

ΦΥΛΛΟΠΥΡΙΤΙΚΑ ΟΡΥΚΤΑ (PHYLLOSILICATES)

- Μαρμαρυγίες (Micas)
 - Ομάδα χλωρίτη (Chlorite group)
 - Τάλκης (Talc)
 - Ομάδα σερπεντίνη (Serpentine group)
- ## AMIANΤΟΣ (ASBESTOS)
- Ορυκτά της αργίλου (Clay minerals)

ΔΟΜΗ ΦΥΛΛΟΠΥΡΙΤΙΚΩΝ ΟΡΥΚΤΩΝ

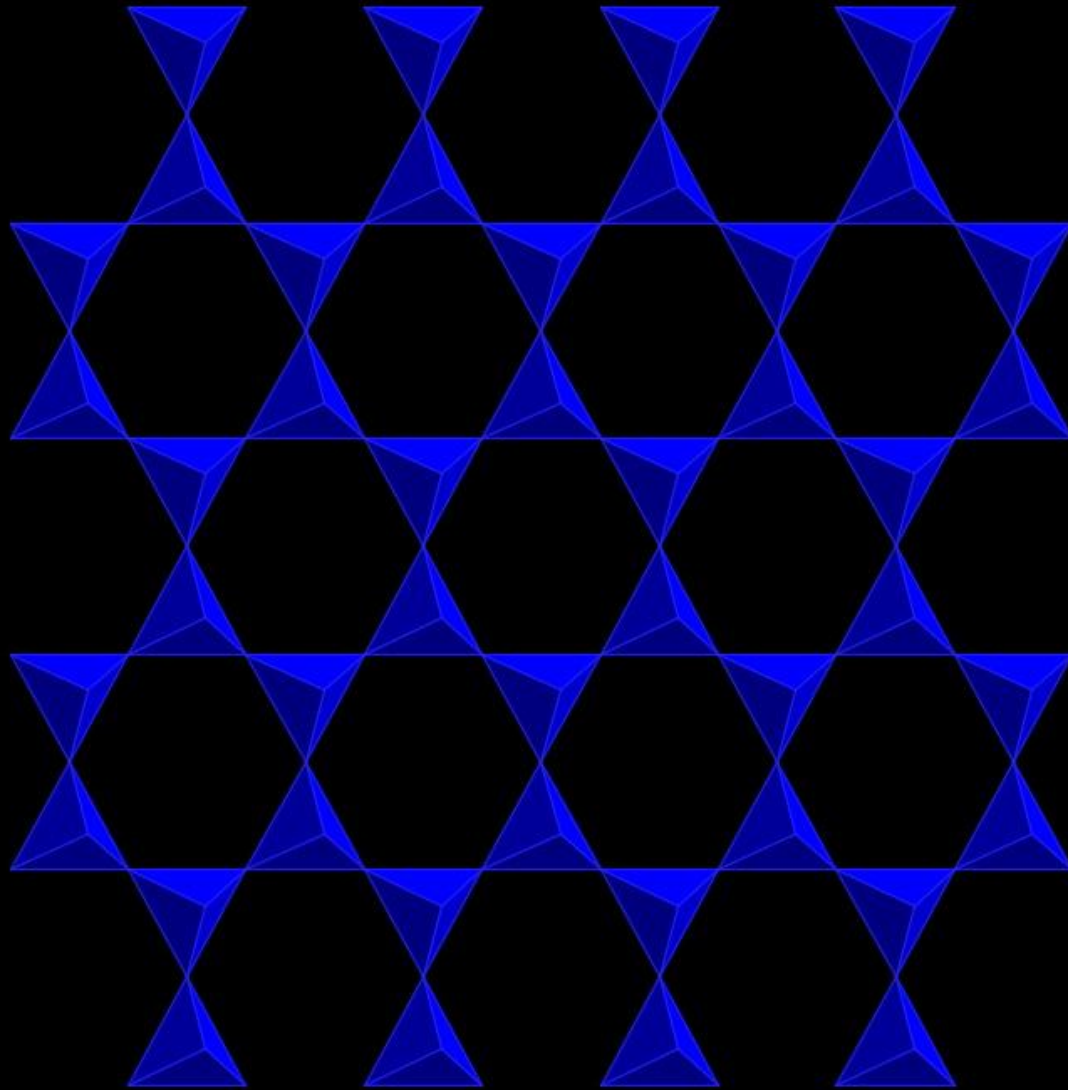
- Δύο είδη στρωμάτων (στοιβάδες):
Τετραεδρικά (T) και Οκταεδρικά (O)
- Τα στρώματα T και O ενώνονται μεταξύ τους
ώστε να σχηματίζουν φύλλα
- Τα φύλλα στοιβάζονται το ένα πάνω στο άλλο
- Ο χώρος μεταξύ των φύλλων μπορεί να είναι
κενός ή να περιέχει κατιόντα ή και OH^-
- Αποτέλεσμα των χαλαρών δεσμών μεταξύ των
στρωμάτων είναι ο τέλειος σχισμός των
φυλλοπυριτικών

ΤΕΤΡΑΕΔΡΙΚΟ ΣΤΡΩΜΑ (T)

Ιόντα Si^{+4} ή (Al^{+3}) σε τετραεδρική συνδιάταξη

- Γενικός τύπος T_2O_5 ($\text{T}=\text{Si}$ ή Al)
- Τα τετράεδρα σχηματίζουν 6-μελείς δακτυλίους
- Βασικά Οξυγόνα: Τα 3 O^{-2} που είναι κοινά στα γειτονικά τετράεδρα
- Κορυφαία Οξυγόνα: Τα O^{-2} που είναι ελεύθερα, στις κορυφές

ΤΕΤΡΑΕΔΡΙΚΟ ΣΤΡΩΜΑ (T)

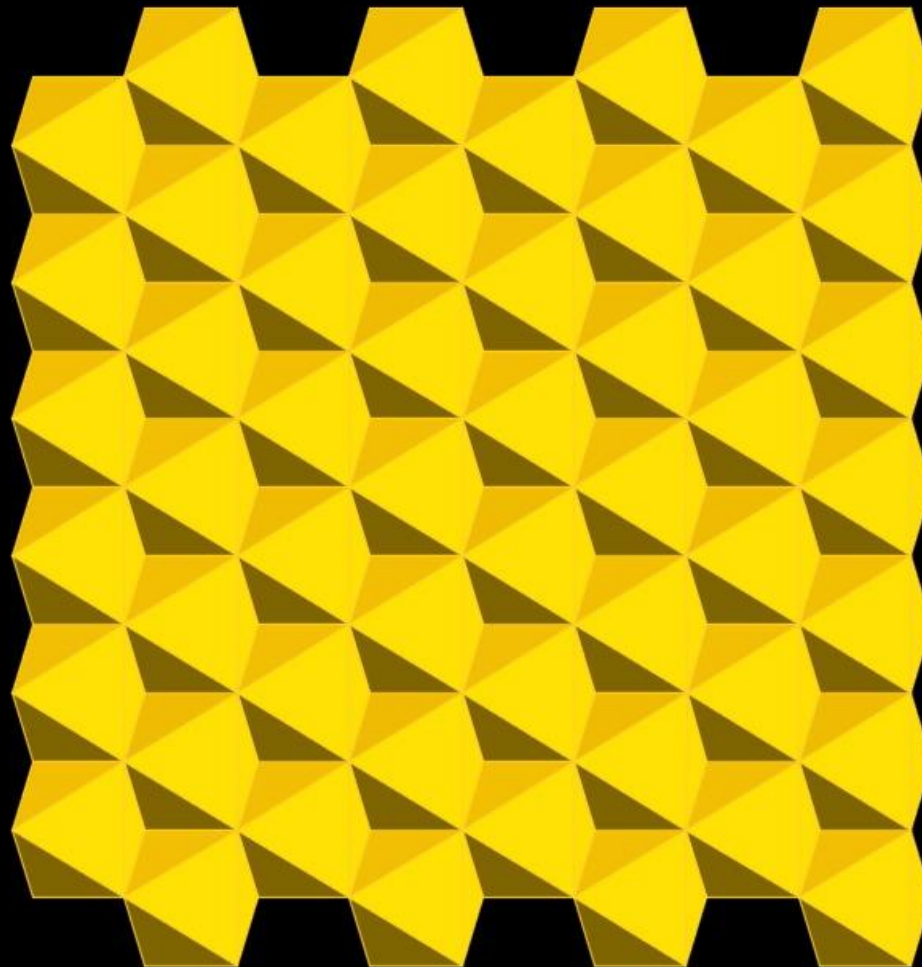


ΟΚΤΑΕΔΡΙΚΟ ΣΤΡΩΜΑ (O)

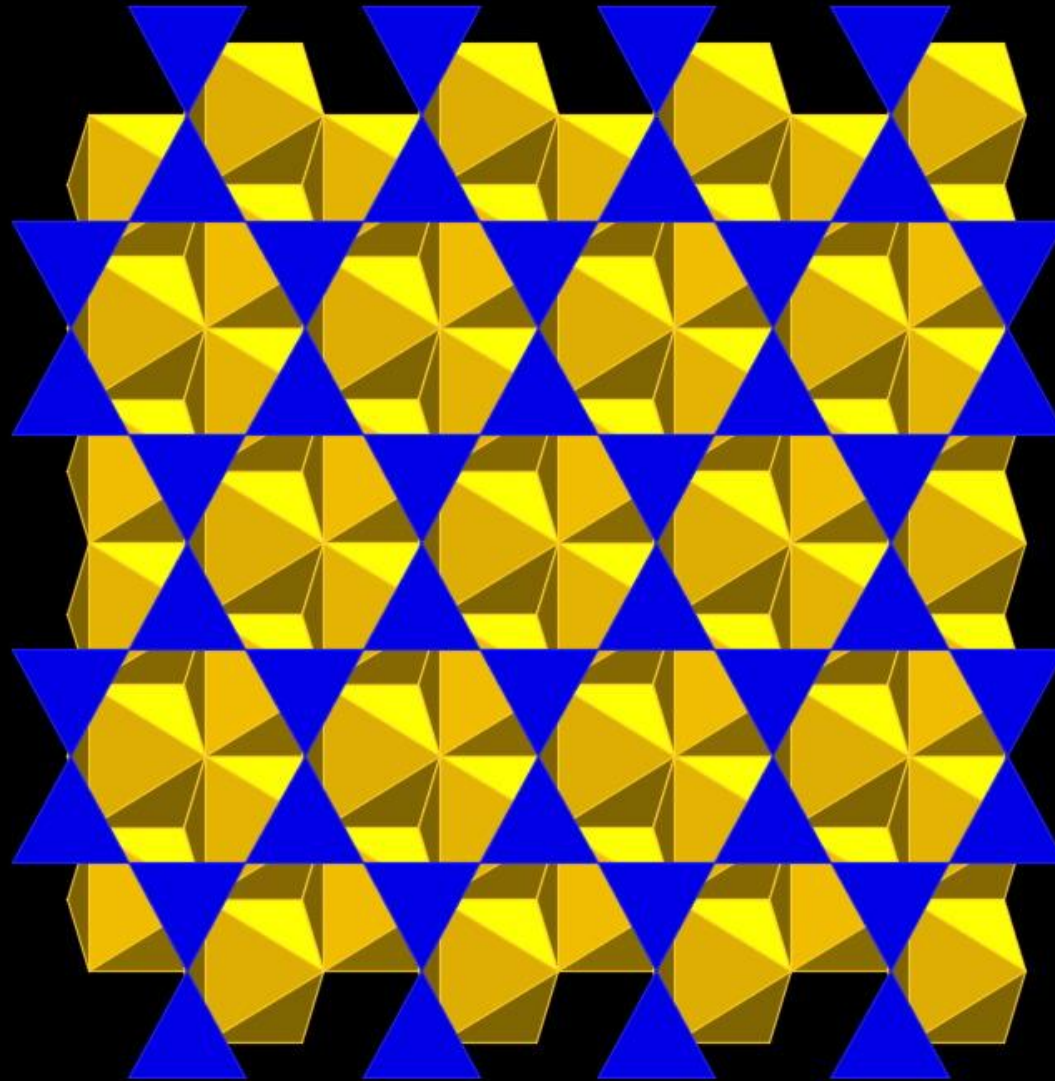
- Στο κέντρο των εξαμελών δακτυλίων τοποθετούνται ιόντα OH^-
- Ενώνονται με τα κορυφαία O^{2-}
- Οκταεδρική συνδιάταξη
- Έτσι, οι οκταεδρικές θέσεις συνίστανται από δύο επίπεδα ανιόντων OH^-
- Οι ενδιάμεσες θέσεις καταλαμβάνονται από δισθενή (συνήθως Mg^{+2} , Fe^{+2}) ή τρισθενή (συνήθως Al^{+3} , Fe^{+3}) κατιόντα

ΟΚΤΑΕΔΡΙΚΟ ΣΤΡΩΜΑ (Ο)

Τριοκταεδρικό – δισθενή κατιόντα π.χ. Mg^{2+}



Συνδυασμός T-O (O: τριοκταεδρικό)

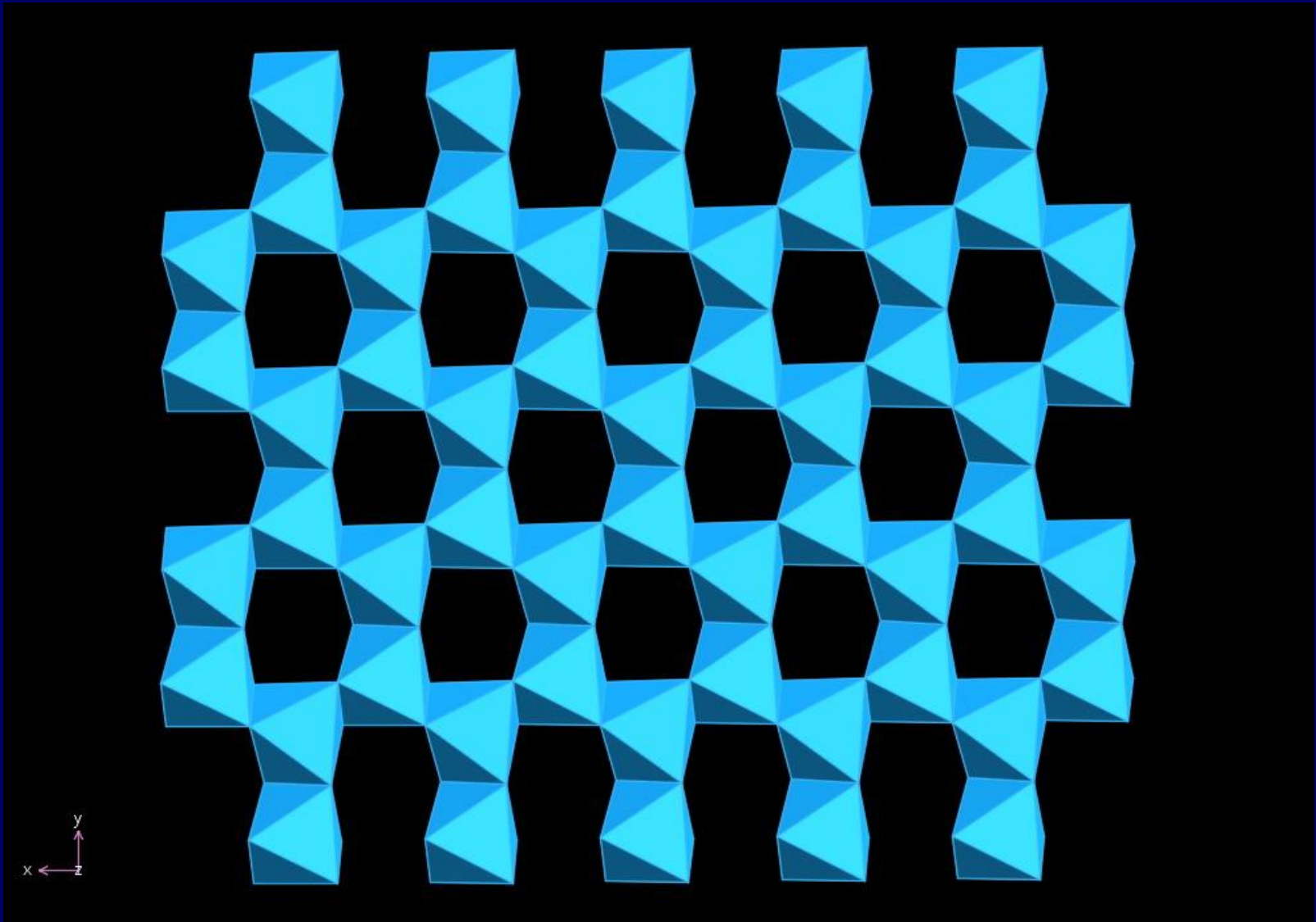


Συνδυασμός T-O (O: τριοκταεδρικό)

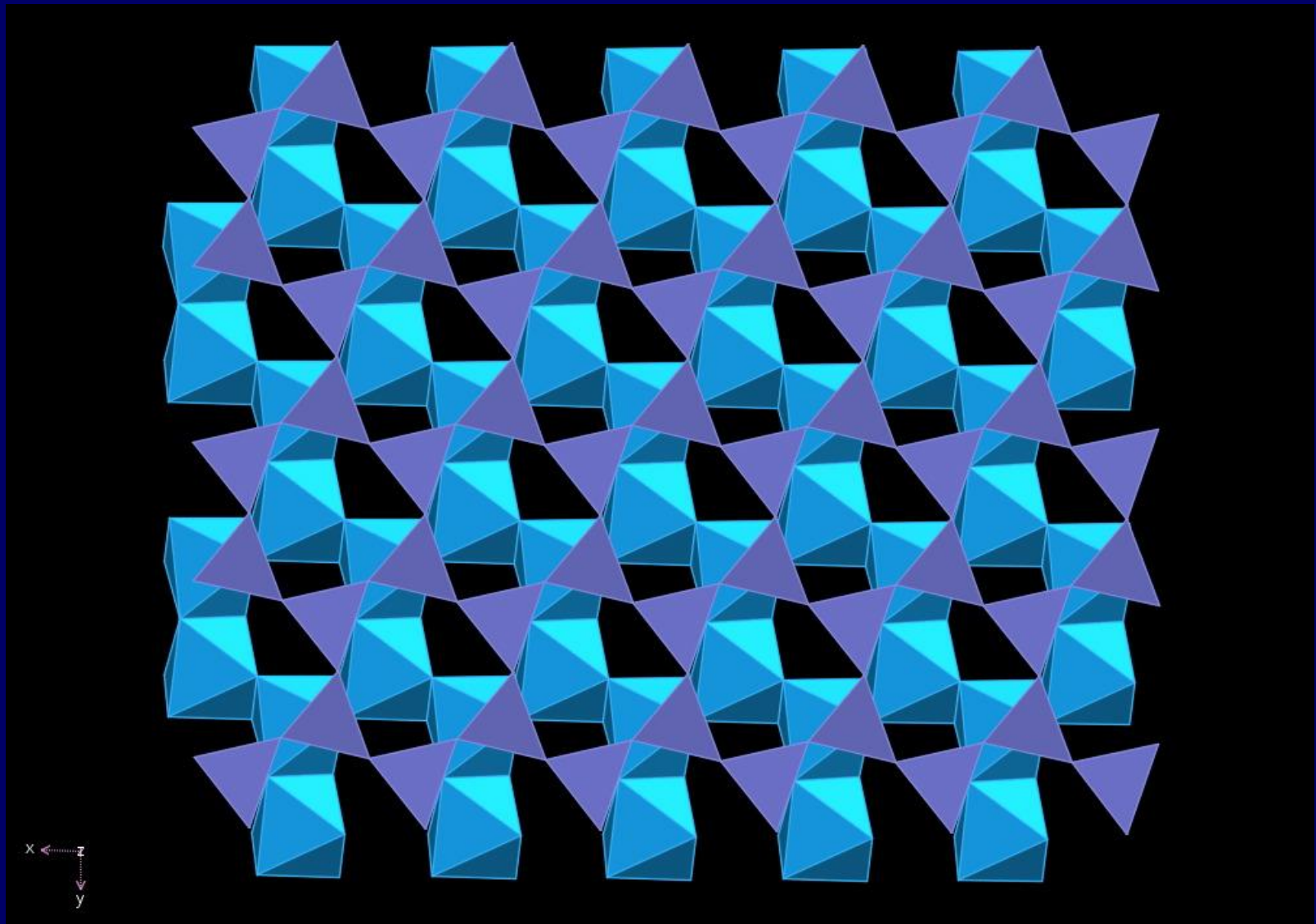


ΟΚΤΑΕΔΡΙΚΟ ΣΤΡΩΜΑ (Ο)

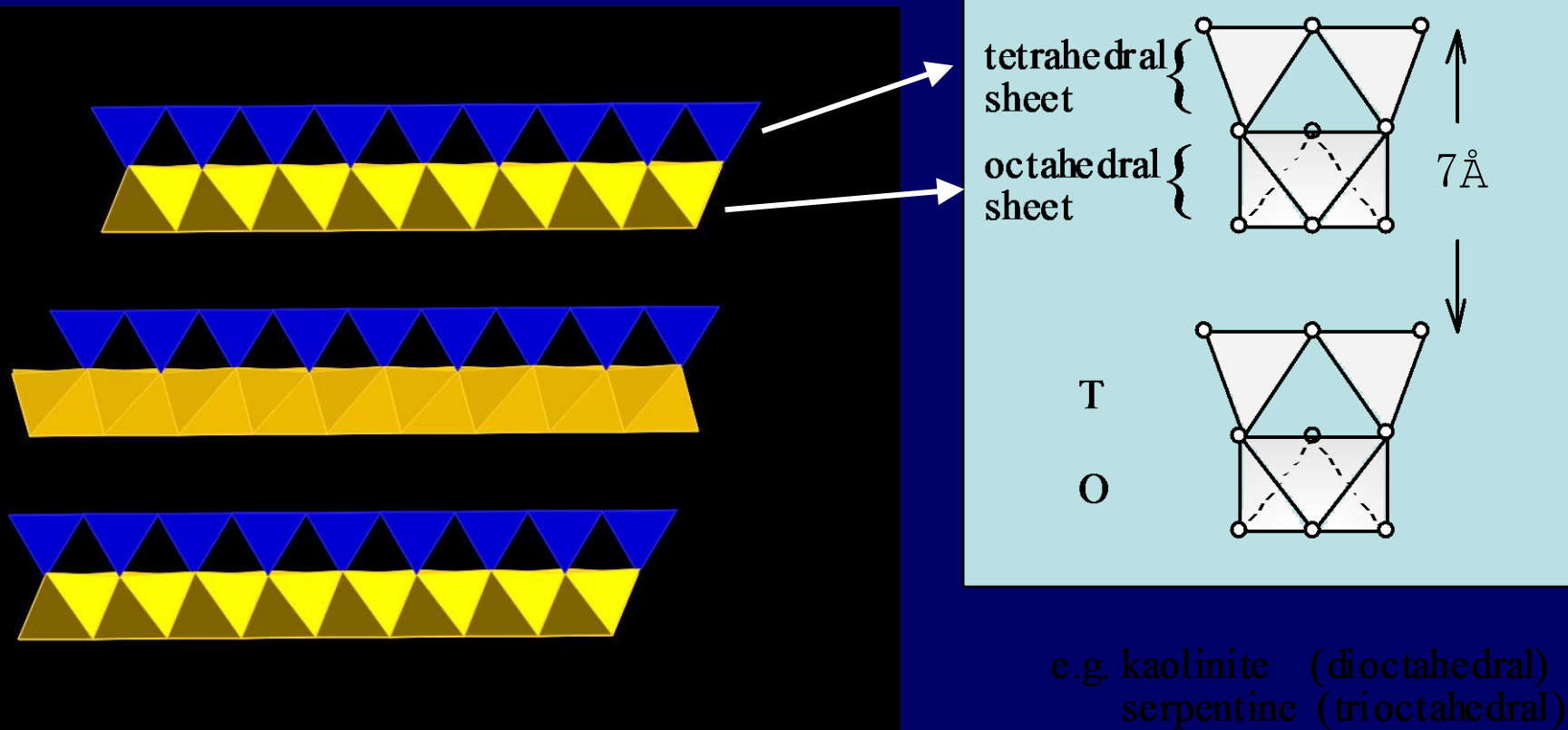
Διοκταεδρικό – τρισθενή κατιόντα π.χ. Al^{3+}



Συνδυασμός T-O (O: διοκταεδρικό)



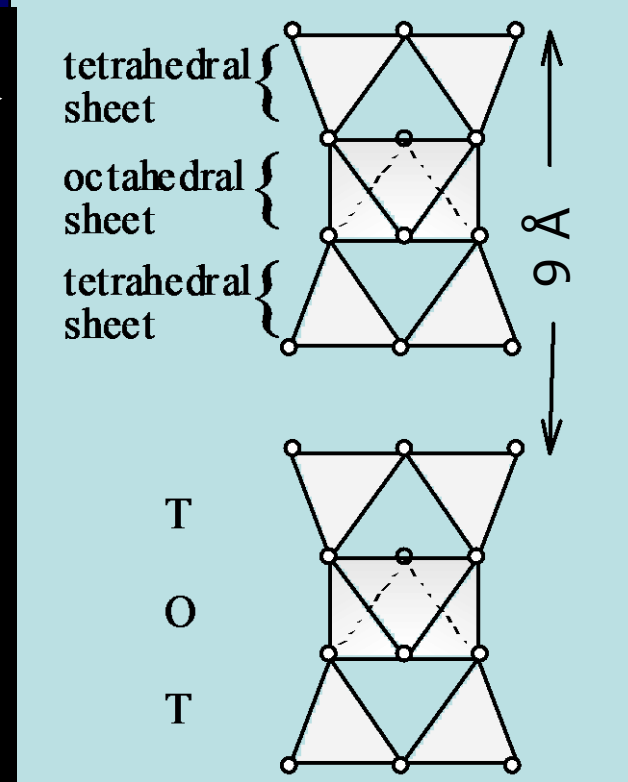
ΦΥΛΛΟΠΥΡΙΤΙΚΑ 1:1 (T-O)



Τριοκταεδρικό: $\text{Mg}_3\text{Si}_2\text{O}_5(\text{OH})_4$ – **Σερπεντίνης**

Διοκταεδρικό: $\text{Al}_2\text{Si}_2\text{O}_5(\text{OH})_4$ – **Καολινίτης**

ΦΥΛΛΟΠΥΡΙΤΙΚΑ 2:1 (T-O-T)

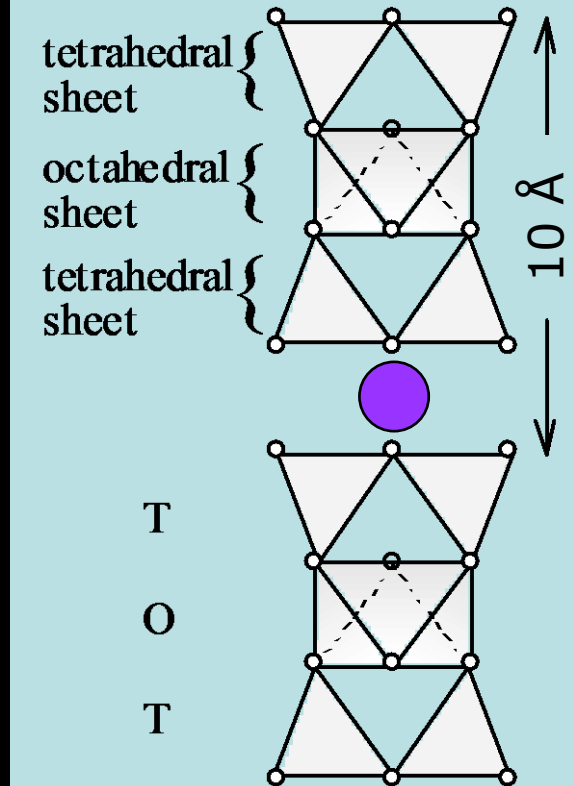
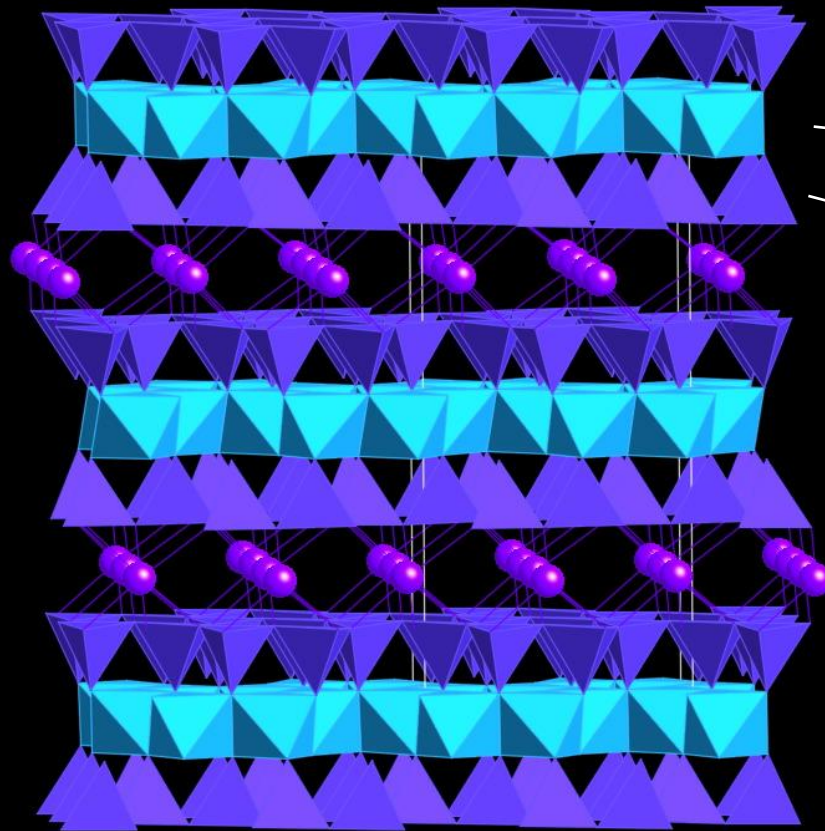


(i) no interlayer sites ($c = 9 \text{ \AA}$):
pyrophyllite (dioctahedral)
talc (trioctahedral)

Τριοκταεδρικό: $\text{Mg}_3\text{Si}_4\text{O}_{10}(\text{OH})_2$ – **Τάλκης**

Διοκταεδρικό: $\text{Al}_2\text{Si}_4\text{O}_{10}(\text{OH})_2$ – **Πυροφυλλίτης**

ΦΥΛΛΟΠΥΡΙΤΙΚΑ 2:1 (T-O-T)



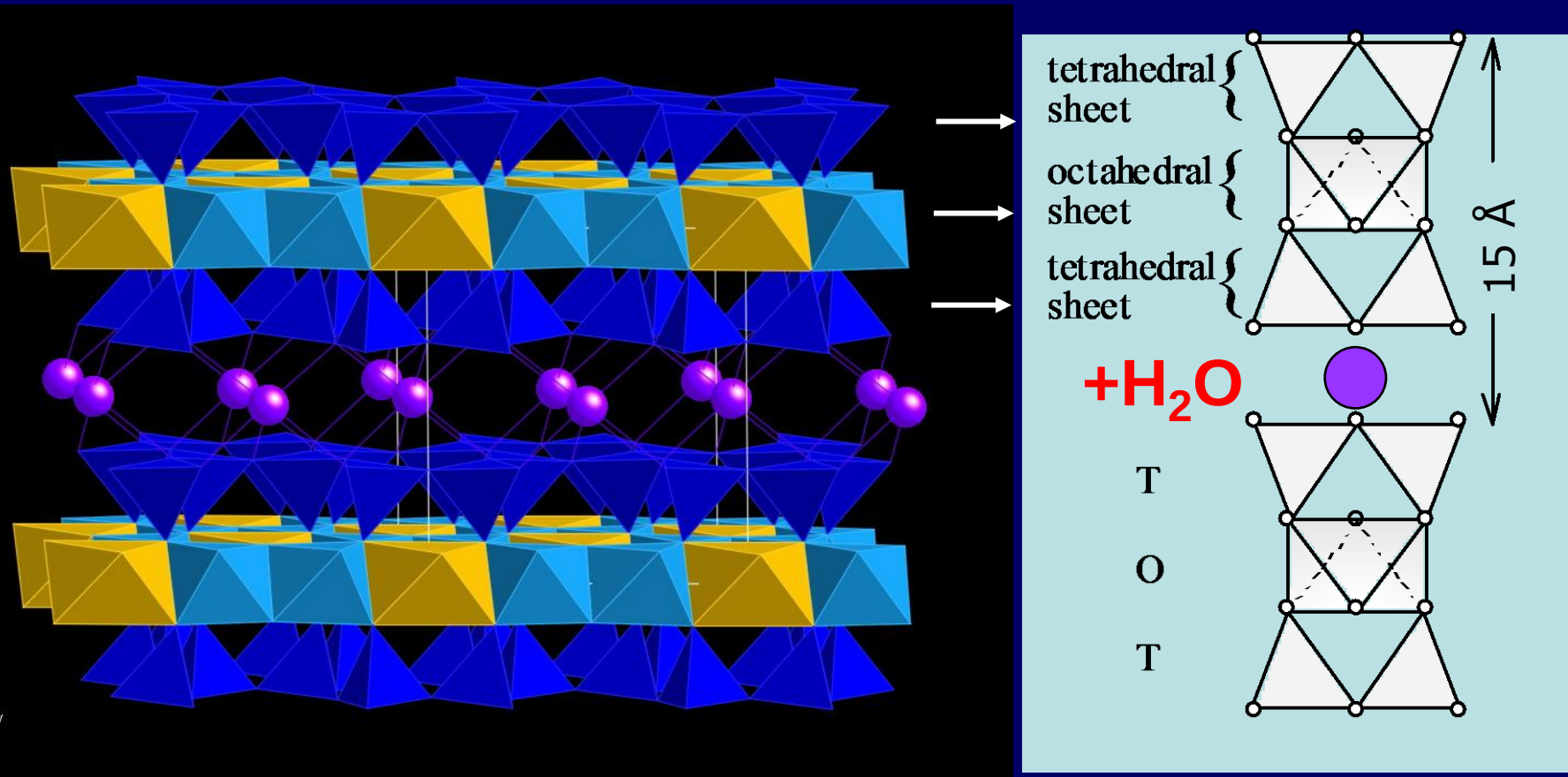
$\text{K}(\text{Mg}, \text{Fe}^{2+})_3(\text{Al}, \text{Fe}^{3+})\text{Si}_3\text{O}_{10}(\text{OH}, \text{F})_2$ – **Βιοτίτης**

Τριοκταεδρικό: $\text{KMg}_3(\text{AlSi}_3\text{O}_{10})(\text{OH})_2$ – **Φλογοπίτης**

Διοκταεδρικό: $\text{KAl}_2(\text{AlSi}_3\text{O}_{10})(\text{OH})_2$ – **Μοσχοβίτης**

(ii) with cations (e.g. K^+) in interlayer sites ($c = 10\text{\AA}$):
 muscovite (dioctahedral)
 phlogopite (trioctahedral)

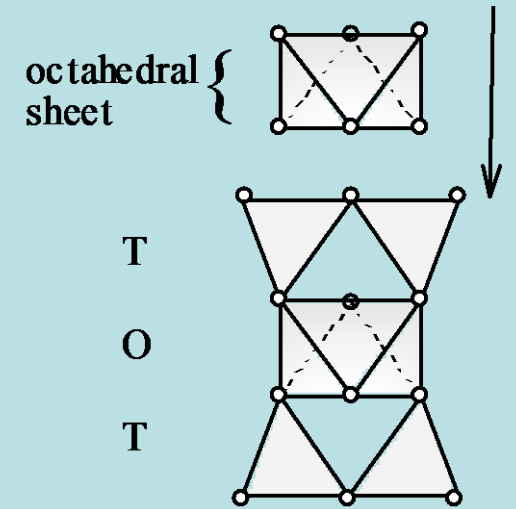
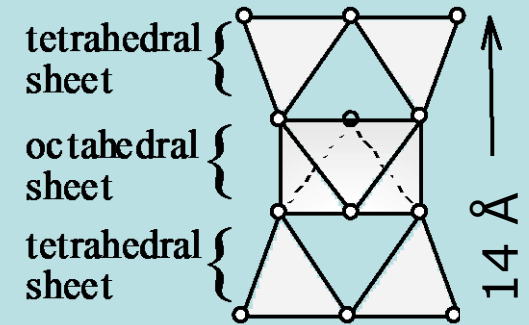
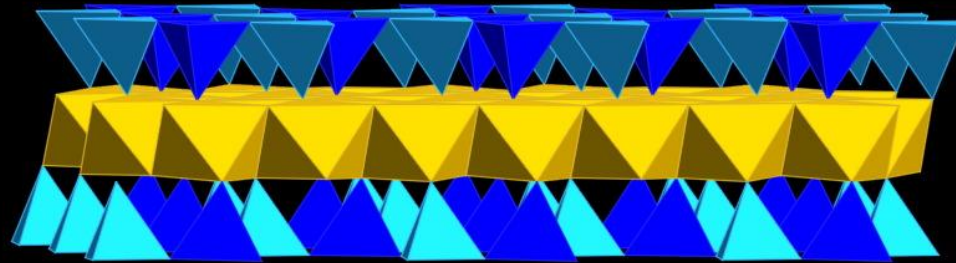
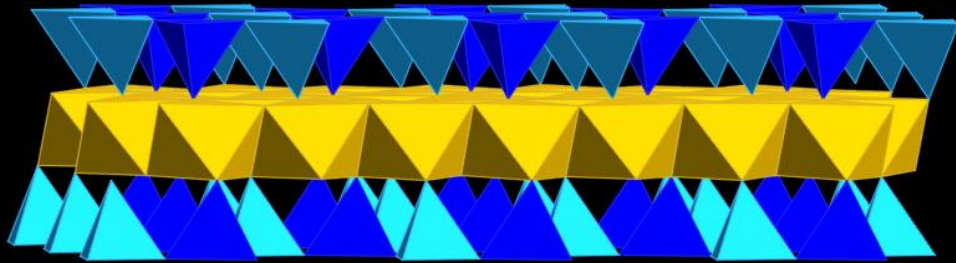
ΦΥΛΛΟΠΥΡΙΤΙΚΑ 2:1 (T-O-T)



Τριοκταεδρικό: $(Mg, Fe^{3+}, Al)_3(Si, Al)_4O_{10}(OH)_2 \cdot 4H_2O$ - **Βερμικουλίτης**

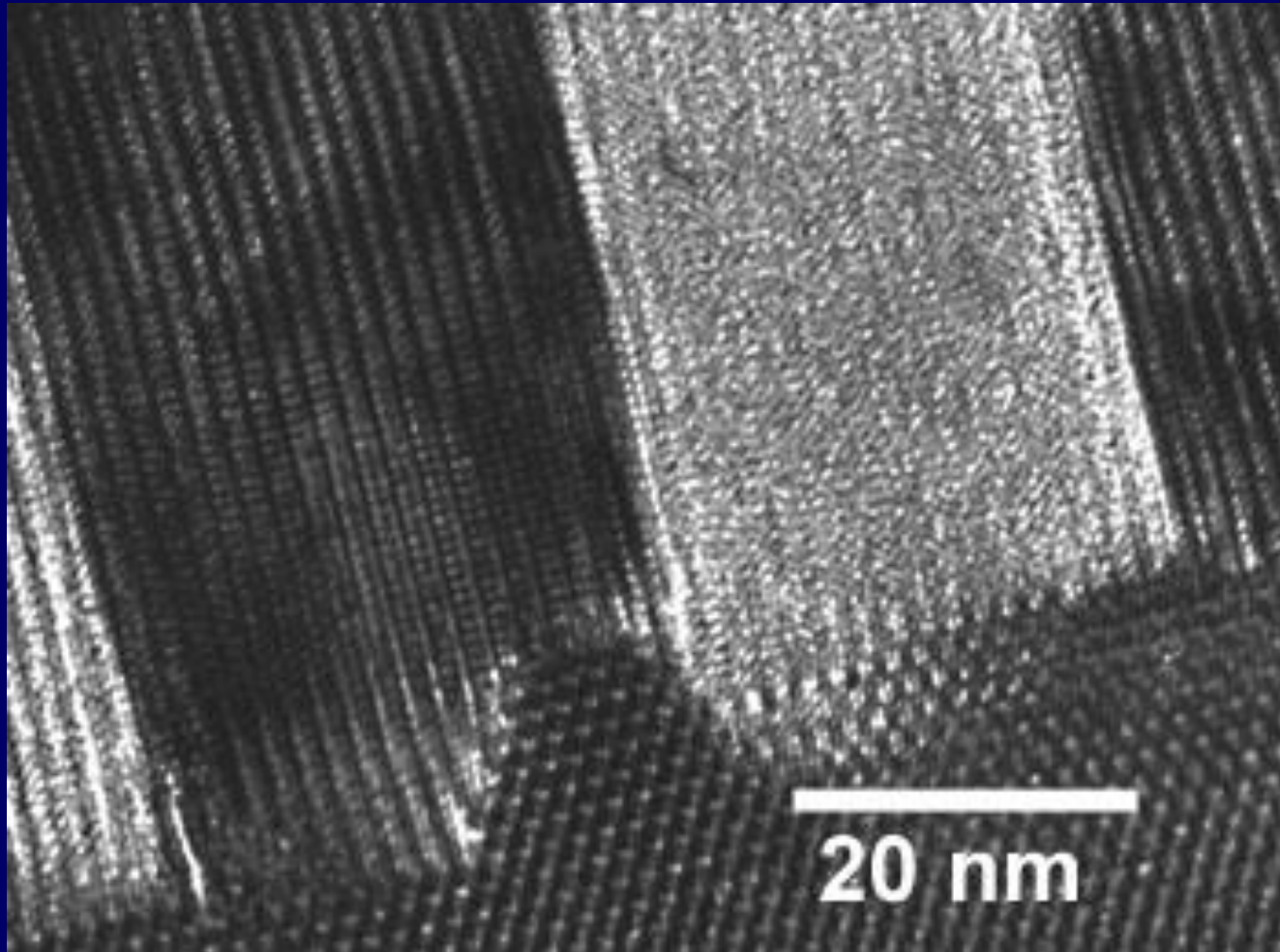
Διοκταεδρικό: $(Na, Ca)_{0.3}(Al, Mg)_2Si_4O_{10}(OH)_2 \cdot nH_2O$ -
Μοντοριλλονίτης (Ομάδα Σμεκτίτη)

ΦΥΛΛΟΠΥΡΙΤΙΚΑ 2:1:1 (T-O-T-O)



Τριοκταεδρικό: $(\text{Mg,Fe})_5\text{Al}(\text{AlSi}_3\text{O}_{10})(\text{OH})_2$ – **Χλωρίτης**

ΣΥΜΦΥΣΗ ΚΡΥΣΤΑΛΙΚΩΝ ΠΛΕΓΜΑΤΩΝ
ΦΥΛΛΟΠΥΡΙΤΙΚΟΥ & ΠΥΡΟΞΕΝΟΥ ΣΕ
ΝΑΝΟΚΛΙΜΑΚΑ (TEM)



ΦΥΛΛΟΠΥΡΙΤΙΚΑ ΟΡΥΚΤΑ (PHYLLOSILICATES)

- **Μαρμαρυγίες (Micas)**

ΦΥΛΛΟΠΥΡΙΤΙΚΑ ΟΡΥΚΤΑ

• ΜΑΡΜΑΡΥΓΙΕΣ



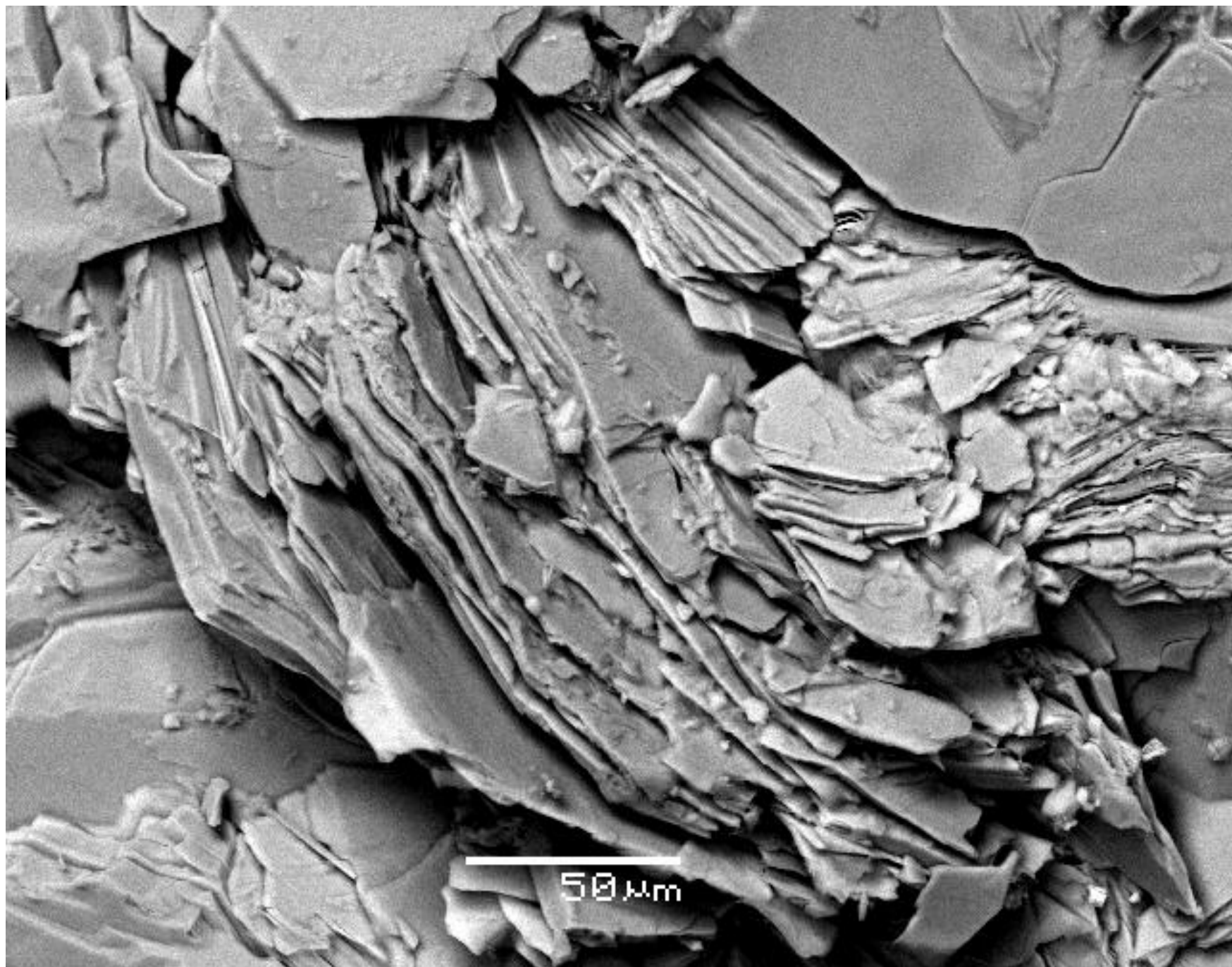
ΦΥΛΛΟΠΥΡΙΤΙΚΑ ΟΡΥΚΤΑ

• ΜΑΡΜΑΡΥΓΙΕΣ





ΠΕΝΤΕΛΗ





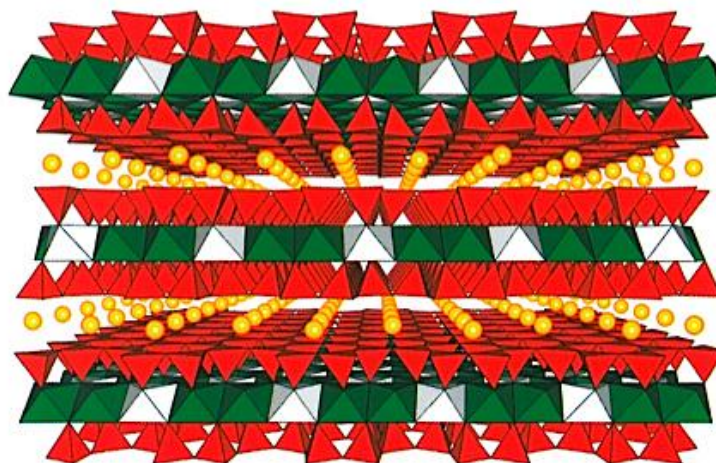
REVIEWS in
**MINERALOGY &
GEOCHEMISTRY**
Volume 46



**MICAS: CRYSTAL CHEMISTRY
& METAMORPHIC PETROLOGY**

EDITORS:

ANNIBALE MOTTANA, FRANCESCO PAOLO SASSI,
JAMES B. THOMPSON, JR., STEPHEN GUGGENHEIM



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Nomenclature of Micas

MICA SIMPLIFIED FORMULA: $I M_{2-3} \square_{1-0} T_4 O_{10} A_2$

where

I = Cs, **K**, **Na**, NH₄, Rb, Ba, **Ca**

M = **Li**, **Fe** (2+, 3+), **Mg**, Mn, Zn, **Al**, Cr, V, **Ti**

$\square$ = vacancy

T = Be, **Al**, B, **Fe**(3+), **Si**

A = Cl, **F**, **OH**, O, S

$KAl_2(AlSi_3O_{10})(OH)_2$ - **Μοσχοβίτης**

$K(Mg, Fe^{2+})_3(Al, Fe^{3+})Si_3O_{10}(OH, F)_2$ - **Βιοτίτης**

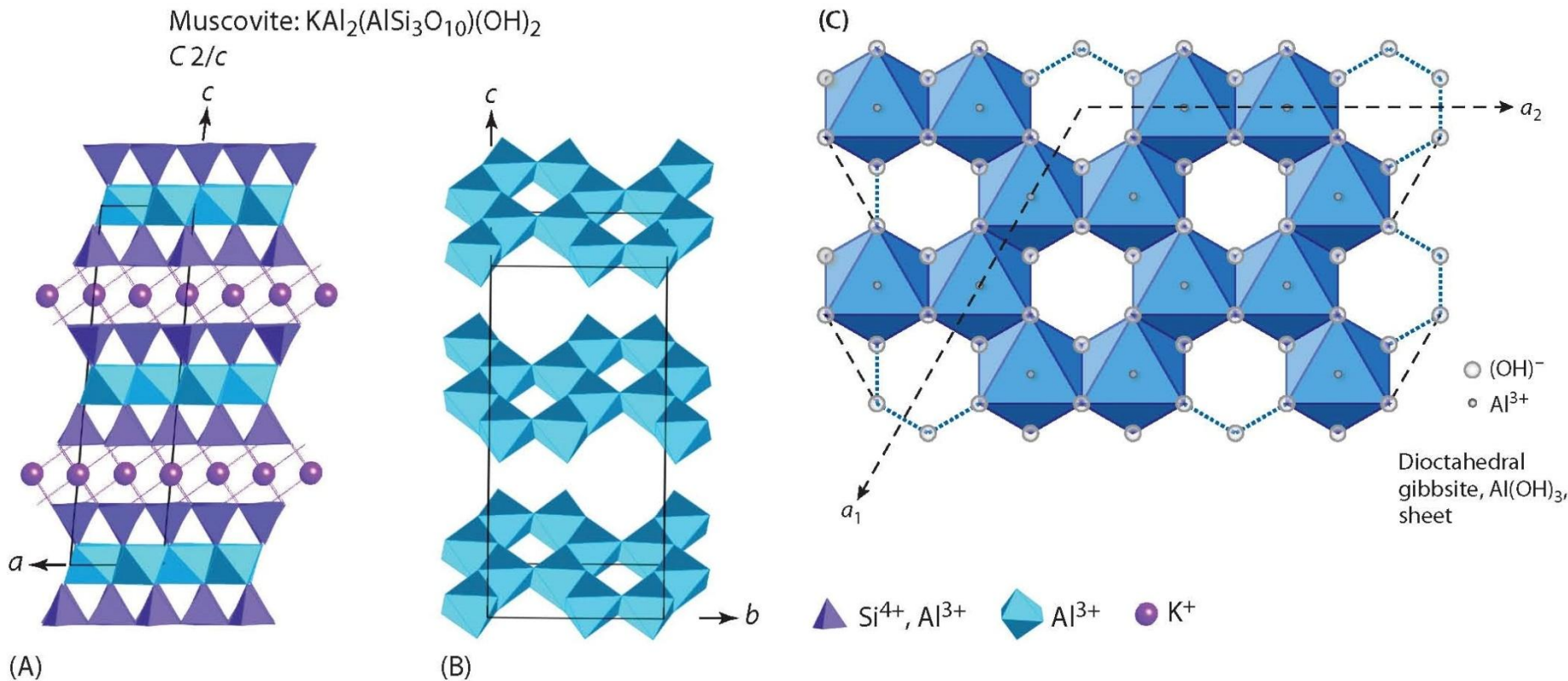
2:1 (T-O-T)

Διοκταεδρικό: $\text{KAl}_2(\text{AlSi}_3\text{O}_{10})(\text{OH})_2$ - **Μοσχοβίτης**

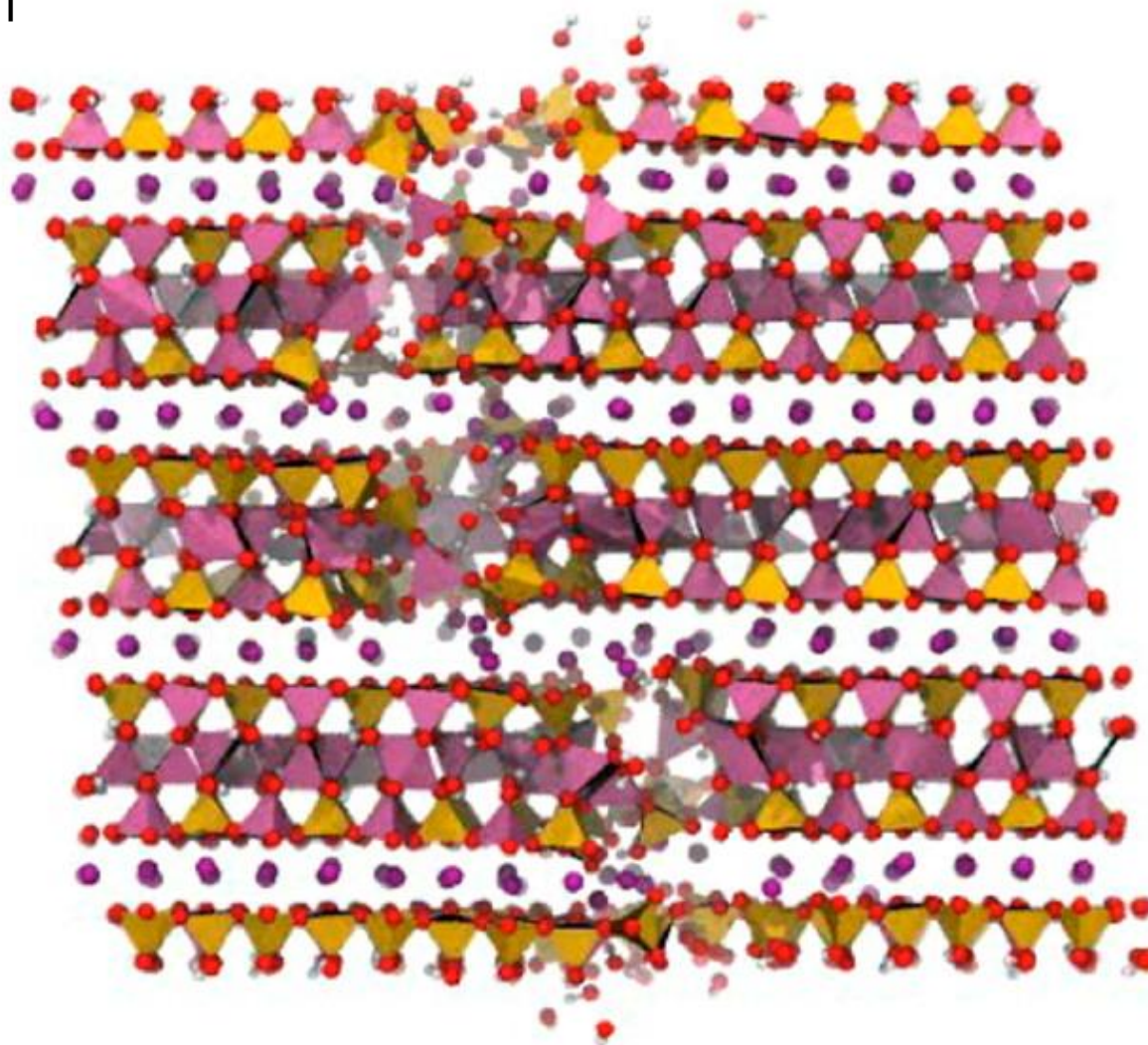


2:1 (T-O-T)

Διοκταεδρικό: $\text{KAl}_2(\text{AlSi}_3\text{O}_{10})(\text{OH})_2$ - Μοσχοβίτης



Υπολογιστική προσομοίωση μοριακής δυναμικής της δομής και των μηχανικών ιδιοτήτων (θραύση υπο P,T) μοςχοβίτη



$\text{K(Al,Cr)}_2(\text{AlSi}_3\text{O}_{10})(\text{OH})_2$ – Χρωμιούχος **Μοσχοβίτης**
“Φουξίτης”



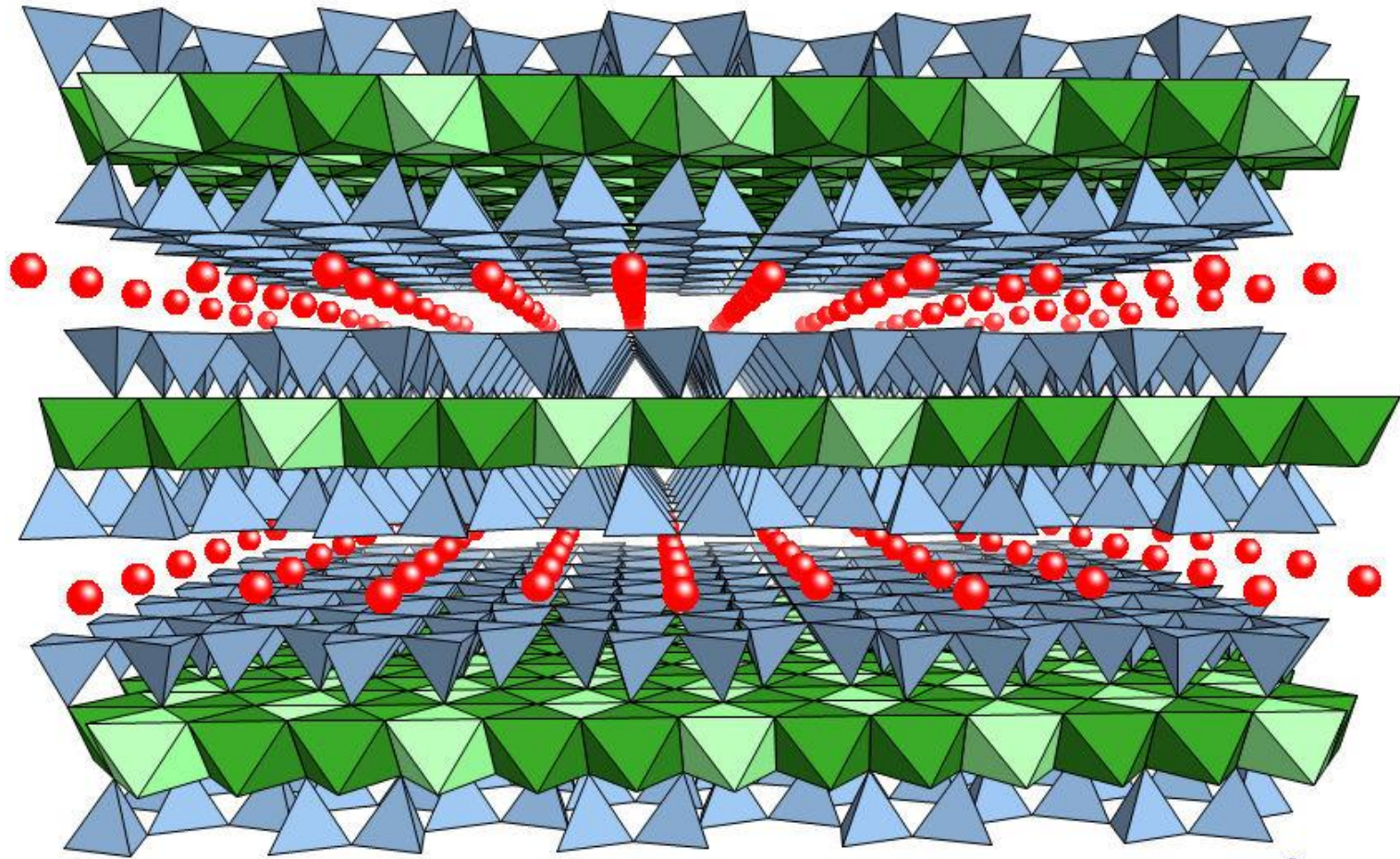
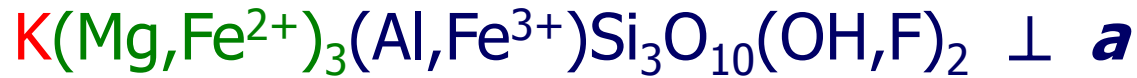
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2:1 (T-O-T)

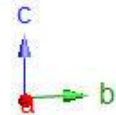
Τριοκταεδρικό: $\text{K}(\text{Mg}, \text{Fe}^{2+})_3(\text{Al}, \text{Fe}^{3+})\text{Si}_3\text{O}_{10}(\text{OH}, \text{F})_2$ – **Βιοτίτης**



Η ΚΡΥΣΤΑΛΛΙΚΗ ΔΟΜΗ ΤΟΥ ΜΑΡΜΑΡΥΓΙΑ **BIOTITE**

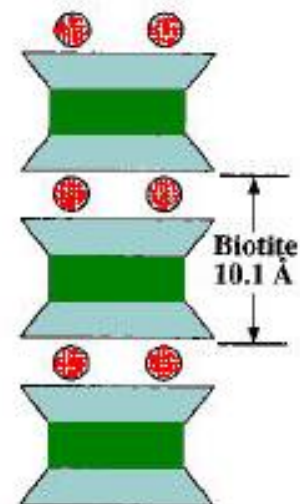
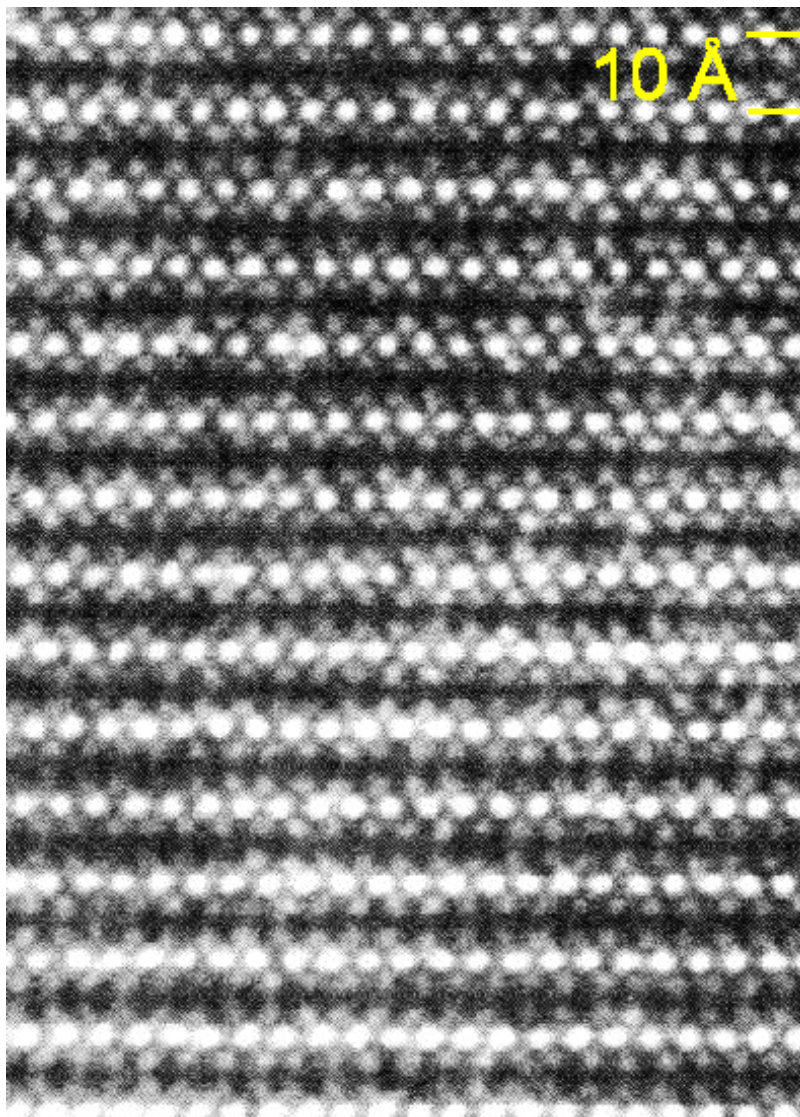


$$[12] \mathbf{r}_{\text{K}^+} = 1.64 \text{ \AA}$$

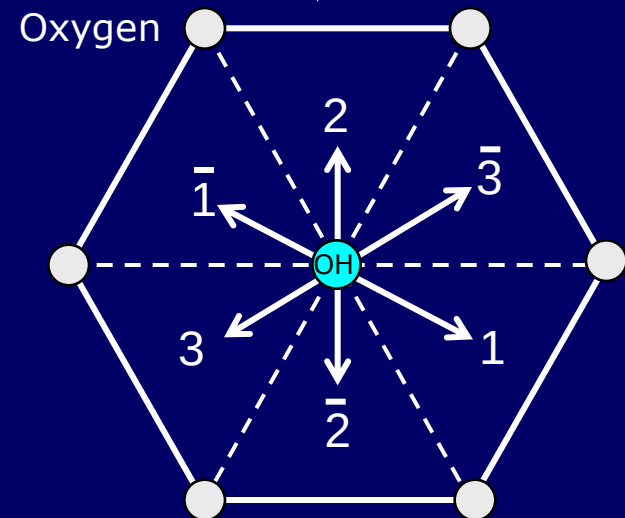
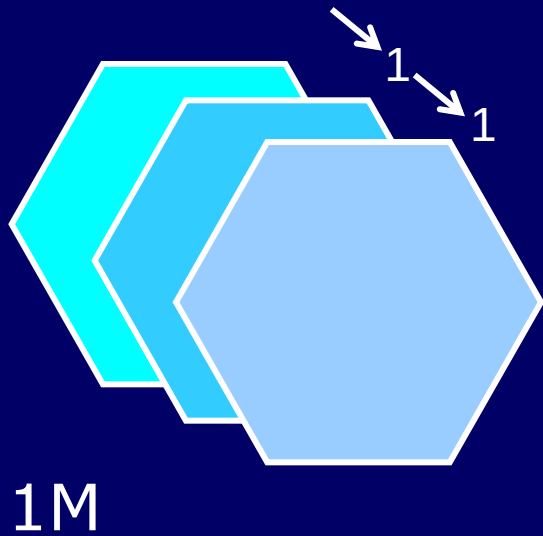
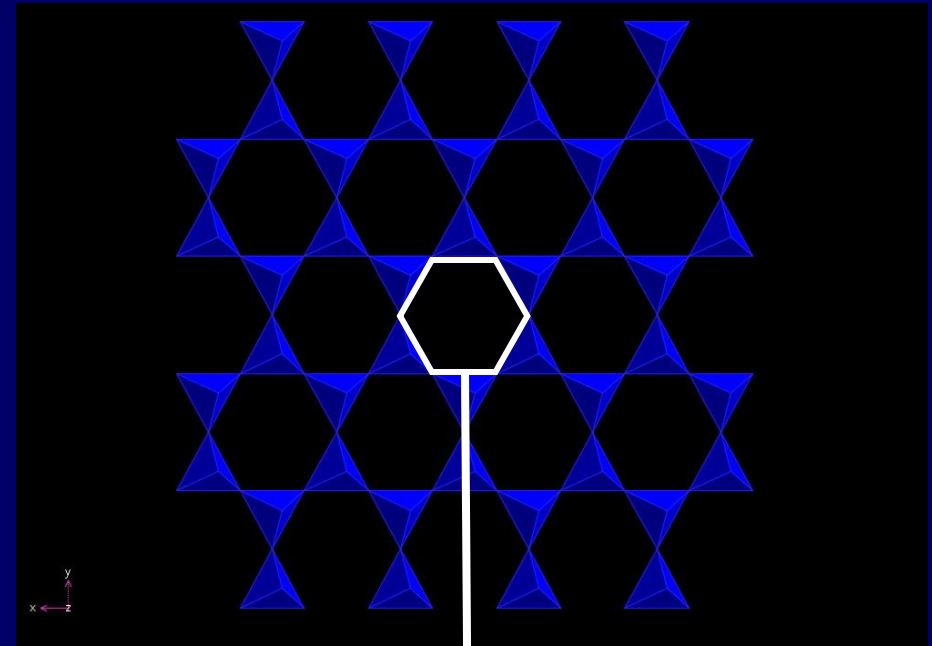
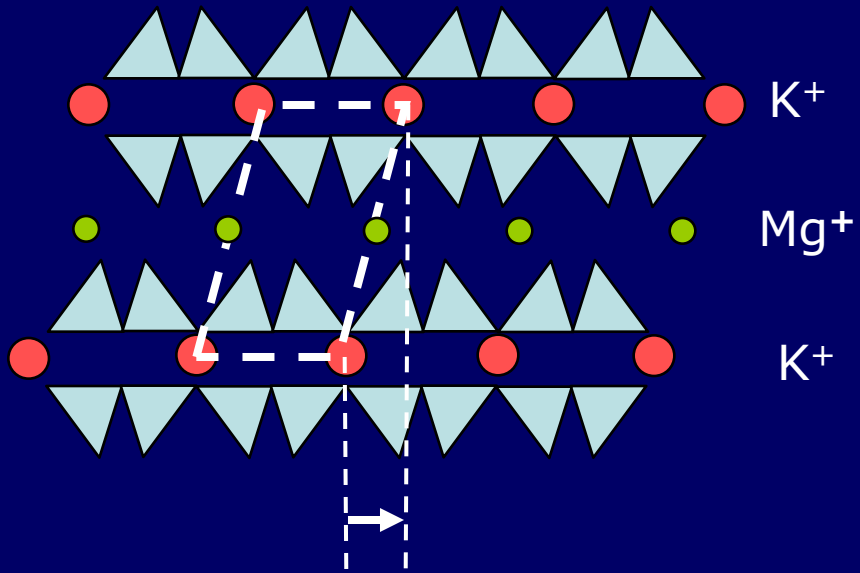


Η ΚΡΥΣΤΑΛΛΙΚΗ ΔΟΜΗ ΤΟΥ ΜΑΡΜΑΡΥΓΙΑ

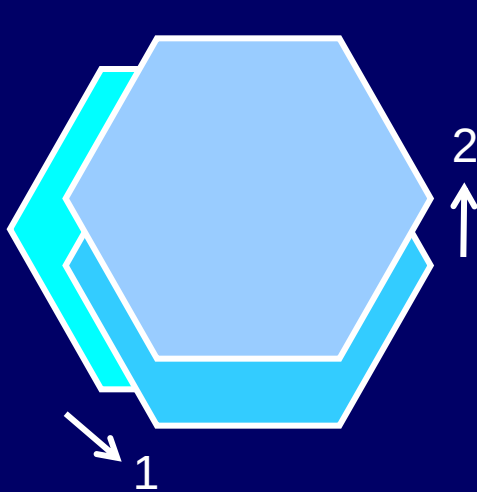
ΒΙΟΤΙΤΗ ΣΤΟ **ΤΕΜ**



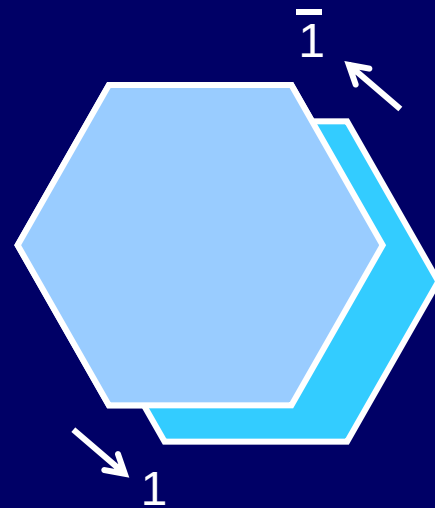
ΠΟΛΥΤΥΠΙΣΜΟΣ ΜΑΡΜΑΡΥΓΙΩΝ



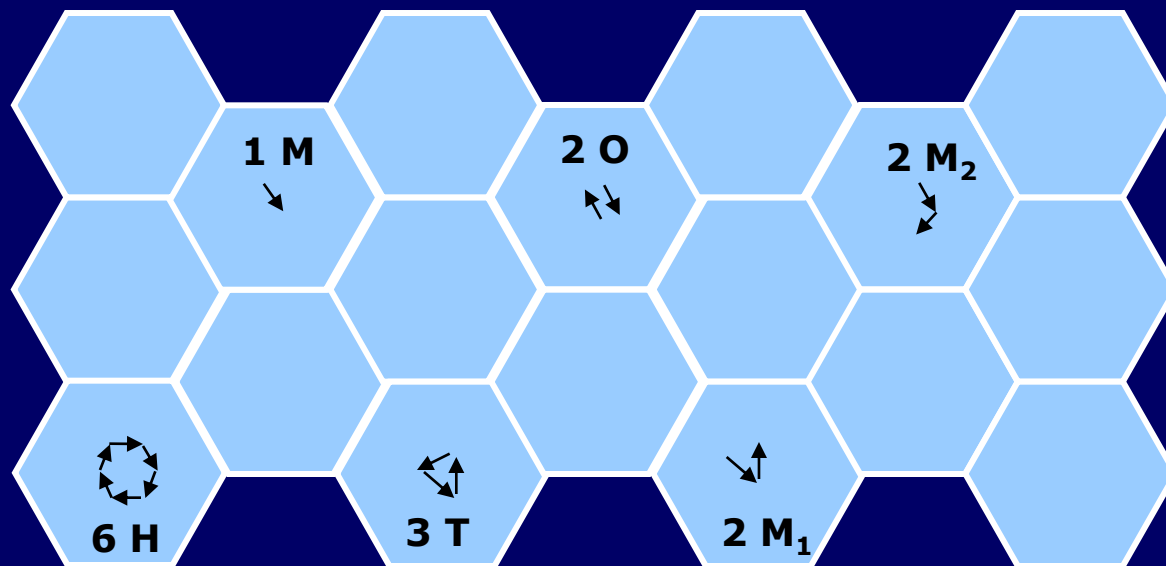
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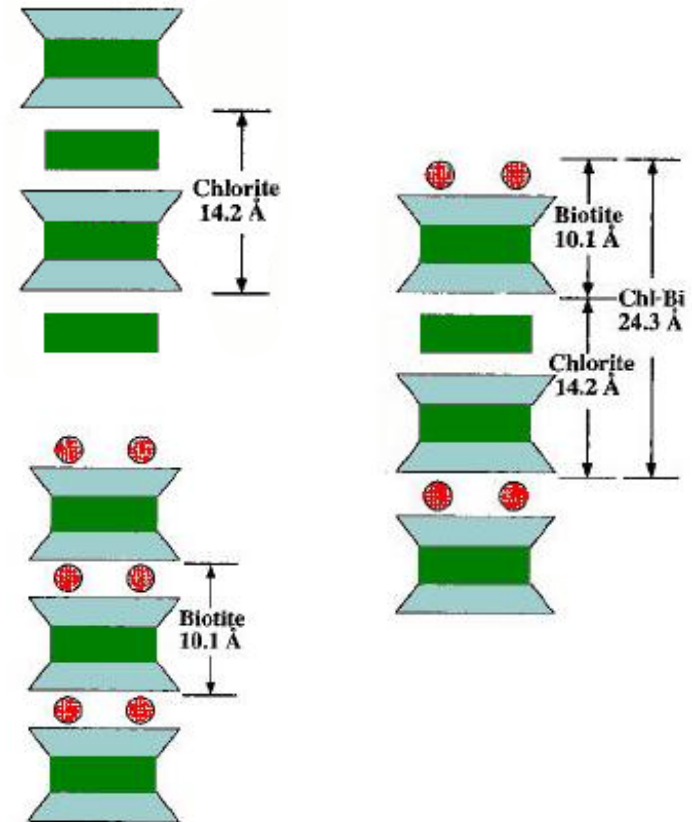
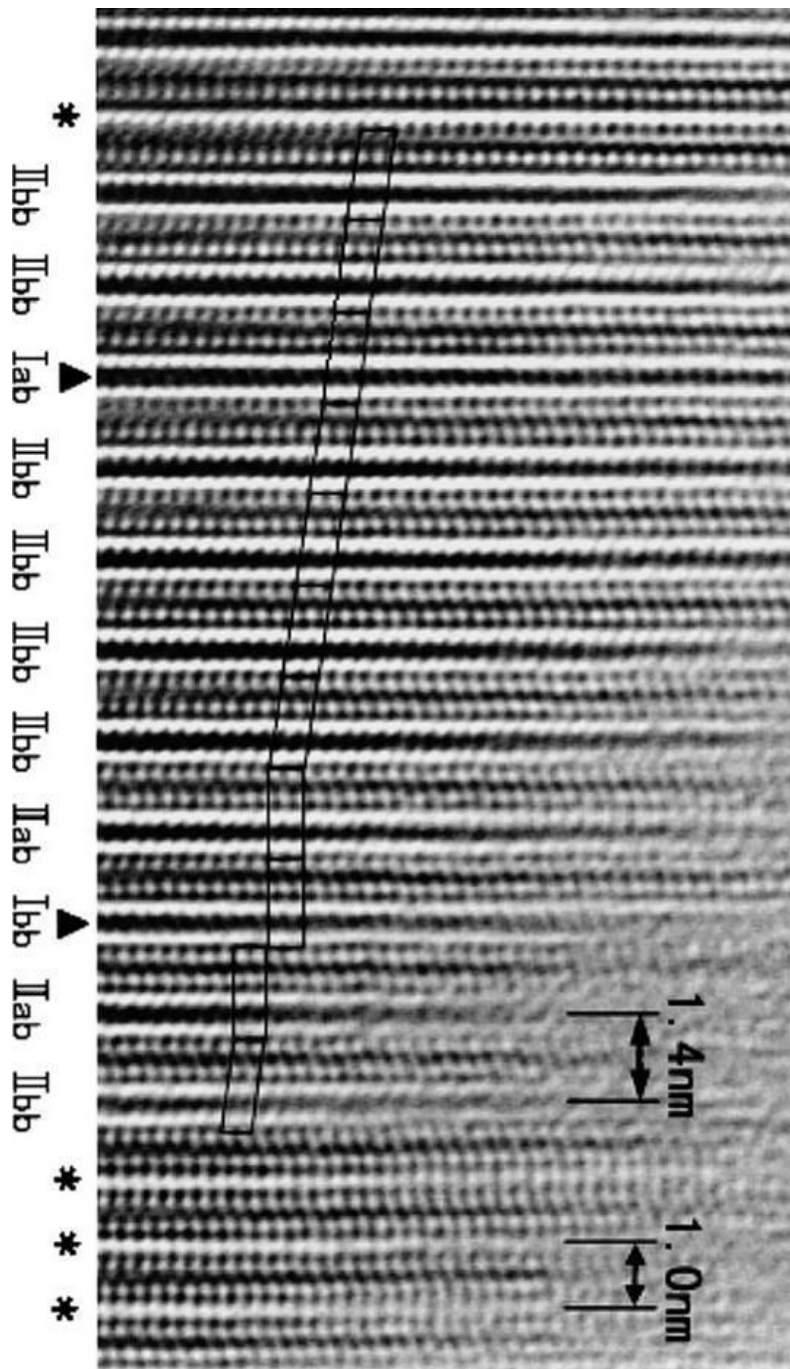
2 M



2 O



Ο ΠΟΛΥΤΥΠΙΣΜΟΣ ΤΟΥ
ΒΙΟΤΙΤΗ ΣΥΣΧΕΤΙΖΕΤΑΙ
ΣΥΧΝΑ ΜΕ ΤΗ "ΧΛΩΡΙΤΙΩΣΗ"
(ΔΗΜΙΟΥΡΓΙΑ ΣΤΟΙΒΑΔΩΝ
ΧΛΩΡΙΤΗ)



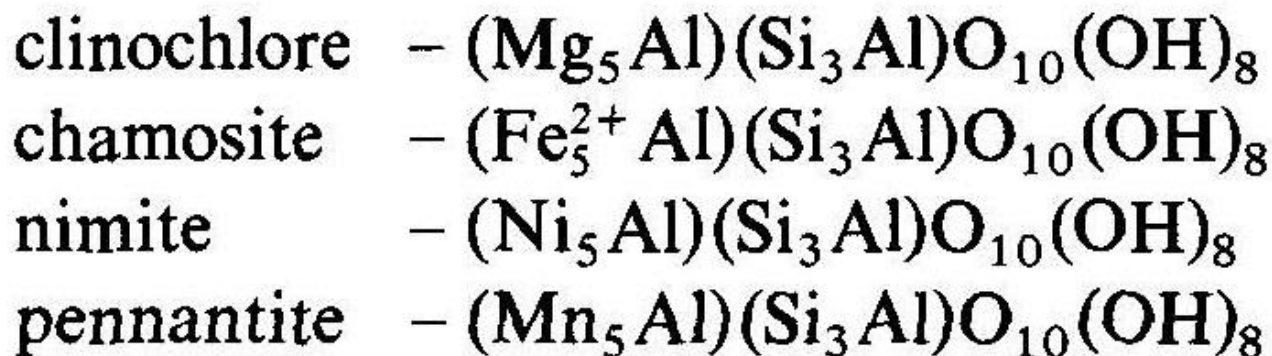


<http://www.geo.auth.gr/courses/gmo/gmo212y/>

CRYSTALLOCHEMICAL CLASSIFICATIONS OF
PHYLLOSILICATES BASED ON THE UNIFIED
SYSTEM OF PROJECTION OF CHEMICAL
COMPOSITION:
II. THE CHLORITE GROUP

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$(\text{Mg}, \text{Fe}^{2+})_5\text{Al}(\text{Si}_3\text{Al})\text{O}_{10}(\text{OH})_8$ – **Κλινόχλωρο**



<https://www.mindat.org/photo-194447.html>

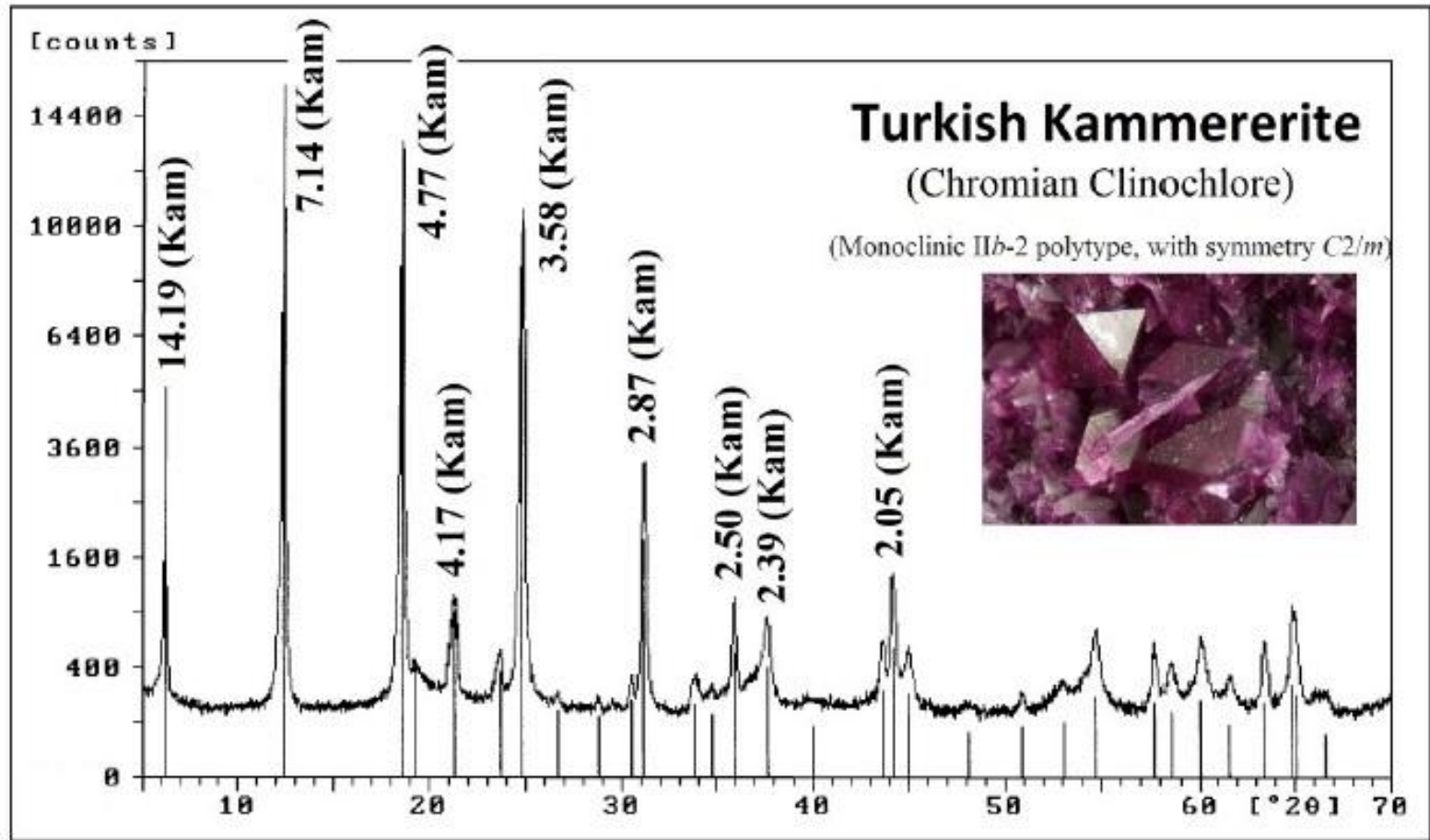
$\text{Mg}_5(\text{Al,Cr,Fe})_2\text{Si}_3\text{O}_{10}(\text{OH})_8$ – Χρωμιούχο **Κλινόχλωρο**

Ν.ΡΟΔΑ (ΧΑΛΚΙΔΙΚΗ)



<https://www.mindat.org/photo-16110.html>

$\text{Mg}_5(\text{Al,Cr,Fe})_2\text{Si}_3\text{O}_{10}(\text{OH})_8$ – Χρωμιούχο **Κλινόχλωρο**
“Κεμερερίτης”



$(\text{Mg,Fe,Ni})_5\text{Al}(\text{Si}_3\text{Al})\text{O}_{10}(\text{OH})_8$ – Νικελιούχος **Χλωρίτης**
συχνό ορυκτό του “Γαρνιερίτη”



$(\text{Mg,Fe,Ni})_5\text{Al}(\text{Si}_3\text{Al})\text{O}_{10}(\text{OH})_8$ – Νικελιοῦχος **Χλωρίτης**

ΜΕΤΑΛΛΕΥΜΑ Ni - ΛΑΤΕΡΙΤΗΣ
ΕΥΒΟΙΑ & ΑΓ. ΙΩΑΝΝΗΣ



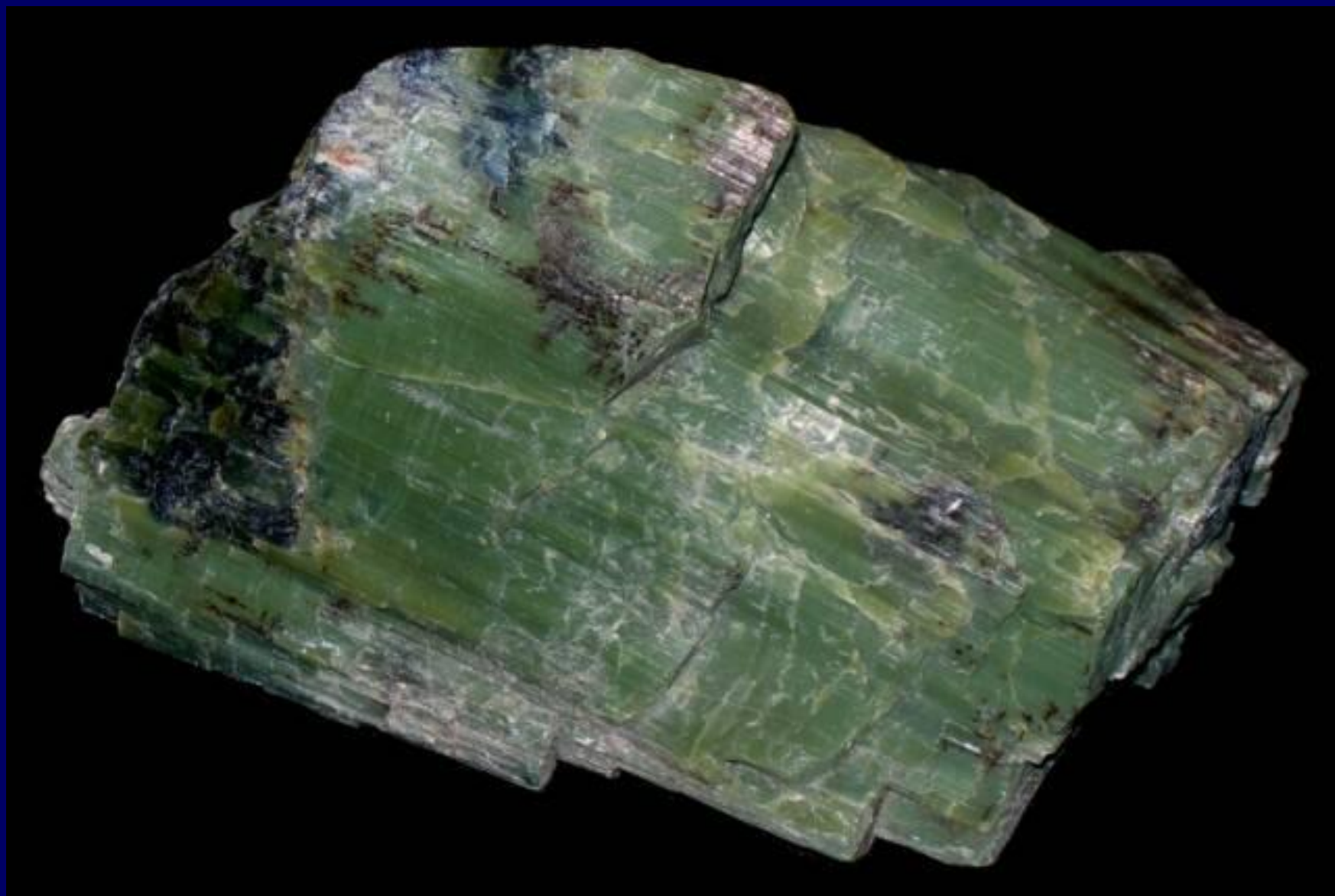
ΛΑΤΕΡΙΤΗΣ ΕΥΒΟΙΑ



ΦΥΛΛΟΠΥΡΙΤΙΚΑ ΟΡΥΚΤΑ (PHYLLOSILICATES)

- Ομάδα σερπεντίνη (Serpentine group)

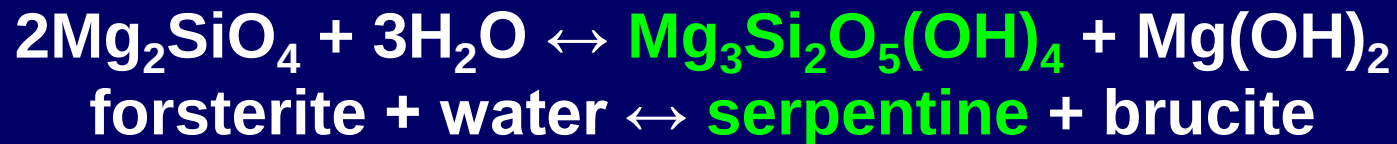
**ΑΜΙΑΝΤΟΣ
(ASBESTOS)**



ΛΟΥΤΡΑΚΙ



Serpentinization is probably the most important *metamor-phic hydration process*. The reaction of olivine-rich, mantle-derived peridotite to form serpentinite is associated with a reduction in rock density from $\sim 3.3 \text{ g/cm}^3$ to less than 2.7 g/cm^3 . Hydration of end-members forsterite (Mg-olivine) and fayalite (Fe-olivine) can be described by the reactions:



or



and



The above reactions represent an abundant source of geological reducing power. These reactions occur at depths of roughly 2–8 km under the ocean floor and at temperatures between ca. 80 °C and 200 °C. They provide copious amounts of molecular hydrogen for organic synthesis, and they bring dissolved carbon compounds in contact with reduced transition metals. The final mineralogy depends both on rock and fluid compositions, temperature, and pressure. **Talc** and **Mg-chlorite** are possible products, together with the **serpentine common polymorphs (antigorite, lizardite, chrysotile)**. In the presence of carbon dioxide, however, serpentinization may form either **magnesite** (MgCO_3) or generate **methane** (CH_4):



or



and



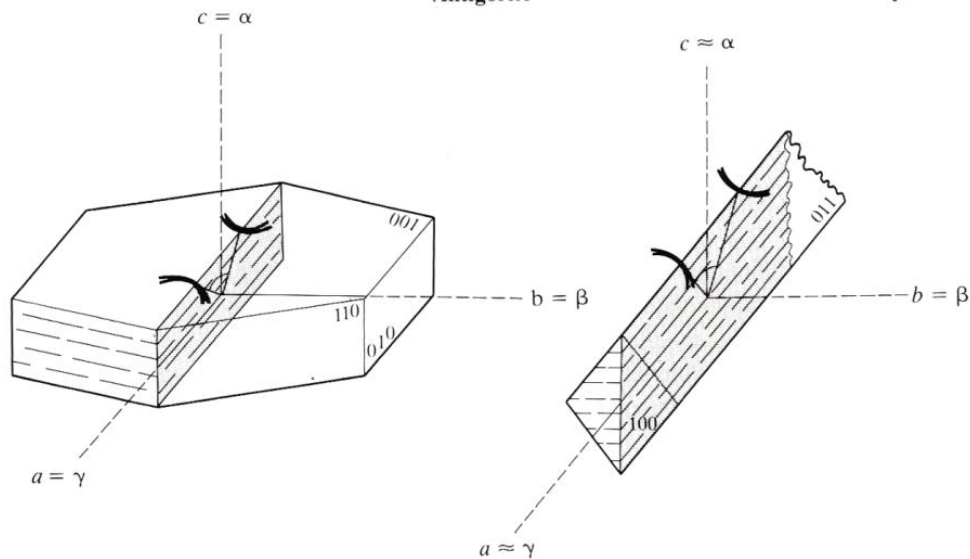
Serpentine $\text{Mg}_3\text{Si}_2\text{O}_5(\text{OH})_4$

monoclinic
 $0.57:1:1.31, \beta = 93^\circ$

Serpentine includes a variety of minerals, one fibrous (**chrysotile**) and two tabular (**lizardite** and **antigorite**)

Antigorite

Chrysotile

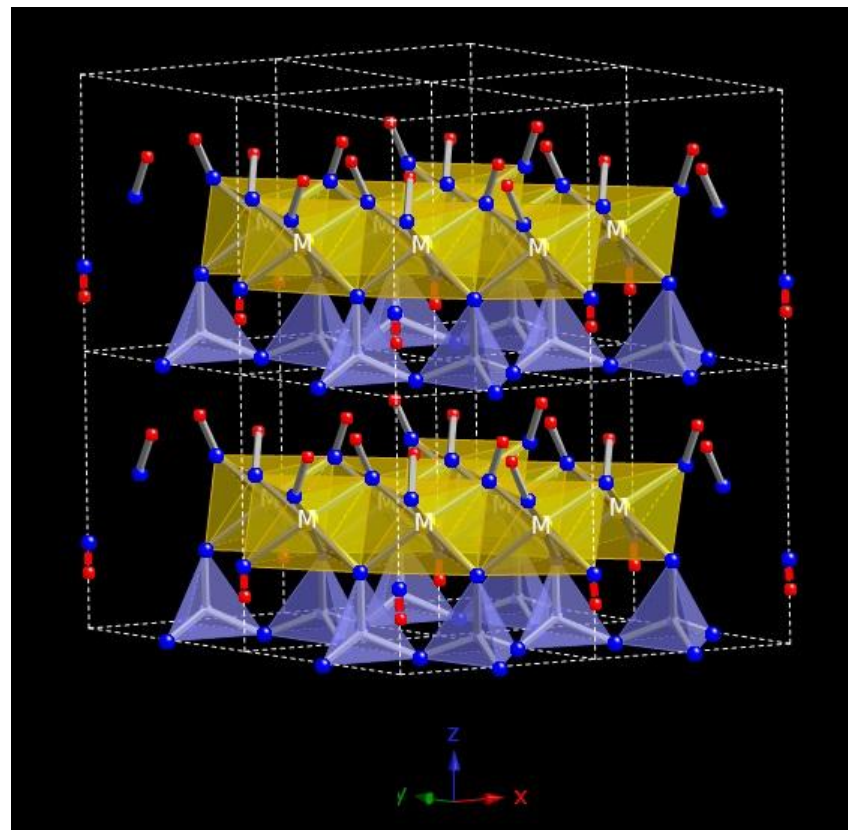


	Chrysotile	Lizardite	Antigorite
n_a	1.53–1.55	1.54–1.55	1.56–1.57
n_β	—	—	1.57
n_γ	1.55–1.56	1.55–1.56	1.56–1.57
δ	0.013–0.017	0.006–0.008	0.004–0.007
$2V_a$	variable – ve	?	37° – 61° – ve
OAP	parallel to (010)	?	parallel to (010)
D	2.55	2.55	2.6
H	$2\frac{1}{2}$	$2\frac{1}{2}$	2 – $3\frac{1}{2}$

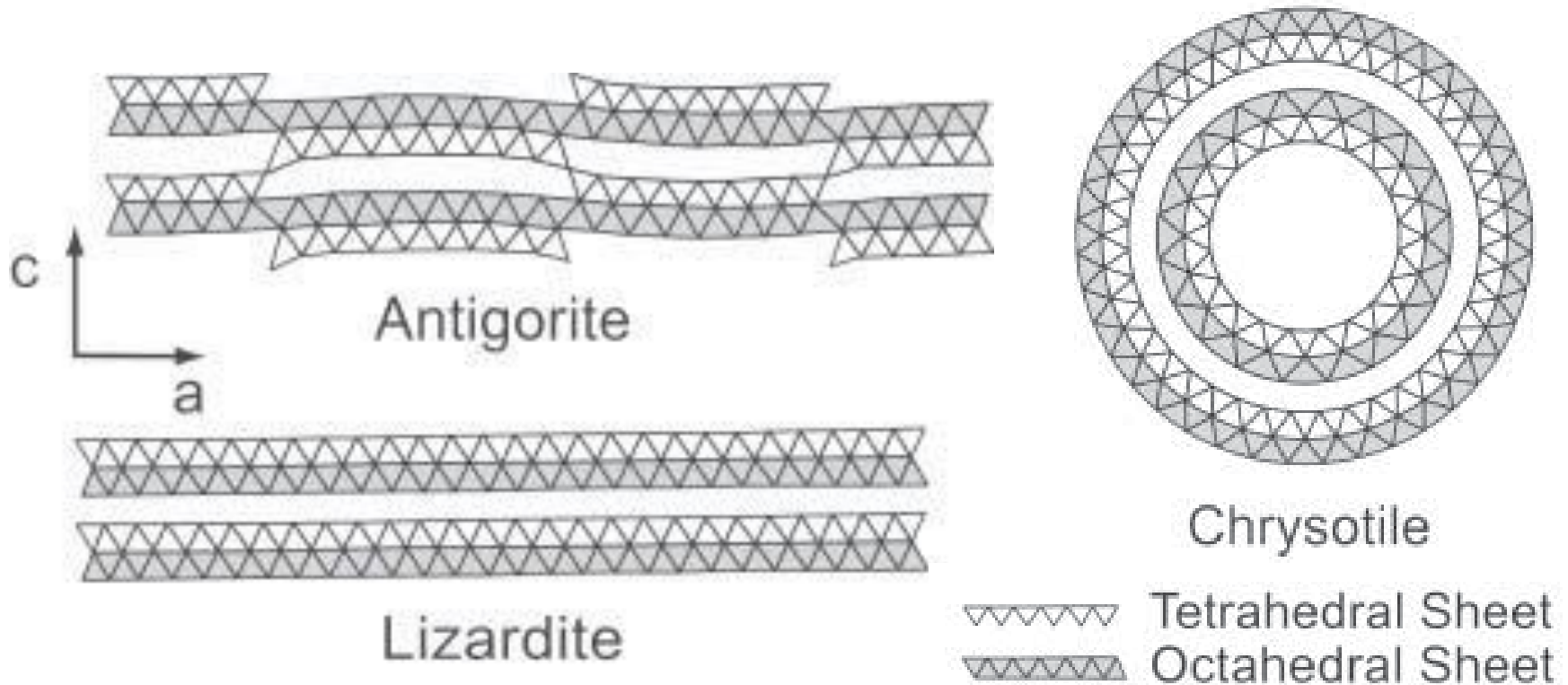
COLOUR Colourless to pale green.

HABIT Chrysotile is fibrous elongated parallel to the a crystallographic axis, and lizardite and antigorite are both flat, tabular crystals.

CLEAVAGE Chrysotile has a fibrous cleavage, and lizardite a basal cleavage.

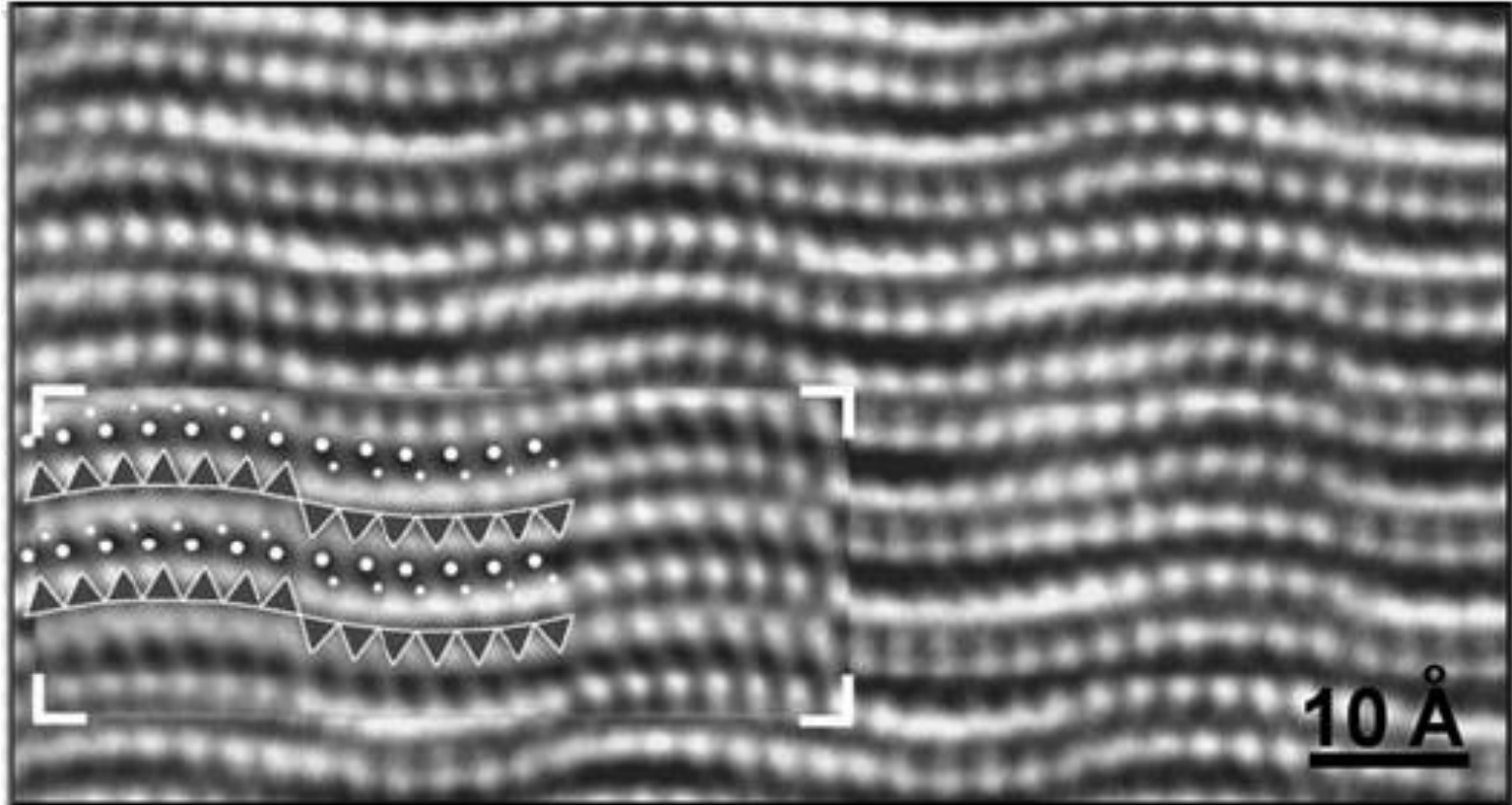


ΠΟΛΥΜΟΡΦΑ ΣΕΡΠΕΝΤΙΝΗ



Αντιγορίτης, Λιζαρδίτης, Χρυσοτίλης

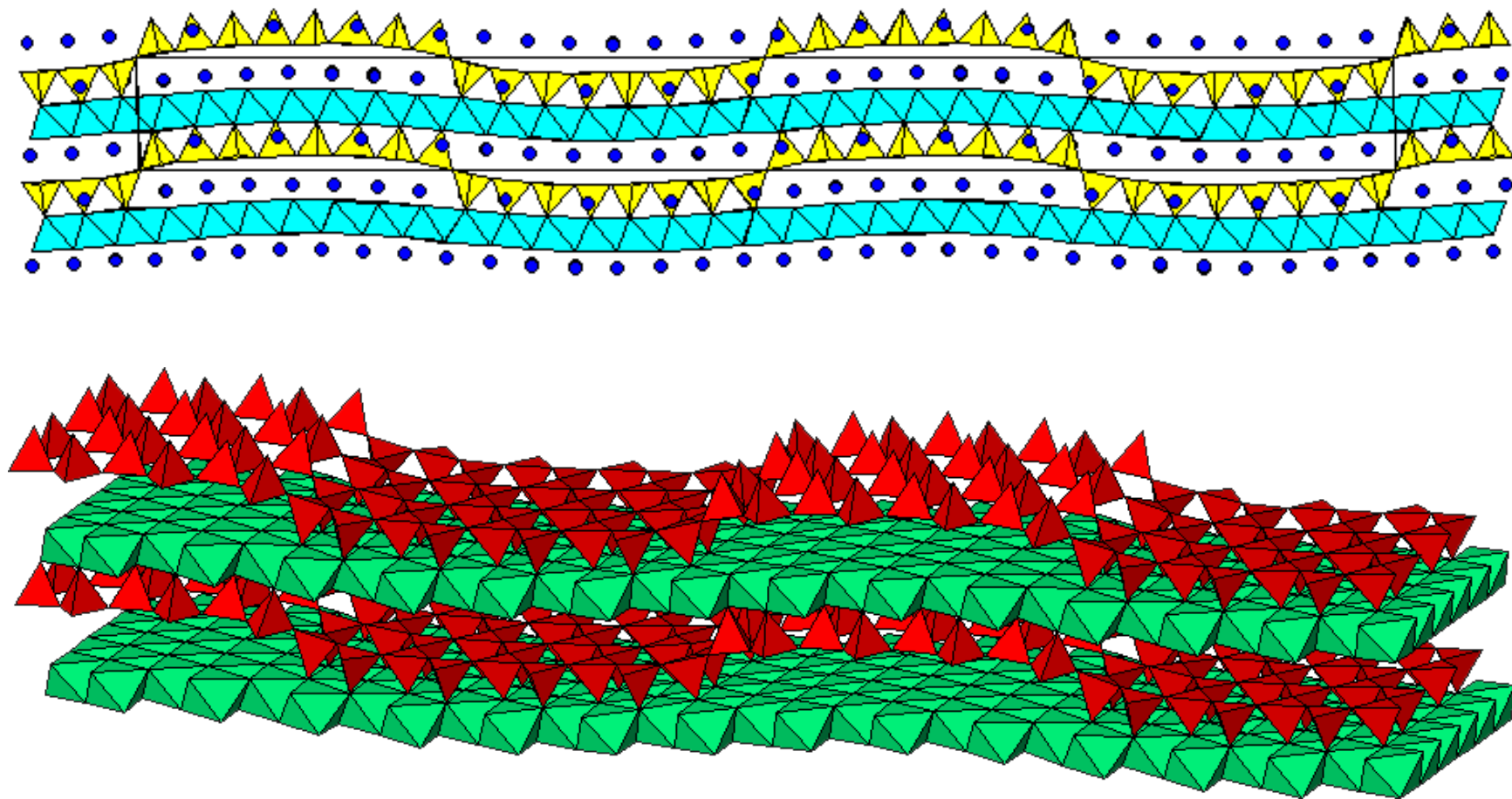
Αντιγορίτης



TEM

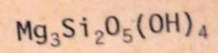
Experimental and simulated (inserted) [010] HRTEM images of antigorite ($m = 14$). A sketch indicates the tetrahedral sheets (triangles) and Mg positions (larger white spots), hydroxyls are small white dots.

Αντιγορίτης



Χρυσοτίλης

CRISOTILO

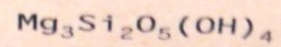


Alto Capapa (Mozambique)



UNIVERSIDAD
COMPLUTENSE
MADRID

CRISOTILO



Ronda (Málaga)

AN

(Mg, Fe)

Overstjen.

Χρυσotίλης



translucent fibrous
Soanesville, Western Australia

N NATURAL
HISTORY
MUSEUM

Χρυσοτίλης



Chrysotil

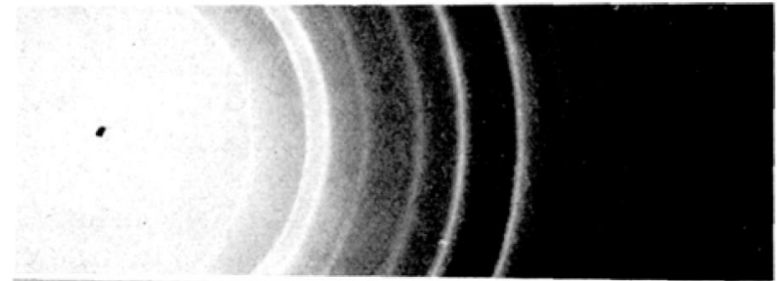
Kaapsche Hoop bei Barberton,
Transvaal/Südafrika

Χρυσοτίλης



Abb. 1. 875/40. Serpentinastbest. Elektronenoptisch: 9000 : 1; Abbildung: 10 800 : 1.

Kühn (1941)



TEM

Ruska (1943)

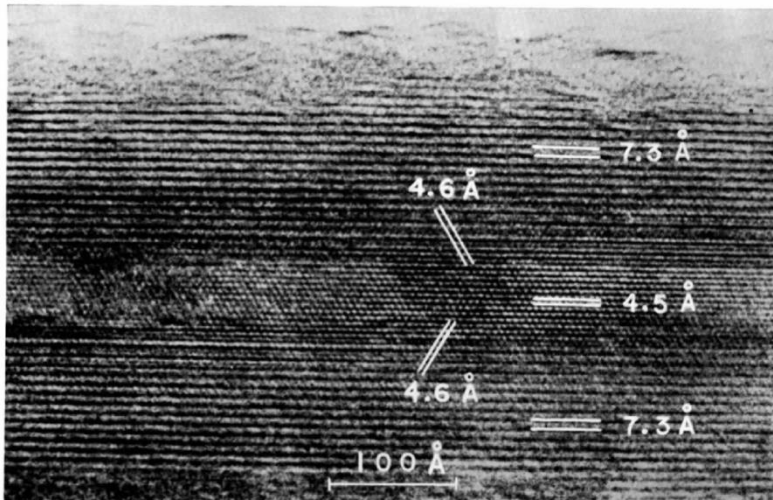


Fig. 3. A typical example of the lattice image in chrysotile observed from the direction perpendicular to the fiber axis.

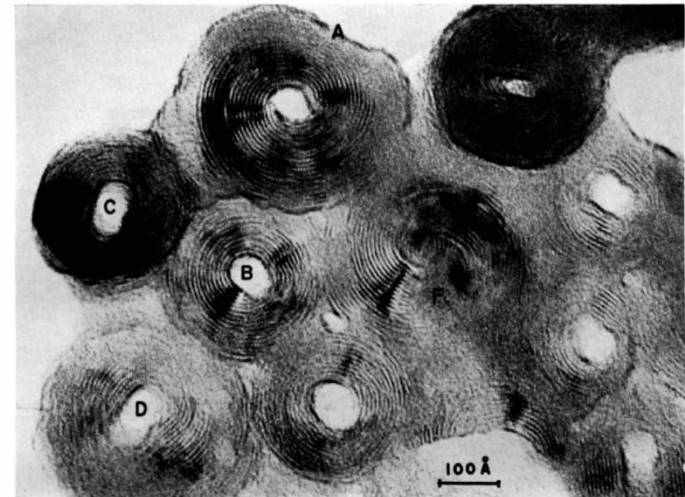


Fig. 7. A typical example of the lattice images of sectioned chrysotile observed from the direction parallel to the fiber axis.

Yada, K. *Acta Crystallographica*, **23**, 704–707 (1967)

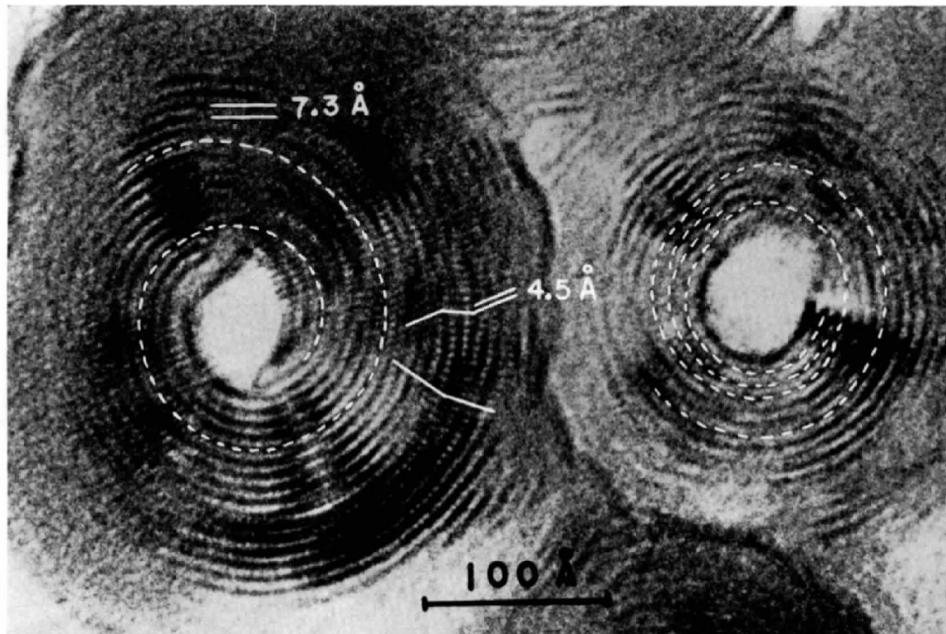
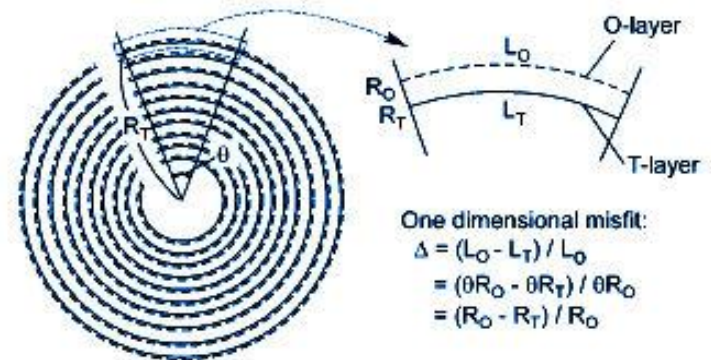
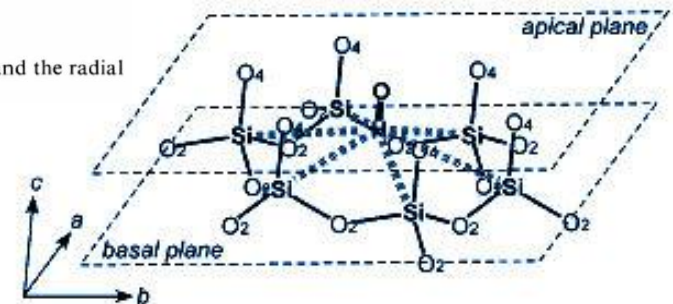
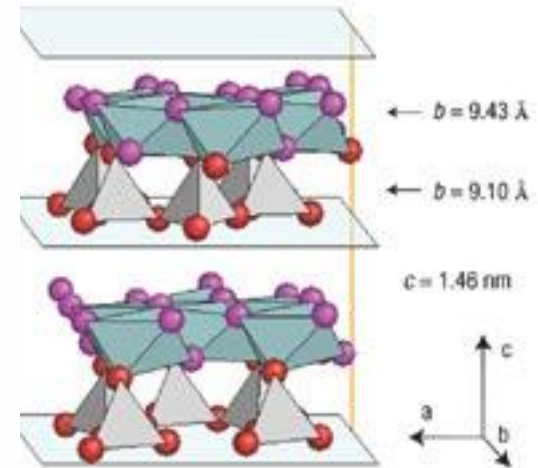


Fig.8. Enlarged image of Fig.7 (crystallites *A, B*) showing two kinds of fringe systems of the circumferential (001) and the radial (020) planes.

Χρυσοτίλης

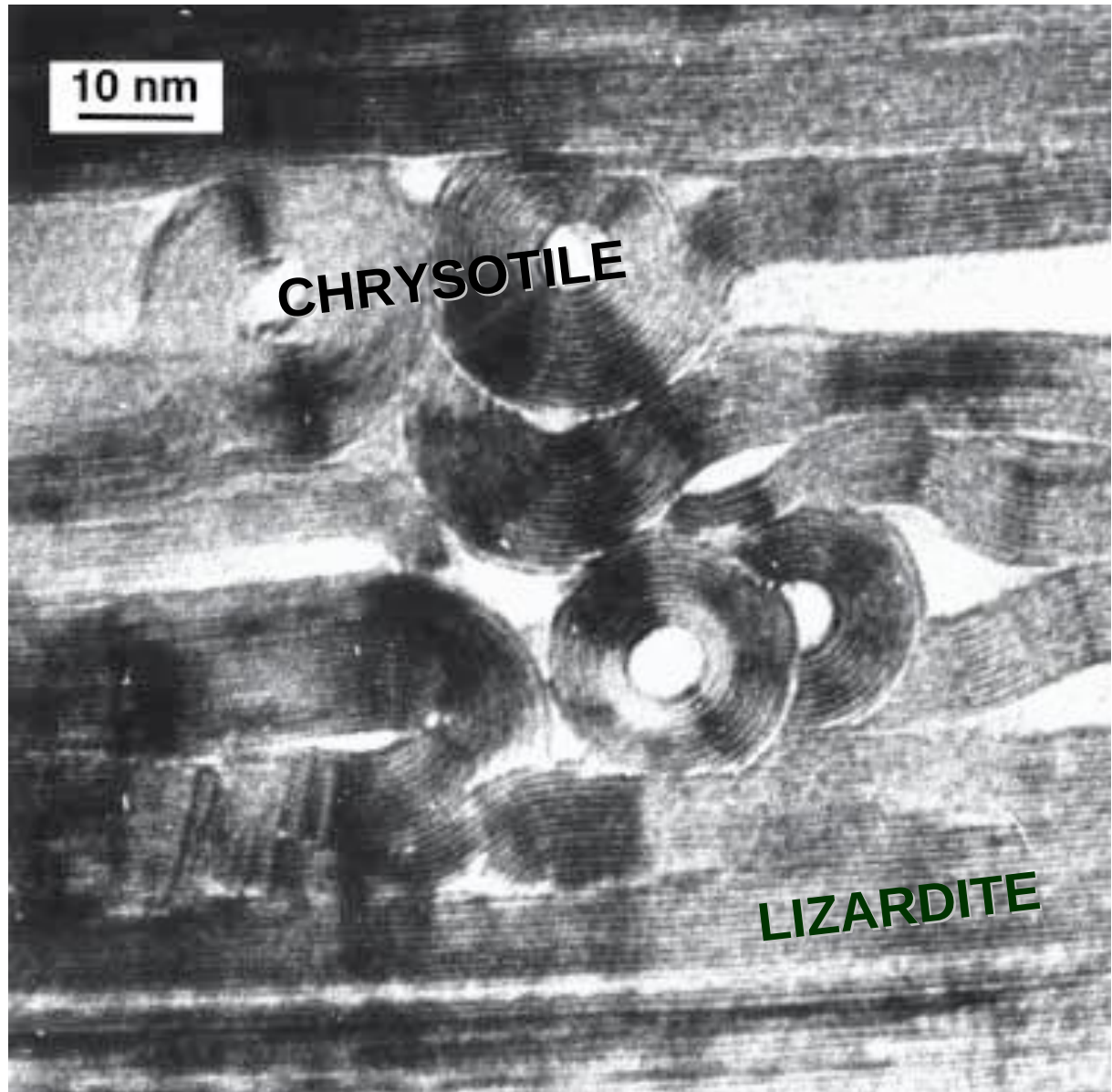
TEM

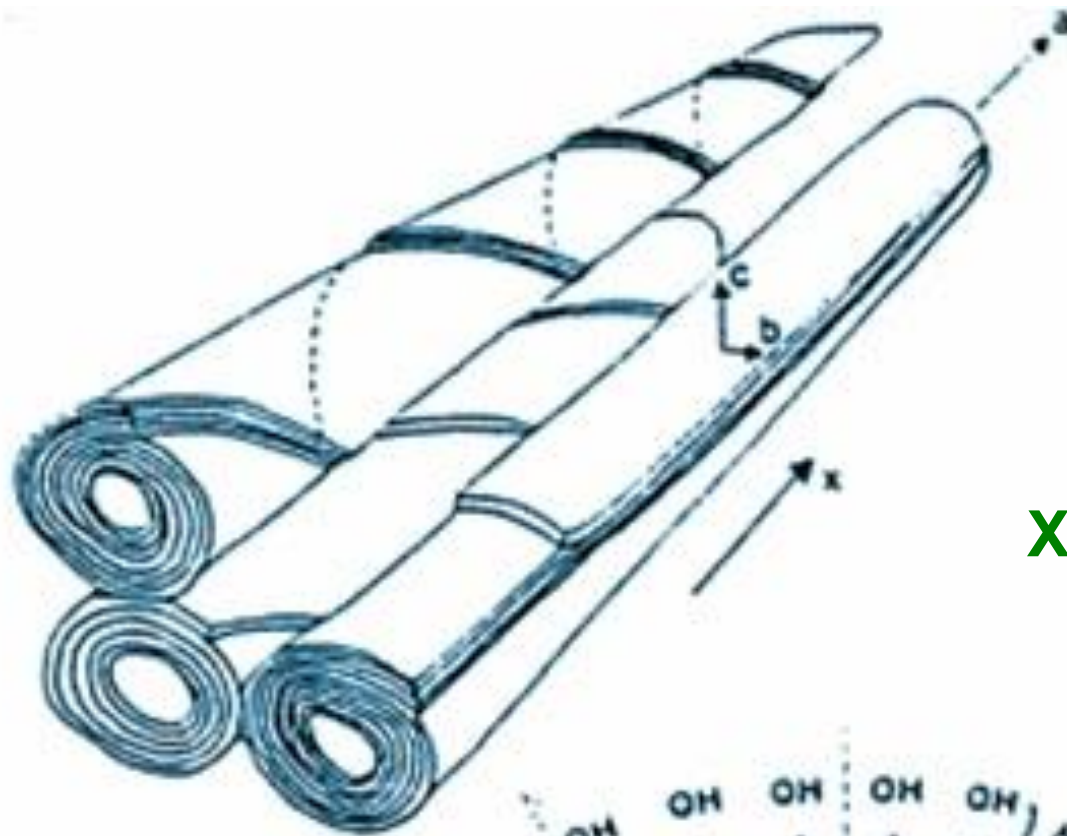
Misfit between the smaller Si-rich tetrahedral sheet and larger Mg-rich octahedral sheet results in curl



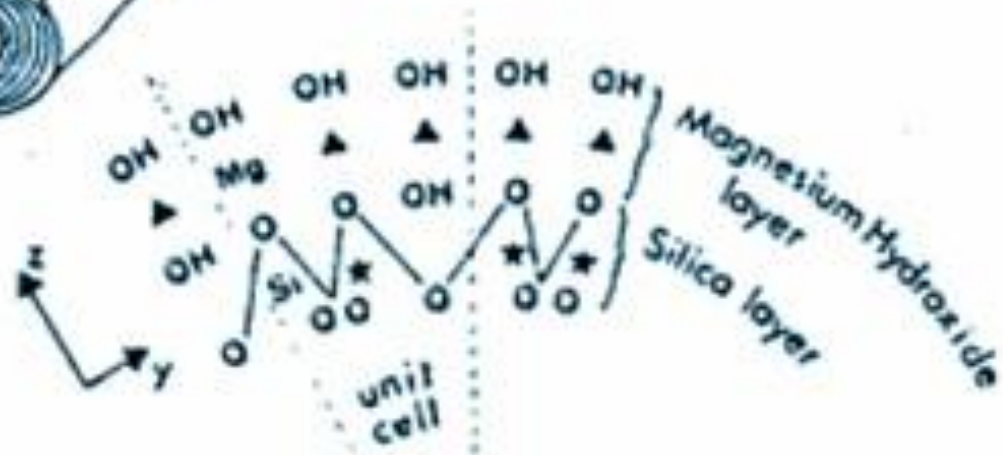
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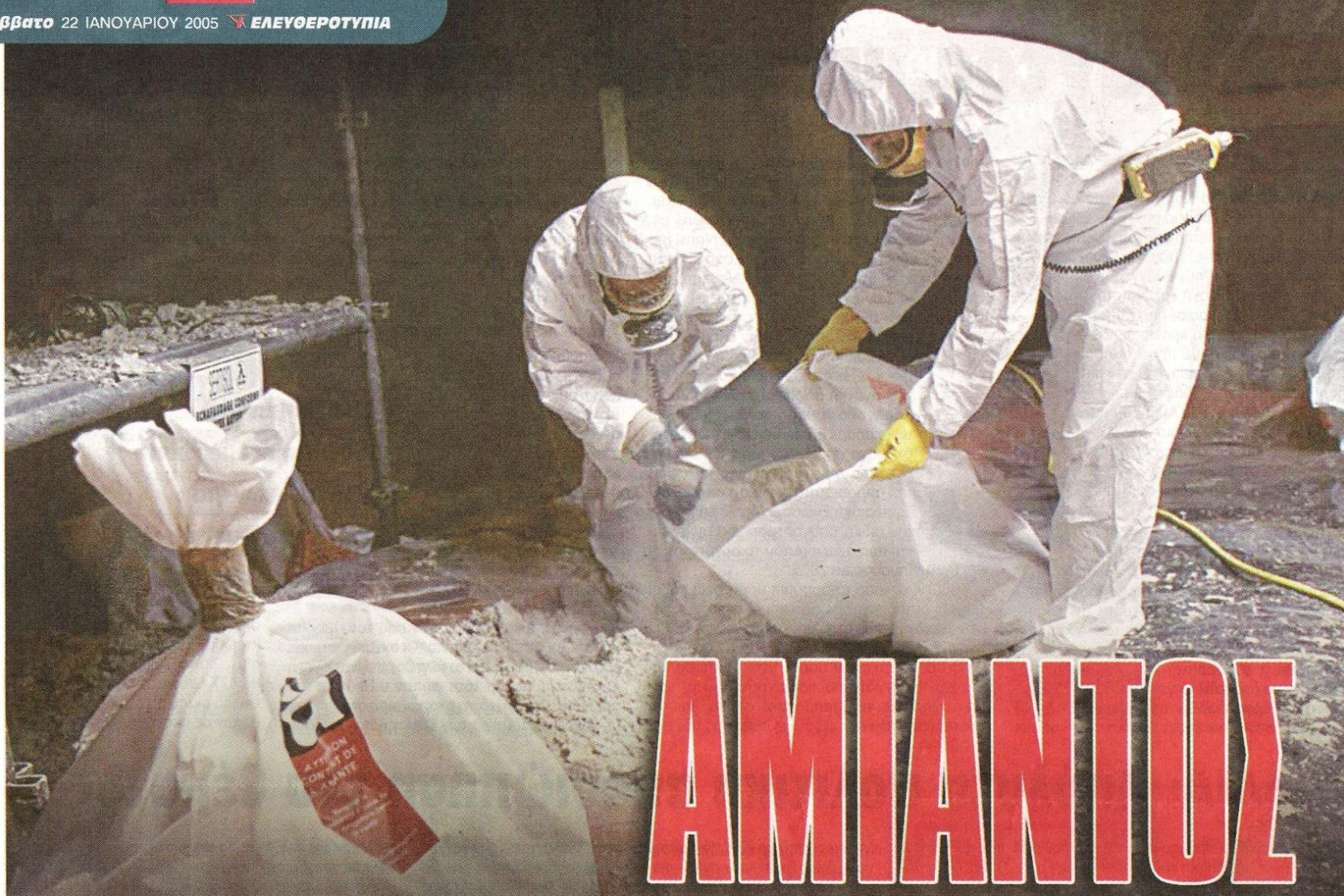
Μετασχηματισμός
Λιαζαρδίτη προς
Χρυσοτίλη σε
νανοκλίμακα
(**νανο-
συμφύσεις
πολύμορφων
Σερπεντίνη**)



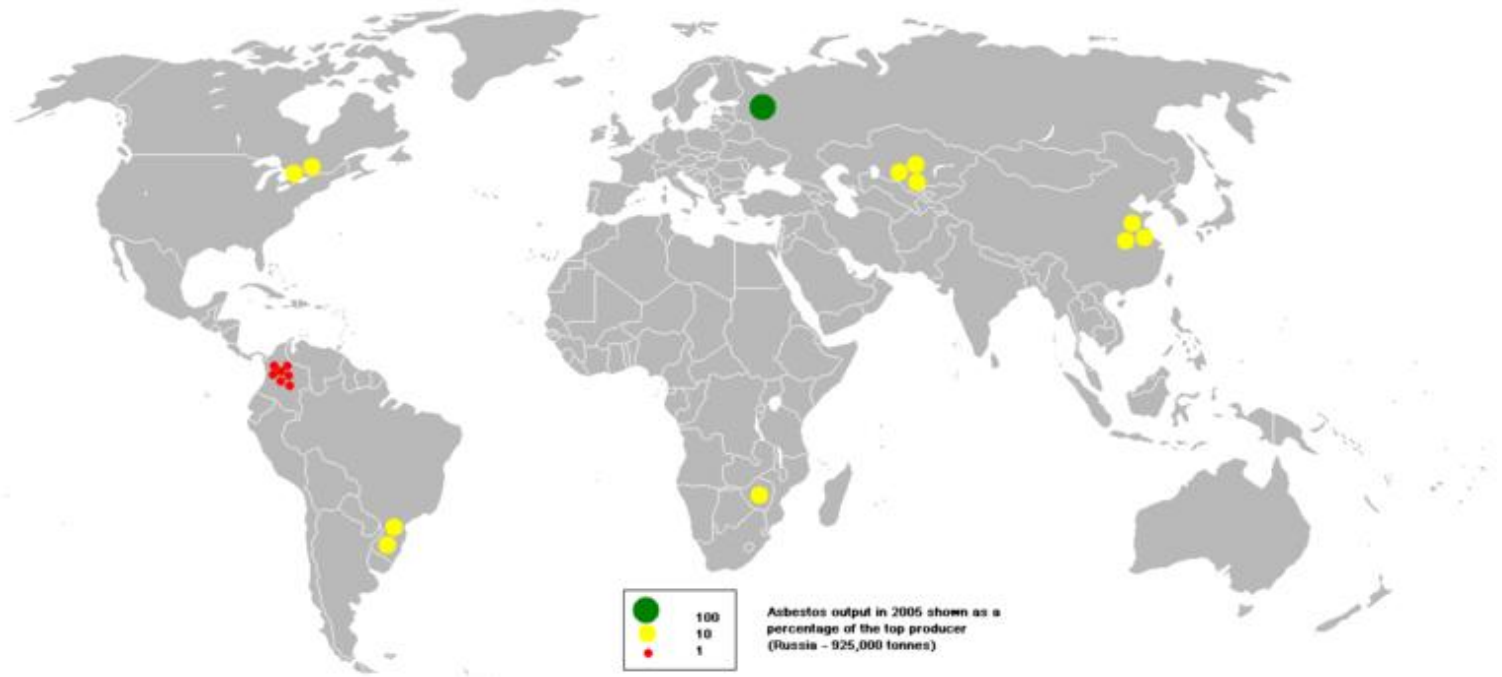


Χρυστίλης





AMIANTOΣ



Palace of the Republic (Palast der Republik)
former German Democratic Republic/GDR (Deutsche Demokratische Republik/DDR)

(east) BERLIN

1973/1976 - 2008

5000 tones of spay Asbestos







ΖΙΔΑΝΙ ΚΟΖΑΝΗΣ



ΖΙΔΑΝΙ ΚΟΖΑΝΗΣ





Πανοραμική ἄποψις τῶν Βιομηχανικῶν Ἐγκαταστάσεων τοῦ ἐργοστασίου τῆς ΕΛΕΝΙΤ
εἰς Ν. Λάμψακον Χαλκίδος





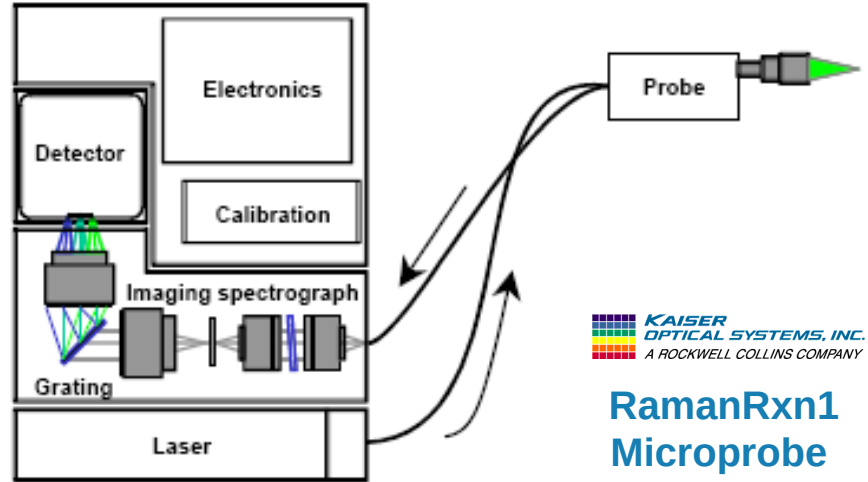
SEM-EDS



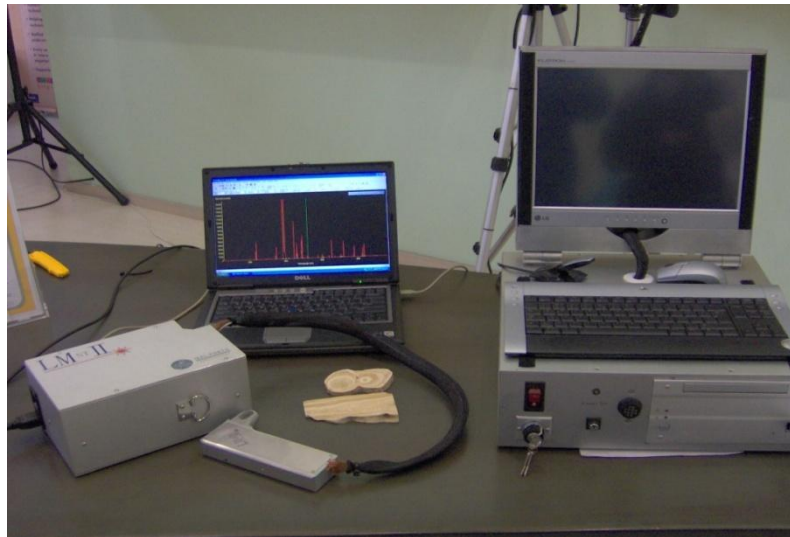


50µm

Portable Laser μ -Raman



Portable LIBS microprobe



ΦΥΛΛΟΠΥΡΙΤΙΚΑ ΟΡΥΚΤΑ (PHYLLOSILICATES)

- Ορυκτά της αργίλου (Clay minerals)

ΦΥΛΛΟΠΥΡΙΤΙΚΑ ΟΡΥΚΤΑ

• ΟΡΥΚΤΑ ΤΗΣ ΑΡΓΙΛΟΥ



ΦΥΛΛΟΠΥΡΙΤΙΚΑ ΟΡΥΚΤΑ

• ΟΡΥΚΤΑ ΤΗΣ ΑΡΓΙΛΟΥ

ΚΡΥΣΤΑΛΛΟΙ

$<2 \mu\text{m}$ ΠΡΕΠΕΙ ΝΑ
ΠΑΡΟΥΜΕ ΔΕΙΓΜΑ
ΓΙΑ ΕΡΓΑΣΤΗΡΙΟ ☺





ΦΛΥΣΧΗΣ
(ΗΠΕΙΡΟΣ)

A. ΔΟΛΙΑΝΑ



A. ΔΟΛΙΑΝΑ





ΑΣΒΕΣΤΟΛΙΘΟΙ
(ΗΠΕΙΡΟΣ)



ΔΙΑΒΡΩΣΗ –
ΑΠΟΣΑΘΡΩΣΗ - ☹

Α. ΔΟΛΙΑΝΑ





ΕΔΑΦΟΣ

Α. ΔΟΛΙΑΝΑ



ΗΠΕΙΡΟΣ

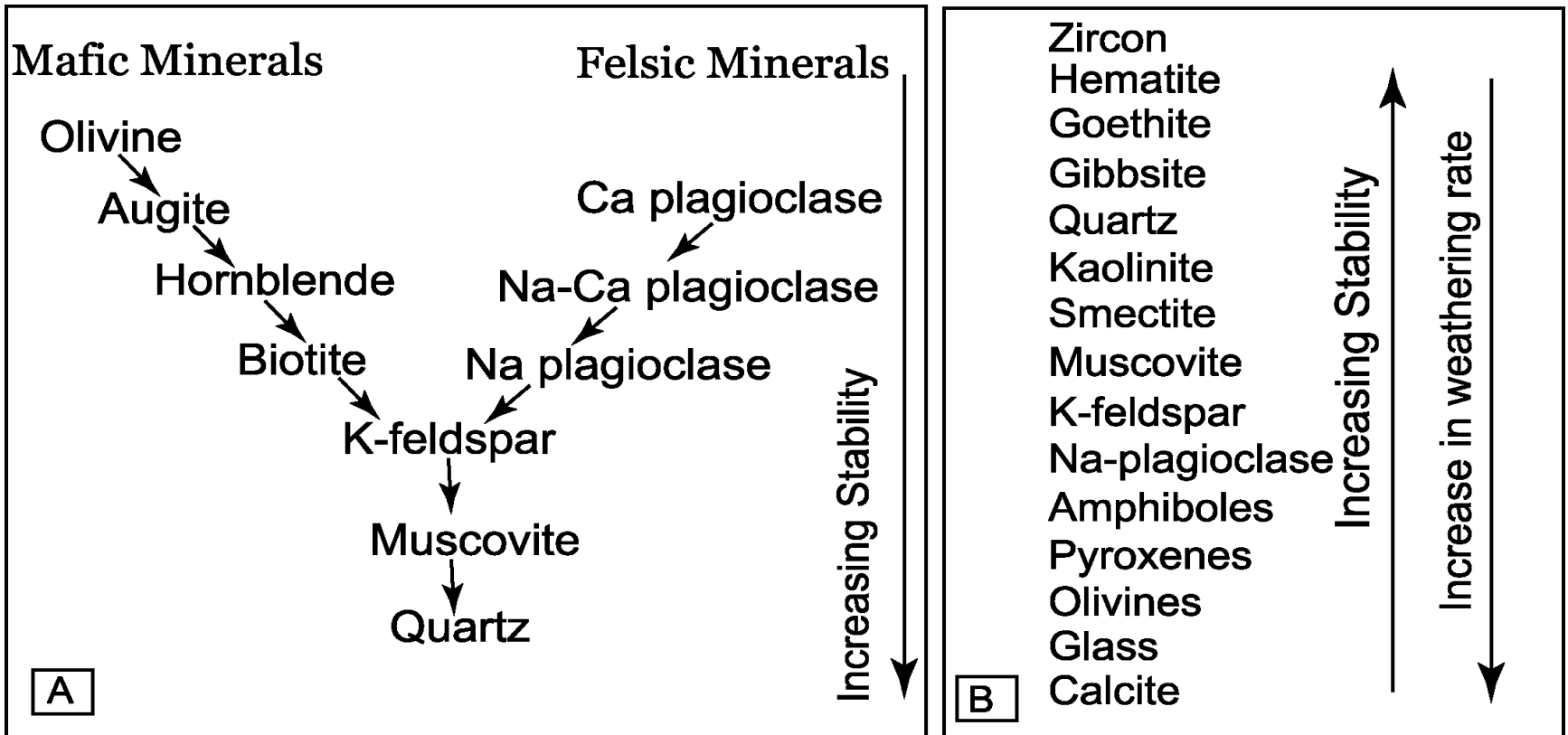




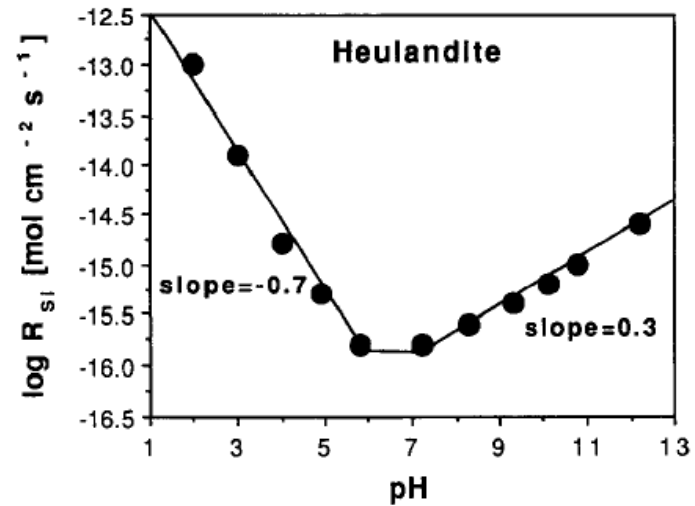
N.L. Bowen
(1922)



S. Goldich
(1938)



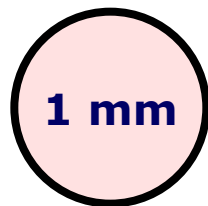
- DISSOLUTION RATE (R)
ΡΥΘΜΟΣ ΔΙΑΛΥΤΟΠΟΙΗΣΗΣ



ΖΕΟΛΙΘΟΣ

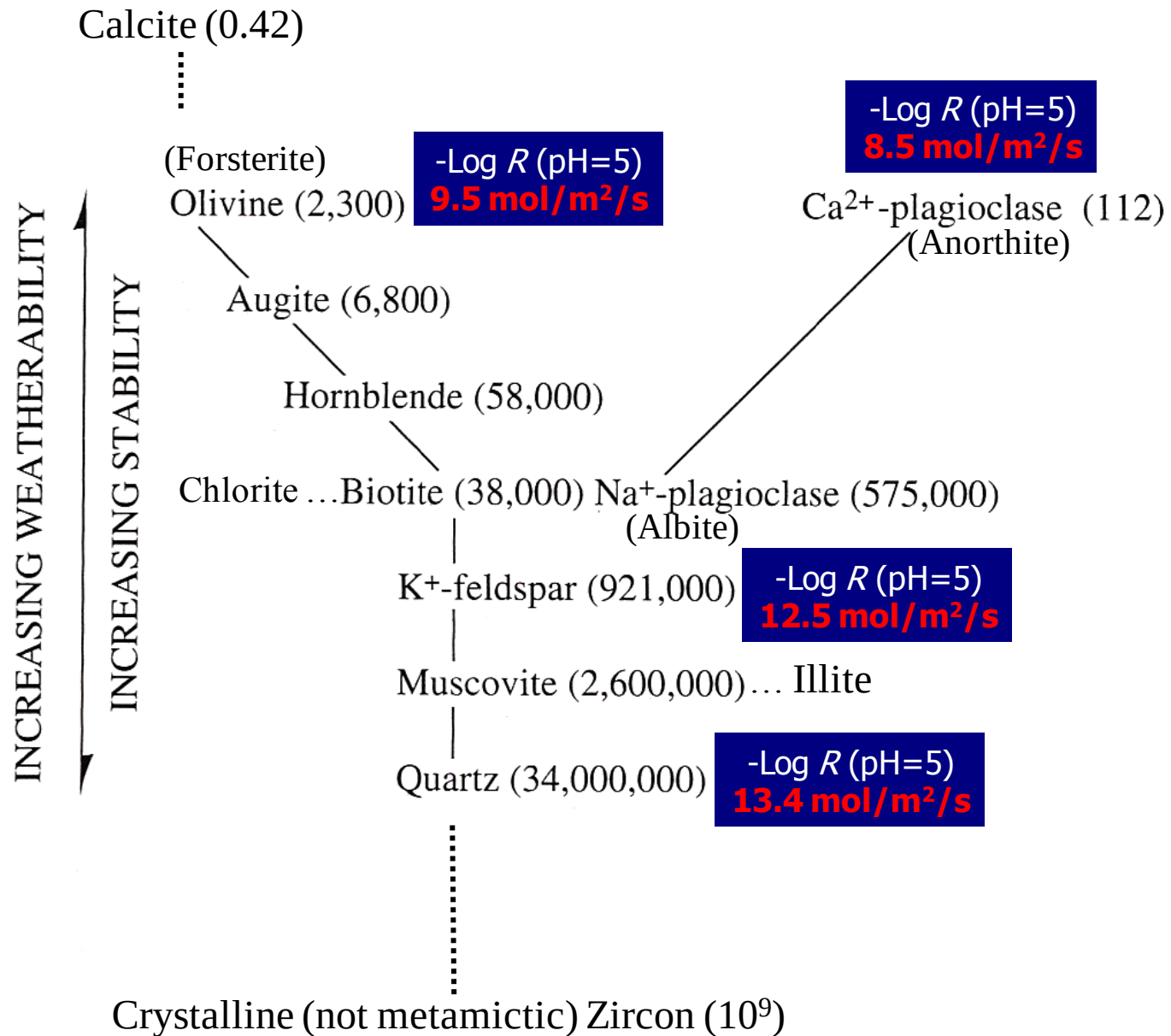
$-\log R$ (pH ~ 7)

11.8 mol/m²/s

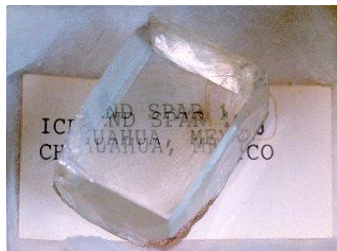
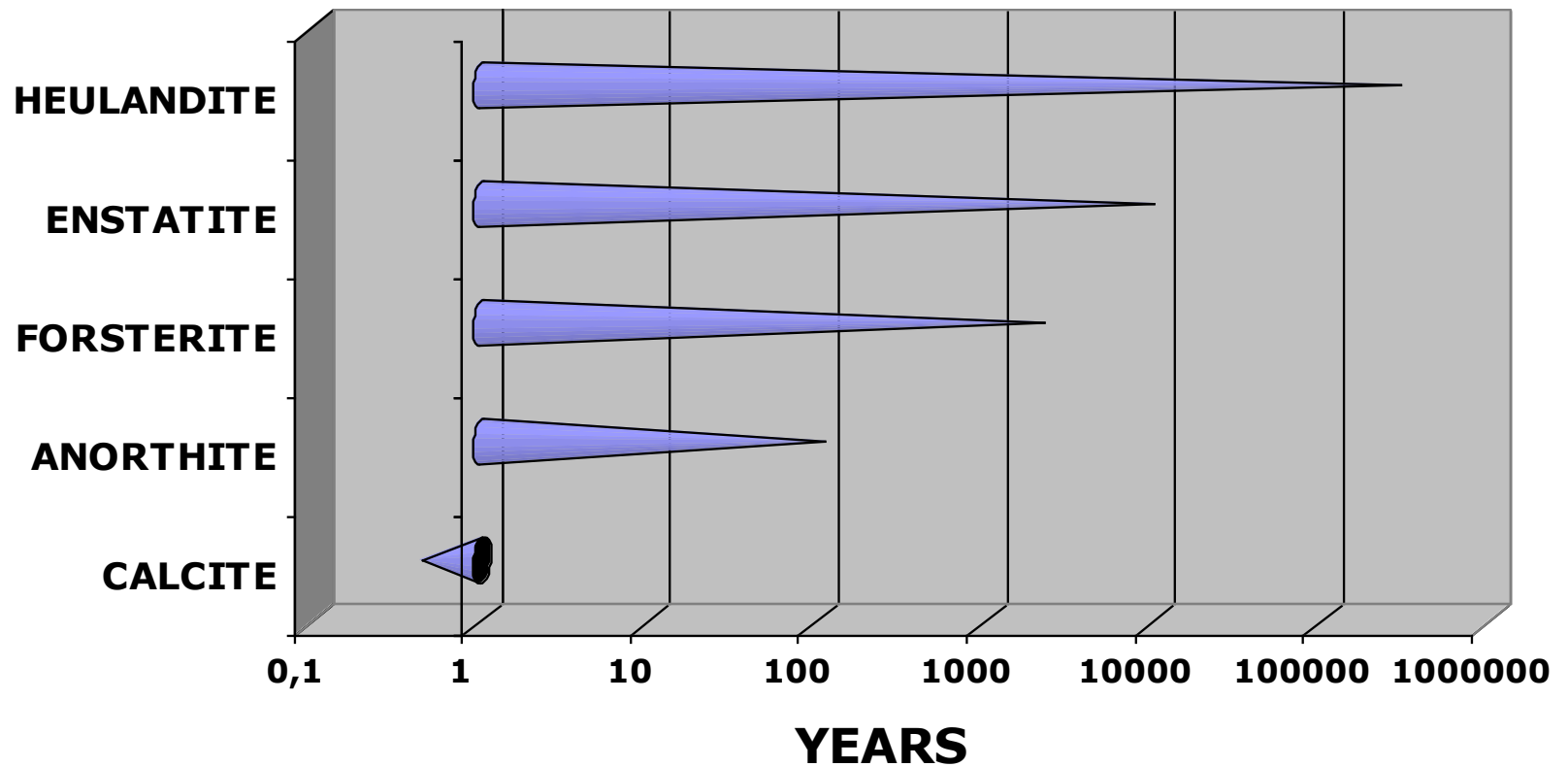


300 000 yrs



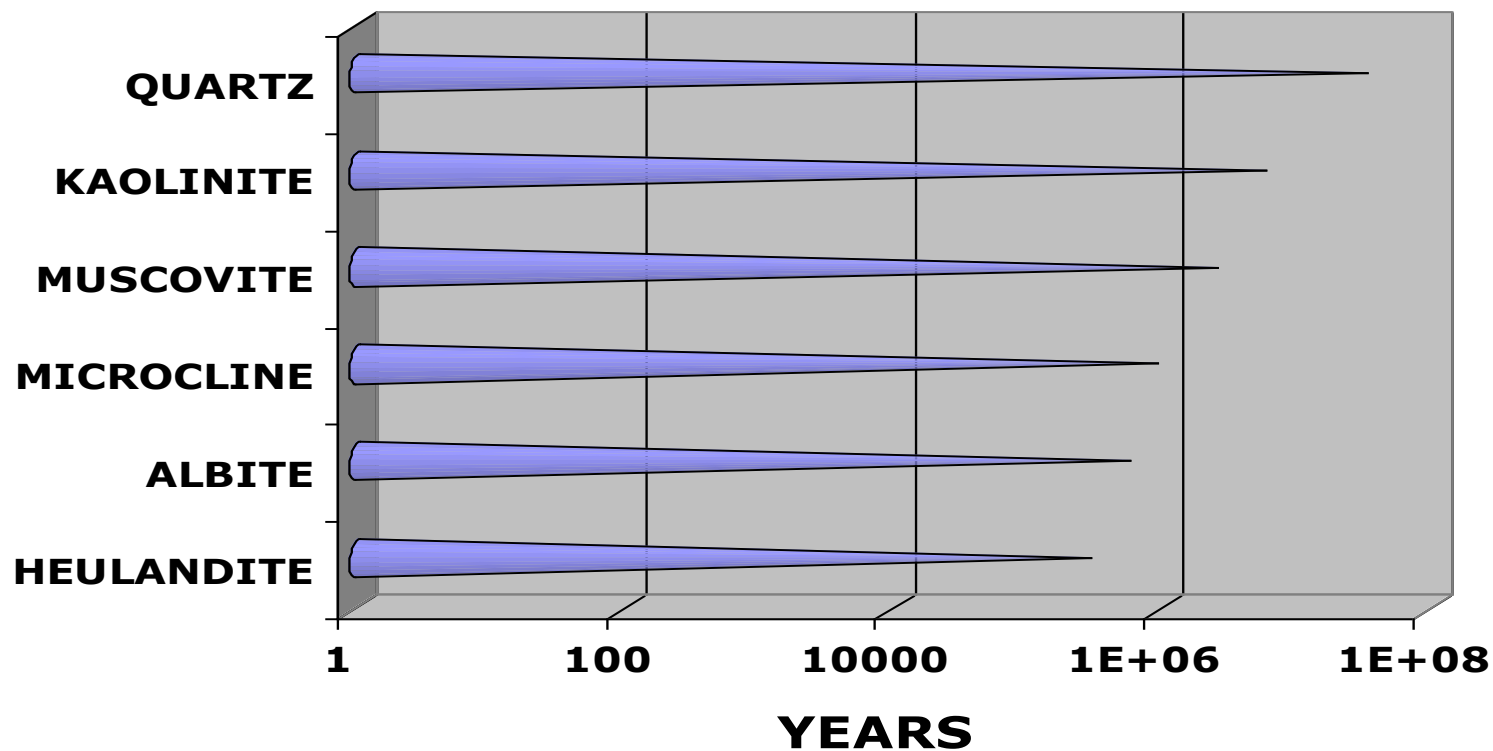


1 mm crystal, 25 C, pH=5



..... **ΑΣΒΕΣΤΙΤΗΣ: 150 ημέρες**

1 mm crystal, 25 C, pH=5



ΧΑΛΑΖΙΑΣ: 34 000 000 έτη.....

Alain Meunier
Clays

 Springer

SECOND EDITION

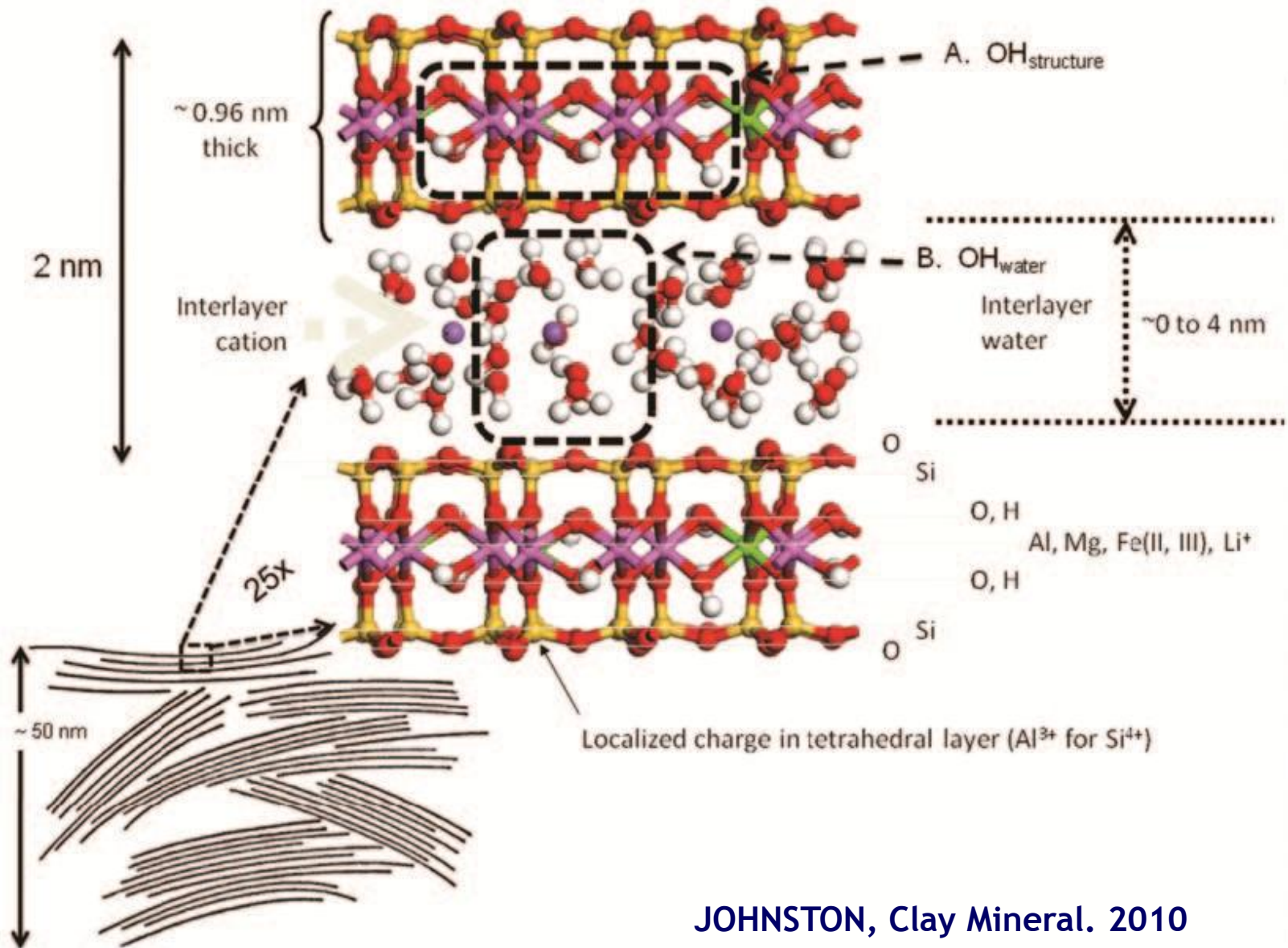
X-Ray Diffraction
and the Identification and Analysis of
Clay Minerals



Duane M. Moore Robert C. Reynolds, Jr.

Copyrighted Material

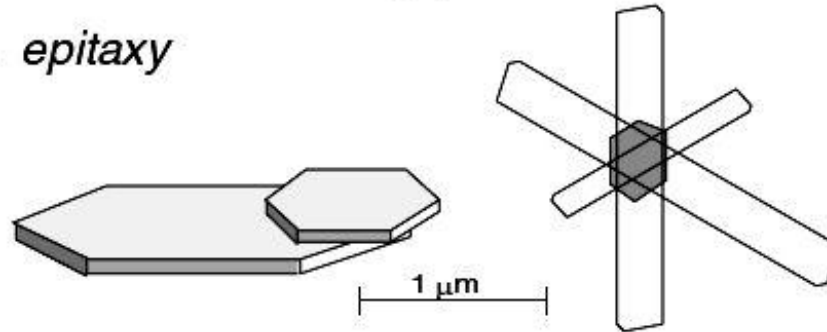
Ορυκτά της αργίλου (Clay minerals)



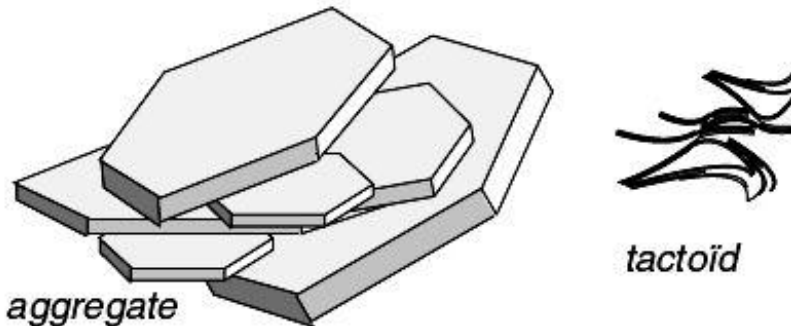
Ορυκτά της αργίλου (Clay minerals)

common clay particles

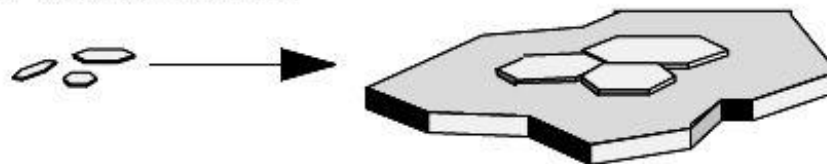
a *epitaxy*



b *aggregation*



c *coalescence*

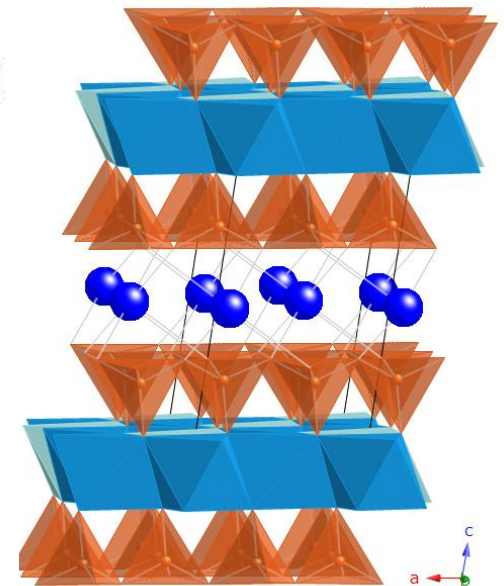


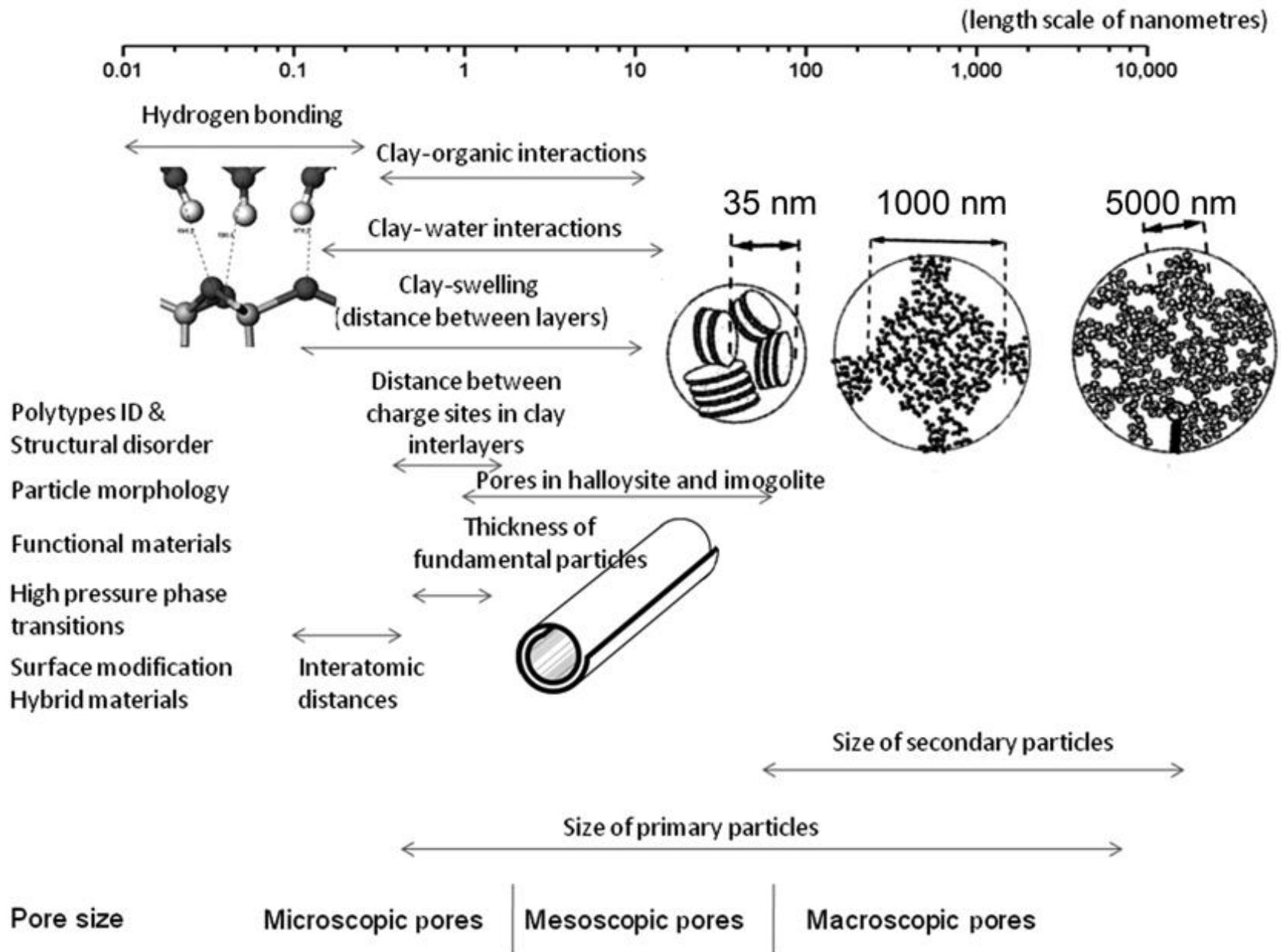
The main types of particles and aggregates of clay minerals.

a) Epitaxy, i.e. growth on a crystalline support.

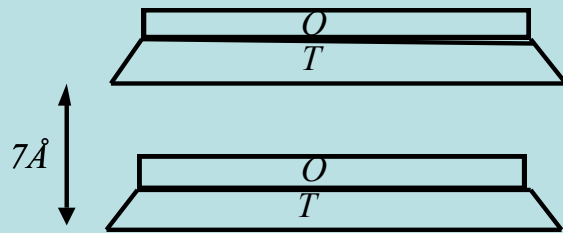
b) Aggregation of rigid or flexible particles or crystallites (tactoid or quasi-crystal networks).

c) Coalescence: neighbouring crystals are joined by the growth of common layers

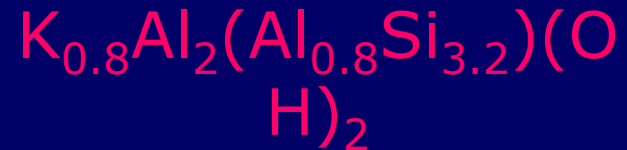
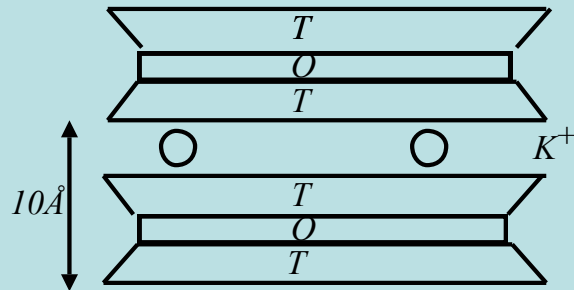




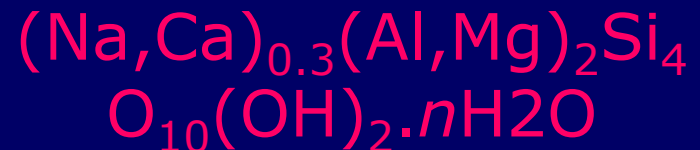
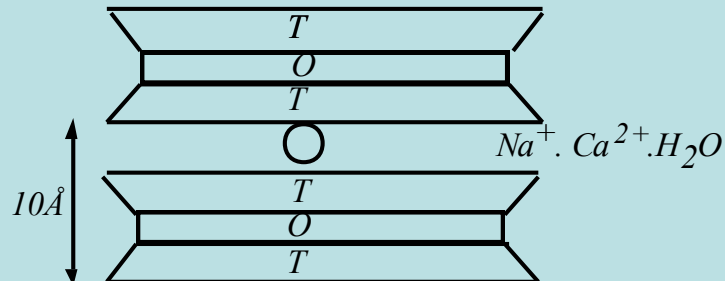
Ορυκτά της αργίλου (Clay minerals)



Καολινίτης

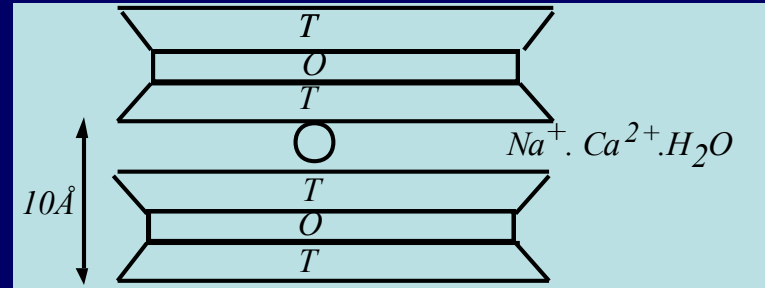


Ιλλίτης

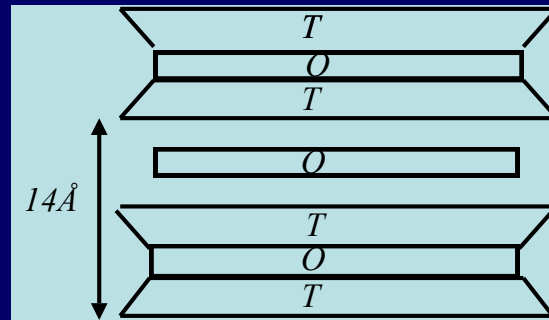


**Μοντμοριλλονίτης
(Ομάδα Σμεκτίτη)**

Ορυκτά της αργίλου (Clay minerals)

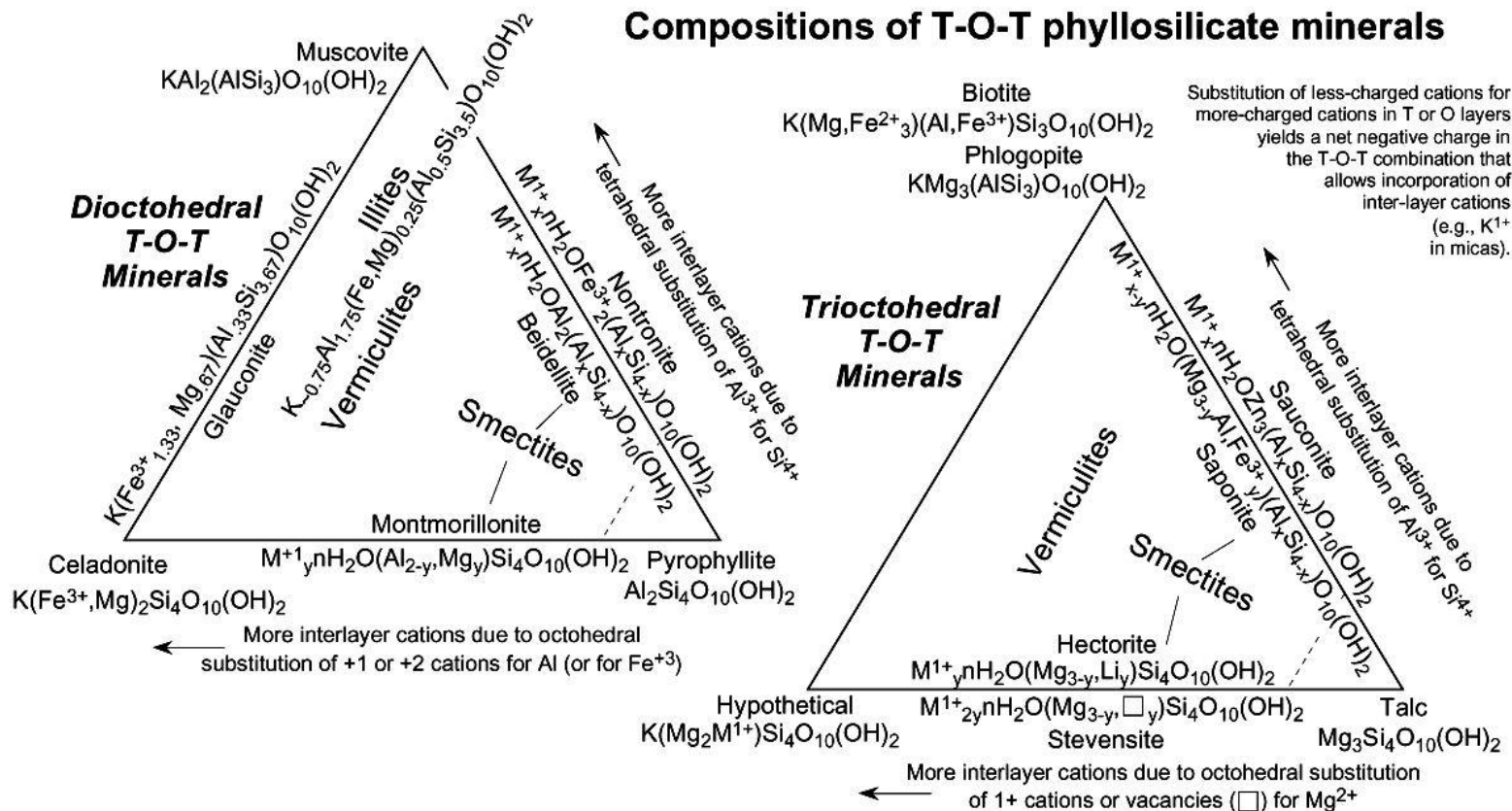


$(\text{Mg}, \text{Fe}^{3+}, \text{Al})_3(\text{Si}, \text{Al})_4\text{O}_{10}(\text{OH})_2 \cdot 4\text{H}_2\text{O}$ - **Βερμικουλίτης**

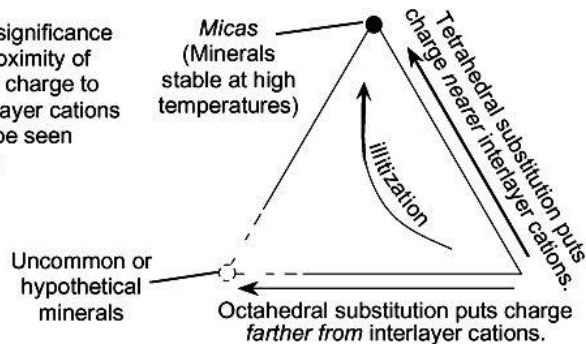


$(\text{Mg}, \text{Fe})_5\text{Al}(\text{AlSi}_3\text{O}_{10})(\text{OH})_2$ - **Χλωρίτης**

Compositions of T-O-T phyllosilicate minerals



The significance of proximity of layer charge to interlayer cations can be seen here:



Smectite = Montmorillonite + Beidellite + Nontronite + Hectorite + Stevensite + Saponite + Sauconite (+ others)

= "Swelling Clays" = "Expandable Clays"

= "Montmorillonite" in archaic broad sense of "montmorillonite"



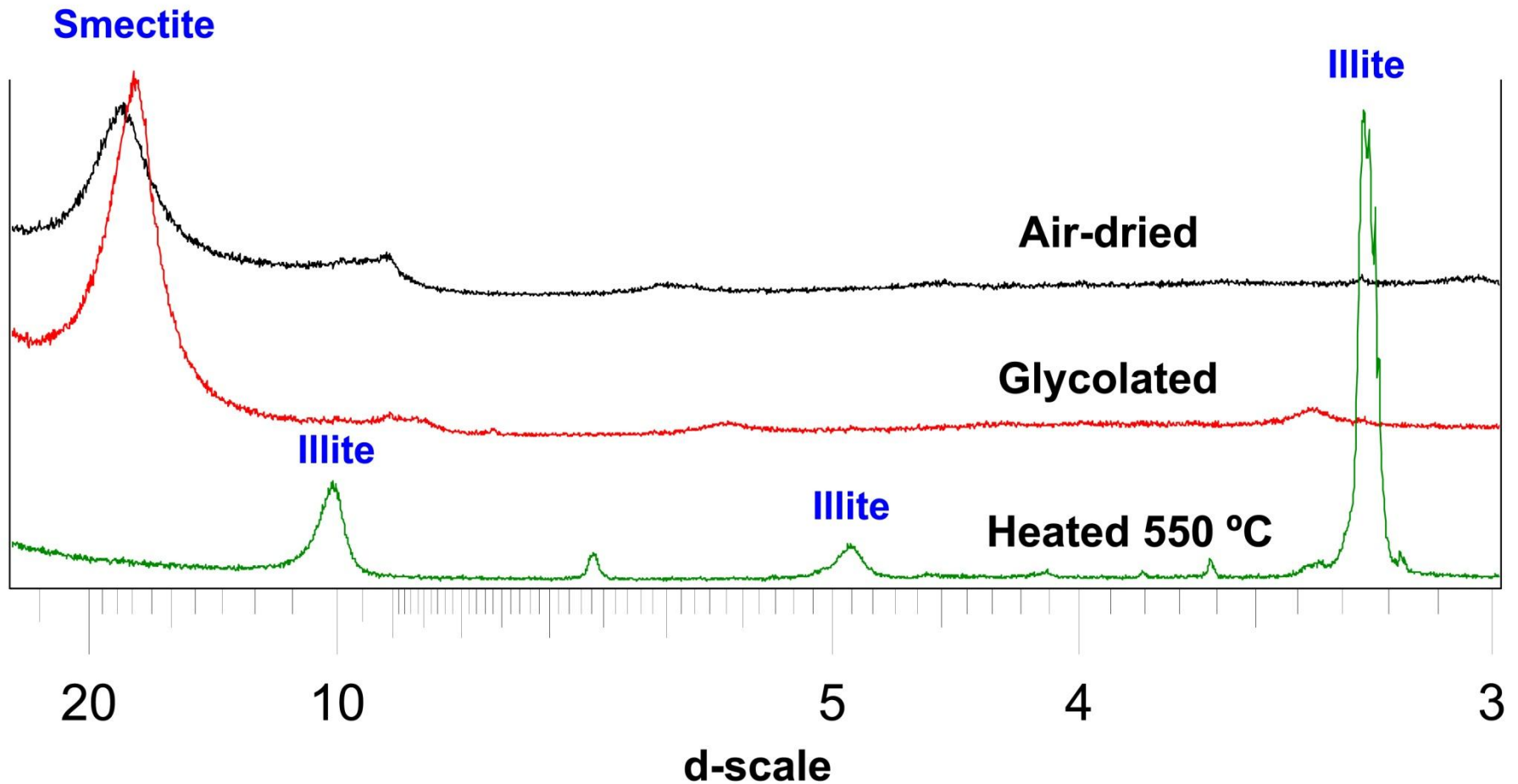
ΚΙΜΩΛΟΣ



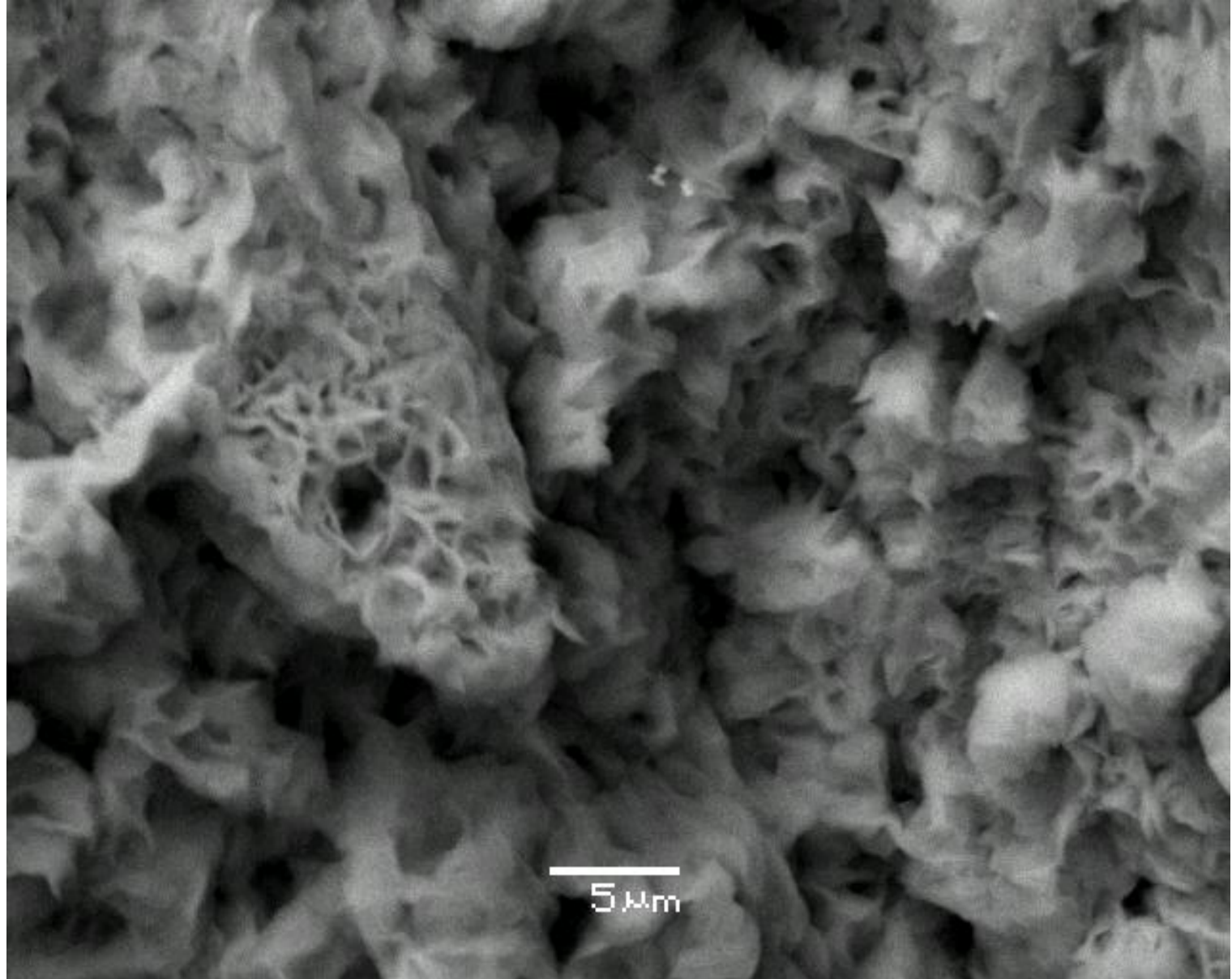


XRD

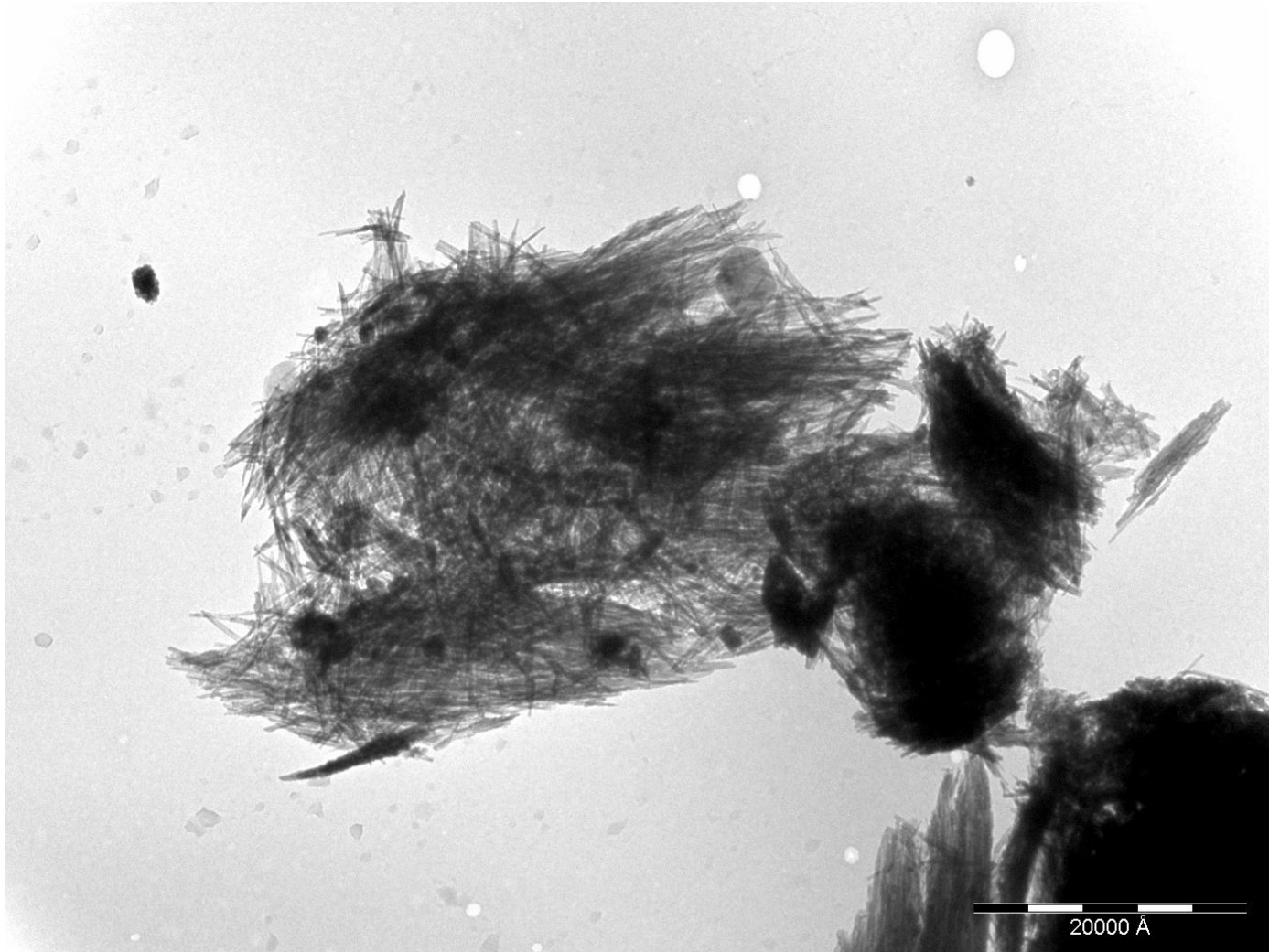
Fraction < 0.2 μm



SEM



TEM



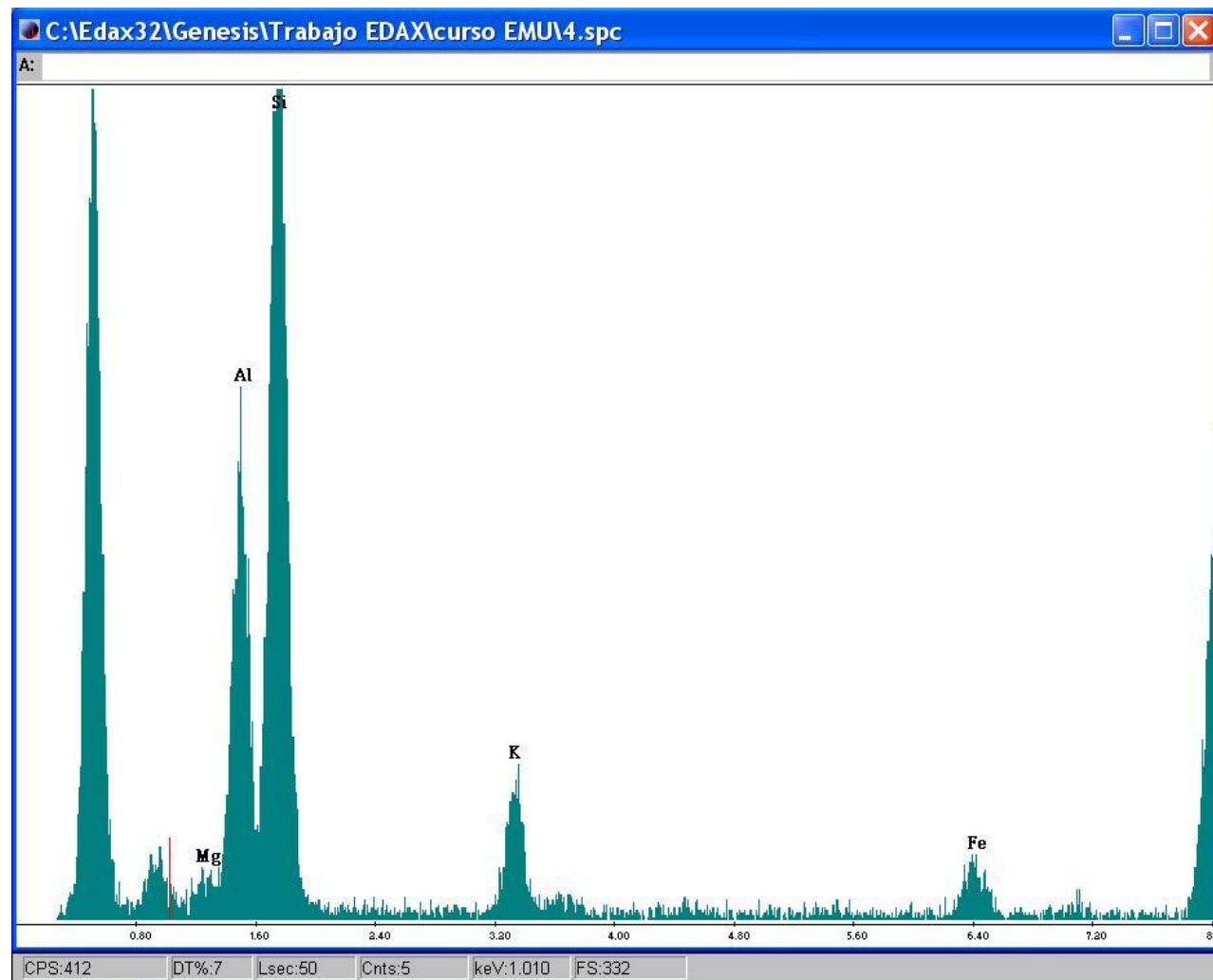
ugr

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TEM



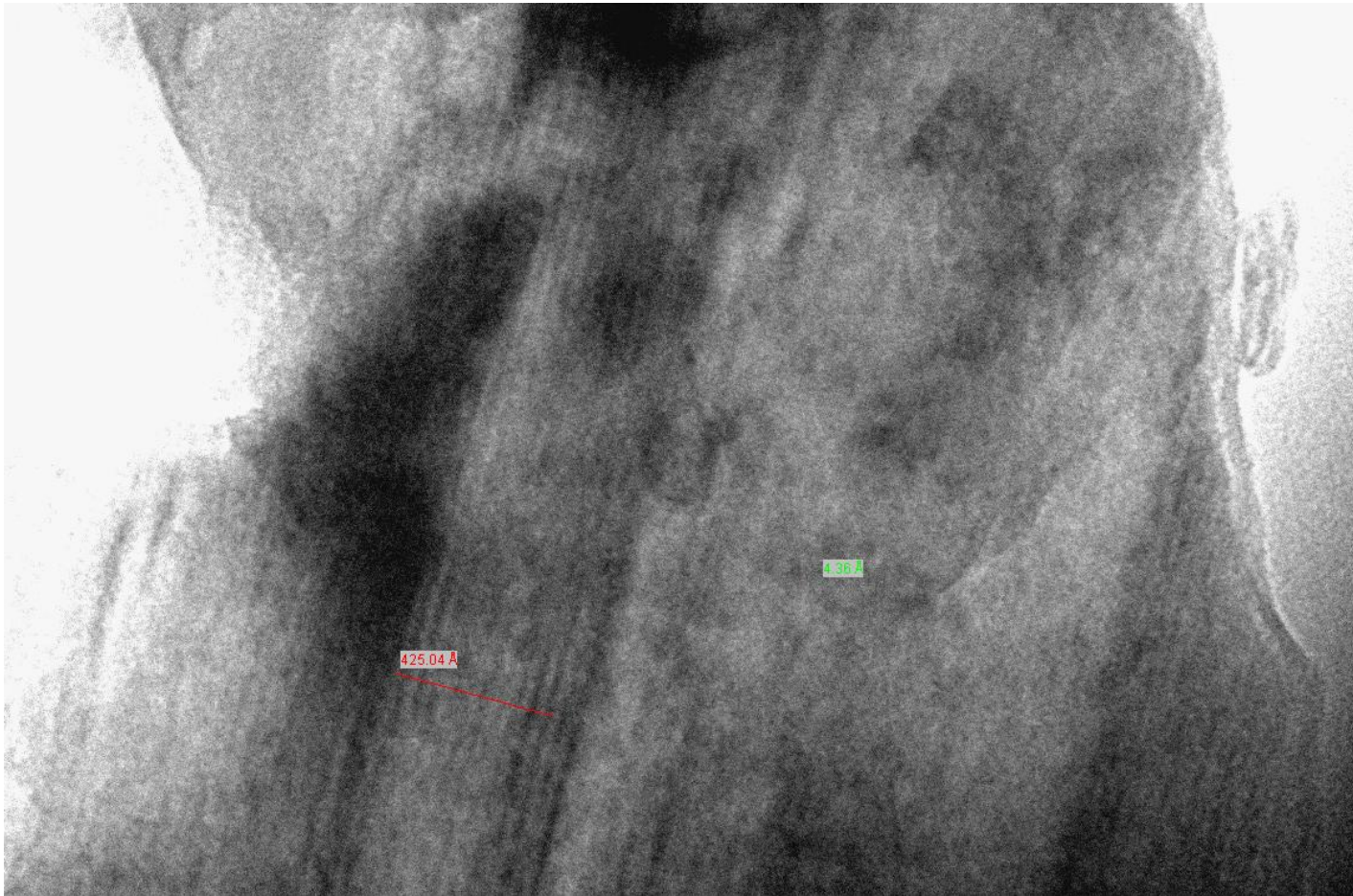
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TEM



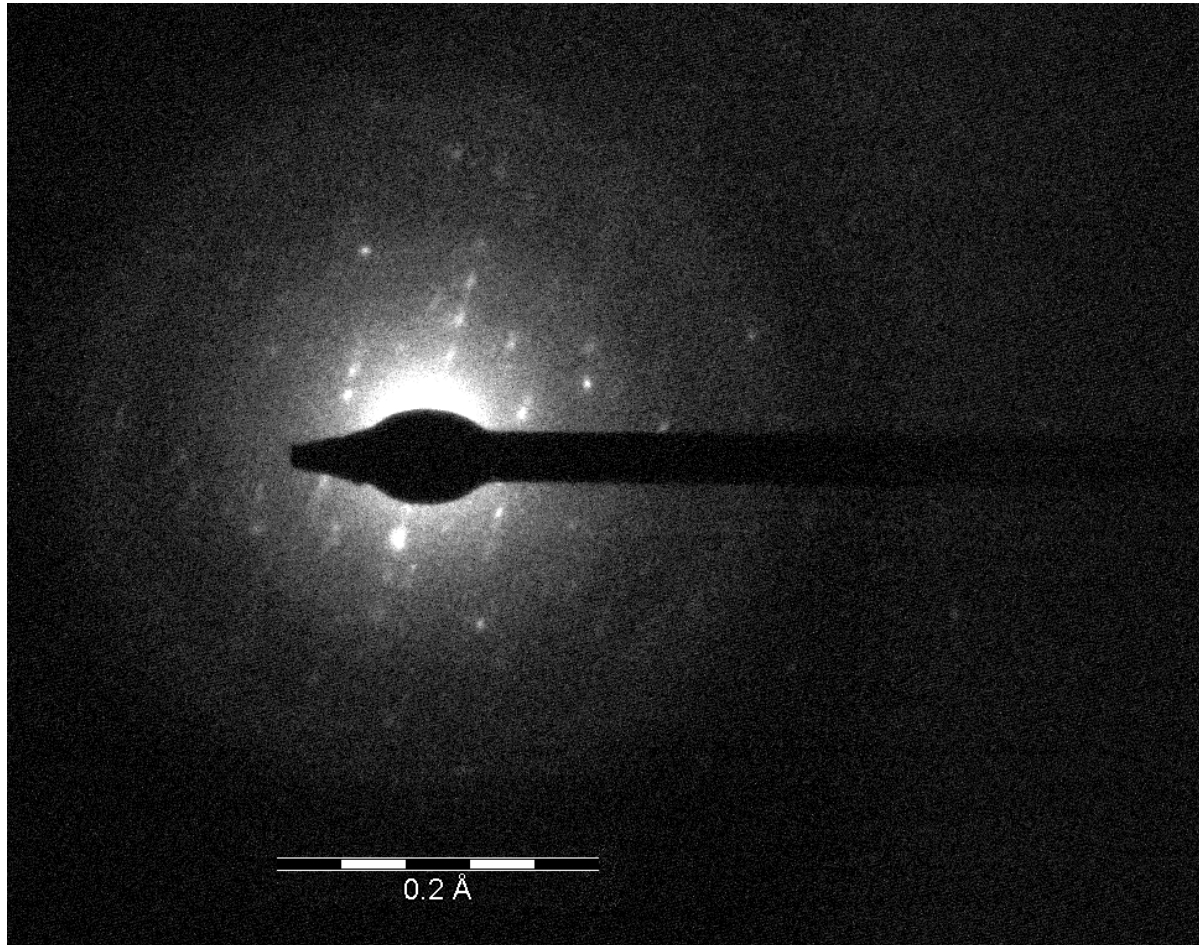
ugr

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TEM



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Universidad de Granada

EUROPEAN MINERALOGICAL UNION

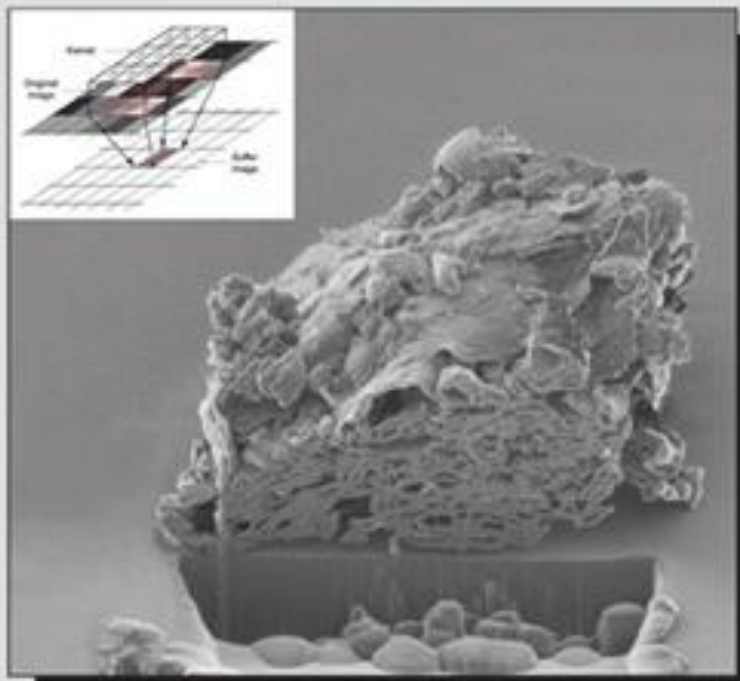
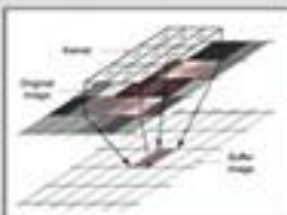


EMU NOTES IN
MINERALOGY

9

Advances in the characterization of Industrial Minerals

Editor
GEORGE E. CHRISTIDIS



THE MINERALOGICAL SOCIETY OF GREAT BRITAIN & IRELAND

EUROPEAN MINERALOGICAL UNION

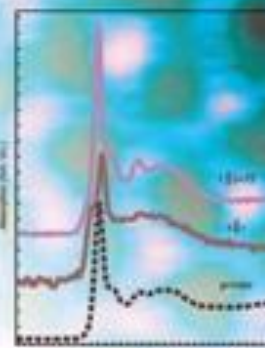


EMU NOTES IN
MINERALOGY

11

Layered Mineral Structures and their Application in Advanced Technologies

Editors
M.F. BRIGATTI and A. MOTTANA



THE MINERALOGICAL SOCIETY OF GREAT BRITAIN & IRELAND