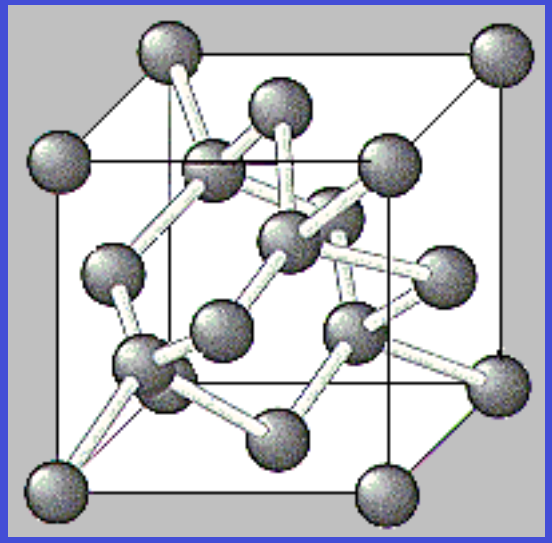

Minerali e Rocce

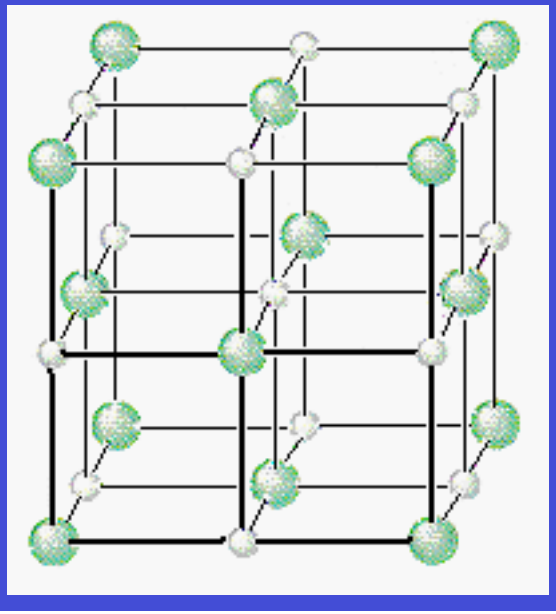
Definizione di minerale:

- elemento o composto chimico rinvenibile in natura
- generalmente cristallino
- composizione definita (in genere non fissa)
- formato per processi geologici

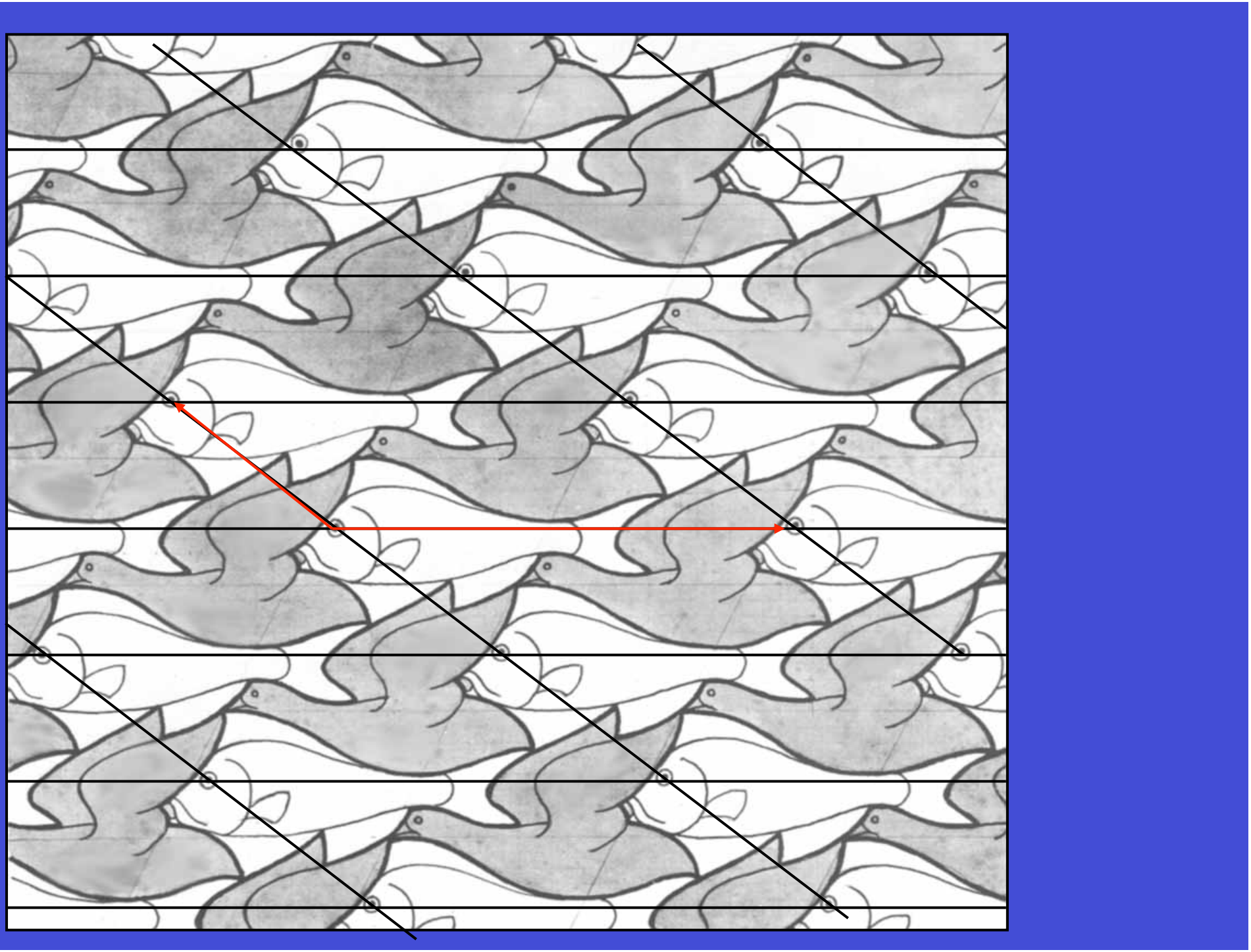
Struttura (ordinamento cristallino)

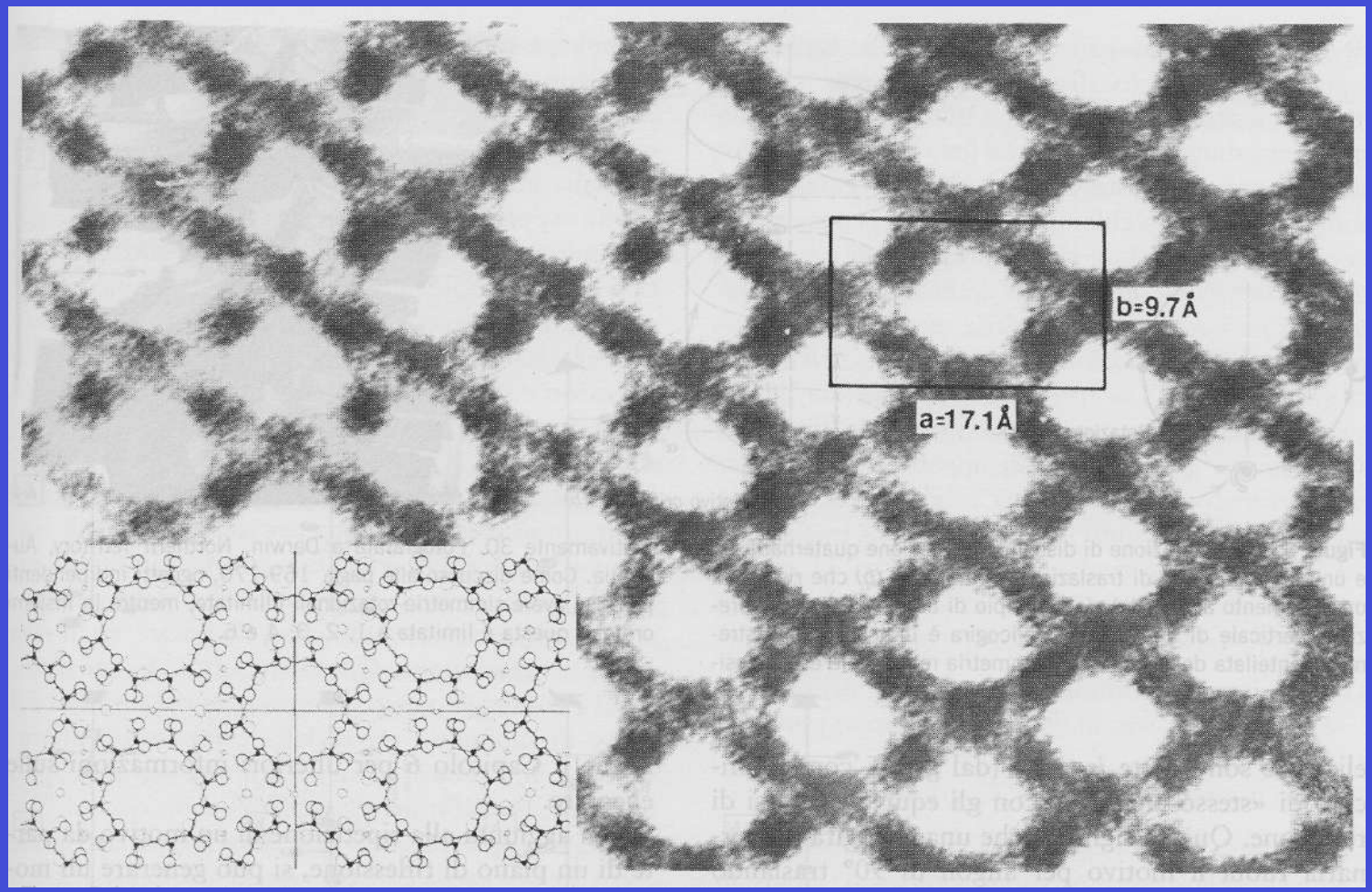


Diamante: C



Salgemma: NaCl





Cordierite ($Mg_2Al_4Si_5O_{18}$)

Composizione

Quarzo: SiO_2 composizione **definita** e **fissa**

Forsterite: Mg_2SiO_4
Fayalite: Fe_2SiO_4

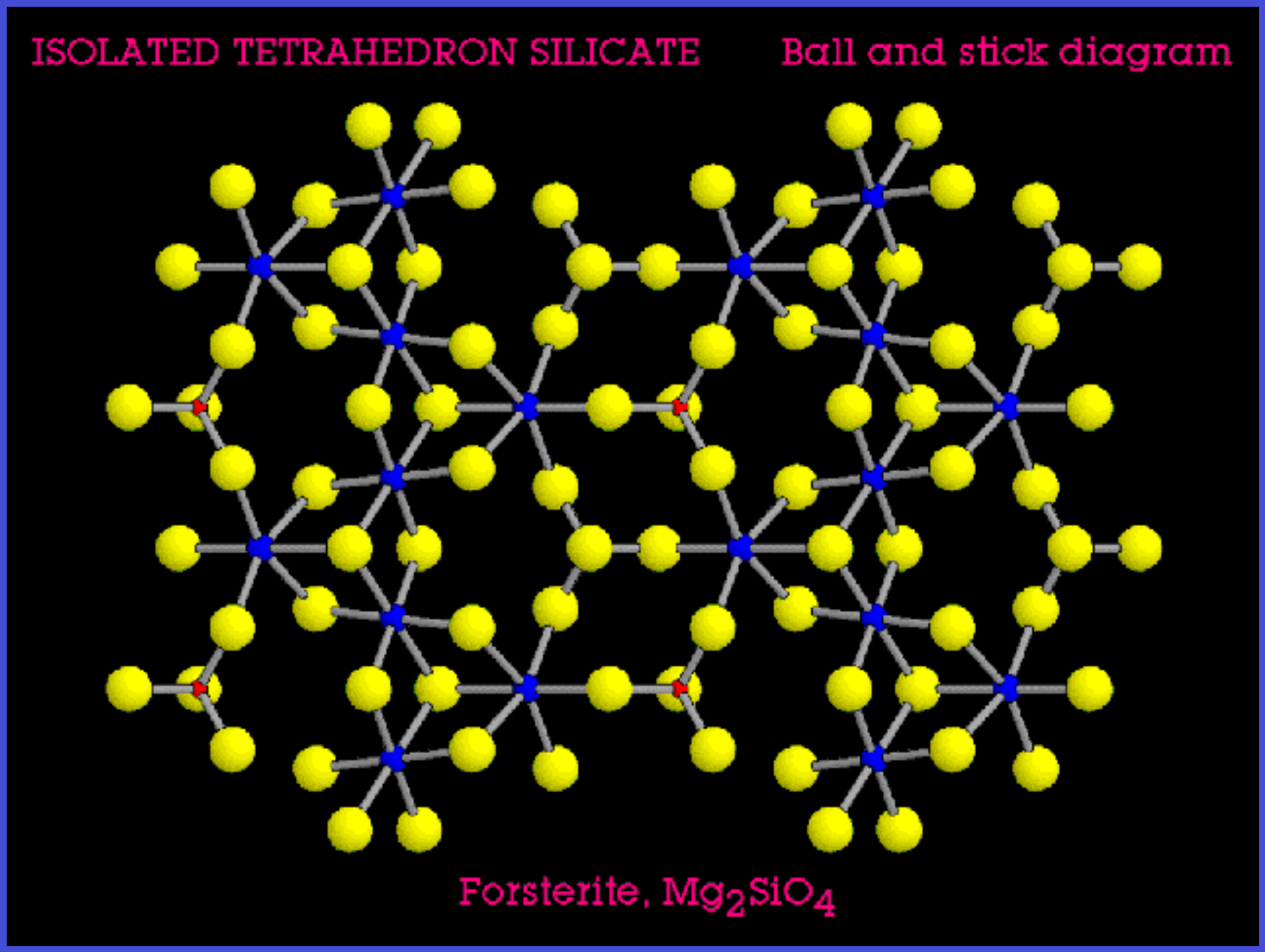
} Esistono composizioni intermedie

$(Mg_{1-X}Fe_X)_2SiO_4$ composizione **definita** ma non fissa

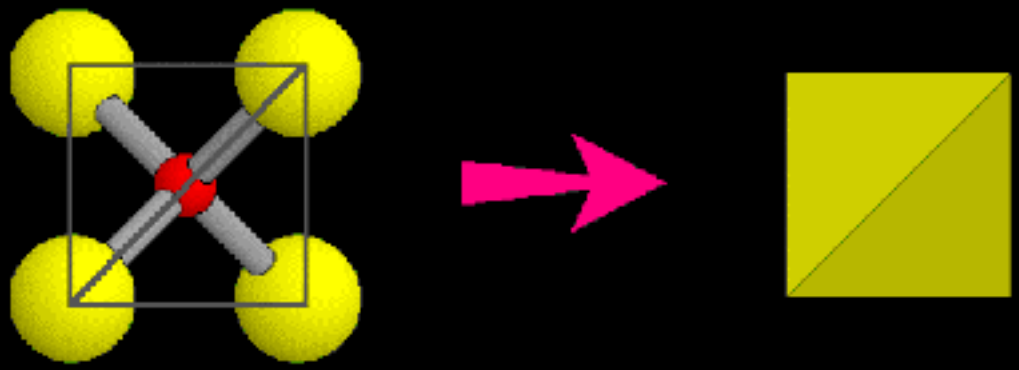
Classi di minerali:

Elementi nativi	C, Au, Ag, Cu
Alogenuri	NaCl, CaF_2
Solfuri	FeS_2, ZnS
Ossidi	Al_2O_3
Carbonati	$CaCO_3$
Solfati	$CaSO_4{:}2H_2O$
Arseniati, fosfati, vanadati, molibdati, nitrati	$Ca_5\,[PO_4]_3\,(F,OH)$
Silicati	$KAlSi_3O_8$
Minerali organici	$Ca_2[C_2O_4]H_2O$

Struttura

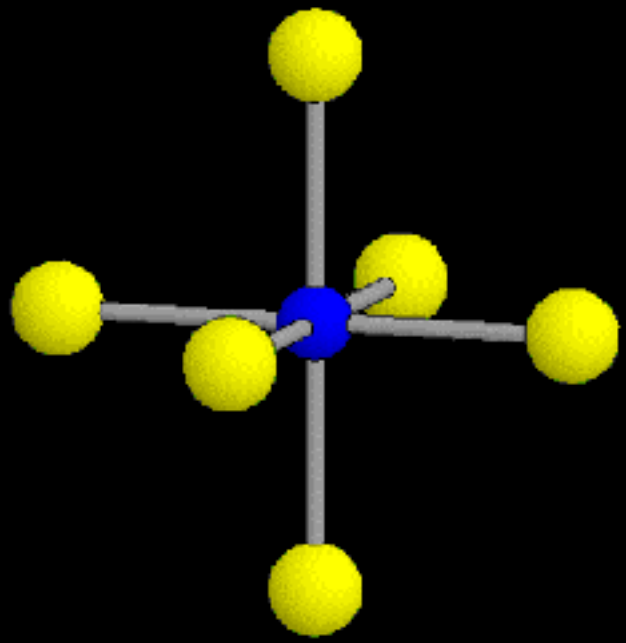

ISOLATED TETRAHEDRON SILICATE
Ball and stick diagram
Forsterite, Mg_2SiO_4

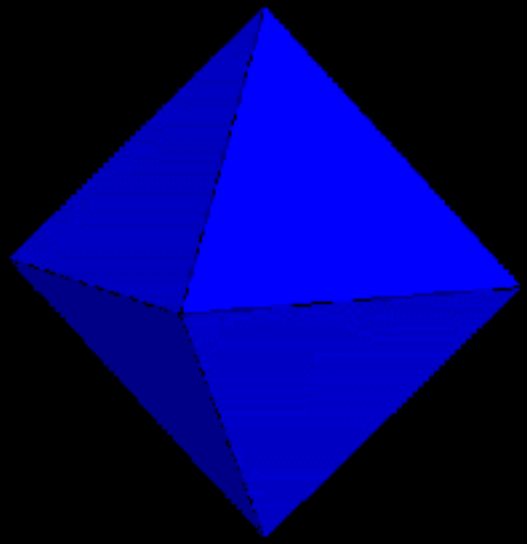
In complex structures it is better to view the silicate unit as a tetrahedron.



The silicate tetrahedron is formed by connecting the centers of the four oxygen atoms.

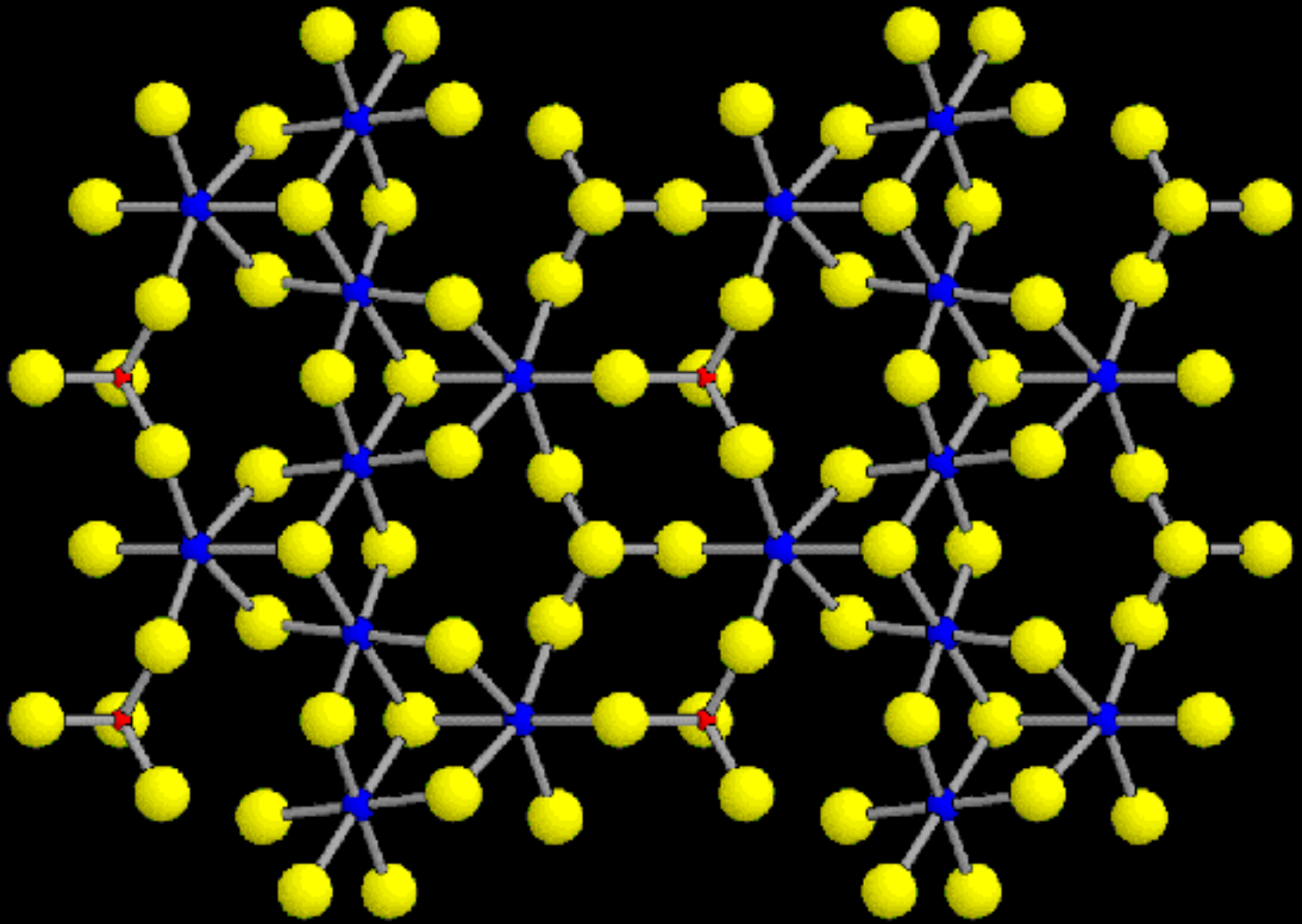
Certain positively charged atoms such as Mg(+2) and Fe(+2) bond to six surrounding oxygens.





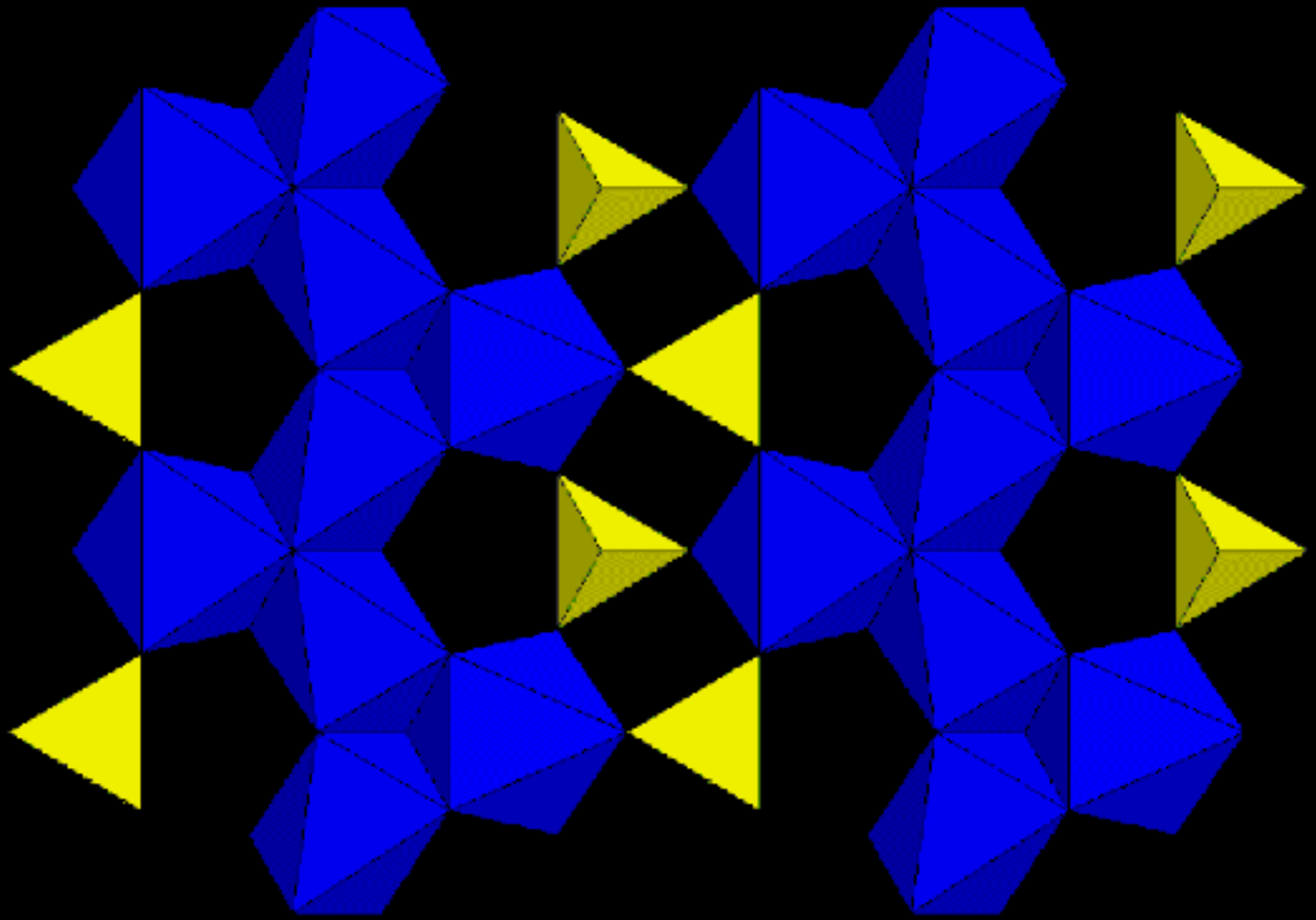
These units can be symbolized by a six-cornered shape called an octahedron.

ISOLATED TETRAHEDRON SILICATE Ball and stick diagram



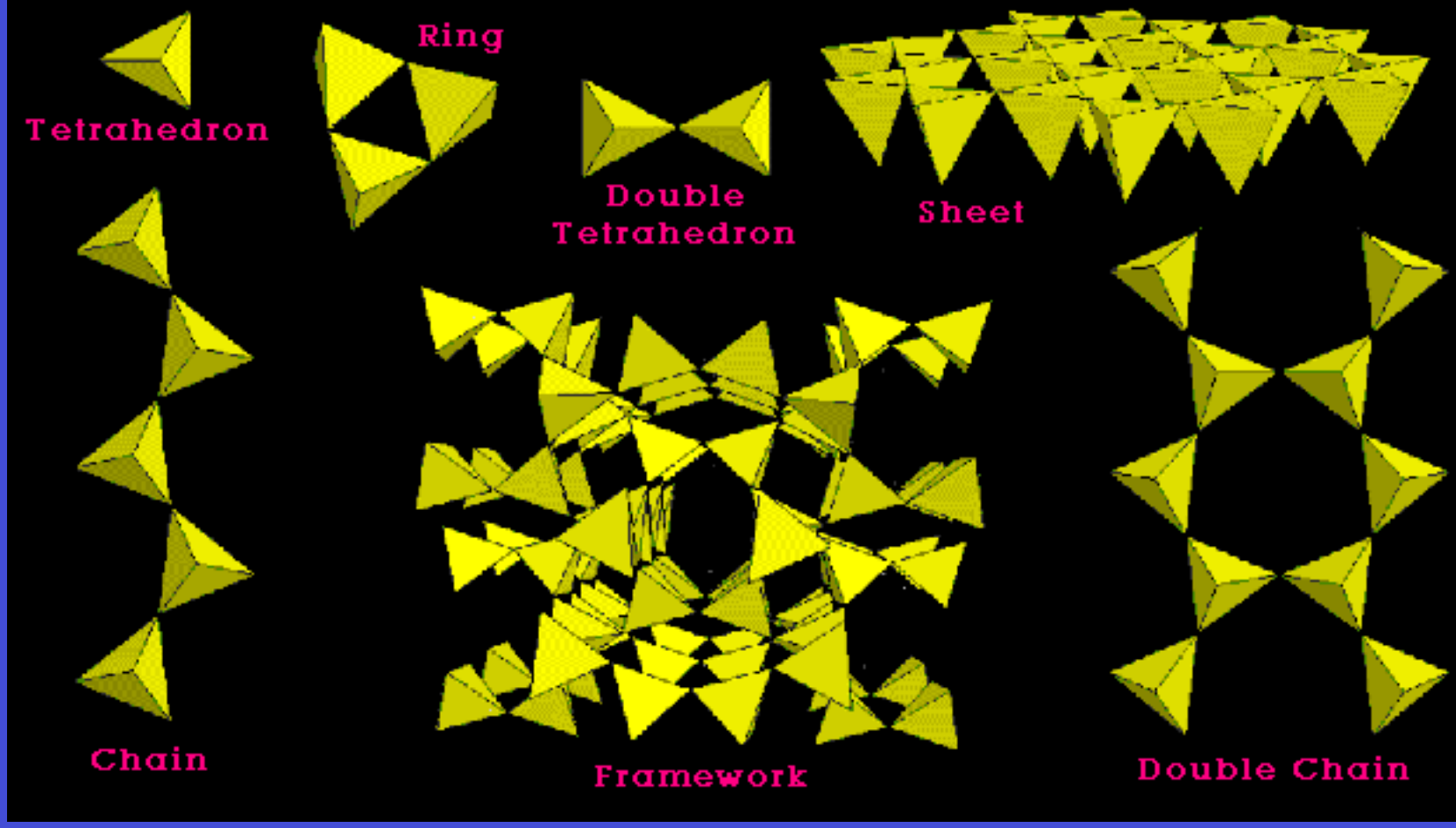
Forsterite, Mg_2SiO_4

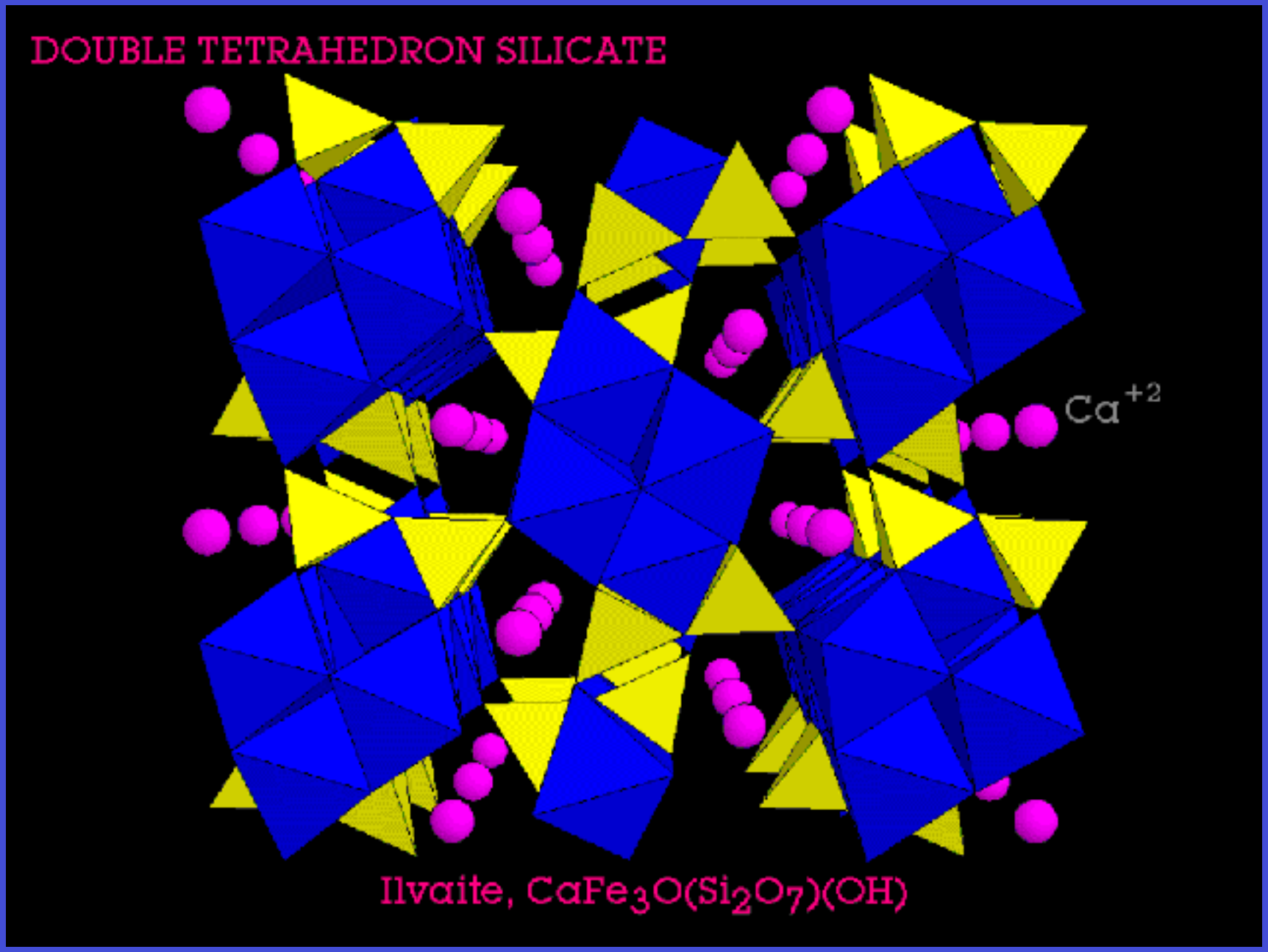
ISOLATED TETRAHEDRON SILICATE polyhedral diagram

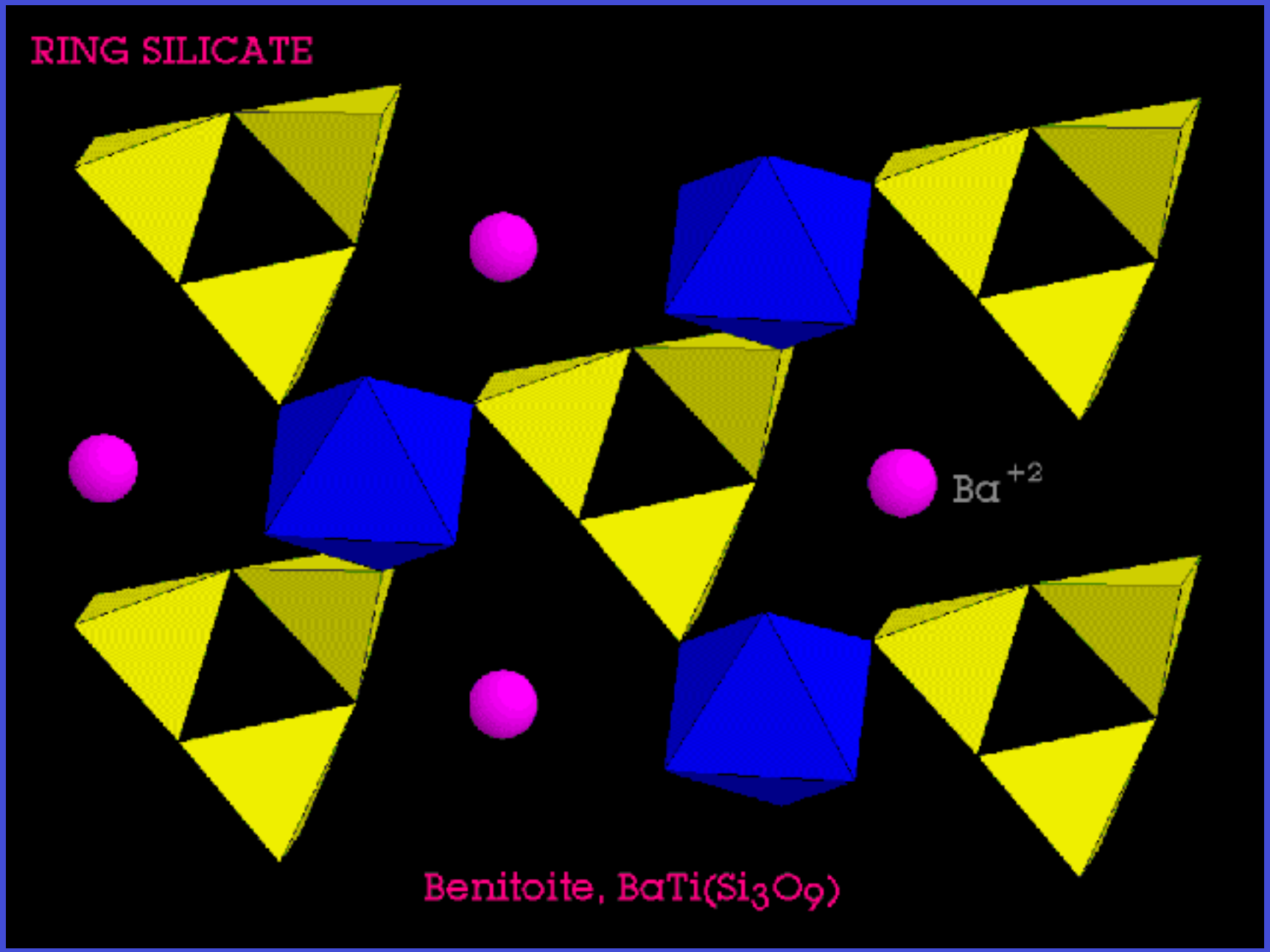


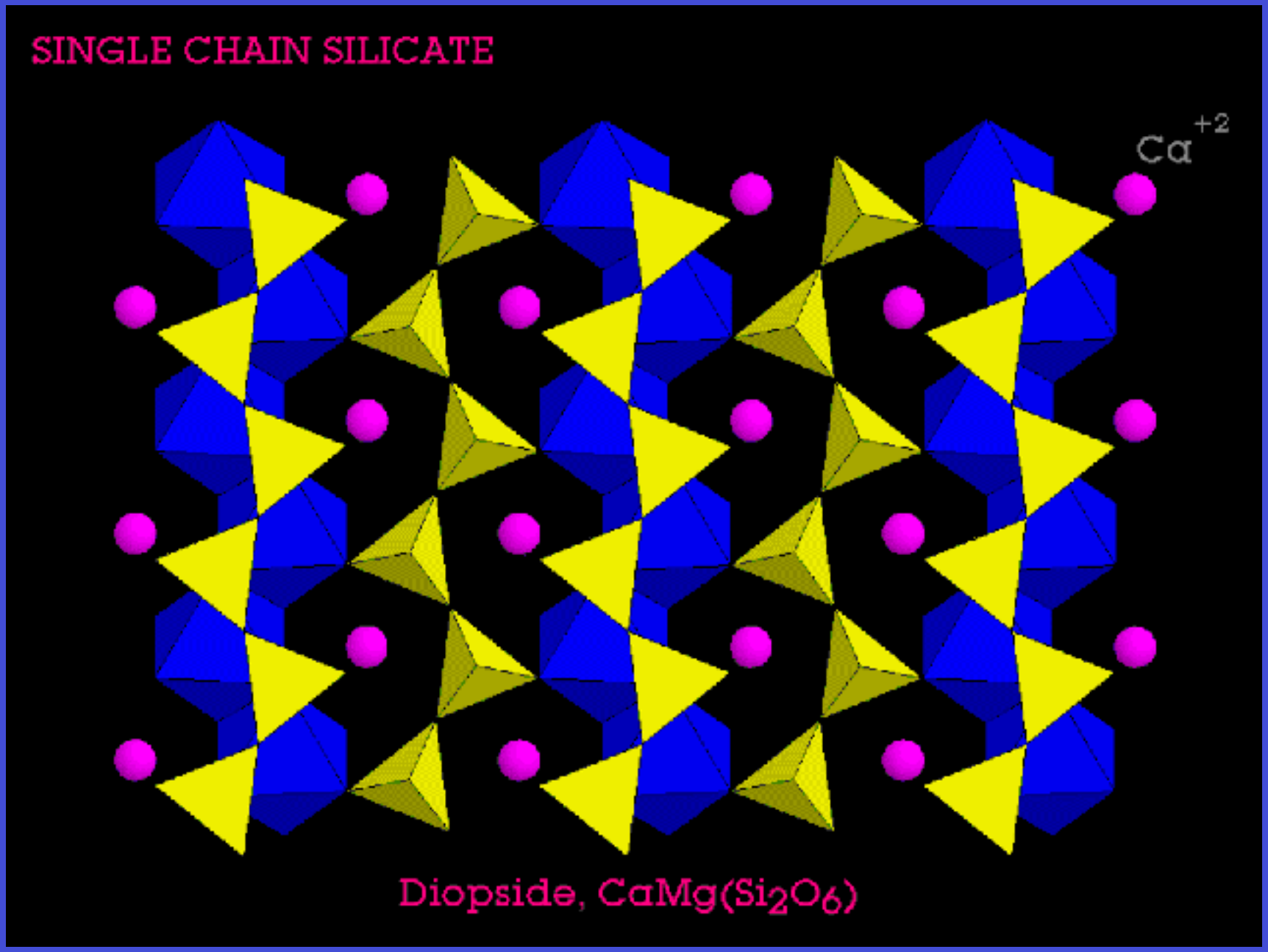
Forsterite, Mg_2SiO_4

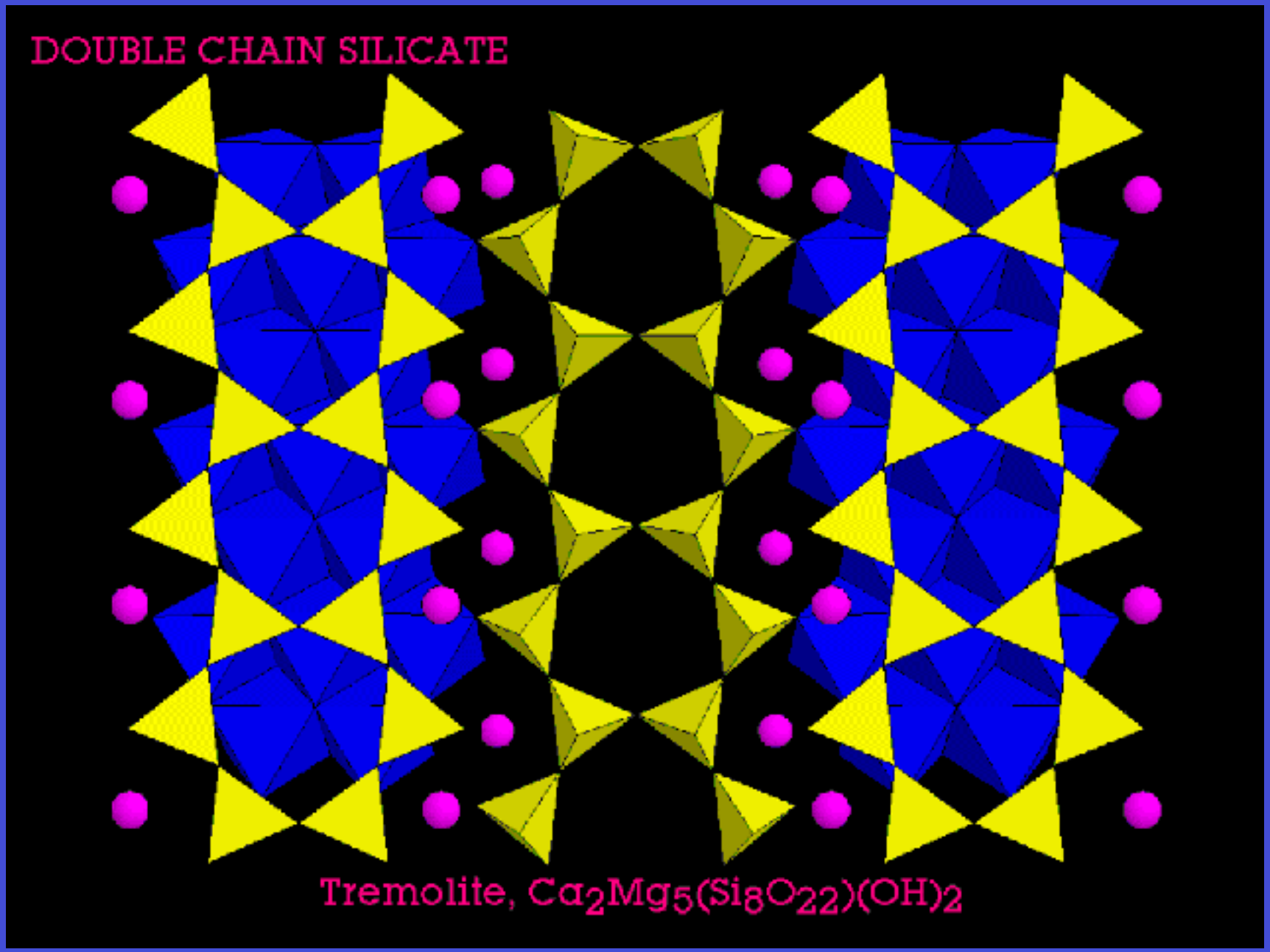
The ability of silicate tetrahedra to join by sharing oxygen corners leads to a vast assortment of complex structures.




DOUBLE TETRAHEDRON SILICATE
Ca^{+2}
Ilvaite, $CaFe_3O(Si_2O_7)(OH)$

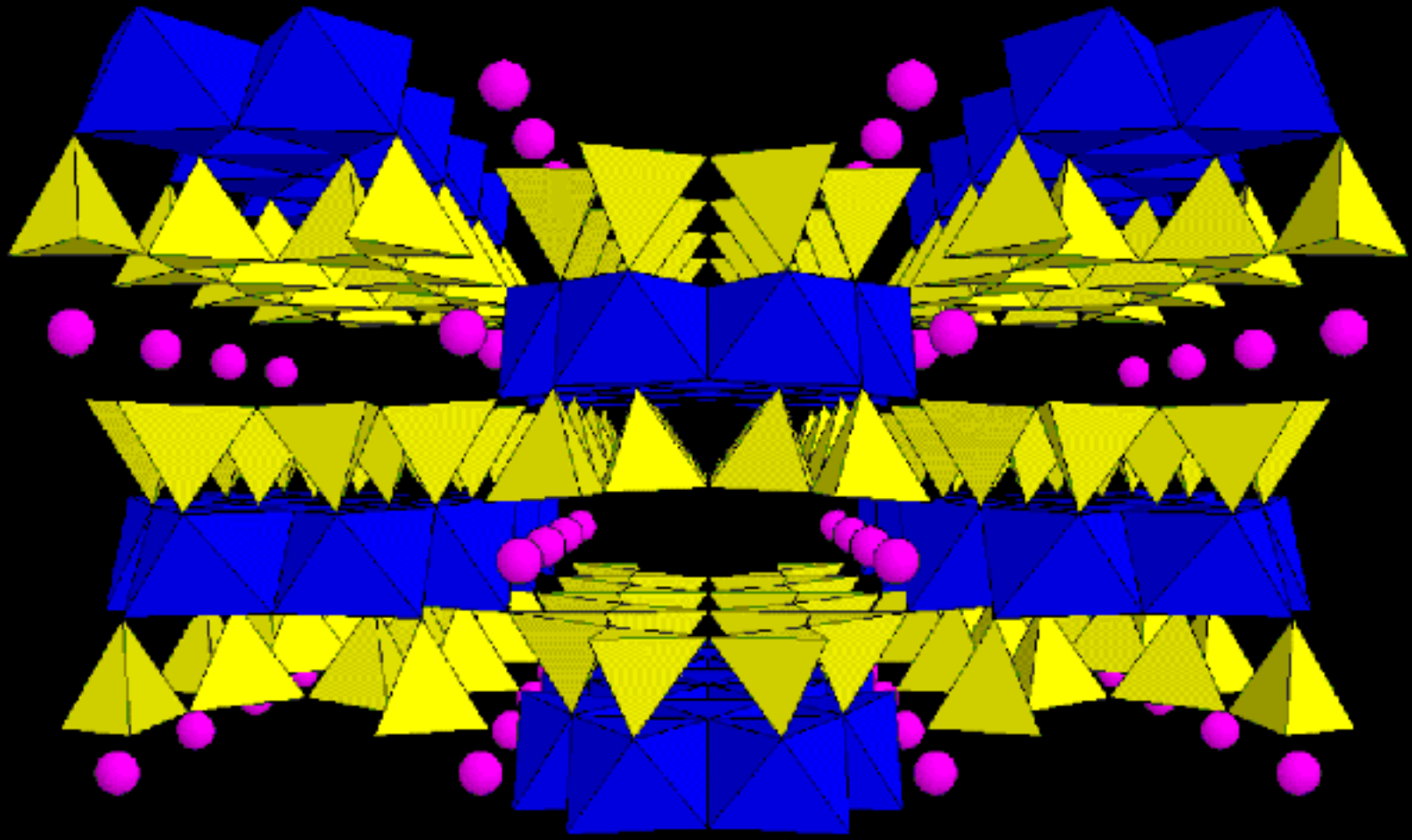

RING SILICATE
Ba +2
Benitoite, BaTi(Si3O9)


SINGLE CHAIN SILICATE
Ca^{+2}
Diopside, $CaMg(Si_2O_6)$


DOUBLE CHAIN SILICATE
Tremolite, $Ca_2Mg_5(Si_8O_{22})(OH)_2$

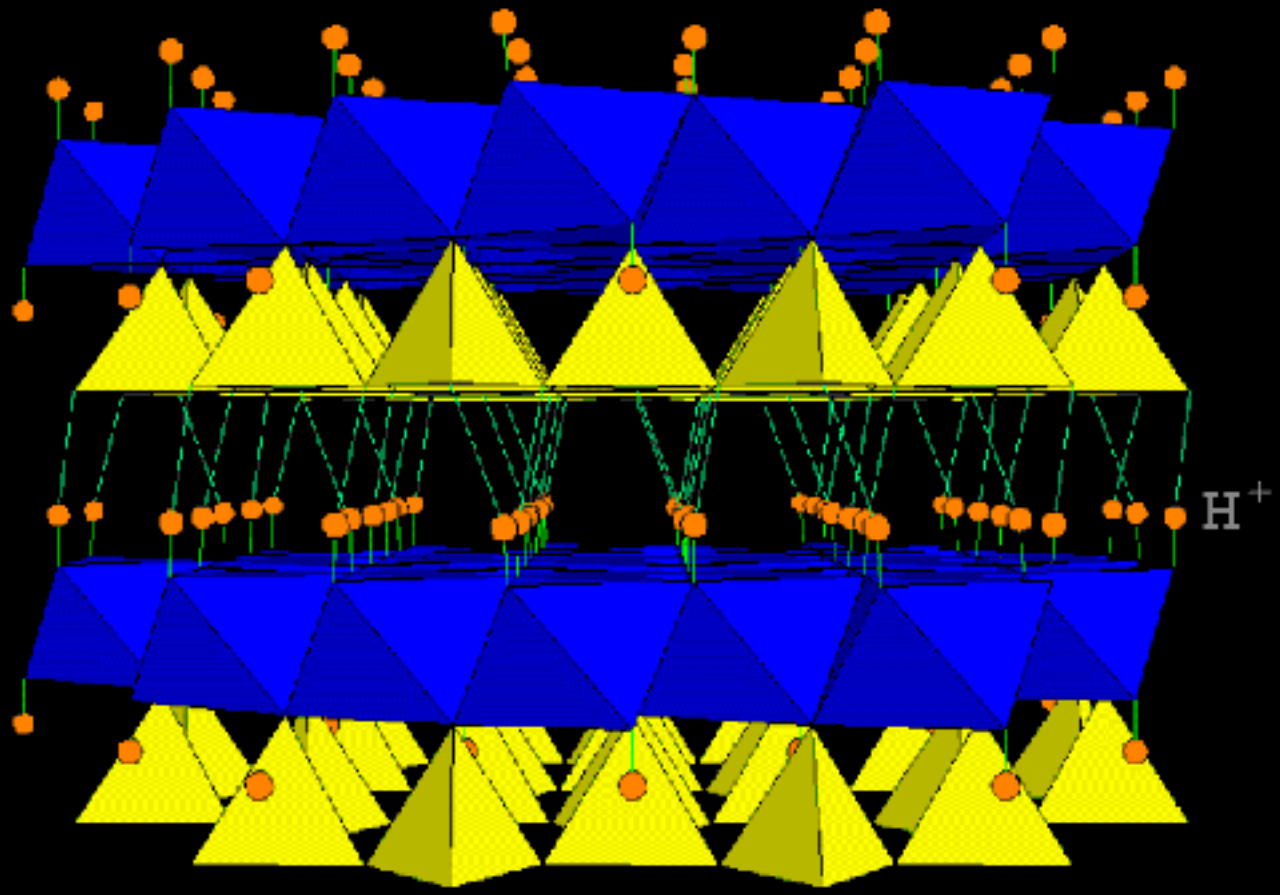
DOUBLE CHAIN SILICATE

viewed down the chains



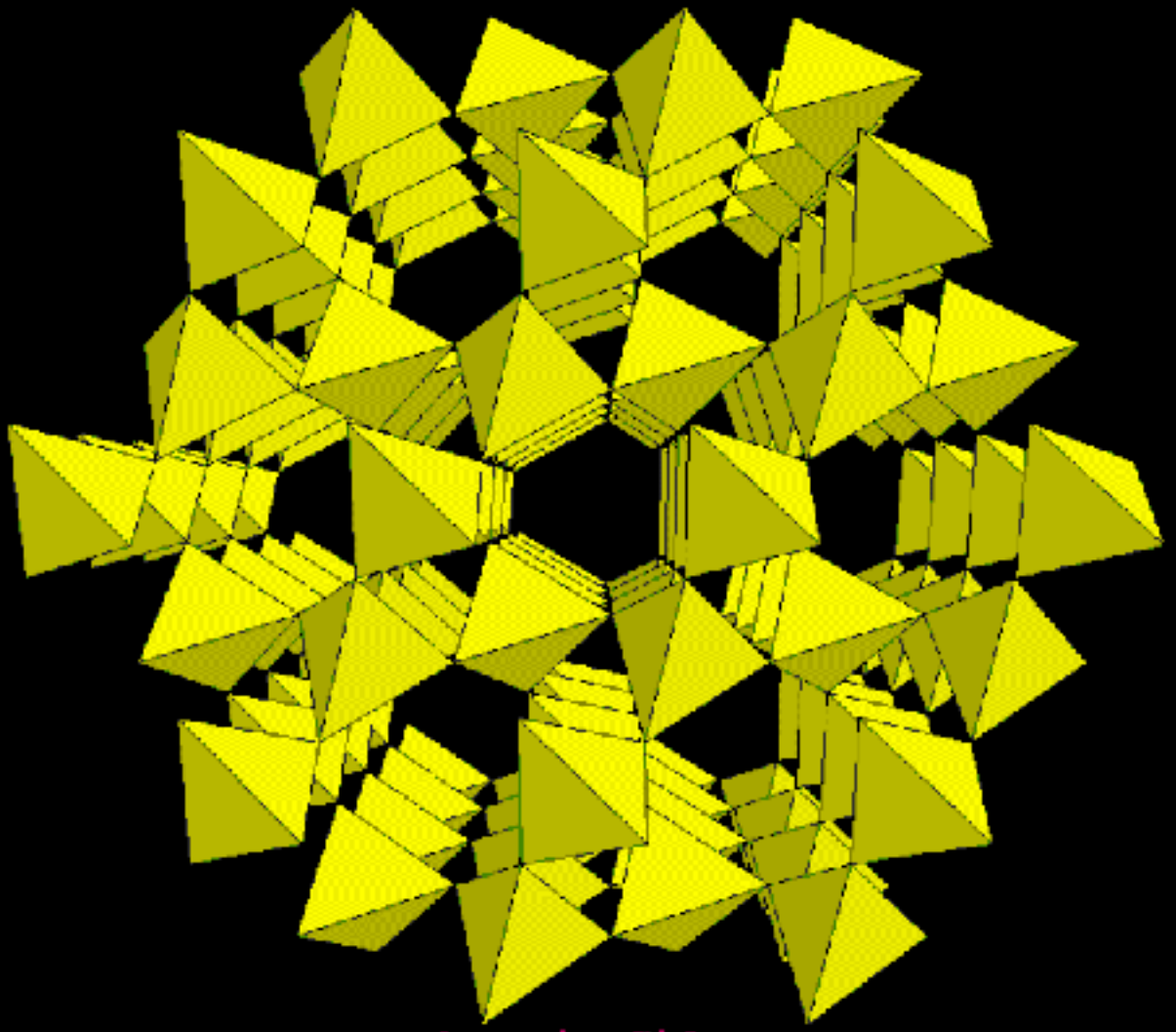
Tremolite, $Ca_2Mg_5(Si_8O_{22})(OH)_2$

SHEET SILICATE



Lizardite, $Mg_3(Si_2O_5)(OH)_4$

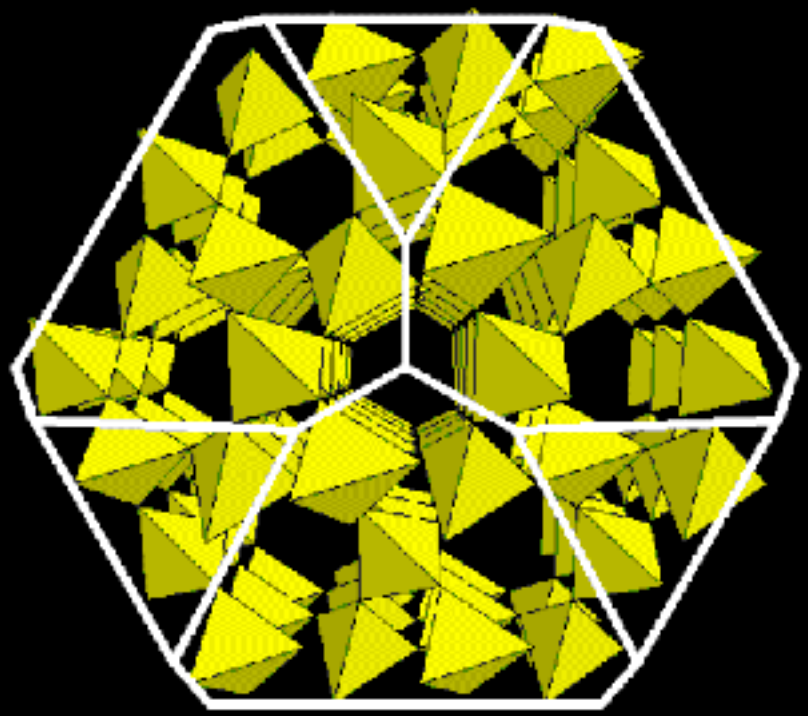
FRAMEWORK SILICATE



Quartz, SiO_2

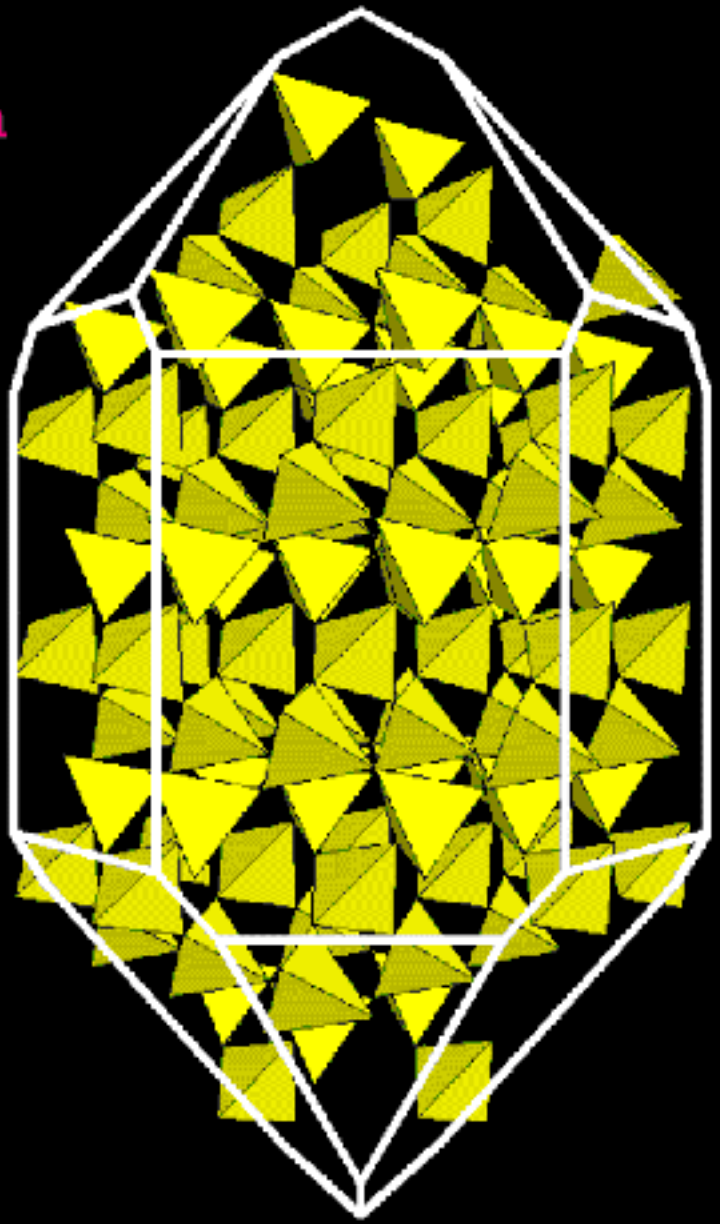
QUARTZ

showing outline of crystal shape
superimposed on atomic structure



QUARTZ

rotated 90° from
previous view



Corindone

Al_2O_3

Ematite

Fe_2O_3

Gruppo degli spinelli

$M^{II}M^{III}_2O_4$

$MgAl_2O_4$

$Fe^{II}Fe^{III}_2O_4$

$Fe^{II}Cr^{III}_2O_4$

Quarzo

SiO_2

Olivine

Mg_2SiO_4

Fe_2SiO_4

Pirosseni

$CaMgSi_2O_6$

$CaFeSi_2O_6$

$Mg_2Si_2O_6$

$Fe_2Si_2O_6$

Biotite

$KMg_3[AlSi_3O_{10}](OH)_2$

$KFe_3[AlSi_3O_{10}](OH)_2$

Feldspati

- potassici — $KAlSi_3O_8$
- Sodico-calcici — $NaAlSi_3O_8$, $CaAl_2Si_2O_8$

Le rocce sono aggregati naturali di uno o piu' minerali che costituiscono sulla terra masse geologicamente indipendenti e cartografabili.

Le rocce ignee si caratterizzano tramite:

- Composizione mineralogica/chimica
costituenti essenziali (definiscono la roccia)
costituenti accessori (sempre presenti in piccole quantita')
costituenti accidentali (talvolta presenti)
composizione chimica totale (per le rocce vulcaniche)

- Tessitura
rapporto cristalli/amorfo
grandezza dei cristalli
rapporti geometrici fra i costituenti

CLASSIFICAZIONE DELLE ROCCE:

ROCCE MAGMATICHE

ROCCE METAMORFICHE

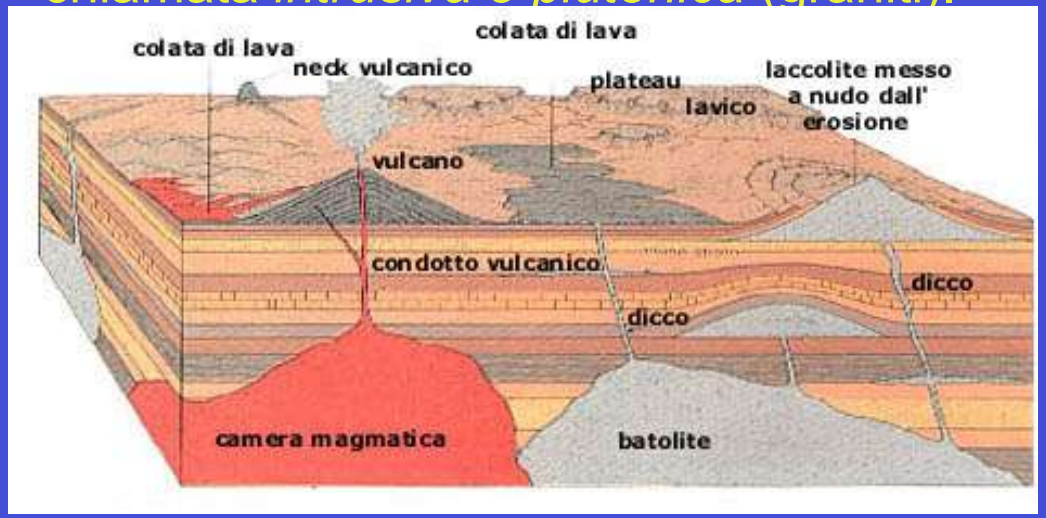
ROCCE SEDIMENTARIE

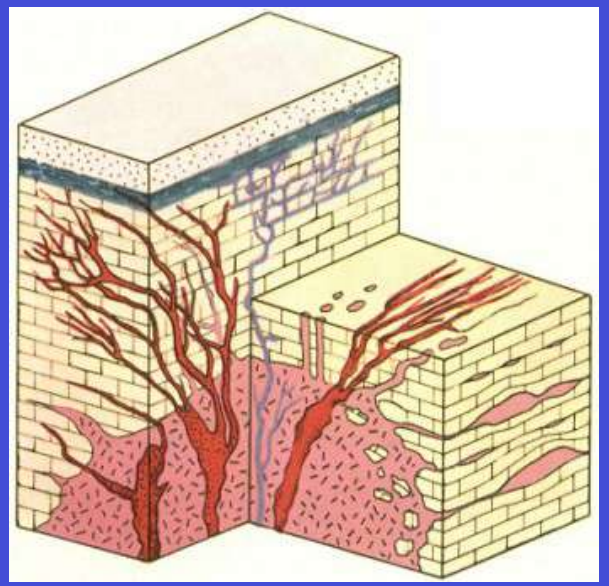
LE ROCCE MAGMATICHE

Le *rocce magmatiche* si formano dal raffreddamento di un magma.

-Se il magma viene emesso in superficie attraverso un apparato vulcanico, la roccia che si forma per raffreddamento viene detta *vulcanica* (basalto).

- Se invece una massa di magma raffredda in profondità, cioé non raggiunge la superficie terrestre, allora la roccia che si forma viene chiamata *intrusiva o plutonica* (graniti).





LE ROCCE VULCANICHE

DA DOVE VENGONO?

DALLE ERUZIONI EFFUSIVE

DALLE ERUZIONI ESPLOSIVE

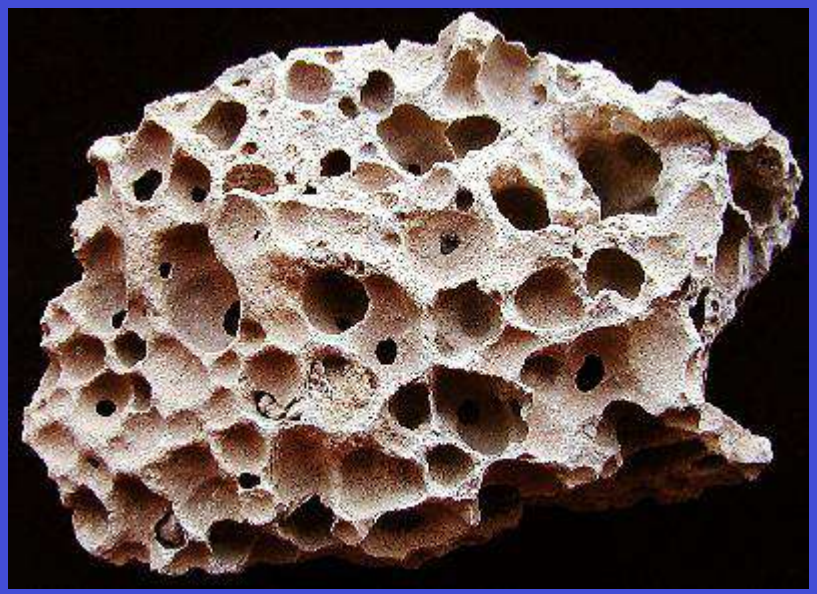
LE ROCCE VULCANICHE

Caratteristiche rocce vulcaniche:

Raffreddamento veloce,

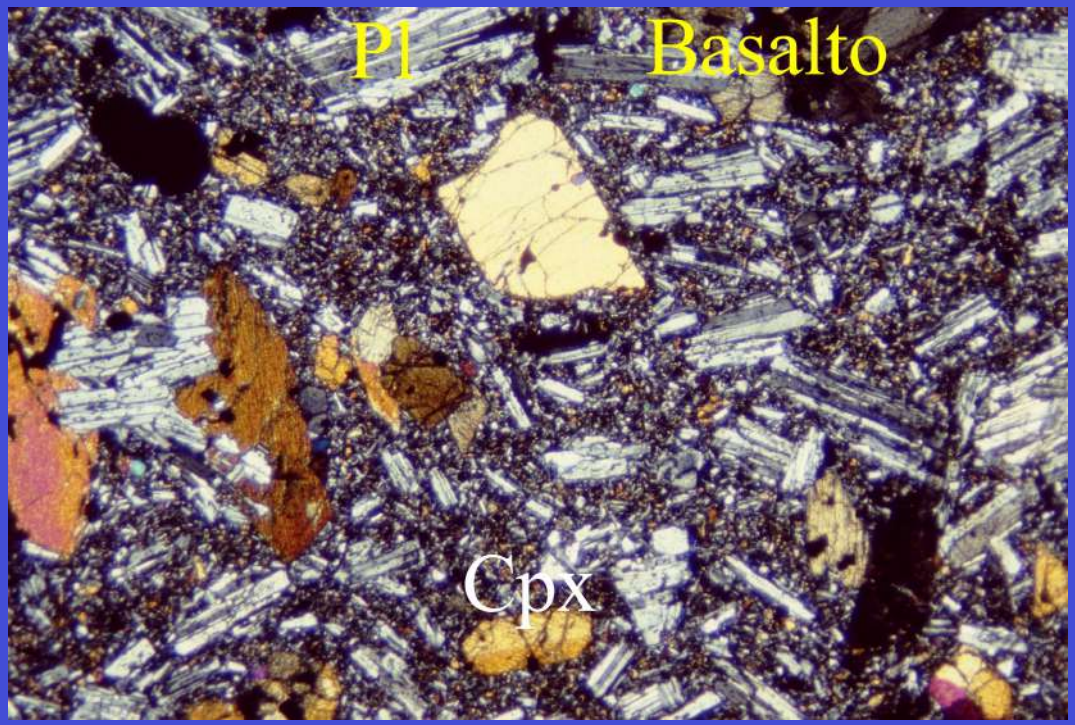
Si riconoscono per la tessitura *vetrosa* o *a grana fine*, (la tessitura è definita come l'insieme delle caratteristiche geometriche di una roccia, in genere visibili a scala microscopica),

Sono *vescicolate.*



LE ROCCE VULCANICHE

CHE MINERALI COSTITUISCONO QUESTE ROCCE?



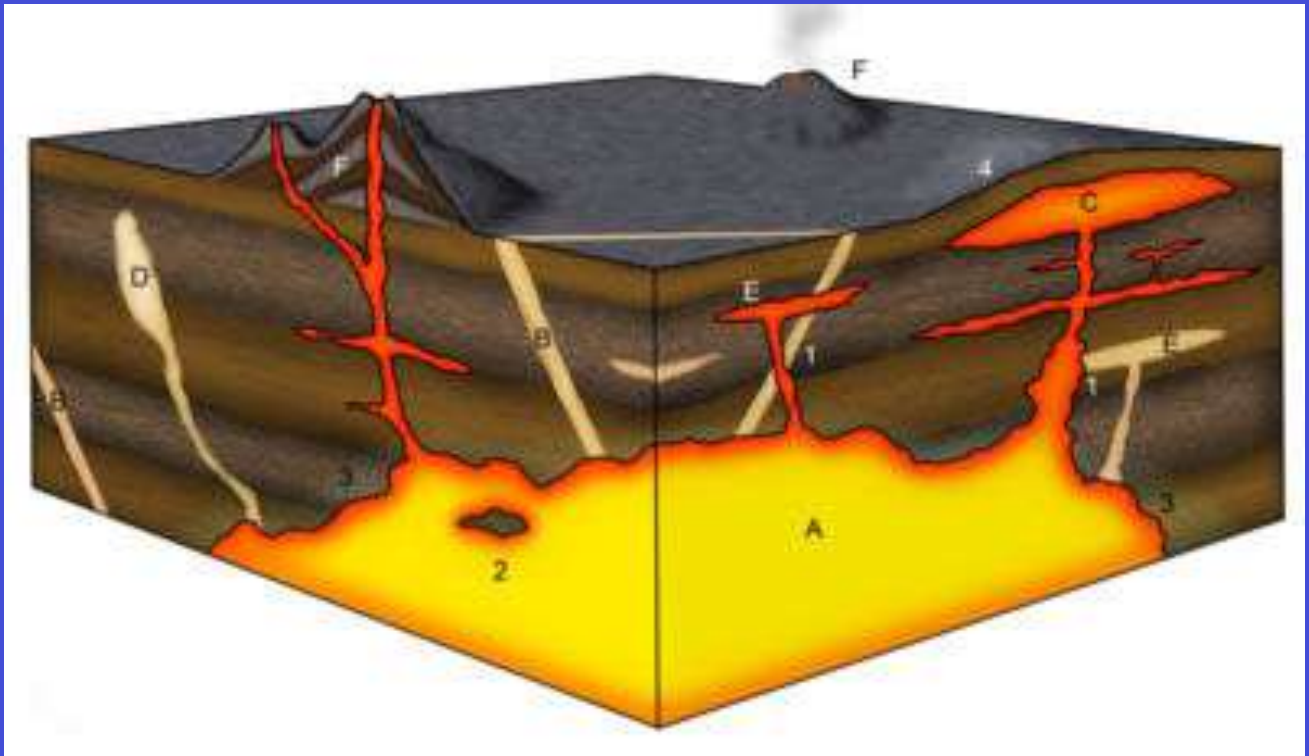
PLAGIOCLASI

OLIVINE

PIROSSENI

LE ROCCE PLUTONICHE

DA DOVE VENGONO?



DICCHI

BATOLITI

FILONI STRATO

PLUTONI

LE ROCCE PLUTONICHE

Caratteristiche rocce plutoniche:

Raffreddamento lento,

Si riconoscono per la tessitura *olocristallina*, (la tessitura è definita come l'insieme delle caratteristiche geometriche di una roccia, in genere visibili a scala microscopica),

LE ROCCE PLUTONICHE

CHE MINERALI COSTITUISCONO QUESTE ROCCE?

PLAGIOCLASI

ORTOCLASIO

QUARZO

BIOTITE

MINERALI ACCESSORI

LE ROCCE METAMORFICHE

Le *rocce metamorfiche* sono prodotte da trasformazioni mineralogiche e tessiturali di tutti i tipi di rocce allo stato solido.

Si formano sotto l'influenza di:

- Alte Temperature

- Alte Pressioni

- Alte Temperature e Alte Pressioni

LE ROCCE METAMORFICHE

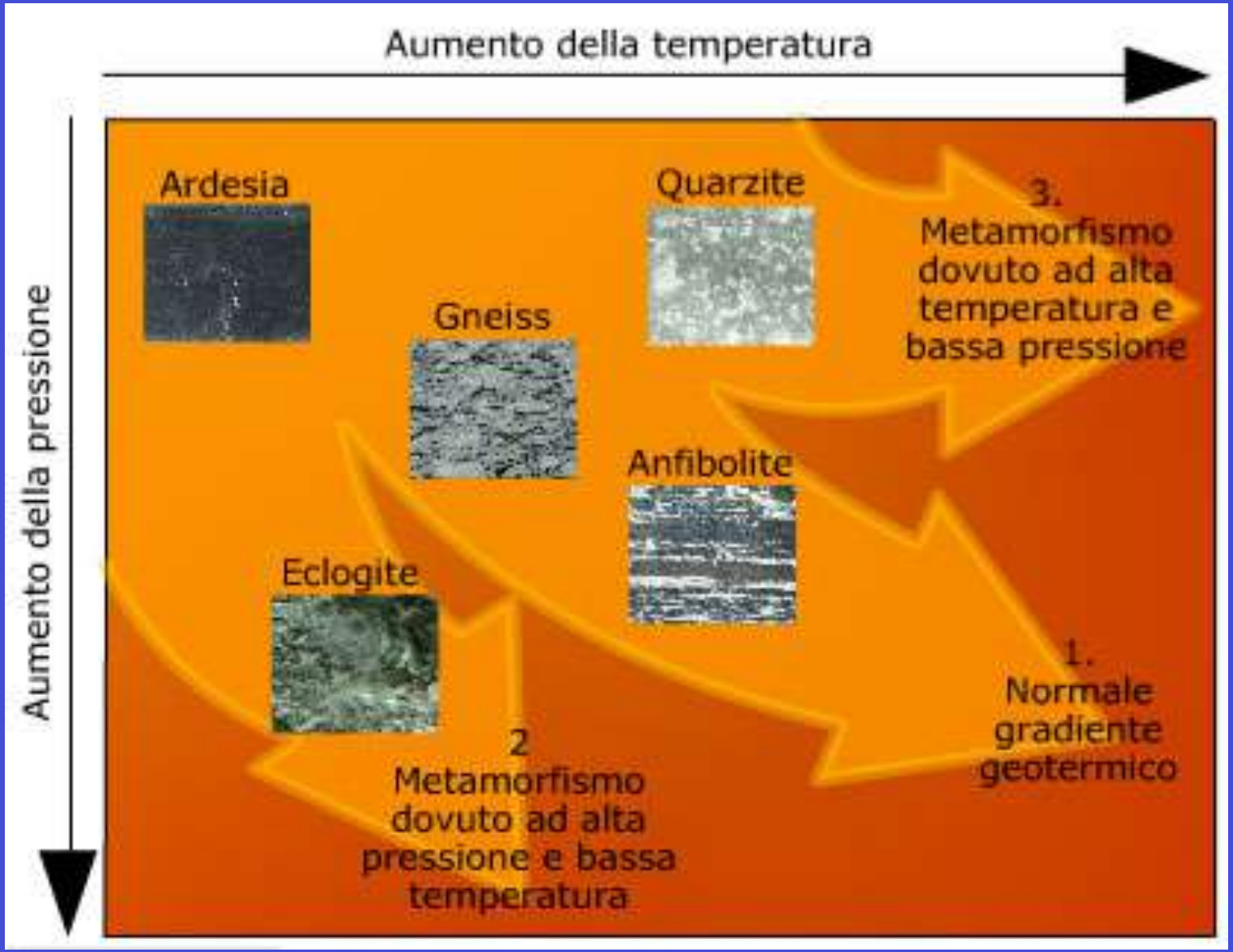
TIPI DI METAMORFISMO:

METAMORFISMO DI CONTATTO: consiste in un aumento di temperatura, per vicinanza di magmi caldi in via raffreddamento o che percorrono i camini vulcanici.

METAMORFISMO CATACLASTICO: si verifica a causa di un aumento della pressione, in corrispondenza di grandi fratture (faglie).

METAMORFISMO REGIONALE : si verifica per azione combinata di pressione e temperatura, in seguito ai movimenti della crosta terrestre che trasportano il materiale a profondità maggiori rispetto alla posizione originaria.

LE ROCCE METAMORFICHE



Classification of Igneous Rocks

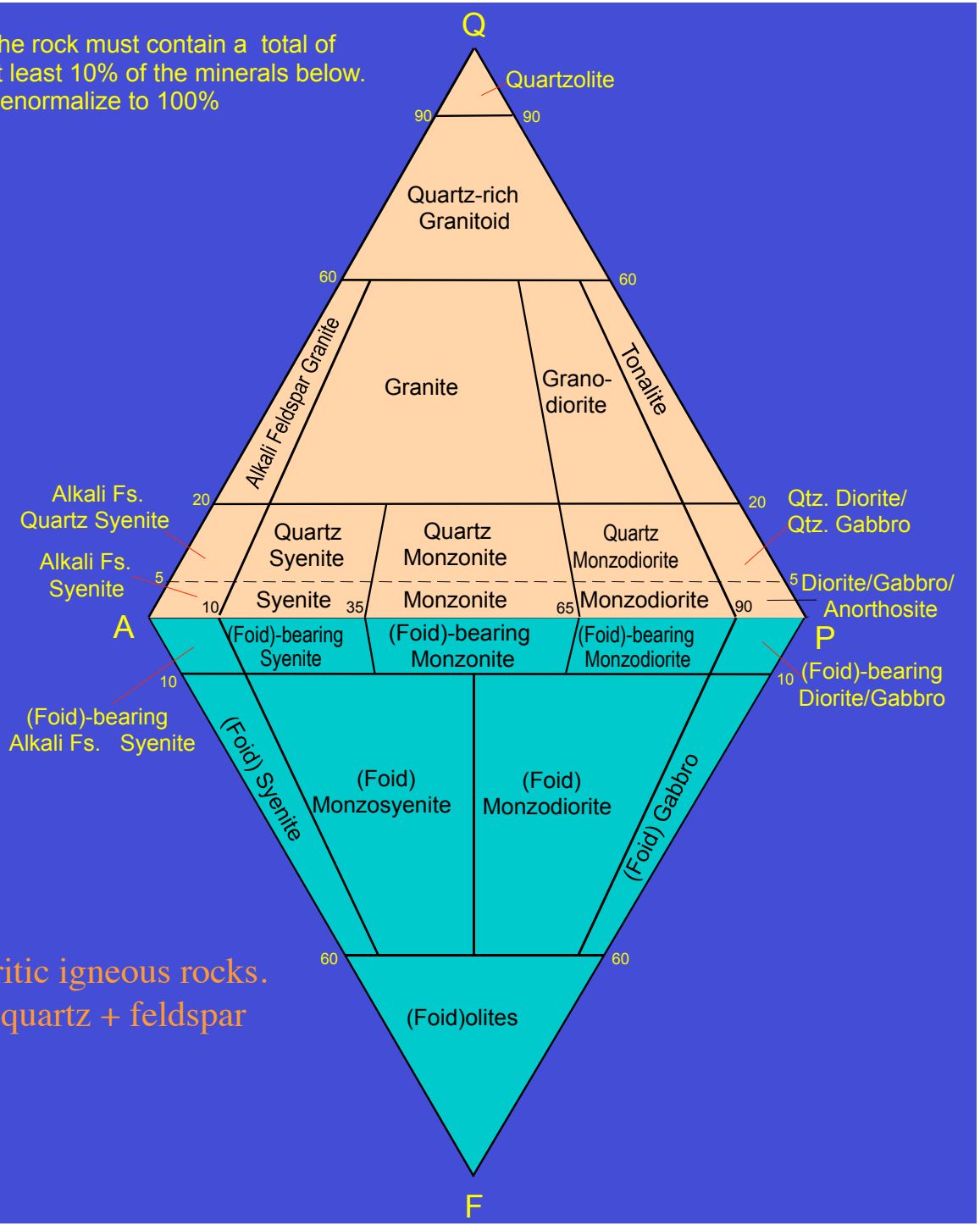


Figure 2-2. A classification of the phaneritic igneous rocks. **a.** Phaneritic rocks with more than 10% (quartz + feldspar + feldspathoids). After IUGS.

Classification of Igneous Rocks

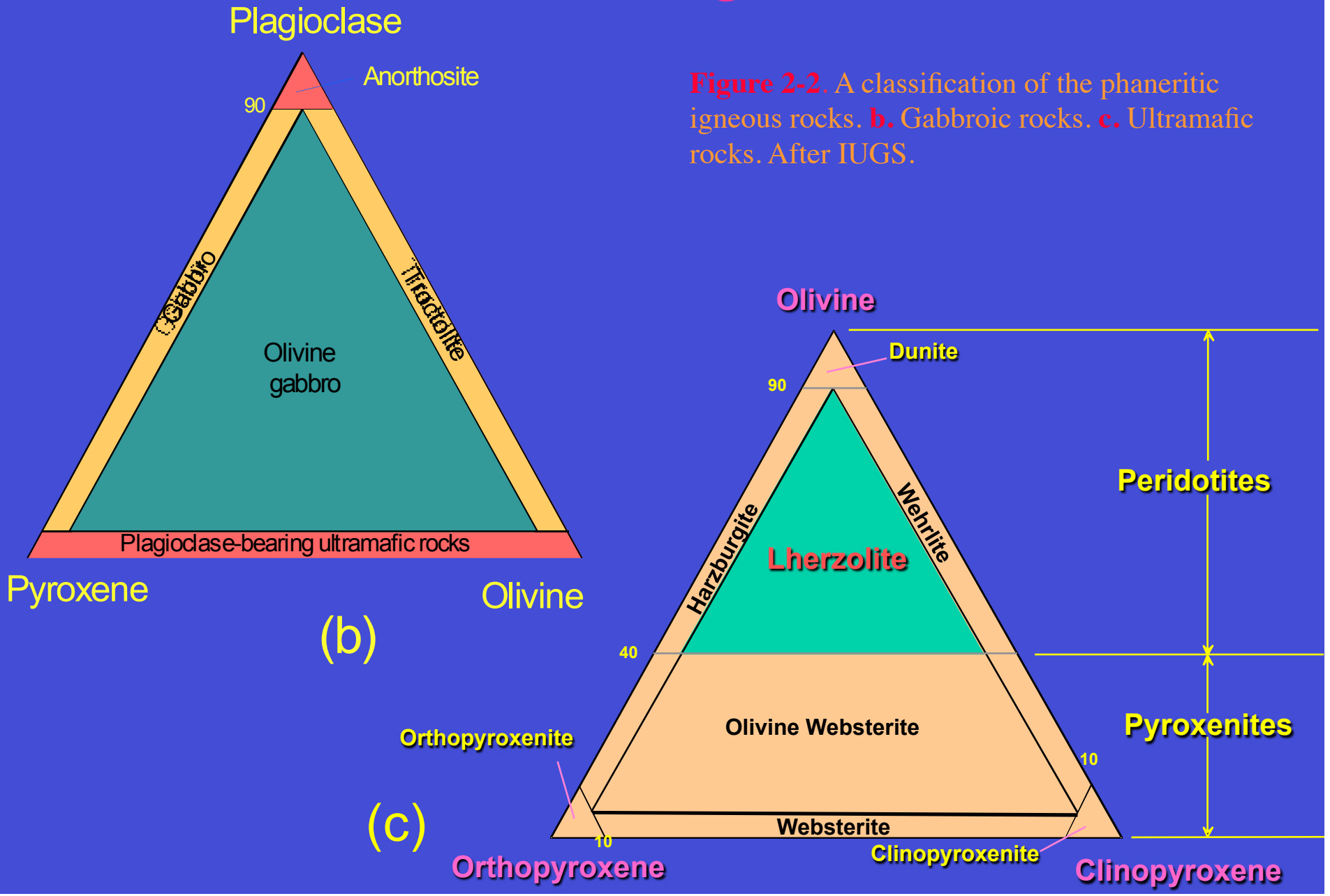


Figure 2-2. A classification of the phaneritic igneous rocks. **b.** Gabbroic rocks. **c.** Ultramafic rocks. After IUGS.

Classification of Igneous Rocks

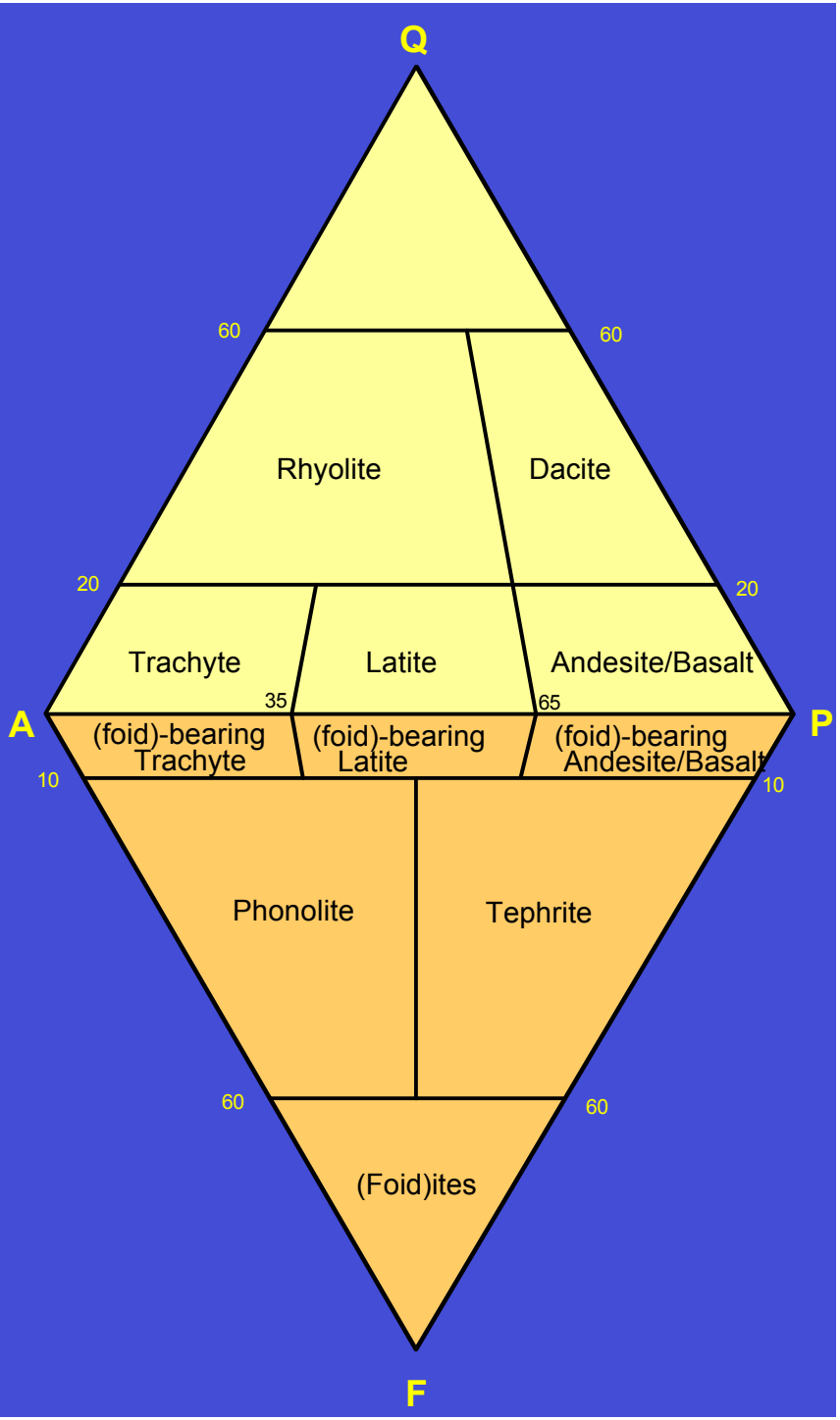


Figure 2-3. A classification and nomenclature of volcanic rocks. After IUGS.

Classification of Igneous Rocks

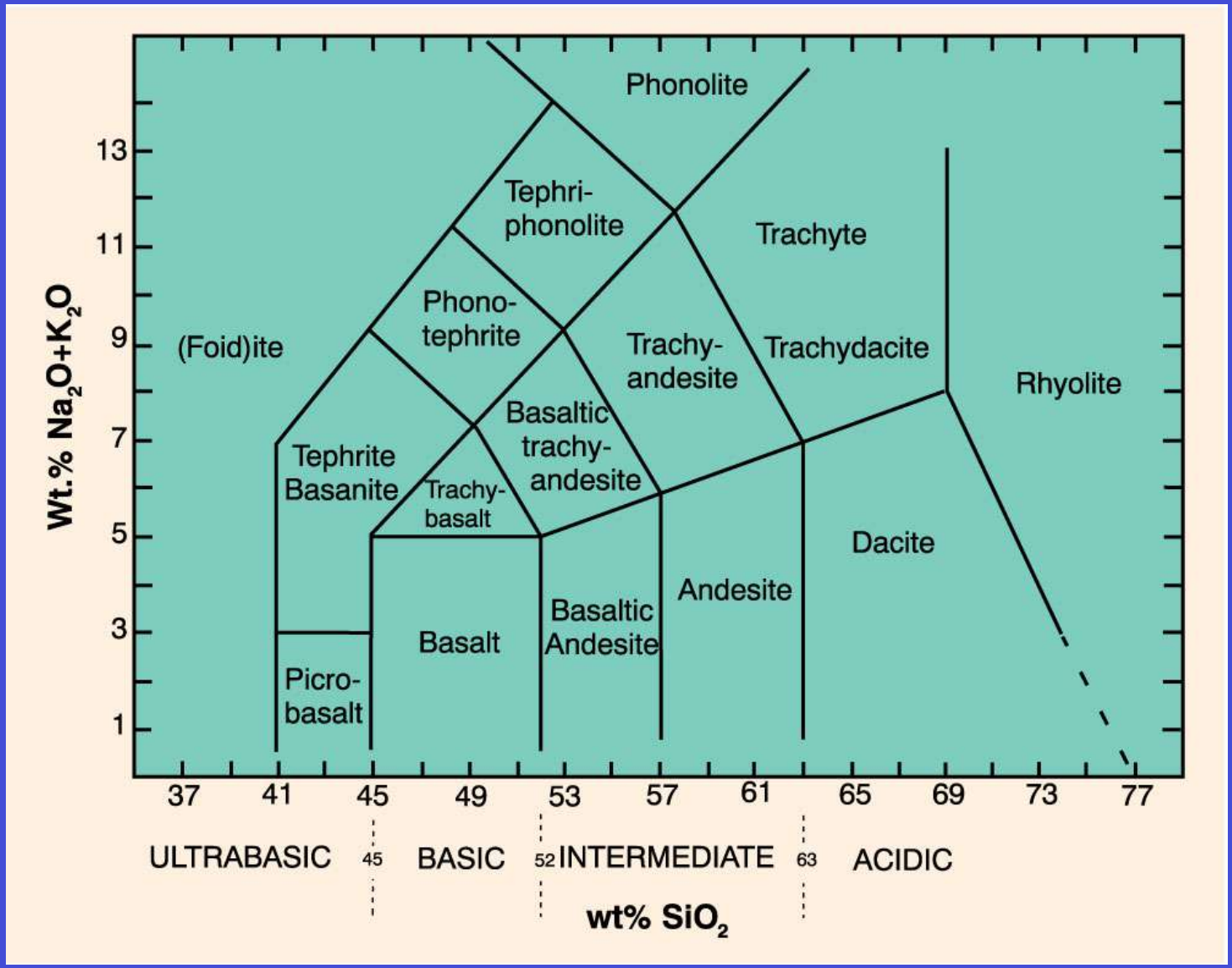


Figure 2-4. A chemical classification of volcanics based on total alkalis vs. silica. After Le Bas *et al*. (1986) J. Petrol., **27**, 745-750. Oxford University Press.

Classification of Igneous Rocks

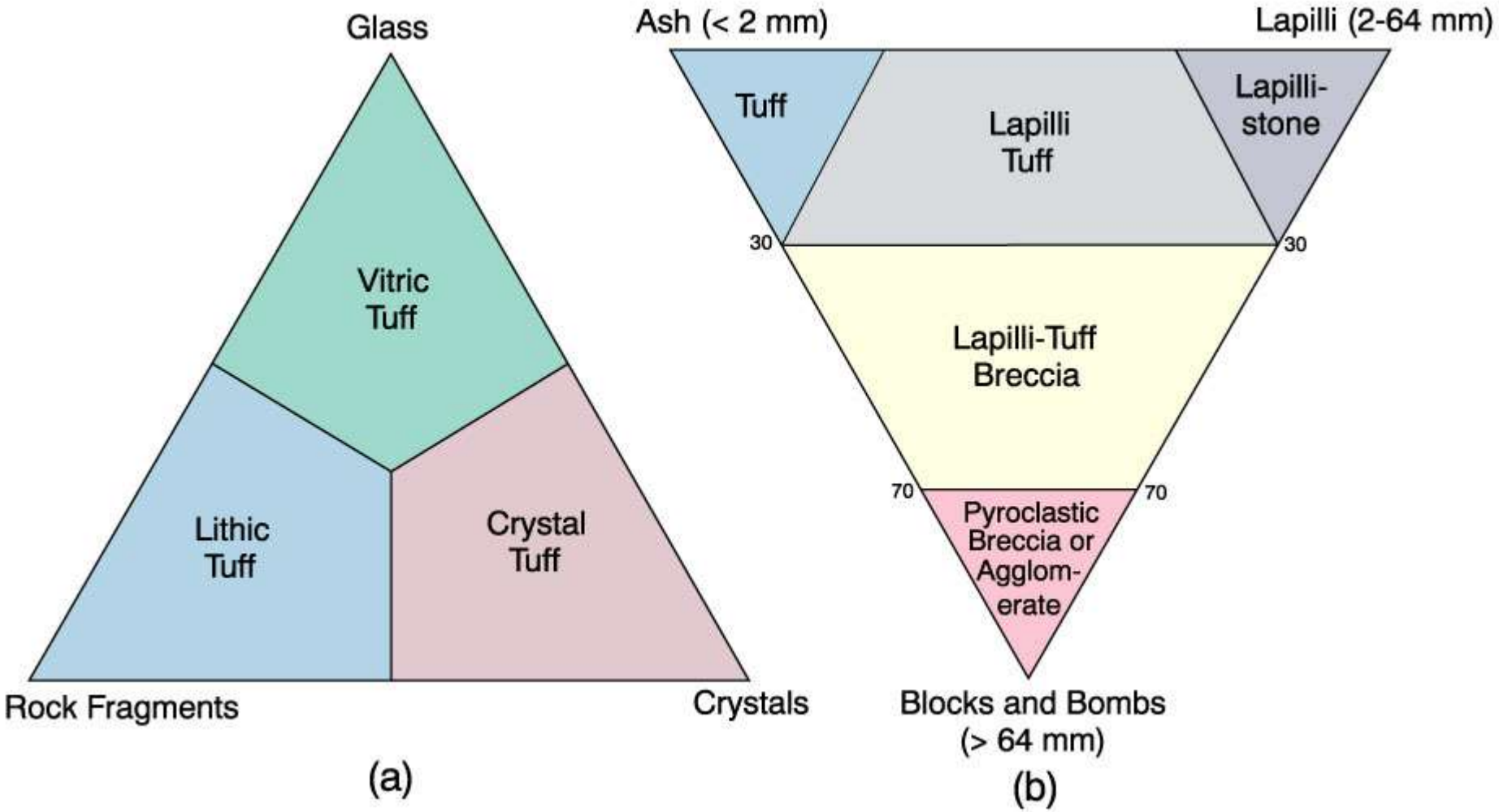
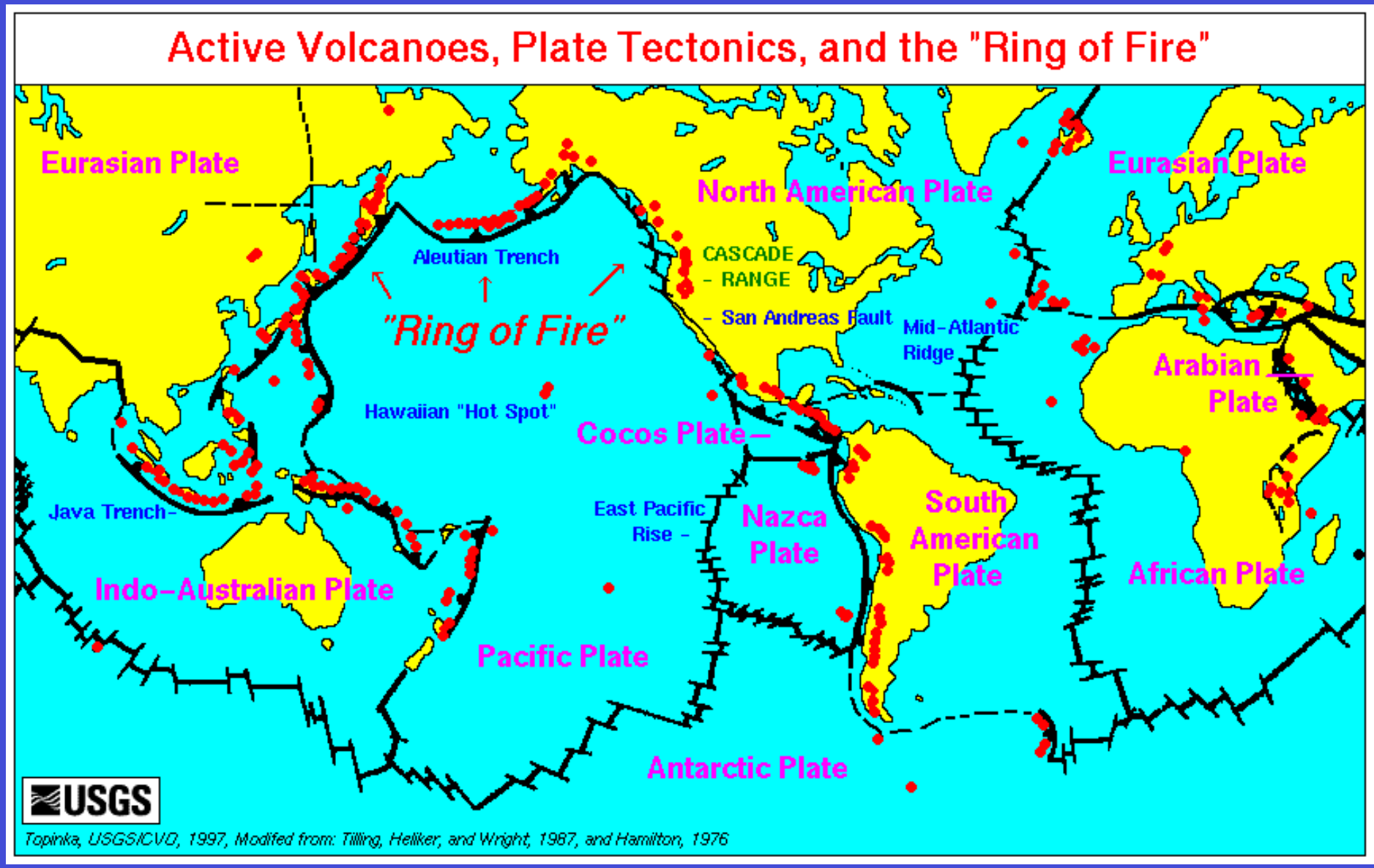
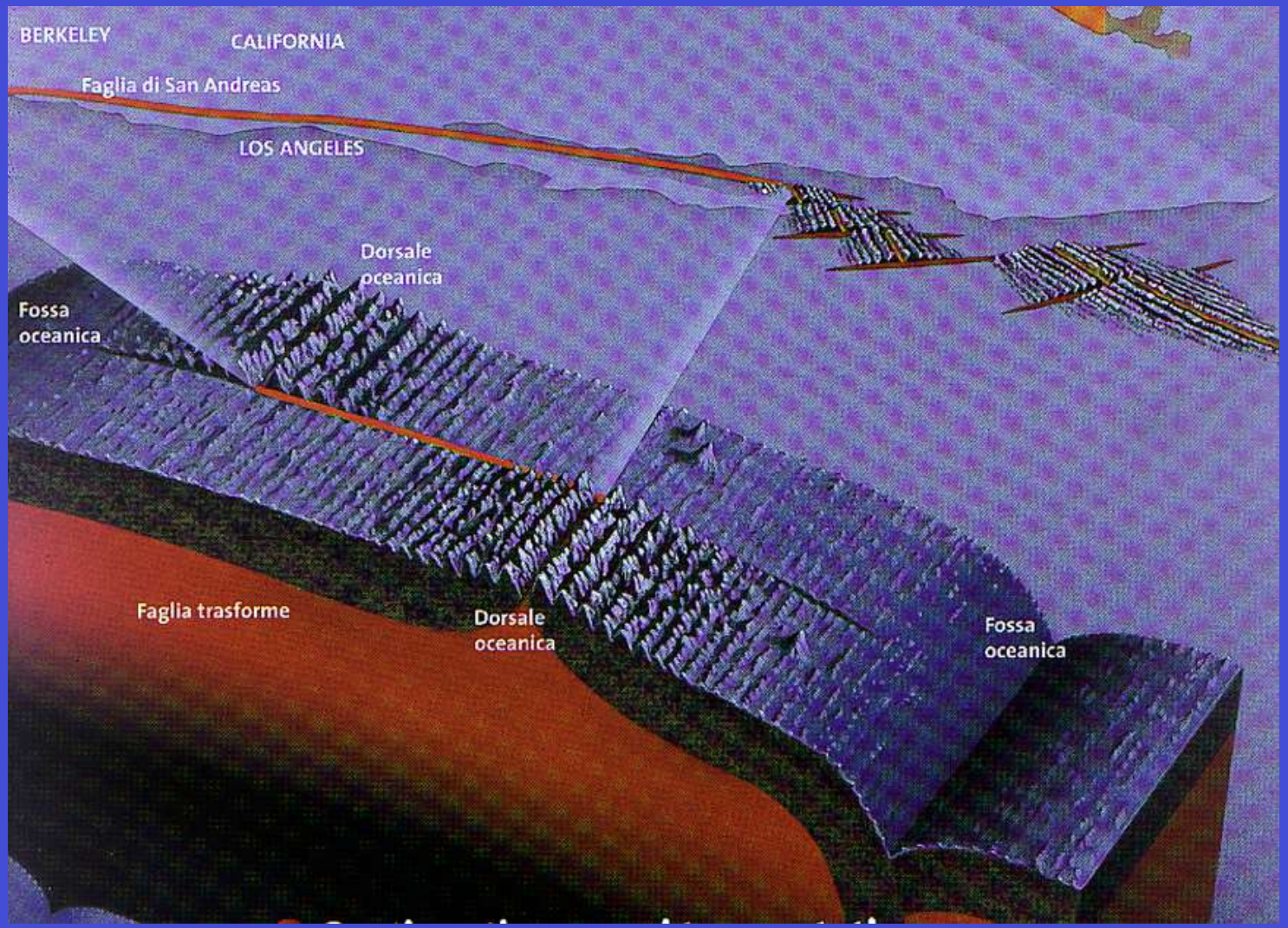


Figure 2-5. Classification of the pyroclastic rocks. **a.** Based on type of material. After Pettijohn (1975) *Sedimentary Rocks*, Harper & Row, and Schmid (1981) Geology, **9**, 40-43. **b.** Based on the size of the material. After Fisher (1966) Earth Sci. Rev., **1**, 287-298.

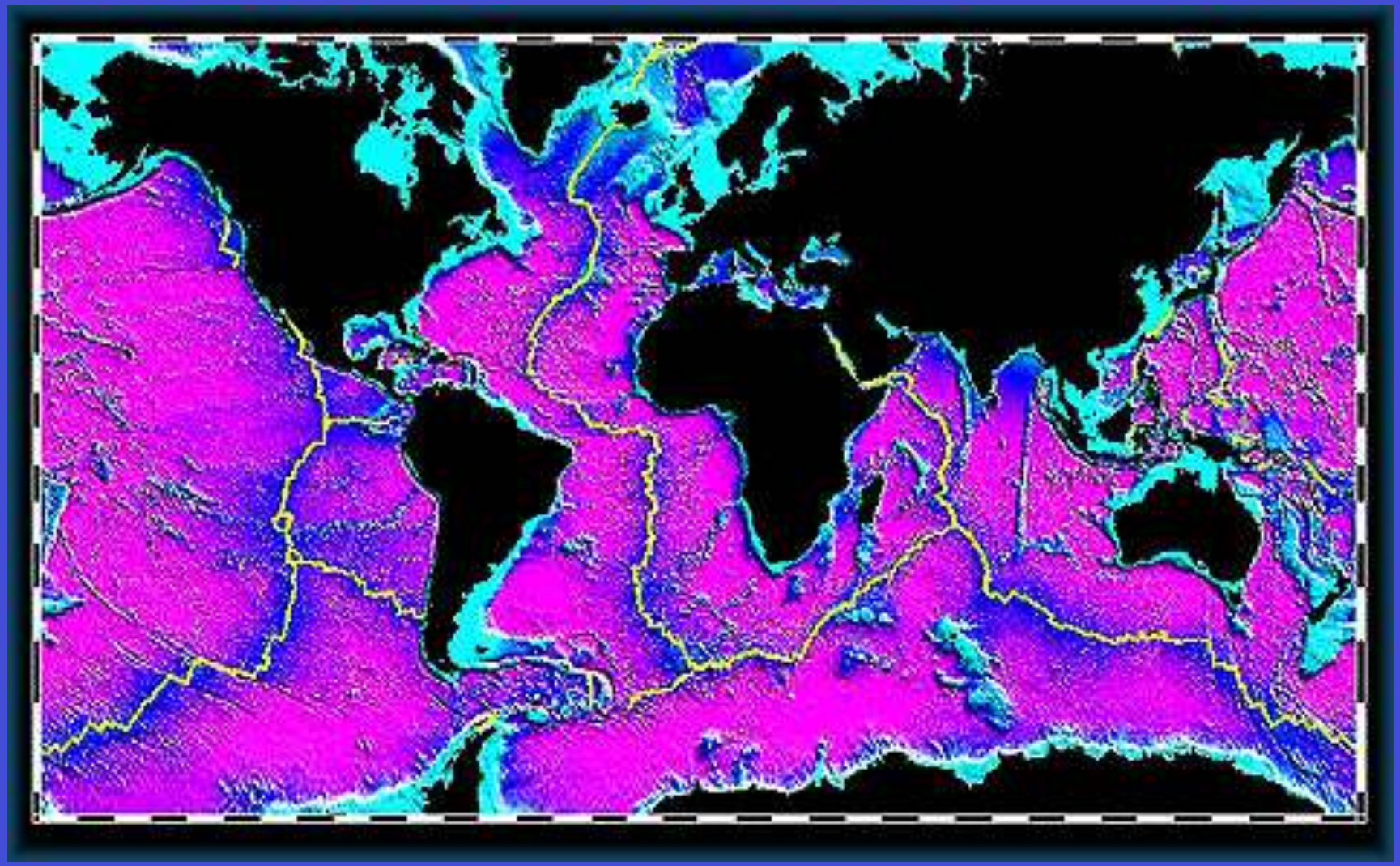
DISTRIBUZIONE DEL VULCANISMO SULLA SUPERFICIE TERRESTRE



Magmatismo di rift



Distribuzione delle dorsali medio oceaniche



Giallo= dorsale

La profondità cresce nella seq. celeste-blu-porpora

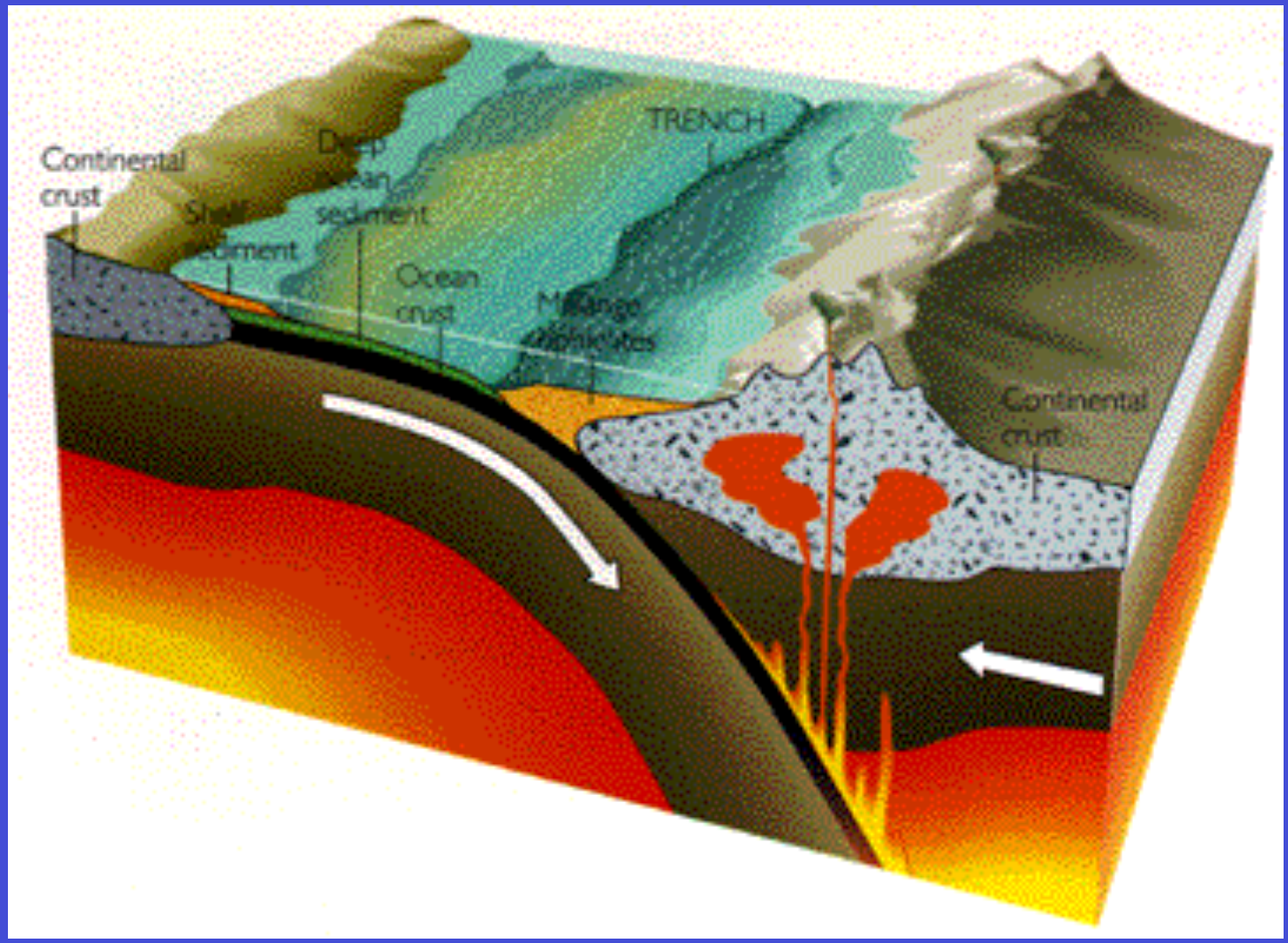
Lave a cuscino (pillow lavas)

Porzione meridionale del Juan de Fuca Ridge; http://oceanexplorer.noaa.gov/explorations/02fire/background/volcanism/media/newlava.html

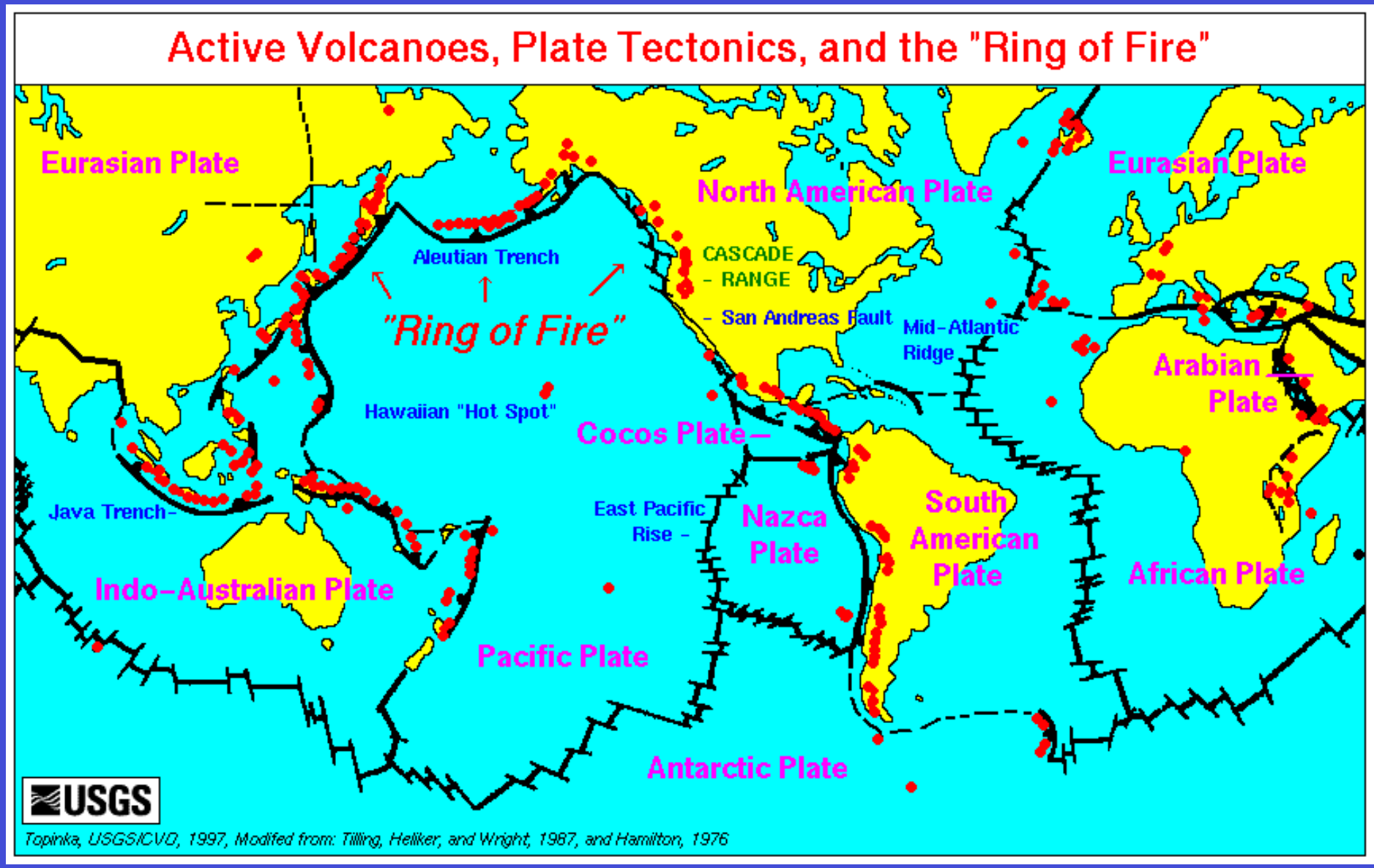
Pillow lavas (Isole Galapagos)

Attività idrotermale associata al magmatismo

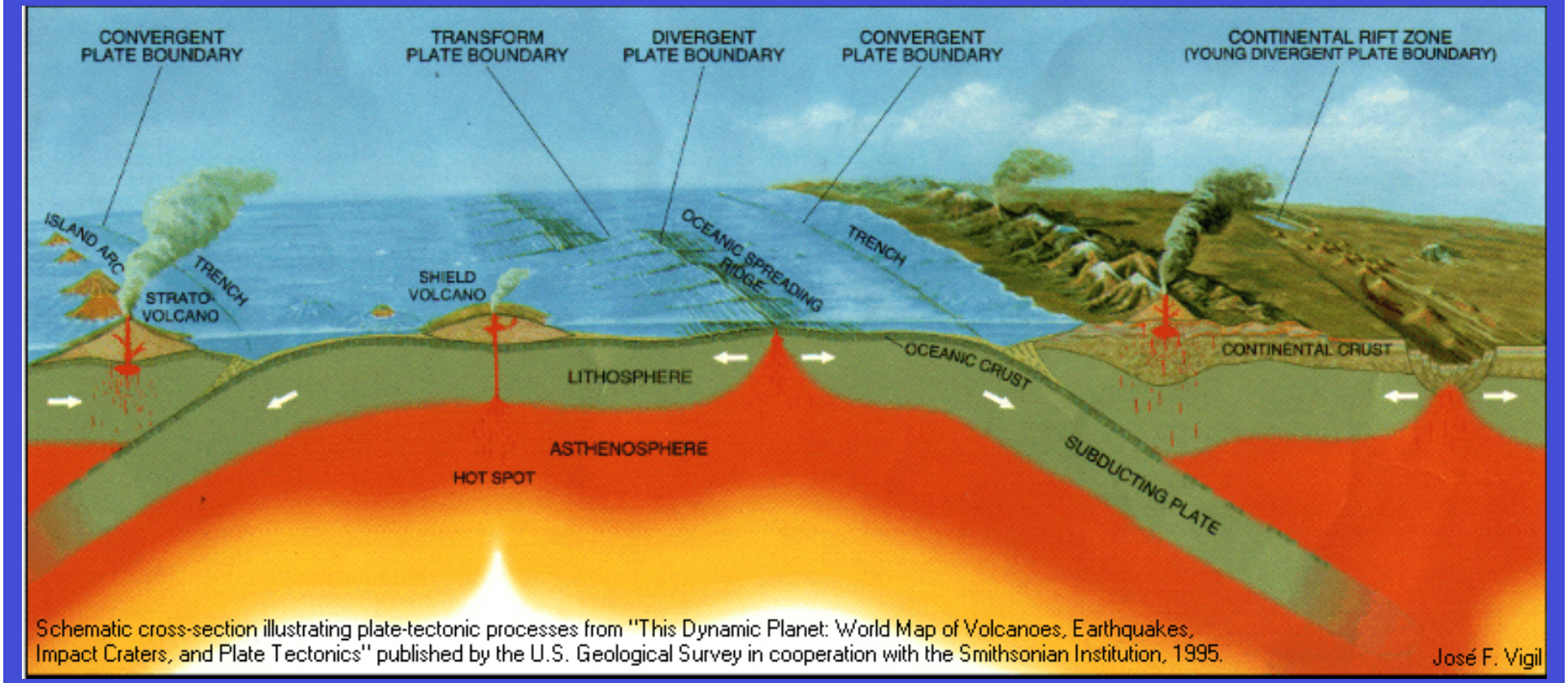
Magmatismo delle zone di convergenza



DISTRIBUZIONE DEL VULCANISMO SULLA SUPERFICIE TERRESTRE



STRUTTURA INTERNA DELLA TERRA ED AMBIENTI GEODINAMICI

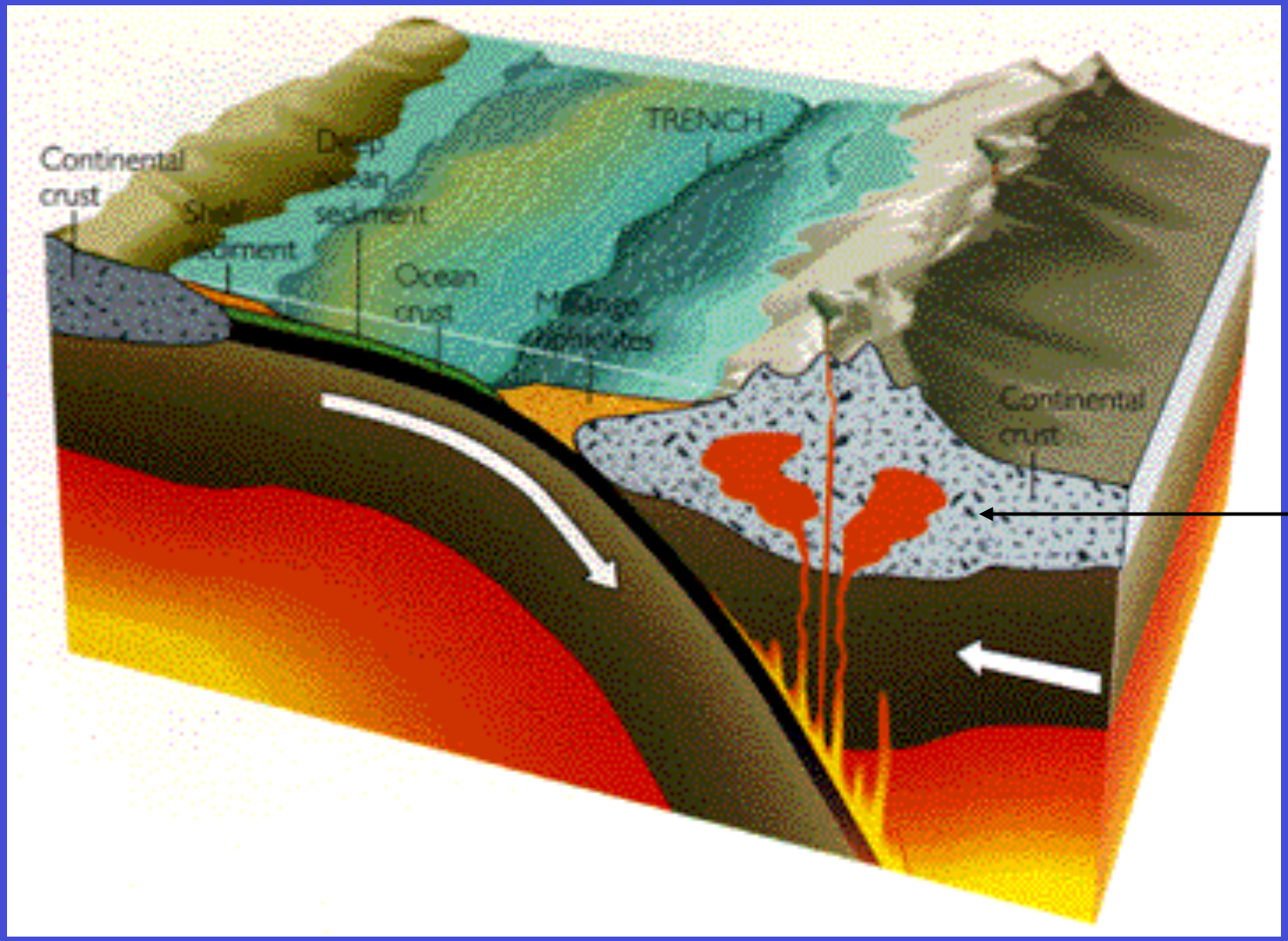


La distribuzione dei vulcani sulla superficie della terra non è casuale ma dipende dalla Tettonica delle Placche cioè da come le placche litosferiche si muovono le une rispetto alle altre. Da questo moto relativo, si originano diversi ambienti geodinamici e, ad ogni ambiente è correlato un vulcanismo con caratteristiche distinte.

-la placca subdotta si disidrata

-Il mantello sovrastante riceve acqua-> fonde parzialmente

-Il magma formato risale perché meno denso delle rocce circostanti



Formazione di crosta continentale

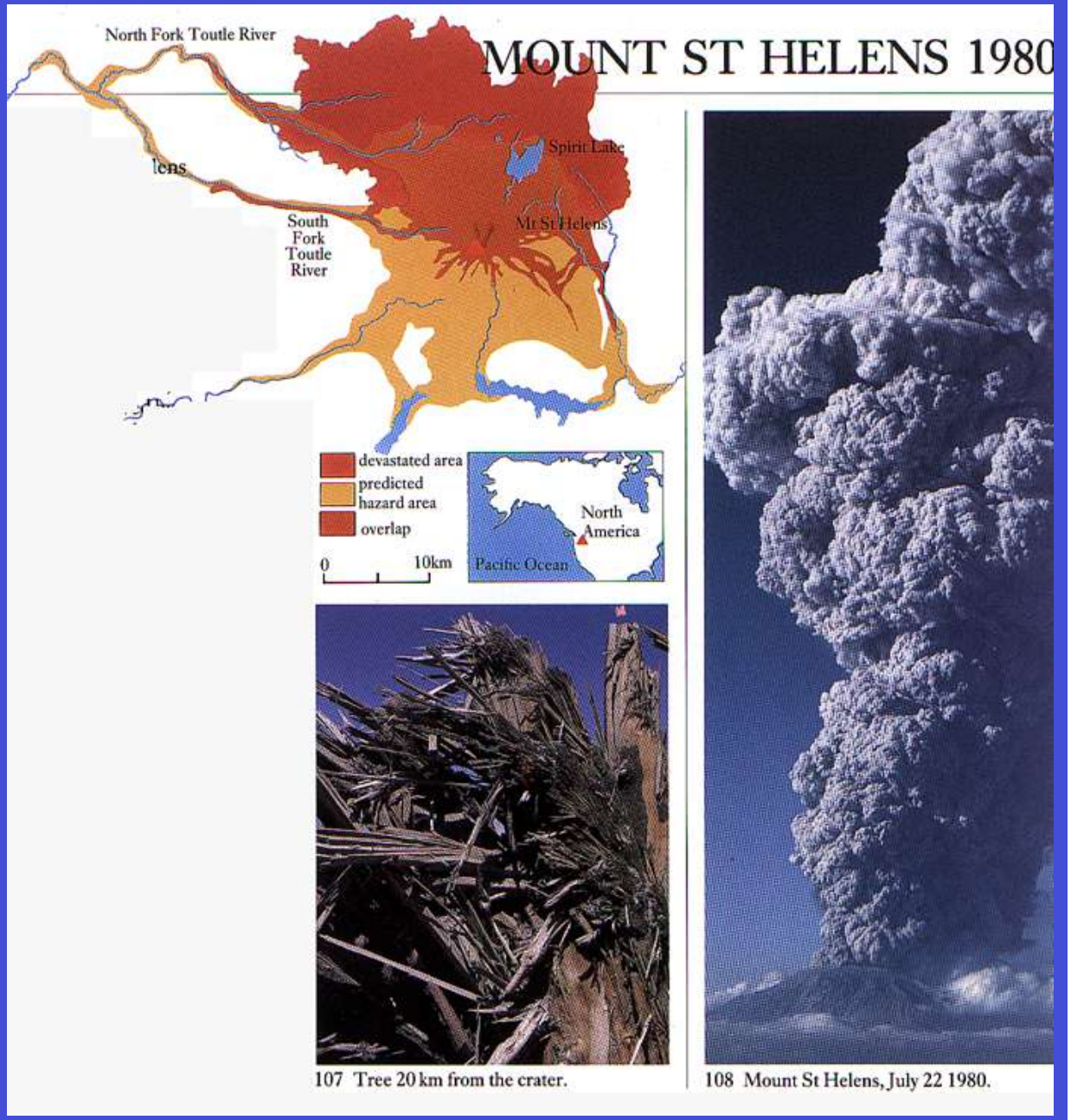
Arenal (Costa Rica)

Augustine (Alaska)

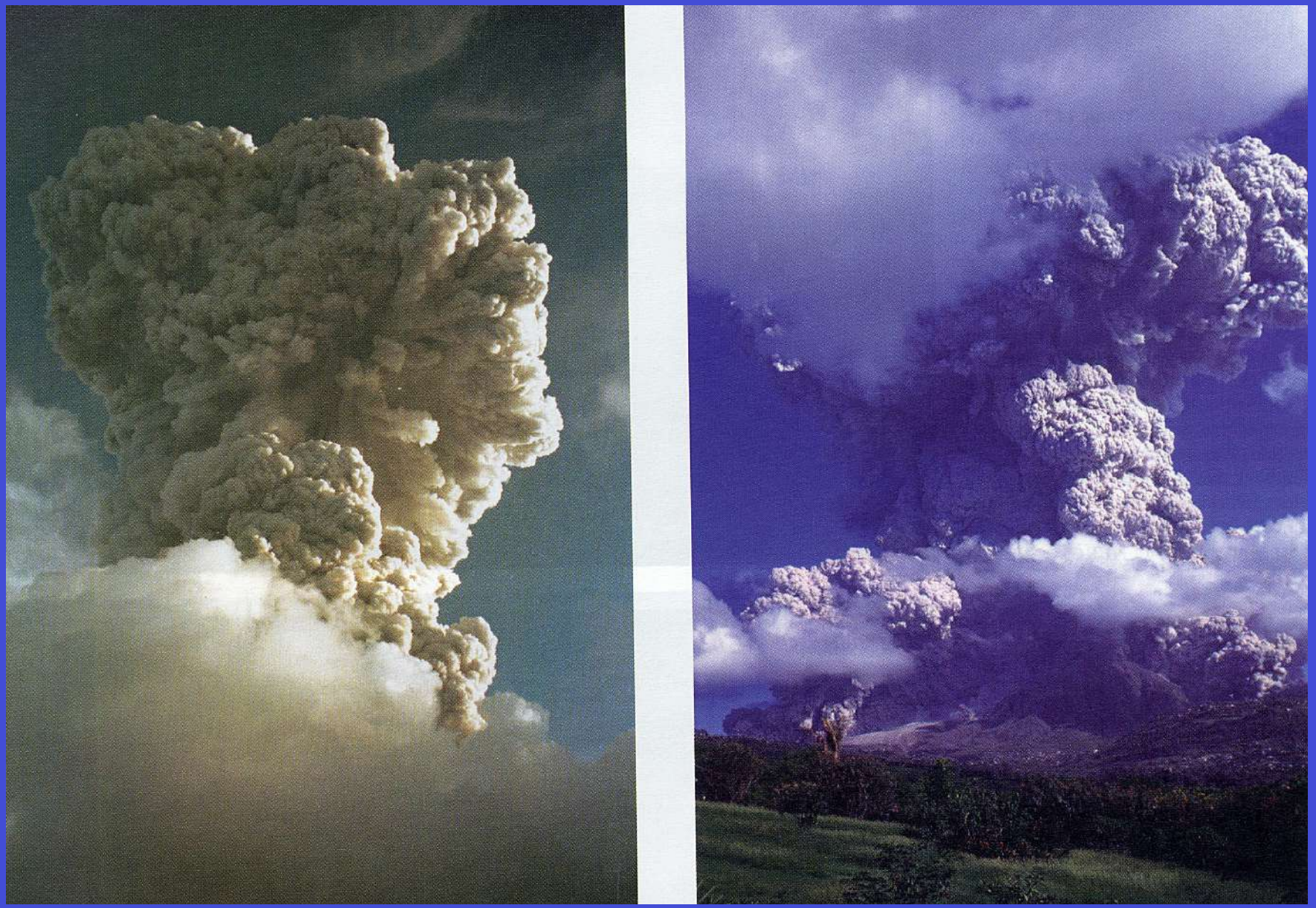
Fontana di lava (Parricutin)

Attività esplosiva (Cerro Negro- Nicaragua)

Eruzione del monte St. Helens, 1980

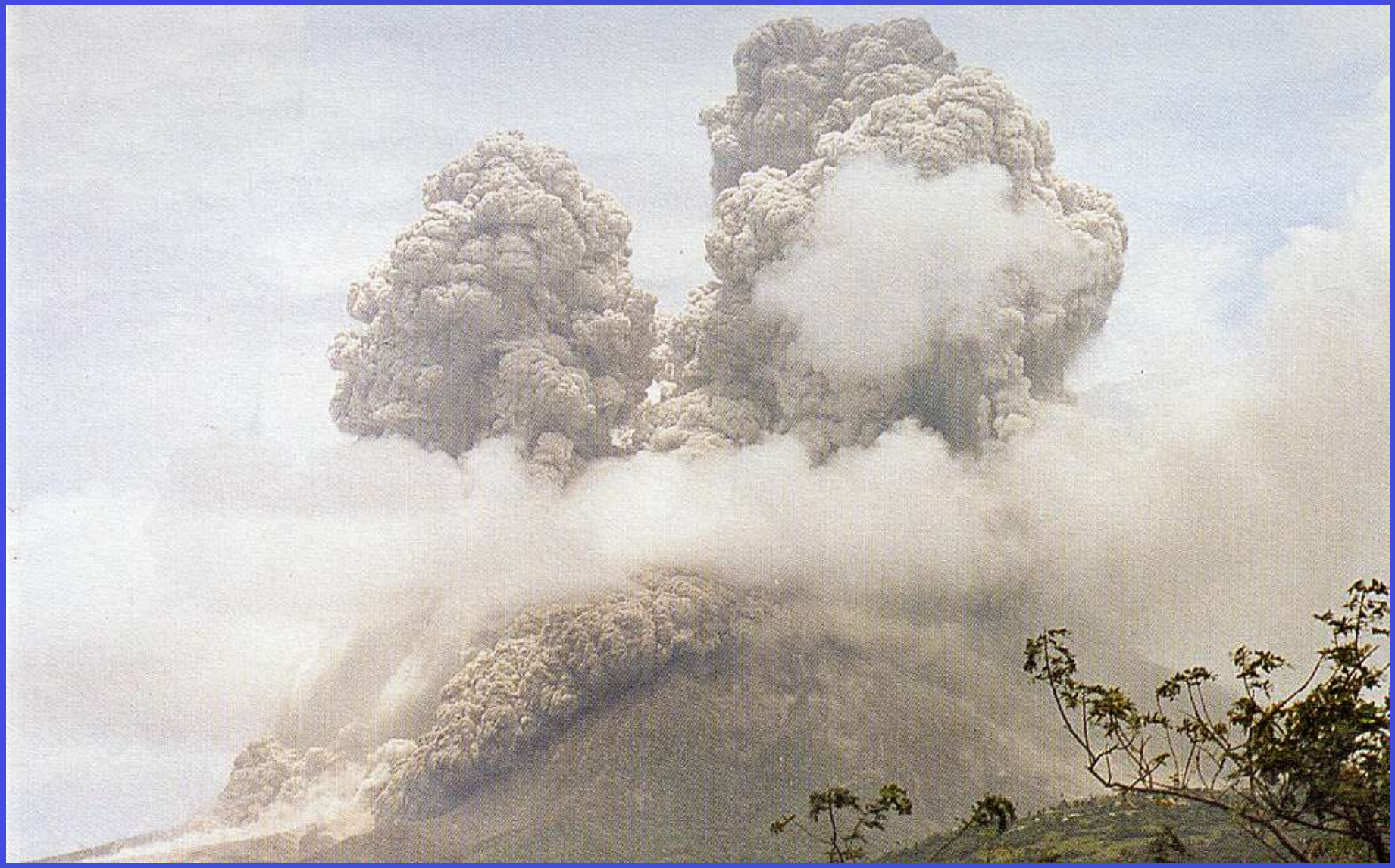


Montserrat (Caraibi) 1995-1999



Colonne di cenere

Flusso piroclastico



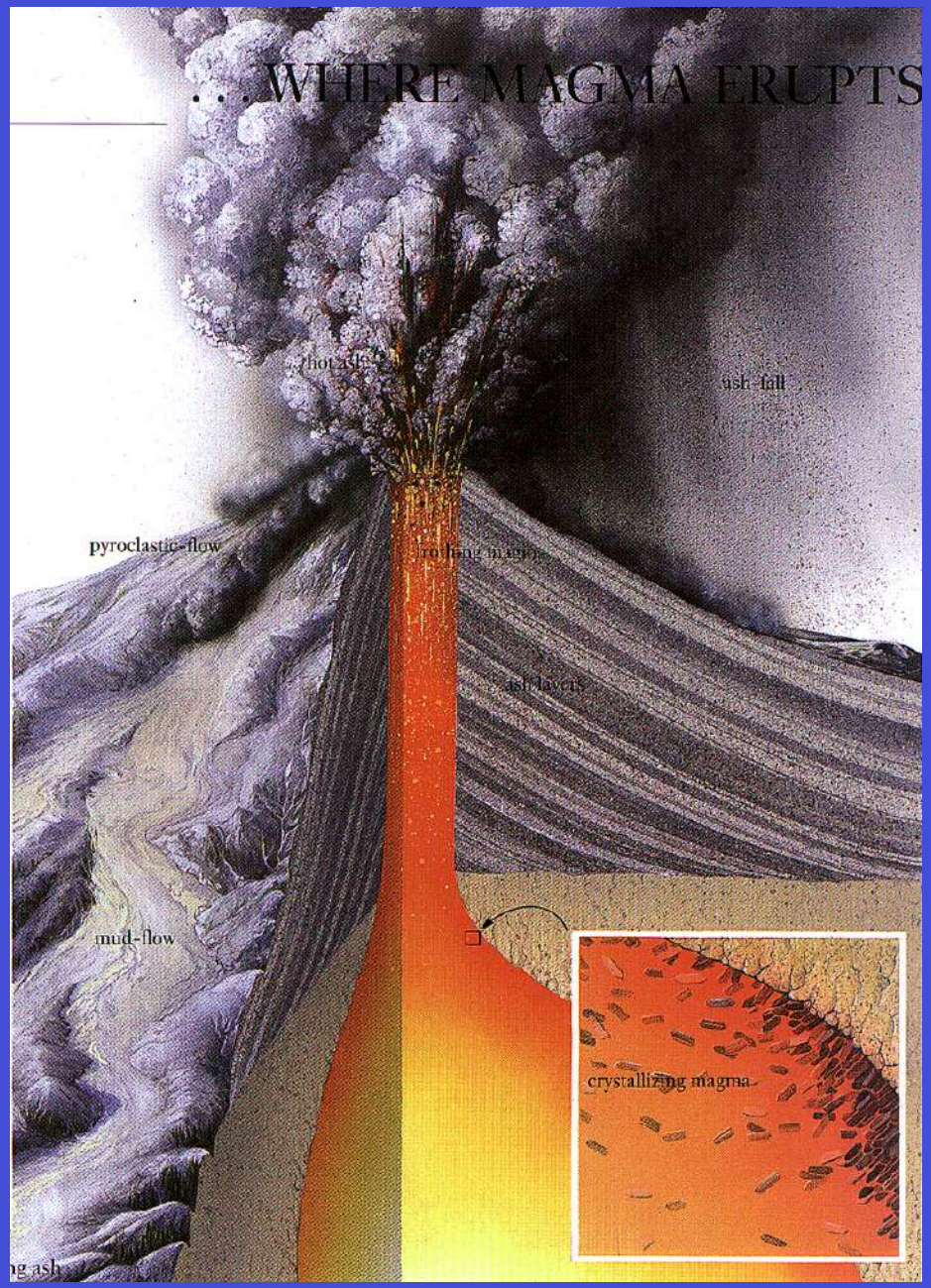
Colonna di fumo e flusso piroclastico

Effetto della caduta di cenere e delle colate di fango

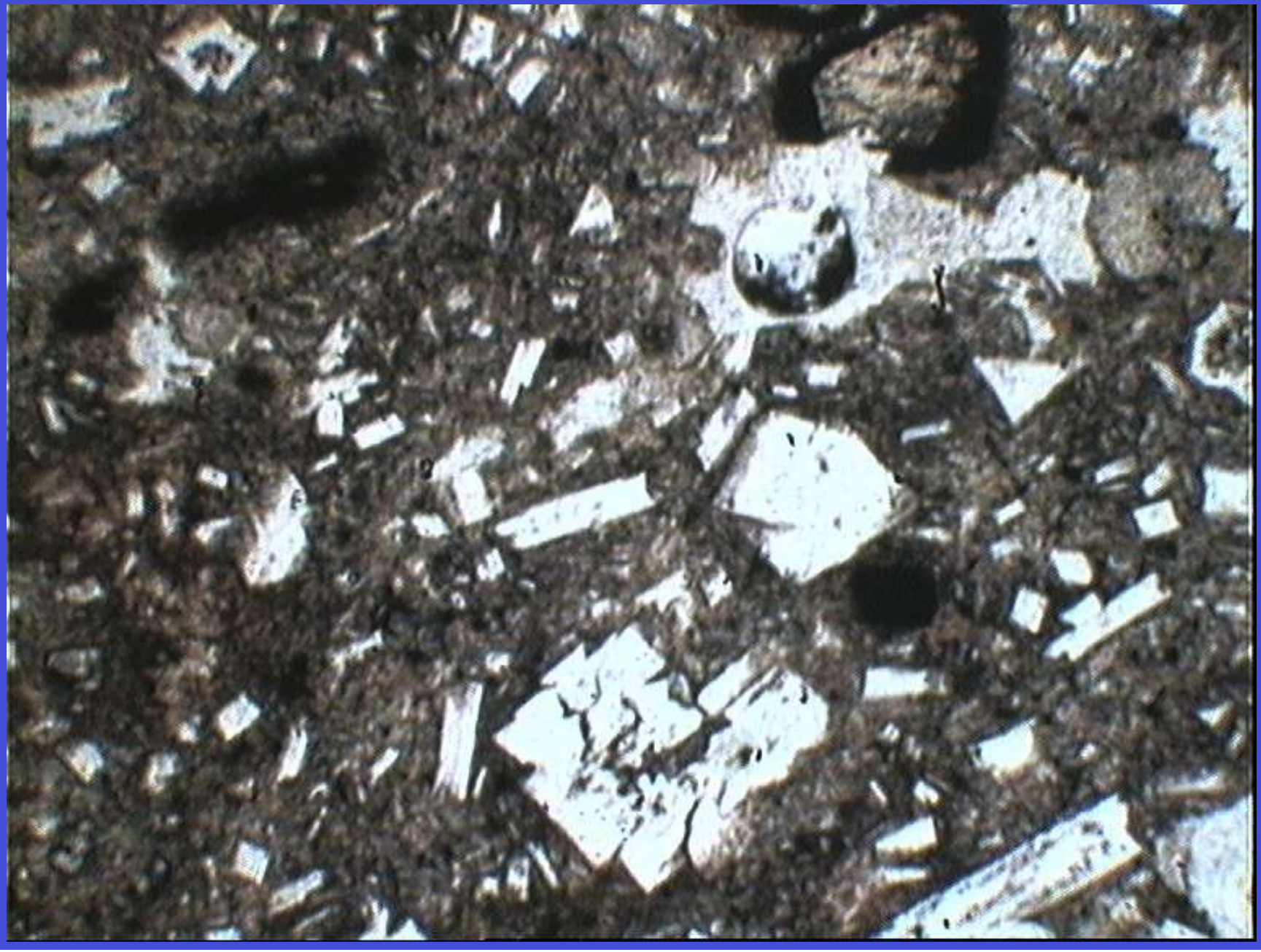
Dinamica di un eruzione

Parametri che determinano il tipo di eruzione:

- viscosità del magma
- Contenuto in volatili

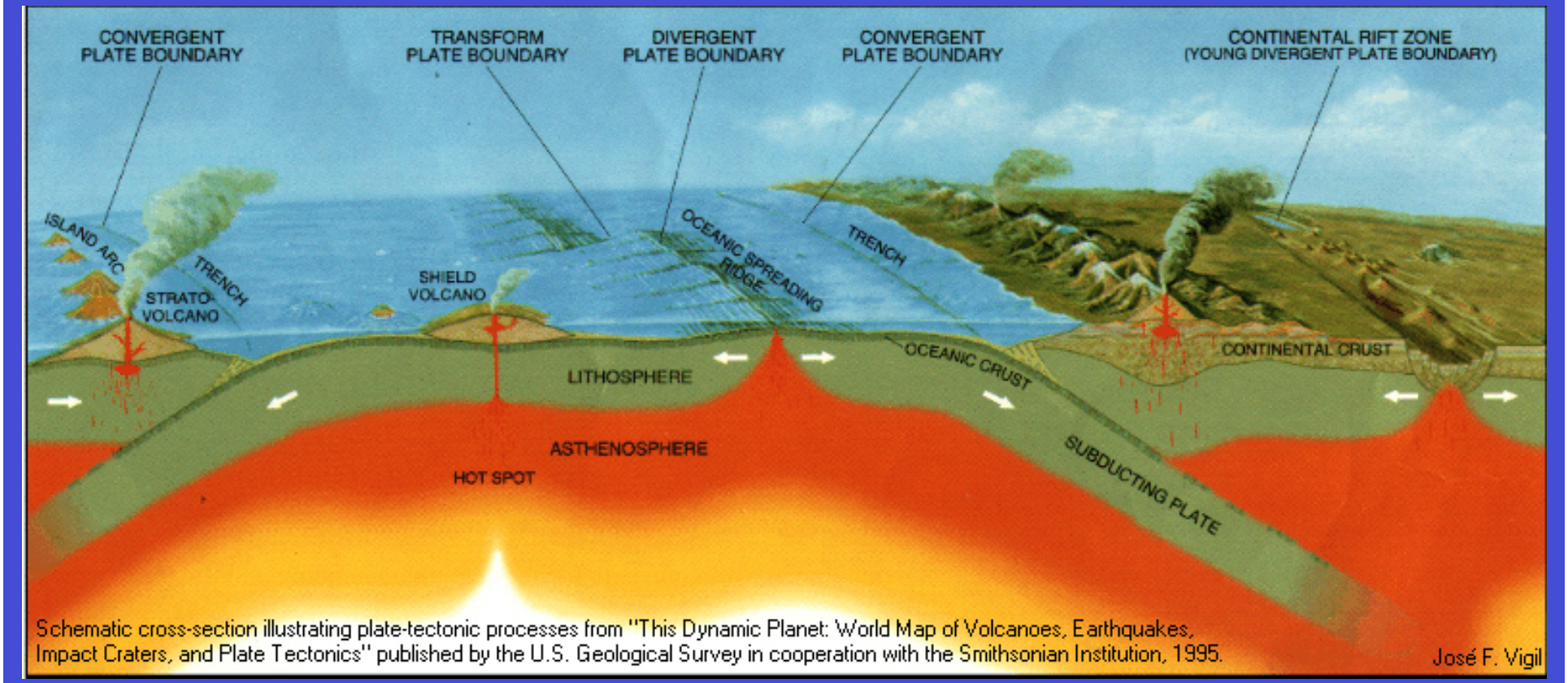


Andesite (pol //)



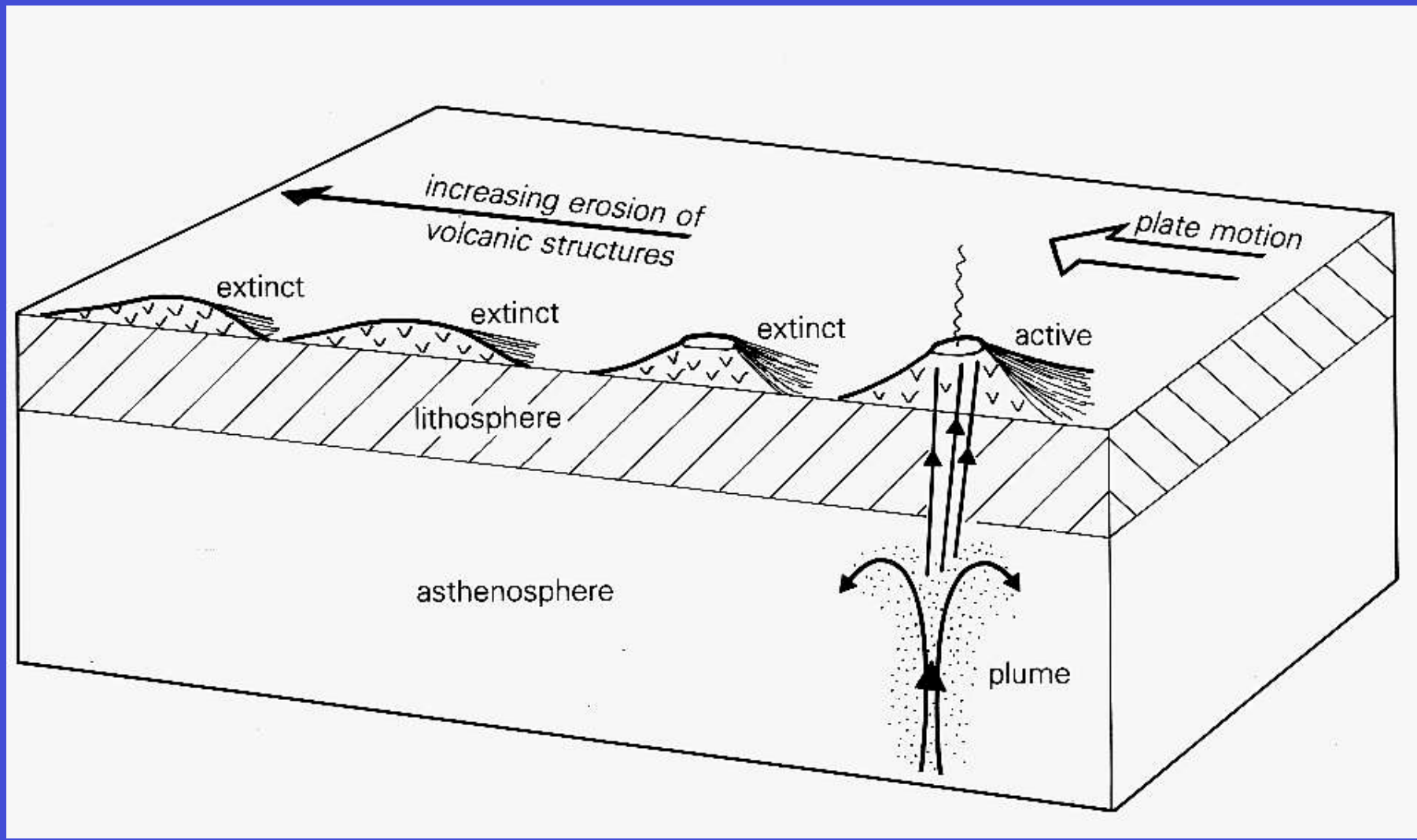
Andesite (pol X)

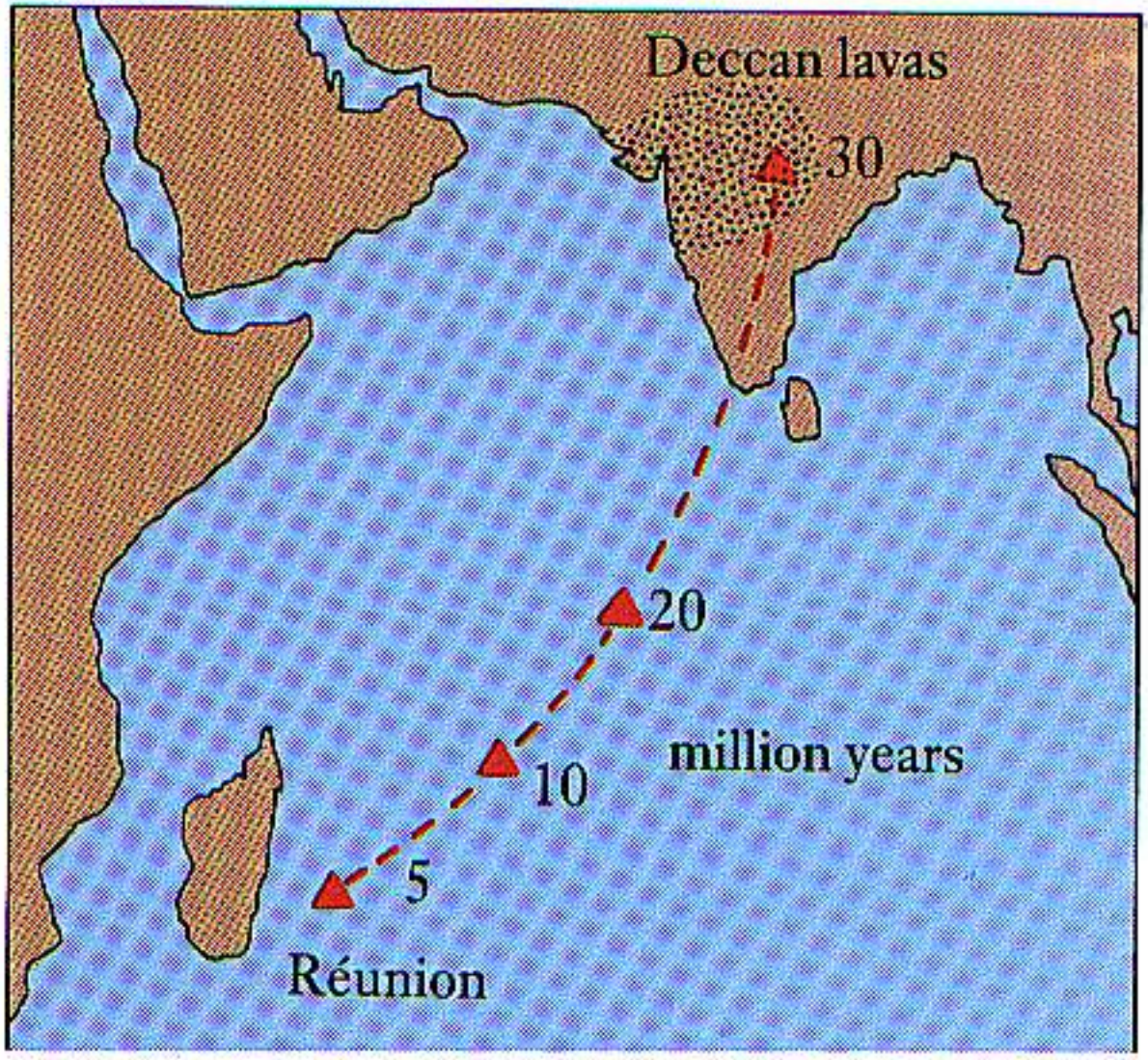
Magmatismo intraplacca



Schematic cross-section illustrating plate-tectonic processes from "This Dynamic Planet: World Map of Volcanoes, Earthquakes, Impact Craters, and Plate Tectonics" published by the U.S. Geological Survey in cooperation with the Smithsonian Institution, 1995.

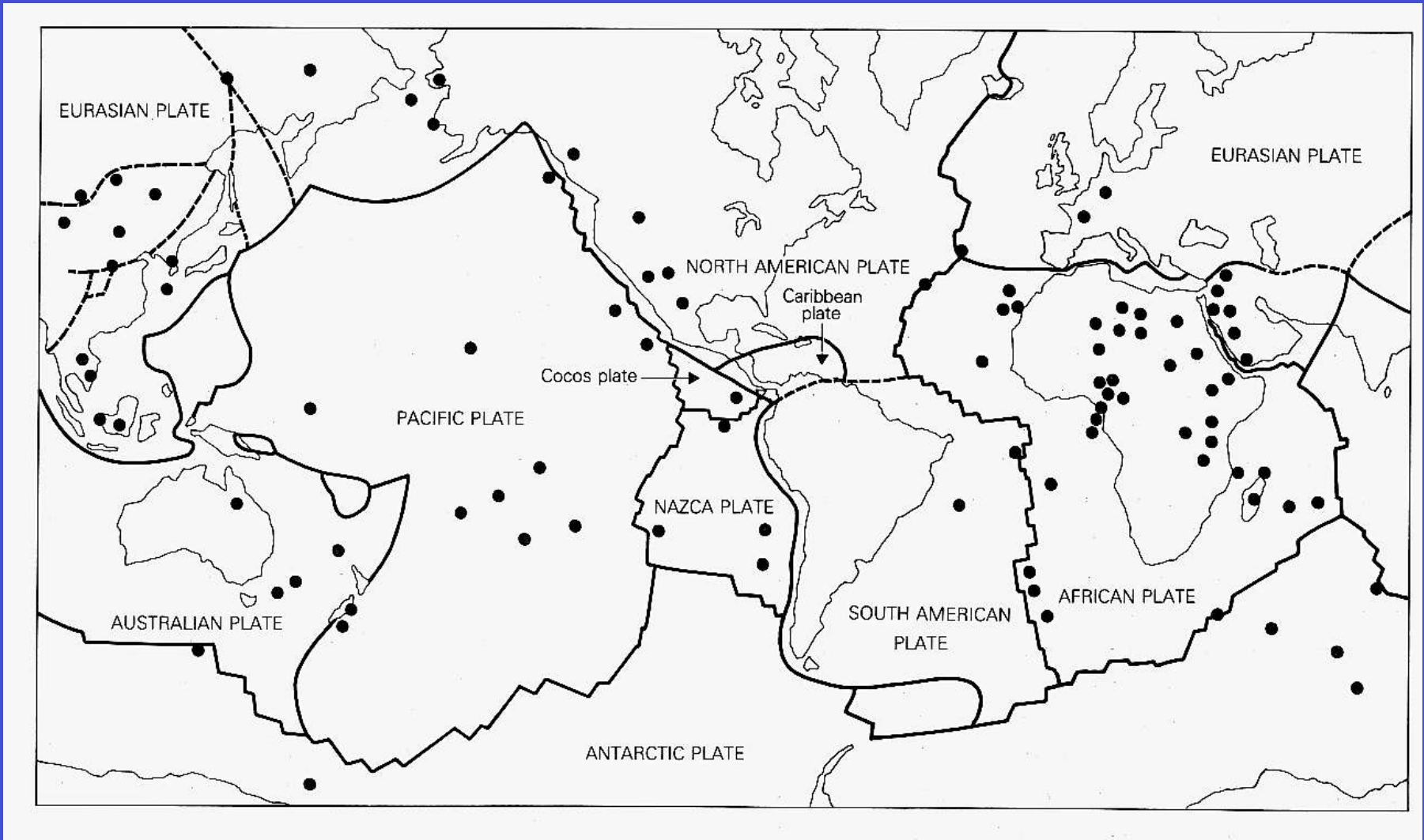
José F. Vigil


increasing erosion of
volcanic structures
plate motion
extinct
extinct
extinct
active
lithosphere
asthenosphere
plume



51 Movement over a hot-spot.

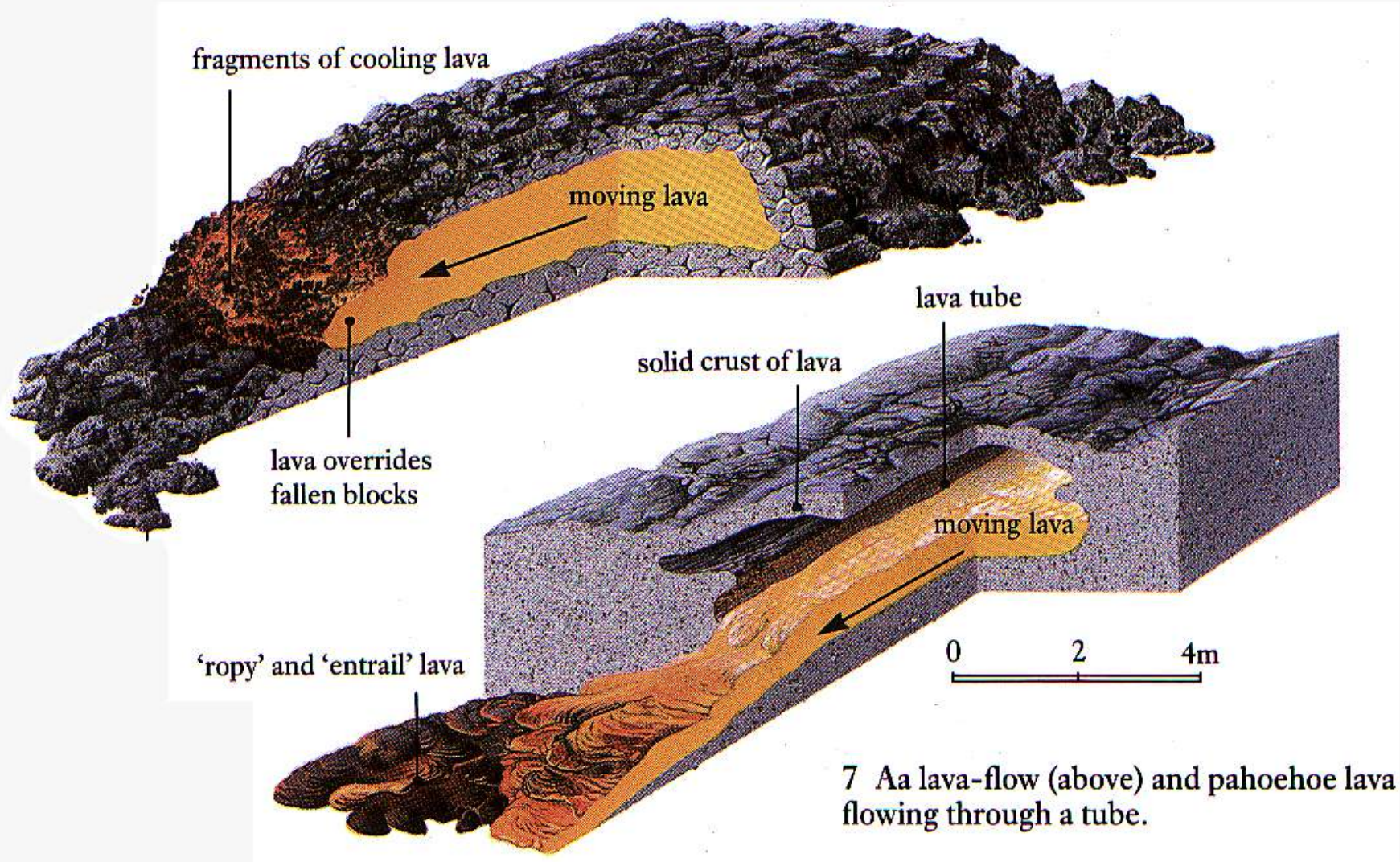
Localizzazione dei fenomeni vulcanici di tipo Hot Spot



Lago di lava (Kilauea, Hawai)

flusso lava (Kilauea, Hawai)

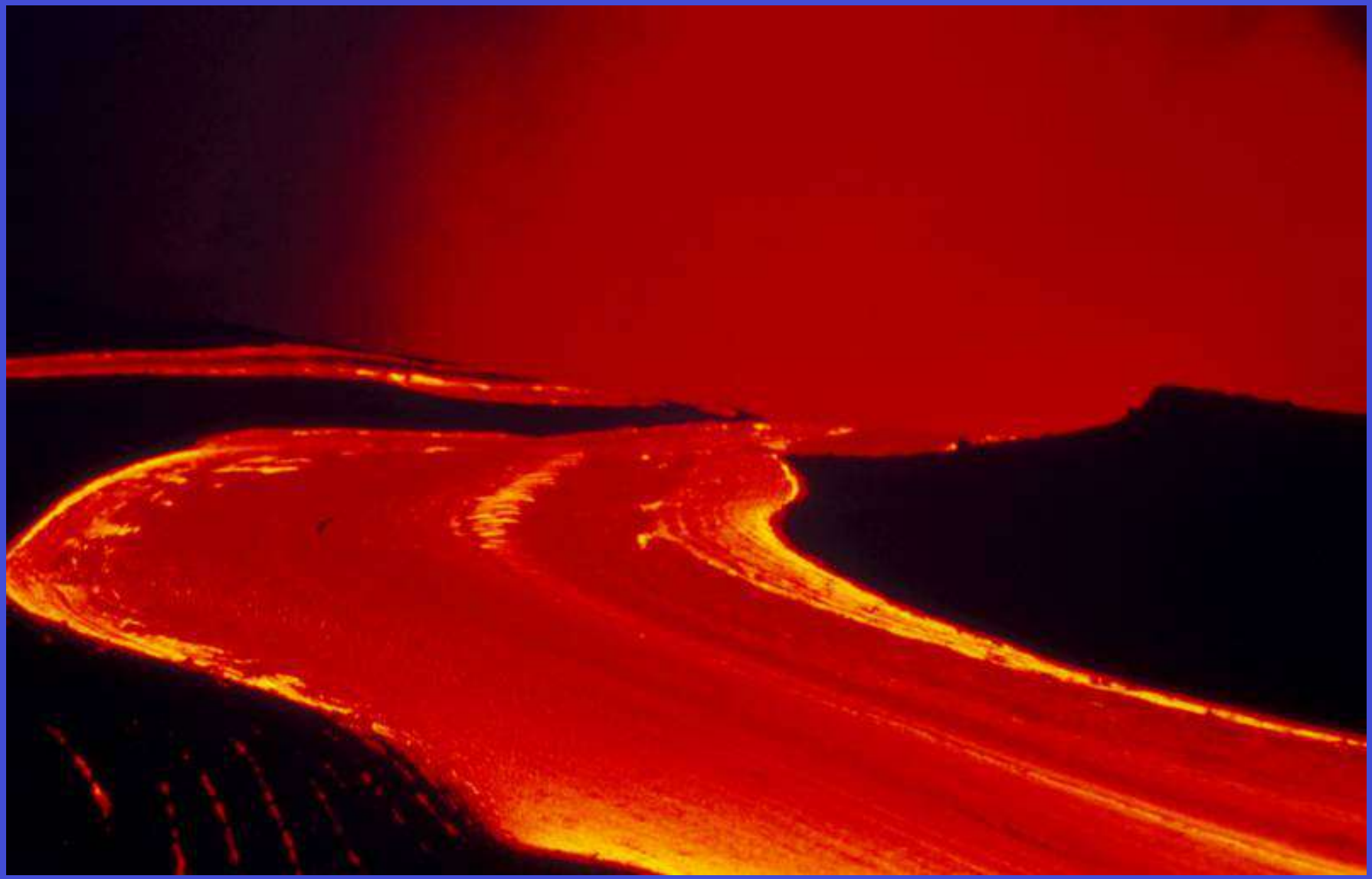
Fronte lavico (Kilauea, Hawai)



7 Aa lava-flow (above) and pahoehoe lava flowing through a tube.

6 Pahoehoe tube, Hawaii.

Cascate di lava (Hawai)



Fiume di lava (Hawai)

Eruzione fissurale (Hawai)

Il vulcanismo da hot spot, nonostante geograficamente poco importante, puo' portare alla estrusione di enormi volumi di magma (es. Trappi basaltici del Deccan)

INDAGINI CONOSCITIVE E STRUMENTALI

Composizione chimica

- elementi presenti

Composizione mineralogica

- minerali presenti
- quantita' relative

Struttura

- granulometria
- informazioni morfologiche

Ottica Mineralogica

- informazioni tessiturali
- composizione mineralogica
- presenza di fasi amorfe

Diffrattometria dei raggi-X

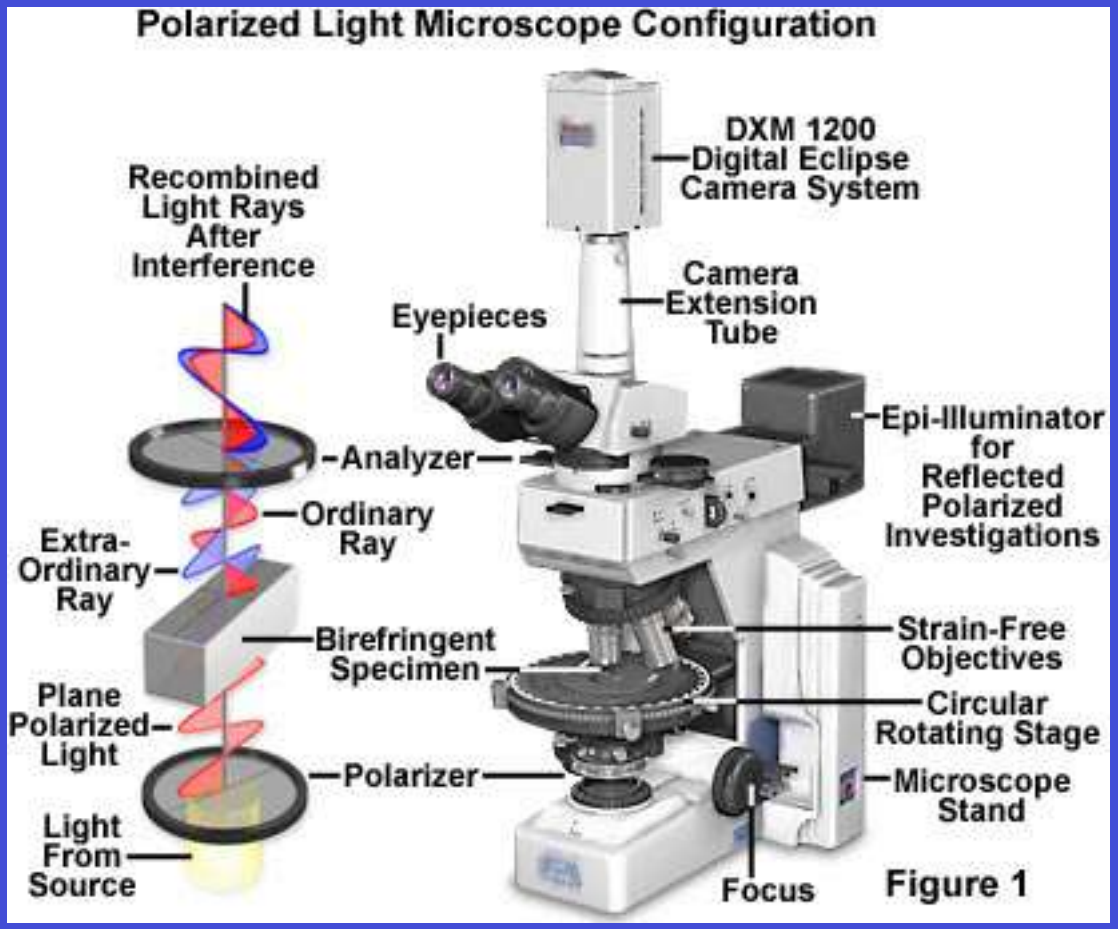
- informazioni strutturali su una fase cristallina (o miscela di fasi cristalline)
- informazioni composizionali sulle soluzioni solide

Microscopia Elettronica

- informazioni morfologiche
- composizione chimica

MICROSCOPIA OTTICA

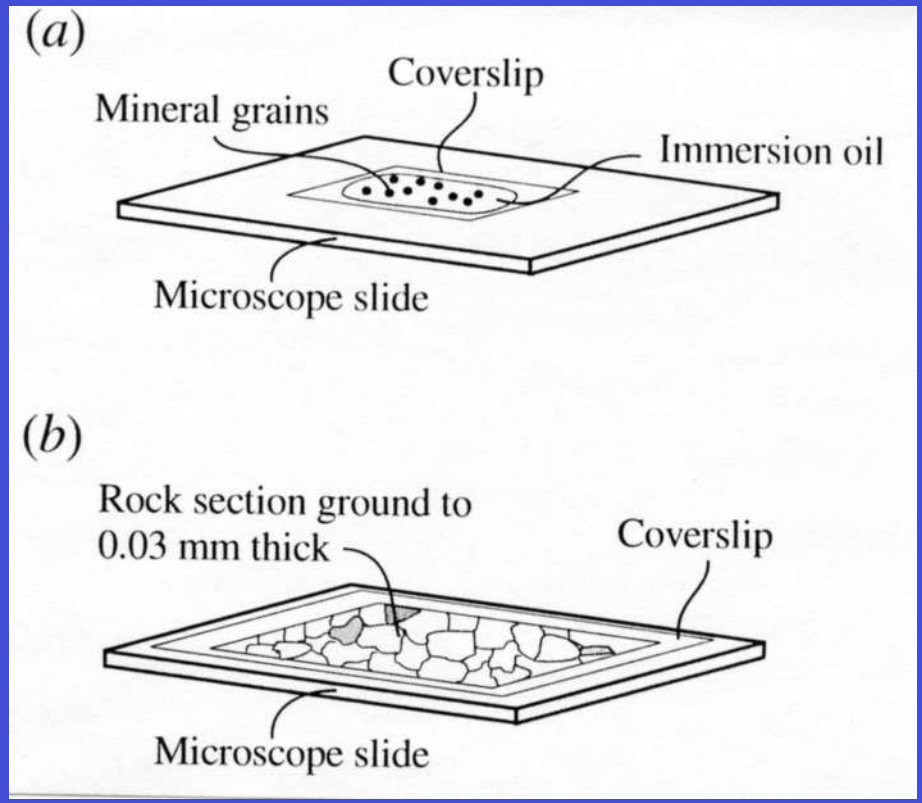
Interazione luce polarizzata- campione

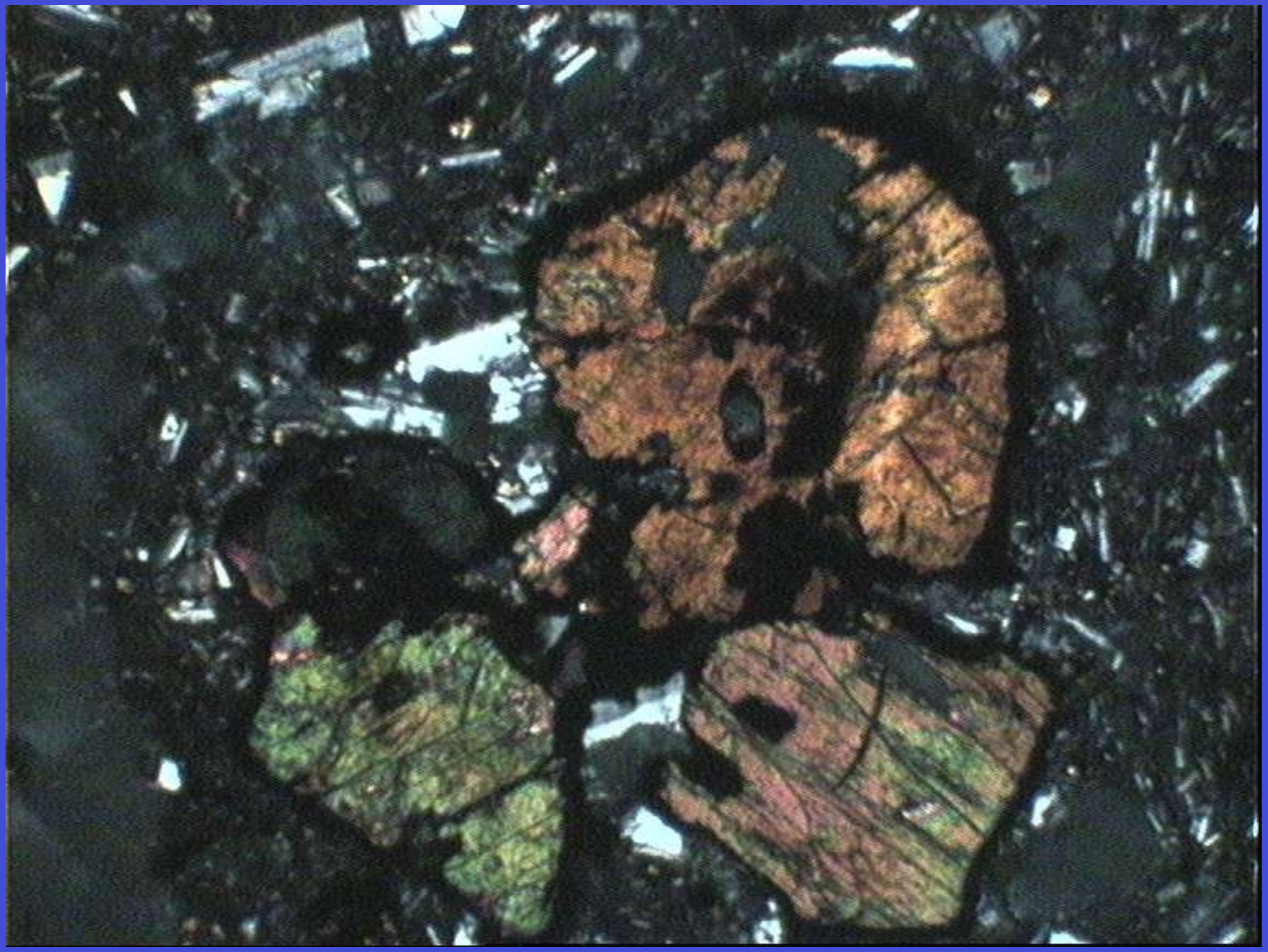


PREPARAZIONE DEI CAMPIONI

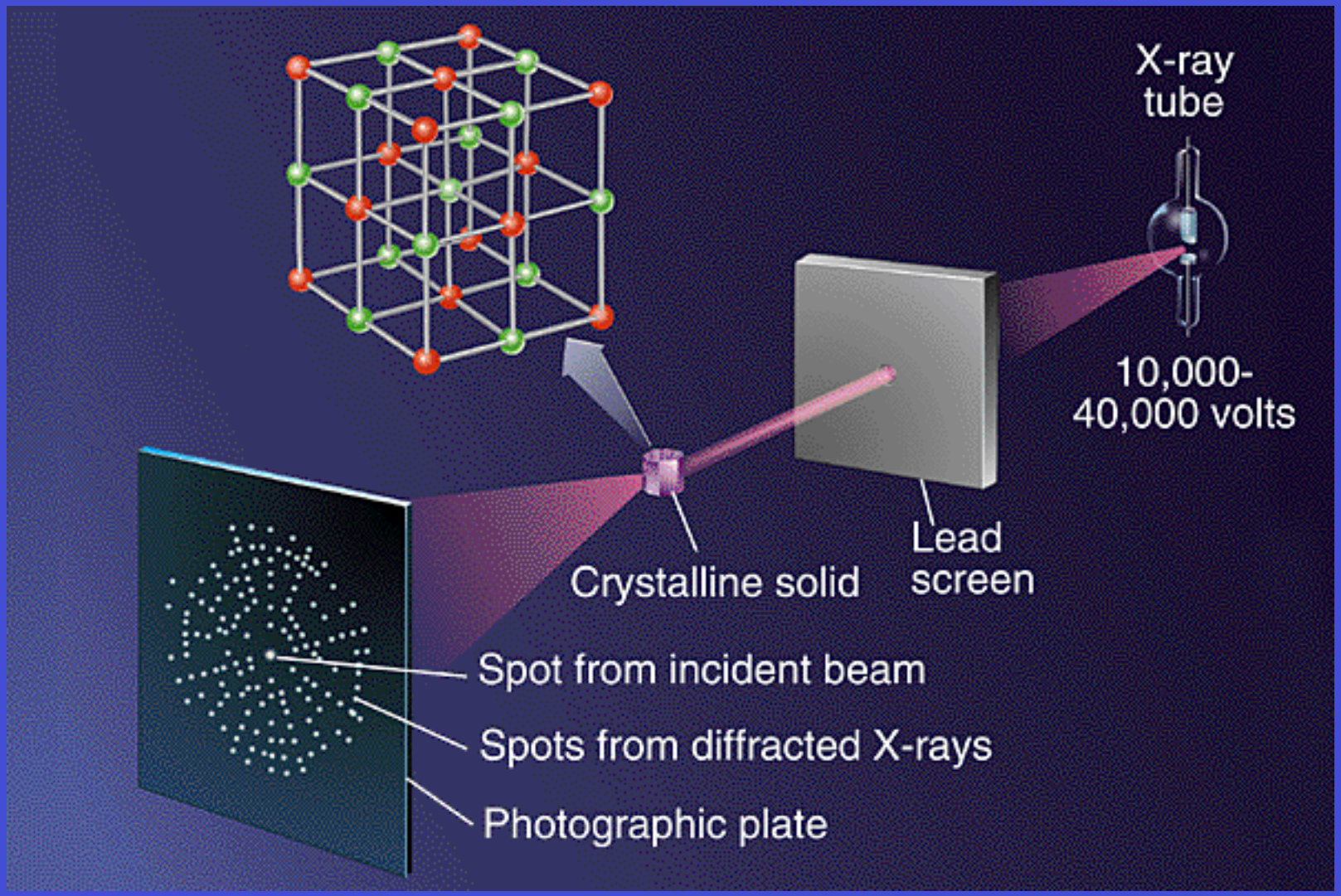
granulati

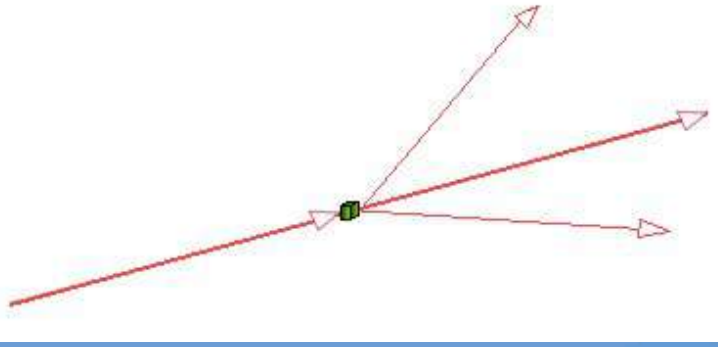
Sezioni sottile



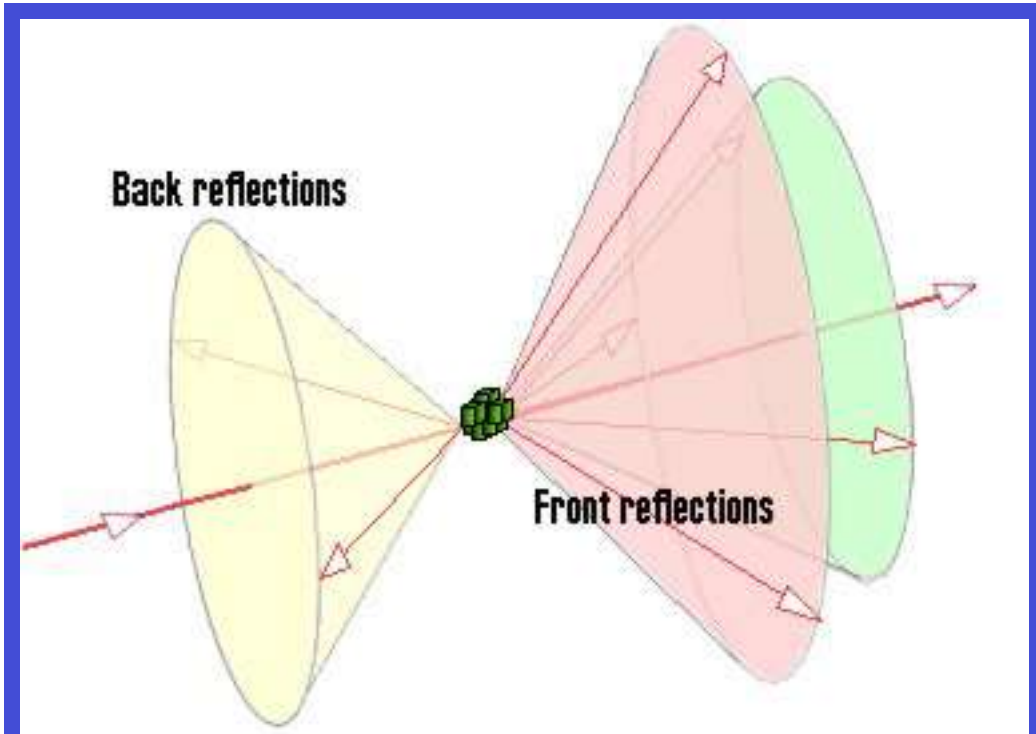


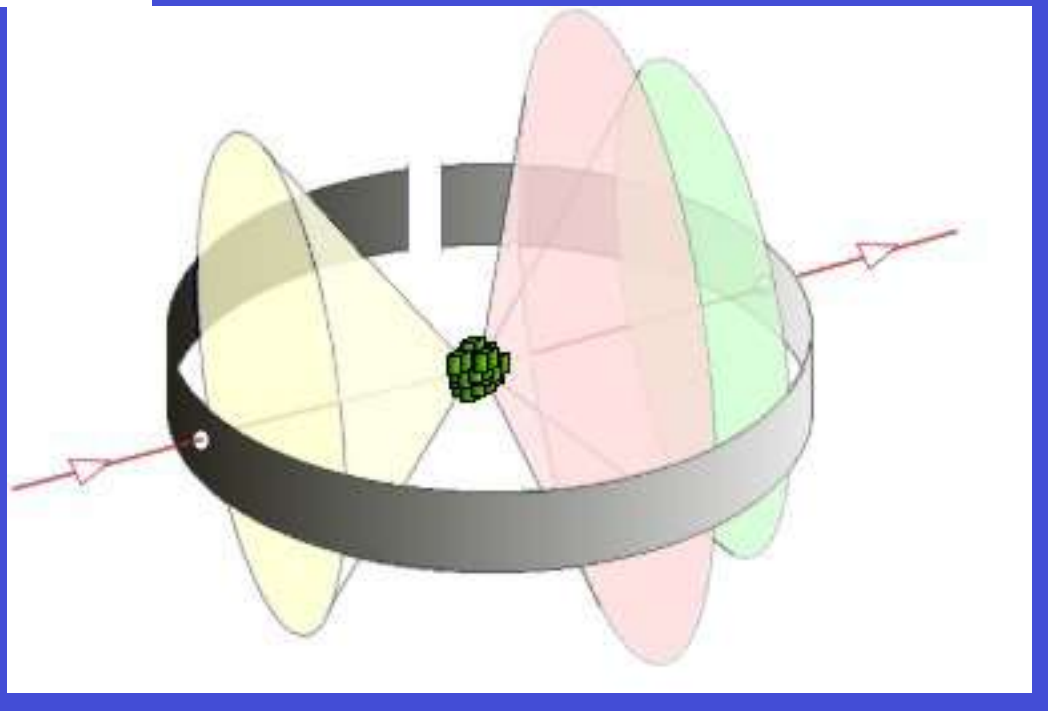
DIFFRAZIONE DEI RAGGI-X

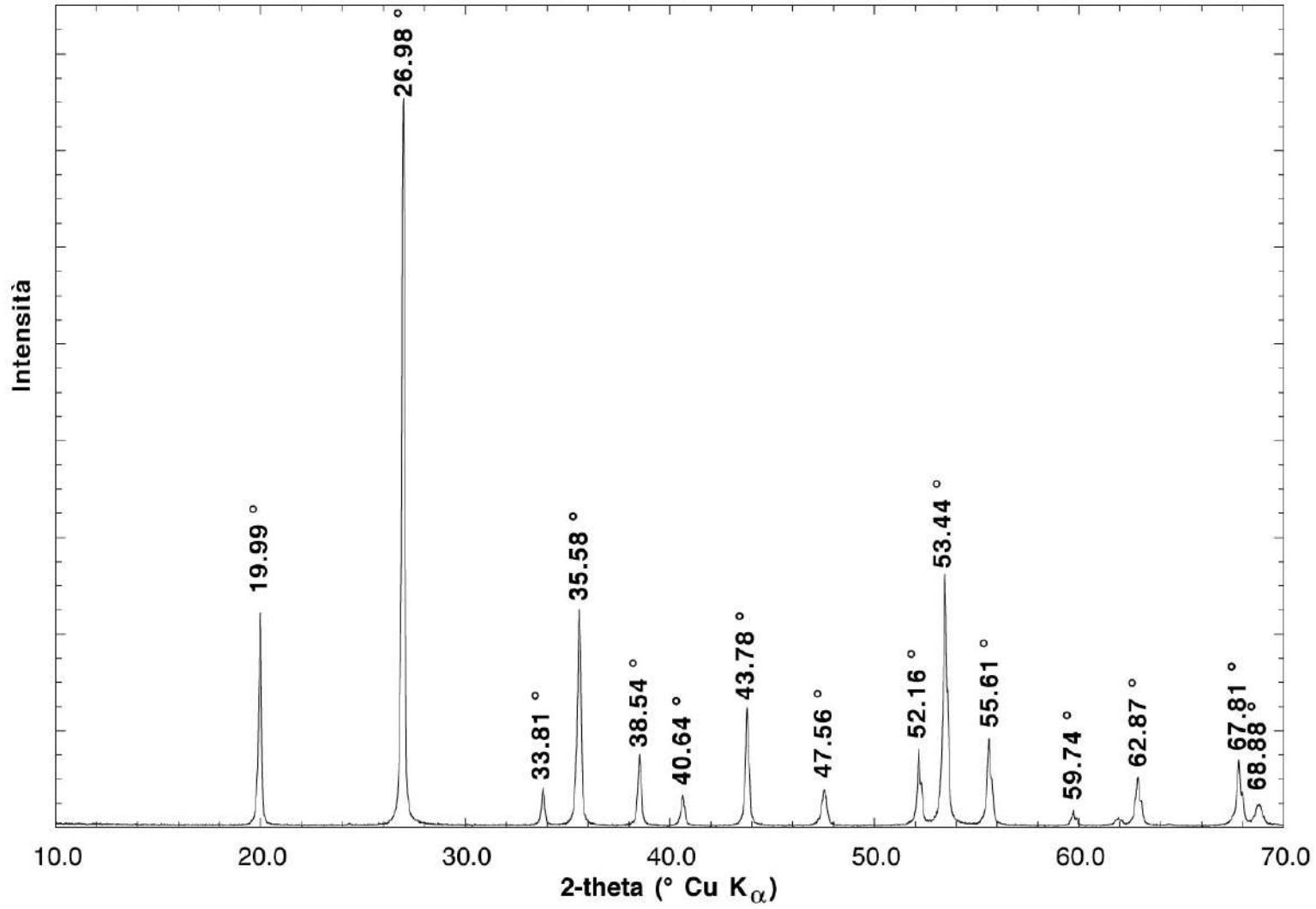


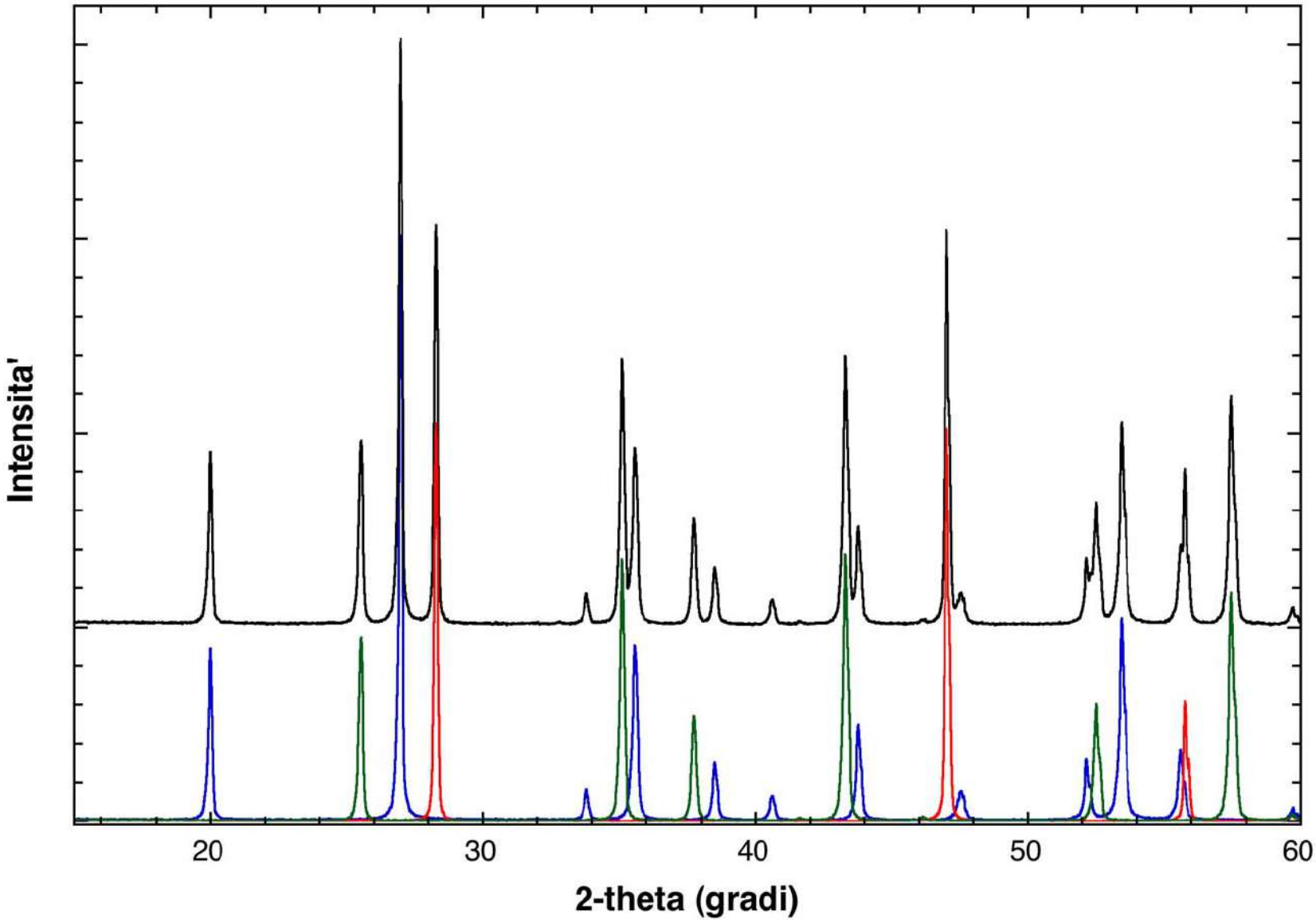



Enhance
Sapphire2
oxford diffraction


Back reflections
Front reflections




Intensità
26.98 °
19.99 °
33.81 °
35.58 °
38.54 °
40.64 °
43.78 °
47.56 °
52.16 °
53.44 °
55.61 °
59.74 °
62.87 °
67.81 °
68.88 °
10.0
20.0
30.0
40.0
50.0
60.0
70.0
2-theta (° Cu Kα)


Intensita'
20
30
40
50
60
2-theta (gradi)

Scanning Electron Microscope

- Microanalisi

  - analisi chimica qualitativa e semiquantitativa di piccoli volumi di materiale.

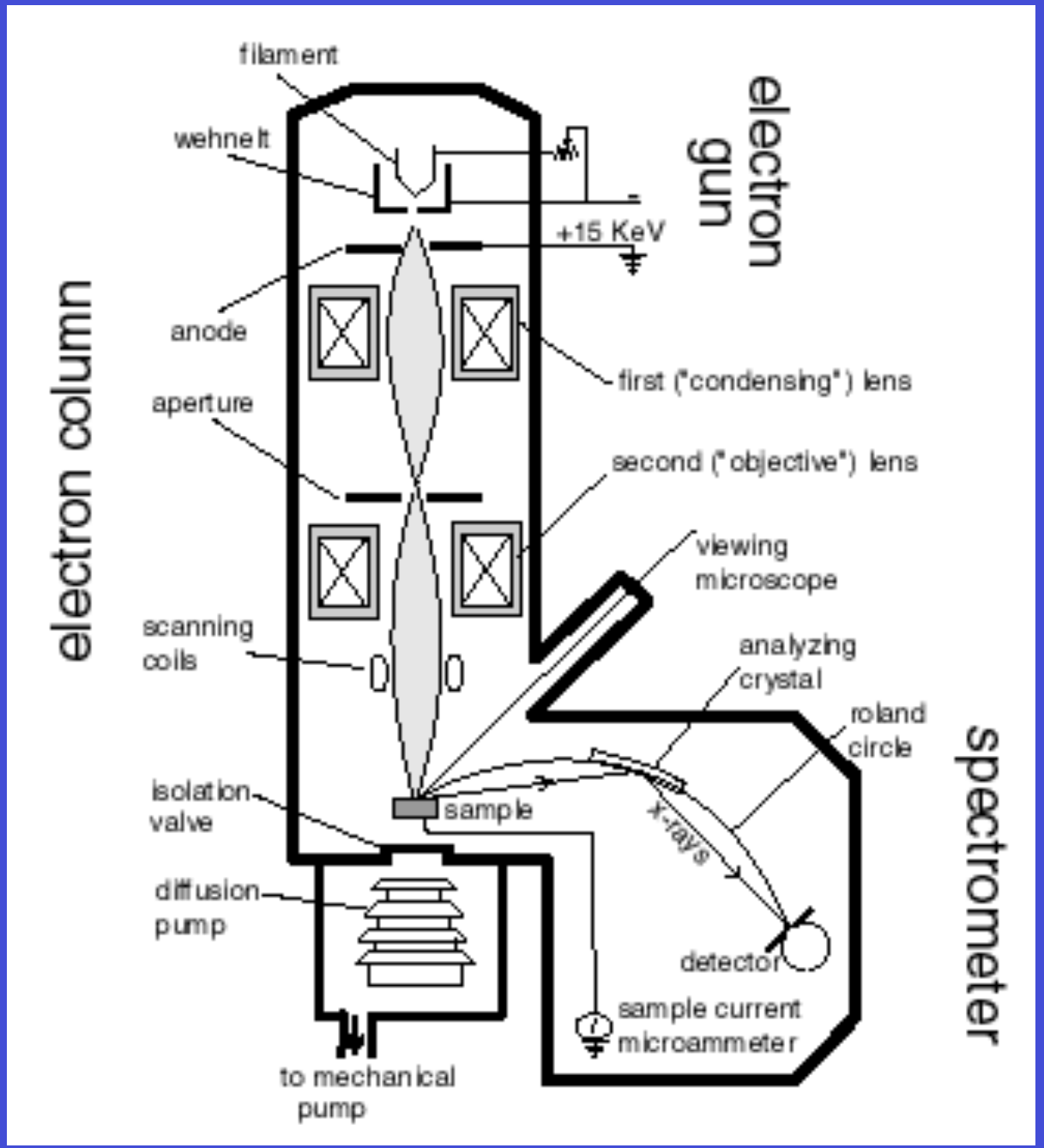
- Analisi Morfologica

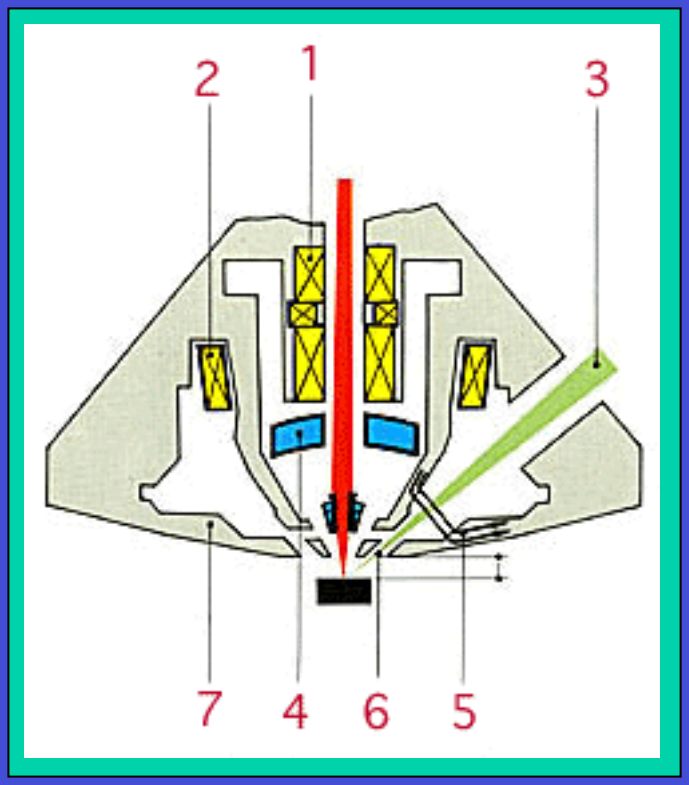
  - forte ingrandimento (fino a 200000x);

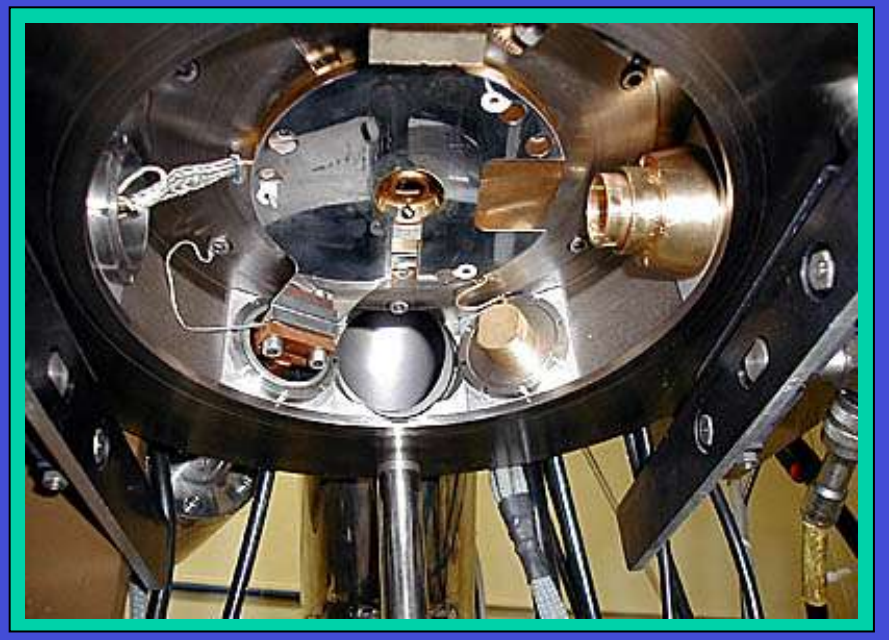
  - ampia profondità di campo.

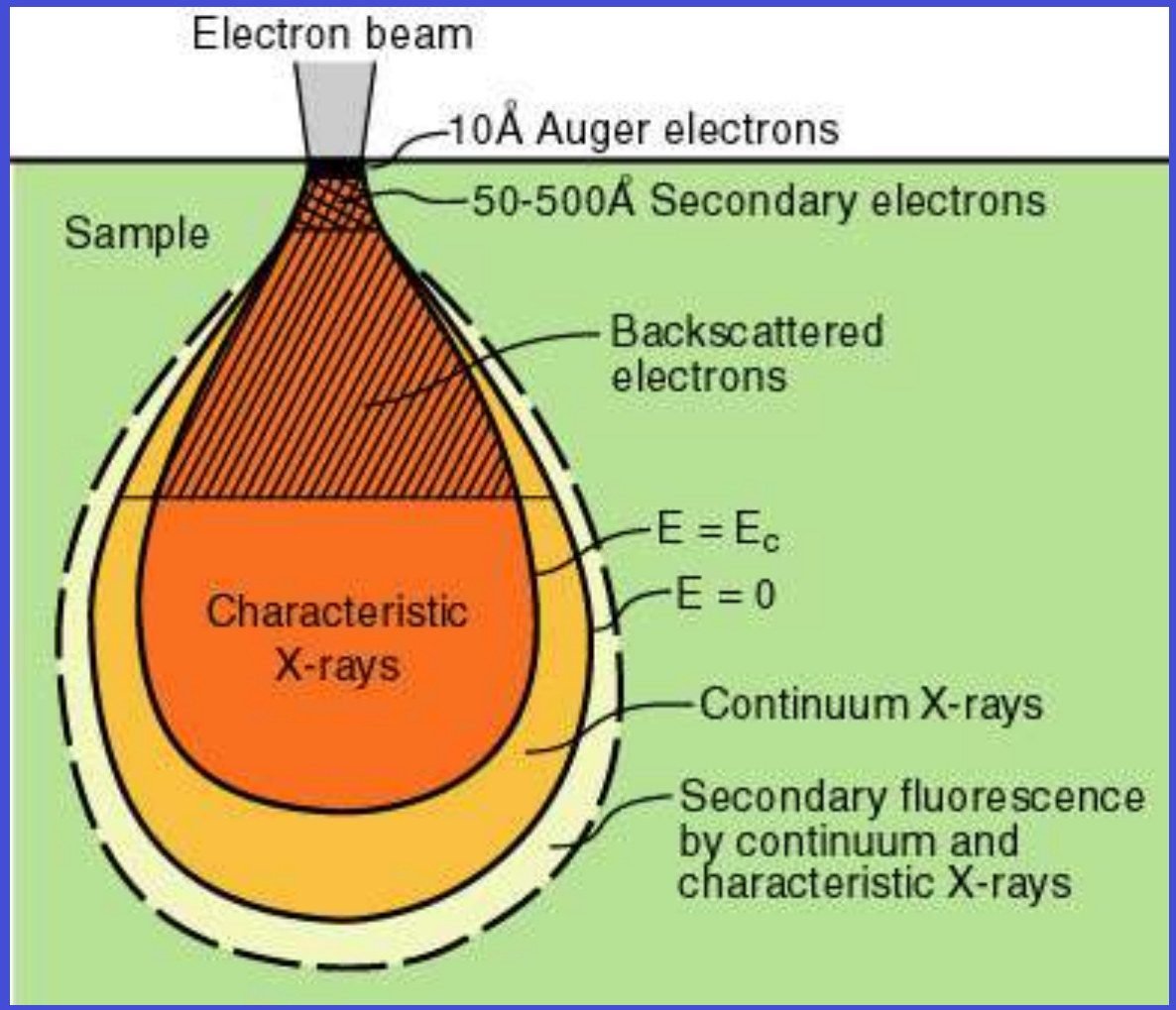
- Mappe chimiche

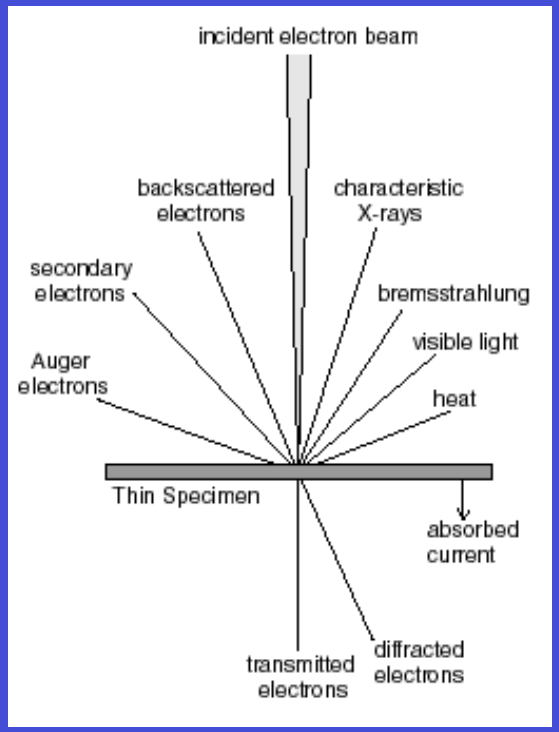
  - visualizza la distribuzione di singoli elementi.

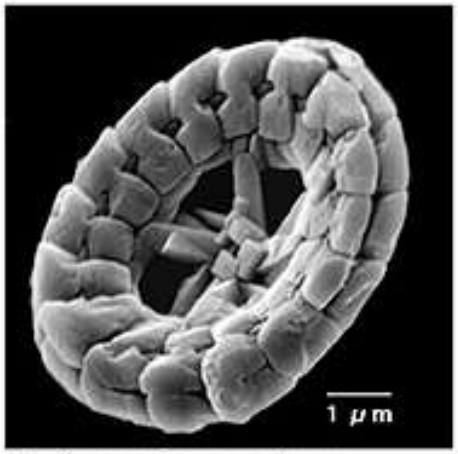

filament
wehnelt
electron gun
+15 KeV
anode
first ("condensing") lens
aperture
second ("objective") lens
viewing microscope
electron column
scanning coils
analyzing crystal
roland circle
spectrometer
isolation valve
sample
x-rays
diffusion pump
detector
sample current microammeter
to mechanical pump


2
1
3
7
4
6
5

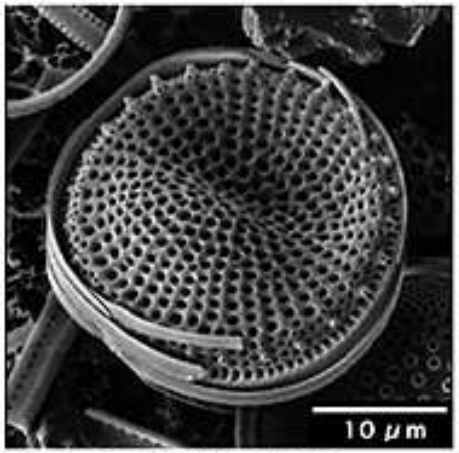



Electron beam
10Å Auger electrons
50-500Å Secondary electrons
Sample
Backscattered electrons
E = Ec
E = 0
Characteristic X-rays
Continuum X-rays
Secondary fluorescence by continuum and characteristic X-rays

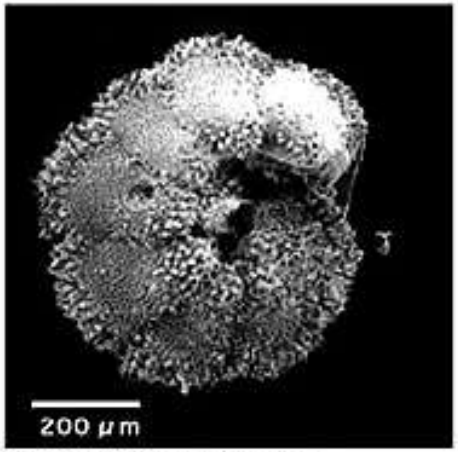

incident electron beam
backscattered electrons
characteristic X-rays
secondary electrons
bremsstrahlung
visible light
Auger electrons
heat
Thin Specimen
absorbed current
transmitted electrons
diffracted electrons



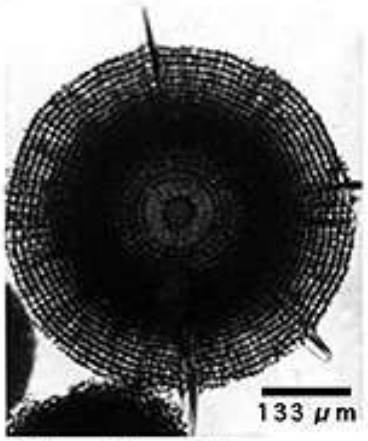
Prediscosphaera cretacea



Thalassiosira transitoria



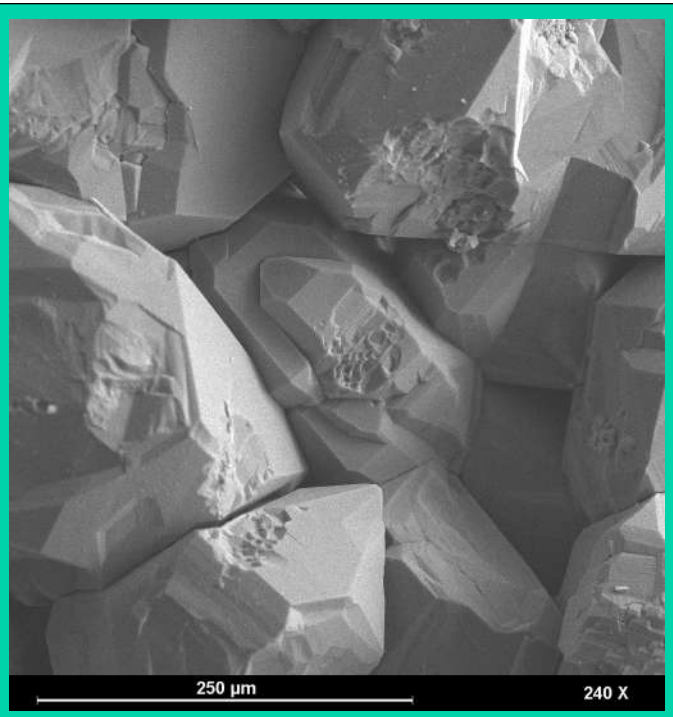
Morozovella paisonensis

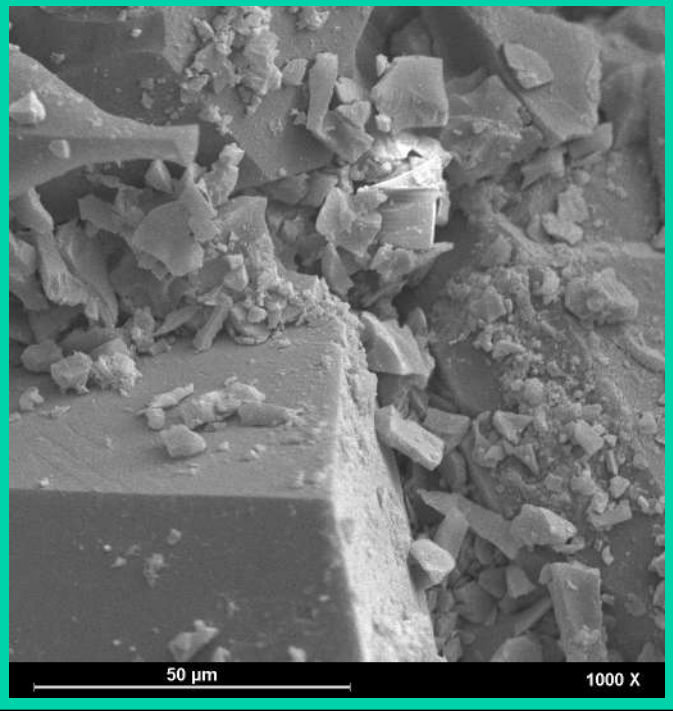


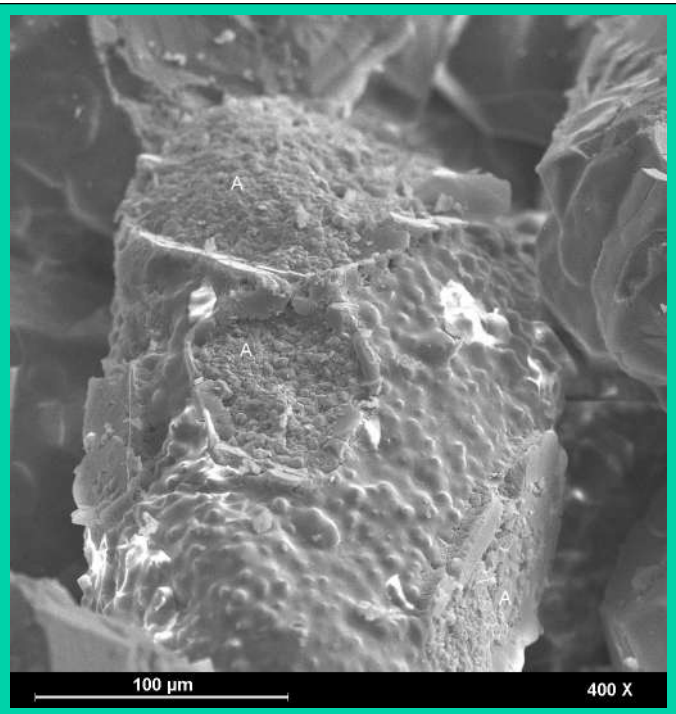
Lithocyclia ocellus

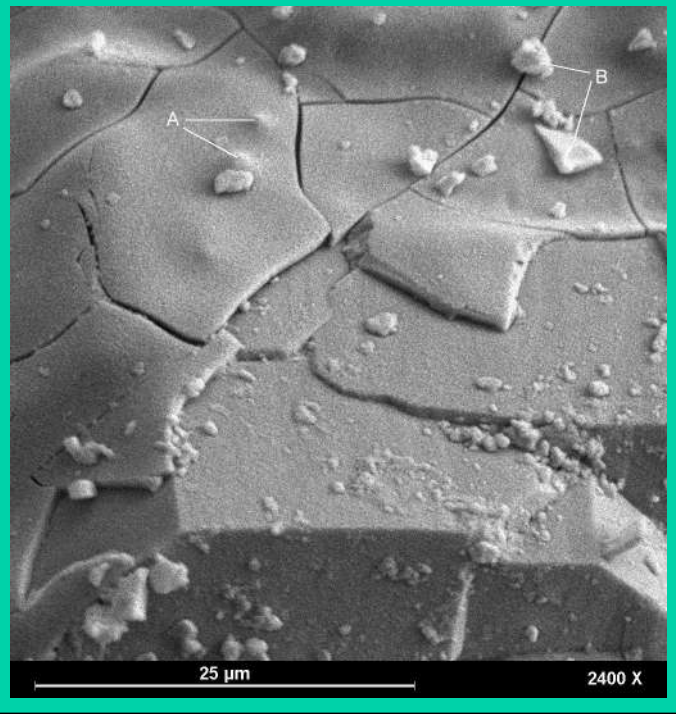
Topografia dei campioni

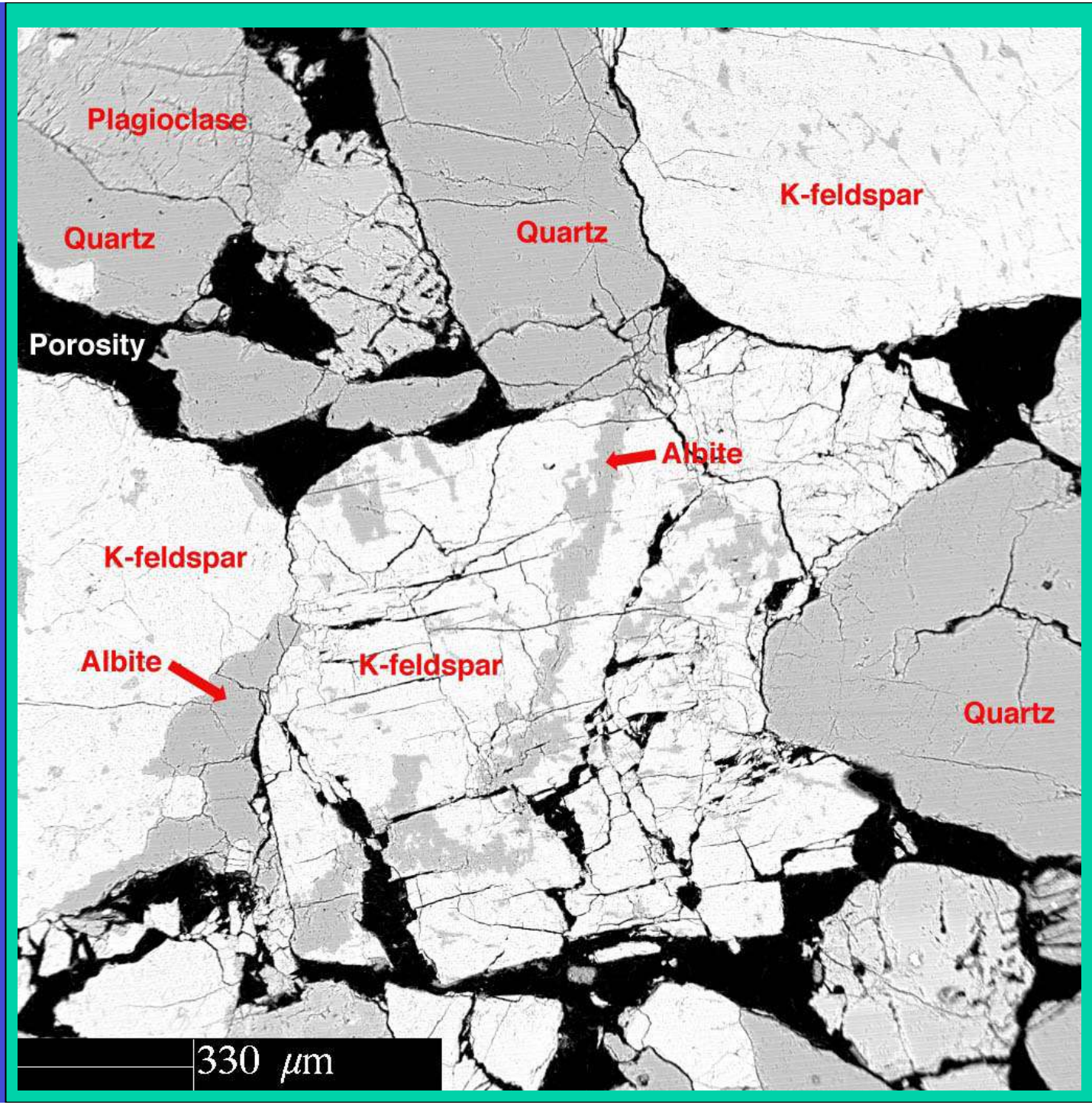
Elettroni secondari

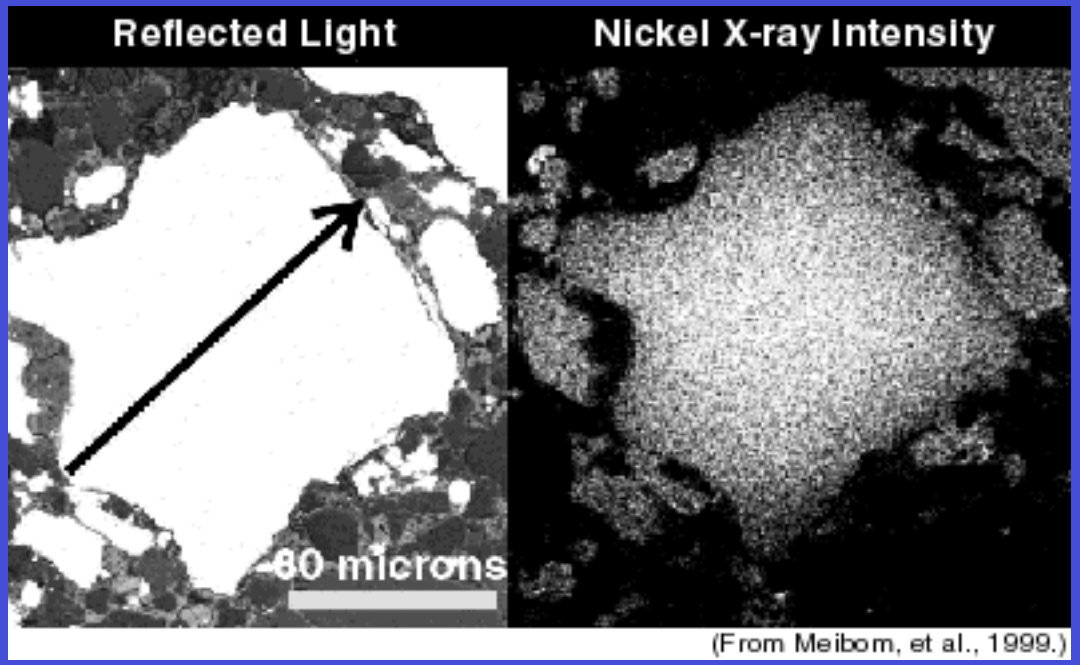

250 µm
240 X

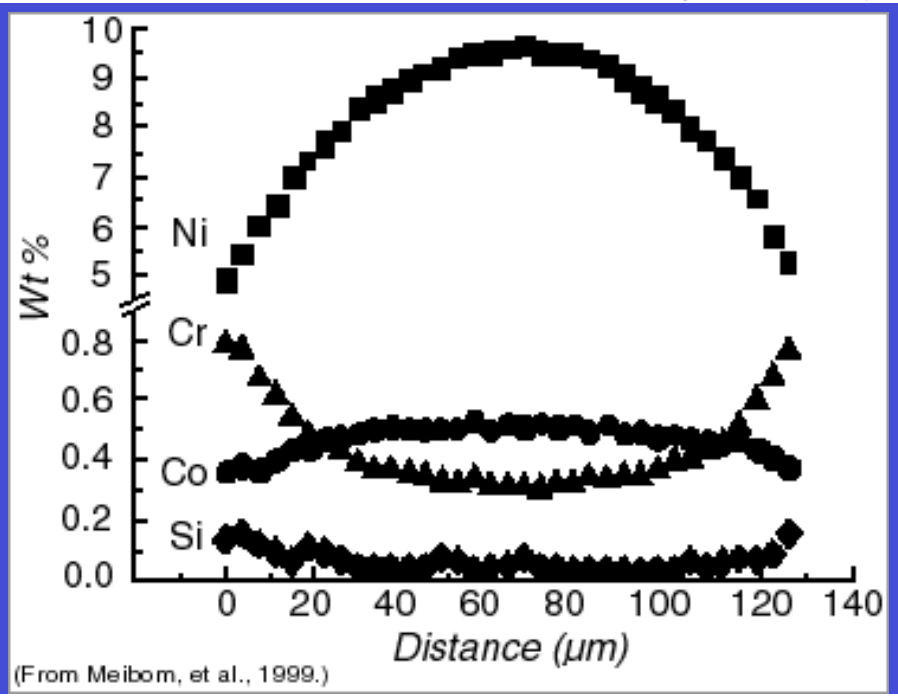

50 µm
1000 X

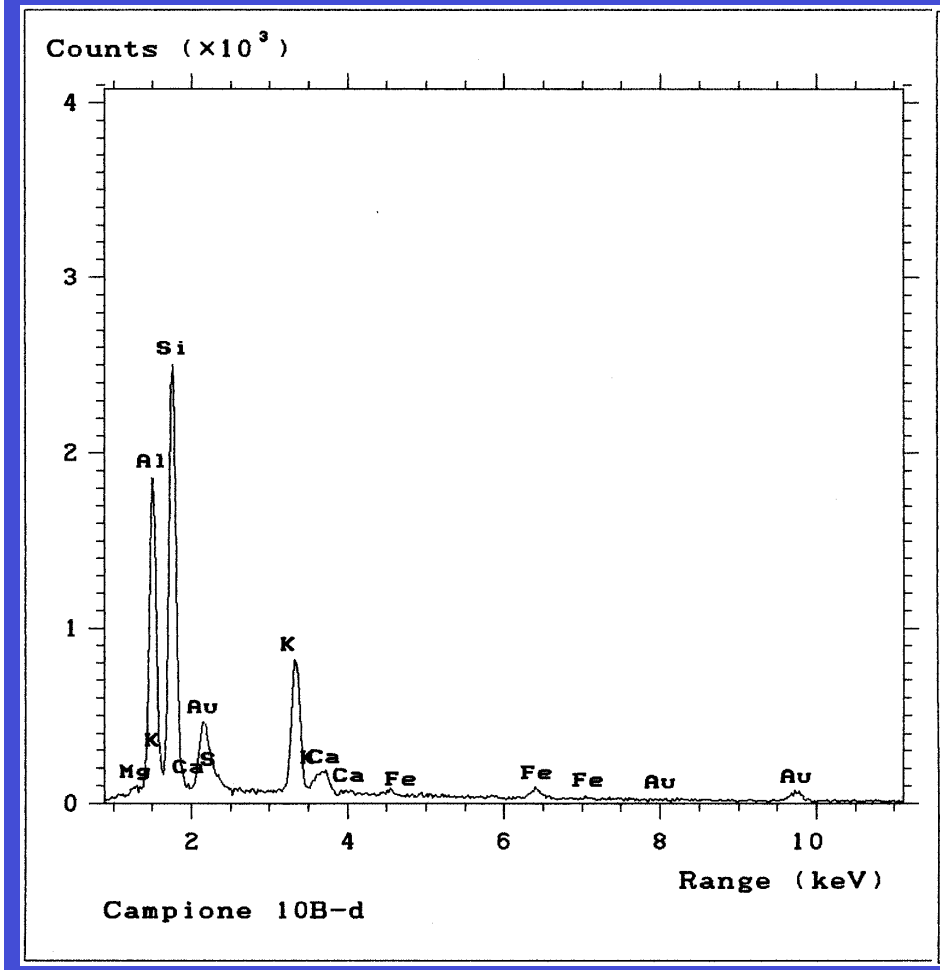

A
A
A
100 µm
400 X

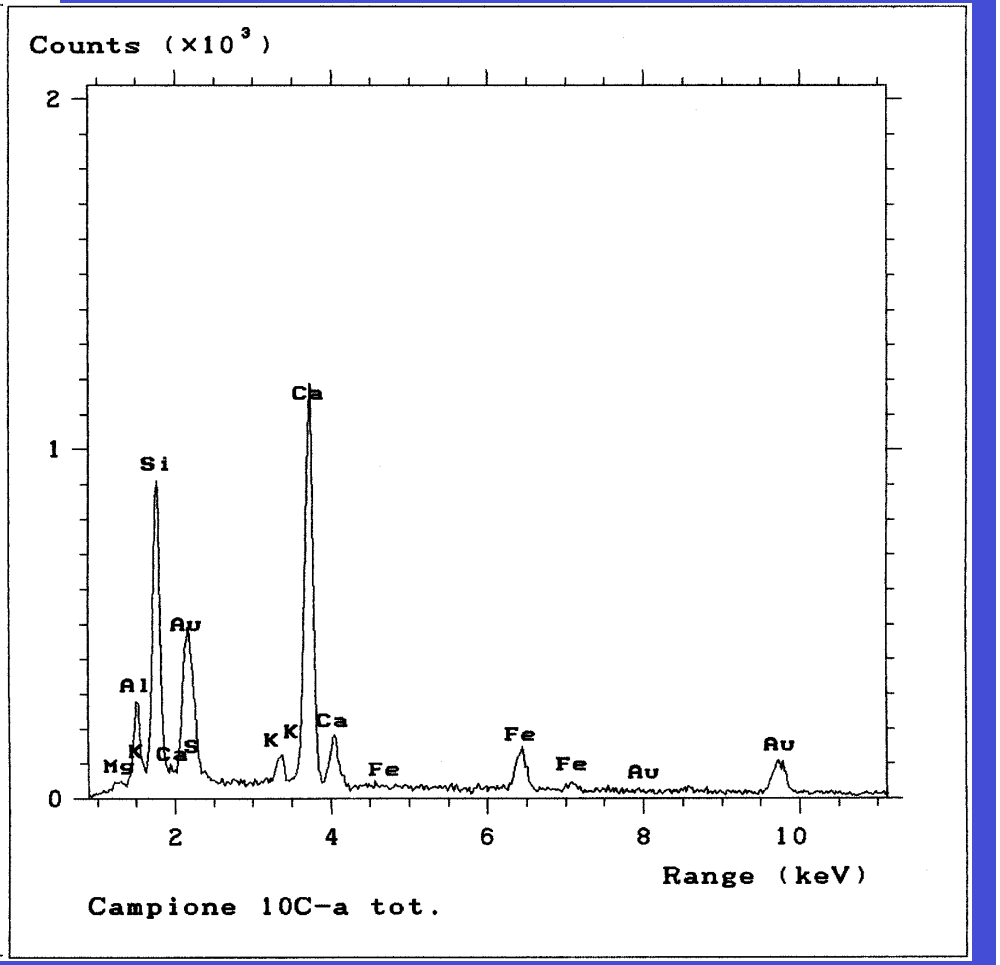

A
B
25 µm
2400 X


Plagioclase
Quartz
Quartz
K-feldspar
Porosity
Albite
K-feldspar
Albite
K-feldspar
Quartz
330 μm


Reflected Light
Nickel X-ray Intensity
~60 microns
(From Meibom, et al., 1999.)


Wt %
10
9
8
7
6
5
0.8
0.6
0.4
0.2
0.0
Ni
Cr
Co
Si
0
20
40
60
80
100
120
140
Distance (μm)
(From Meibom, et al., 1999.)


Counts (×10³)
4
3
2
1
0
Si
Al
K
Au
Mg
K
Ca
S
K
Ca
Ca
Fe
Fe
Fe
Au
Au
2
4
6
8
10
Range (keV)
Campione 10B-d


Counts (×10³)
2
1
0
Ca
Si
Au
Al
K
K
Ca
Mg
K
Ca
S
Fe
Fe
Fe
Au
Au
2
4
6
8
10
Range (keV)
Campione 10C-a tot.

Ulteriori metodi analitici:

Spettroscopia Infrarosso	gruppi anionici, molecole organiche
Analisi Termica	minerali argillosi, contenuto di acqua
Fluorescenza raggi-X	elementi in traccia