συ-

Νερό στον Αρη. Τα σκάφη Spirit και Opportunity της NASA ανακάλυψαν πειστικές ενδείξεις για την παρατεταμένη ύπαρξη στον Αρη, αλμυρού, όξινου νερού.

χρι πριν 13.000 χρόνια (πολύ πρόσφατα, σε σχέση με την ιστορία του ανθρώπινου είδους) μία φυλή ανθρώπων-νάνων, που ονομάστηκε Λιαγκ Μπουά 1, ή LB 1. «Το εύρημα εξήψε τη φαντασία πολλών» έγραψε ο Ντόναλντ Κένεντι, εκδότης του περιοδικού Science, παρουσιάζοντας τον κατάλογο. «Το κρανίο και τα υπόλοιπα ευρήματα τώρα επανεξετάζονται και περιμένουμε να δούμε πώς θα εξελιχθεί το θέμα αυτό.

Ιδιαίτερα σημαντική θεωρήθηκε και η κλωνοποίηση 30 ανθρωπίνων εμβρύων από Νοτιοκορεάτες επιστήμονες. Η κλωνοποίηση δεν είχε στόχο τη γέννηση ανθρώπινων κλώνων, αλλά τη δημιουργία βλαστοκυττάρων με το ίδιο ακριβώς DNA ενός ενήλικα, ώστε να χρησιμοποιηθούν για μελλοντικές, εξατομικευμένες θεραπείες.

Πάλσαρ σε φωτογραφικό ντεμπούτο, αμφίβια σε τροχιά εξαφάνισης, μωρά-κλώνοι στον προθάλαμο.

Επιστημονικά επιτεύγματα του 2004 σύμφωνα με το Science

Νερό στον Αρη. Τα σκάφη Spirit και Opportunity της NASA ανακάλυψαν πειστικές ενδείξεις για την παρατεταμένη ύπαρξη στον Αρη, αλμυρού, όξινου νερού.

Ινδονησιακό χόμπιτ. Ομάδα παλαιοντολόγων ανακάλυψε ότι στη νήσο Φλόρες της Ινδονησίας ζούσε είδος ανθρώπων που είχαν ύψος μόλις ένα μέτρο.

Ανθρώπινη Κλωνοποίηση. Νοτιοκορεάτες επιστήμονες ανακοίνωσαν ότι κλωνοποίησαν ανθρώπινα έμβρυα. Πρώτη φορά αποδείξεις για την τεχνική αυτή δημοσιεύθηκαν σε επιστημονική επιθεώρηση.

Συμπεριφορά πολύ πυκνών αερίων. Το 2004 οι επιστήμονες έκαναν σημαντικά βήματα για την κατανόησή της.

Κρυμμένοι θησαυροί του DNA. Τα θεωρούμενα ως άχρηστα τμήματα του DNA αποδείχθηκε ότι επιτελούν σημαντικό ρόλο στο να βοηθούν τα γονίδια να ενεργοποιούνται την κατάλληλη στιγμή.

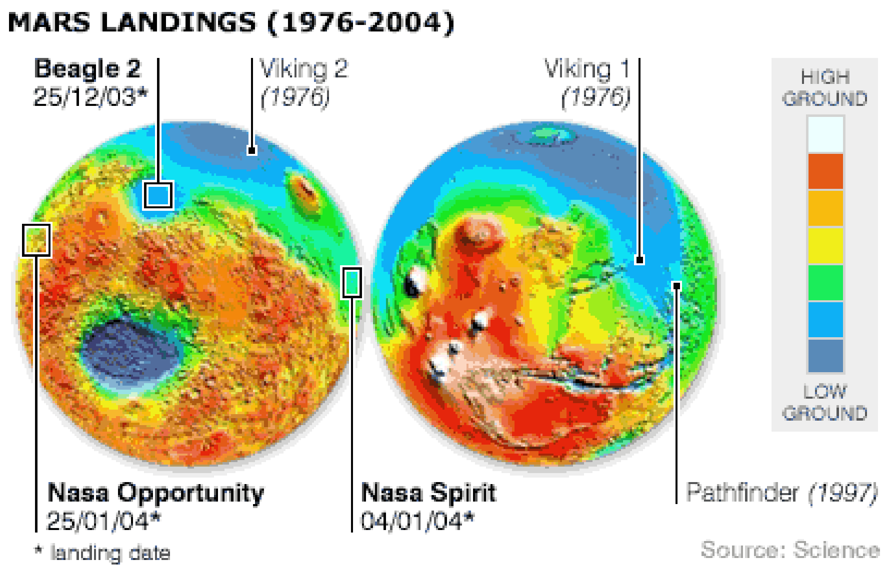
Ζεύγος Πάλσαρ. Αστροφυσικοί ανακάλυψαν το πρώτο γνωστό ζεύγος Πάλσαρ, αστεριών από νετρόνια που εκπέμπουν πίδακες ραδιενέργειας.

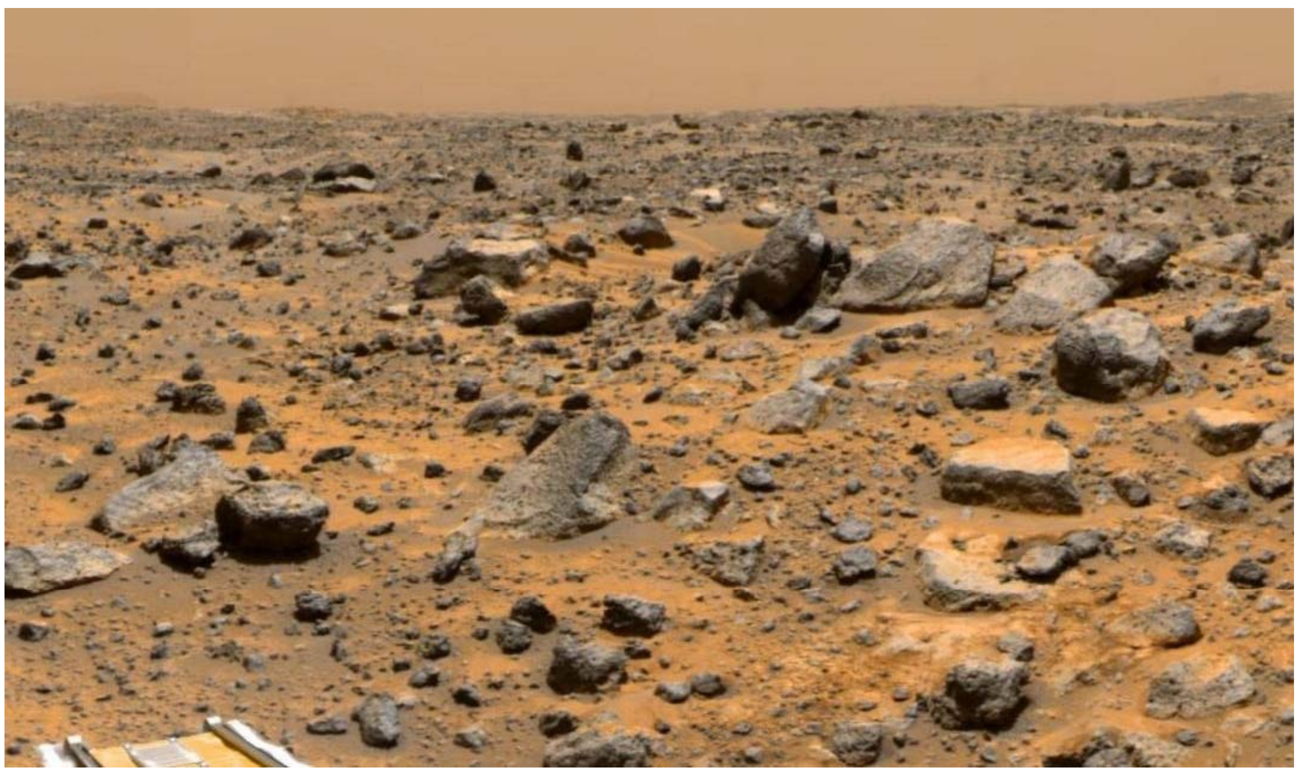
Εξαφάνιση φυτών και ζώων. Μελέτες κατέληξαν σε ανησυχητικά συμπεράσματα για τη μείωση της ποικιλίας των ειδών αμφίβιων, πεταλούδων, πουλιών και φυτών.

Νερό υπό έλεγχο. Νέες μελέτες για τη δομή και τη χημική συμπεριφορά του νερού άνοιξαν νέους δρόμους σε κλάδους της χημείας και μελέτης της ατμόσφαιρας.

Φάρμακα για τους φτωχούς. Οι «συμμαχίες δημοσίου-ιδιωτικού τομέα» ενισχύθηκαν το 2004, επηρεάζοντας την έρευνα και διανομή φαρμάκων.

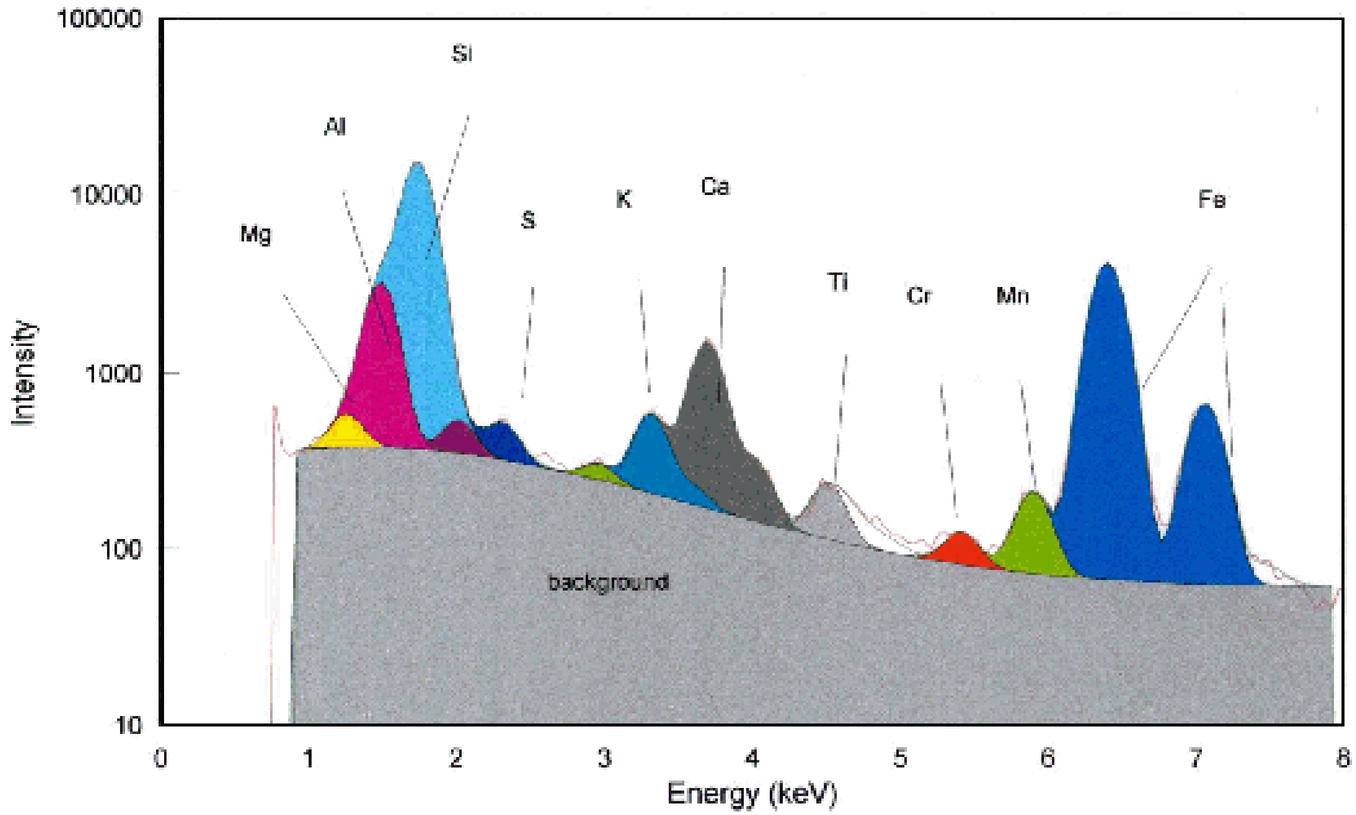
Γονίδια σε μια σταγόνα. Επιστήμονες βρήκαν νέο τρόπο να αναλύουν πολύ μικρούς έμβιους οργανισμούς. Συνέλεξαν νερό και αποκωδικοποίησαν τη δομή των γονιδίων που κολυμπούν σε αυτό.


MARS LANDINGS (1976-2004)
Beagle 2
25/12/03*
Viking 2
(1976)
Viking 1
(1976)
HIGH
GROUND
LOW
GROUND
Nasa Opportunity
25/01/04*
Nasa Spirit
04/01/04*
Pathfinder (1997)
* landing date
Source: Science



Barnacle Bill Martian Rock

APXS X-ray Spectrum 7/7/97



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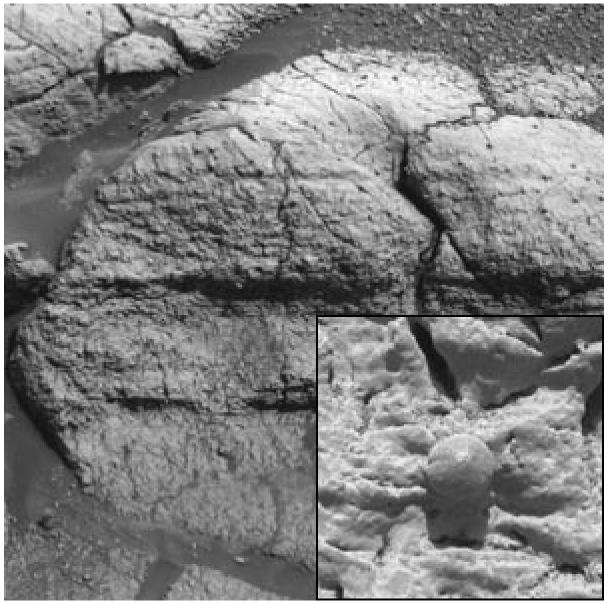
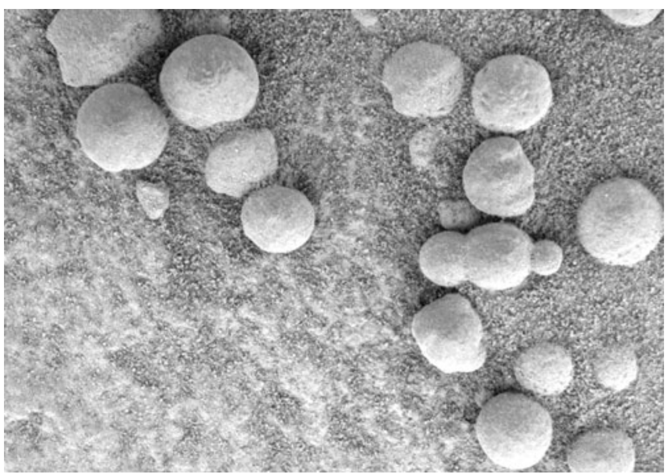
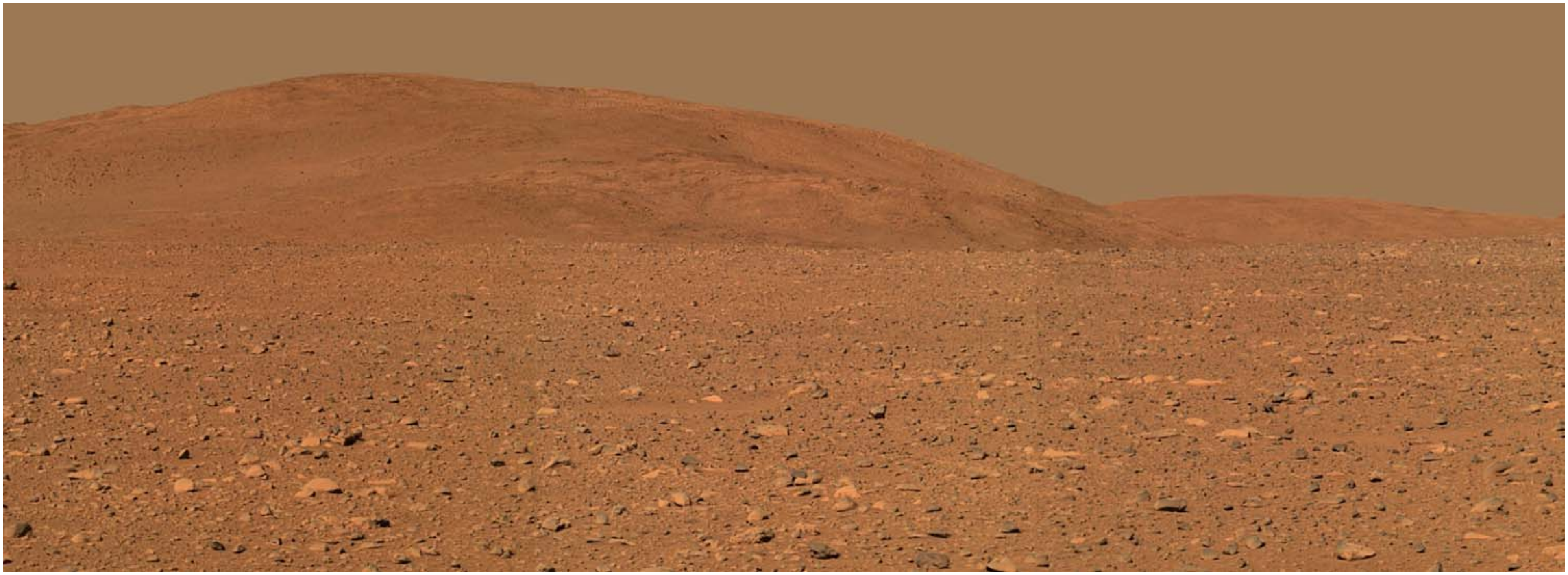
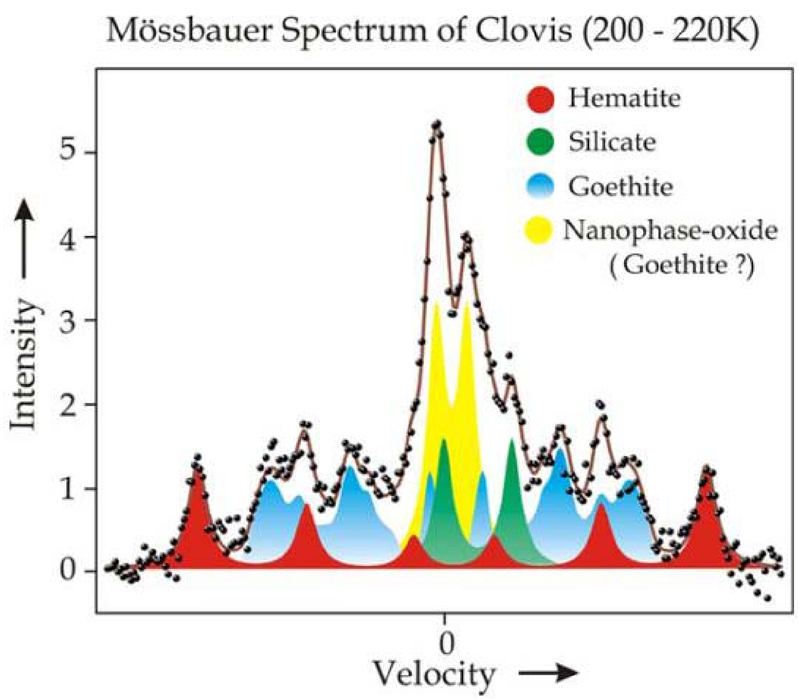


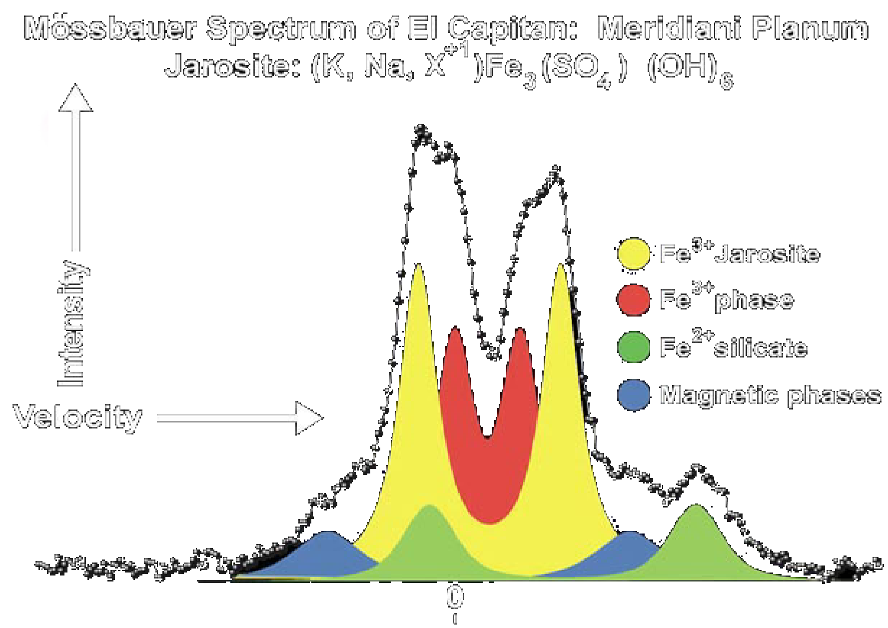


ΑΙΜΑΤΙΤΗΣ (Hematite) : Fe_2O_3

ΤΖΑΡΟΣΙΤΗΣ (Jarosite) : $KFe_3(SO_4)_2(OH)_6$



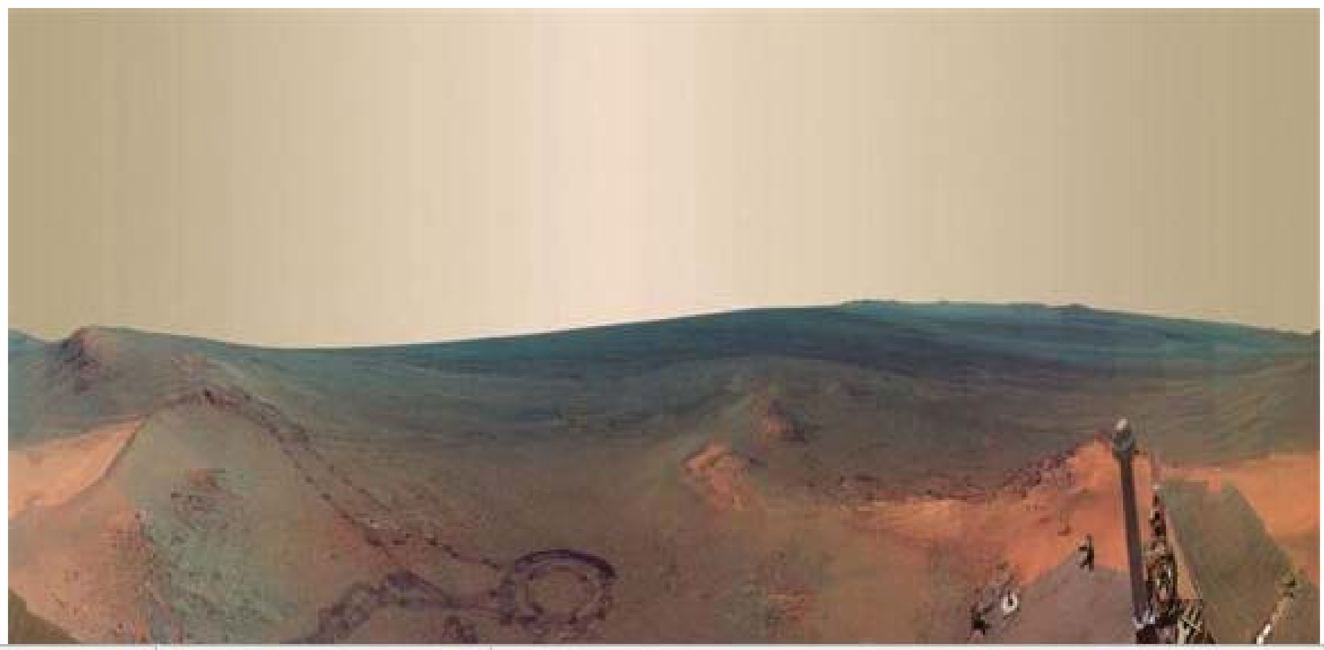

Mössbauer Spectrum of Clovis (200 - 220K)
Hematite
Silicate
Goethite
Nanophase-oxide (Goethite ?)
Intensity
5
4
3
2
1
0
0
Velocity


Mössbauer Spectrum of El Capitan: Meridiani Planum
Jarosite: (K, Na, X^{+1})$Fe_3(SO_4)$ $(OH)_6$
Intensity
Velocity
Fe^{3+}Jarosite
Fe^{3+}phase
Fe^{2+}silicate
Magnetic phases
0

NASA rover Opportunity finds signs Mars once had fresh water

BY IRENE KLOTZ

Thu Jan 23, 2014 6:41pm EST



Published Online December 9 2013
Science 24 January 2014:
Vol. 343 no. 6169
DOI: 10.1126/science.1243480
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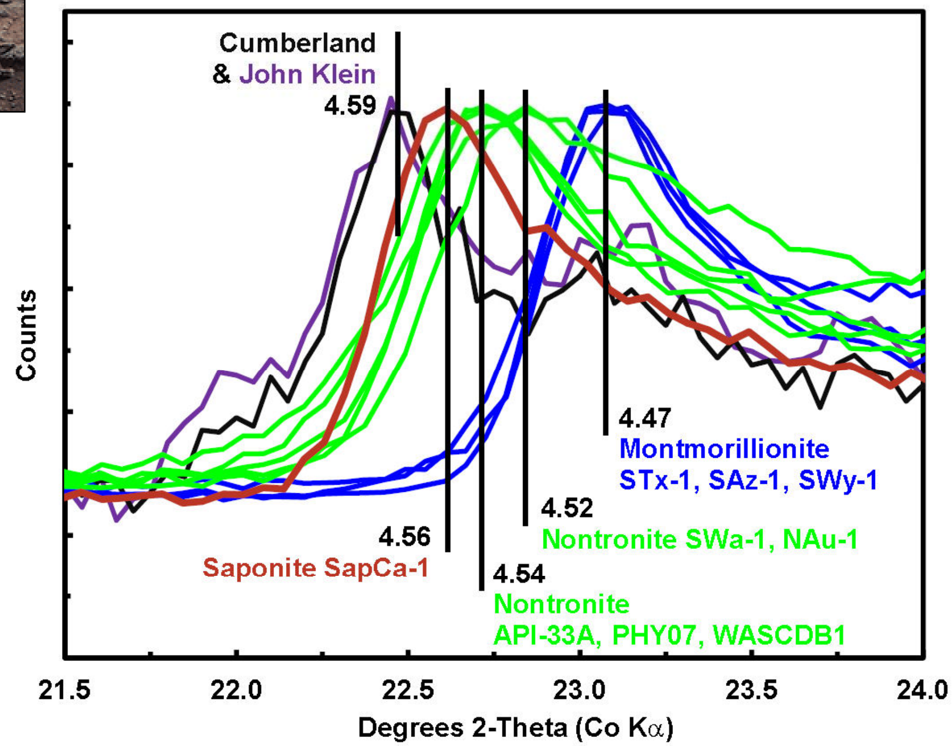
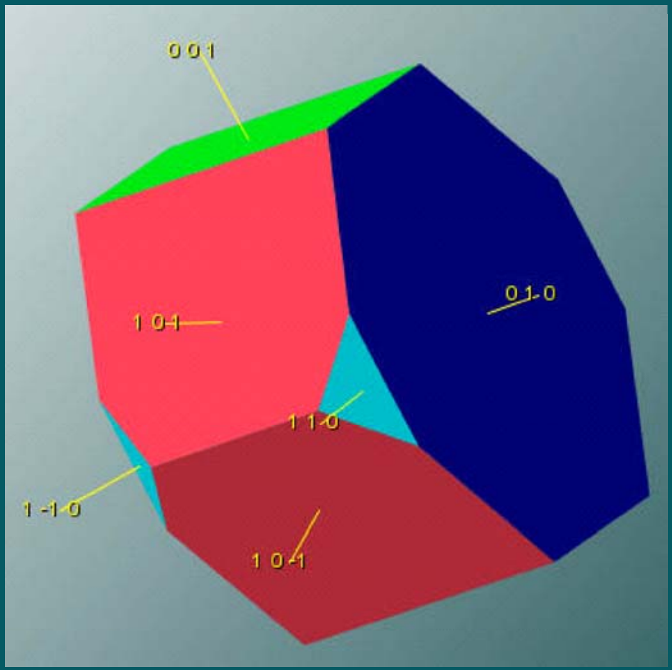
RESEARCH ARTICLE

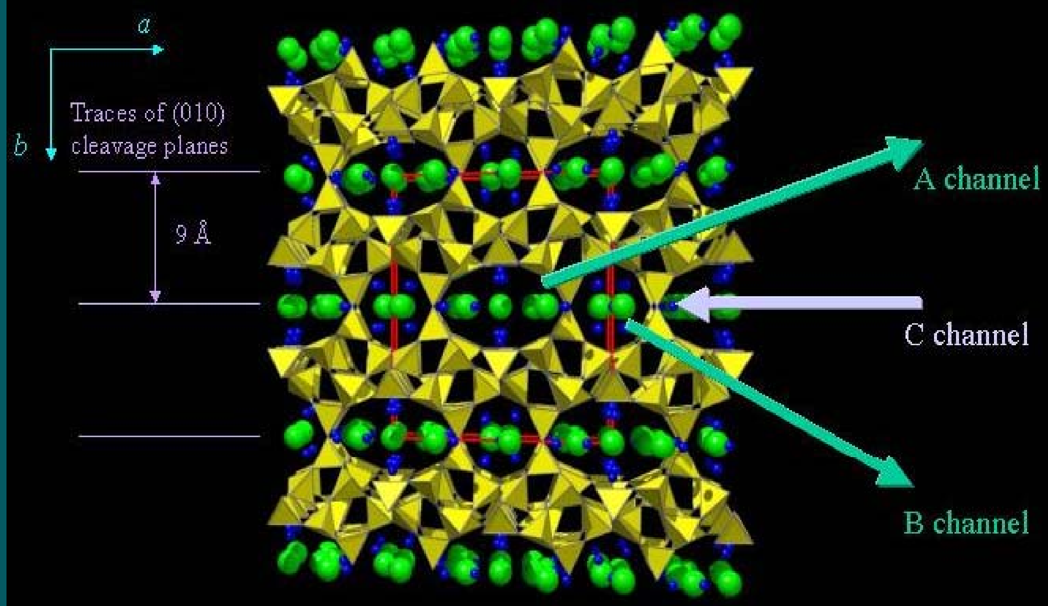
Mineralogy of a Mudstone at Yellowknife Bay, Gale Crater, Mars

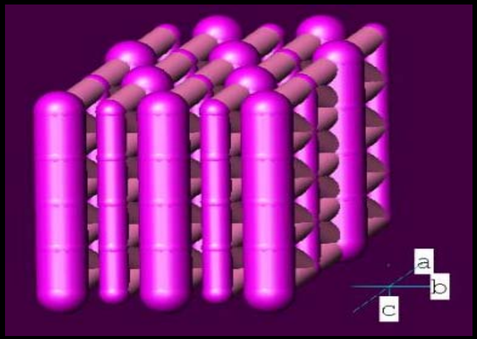
D. T. Vaniman[1,*], D. L. Bish[2], D. W. Ming[3], T. F. Bristow[4], R. V. Morris[3], D. F. Blake[4], S. J. Chipera[5], S. M. Morrison[6], A. H. Treiman[7], E. B. Rampe[3], M. Rice[8], C. N. Achilles[9,†], J. P. Grotzinger[8], S. M. McLennan[10], J. Williams[11], J. F. Bell III[12], H. E. Newsom[11], R. T. Downs[6], S. Maurice[13], P. Sarrazin[14], A. S. Yen[15], J. M. Morookian[15], J. D. Farmer[12], K. Stack[8], R. E. Milliken[16], B. L. Ehlmann[8,15], D. Y. Sumner[17], G. Berger[13], J. A. Crisp[15], J. A. Hurowitz[10], R. Anderson[15], D. J. Des Marais[4], E. M. Stolper[8], K. S. Edgett[18], S. Gupta[19], N. Spanovich[15], MSL Science Team[‡]

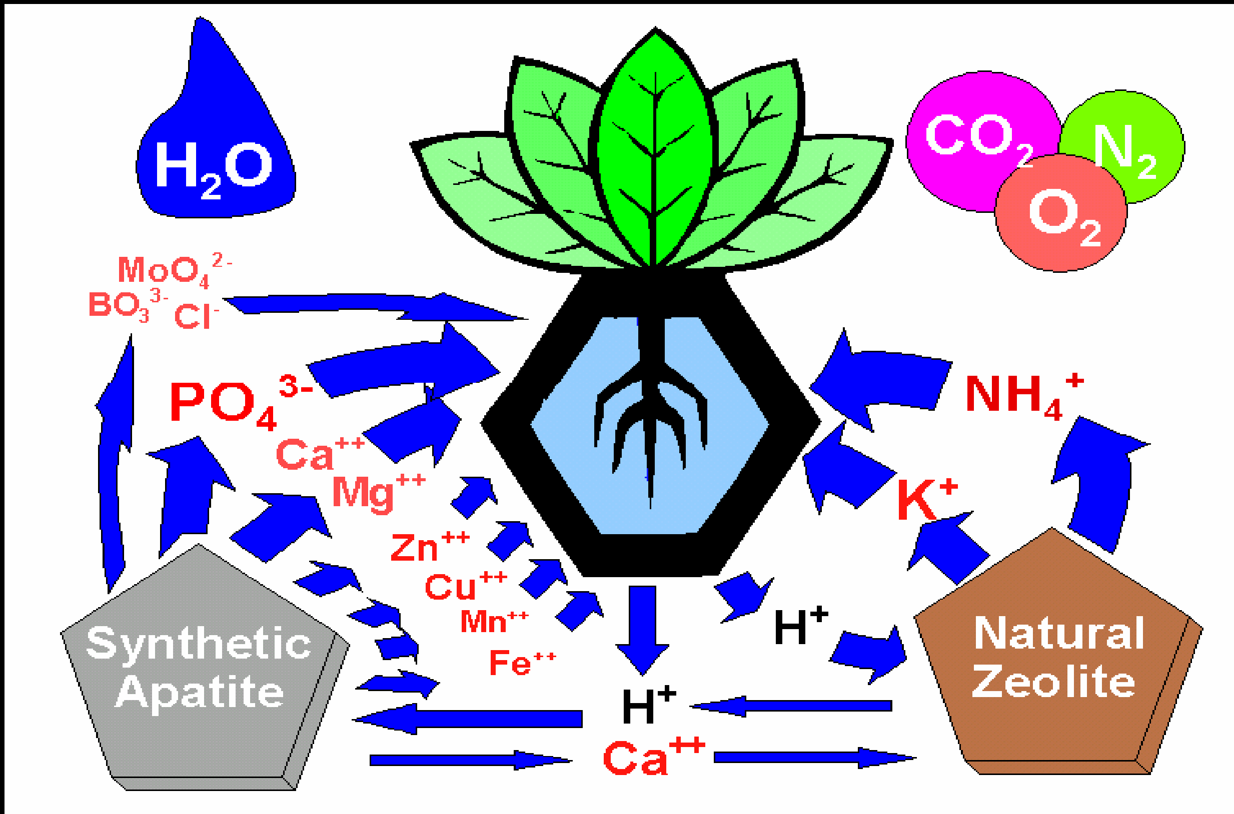


ΖΕΟΛΙΘΟΣ (zeolite)









“ΔΙΑΣΤΗΜΙΚΟ”
ΕΔΑΦΟΣ
ΜΕ ΖΕΟΛΙΘΟ & ΑΠΑΤΙΤΗ

Πηγές … Χαμπλ

Του Warren …
The New York …

Το διαστημικό τηλεσκ…
αποστολή του οποίου
θως η μελέτη των άκ
μπαντος, έστρεψε τ
του στη Σελήνη μας
ψε εκεί την ύπαρξη μ
νώσεων, που ίσως
πλούσιες πηγές οξυγό
ανθρώπινους επισκέ
ρυφόρου της Γης.

Με αυτή την ασυνή
του Χαμπλ, οι αστρο
ψαν το γιγάντιο τηλε
το φεγγάρι, τον Αύγο
εξασφαλίσουν τις πρ
δεις φωτογραφίες με
γεωλογικό ενδιαφέρο
αυτές επιτρέπουν στη
νική κοινότητα να
την ύπαρξη περιοχώ
διαφορές στα μέταλλ
φους τους. Οι παρατη
επιτρέπουν με τη σε
επιλογή των ιδανικώ
για μελλοντικές προσ
πανδρωμένων ή μη, ο

«Οι εικόνες του Χα
τρεψαν να κοιτάξουμ
με νέο μάτι. Ποτέ σ
δεν διαθέταμε τόσο
δη απεικόνιση», εί

έκταση. Ο κρατήρας του Αρίσταρχου, διαμέτρου 34 χιλιομέτρων και βάθους τριών, μπορεί να έχει γεωλογική ηλικία μόλις 100 εκατομμυρίων ετών. Τα άκρα του είναι απότομα, ενώ εμφανίζει και πολλά άλλα χαρακτηριστικά της γεωλογικής νεότητας, σύμφωνα με τον δρα Μαρκ Ρόμπινσον, πλανητικό γεωλόγο του Πανεπιστημίου Νορθουέστερν στο Εβανστον του Ιλινόι των ΗΠΑ.

Οι εικόνες του τηλεσκοπίου δείχνουν μεγάλη ποικιλία υλικών στο εσωτερικό του κρατήρα. Οι επιστήμονες ξεχώρισαν μεταξύ αυτών βασάλτιο, ολιβίνη, ανορθωσίτη και ιλμενίτη. Οι επιστήμονες εκτιμούν ότι ο ιλμενίτης, το κρυσταλλικό ορυκτό που δημιουργείται από τιτάνιο, σίδηρο και οξυγόνο, παρουσιάζει το μεγαλύτερο ενδιαφέρον, καθώς μπορεί να αποτελέσει πηγή οξυγόνου για τους επισκέπτες της Σελήνης. Μεγάλες ποσότητες ιλμενίτη ανακαλύφθηκαν στον κρατήρα του Αρίσταρχου.

Ο ιλμενίτης είχε εντοπισθεί σε δείγματα που εξασφάλισαν οι αστροναύτες του Απόλλωνα 17. Τα δείγματα αυτά επέτρεψαν στους αστρονόμους να ρυθμίζουν κατάλληλα τα όργανα του Χαμπλ, ώστε να εντοπίσει τα επιθυμητά υλικά.

Οι επιστήμονες εκτιμούν ότι ο ιλμενίτης, το κρυσταλλικό ορυκτό που δημιουργείται από τιτάνιο, σίδηρο και οξυγόνο, παρουσιάζει το μεγαλύτερο ενδιαφέρον, καθώς μπορεί να αποτελέσει πηγή οξυγόνου για τους επισκέπτες της Σελήνης. Μεγάλες ποσότητες ιλμενίτη ανακαλύφθηκαν στον κρατήρα του Αρίσταρχου.

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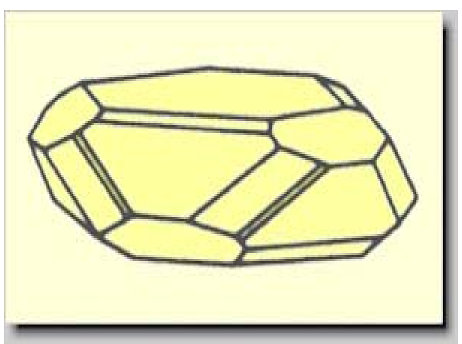
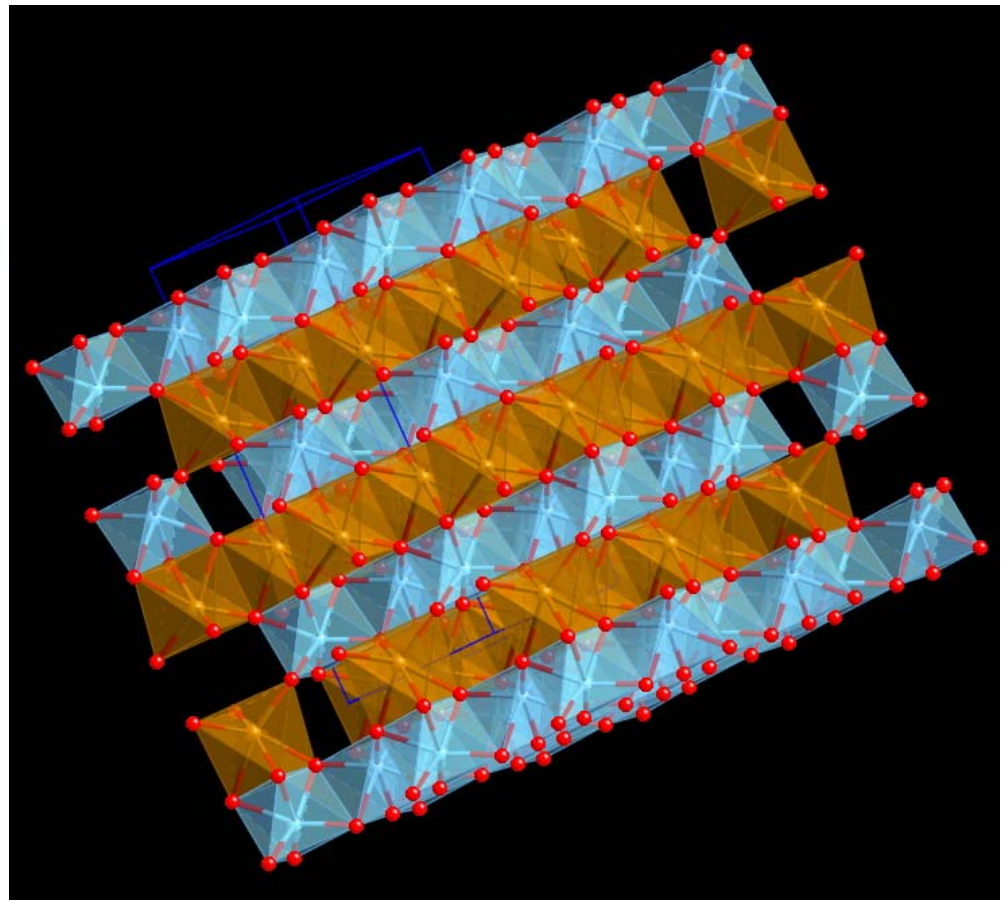
ΙΛΜΕΝΙΤΗΣ ($FeTiO_3$)





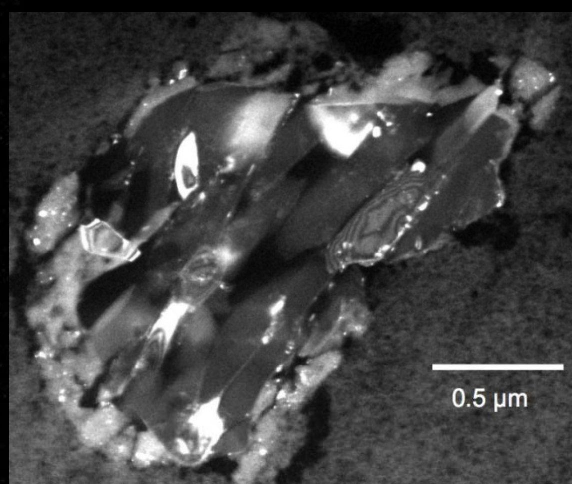
$$FeTiO_3 + H_2 \Leftrightarrow Fe + TiO_2 + H_2O \ (700\text{-}1000\ °C)$$

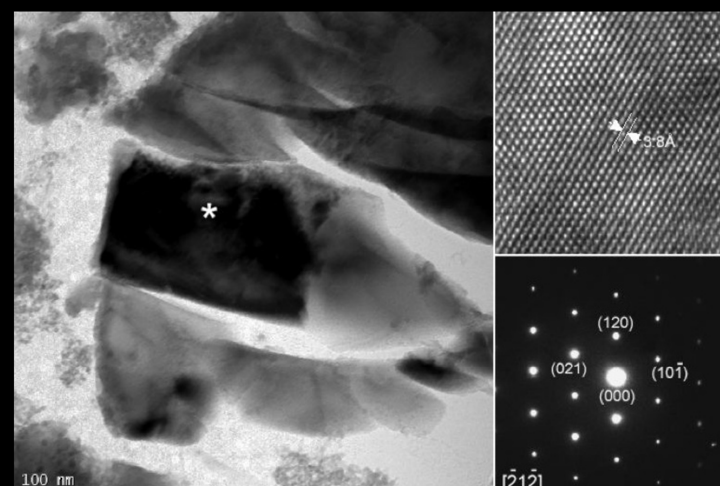
$$H_2O \rightarrow H_2 + 0.5\ O_2$$

ΟΛΙΒΙΝΗΣ

$(Mg,Fe)_2SiO_4$

OLIVINE

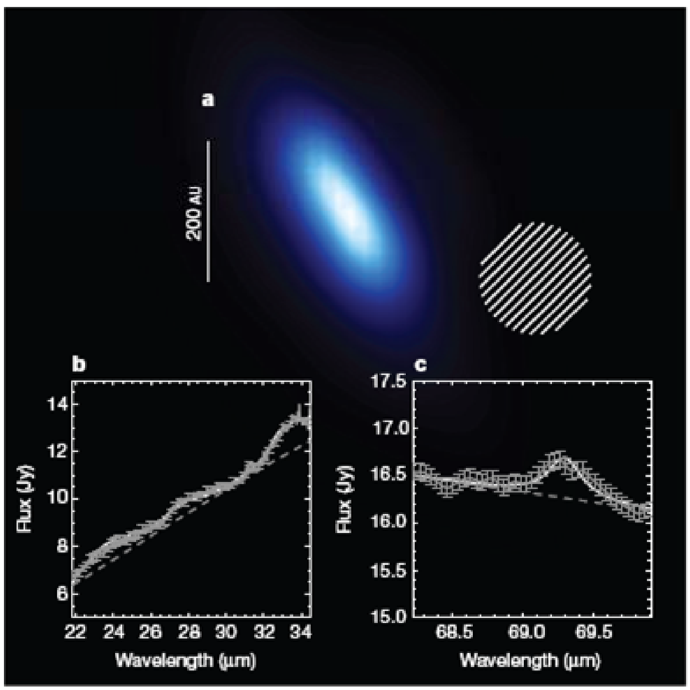




 74 | NATURE | VOL 490 | 4 OCTOBER 2012
doi:10.1038/nature11469

Comet-like mineralogy of olivine crystals in an extrasolar proto-Kuiper belt

B. L. de Vries[1], B. Acke[1], J. A. D. L. Blommaert[1], C. Waelkens[1], L. B. F. M. Waters[2,3], B. Vandenbussche[1], M. Min[3], G. Olofsson[4], C. Dominik[3,5], L. Decin[1,3], M. J. Barlow[6], A. Brandeker[4], J. Di Francesco[7], A. M. Glauser[8,9], J. Greaves[10], P. M. Harvey[11], W. S. Holland[9,12], R. J. Ivison[9], R. Liseau[13], E. E. Pantin[14], G. L. Pilbratt[15], P. Royer[1] & B. Sibthorpe[9]



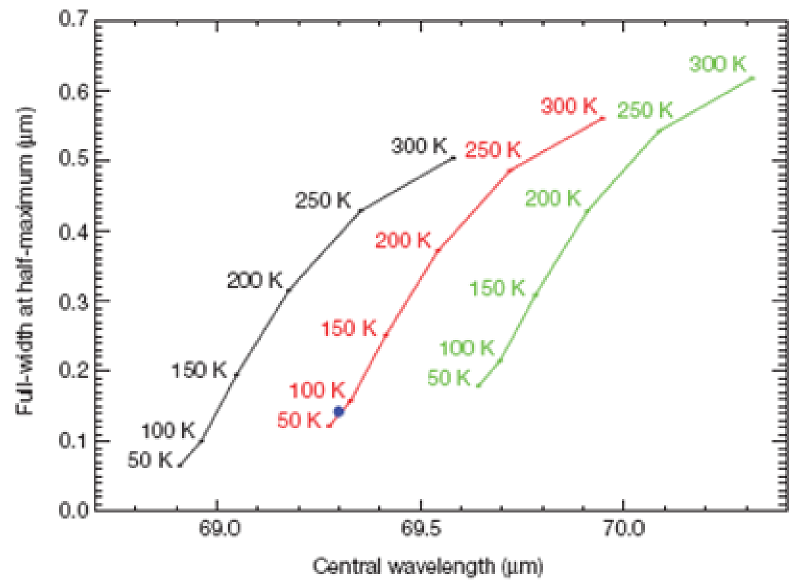


Figure 2 | Diagram demonstrating the dependence of the 69-μm band on grain temperature and composition. The diagram gives the width and central wavelength of the 69-μm band for six temperatures and for crystalline olivine ($Mg_{2-2x}Fe_{2x}SiO_4$) with $x = 0.0$ (black), $x = 0.01$ (red) and $x = 0.02$ (green). The width and central wavelength are measured by fitting Lorentzian profiles to laboratory measurements[23,24] of crystalline olivine at different temperatures and compositions (see Supplementary Information for additional

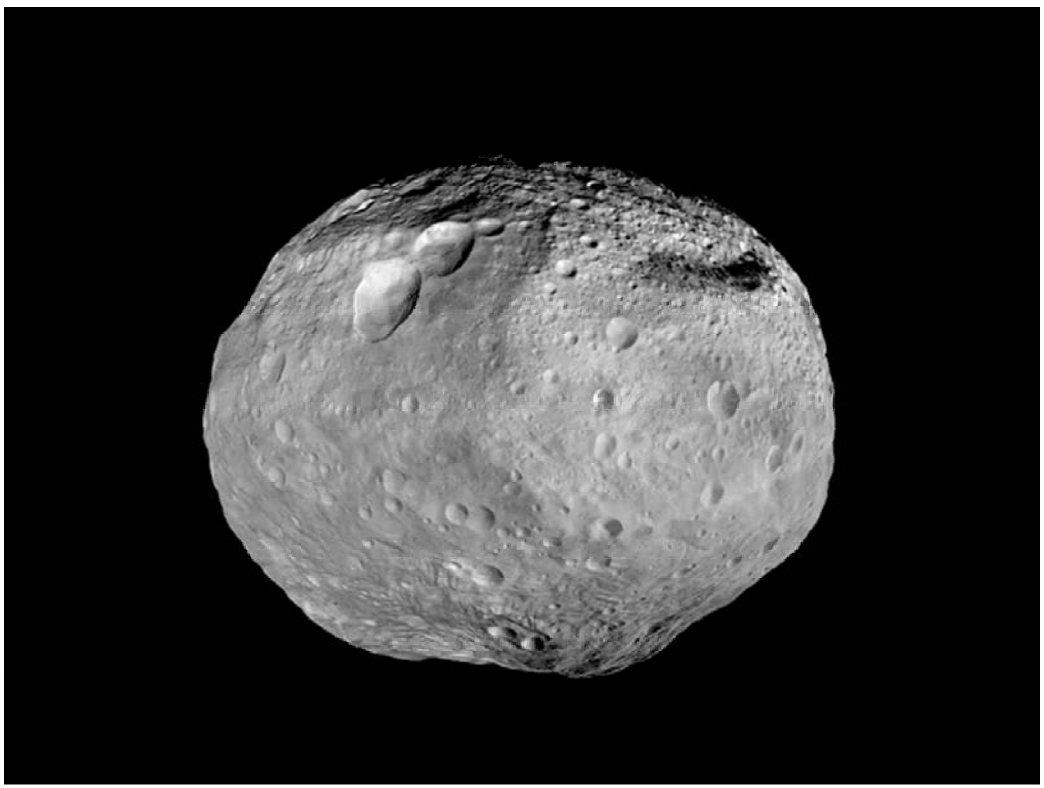
LETTER

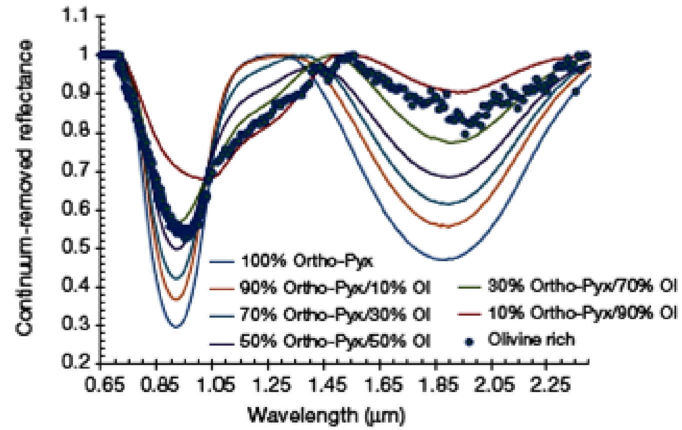
00 MONTH 2013 | VOL 000 | NATURE | 1

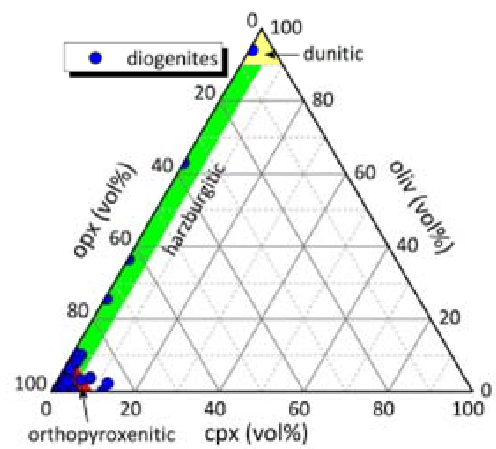
doi:10.1038/nature12665

Olivine in an unexpected location on Vesta's surface

E. Ammannito[1], M. C. De Sanctis[1], E. Palomba[1], A. Longobardo[1], D. W. Mittlefehldt[2], H. Y. McSween[3], S. Marchi[1,4], M. T. Capria[1], F. Capaccioni[1], A. Frigeri[1], C. M. Pieters[5], O. Ruesch[6], F. Tosi[1], F. Zambon[1], F. Carraro[1], S. Fonte[1], H. Hiesinger[6], G. Magni[1], L. A. McFadden[7], C. A. Raymond[8], C. T. Russell[9] & J. M. Sunshine[10]







THE JOURNAL OF PHYSICAL CHEMISTRY C

Article

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Ab Initio Calculations of the Main Crystal Surfaces of Forsterite (Mg_2SiO_4): A Preliminary Study to Understand the Nature of Geochemical Processes at the Olivine Interface

M. Bruno,[*,†] F. R. Massaro,[‡] M. Prencipe,[†] R. Demichelis,[§] M. De La Pierre,[∥] and F. Nestola[‡]

[†]Dipartimento di Scienze della Terra, Università degli Studi di Torino, Via Valperga Caluso 35, 10125 Torino, Italy

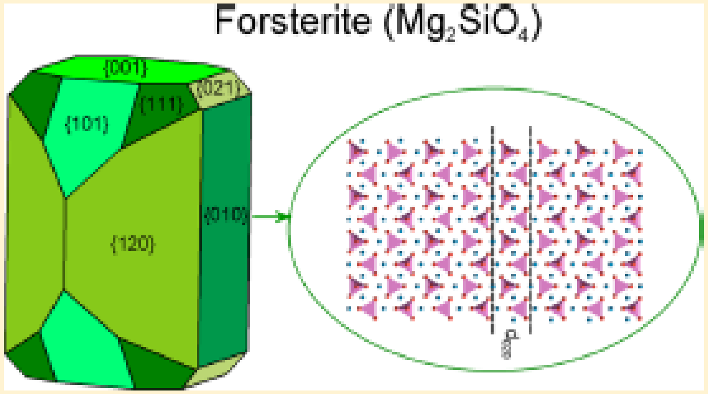
[‡]Dipartimento di Geoscienze, Università degli Studi di Padova, Via Gradenigo 6, 35131 Padova, Italy

[§]Nanochemistry Research Institute, Department of Chemistry, Curtin University, P.O. Box U1987, Perth, WA 6845, Australia

[∥]Dipartimento di Chimica, Università degli Studi di Torino and NIS -Nanostructured Interfaces and Surfaces - Centre of Excellence, Via P. Giuria 7, 10125 Torino, Italy

Supporting Information

ABSTRACT: We present an accurate ab initio study of the structure and surface energy at 0 K of the (010), (101), (111), (001), (110), (120), and (021) faces of forsterite (Mg_2SiO_4) using the hybrid Hartree–Fock/density functional B3LYP Hamiltonian and a localized all-electron Gaussian-type basis set. According to the surface energy values, the stability order of the forsterite faces was found to be (010) < (120) < (001) < (101) < (111) < (021) < (110). Then, the equilibrium shape of forsterite was drawn and compared with the previous ones obtained at an empirical level. Our results were combined with experimental evidence to develop some considerations about the shape and genesis of olivine included in diamond. They provide crucial information on the diamond formation mechanism with respect to its guest inclusions, a topic that is still under strong debate in the scientific community. In particular, we discuss the peculiar crystal morphology of olivine included in diamond, and we demonstrate that it cannot be considered as evidence of syngenesis (i.e., inclusion and host diamond formed at the same time). Furthermore, if the morphology of olivine is modified during its encapsulation in diamond but it does not show a preferential orientation with respect to diamond, we can state that (i) the bulk of olivine is protogenetic (i.e., a piece of previously formed olivine is encapsulated by the host diamond), whereas (ii) its shape is syngenetic, that is, the morphology is rearranged during the encapsulation.



THE JOURNAL OF PHYSICAL CHEMISTRY C
Article
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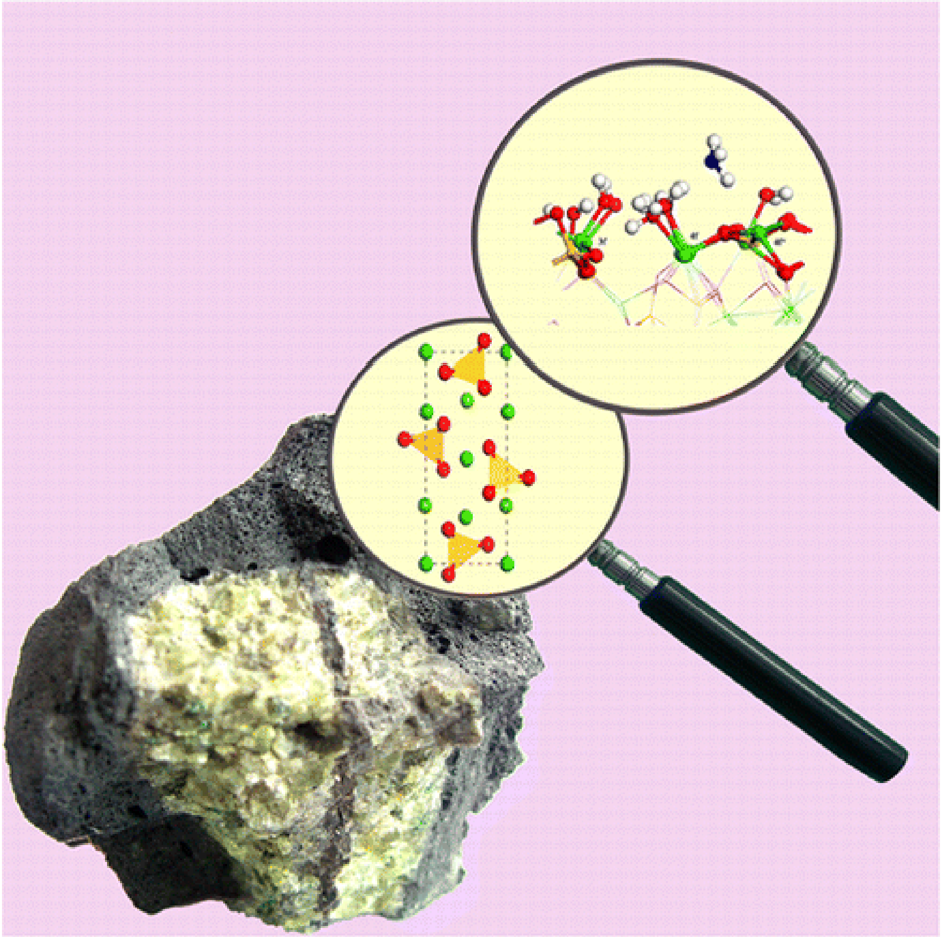
Amorphous Ammonia–Water Ice Deposited onto Silicate Grain: Effect on Growth of Mantles Ice on Interstellar and Interplanetary Dust

Elizabeth Escamilla-Roa*[,†,‡] and C. Ignacio Sainz-Díaz[‡]

[†]Instituto de Astrofísica de Andalucía (CSIC), Glorieta de la Astronomía s/n, 18008 Granada, Spain
[‡]Instituto Andaluz de Ciencias de la Tierra (CSIC-UGR), Avenida de las Palmeras 4, 18100 Granada, Spain



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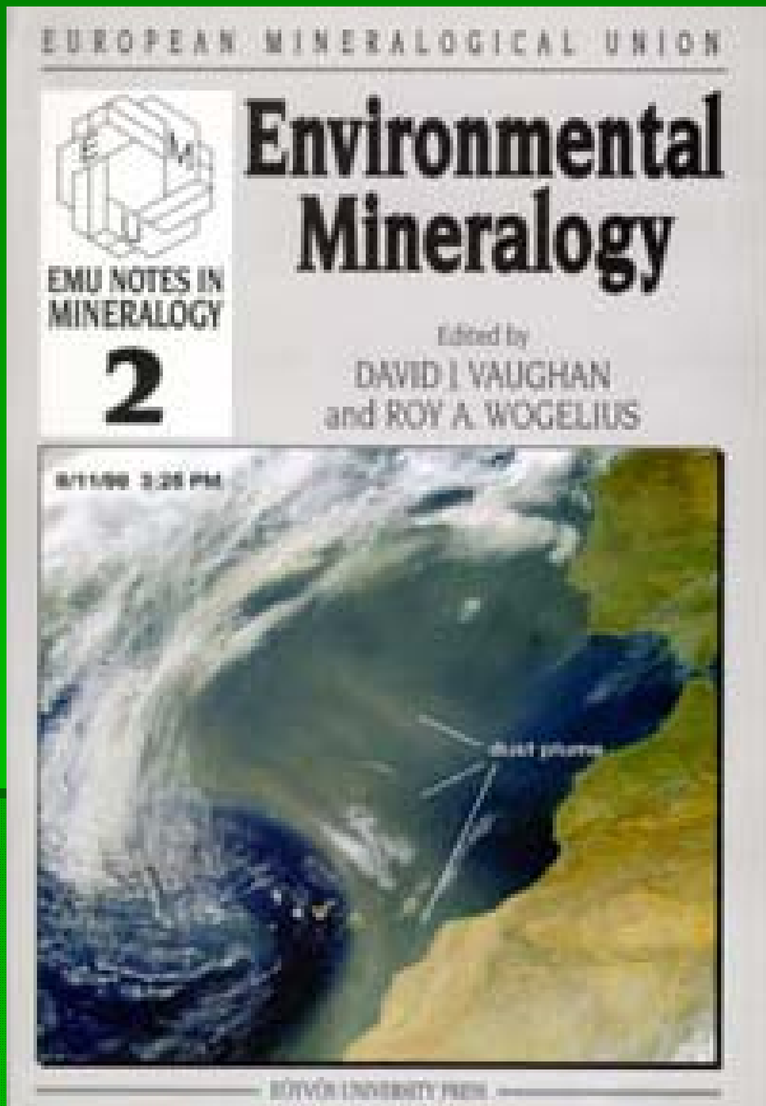
ENVIRONMENTAL MINERALOGY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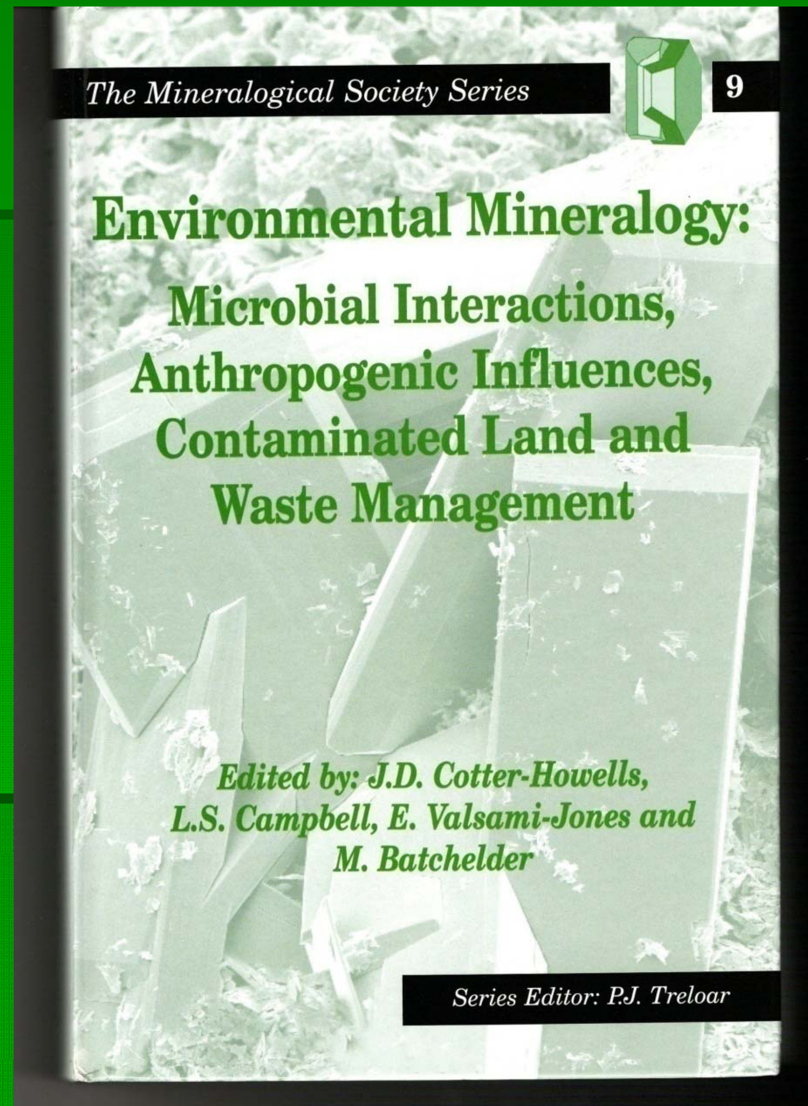
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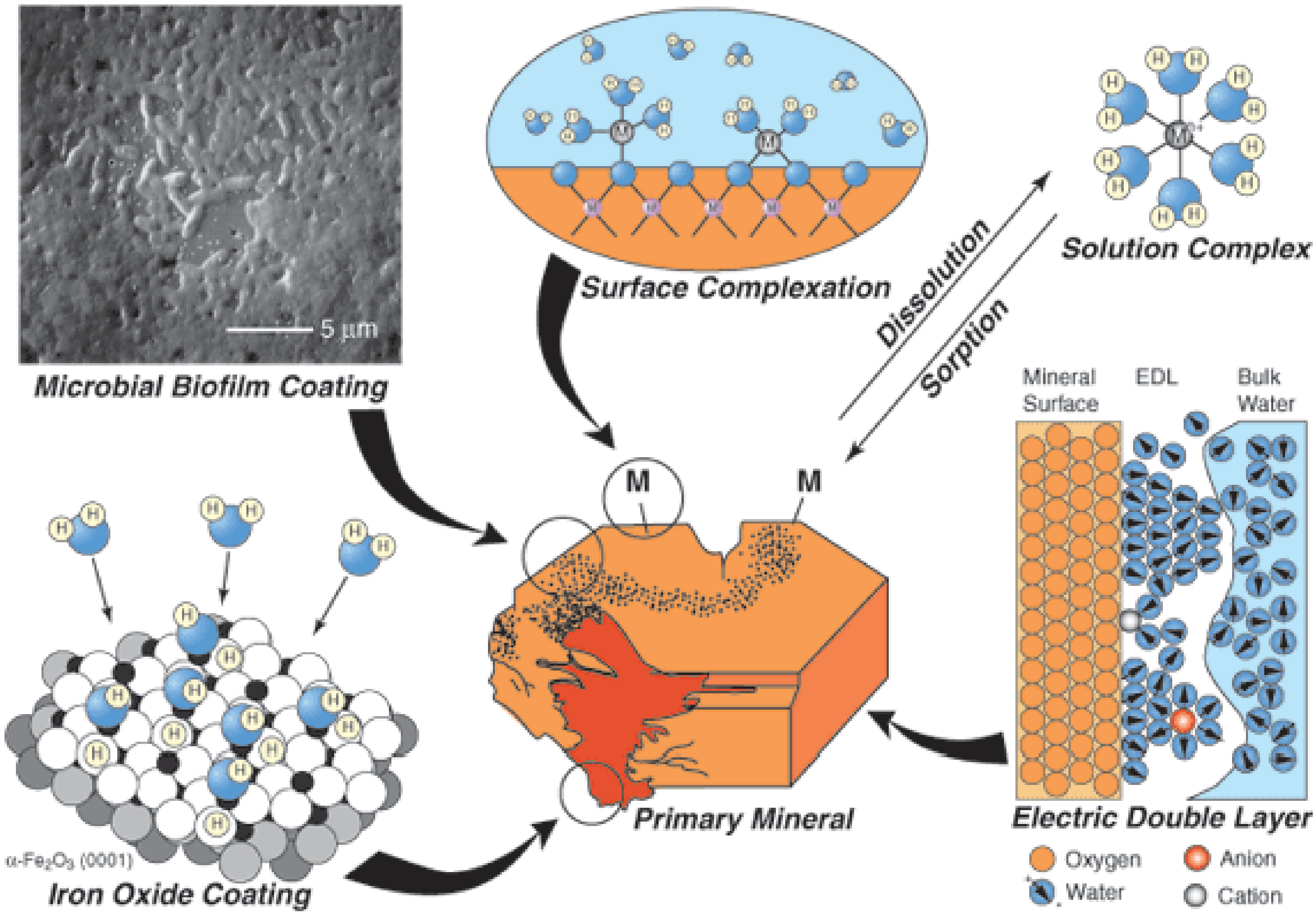
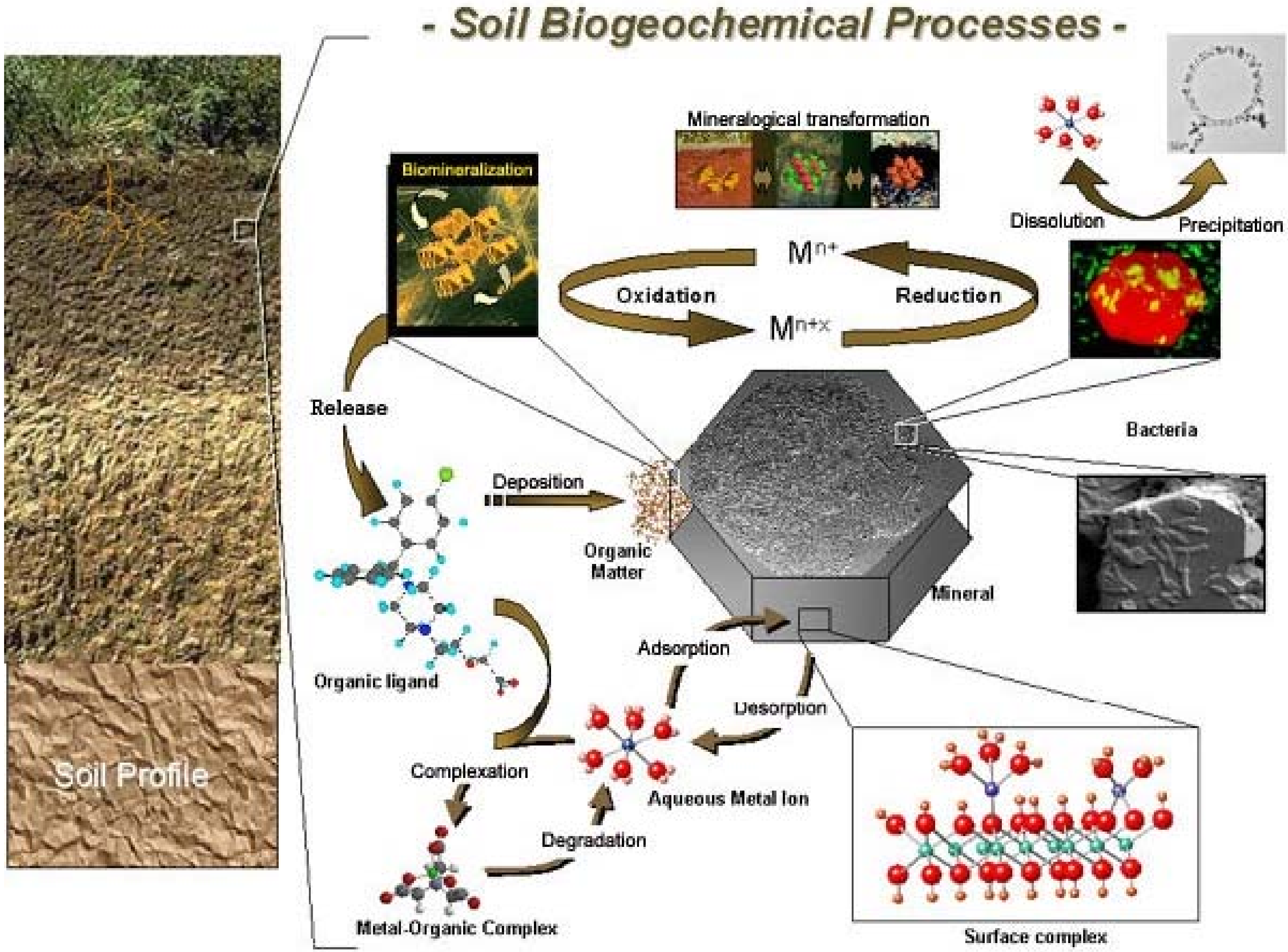


BROWN Jr., Science 2001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Precipitation
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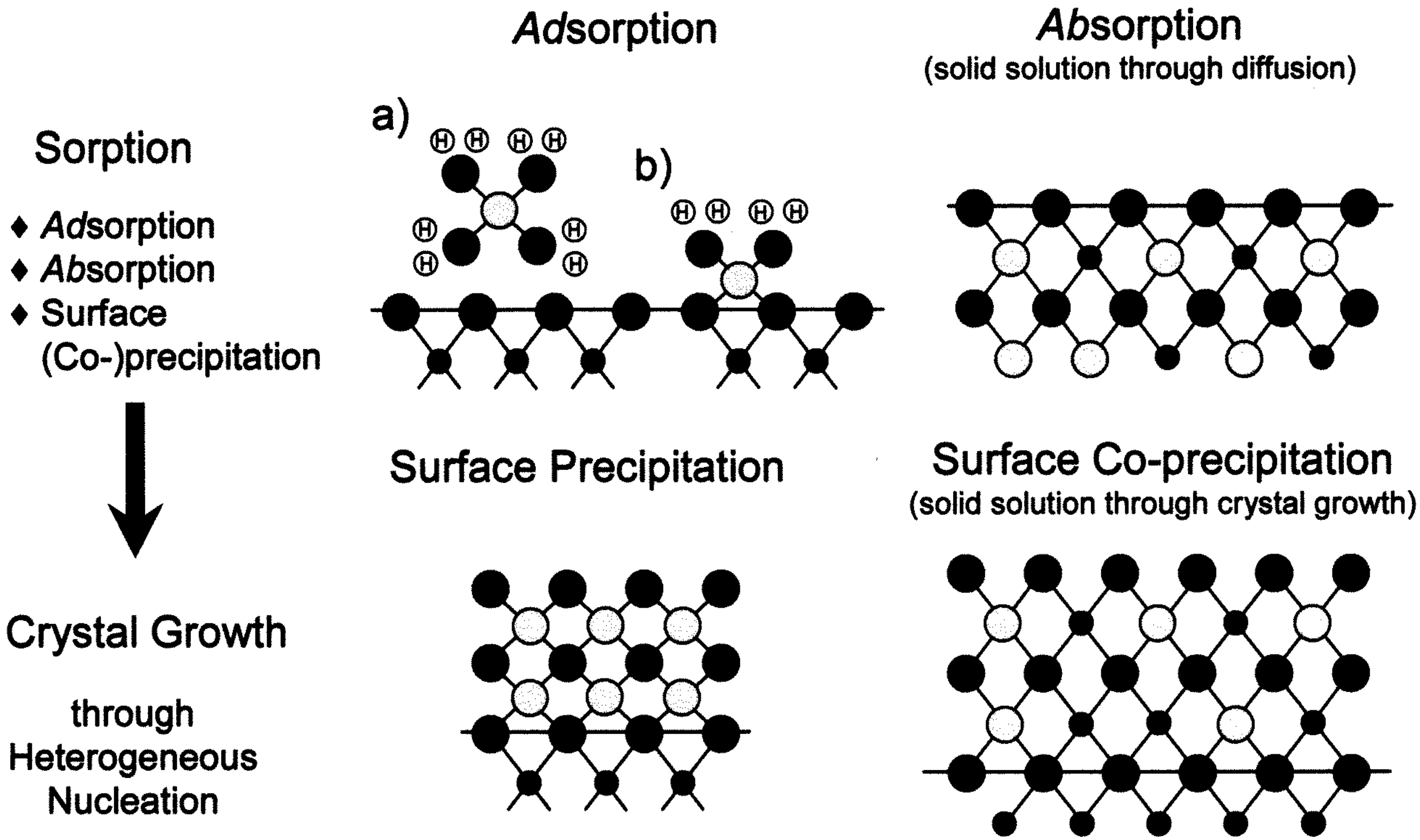
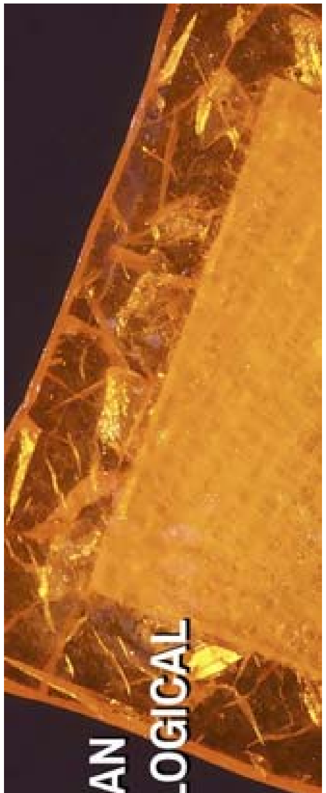
Oxidation
Reduction
M^{n+x}
Release
Bacteria
Deposition
Organic Matter
Mineral
Organic ligand
Adsorption
Desorption
Complexation
Aqueous Metal Ion
Degradation
Metal-Organic Complex
Surface complex
Soil Profile



GODELITSAS & ASTILLEROS, EMU Notes 2010



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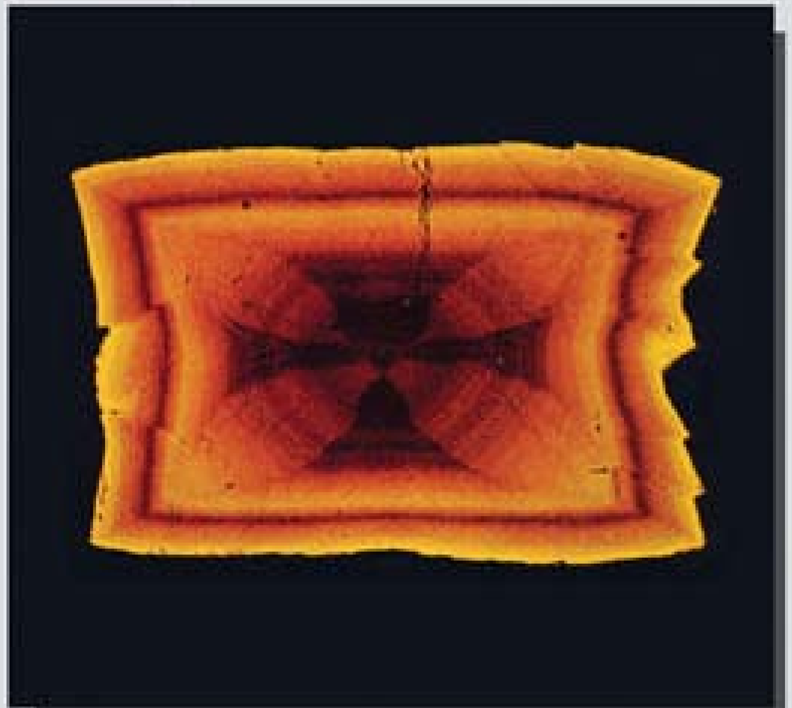
EMU NOTES IN MINERALOGY
10

Ion partitioning in ambient-temperature aqueous systems

Editors
MANUEL PRIETO and HEATHER STOLL



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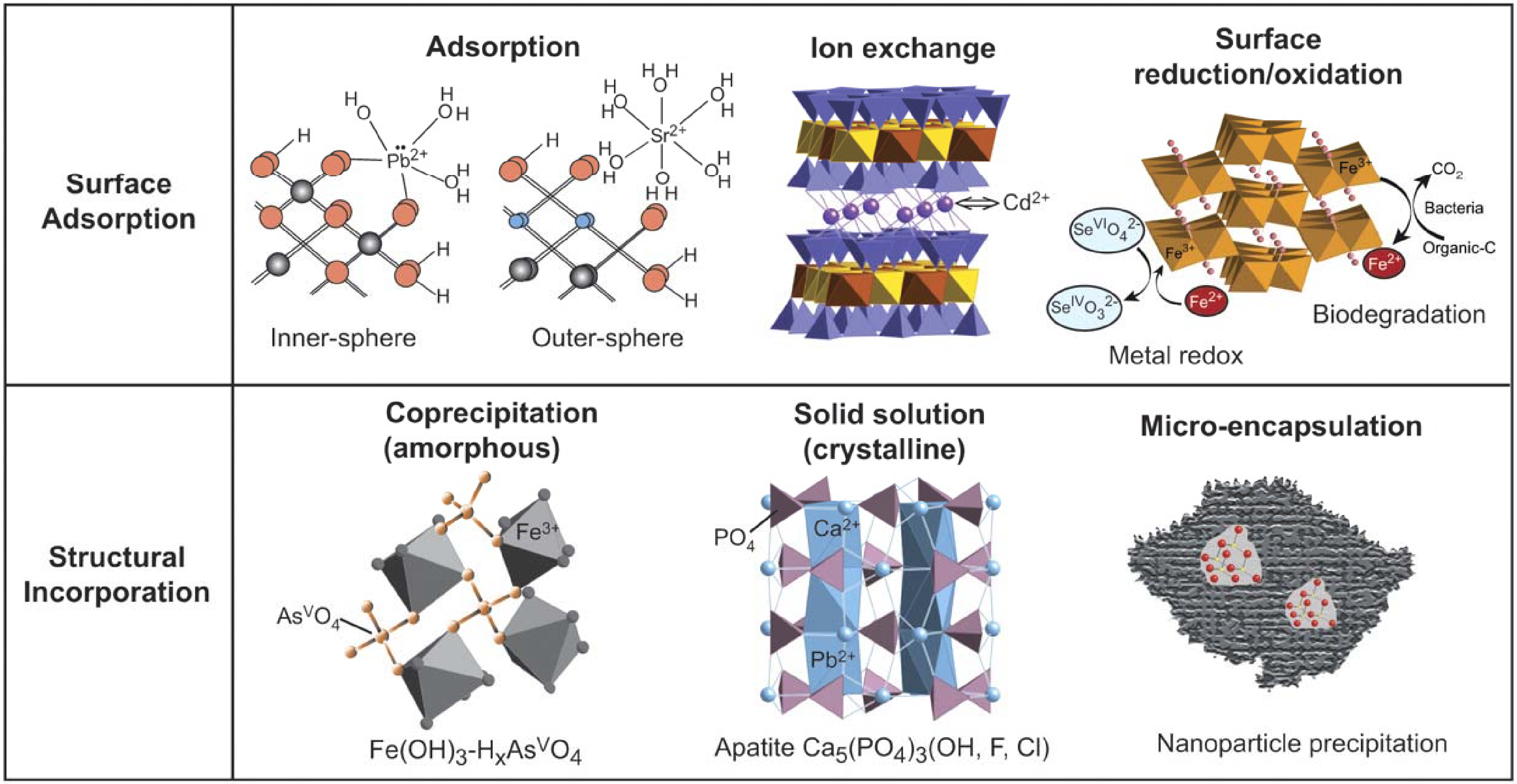
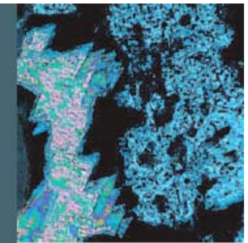


O'DAY & VLASSOPOULOS, Elements 2010

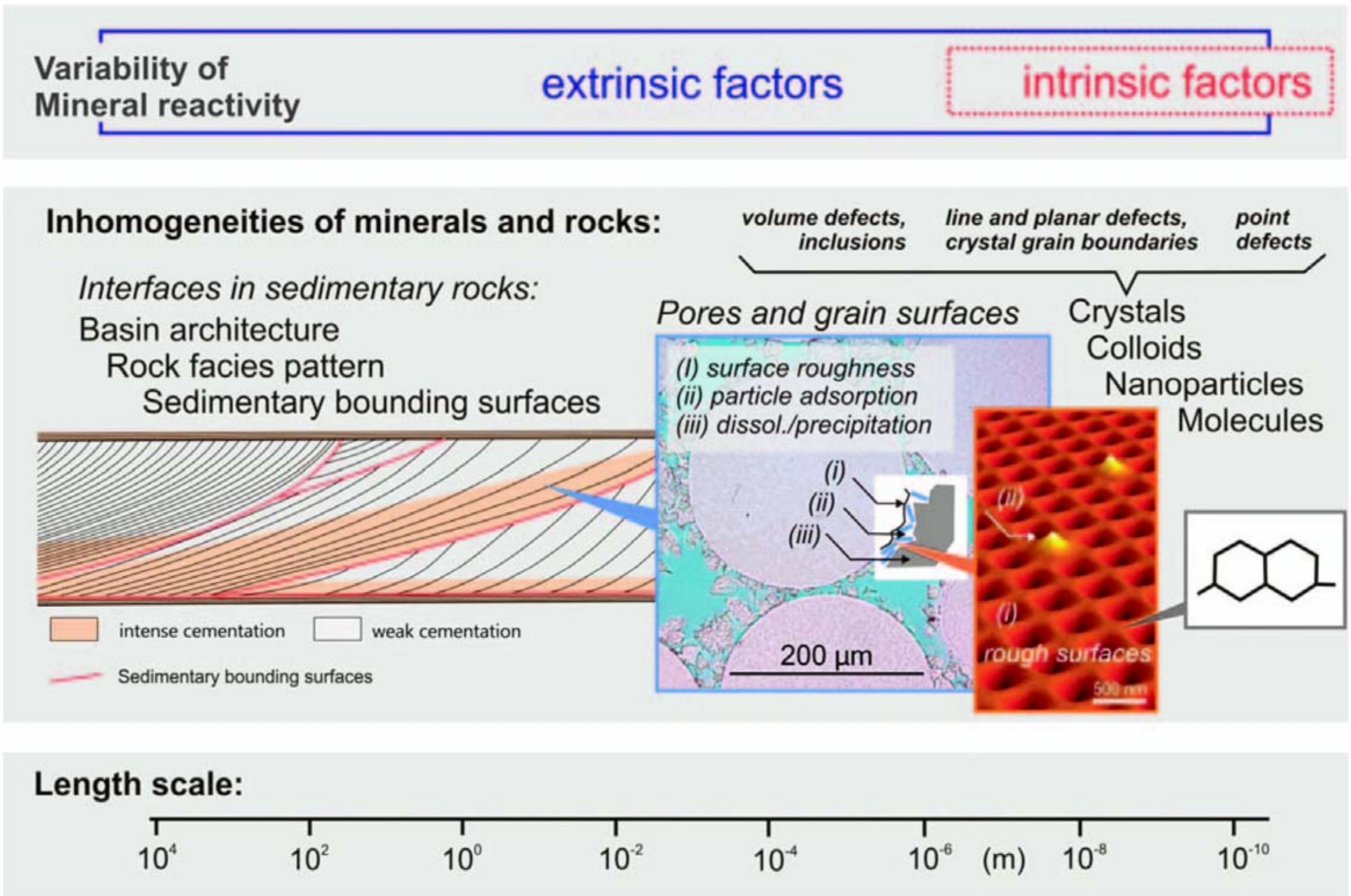
A Stochastic Treatment of Crystal Dissolution Kinetics

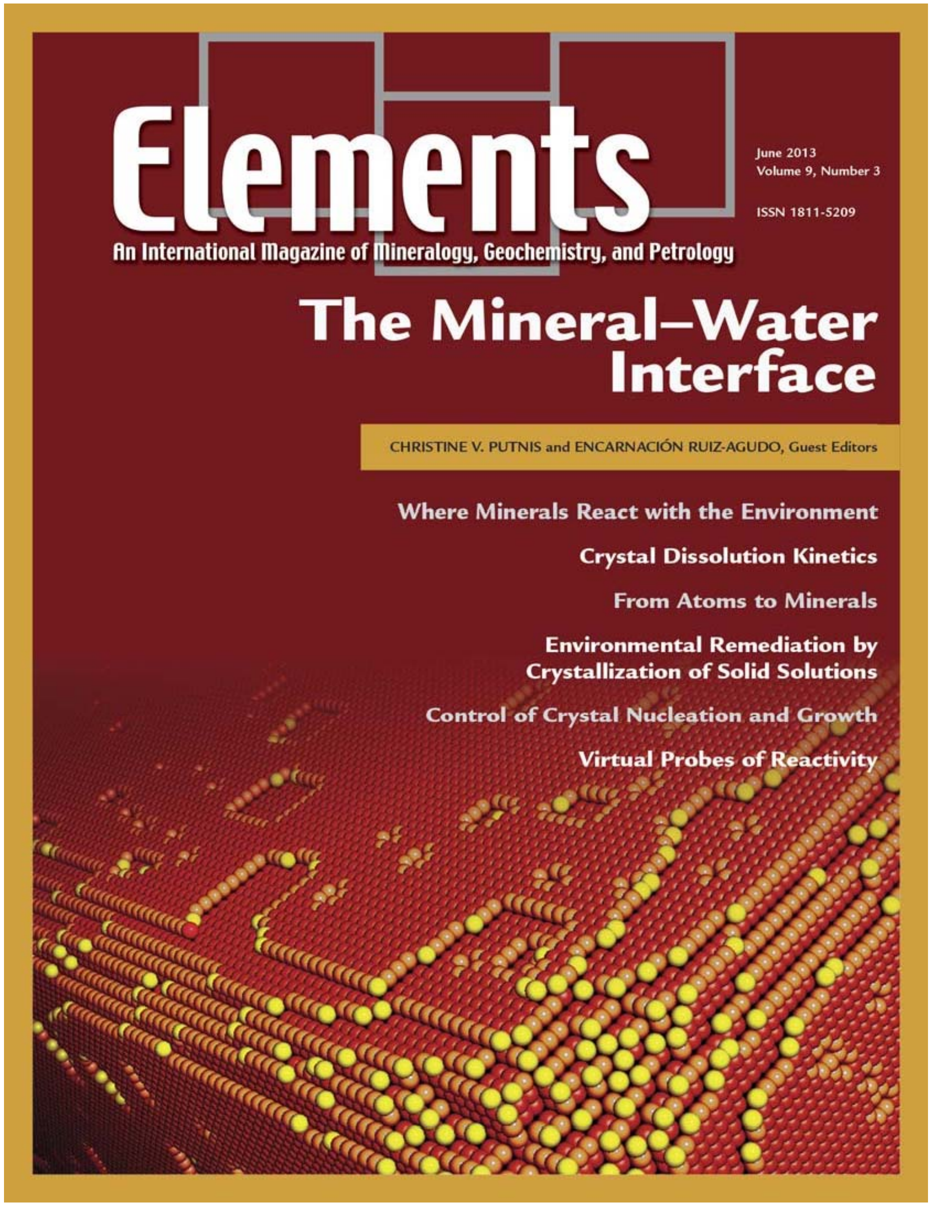
Andreas Lüttge[1*,2,3], Rolf S. Arvidson[1,2], and Cornelius Fischer[1,2]

1811-5209/13/0009-183$2.50 DOI: 10.2113/gselements.9.3.183



Dissolution of diagenetic pore-filling calcite (left) and barite (right) highlight variability in reactivity (Permian Upper Rotliegend sandstone, 200 µm image, crossed nicols).




Elements
June 2013
Volume 9, Number 3
ISSN 1811-5209
An International Magazine of Mineralogy, Geochemistry, and Petrology
The Mineral–Water Interface
CHRISTINE V. PUTNIS and ENCARNACIÓN RUIZ-AGUDO, Guest Editors
Where Minerals React with the Environment
Crystal Dissolution Kinetics
From Atoms to Minerals
Environmental Remediation by Crystallization of Solid Solutions
Control of Crystal Nucleation and Growth
Virtual Probes of Reactivity


NOVEMBER 28, 2013
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Kinetic Monte Carlo Simulations: Our Opportunity to Predict Crystal Dissolution Mechanisms, Surface Topographies (see page 5A)
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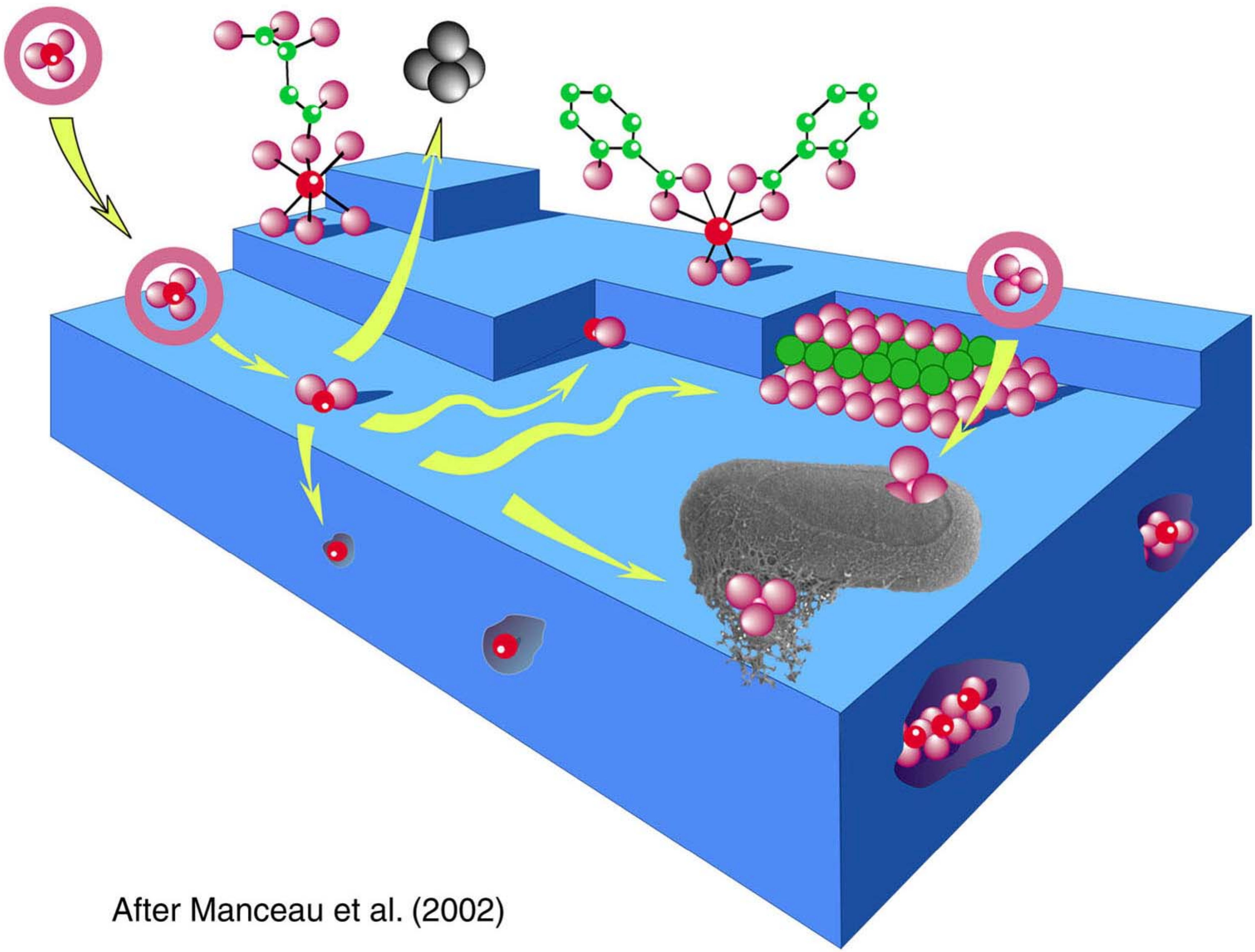
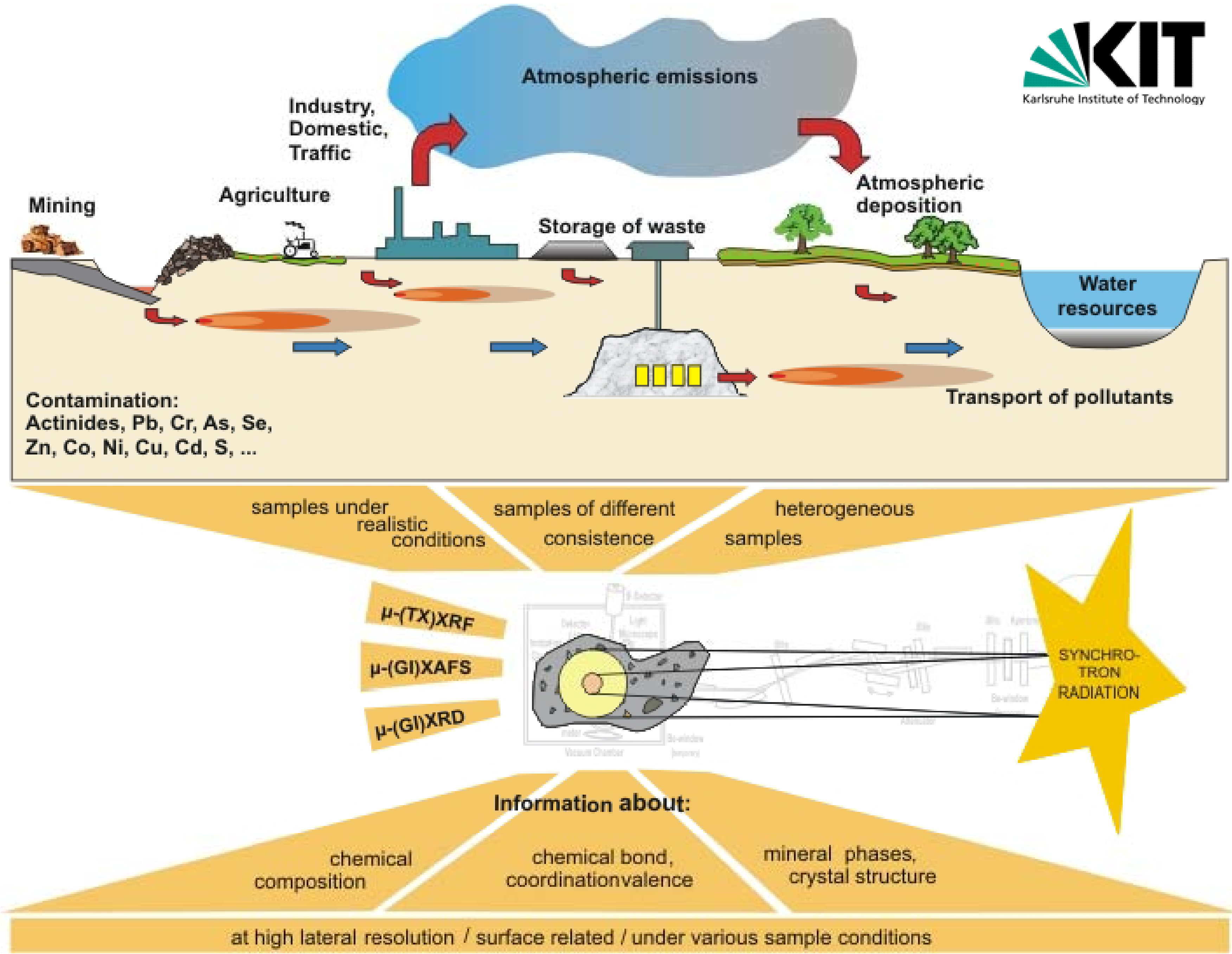


After Manceau et al. (2002)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Traffic
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Mining
Agriculture
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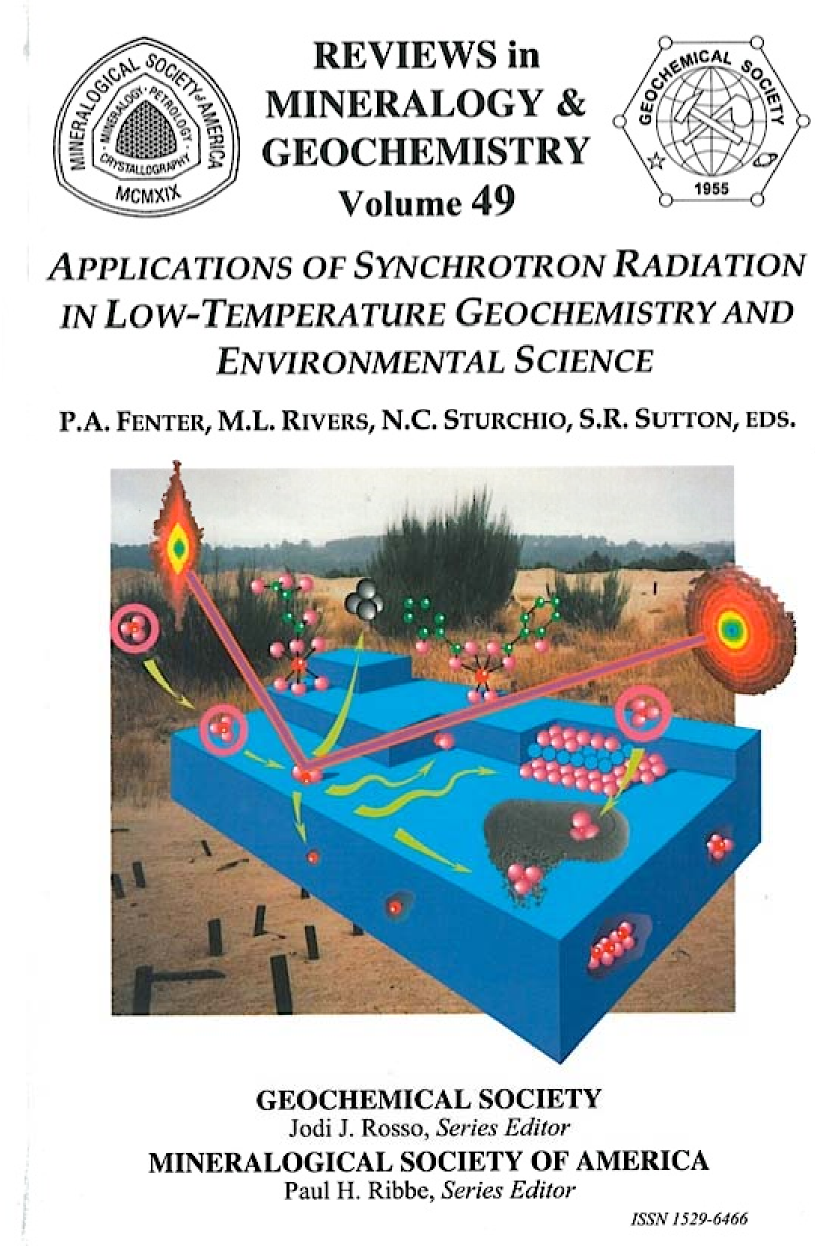
Water
resources
Transport of pollutants
Contamination:
Actinides, Pb, Cr, As, Se,
Zn, Co, Ni, Cu, Cd, S, ...
samples under
realistic
conditions
samples of different
consistence
heterogeneous
samples
μ-(TX)XRF
μ-(GI)XAFS
μ-(GI)XRD
SYNCHRO-
TRON
RADIATION
Information about:
chemical
composition
chemical bond,
coordinationvalence
mineral phases,
crystal structure
at high lateral resolution / surface related / under various sample conditions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1955
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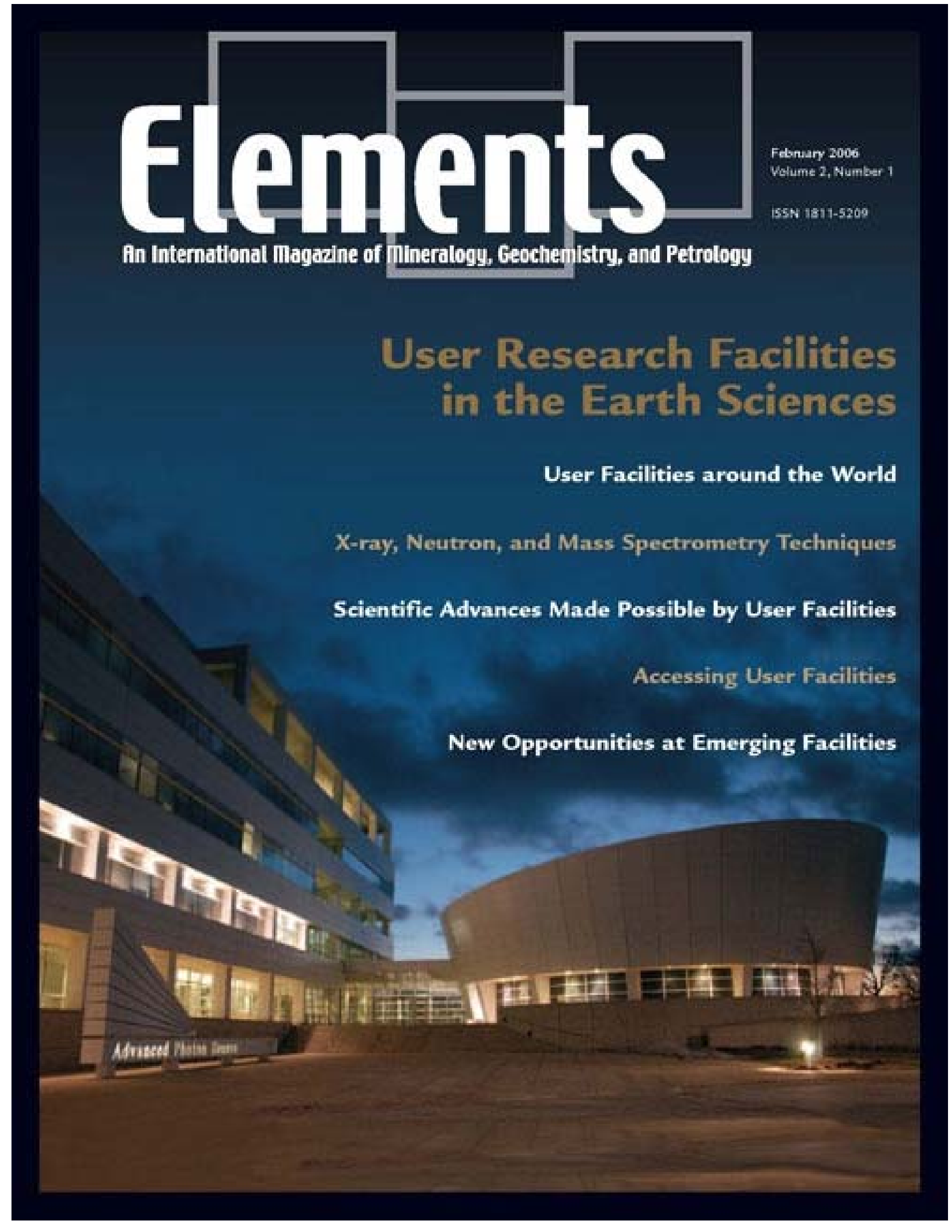
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ISSN 1811-5209
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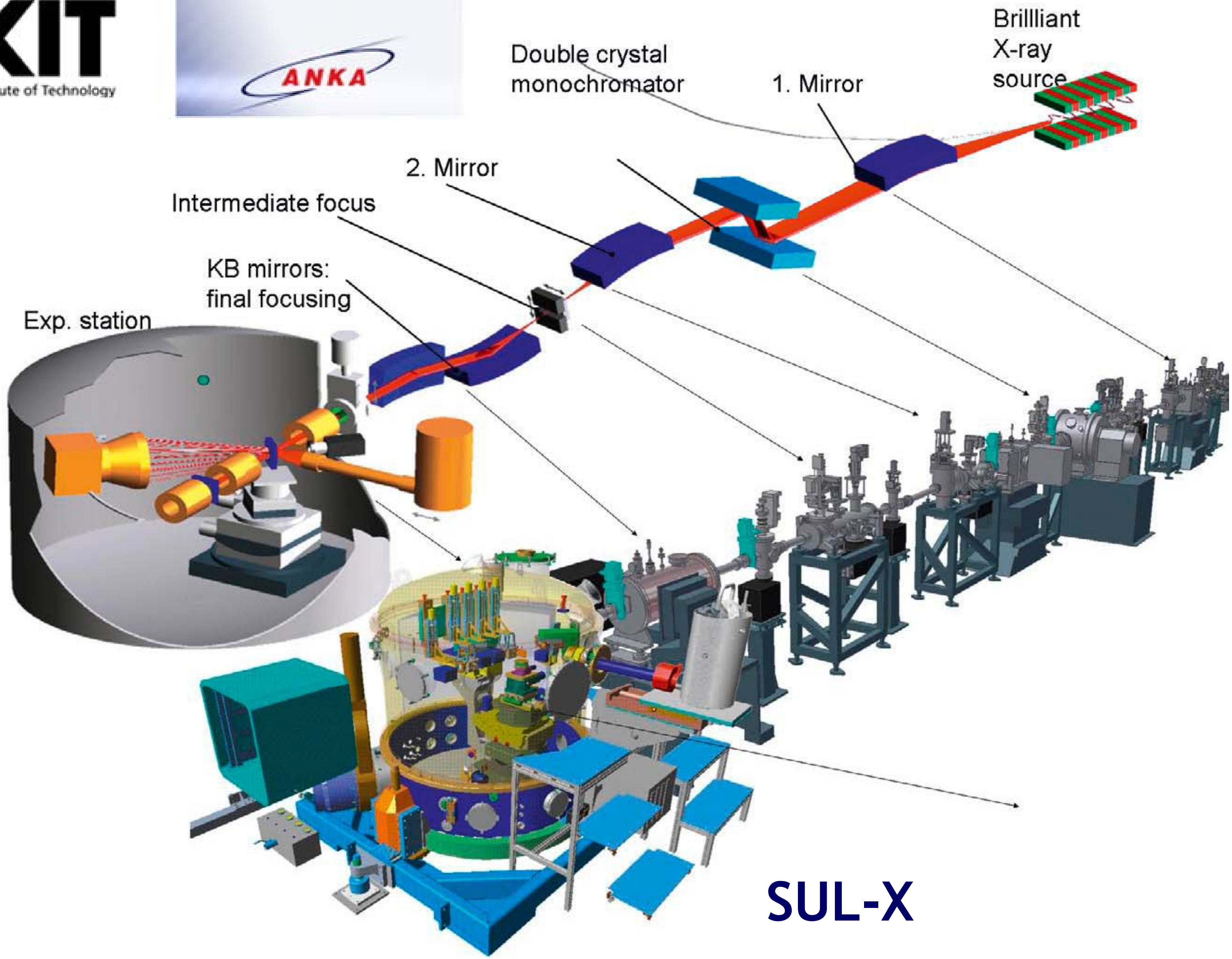
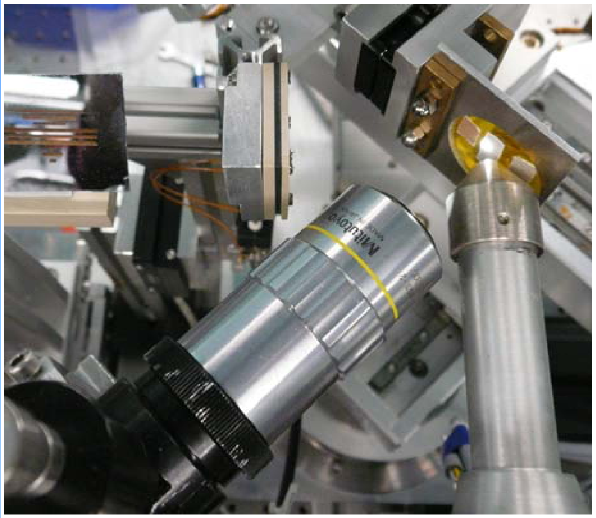
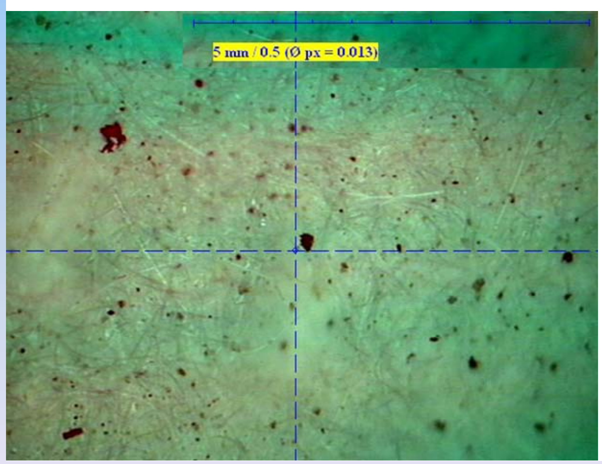

Brillliant
X-ray
source
Double crystal
monochromator
1. Mirror
2. Mirror
Intermediate focus
KB mirrors:
final focusing
Exp. station

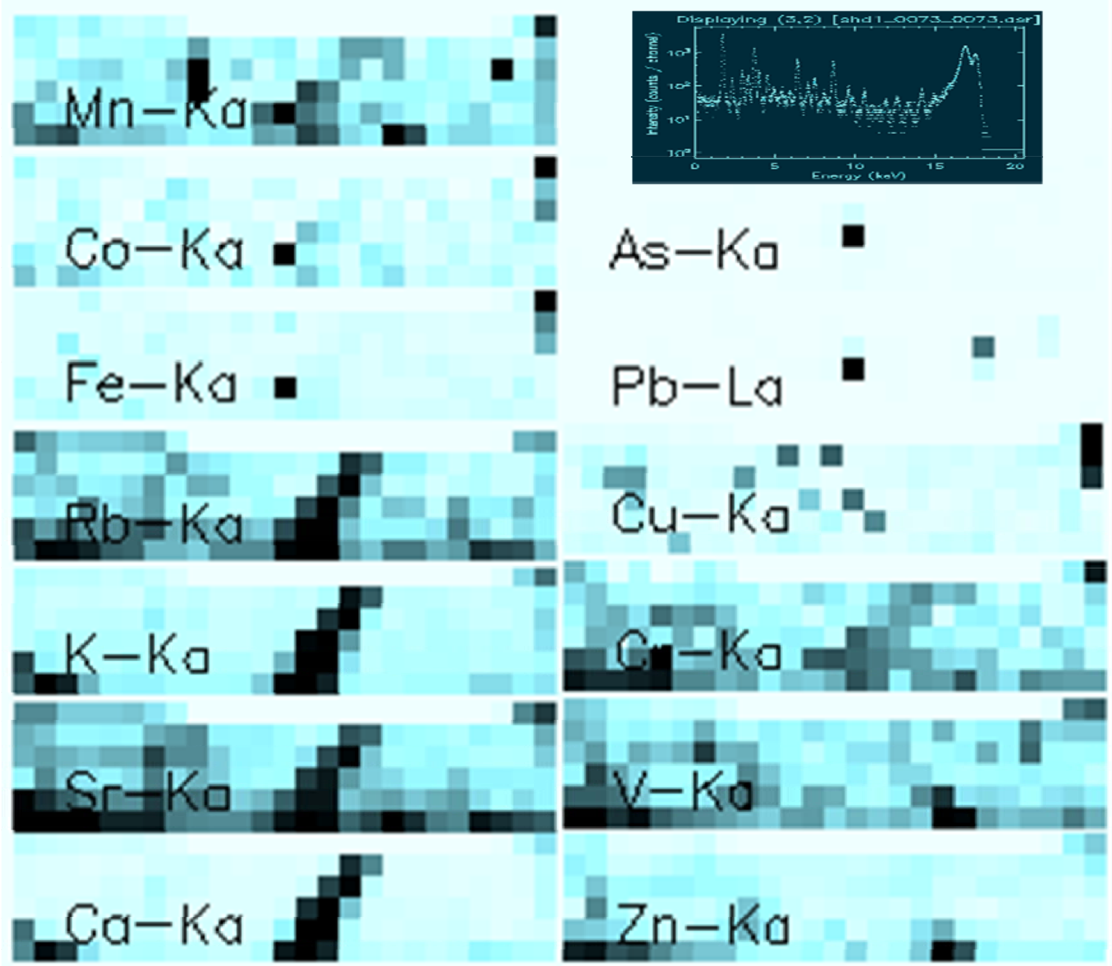
SUL-X


Athens megacity (~4 million people)
URBAN ATMOSPHERIC PARTICLES

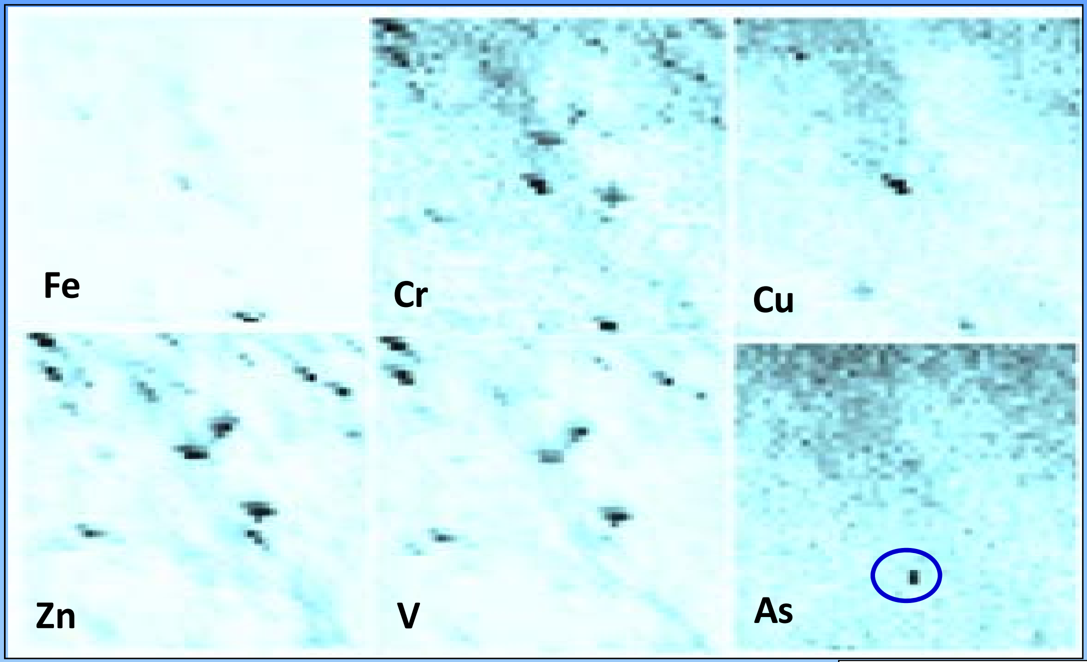
Synchrotron micro-XRF analyses



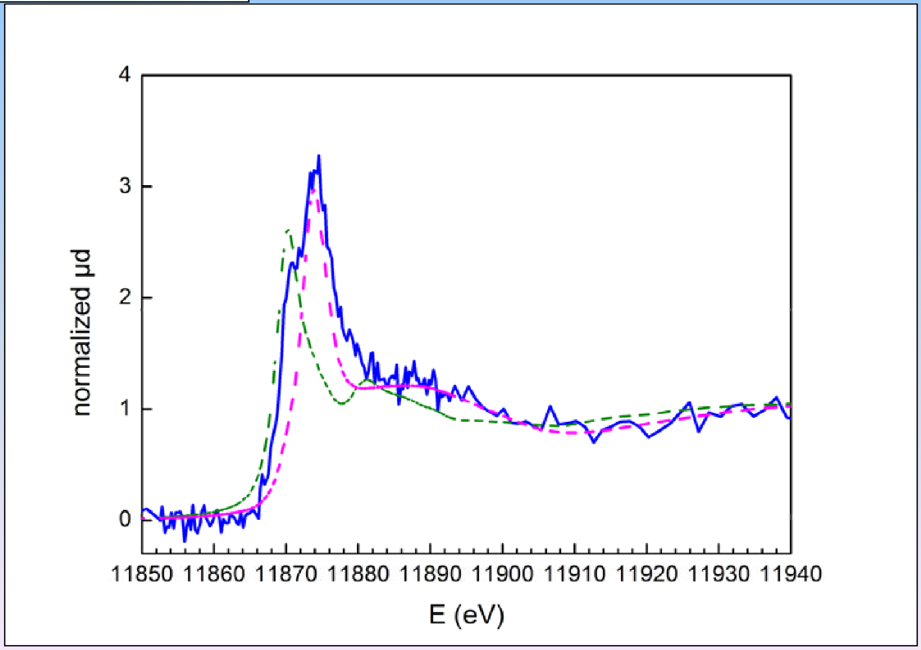




GODELITSAS et al., NIMB 2011



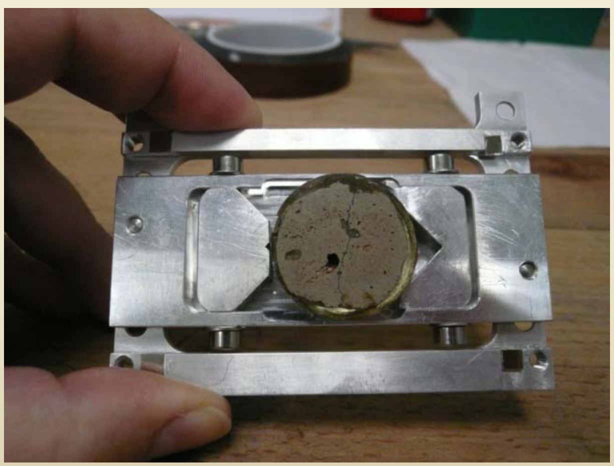
Combined micro-XRF/-XANES

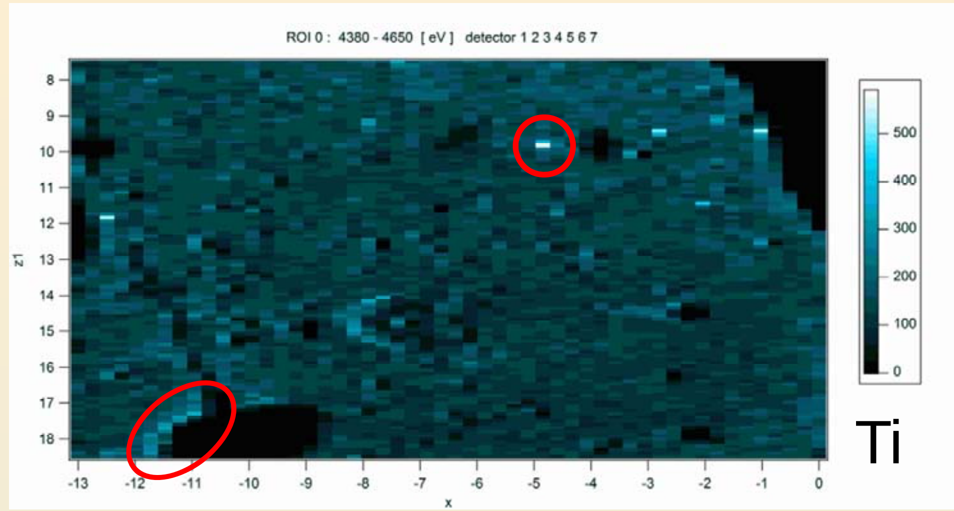


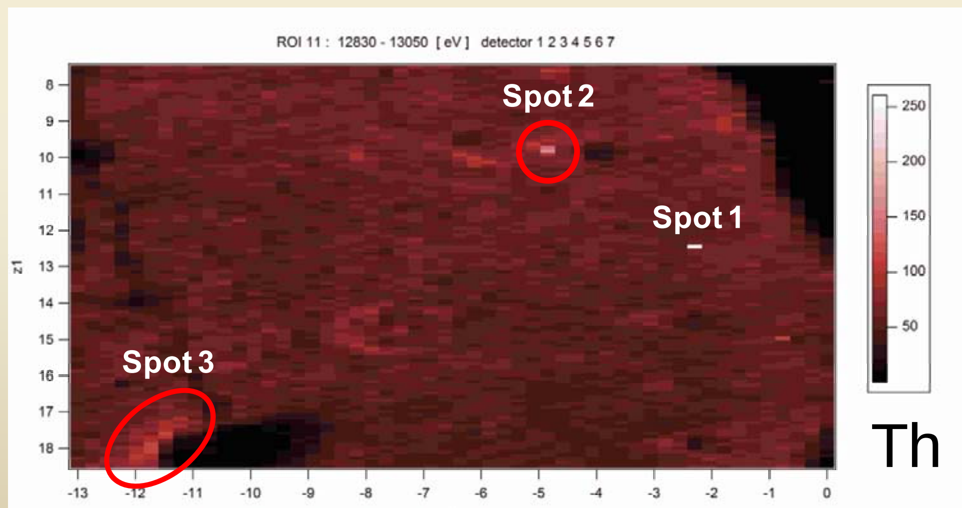
As speciation (As^{5+}, As^{3+})

GODELITSAS et al., NIMB 2011

ACTINIDES IN GREEK Al-ORE (BAUXITE)

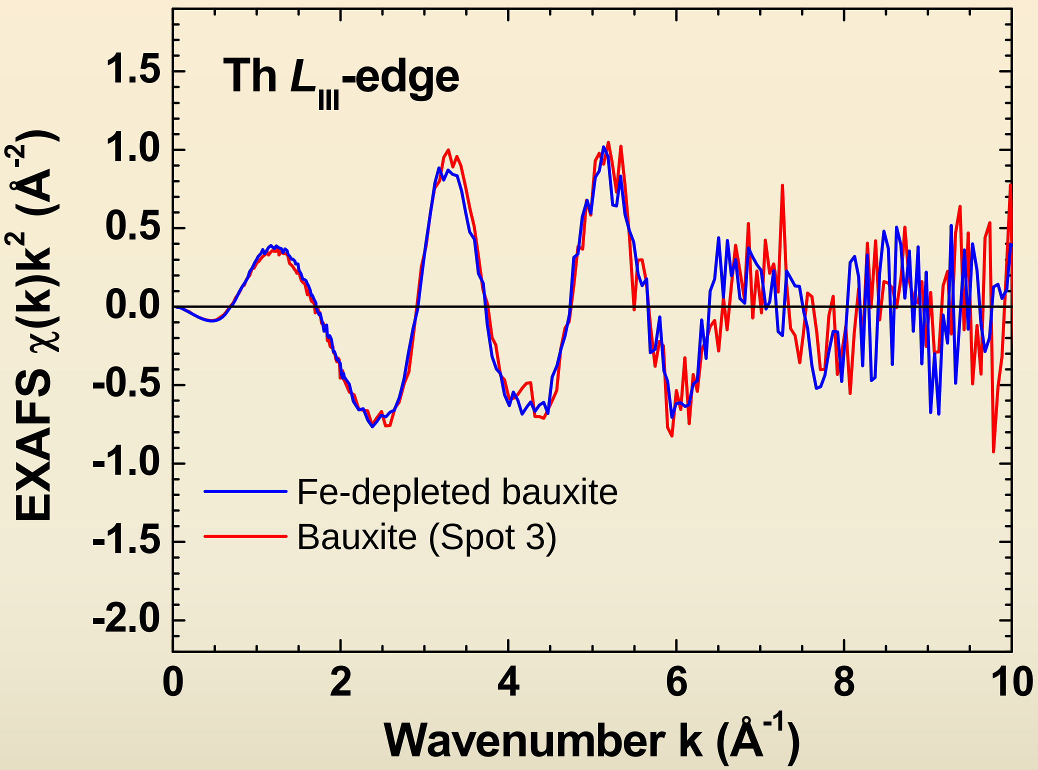




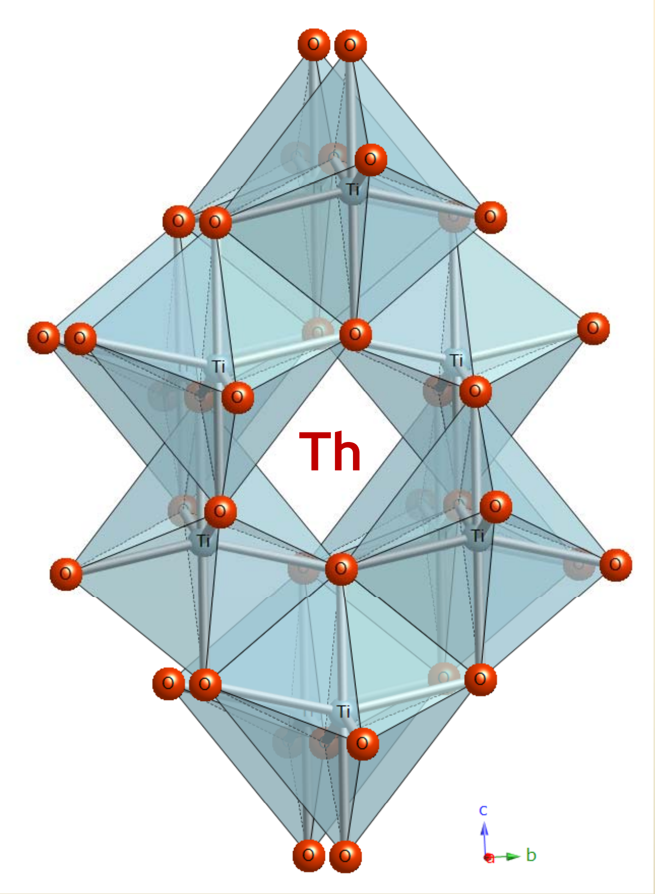


GAMALETSOS et al., NIMB 2011

ACTINIDES IN GREEK Al-ORE (BAUXITE)



micro-EXAFS



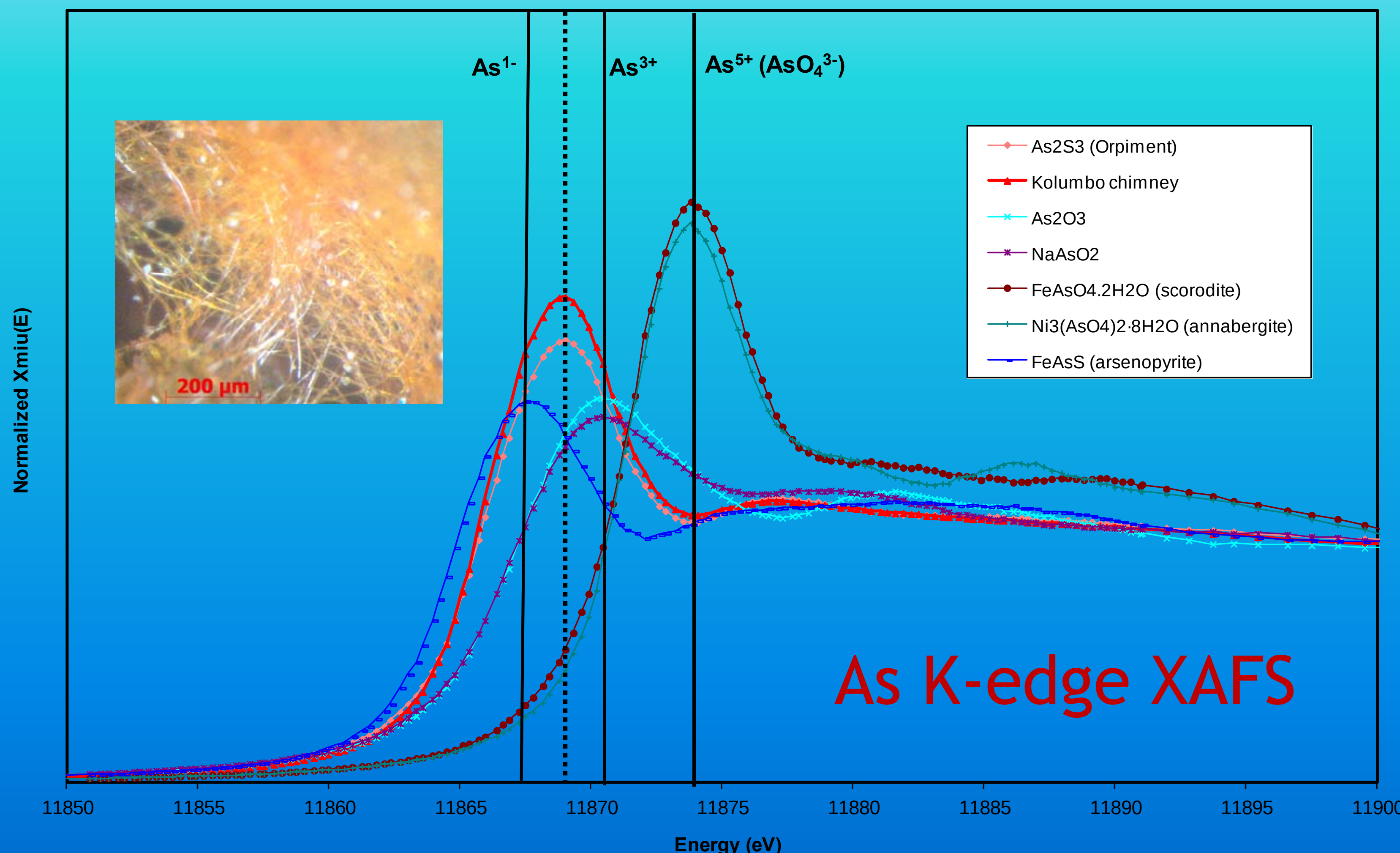
Anatase
(TiO_2 polymorph)

GAMALETSOS et al., NIMB 2011

Fe- & As-(BIO)MINERALS
FROM AEGEAN SUBMARINE VOLCANOES

KILIAS et al., Sci. Reports 2013

Fe- & As-(BIO)MINERALS FROM AEGEAN SUBMARINE VOLCANOES

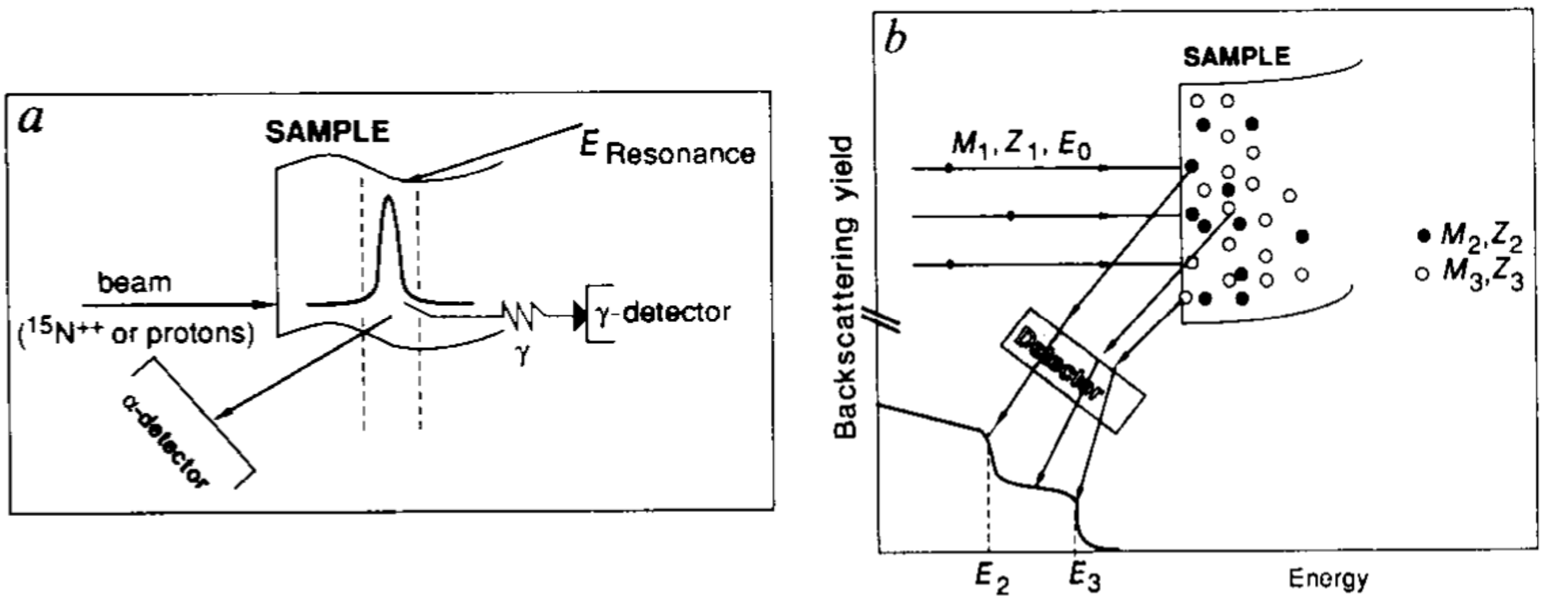


KILIAS et al., Sci. Reports 2013

Energetic ion beam analysis in the Earth sciences

J.-C. Petit, J.-C. Dran & G. Della Mea

Analytical techniques using energetic ion beams are now being used to address important problems of water–rock interaction and mantle dynamics. Their unique capability is to probe the outermost few micrometres of minerals and glasses, providing multi-element depth profiles of this very important surface layer.



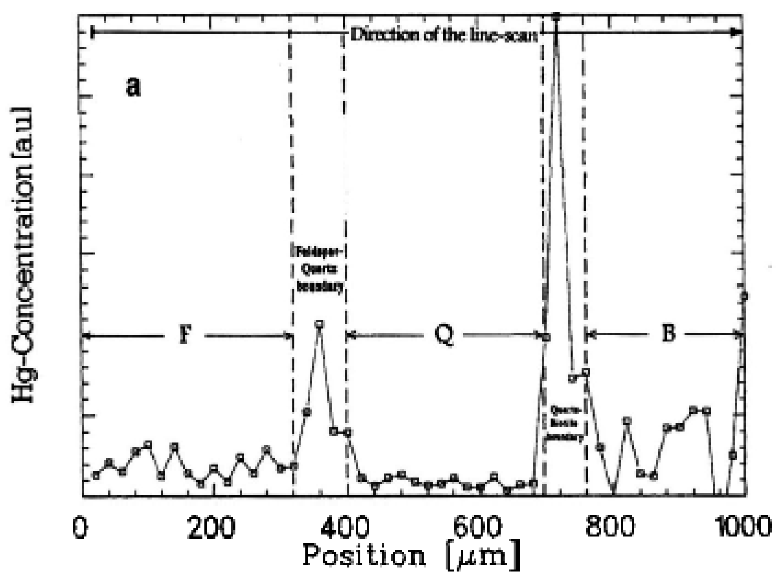
Radiochim. Acta **83**, 43–48 (1998)

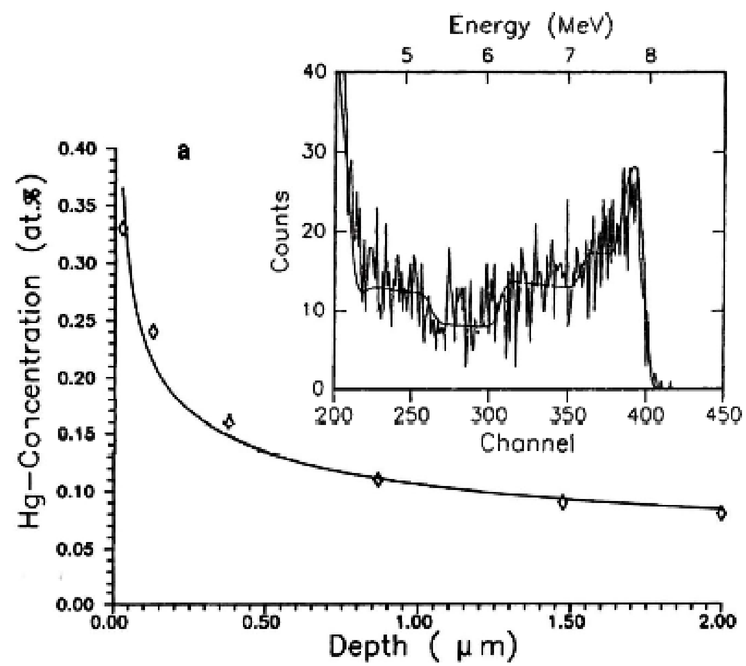
Application of Proton Microprobe and ^{12}C-Rutherford Backscattering Spectroscopy to the Identification of Hg(II)-Cations Sorbed by Granite Minerals

By P. Misaelides[1,*], A. Godelitsas[1], A. Stephan[2], J. Meijer[2], C. Rolfs[2], S. Harissopulos[3], M. Kokkoris[3] and A. Filippidis[4]

[1] Department of Chemistry, Aristotle University of Thessaloniki, P.O. Box 1547, GR-54006 Thessaloniki, Greece
[2] Institut für Physik mit Ionenstrahlen, Ruhr-Universität Bochum, D-44780 Bochum, Germany
[3] Nuclear Physics Institute, N.R.C.P.S. "Demokritos", GR-15310 Aghia Paraskevi, Attiki, Greece
[4] Department of Geology, Aristotle University of Thessaloniki, GR-54006 Thessaloniki, Greece

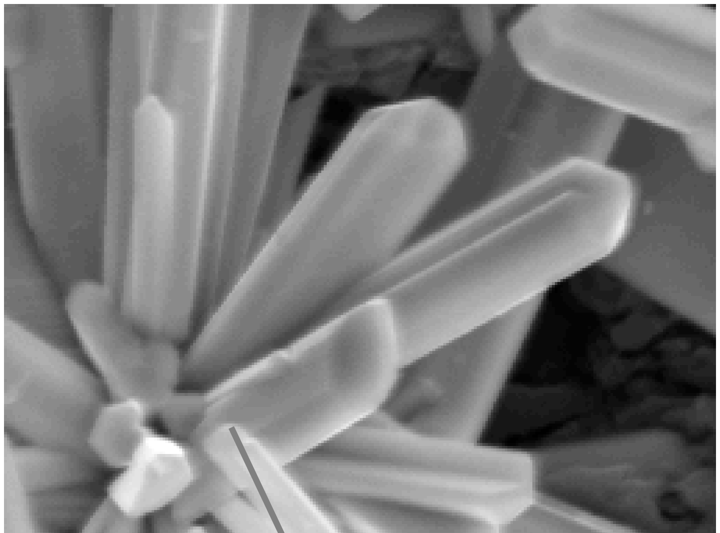
(Received November 5, 1997; accepted in final form June 22, 1998)

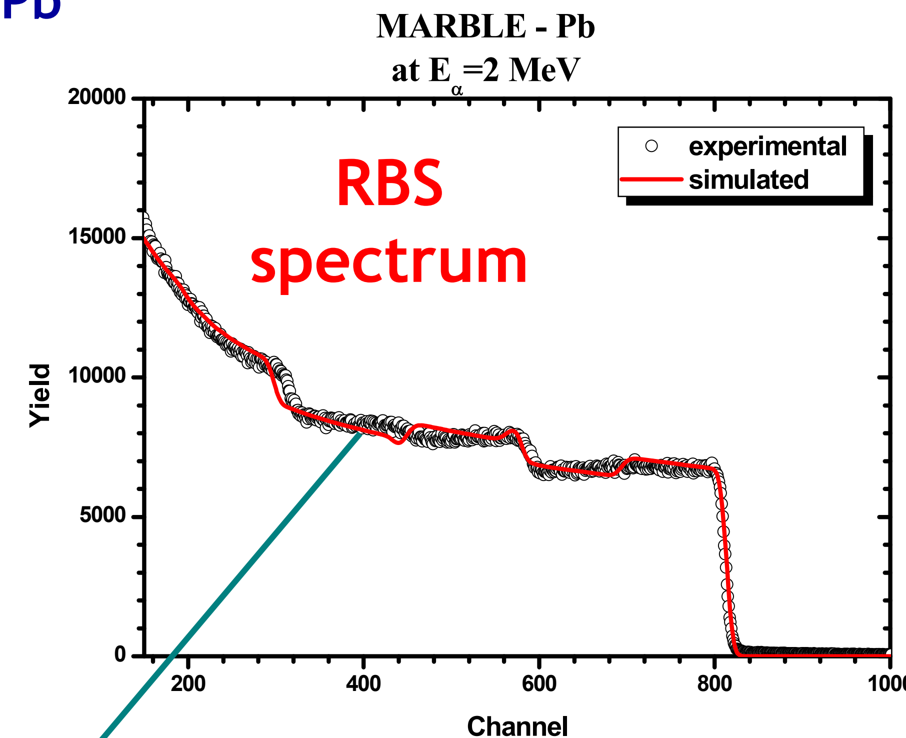


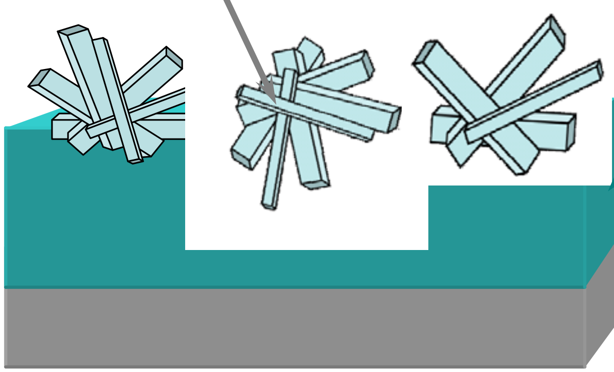


Αλληλεπίδραση της επιφάνειας μαρμάρων με βαρέα μέταλλα

ΔΟΛΟΜΙΤΙΚΟ ΜΑΡΜΑΡΟ - Pb





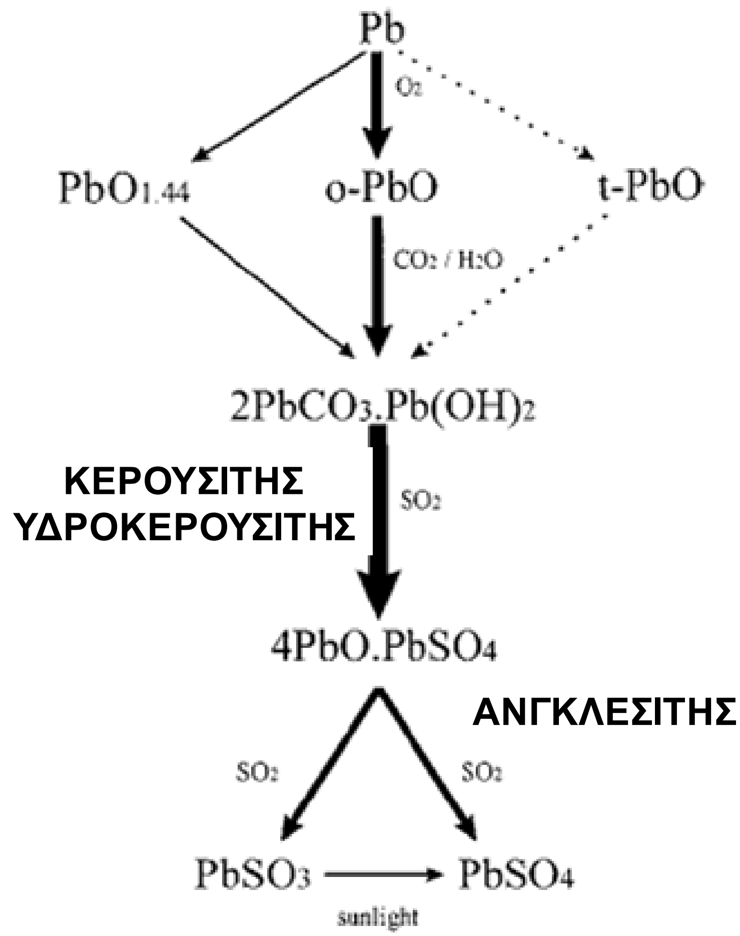


Pb^{2+} carbonate crystals overgrown on the Pb-bearing dissolved surface of marble

GODELITSAS et al., J.Radioanal.Nucl.Chem.2007

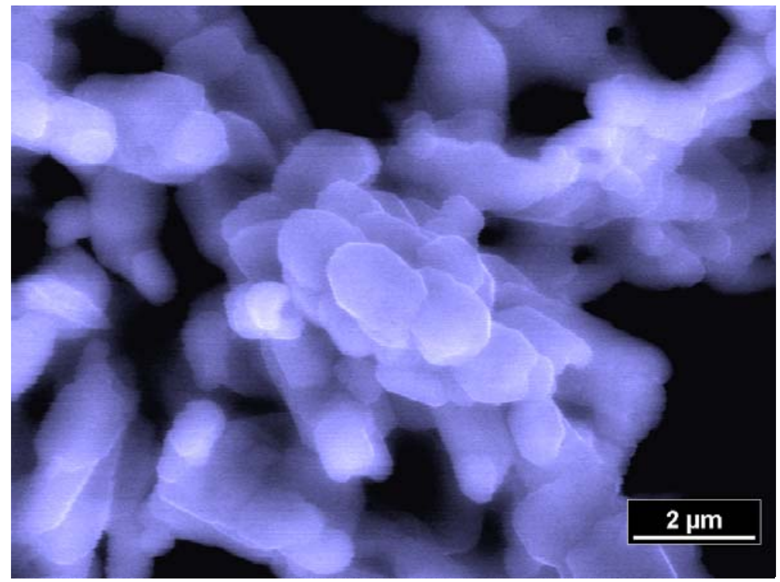
Όρφνωση μεταλλικού Pb

Pb Patination

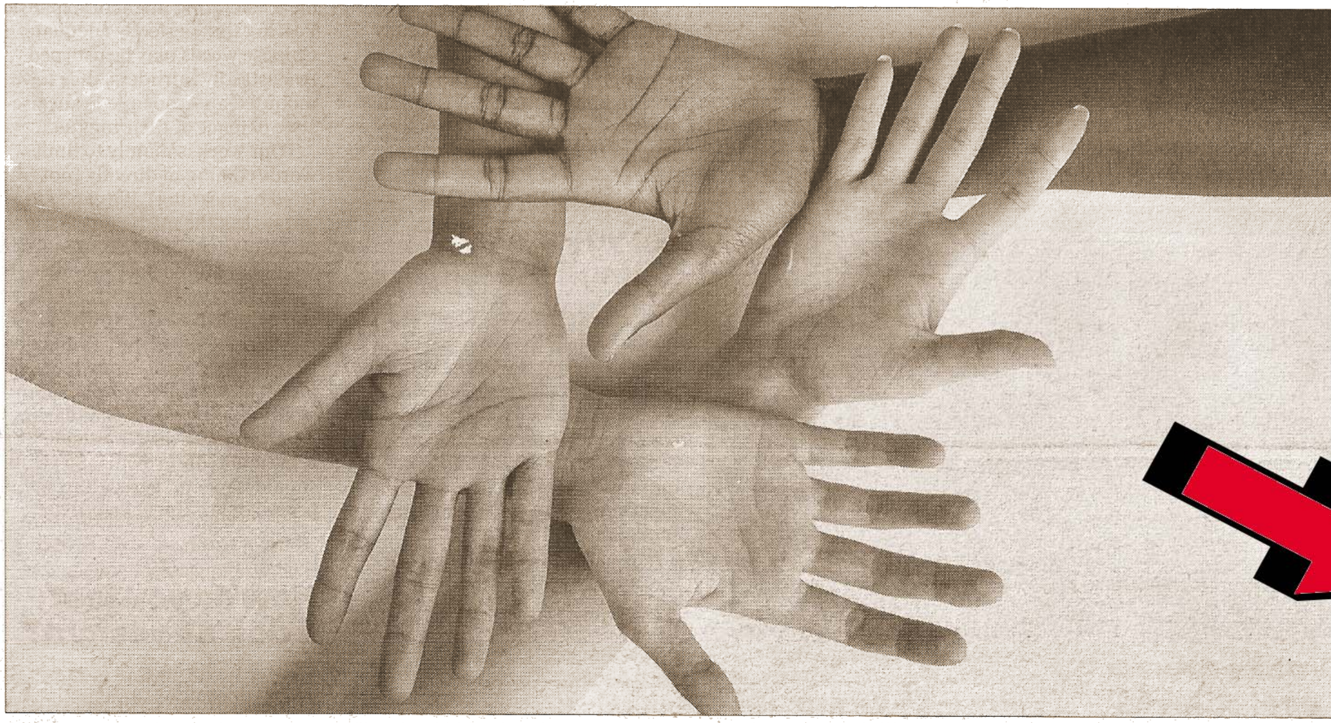


My job is mining lead
but that tells me a lot about PAINT
ANYBODY who's ever worked with lead knows it's a grand metal.
If you could cover a house with lead, it would just about last forever.
And it's not far wrong to say that the next best thing to a metal coating when it comes to protection, is white lead.
Fact is, white lead is made from lead.
You can't use any other metal for making paint and get the same result.
What I mean is, white lead paint gives a tough, elastic coat — a coat that never brittles up or flakes away.
Don't take my say-so. Ask any painter who's been at his job long enough to time the life of white lead. Ask him what he'd paint his own house with.
Any way you look at it, you're money ahead when you paint with white lead.
You'll learn a lot of helpful facts about paint if you read, "What to expect from White Lead Paint." Write for your copy today.
LEAD INDUSTRIES ASSOCIATION
420 Lexington Avenue, New York, N.Y.
Millions
A good painter is always a good investment. For example, pointing up open joints and cracks on wood trim—filling them properly with white lead putty so they will stay watertight—is one of the dozens of things that a real painter knows how to do.
You're money ahead when you paint with
White Lead

"White Lead"



2 µm



Skin colour is an imprecise indicator of race, which points to where in the world our ancestors evolved Photograph: National Geographic

Medicine exploits genetic variations, not stereotypes, writes *David Adam*

Cure is more than skin deep

The central Greek town of Orchomenos seems an unlikely place to start a debate on race and genetics in the 21st century. It is home to several archaeological relics that demonstrate the town's Bronze Age power and influence. The inhabitants of Orchomenos live with a famous tomb, a well preserved 2,400-year-old theatre and a part-excavated Mycenaean palace. They also live

down to "their" disease — when they probably are?

Geneticists tend to avoid questions like these. Historically, biological studies of race have been tainted by eugenics. But in the geneticists' absence, others have stepped in to argue that race is irrelevant to medicine. In 2001 the New England Journal of Medicine went as far in an editorial to declare it "biologic-

evolved. Skin colour is affected by the environment and varies a lot within groups; what we think of as "race" is a crude attempt to group people together for social reasons that do not always tally with their geographical ancestry, and so their biological differences.

A sterotypical term like "Asian" is too broad, Kidd argues. "It might make a difference [to their

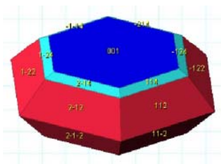
Dispatch

Don't drink, just think

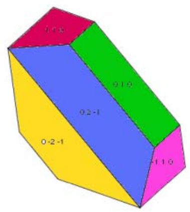
Scientists at the University of North Carolina have watched a burst of new brain cell development during abstinence from chronic alcohol consumption. It happened in rats, but there could be a message for humans too, they report in the Journal of Neuroscience. "When used in excess, alcohol damages brain structure and function," said Fulton Crews, of the university's Bowles Centre for Alcohol Studies. The researchers studied laboratory rats on a four-day binge, and then watched what happened when the rodents went on the wagon. There was a pronounced increase in neuron formation in the hippocampus within four to five weeks.

Do you feel lucky, do you, punk?

In America, where all citizens have the right to bear arms, the bullets fly. An estimated 20m metric tons of lead flew out of American gun barrels during the 20th century. But the US Forest Service firing range near Blacksburg, Virginia, is not suffering from lead poisoning. Donald Rimstidt, a geoscientist at Virginia Tech, told the Geological Society of America, meeting in Denver, that he and colleagues found 11 tons of shot and 12 tons of lead bullets on the range. Did the lead leach into the streams? The metal corrodes in air and water: some of the toxic metal escapes. "But we learned that it is absorbed in the top few inches of soil and does not migrate beyond that," he said.



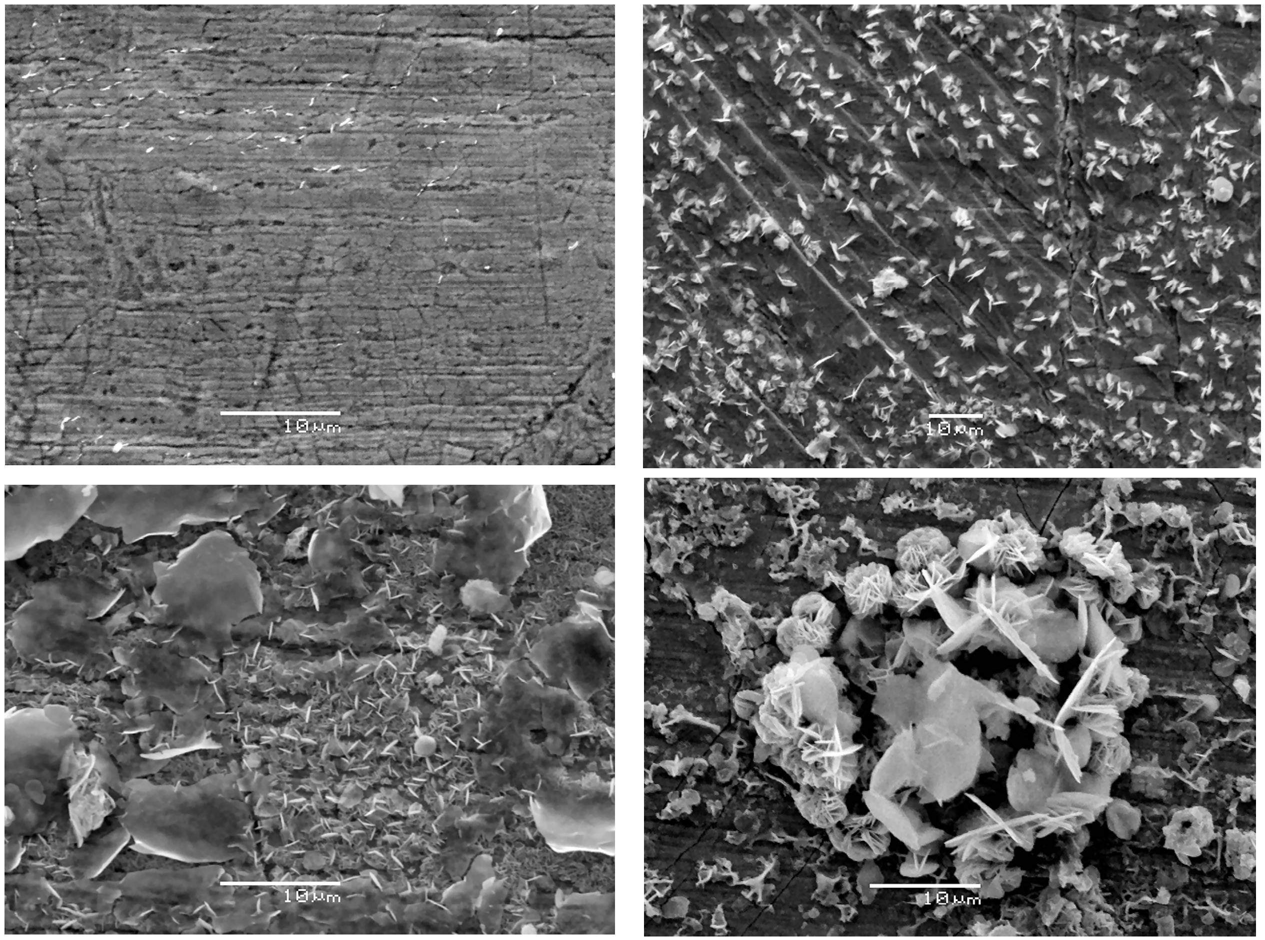
ΥΔΡΟΚΕΡΟΥΣΙΤΗΣ :
$Pb_3(CO_3)_2(OH)_2$



ΚΕΡΟΥΣΙΤΗΣ :
$PbCO_3$

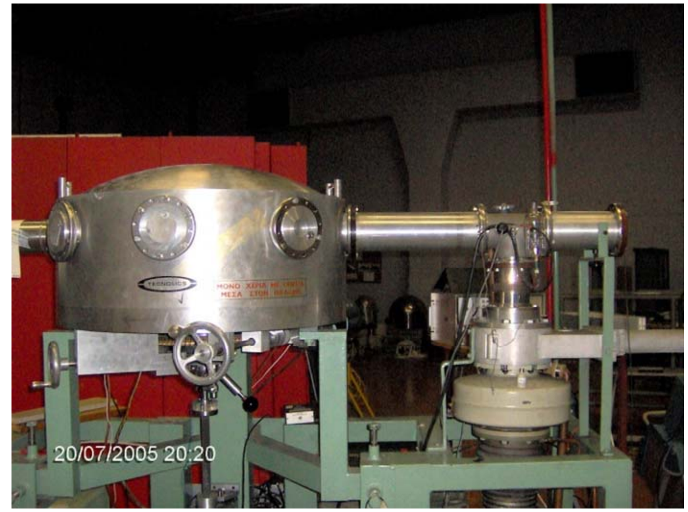
Διερεύνηση της ατμοσφαιρικής ρύπανσης δια της μελέτης φαινομένων ορυκτογένεσης στην επιφάνεια μεταλλικού Pb

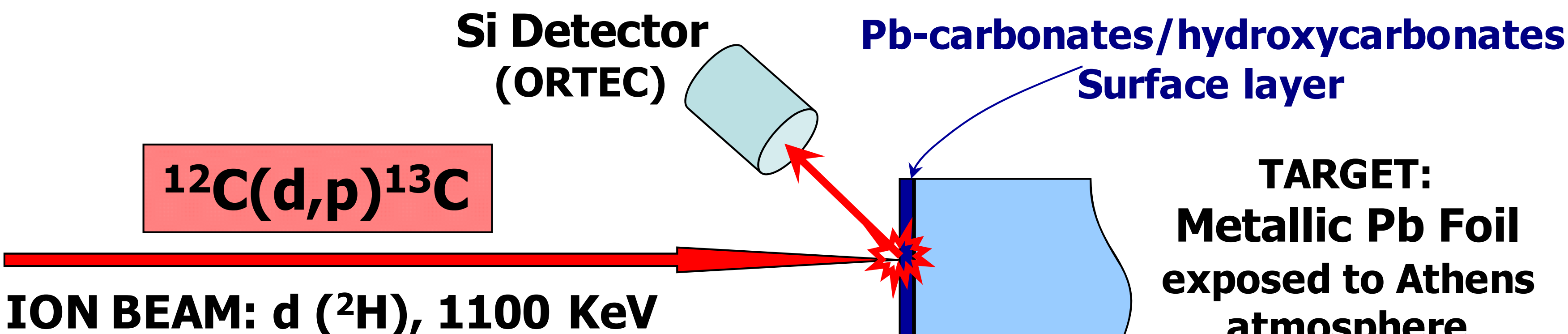
Metallic Pb exposed to atmosphere (1 week - 6 months)



GODELITSAS et al., NIMB 2011

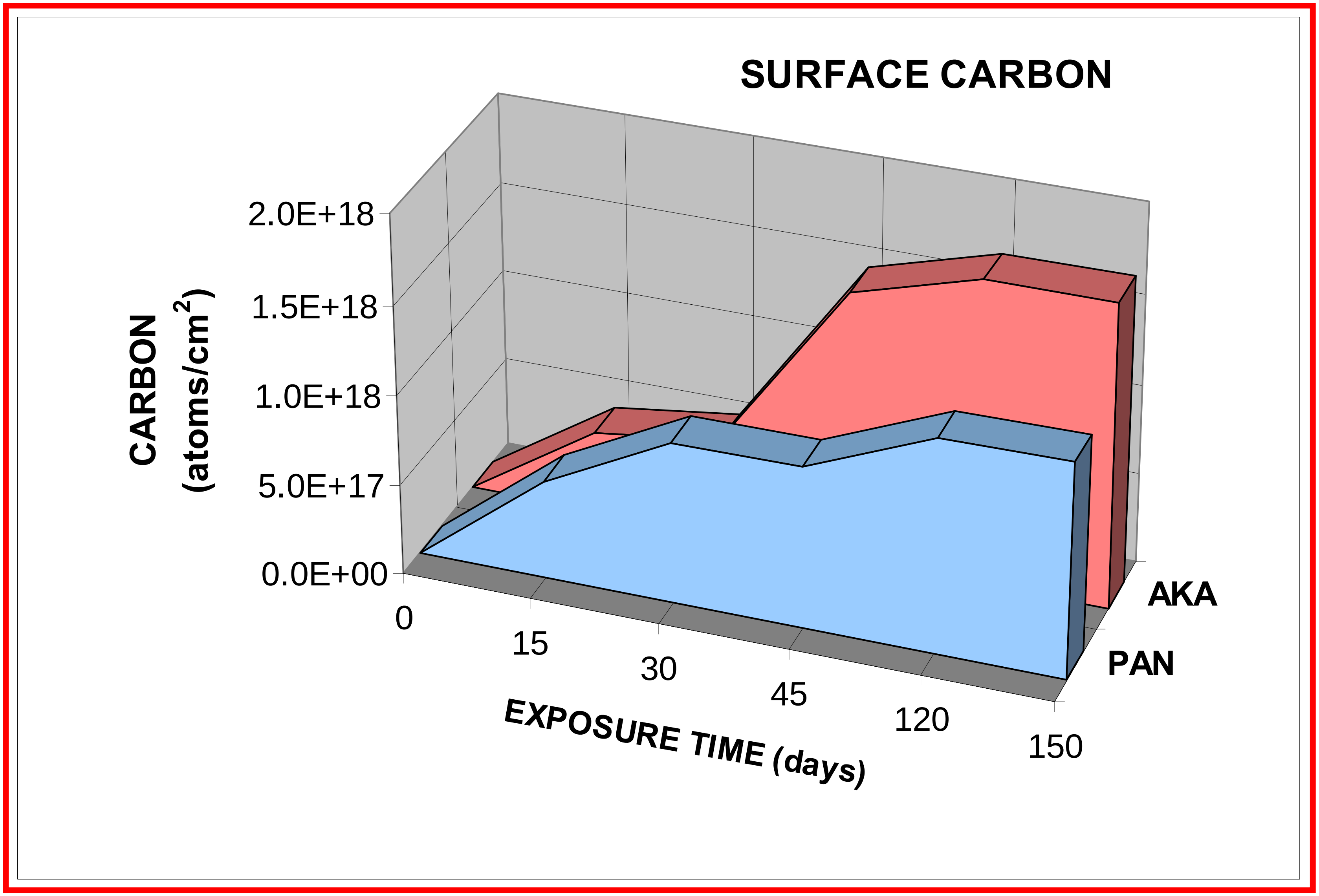
NCSR
"DEMOKRITOS"





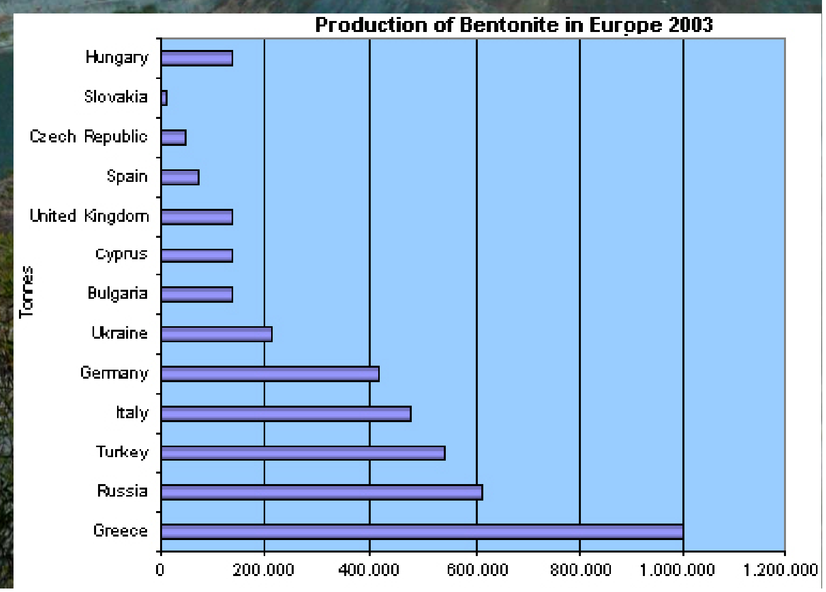
Van de Graaff TANDEM Accelerator Facility

GODELITSAS et al., NIMB 2011

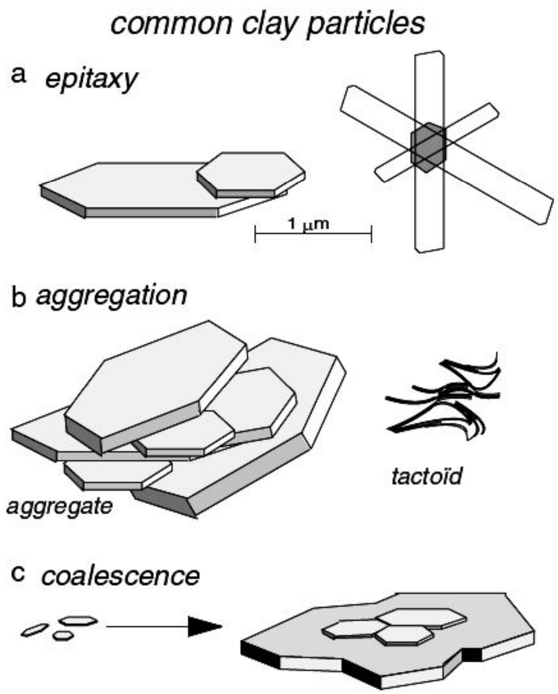


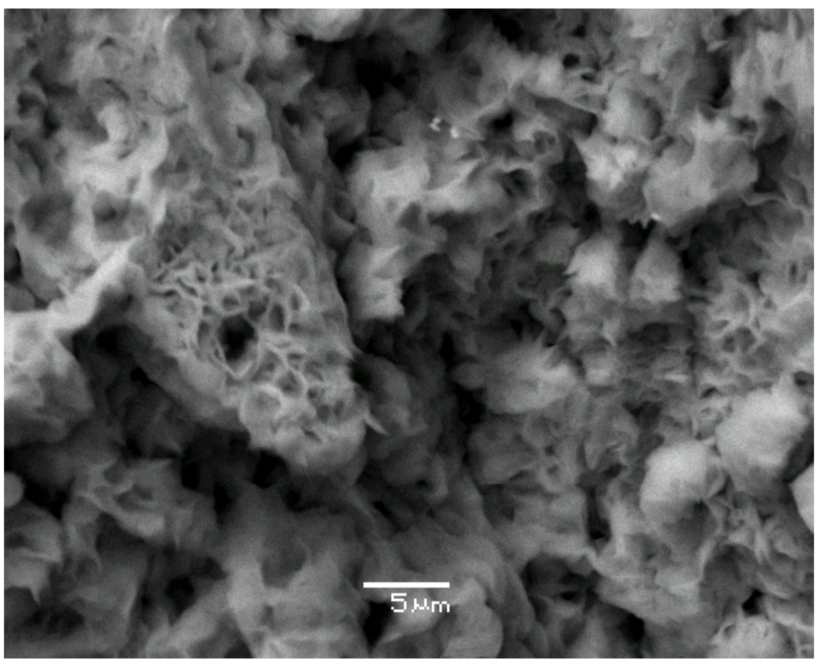
GODELITSAS et al., NIMB 2011

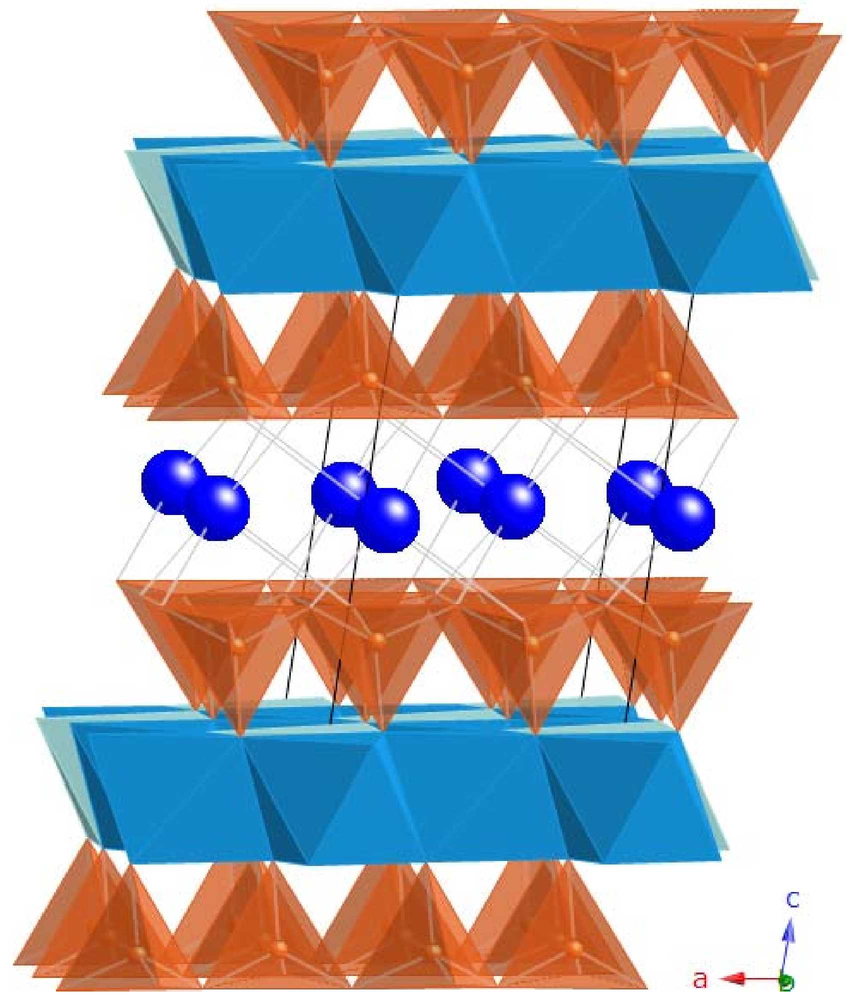
ΜΠΕΝΤΟΝΙΤΗΣ / Ορυκτά της αργίλου
Bentonite / Clay minerals

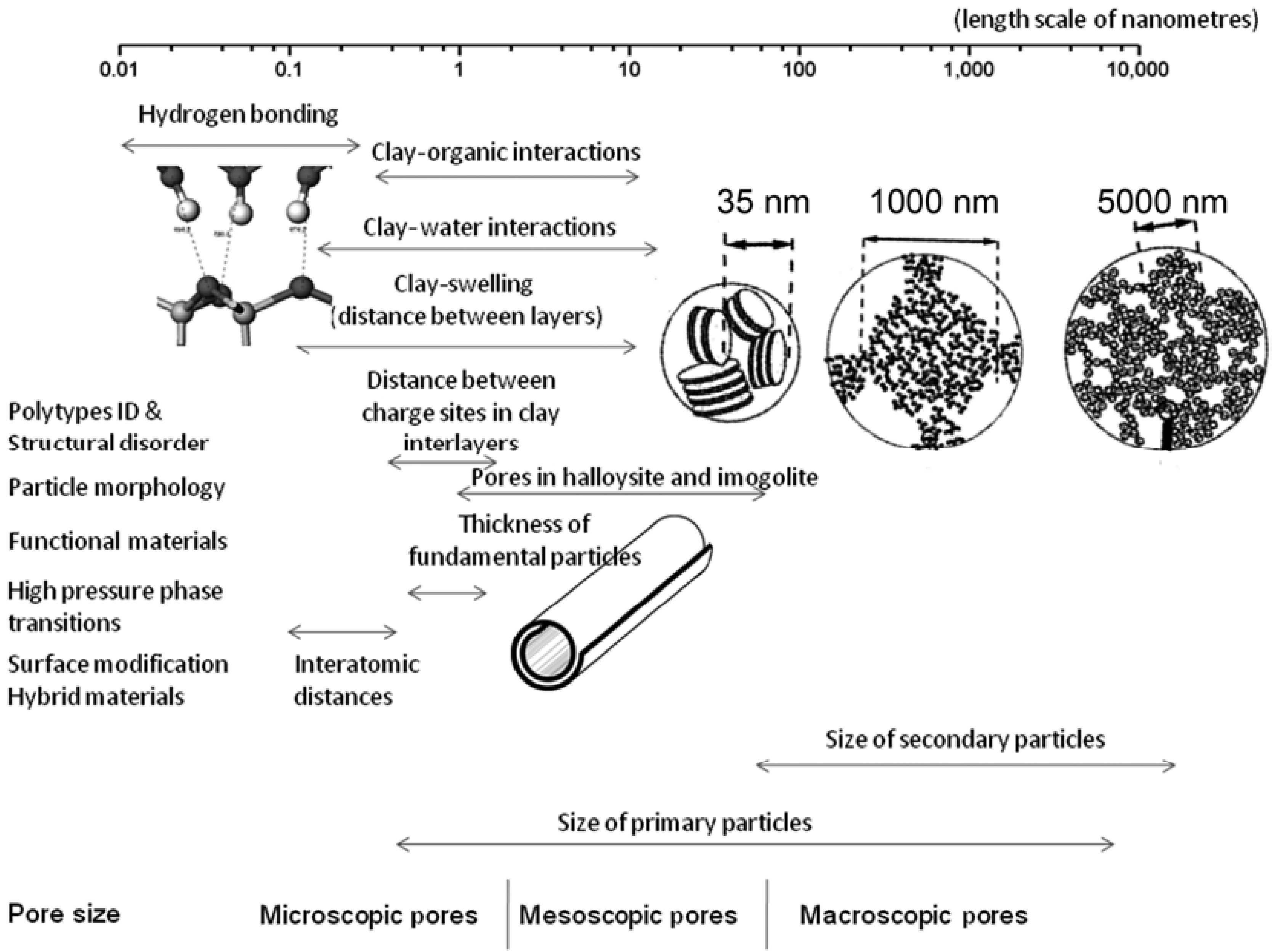


The main types of particles and aggregates of clay minerals. a) Epitaxy, i.e. growth on a crystalline support. b) Aggregation of rigid or flexible particles or crystallites (tactoid or quasi-crystal networks). c) Coalescence: neighbouring crystals are joined by the growth of common layers

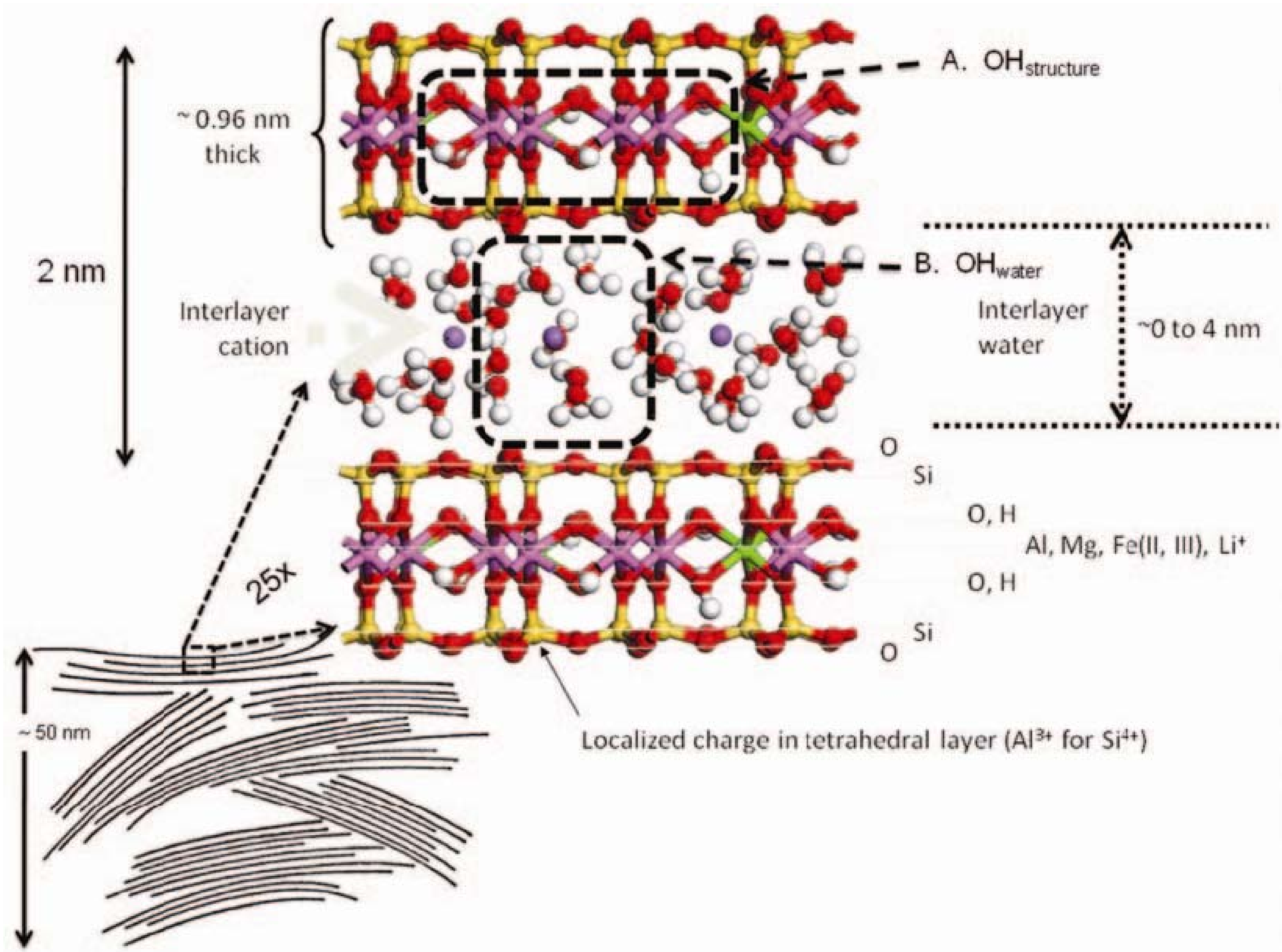




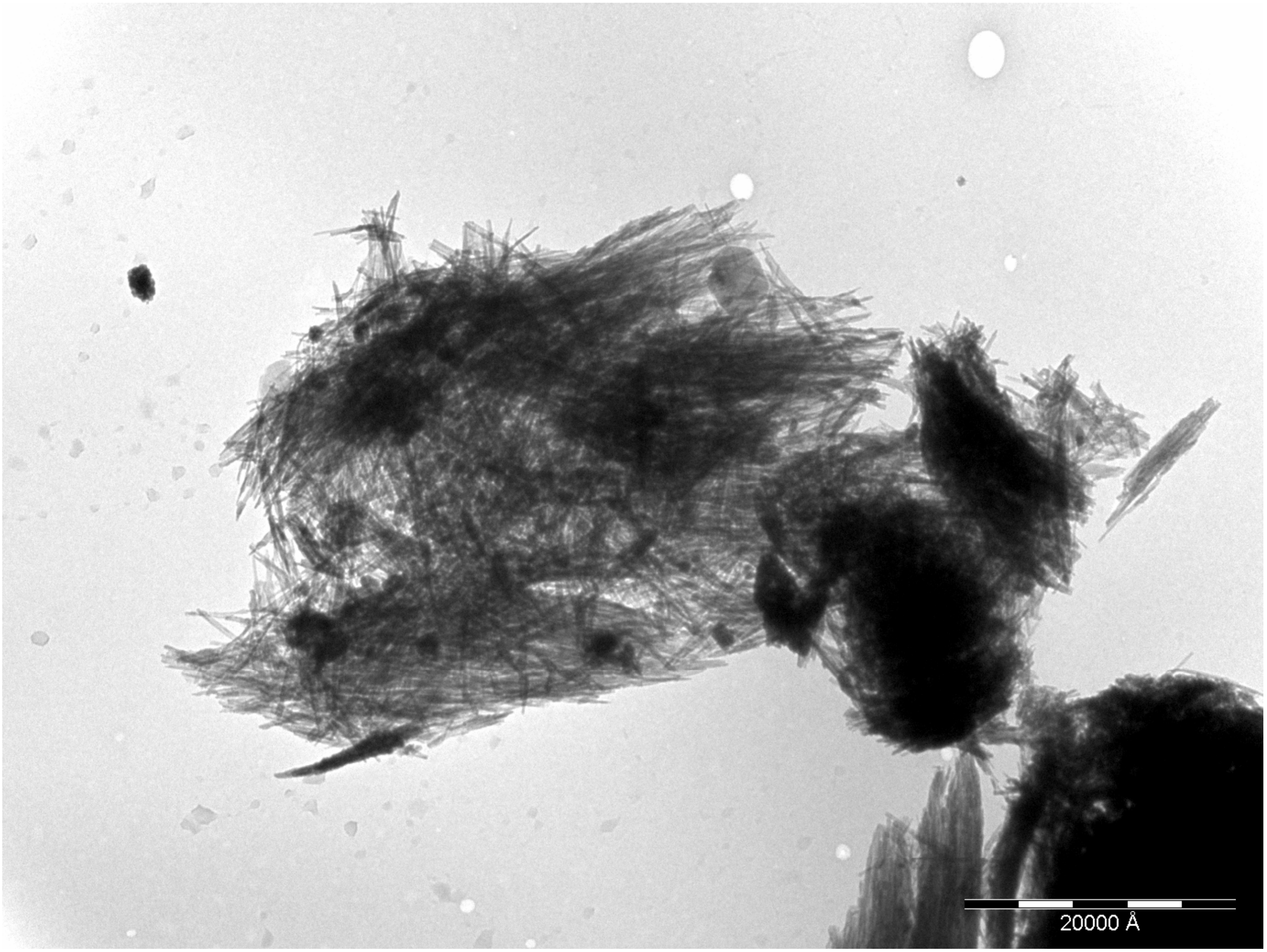




JOHNSTON, Clay Mineral. 2010



JOHNSTON, Clay Mineral. 2010



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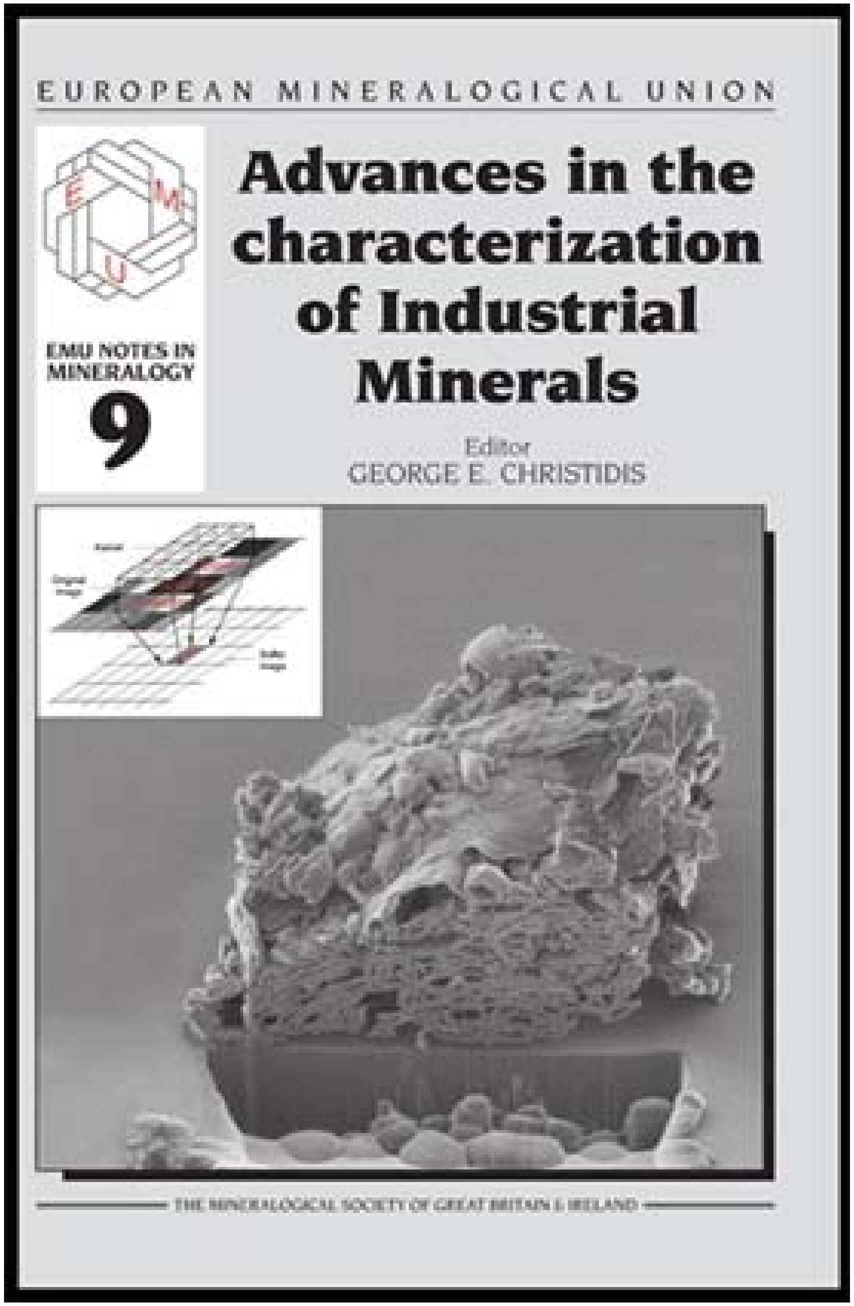
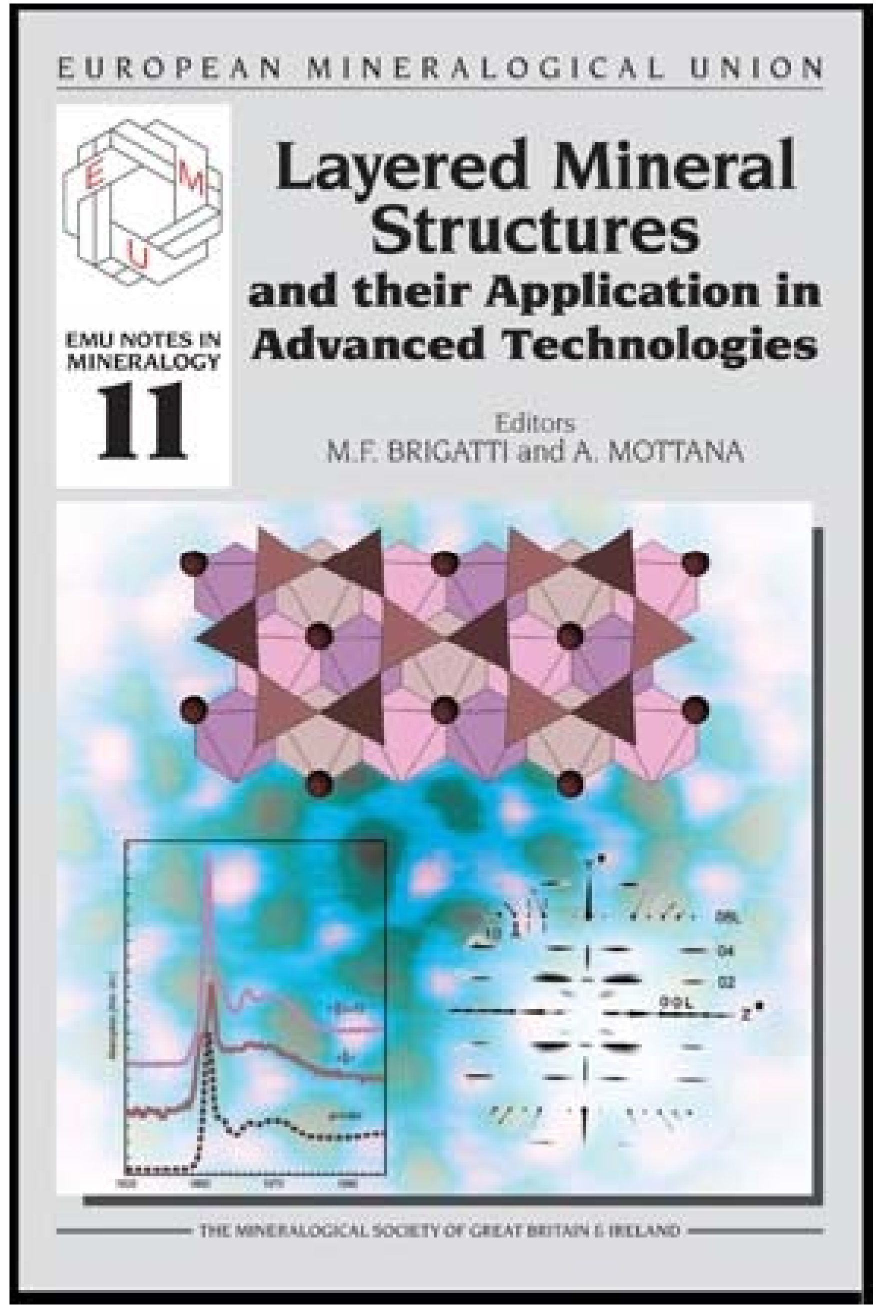
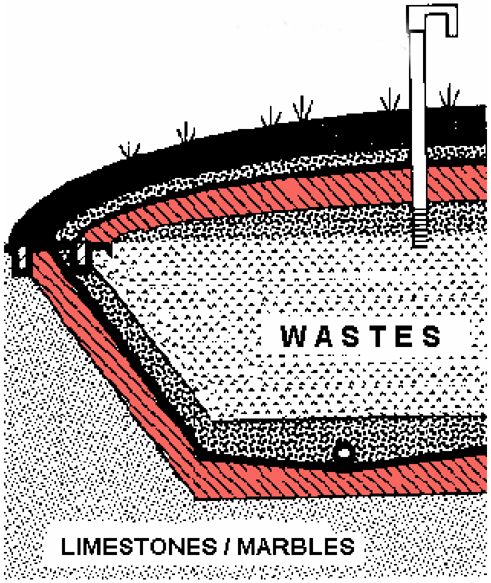

EUROPEAN MINERALOGICAL UNION
EMU NOTES IN MINERALOGY
9
Advances in the characterization of Industrial Minerals
Editor
GEORGE E. CHRISTIDIS
THE MINERALOGICAL SOCIETY OF GREAT BRITAIN & IRELAND

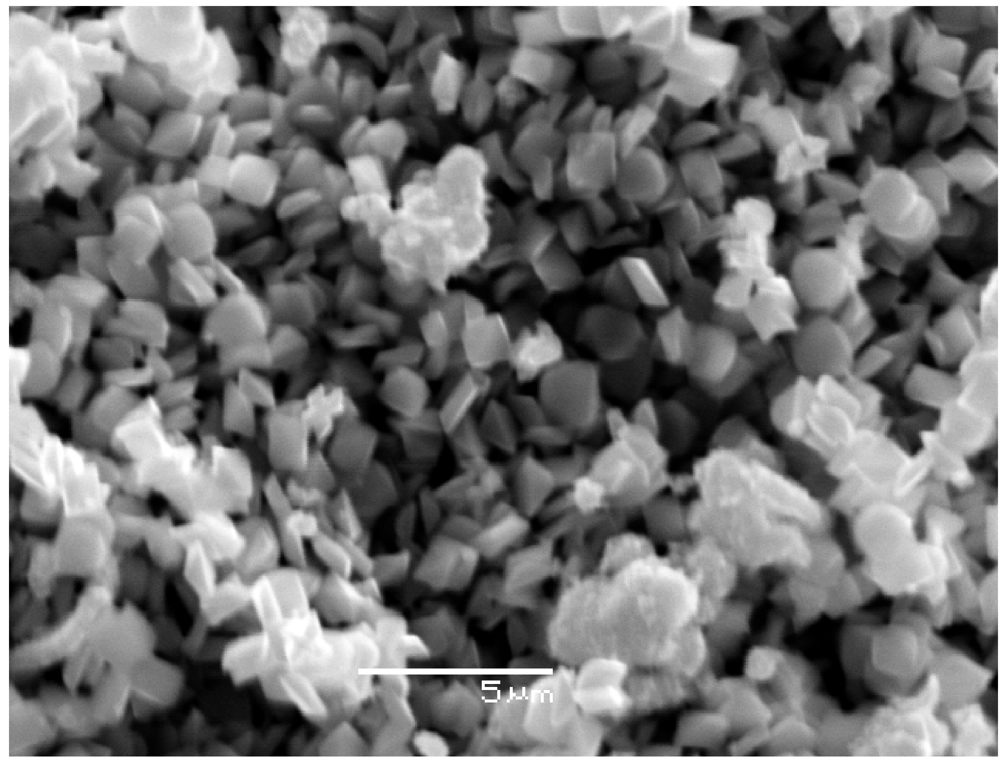

EUROPEAN MINERALOGICAL UNION
EMU NOTES IN MINERALOGY
11
Layered Mineral Structures and their Application in Advanced Technologies
Editors
M.F. BRIGATTI and A. MOTTANA
THE MINERALOGICAL SOCIETY OF GREAT BRITAIN & IRELAND

XYTA



Θειϊκά και οξυ-υδροξυ-θειϊκά ορυκτά του Fe^{3+} σε όξινες απορροές μεταλλείων

A. GODELITSAS et al., Goldschmidt 2009



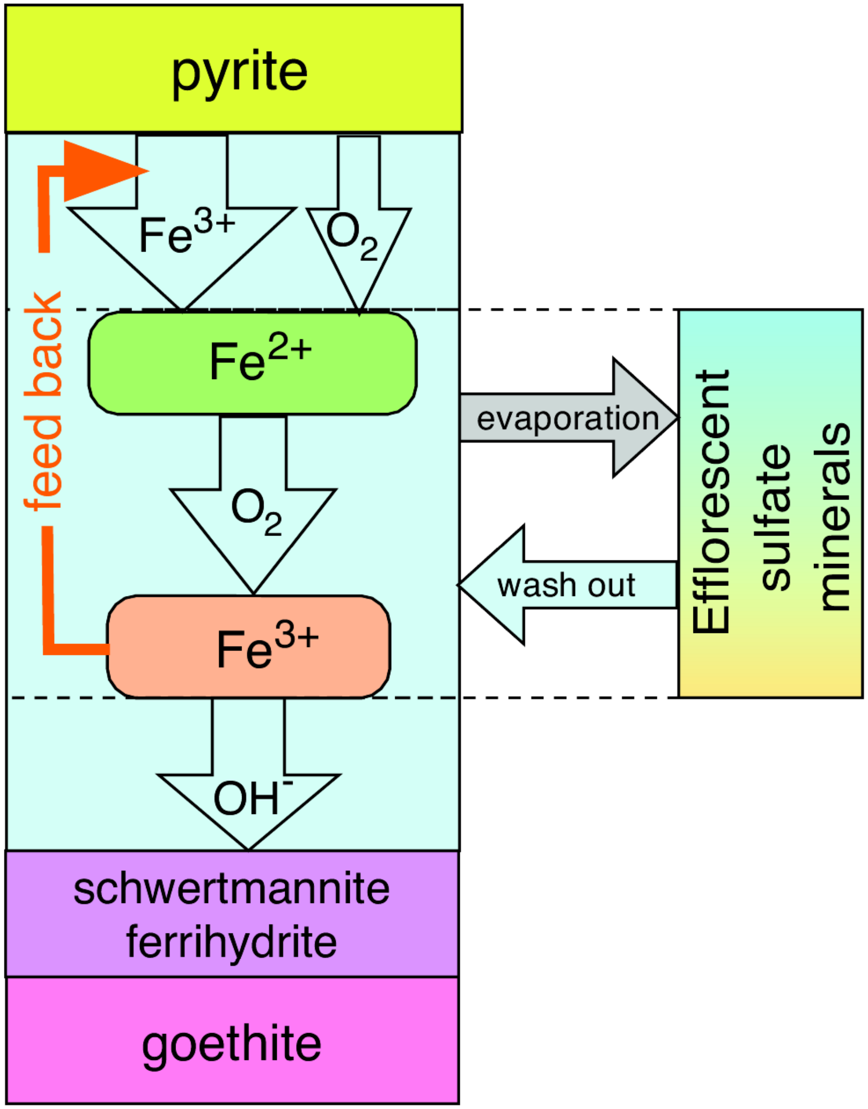
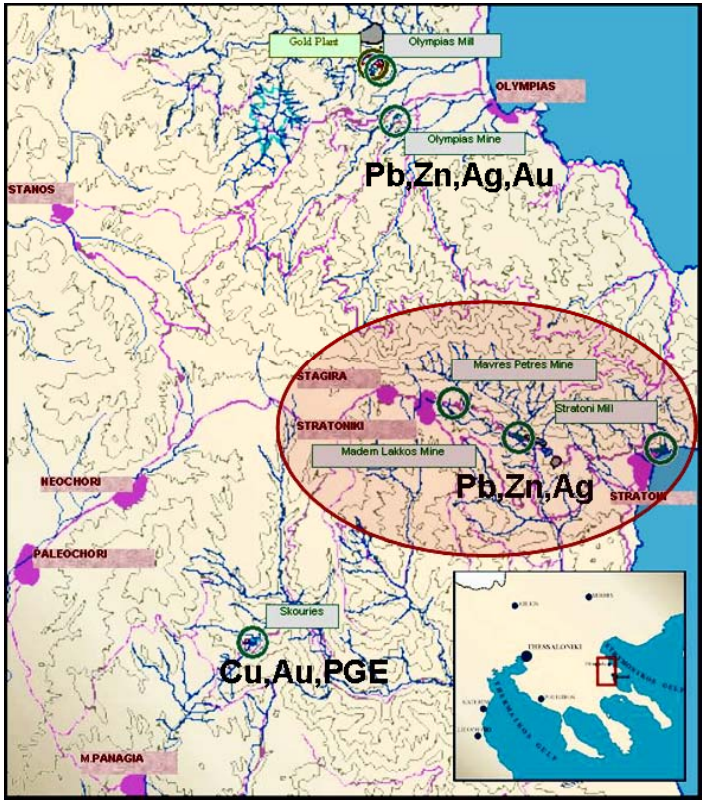
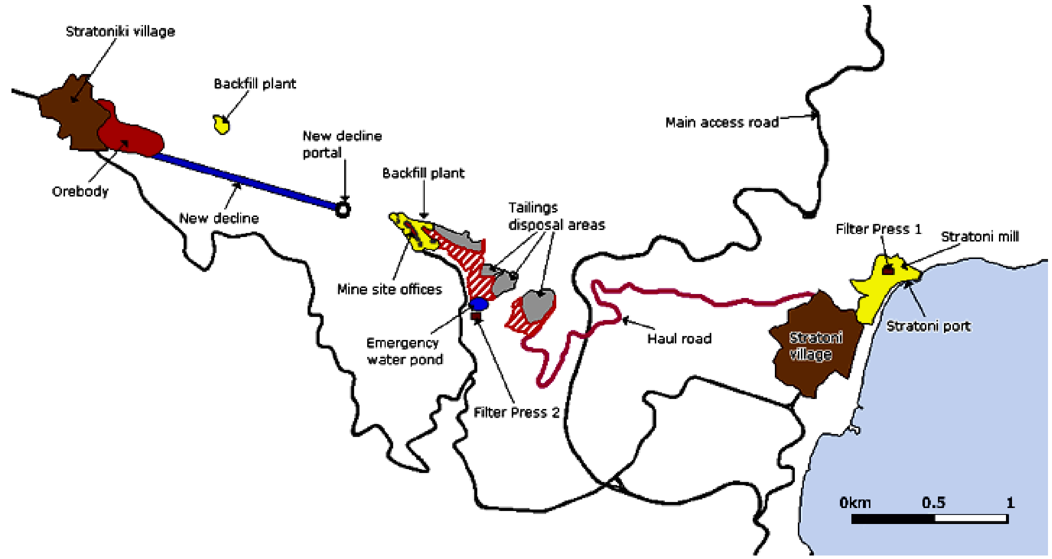
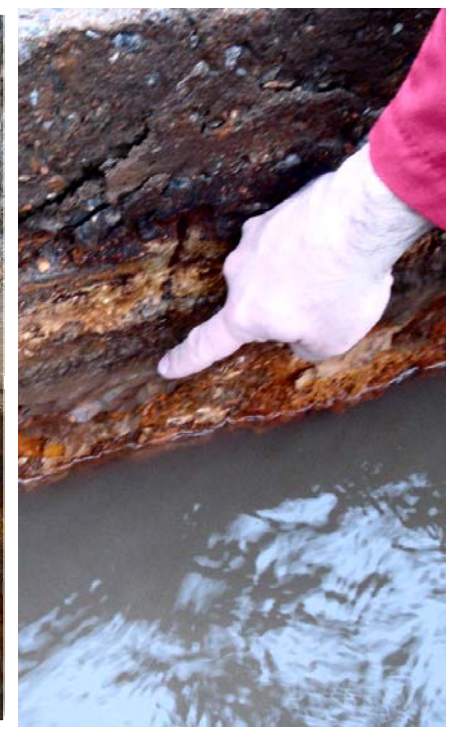
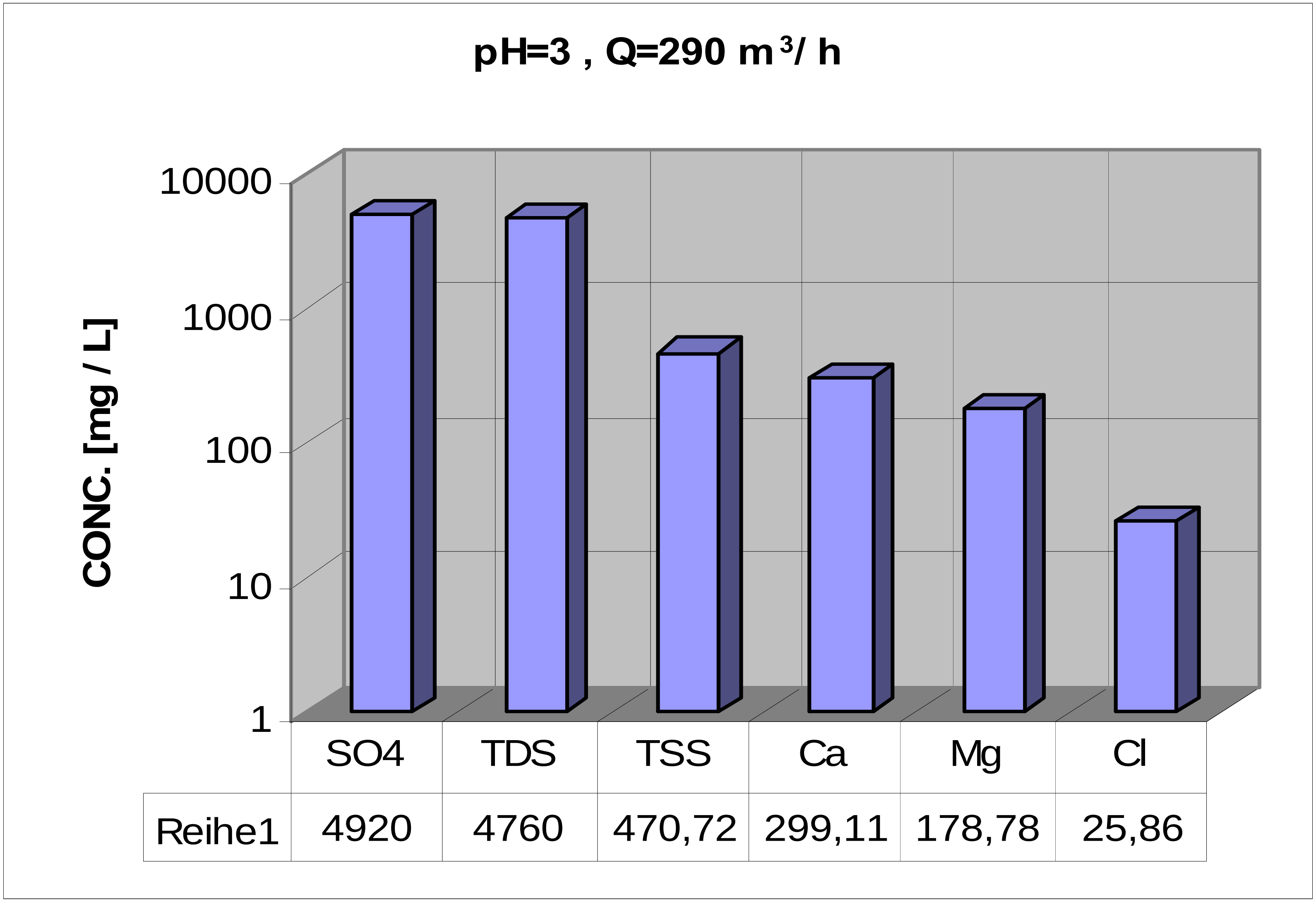


FIGURE 1 **The three steps of AMD**. In step 1, pyrite is oxidized by O_2 or Fe^{3+} and releases ferrous sulfate and sulfuric acid into solution. In step 2, Fe^{2+} is oxidized to Fe^{3+}. This reaction is catalyzed by acidophilic microbes. Much of the Fe^{3+} is consumed by fast reaction with pyrite. During dry periods some of the iron is stored in efflorescent sulfate salts but is returned to solution by rain events. In step 3, the Fe^{3+} undergoes hydrolysis to produce Fe^{3+} polymers, which aggregate into schwertmannite or ferrihydrite. These minerals eventually convert to goethite.


Gold Plant
Olympias Mill
OLYMPIAS
Olympias Mine
Pb,Zn,Ag,Au
STANOS
Mavres Petres Mine
STAGIRA
Stratoni Mill
STRATONIKI
Madem Lakkos Mine
Pb,Zn,Ag
STRATONI
NEOCHORI
PALEOCHORI
Skouries
Cu,Au,PGE
M.PANAGIA

Stratoniki village
Backfill plant
New decline portal
Main access road
Orebody
New decline
Backfill plant
Tailings disposal areas
Filter Press 1
Stratoni mill
Mine site offices
Emergency water pond
Haul road
Stratoni village
Stratoni port
Filter Press 2
0km 0.5 1

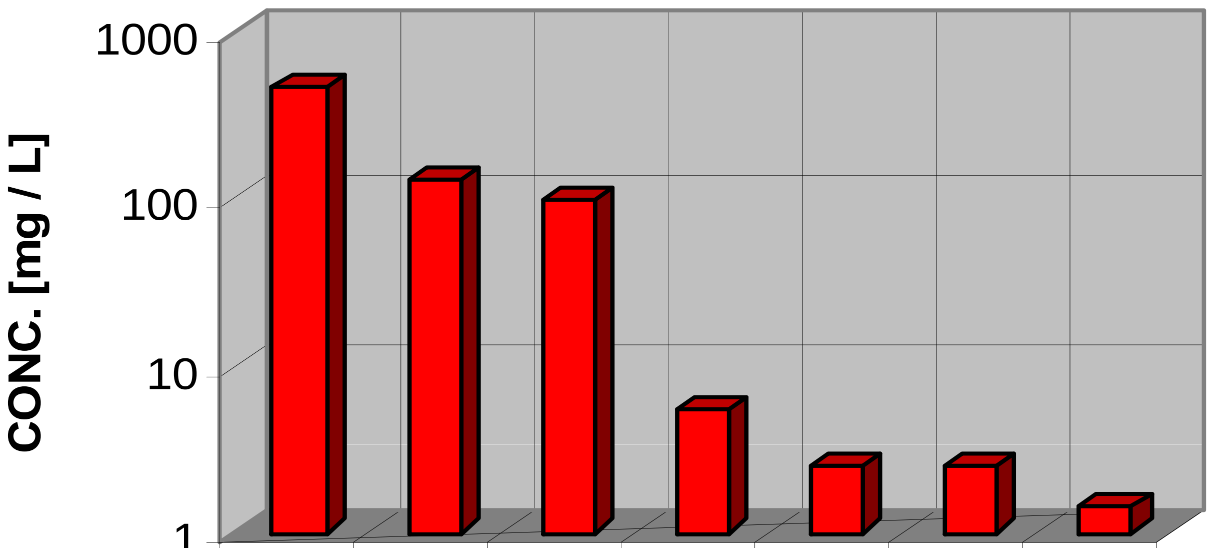
ΧΗΜΙΚΗ ΣΥΣΤΑΣΗ ΝΕΡΩΝ



A. GODELITSAS et al., Goldschmidt 2009

ΧΗΜΙΚΗ ΣΥΣΤΑΣΗ ΝΕΡΩΝ

pH=3 , Q=290 m³ / h

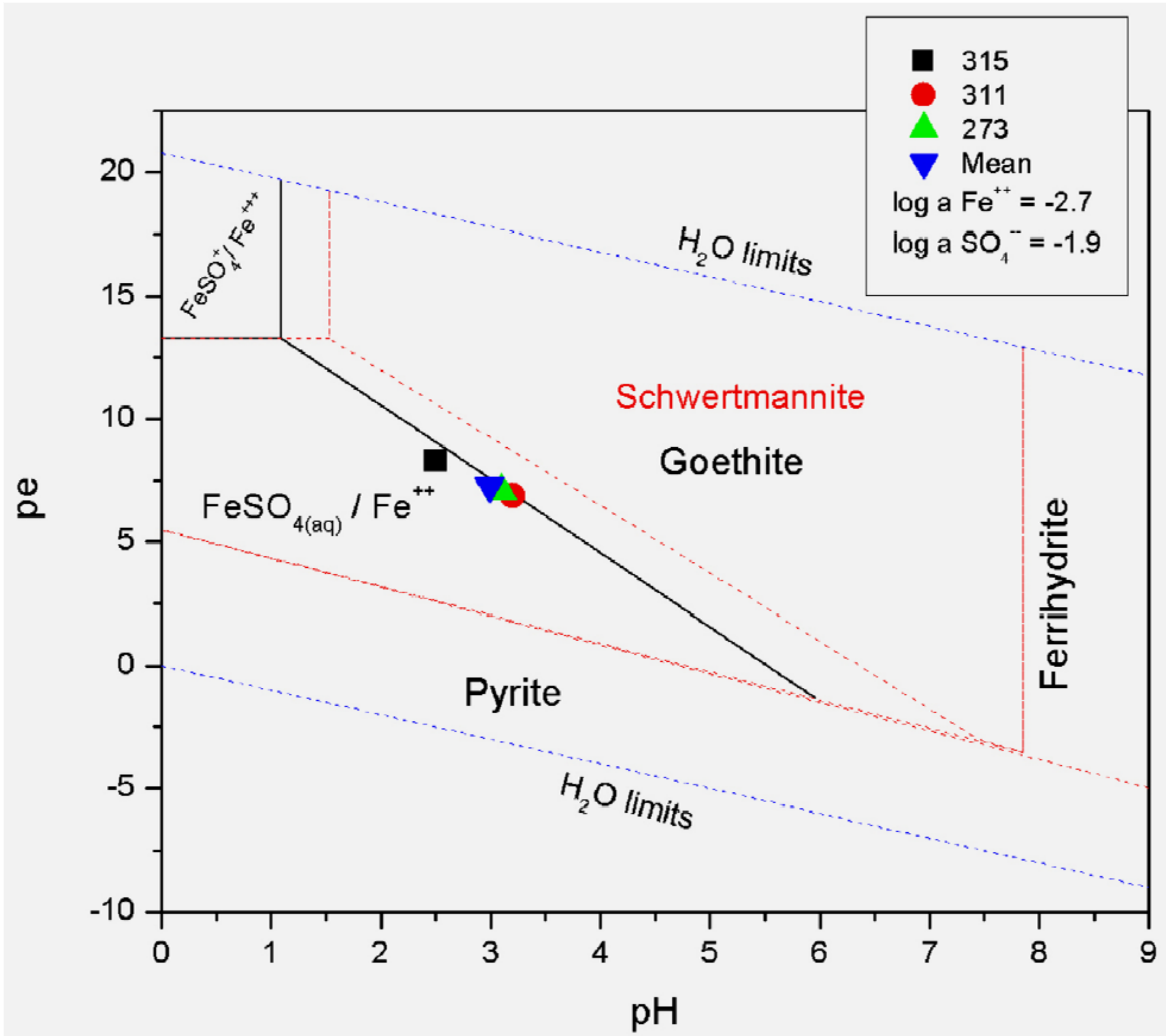


	Fe	Zn	Mn	Cu	Pb	Cd	As
Reihe1	465,6	128,4	99,39	5,44	2,48	2,48	1,45

HEAVY METALS

A. GODELITSAS et al., Goldschmidt 2009

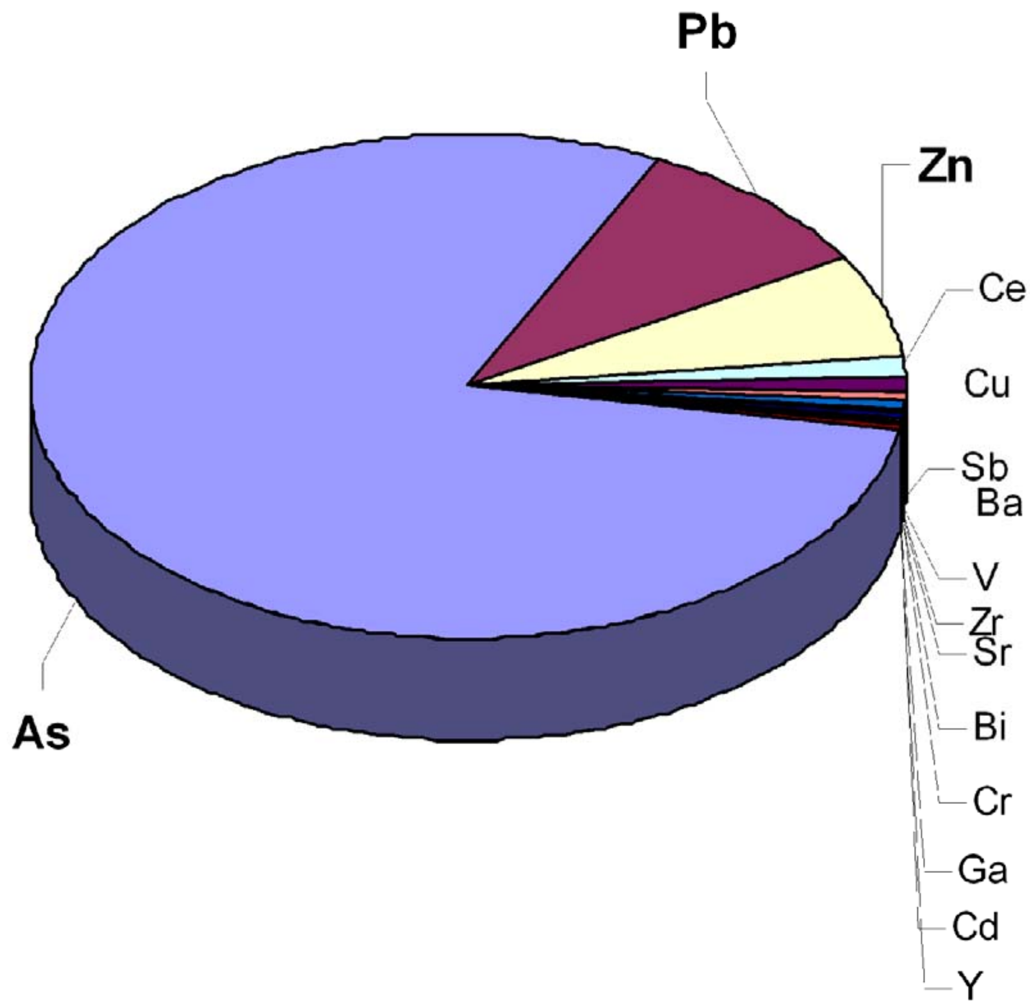
ΔΙΑΓΡΑΜΜΑ ΚΑΘΙΖΗΣΗΣ ΦΑΣΕΩΝ



A. GODELITSAS et al., Goldschmidt 2009

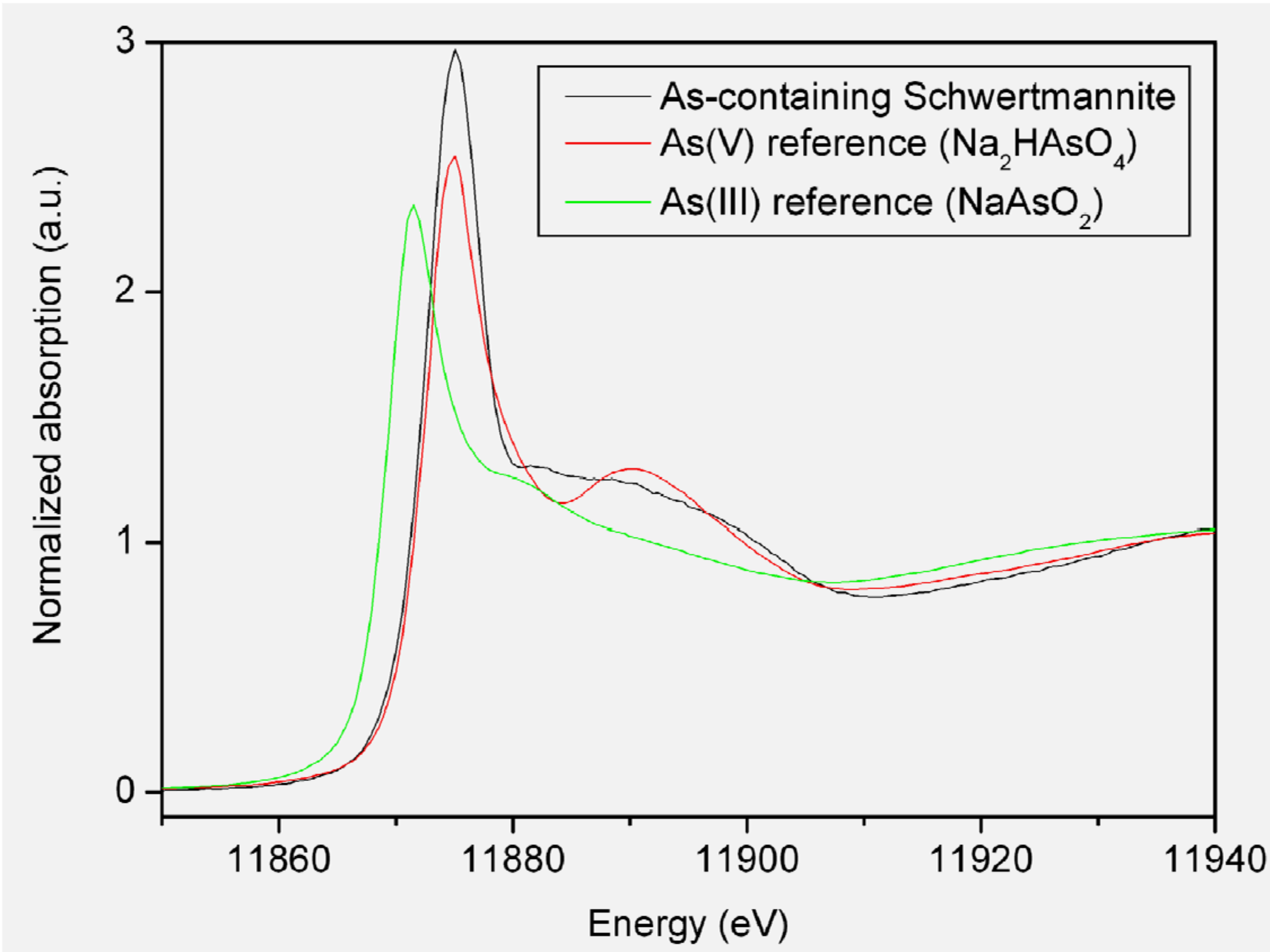
ΧΗΜΙΚΗ ΣΥΣΤΑΣΗ ΣΤΕΡΕΩΝ
(αναλύσεις με ICP-MS)

	μg / g
As	**4920**
Pb	565
Zn	410
Ce	80
Cu	59
Sb	30
Ba	27
V	26
Zr	19
Sr	13
Bi	8
Cr	8
Ga	8
Cd	6
Y	6
Rb	4
Pr	3
Nb	2
Th	0.7



A. GODELITSAS et al., Goldschmidt 2009

Διάκριση As^{3+} και As^{5+} σε ορυκτά όξινων απορροών με φασματοσκοπία XANES



A. GODELITSAS et al., Goldschmidt 2009

The Economist

Volume 374 Number 8416

First published in September 1843
to take part in "a severe contest between intelligence, which presses forward, and an unworthy, timid ignorance obstructing our progress."

Editorial offices in London and also:
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Astrobiology

Life on Mars!!! (Not)

Martians, or the lack of them, sow discord on Earth

ONE can easily be forgiven for suffering confusion over whether life has been detected on Mars. On February 18th, America's space agency, NASA, moved quickly to quash reports that two of its scientists were about to announce strong evidence for it. Five days later Vittorio Formisano, an Italian scientist working with the European Space Agency (ESA), was keen to make just such a claim, and did so at a scientific meeting in the Netherlands. Most of his colleagues remain sceptical, but ESA, notably, as not issued any official denial. So what is going on?

The whole issue of life on Mars is a source of much scientific controversy. In a poll taken at a recent meeting of 250 scientists who study the planet, and released on February 25th, only one-quarter thought that life could exist there now. But nobody can truly say yea or nay yet. There are certainly signs that could be interpreted as evidence of life—in particular the presence of methane in the Martian atmosphere—but they are ambiguous. On Earth, methane is often associated with bacterial activity. But the methane on Mars may have a non-biological origin, such as a volcano.

What Dr Formisano did to fuel the debate was to announce that the instrument he is in charge of on ESA's *Mars Express* orbiter has detected a lot of formaldehyde. One way to make this chemical is to oxidise methane, and Dr Formisano claims that there is so much of the stuff in the Martian atmosphere that if it is there as a result of methane oxidation, then Mars must be producing about 2.5m tonnes of methane a year.

If that is the case, then either Mars is harbouring a lot of microbial life, or the planet is a lot more volcanically active than it looks at first sight. But perhaps it is. Gerhard Schwehm, head of planetary missions at ESA, says that *Mars Express* has also provided evidence of such recent geological activity. Moreover, not everyone is convinced that Dr Formisano's evidence actually proves that formaldehyde exists on Mars. The evidence has yet to be published in a journal.

Although NASA's researchers may not have discovered life on Mars, they have produced some interesting work that supports a biological explanation for the origin of the methane. Later this month Carol Stoker, of the agency's Ames Research Centre in California, and her colleagues, will tell the Lunar and Planetary Science conference in League City, Texas, that they have the first report of a subsurface ecosystem that can use sulphide minerals as an energy source.

Dr Stoker has been exploring a place on Earth that looks geochemically similar to an area of Mars called Sinus Meridiani. The place in question is near the source of the Rio Tinto, in Spain, and the similarity is the presence of a mineral called jarosite. The team drilled beneath the ground to take sample cores from up to 165 metres beneath the surface. There, they found a microbial ecosystem that appeared to be producing jarosite (a sulphate-based mineral) by oxidising rocks made of iron sulphide. One by-product of this process is methane, whose carbon comes from atmospheric carbon dioxide. And Mars, too, has carbon dioxide in its atmosphere. It has yet to be established whether points of methane concentration in the Martian atmosphere coincide with jarosite deposits. If they do, though, the case for life on Mars will look a lot stronger than it does at the moment. ■

A rose-tinted view of the case for Martian life

JAROSITE

$KFe_3(SO_4)_2(OH)_6$

Κάποτε στον πλανήτη Αρη...

Η ύπαρξη νερού στην επιφάνειά του είναι η πρώτη από τις φετινές ανακαλύψεις

Το ερώτημα ποιες ήταν οι σημαντικότερες επιστημονικές κατακτήσεις συγκεκριμένης χρονιάς σπανίως μπορεί να απαντηθεί αν δεν μεσολαβήσει κάποια χρονική απόσταση. Παρόλα αυτά, κάθε χρόνο, η επιθεώρηση Science συντάσσει και αφήνει στην κρίση ιστορικών της επιστήμης, κατάλογο των κατακτήσεων που η επιστημονική επιτροπή τις θεωρεί σημαντικότερες. Στον κατάλογο του 2004, την πρώτη θέση κατέλαβε η ανακάλυψη της NASA ότι κάποτε στον Αρη υπήρχε νερό, το απαραίτητο συστατικό για την ανάπτυξη ζωής. Αναλύοντας τους βράχους στην επιφάνεια του Αρη, με τη βοήθεια του σκάφους Oportunity, οι επιστήμονες διαπίστωσαν ότι είχε περάσει από πάνω τους νερό. Δυστυχώς το σκάφος δεν ήταν σε θέση να χρονολογήσει τους βράχους ή να φέρει στη γη δείγματά τους.

Ανθρωποι νάνοι

Τη δεύτερη θέση κατέλαβε η ανακάλυψη επιστημόνων στην Ινδονησία ότι στη νήσο Φλόρες ζούσε μέχρι πριν 13.000 χρόνια (πολύ πρόσφατα, σε σχέση με την ιστορία του ανθρώπινου είδους) μία φυλή ανθρώπων-νάνων, που ονομάστηκε Λιαγκ Μπουά 1, ή LB 1. «Το εύρημα εξήψε τη φαντασία πολλών» έγραψε ο Ντόναλντ Κένεντι, εκδότης του περιοδικού Science, παρουσιάζοντας τον κατάλογο. «Το κρανίο και τα υπόλοιπα ευρήματα τώρα επανεξετάζονται και περιμένουμε να δούμε πώς θα εξελιχθεί το θέμα αυτό.

Ιδιαίτερα σημαντική θεωρήθηκε και η κλωνοποίηση 30 ανθρωπίνων εμβρύων από Νοτιοκορεάτες επιστήμονες. Η κλωνοποίηση δεν είχε στόχο τη γέννηση ανθρώπινων κλώνων, αλλά τη δημιουργία βλαστοκυττάρων με το ίδιο ακριβώς DNA ενός ενήλικα, ώστε να χρησιμοποιηθούν για μελλοντικές, εξατομικευμένες θεραπείες.

Πάλσαρ σε φωτογραφικό ντεμπούτο, αμφίβια σε τροχιά εξαφάνισης, μωρά-κλώνοι στον προθάλαμο.

Επιστημονικά επιτεύγματα του 2004 σύμφωνα με το Science

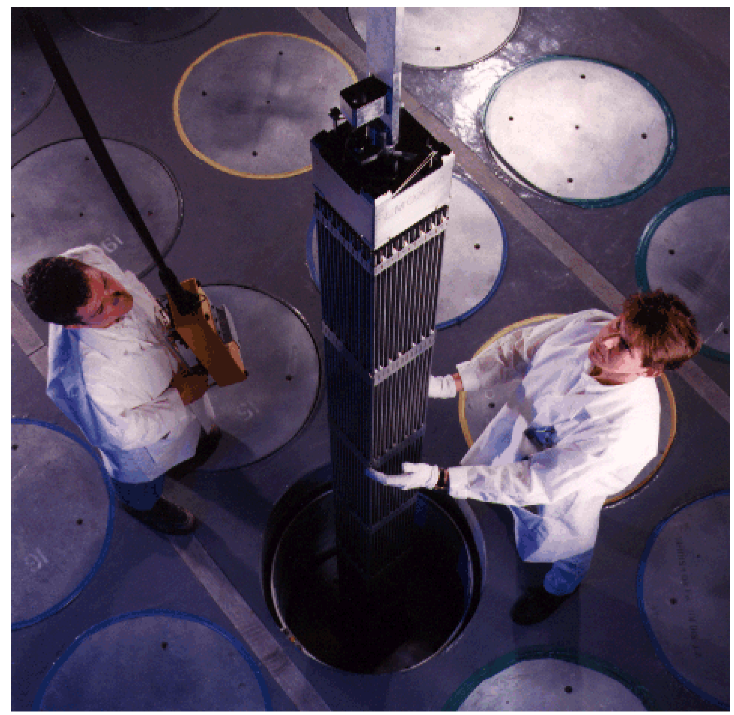
Νερό στον Αρη. Τα σκάφη Spirit και Opportunity της NASA ανακάλυψαν πειστικές ενδείξεις για την παρατεταμένη ύπαρξη στον Αρη, αλμυρού, όξινου νερού.
Ινδονησιακό Χόμπιτ. Ομάδα παλαιοντολόγων ανακάλυψε ότι στη νήσο Φλόρες της Ινδονησίας ζούσε είδος ανθρώπων που είχαν ύψος μόλις ένα μέτρο.
Ανθρώπινη Κλωνοποίηση. Νοτιοκορεάτες επιστήμονες ανακοίνωσαν ότι κλωνοποίησαν ανθρώπινα έμβρυα. Πρώτη φορά αποδείξεις για την τεχνική αυτή δημοσιεύθηκαν σε επιστημονική επιθεώρηση.
Συμπεριφορά πολύ πυκνών αερίων. Το 2004 οι επιστήμονες έκαναν σημαντικά βήματα για την κατανόησή της.
Κρυμμένοι θησαυροί του DNA. Τα θεωρούμενα ως άχρηστα τμήματα του DNA αποδείχθηκε ότι επιτελούν σημαντικό ρόλο στο να βοηθούν τα γονίδια να ενεργοποιούνται την κατάλληλη στιγμή.
Ζεύγος Πάλσαρ. Αστροφυσικοί ανακάλυψαν το πρώτο γνωστό ζεύγος Πάλσαρ, αστεριών από νετρόνια που εκπέμπουν πίδακες ραδιενέργειας.
Εξαφάνιση φυτών και ζώων. Μελέτες κατέληξαν σε ανησυχητικά συμπεράσματα για τη μείωση της ποικιλίας των ειδών αμφίβιων, πεταλούδων, πουλιών και φυτών.
Νερό υπό έλεγχο. Νέες μελέτες για τη δομή και τη χημική συμπεριφορά του νερού άνοιξαν νέους δρόμους σε κλάδους της χημείας και μελέτης της ατμόσφαιρας.
Φάρμακα για τους φτωχούς. Οι «συμμαχίες δημοσίου-ιδιωτικού τομέα» ενισχύθηκαν το 2004, επηρεάζοντας την έρευνα και διανομή φαρμάκων.
Γονίδια σε μια σταγόνα. Επιστήμονες βρήκαν νέο τρόπο να αναλύουν πολύ μικρούς έμβιους οργανισμούς. Συνέλεξαν νερό και αποκωδικοποίησαν τη δομή των γονιδίων που κολυμπούν σε αυτό.

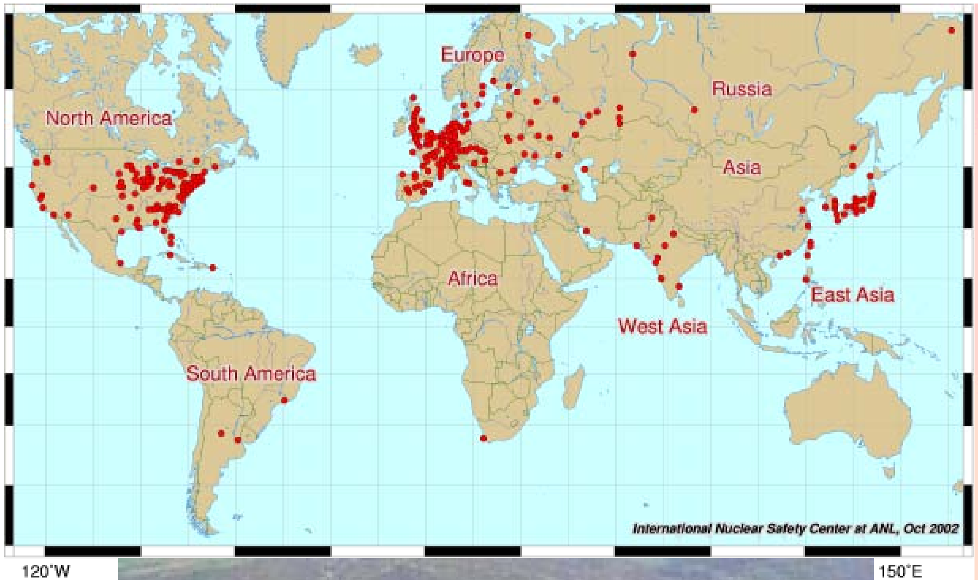
The Future of Nuclear Power

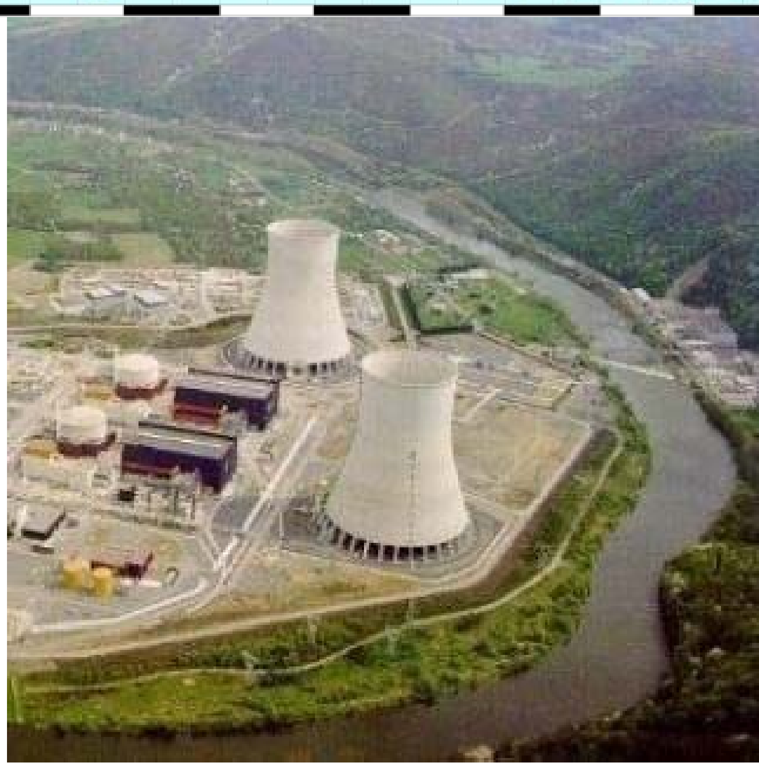
AN INTERDISCIPLINARY MIT STUDY

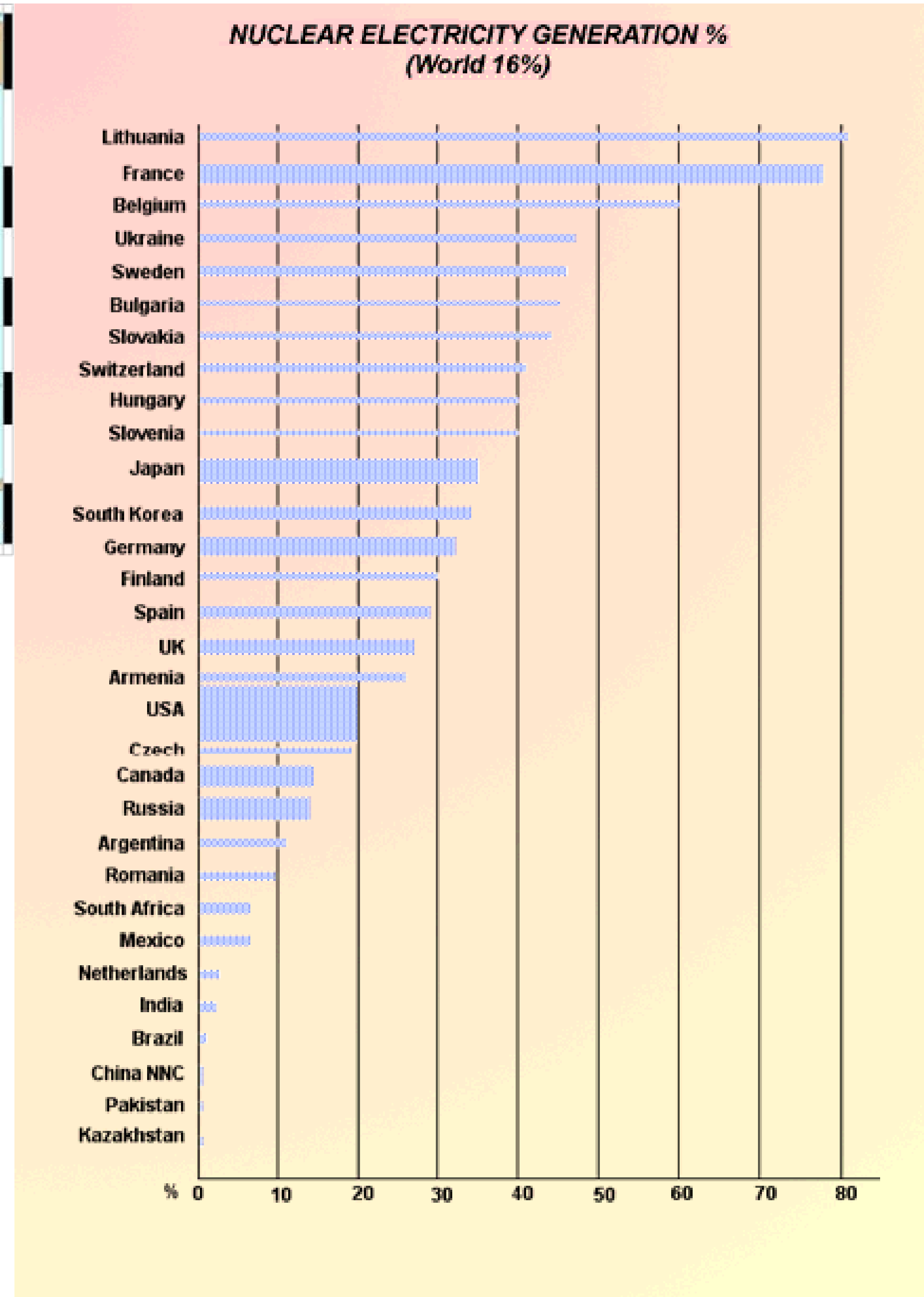
At least for the next few decades, there are only a few realistic options for reducing carbon dioxide emissions from electricity generation:

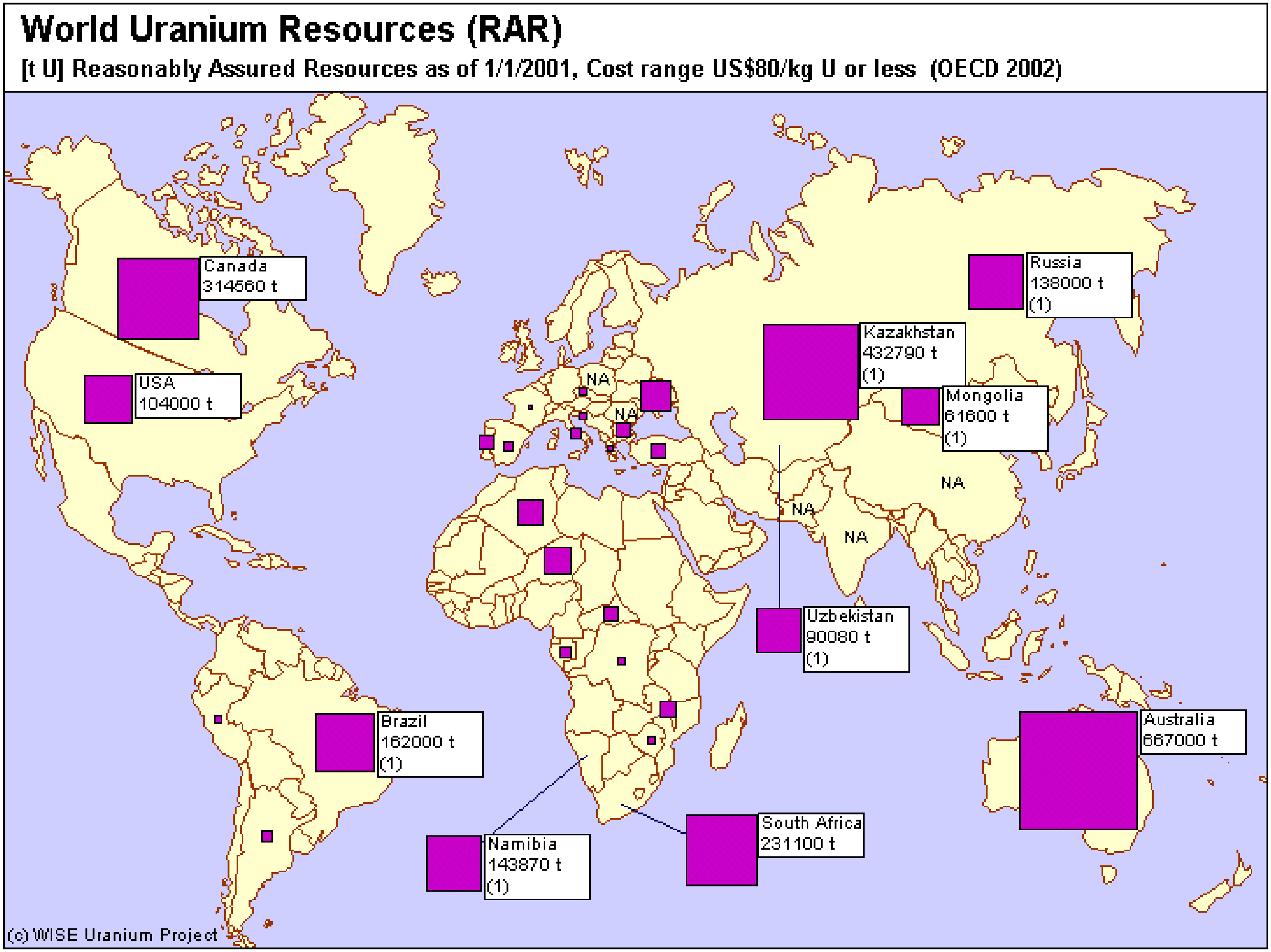
…. increase use of nuclear power !




Europe
Russia
North America
Asia
Africa
East Asia
West Asia
South America
International Nuclear Safety Center at ANL, Oct 2002
120°W
150°E




NUCLEAR ELECTRICITY GENERATION %
(World 16%)
Lithuania
France
Belgium
Ukraine
Sweden
Bulgaria
Slovakia
Switzerland
Hungary
Slovenia
Japan
South Korea
Germany
Finland
Spain
UK
Armenia
USA
Czech
Canada
Russia
Argentina
Romania
South Africa
Mexico
Netherlands
India
Brazil
China NNC
Pakistan
Kazakhstan
%
0
10
20
30
40
50
60
70
80



(1) In situ resources

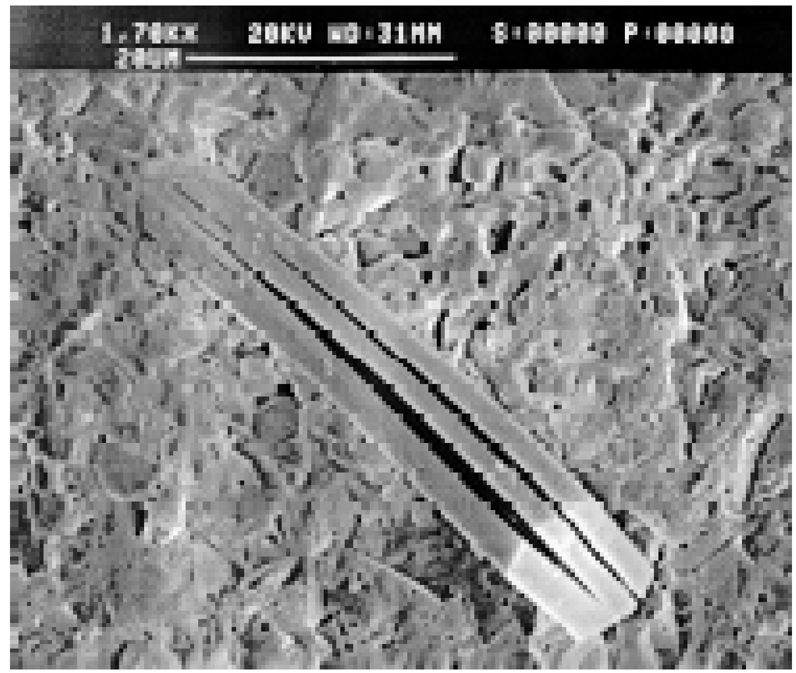
t = metric tonne · NA = Data not available

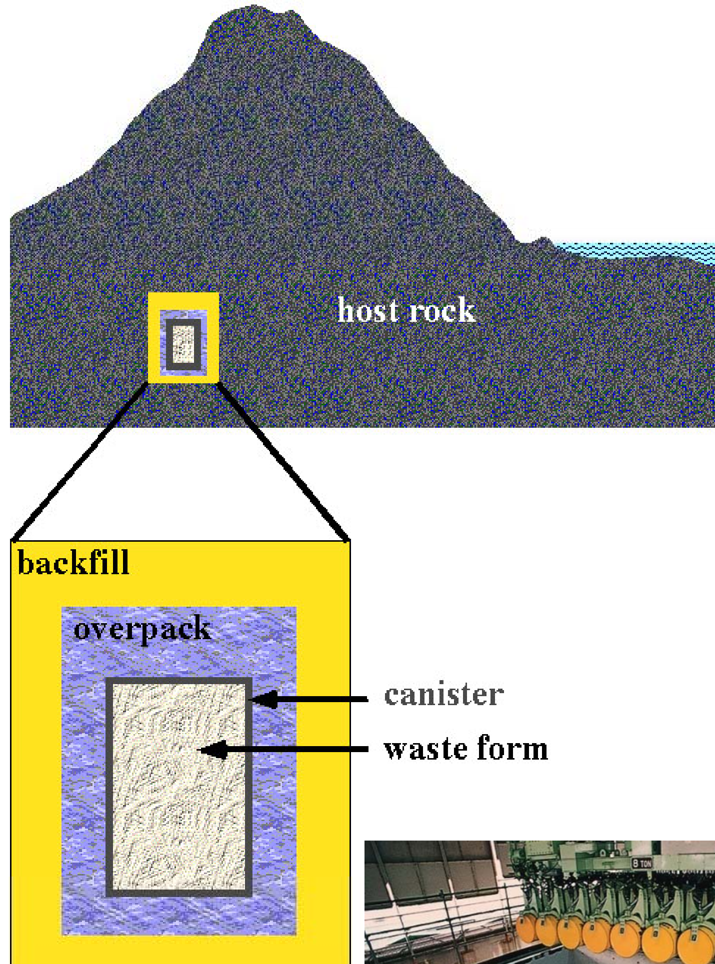
^{238}U, ^{235}U

Depleted uranium…

ΣΟΕΠΙΤΗΣ: $[(UO_2)_8O_2(OH)_{12}](H_2O)_{12}$

ΜΕΤΑΣΟΕΠΙΤΗΣ : $UO_3 \bullet nH_2O$




host rock
backfill
overpack
canister
waste form

Nuclear fuel *Cradle to crypt*

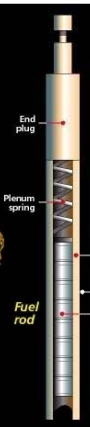
The Energy Department has received congressional approval to ship the nation's high-level nuclear waste to Yucca Mountain for disposal. The materials the department plans to seal inside the mountain, 100 miles northwest of Las Vegas, weigh 77,000 tons, or 70,000 metric tons. One metric ton of these heavy metals would fill a space the size of a refrigerator. Since the first U.S. power reactors were built in the late 1950s, spent fuel has been stored at those sites. The Environmental Protection Agency has required that the repository protect the public from harmful radiation for 10,000 years. However, some of those materials will remain dangerously radioactive beyond the 10,000-year period.

Graphic by MIKE JOHNSON/REVIEW-JOURNAL

Uranium: the beginning

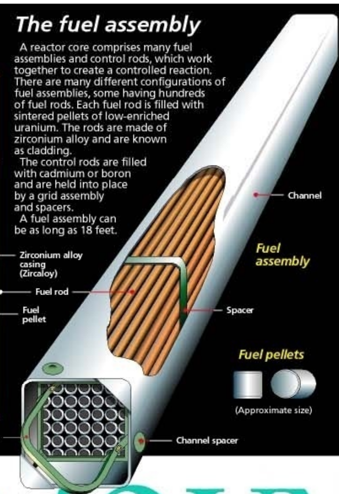
Uranium, a naturally occurring radioactive material, is mined throughout North America. Utah, Wyoming and Nebraska are large producers.
The ore is refined into a brightly colored solid uranium compound known as "yellow cake."

The yellow cake is then converted into various uranium metal alloys or compounds to be formed into pellets for usable nuclear fuel.
The uranium pellets are clad in metals such as stainless steel or Zircaloy to provide structural strength and prevent the release of radioactive particles.



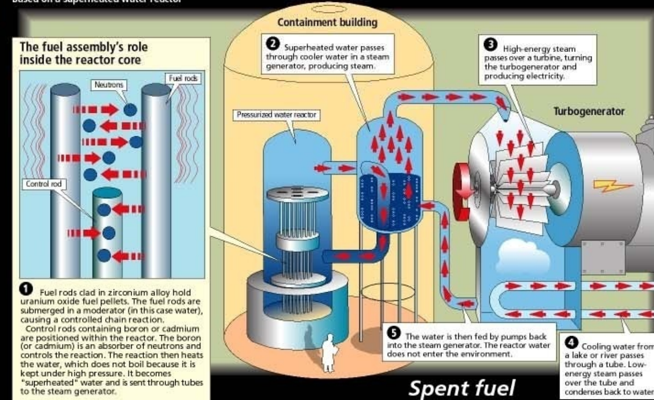
The fuel assembly

A reactor core comprises many fuel assemblies and control rods, which work together to create a controlled reaction. There are many different configurations of fuel assemblies, some having hundreds of fuel rods. Each fuel rod is filled with sintered pellets of low-enriched uranium. The rods are made of zirconium alloy and are known as cladding.
The control rods are filled with cadmium or boron and are held into place by a grid assembly and spacers.
A fuel assembly can be as long as 18 feet.



How a nuclear reactor generates electrical power

Based on a superheated water reactor



1 Fuel rods clad in zirconium alloy hold uranium oxide fuel pellets. The fuel rods are submerged in a moderator (in this case water), causing a controlled chain reaction.
Control rods containing boron or cadmium are positioned within the reactor. The boron (or cadmium) is an absorber of neutrons and controls the reaction. The reaction then heats the water, which does not boil because it is kept under high pressure. It becomes "superheated" water and is sent through tubes to the steam generator.

2 Superheated water passes through cooler water in a steam generator, producing steam.

3 High-energy steam passes over a turbine, turning the turbogenerator and producing electricity.

4 Cooling water from a lake or river passes through a tube. Low-energy steam passes over the tube and condenses back to water.

5 The water is then fed by pumps back into the steam generator. The reactor water does not enter the environment.

Spent fuel

Spent or used fuel has been removed from the reactor because it can no longer generate energy efficiently. Spent fuel is highly radioactive and can be as hot as 200 degrees. Used fuel assemblies must be kept in a cooling pool for at least five years before they can be repackaged in casks and removed for dry storage on concrete.

YUCCA MOUNTAIN

Surface facility

North portal

Radiologically controlled area facilities

1. Airlock building
2. Change house
3. Firewater tank with pump house
4. Switchgear building
5. Substation
6. Transporter maintenance building
7. Pump house
8. Waste handling building
9. Low-level waste treatment building
10. Truck parking
11. Fuel tank with berm
12. Carrier preparation building
13. Rail parking

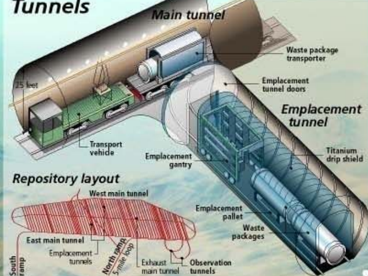
Balance of plant area facilities

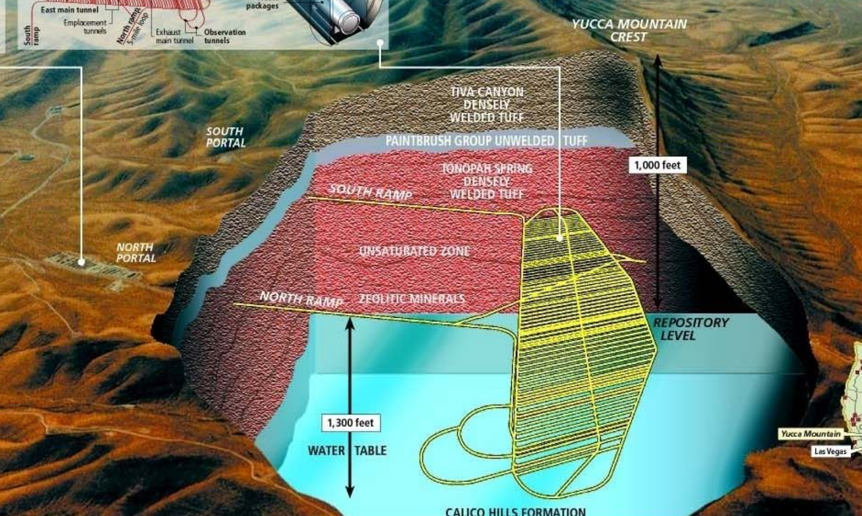
14. Fire station
15. Medical center
16. Security station No. 1
17. Motorpool and facility service station
18. Administration
19. Central shops
20. Security station No. 2
21. Food service facility
22. Training auditorium
23. Computer center
24. Mockup building
25. Central warehouse
26. Utility building
27. Cooling tower
28. Security station No. 3

Site service facilities

29. Visitor center
30. General parking

Tunnels





Nevada transportation plans

Department of Energy officials prefer building a branch rail line to deliver spent nuclear fuel to Yucca Mountain for disposal. The five alternatives for rail corridors are Caliente, Carlin, Caliente-Chalk Mountain, Jean and a modified route in the Las Vegas Valley. If a new rail line is not built, plans call for selecting one site from three potential locations to transfer waste shipments from rail cars to trucks. The waste then would be hauled over highways. These so-called intermodal station sites are Caliente, Sloan/Jean and Apex-Dry Lake.

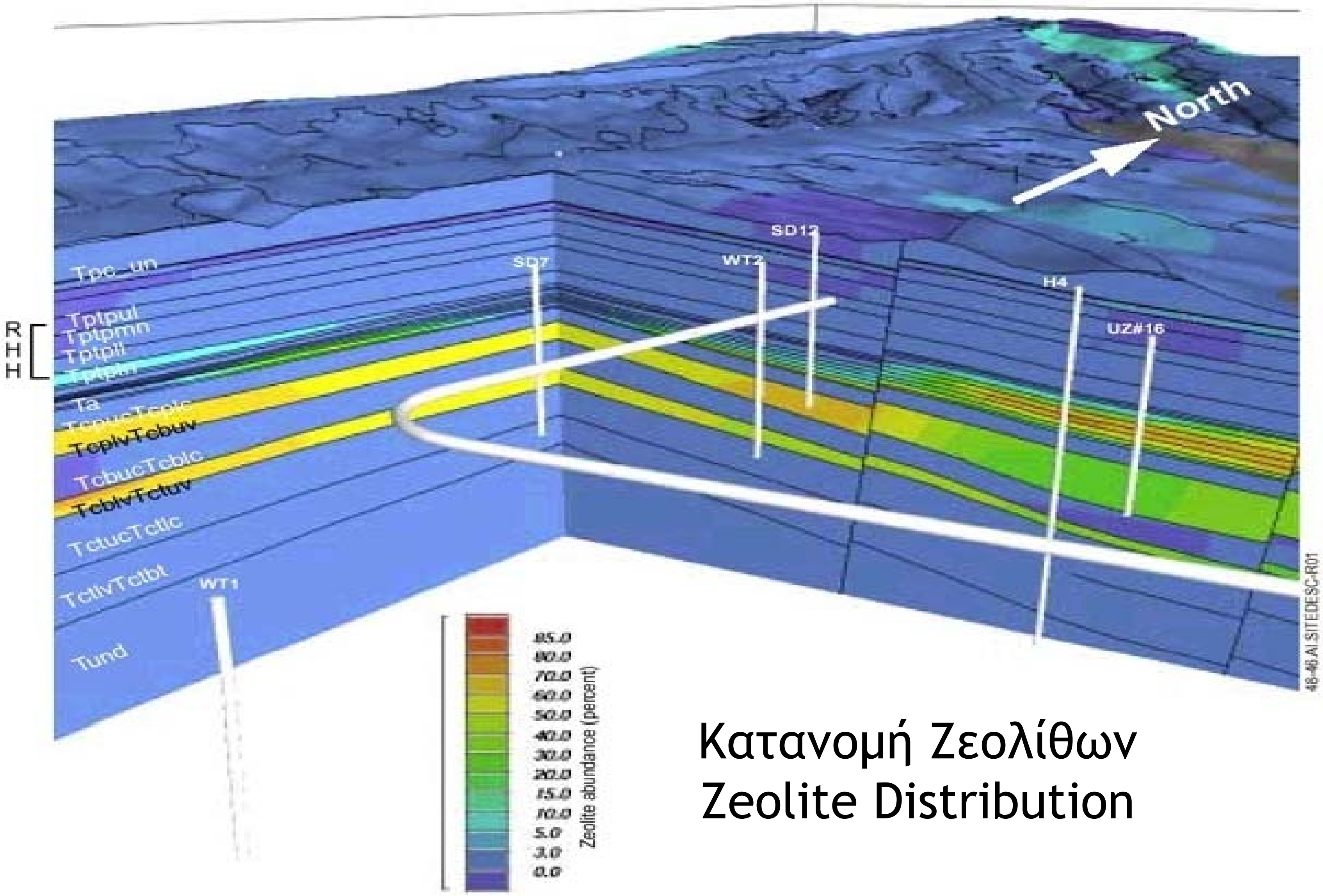
Waste transportation

The waste would be contained and sealed inside shipping casks, similar to the one shown below, and carried by truck, rail car or barge. Routes across the United States would use highways, railways and waterways. The shipments would be made under high security.

Cask construction

Possible national waste routes

Although the Department of Energy has not designated routes for shipping high-level nuclear waste to Yucca Mountain, a Clark County report says much of it probably would be hauled across the nation on interstate highways that funnel into Southern Nevada. The thicker the lines on the map, the more intensely the routes would be used by trucks hauling waste, the report suggests. The Energy Department would prefer to ship most of the spent fuel by rail.



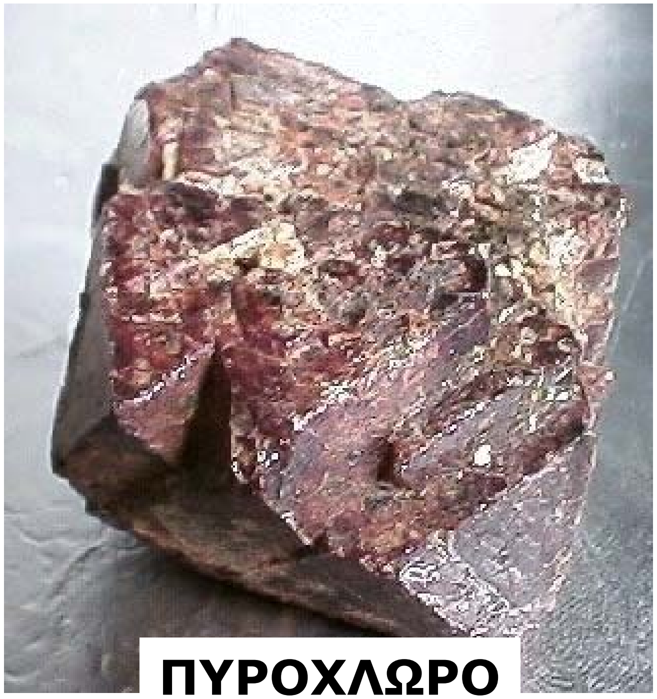
Κατανομή Ζεολίθων
Zeolite Distribution

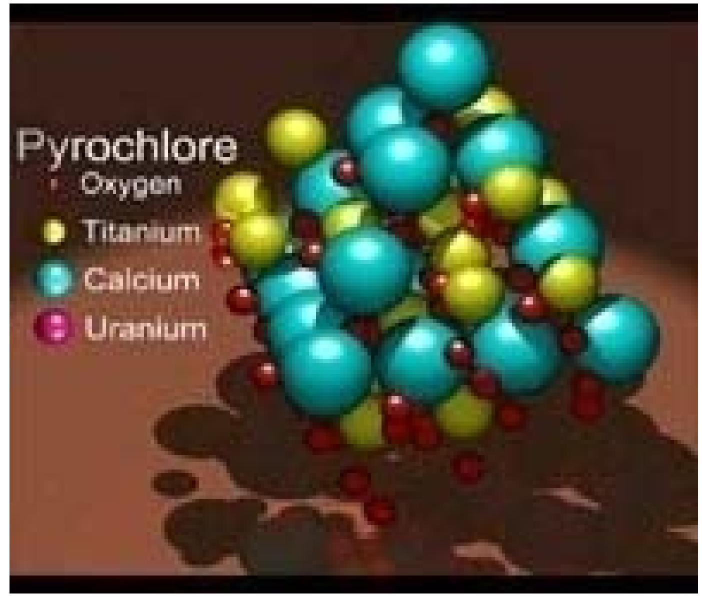
Dear Colleagues,

The 9th International Conference on the Occurrence, Properties, and Utilization of Natural Zeolites - **Zeolite 2014** will be held from the 8th to 13th of June 2014 in Belgrade, Serbia. On behalf of the Organizing Committee of **Zeolite 2014**, we have the pleasure to cordially invite all researchers and interested parties to join us in participating in the scientific conference and related events.

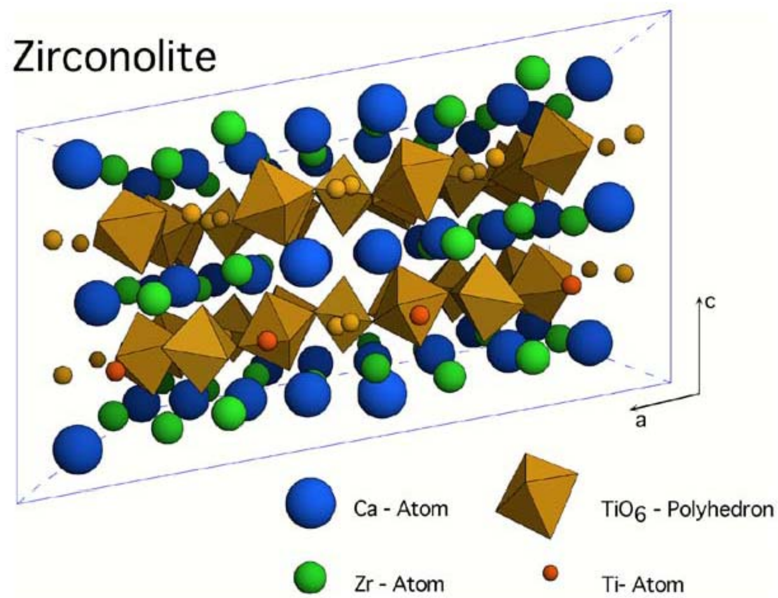
International Natural Zeolite Association

INZA


ΠΥΡΟΧΛΩΡΟ


Pyrochlore
Oxygen
Titanium
Calcium
Uranium

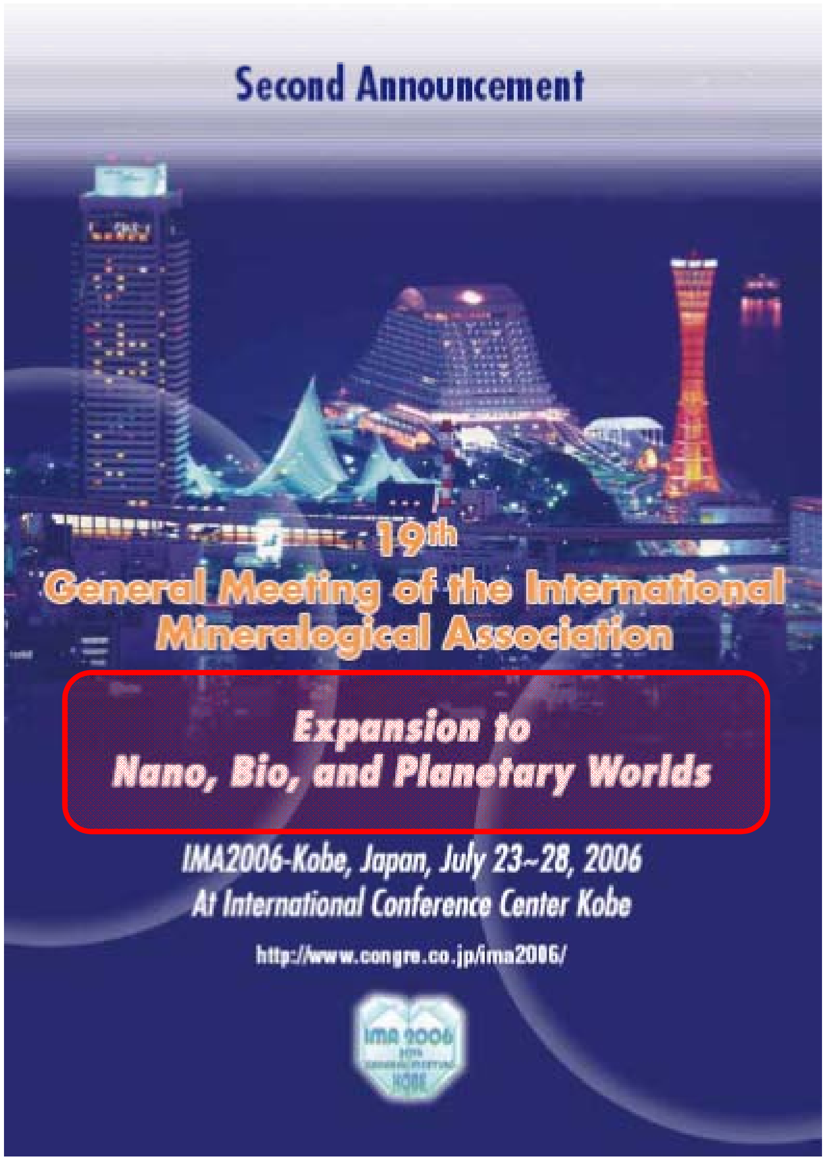

ΖΙΡΚΟΝΟΛΙΤΗΣ

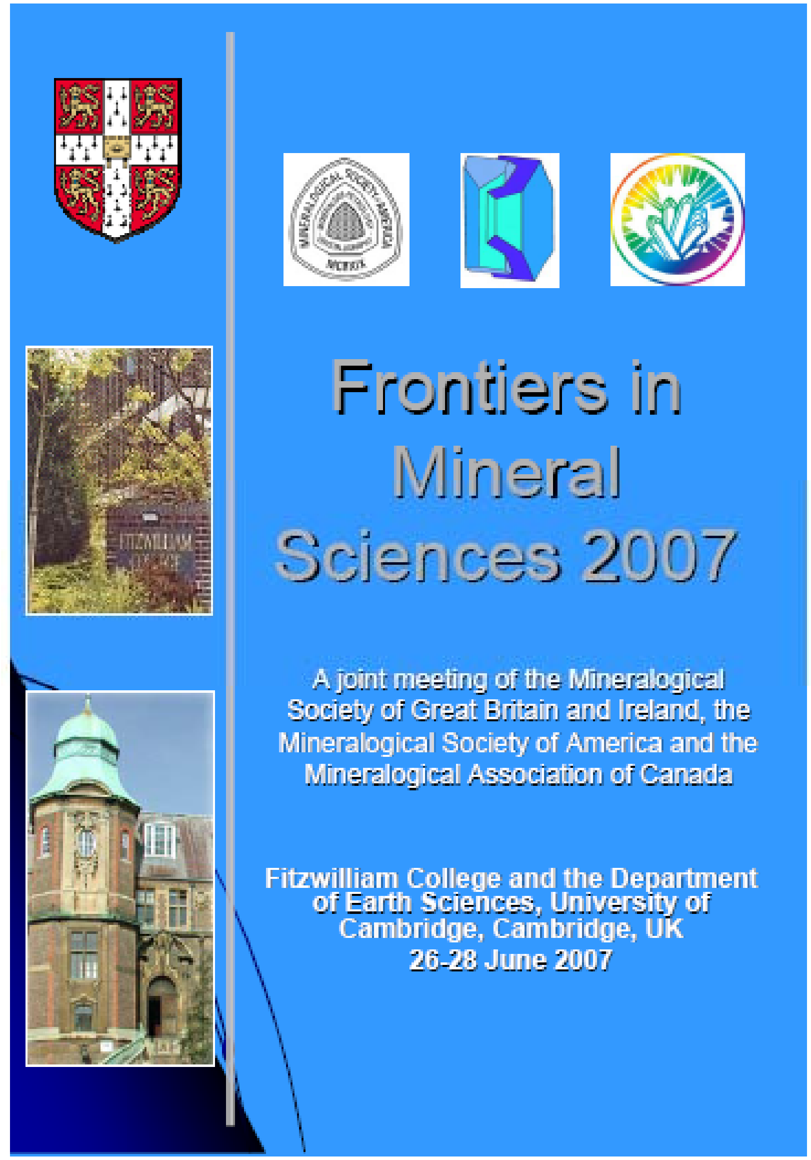

Zirconolite
c
a
Ca - Atom
TiO6 - Polyhedron
Zr - Atom
Ti- Atom

theguardian

Jennifer Duggan, Wednesday 19 March 2014 19.42 GMT

Beijing brings forward deadline for world's first **thorium**-fuelled facility in attempt to break reliance on fossil fuels


Second Announcement
19th
General Meeting of the International Mineralogical Association
Expansion to
Nano, Bio, and Planetary Worlds
IMA2006-Kobe, Japan, July 23~28, 2006
At International Conference Center Kobe
http://www.congre.co.jp/ima2006/


Frontiers in Mineral Sciences 2007
A joint meeting of the Mineralogical Society of Great Britain and Ireland, the Mineralogical Society of America and the Mineralogical Association of Canada
Fitzwilliam College and the Department of Earth Sciences, University of Cambridge, Cambridge, UK
26-28 June 2007


planet earth
from core to surface
emc² 2012
2 - 6 September
european mineralogical
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frankfurt / main
germany
The first European Mineralogical
Conference will take place
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MODERN MINERALOGY

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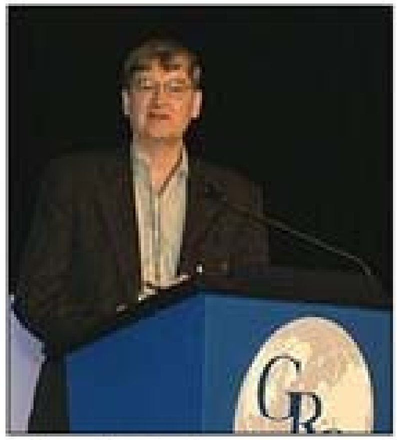

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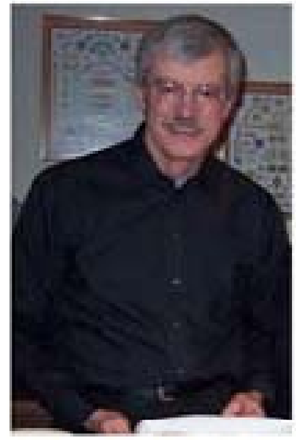

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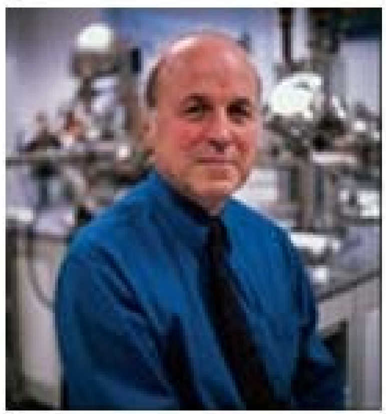

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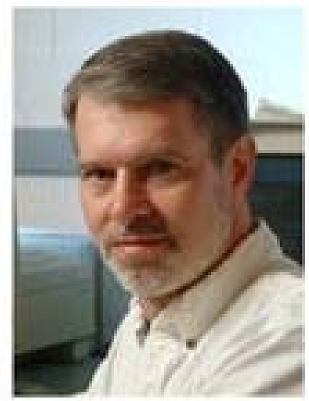

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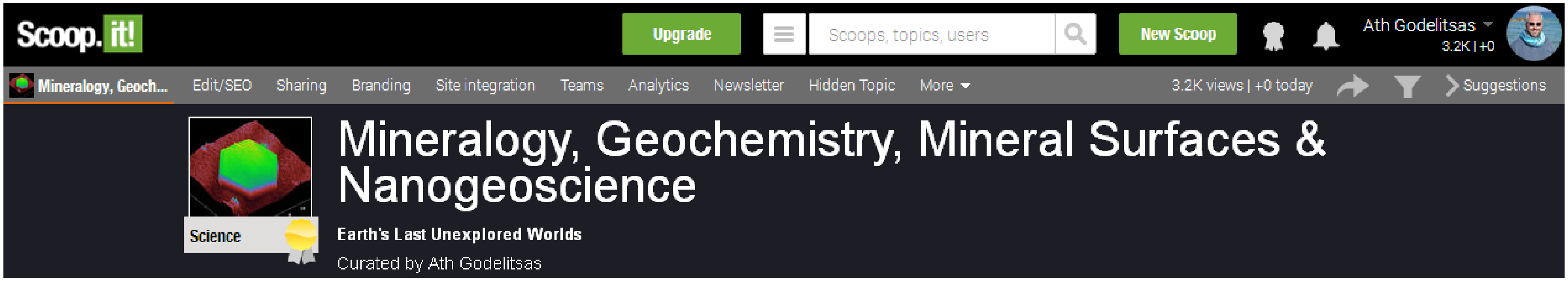
- http://eurominunion.org/
- http://www.minsocam.org/
- http://www.dmg-home.de/
- http://www.minersoc.org



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