

# Earth Science Lecture at PCSHS NST

## Geology Related

by Yoshio Okamoto

PCSHS NST on 21<sup>th</sup> Dec. 2022

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[http://www.yossi-okamoto.net/index\\_e.html](http://www.yossi-okamoto.net/index_e.html)

Rock classification

Your campus rocks

Igneous rock identification

Polarized microscope: What and How?

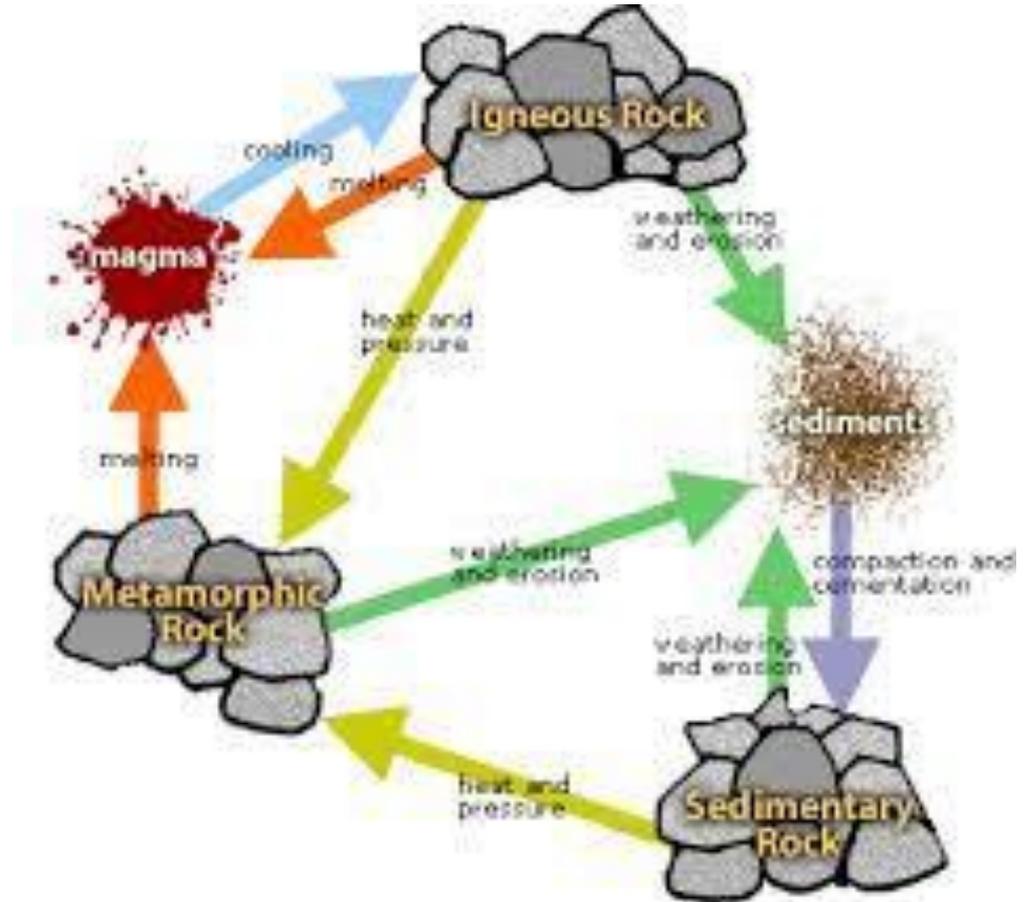
How to make thin sections?

Observing thin sections with a polarized microscope

Sketching thin sections

# Classification of Rocks

- Igneous Rocks
- Sedimentary Rocks
- Metamorphic Rock



# Your Campus Rocks



# How to identify igneous rocks

- Minerals and texture by “Naked eye (Loupe)”
- Minerals and texture by **Polarized microscope**
- Analyze by XRD or EPMA (Chemical comp.)

# Volcanic Rocks

Basalt



Andesite



Rhyolite



# Plutonic Rock

Gabbro



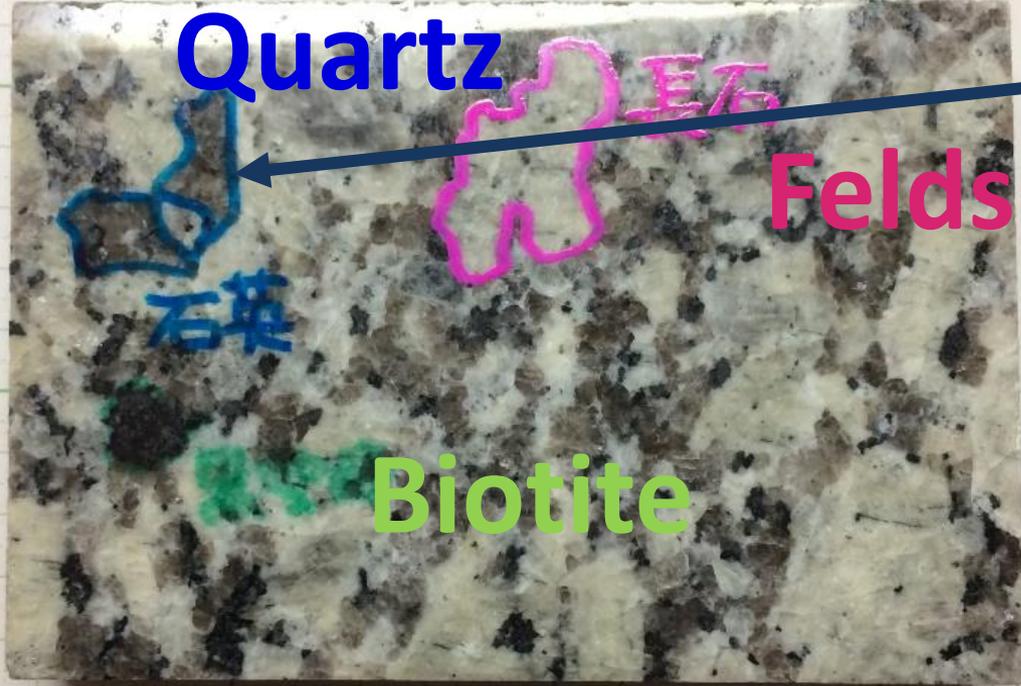
Diorite



Granite







Quartz

Feldspar

Biotite

Quartz looks dark due to transparency. Lay penetrate inside.



Quartz K-Feldspar

石英  
(SiO<sub>2</sub>)

K+長石  
(KAlSi<sub>3</sub>O<sub>8</sub>)

黑雲母  
(K(Mg,Fe)<sub>3</sub>AlSi<sub>3</sub>O<sub>10</sub>)

Biotite

# Rock-Forming Minerals: Seven Sisters!!



**Quartz**  
 $\text{SiO}_2$



**Potassium Feldspar**  
 $\text{KAlSi}_3\text{O}_8$



**Plagioclase Feldspar**  
 $\text{NaAlSi}_3\text{O}_8 - \text{CaAl}_2\text{Si}_2\text{O}_8$



**Biotite**



**Amphibole**



**Pyroxene**



**Olivine**

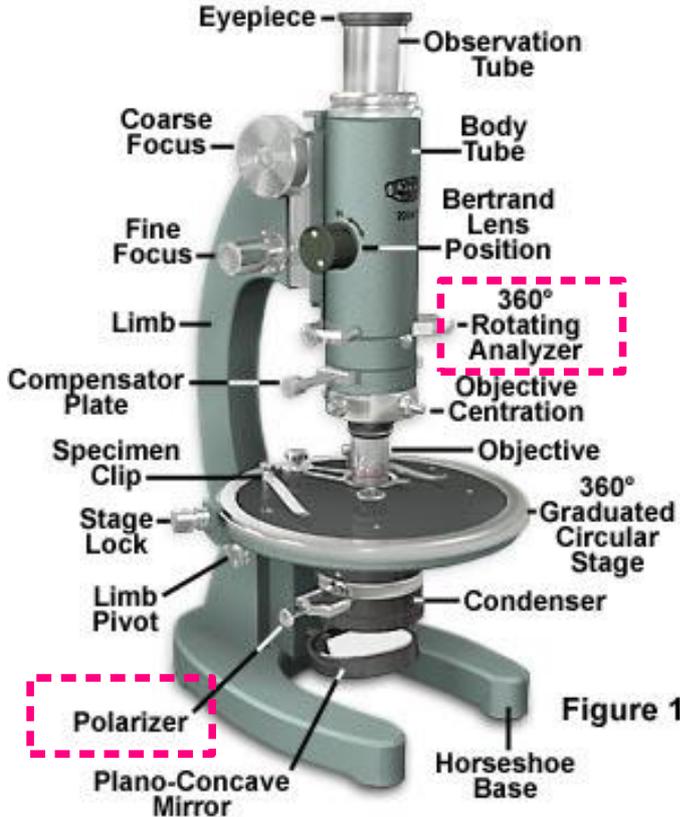


# Igneous Rock table (Y.Okamoto2018)

Volcanic Rock (Aphanitic Tex.)	Komatiite	<b>Basalt</b>	<b>Andesite</b>	<b>Rhyolite</b>
Plutonic Rock (Phaneritic Tex.)	Peridotite	<b>Gabbro</b>	<b>Diorite</b>	<b>Granite</b>
SiO <sub>2</sub> (wt%)	Ultra Basic	Basic	Mid	Acid
		45	52	66
Major Rock forming minerals (Vol%)		(Ca rich)		Quartz
			Plagioclase	K-feldspar
				(Na rich)
	Olivine	Pyroxene	Amphibole	Biotite

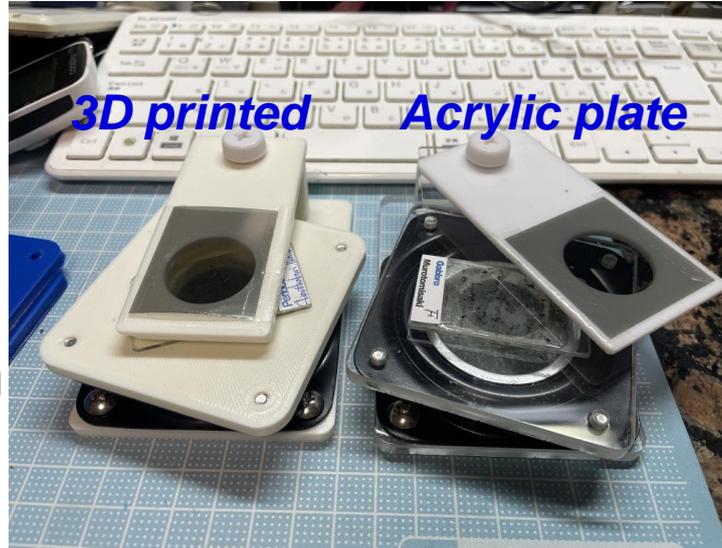
# • Polarized Microscope

Monocular Polarized Light Microscope

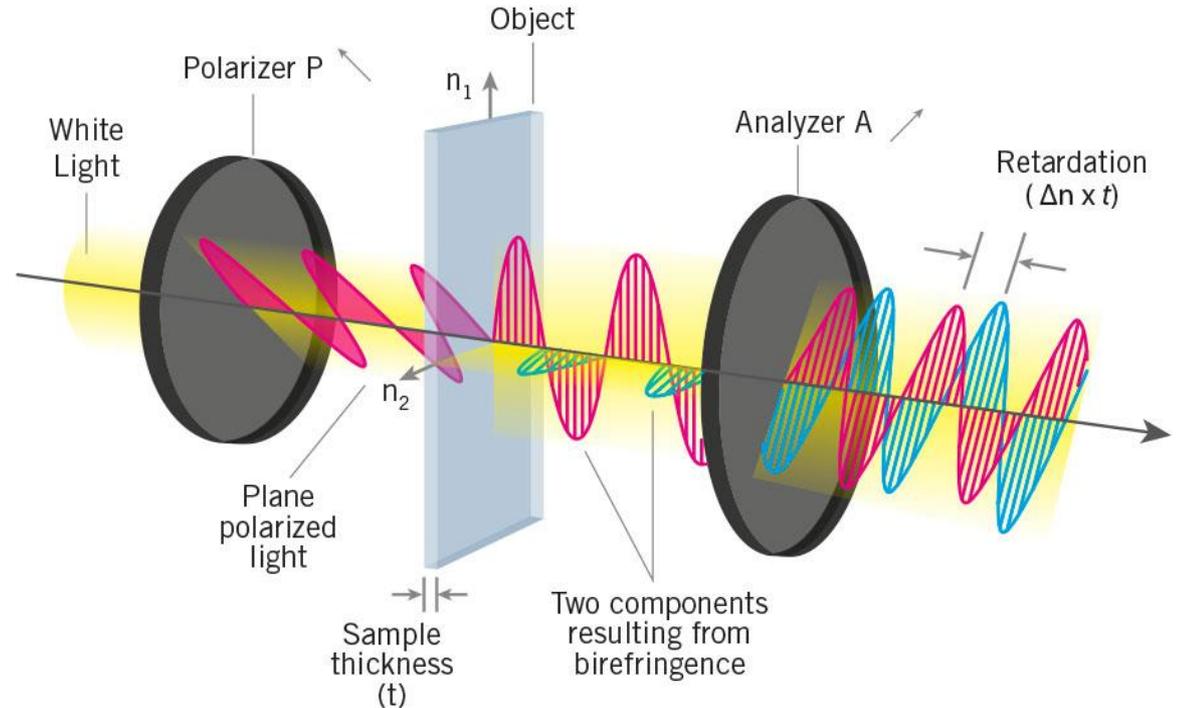
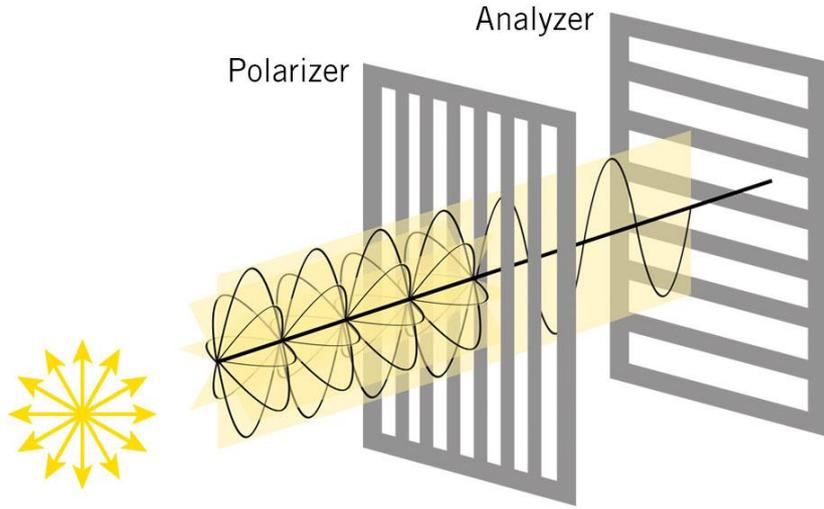


<https://www.olympus-lifescience.com/>

- Normal microscope or USB mscop.
- + Polarized filter + additional parts
- My polarizing unit!



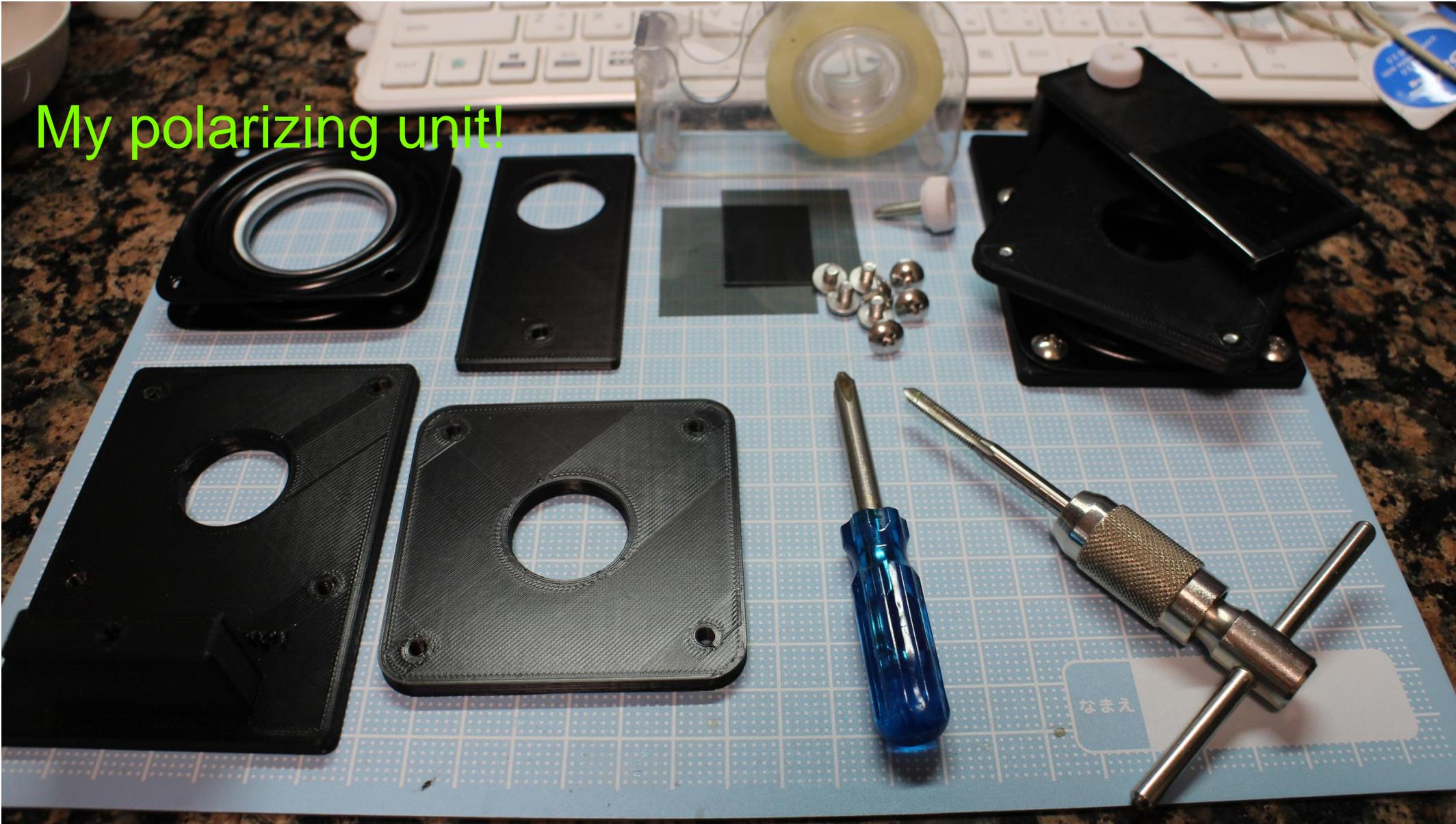
# Polarized light and other physics



Images are from  
<https://moticeurope.blogspot.com>

/

My polarizing unit!



# How to make thin-sections Part 1



<https://youtu.be/VijnnHxqls>

# How to make thin-sections Part 2



<https://youtu.be/TGRfYrV D5E>

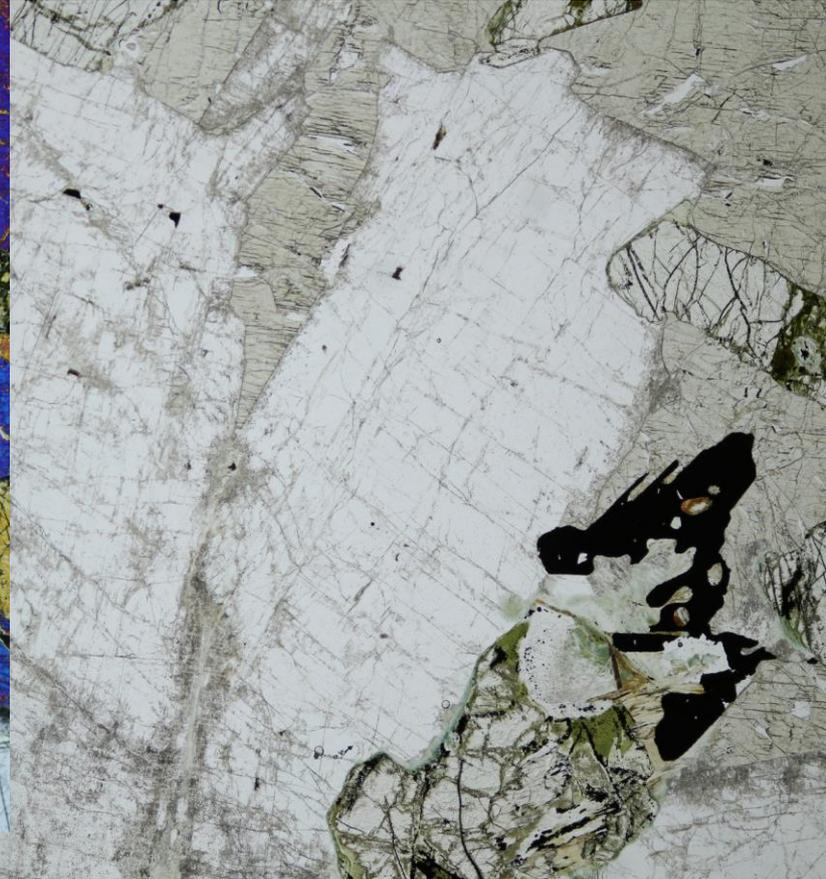
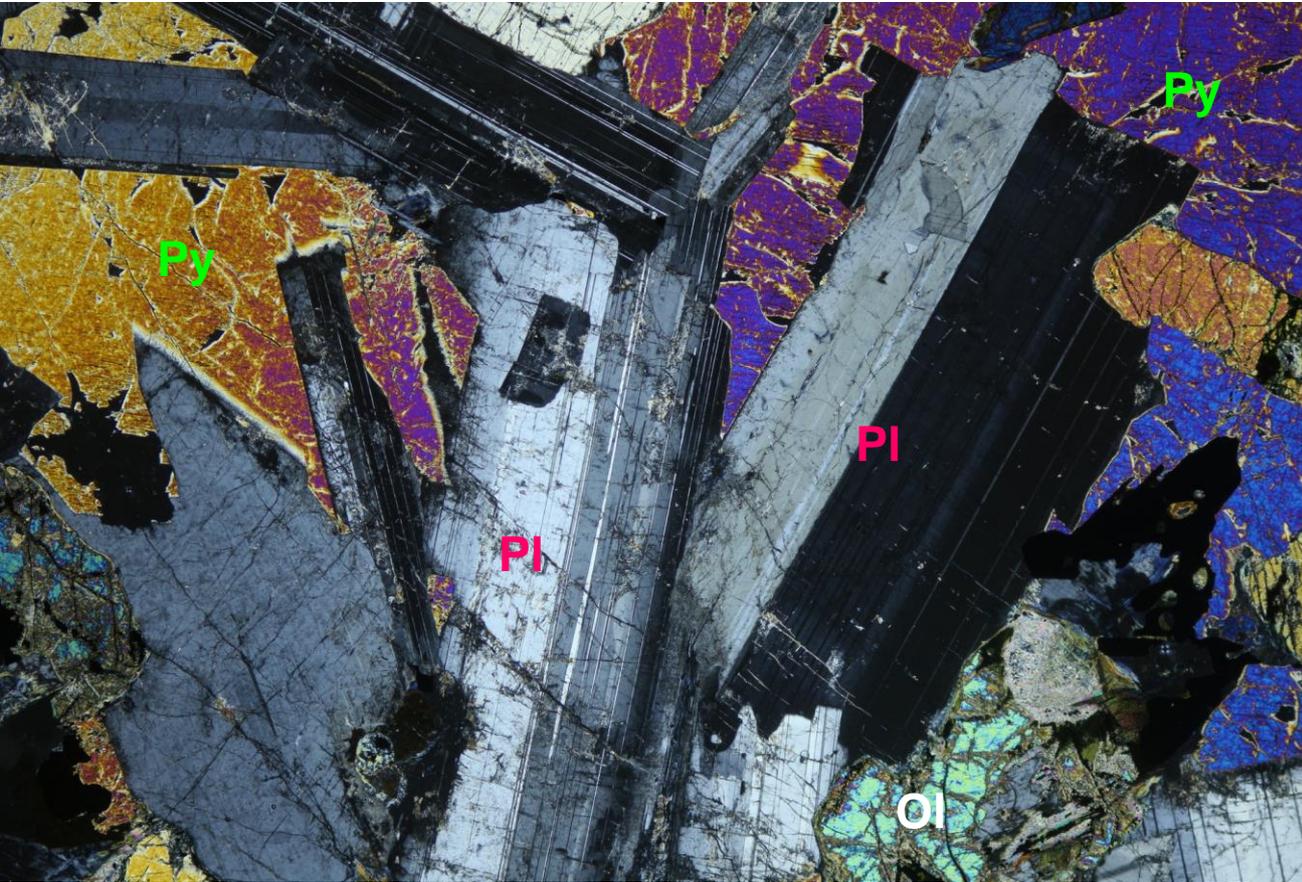
# Observation of Basalt at Chausuyama, Matsue Japan

OI: Olivine  
PI: Plagioclase



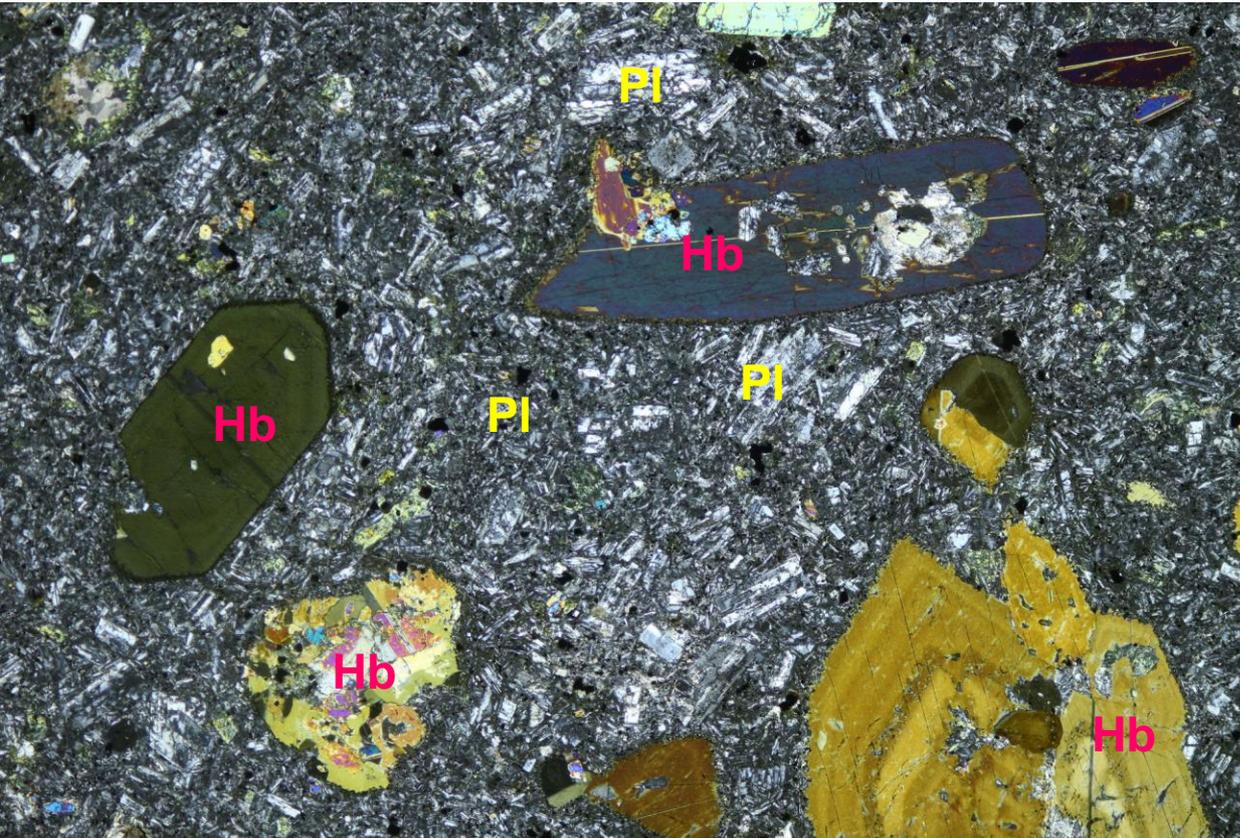
# Observation of Gabbro at Murotomisaki, Kohchi Japan

OI: Olivine  
Py: Pyroxene  
Pl: Plagioclase



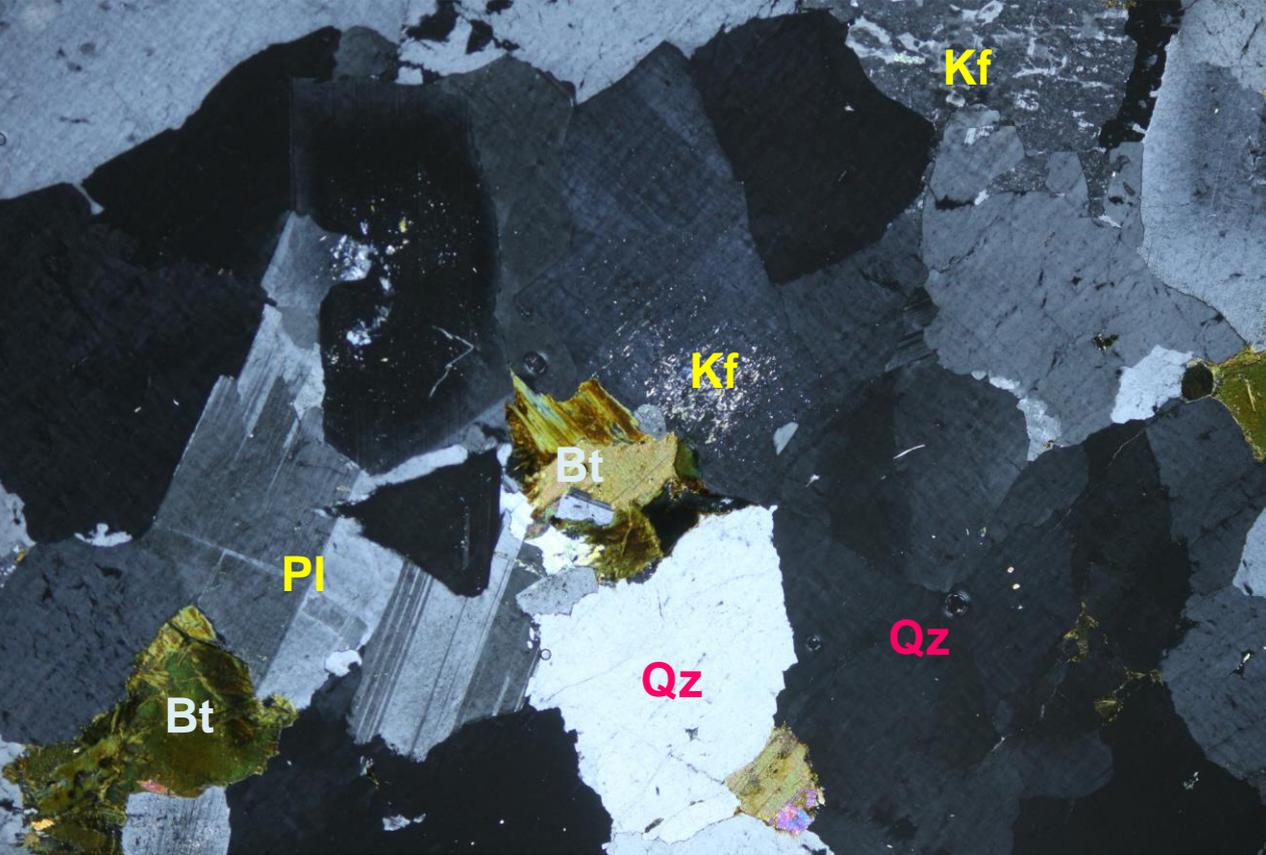
# Observation of Diabase at Miyamacho, Fukui Japan

Hb: Hornblende  
Pl: Plagioclase



# Observation of Granite at various sites including construction stones

Qz: Quartz  
Kf: K-Felspar  
Pl: Plageoclase  
Bt: Biotite

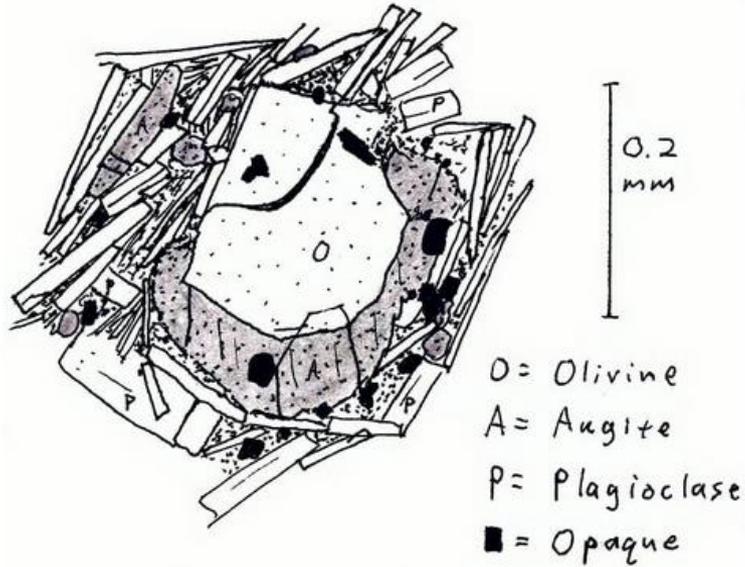


# How to sketch

- Only draw the profile lines and structures
- Do not need painting
- Write features, mineral names, etc. in a callout

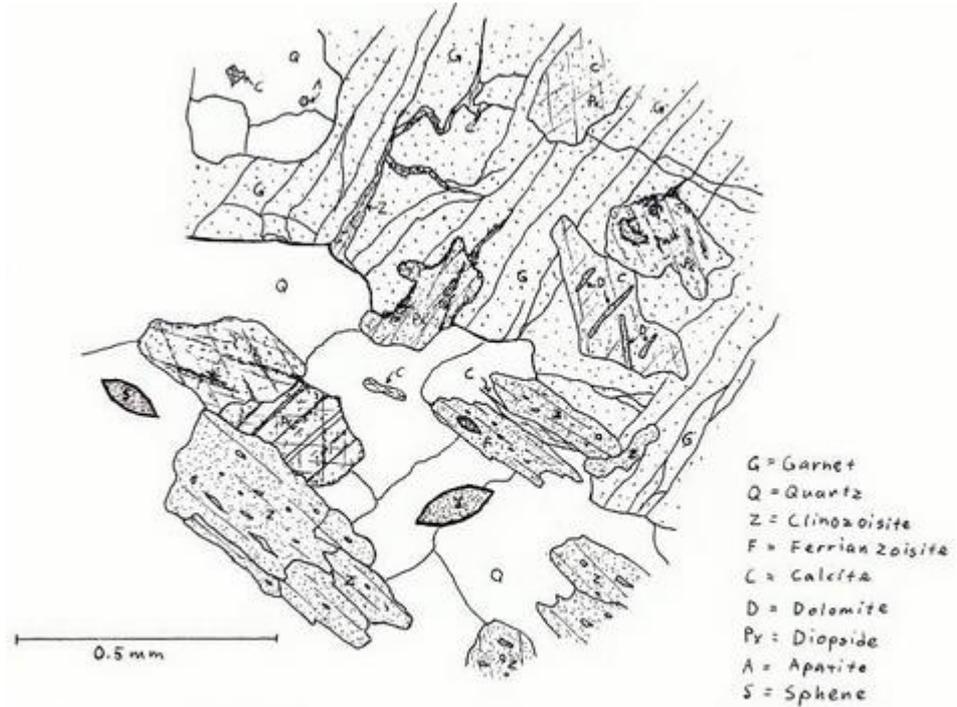
# Some beautiful sketch examples 1

<https://muse.union.edu/hollochk/kurt-hollocher/petrology/the-almost-forgotten-art-of-hand-drawings-in-petrology/>



Typical mineral relations,  
Olivine phenocryst rimmed  
by augite.

Hawaii alkali basalt.

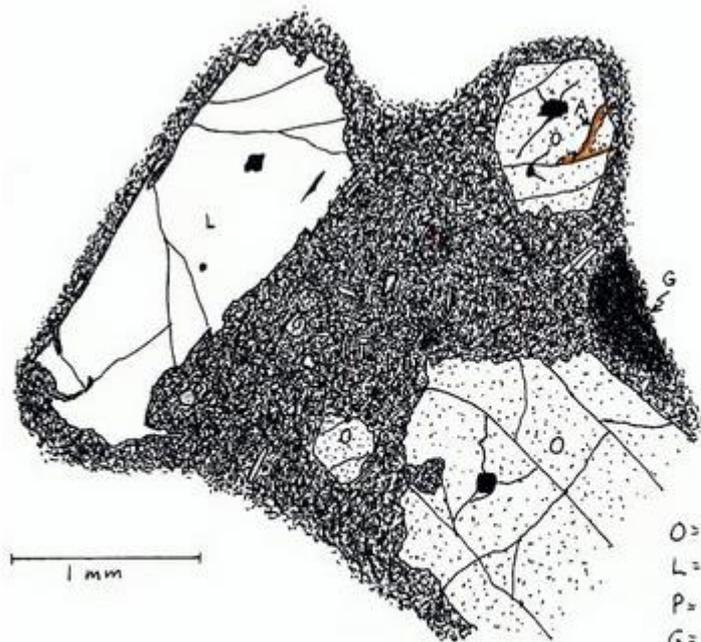


Typical mineral relations. Note filling of a crack  
in garnet with clinzoisite and calcite.

Amphibolite facies calc-silicate rock. Not very  
colorful, except in cross-polarized light.

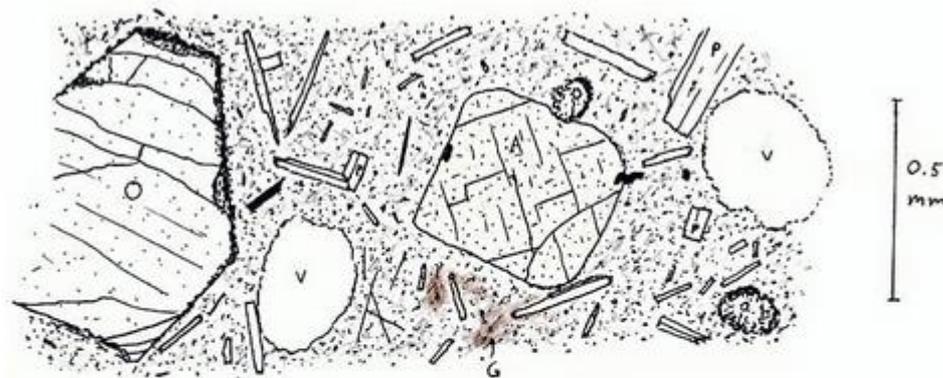
# Some beautiful sketch examples 2

<https://muse.union.edu/hollochk/kurt-hollocher/petrology/the-almost-forgotten-art-of-hand-drawings-in-petrology/>



- O = Olivine
- L = Labradorite
- P = Augite
- G = Glassy globule
- A = Goethite alteration
- = Hematite
- = Magnetite

Phenocrysts and microphenocrysts in a microcrystalline groundmass, slide HW-8A.



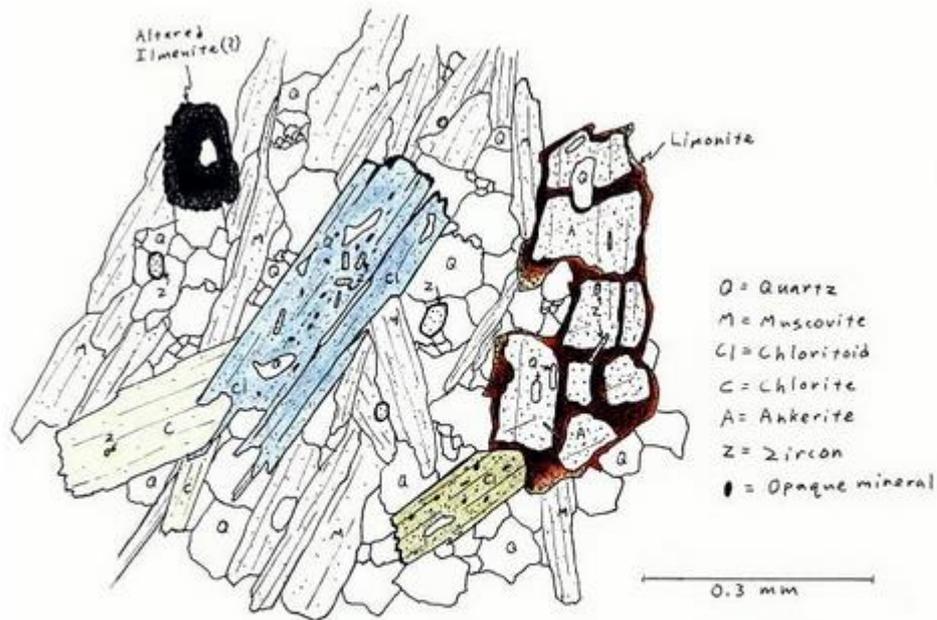
- O = Olivine
- A = Augite
- P = Plagioclase
- V = Vesicle
- G = Glass

Typical mineral relations in HW-9B. Note resorption of olivine and augite.

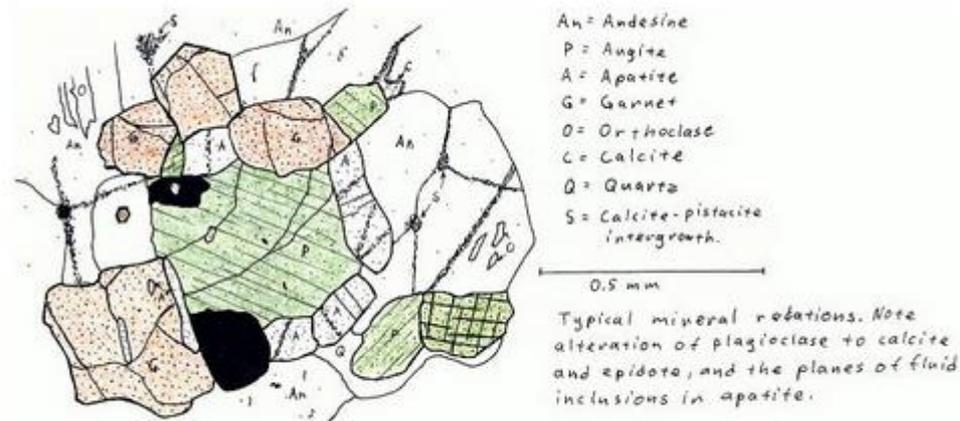
Hawaii olivine basalt.

# Some beautiful sketch examples 3

<https://muse.union.edu/hollochk/kurt-hollocher/petrology/the-almost-forgotten-art-of-hand-drawings-in-petrology/>



Typical Mineral relations. Note alteration of opaque mineral (ilmenite?) to a nearly opaque pseudomorph (leucoshe?), and ankerite to limonite. Also note sharp, unreacting contact between chloritoid and chlorite.

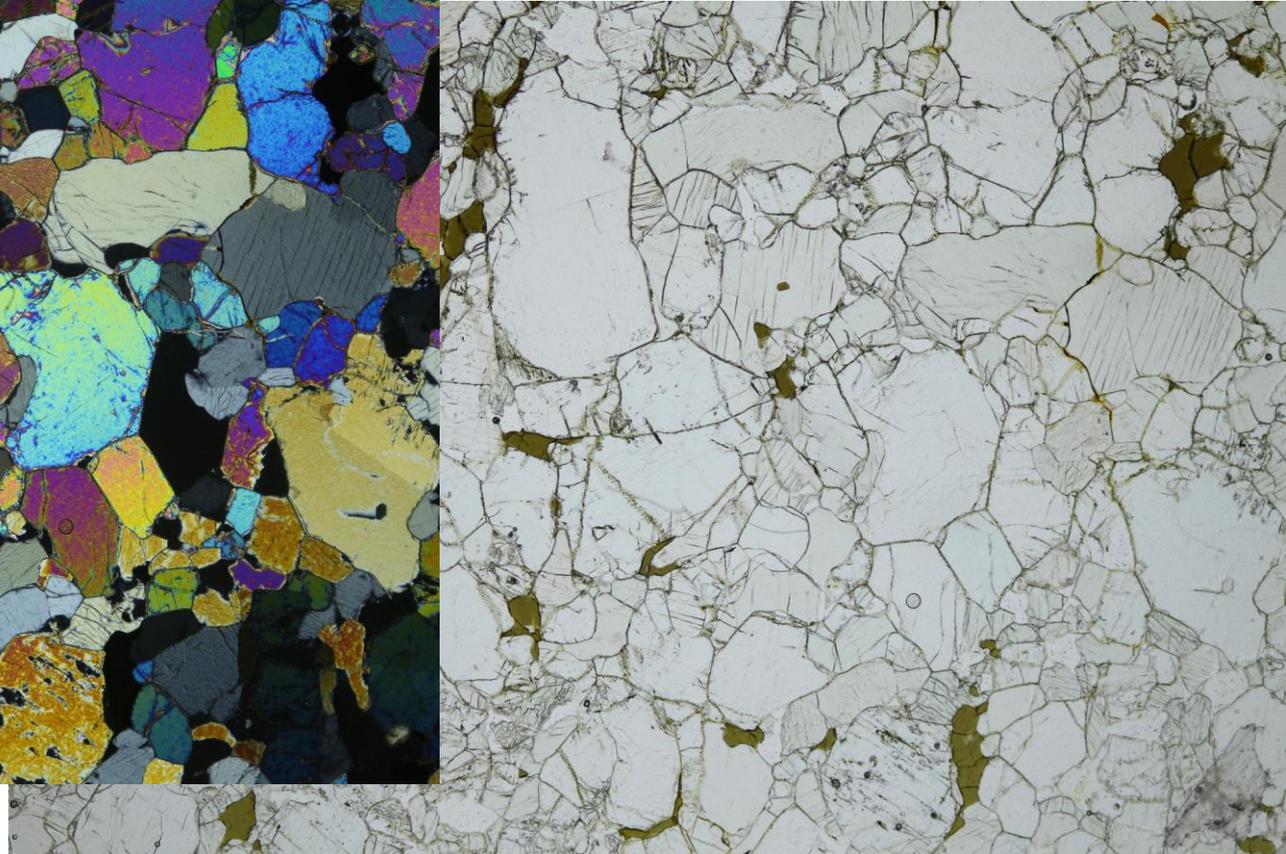
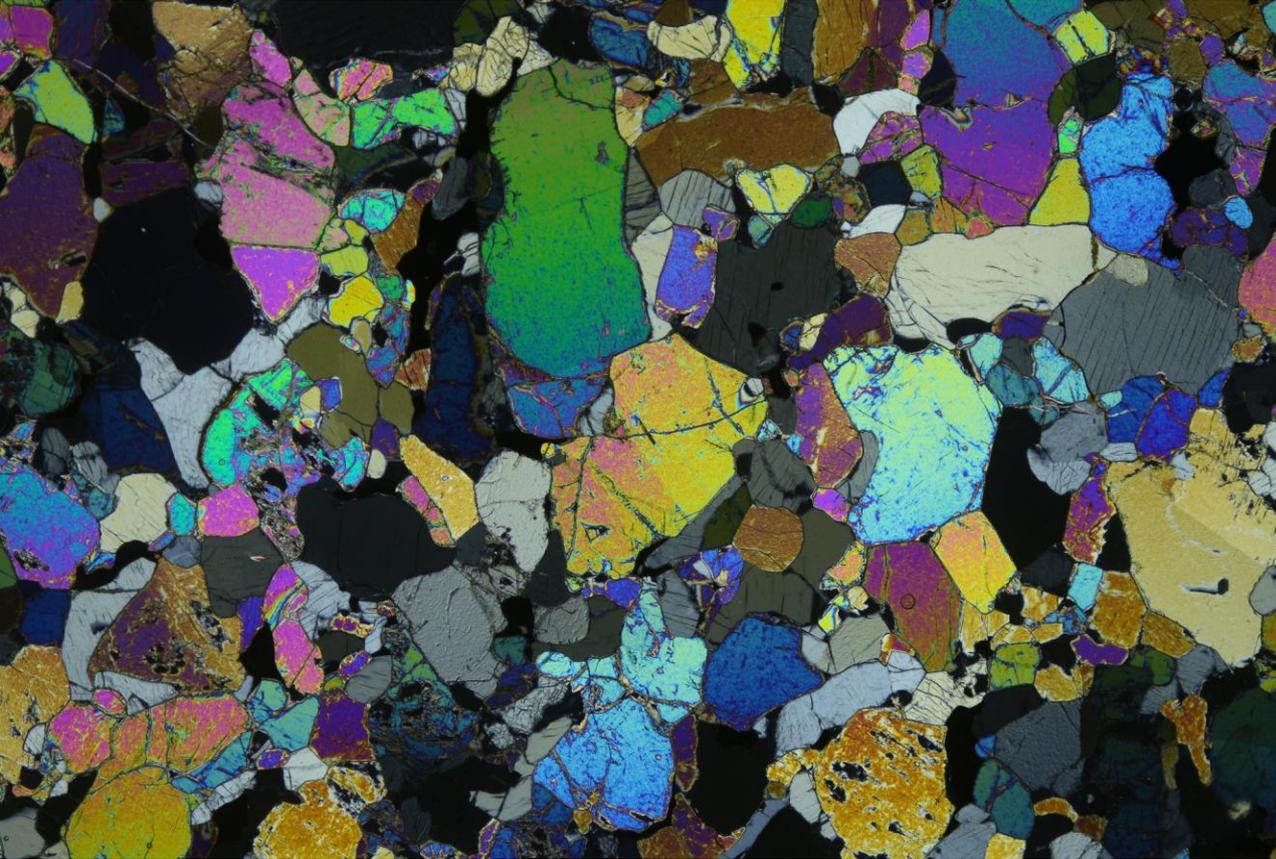


Typical mineral relations. Note alteration of plagioclase to calcite and epidote, and the planes of fluid inclusions in apatite.

Elizabethtown, NY. Two-pyroxene granulite (only one pyroxene illustrated here).

CHL. Greenschist facies chloritoid-chlorite-muscovite schist.

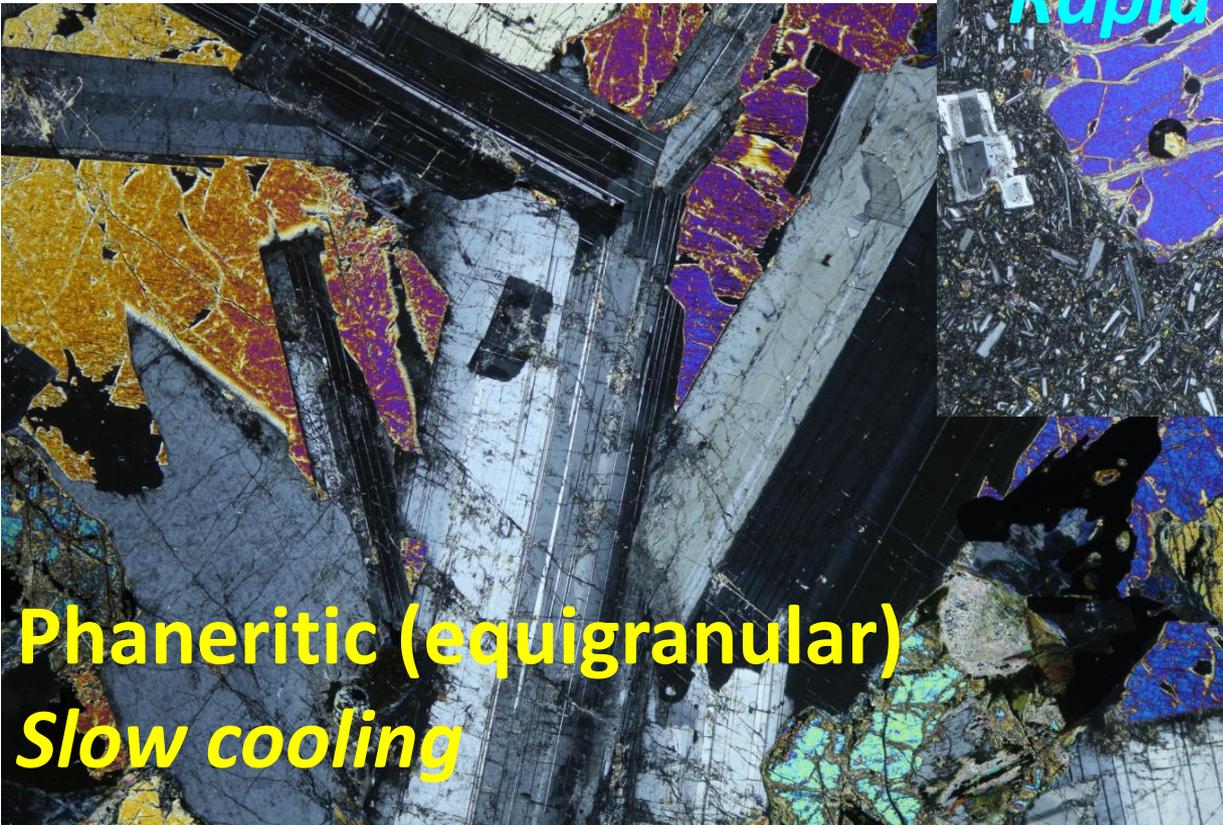
# Observation of Peridotite at Chanthaburi, Thailand





**Aphanitic:**  
**Phenocryst + matrix**  
**(groundmass)**  
*Rapid cooling*

This micrograph shows a dark, fine-grained matrix (groundmass) composed of small, angular crystals. Several larger, irregularly shaped phenocrysts are visible, some with distinct internal textures and colors (e.g., purple, yellow, and white), indicating they crystallized at a higher temperature than the matrix.



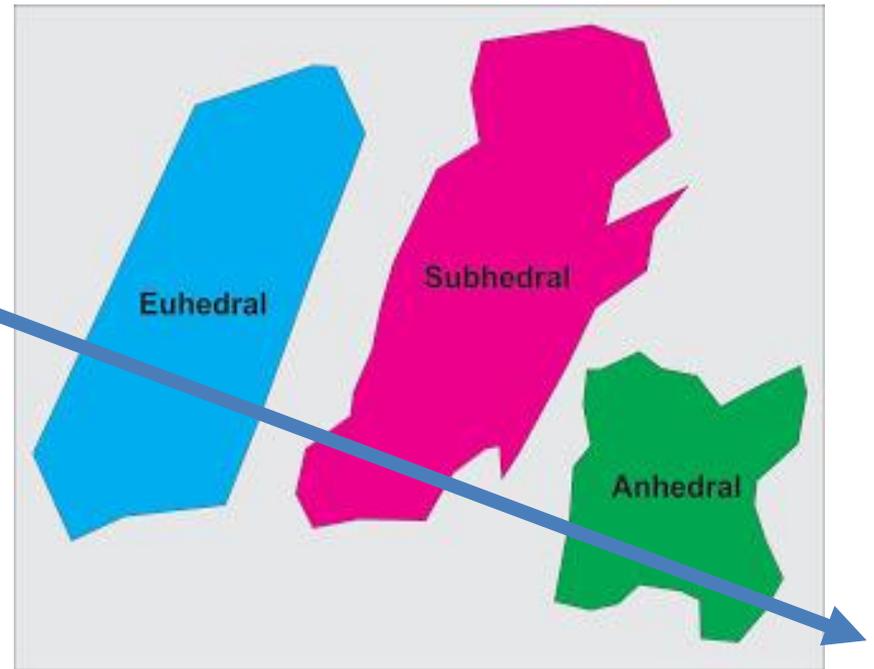
**Phaneritic (equigranular)**  
*Slow cooling*

This micrograph displays a coarse-grained texture with large, interlocking crystals of various colors (purple, yellow, and black). The crystals are roughly equigranular, meaning they have similar sizes, and are clearly visible against a lighter background, characteristic of slow cooling.

# Minerals under Polar-microscope Part1

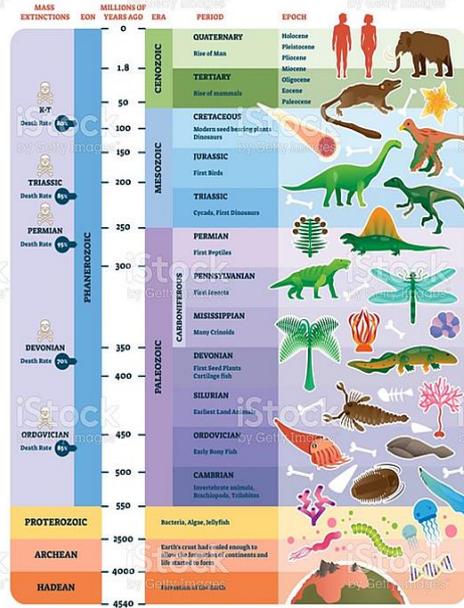
- Texture: volcanic (fine) or plutonic (coarse)
- Profile of minerals
- Euhedral
- Subhedral
- Anhedral

Order of  
Crystallization





# GEOLOGIC TIMELINE



<https://www.australianenvironmentaleducation.com.au/education-resources/the-geologic-timescale/>

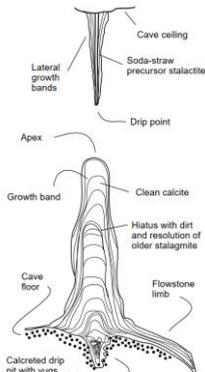
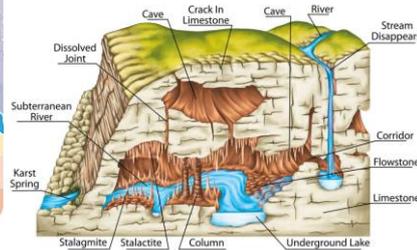


Figure 17.2 The internal structure of stalactite, stalagmite and flowstone.

Stein-Erik Lauritzen(2003)



<https://www.nckri.org/caves/types/>

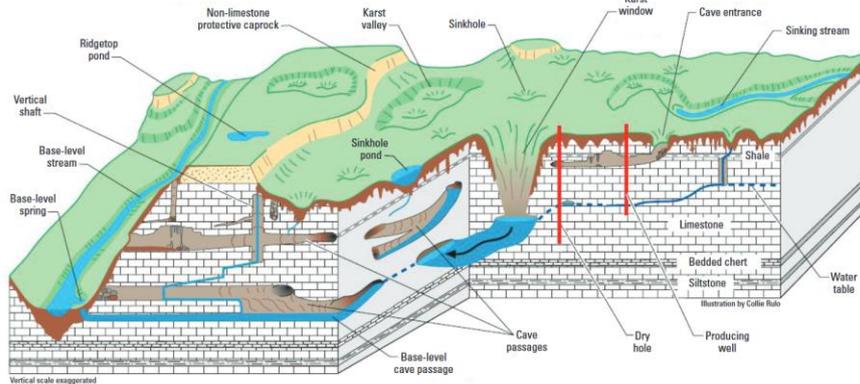
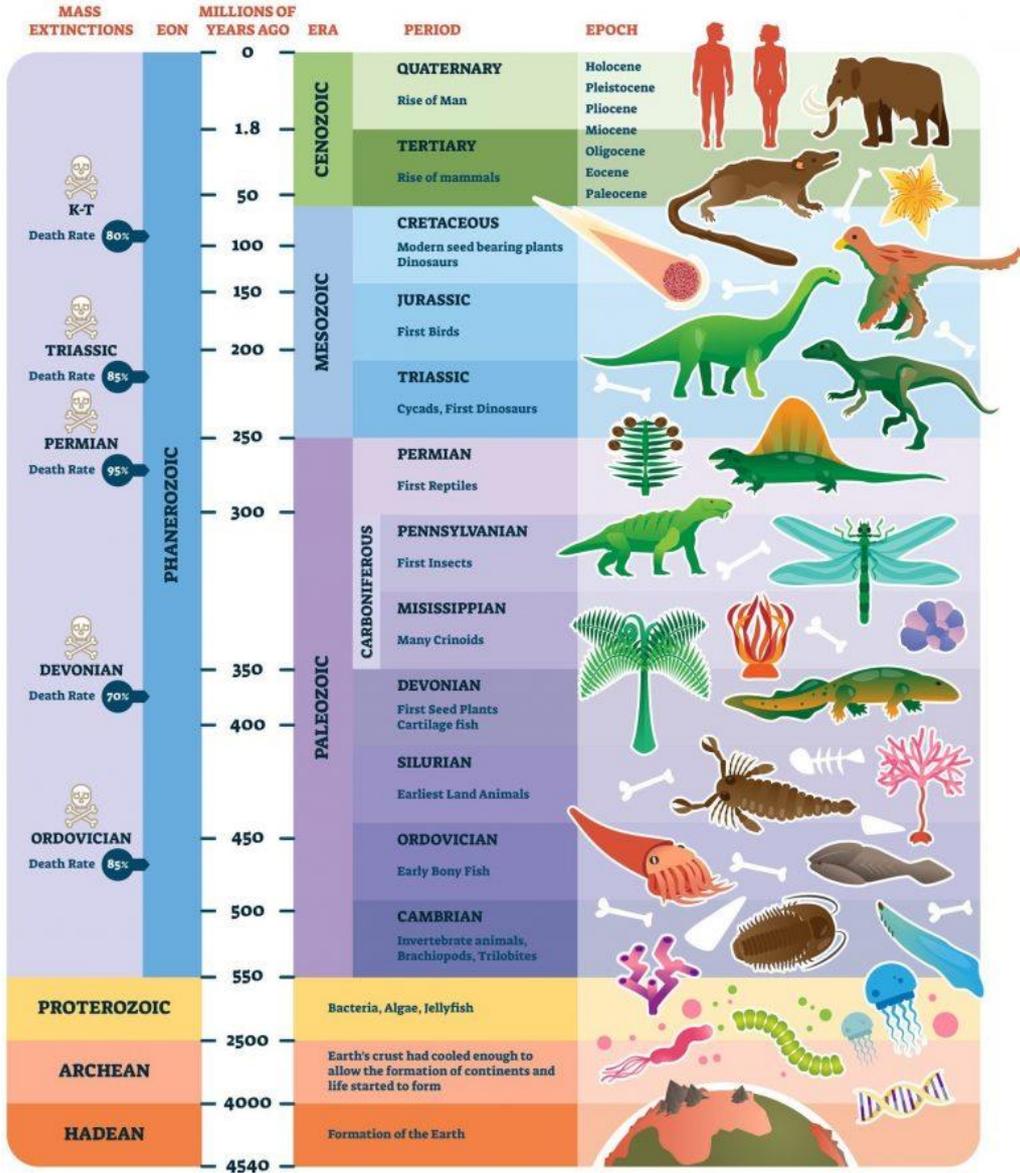


Figure 1. Physiographic and hydrologic features typical of a well-developed karst terrane (modified from Currens, 2001, Kentucky Geological Survey, used with permission).

<https://pubs.usgs.gov/tm/04d02/pdf/TM4-D2-chap3.pdf>

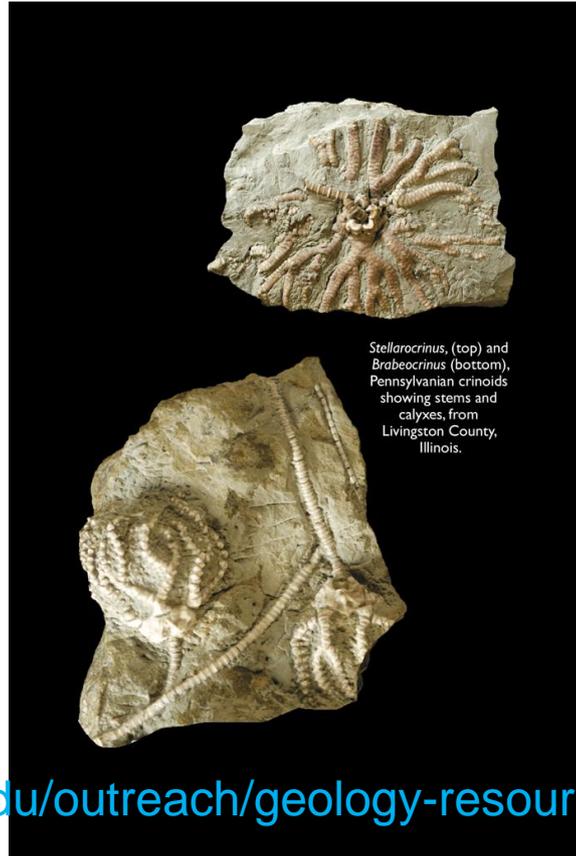


Carboniferous to Permian  
Limestone of  
Orange color

# Fossils of the limestones

## Crinoid

## Fusulina



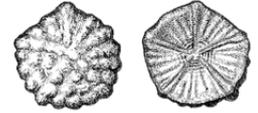
### CRINOIDS



*Talarocrinus* 1x



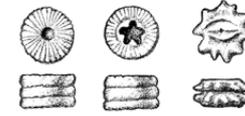
*Pisocrinus* 1x



*Ethelocrinus* 2/3x



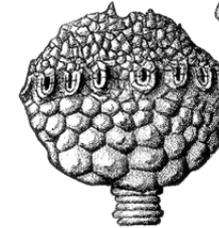
*Clathrocrinus* 1 1/2x



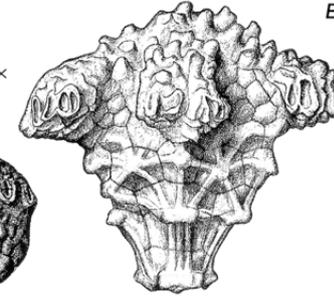
crinoid columnals



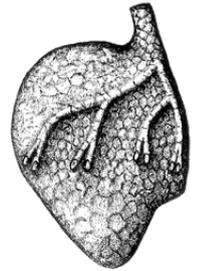
*Eucalyptocrinites* 2/3x



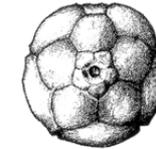
*Megistocrinus* 1x



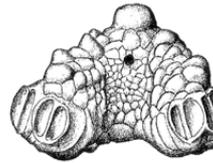
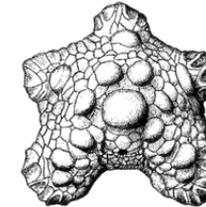
*Actinocrinus* 2/3x



*Siphonocrinus* 1x



*Barycrinus* 2/3x



*Agaricocrinus* 2/3x

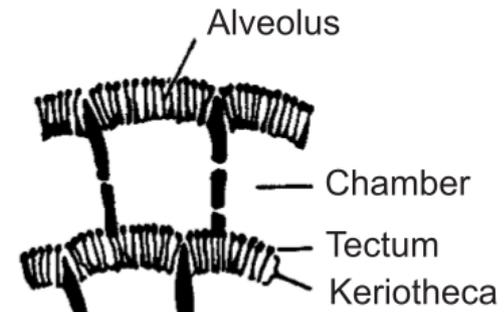
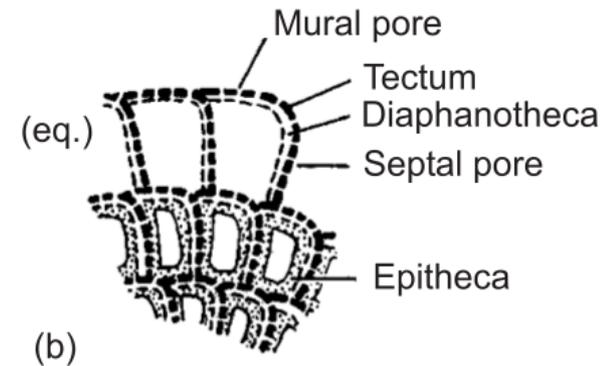
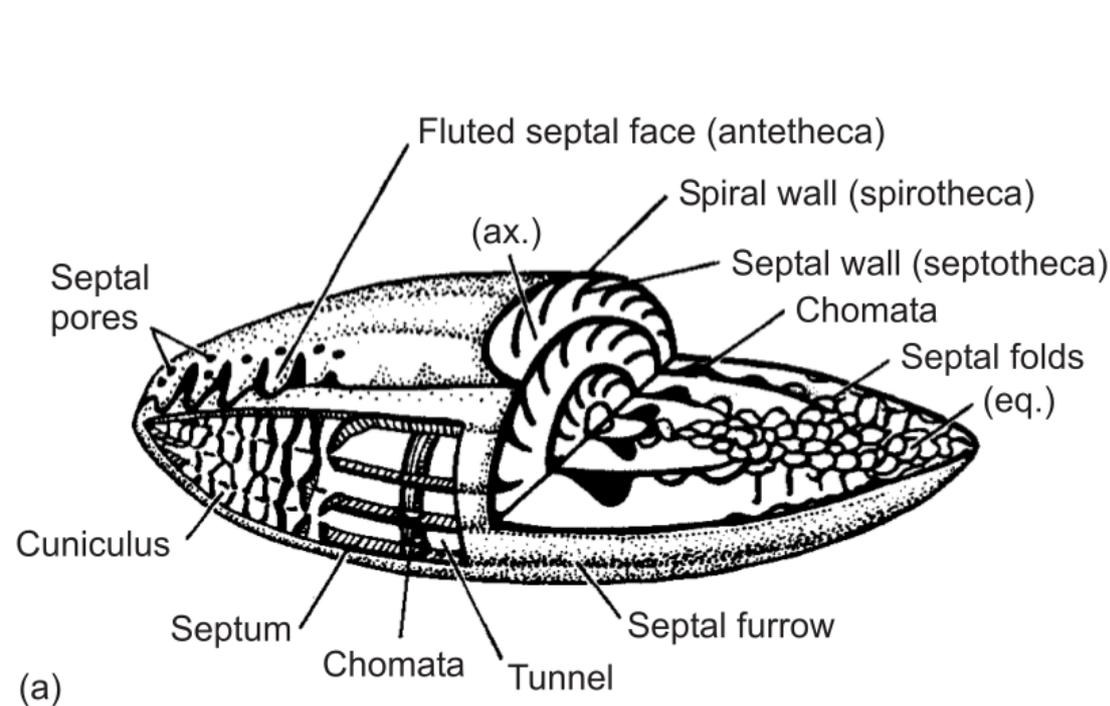


*Rhodocrinites* 2/3x

# Fusulina inner structure

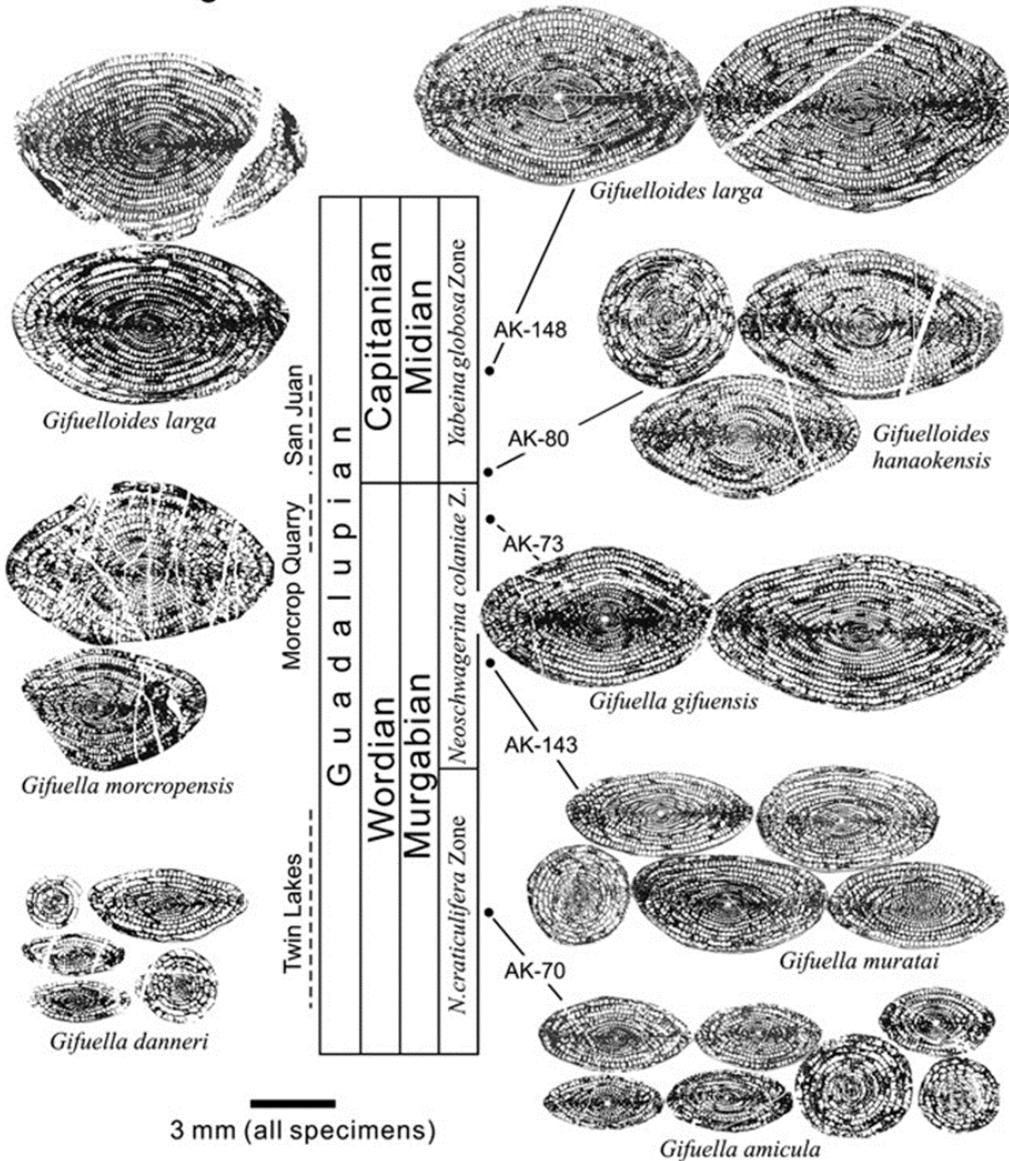
## A kind of plankton

168 Part 4: Inorganic-walled microfossils



# Washington

# Akasaka

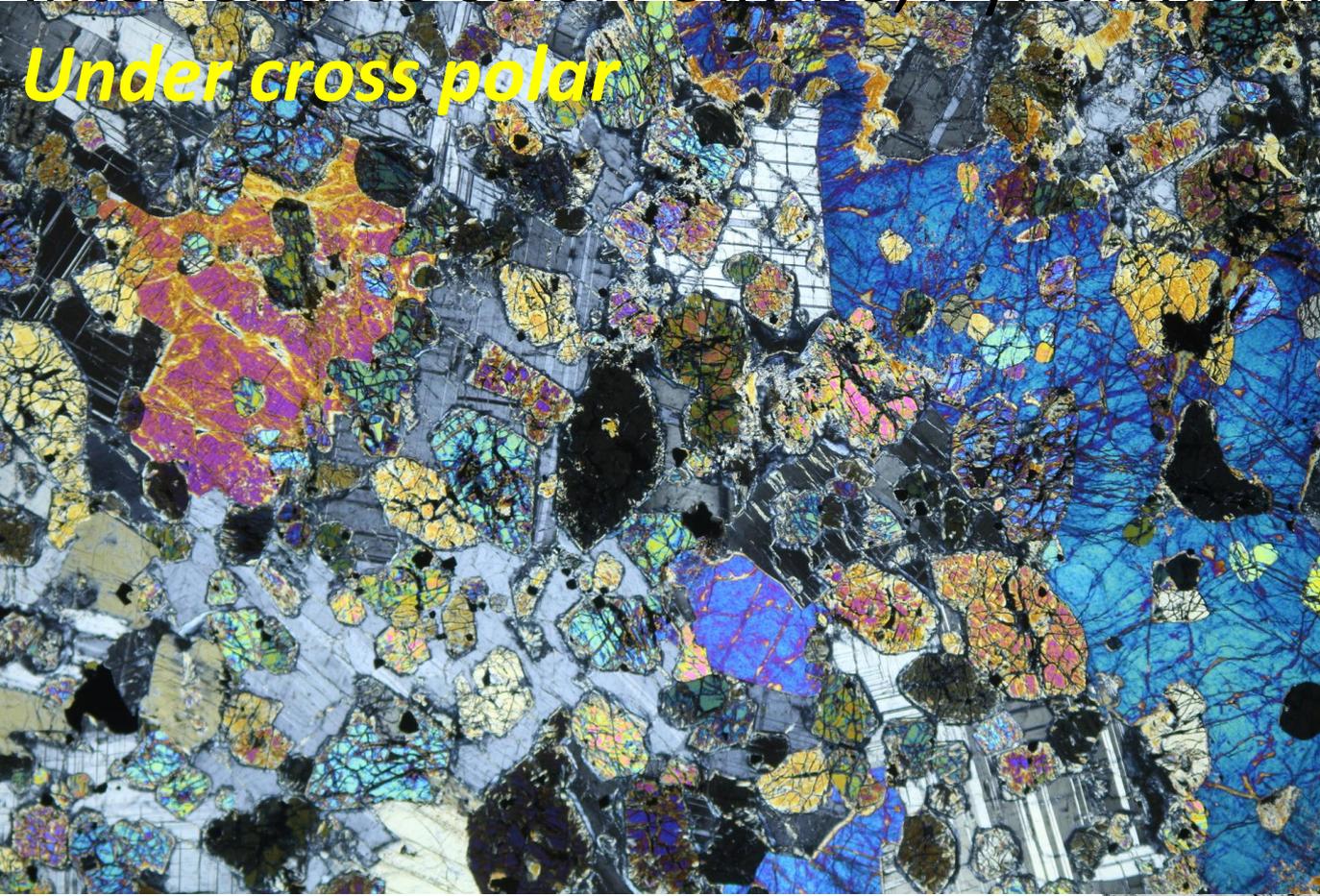


# Minerals under Polar-microscope Part2

- Refraction index (Becke line): Olivine, Pyroxene,
- Garnet,
- Cleavages: Plagioclase, Biotite, Hornblende
- Pleochroism(Open): Biotite, Hornblende
- Interference color(Cross): Olivine, Pyroxene, ,  
Muscovite
- No light (Cross)→ Garnet, Glass, opaque minerals

# Interference color: Olivine, Pyroxene, Muscovite

*Under cross polar*



*Under open polar*



Part 2:

Volcanic ash (Garden soil) observation

# Volcanic ash (Garden soil) observation



**Lazada** ค้นหาในลาซาด้า

เก่งใน inspired | ชุดหน้าจ้อ oppo a74 | กาแฟสด boncafe | ยางติดบั้งโค่น | เคสหูwainova 8i

หมวดหมู่ ▾ LazMall

อุปกรณ์ภายนอกและตกแต่งสวน > สนามหญ้าและสวน > ดิน, ปุ๋ย และอุปกรณ์เพาะชำ > AKADAMA ดินญี่ปุ่น อะคาตามะ ดินบอนไซ วัสดุปลูก ไรยหน้า

**ดินญี่ปุ่น AKADAMA**

Size 1-3mm. Size 3-6mm.

500g.

ส่งไว!  
จาก กทม.

**49.-**

**ราคาแนะนำ**

**AKADAMA ดินญี่ปุ่น อะคาตามะ ดินบอนไซ วัสดุปลูก ไรยหน้า**

★★★★★ 25 คะแนน

แบรนด์: No Brand | เห็นเต็ม สนามหญ้าและสวน จาก No Brand in TH

**฿43.00**  
จะเริ่มภายใน 2 วัน 18:17:39

**฿45.00**

**12.12** เซลใหญ่  
ส่งท้ายปี

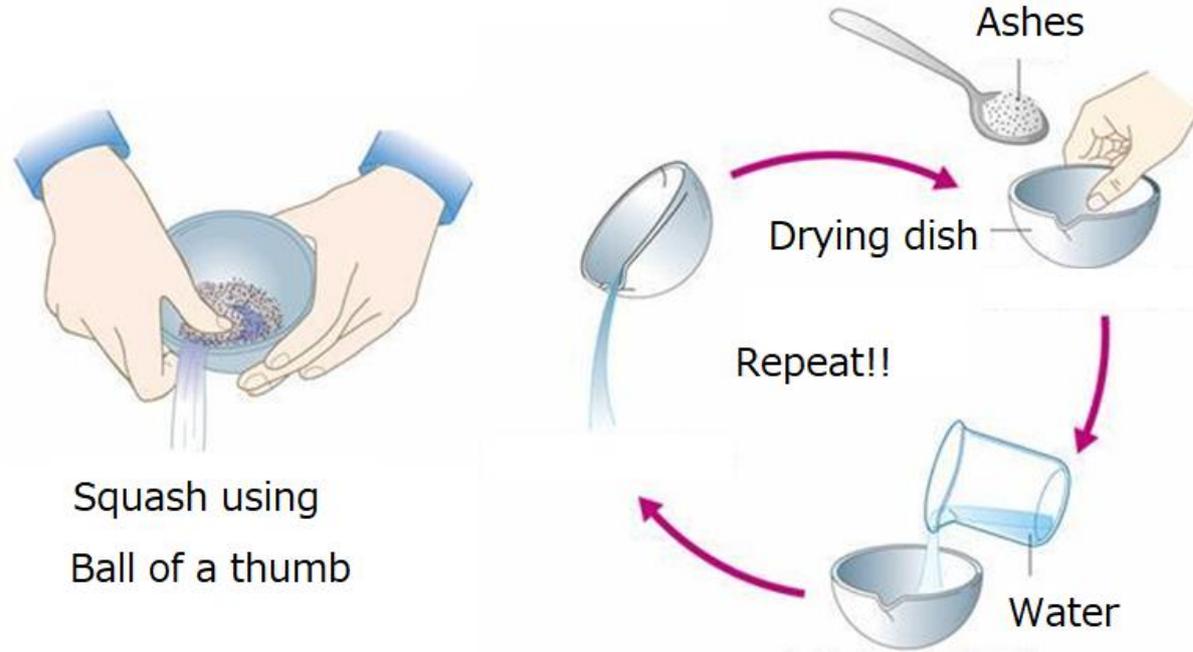
ขนาด เล็ก(1-3mm.) 500g.

เล็ก(1-3mm.) 500g. กลาง(3-6mm.) 500g. เล็ก(1-3mm.) 2kg.

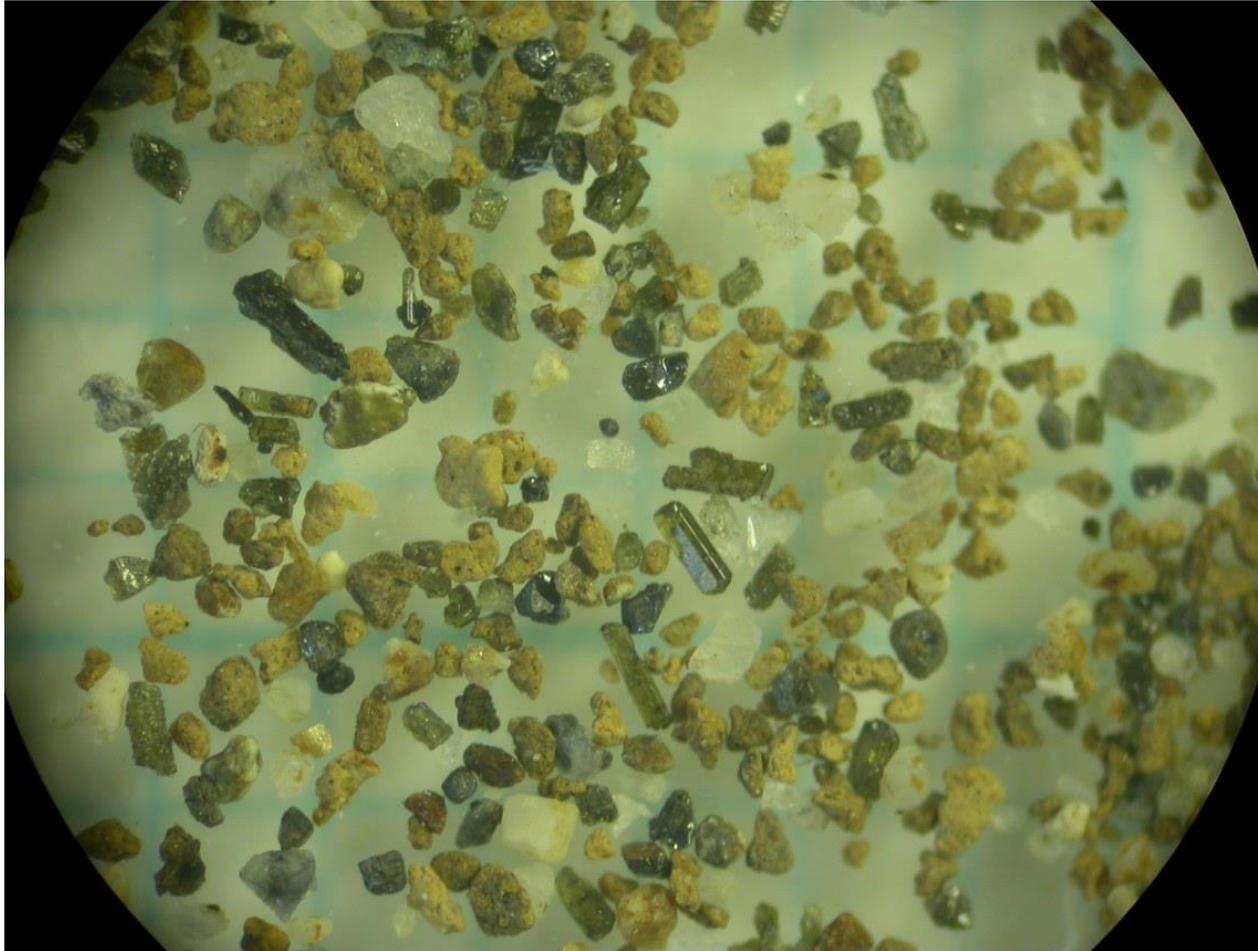
กลาง(3-6mm.) 2kg.

# Wash up dirty soils

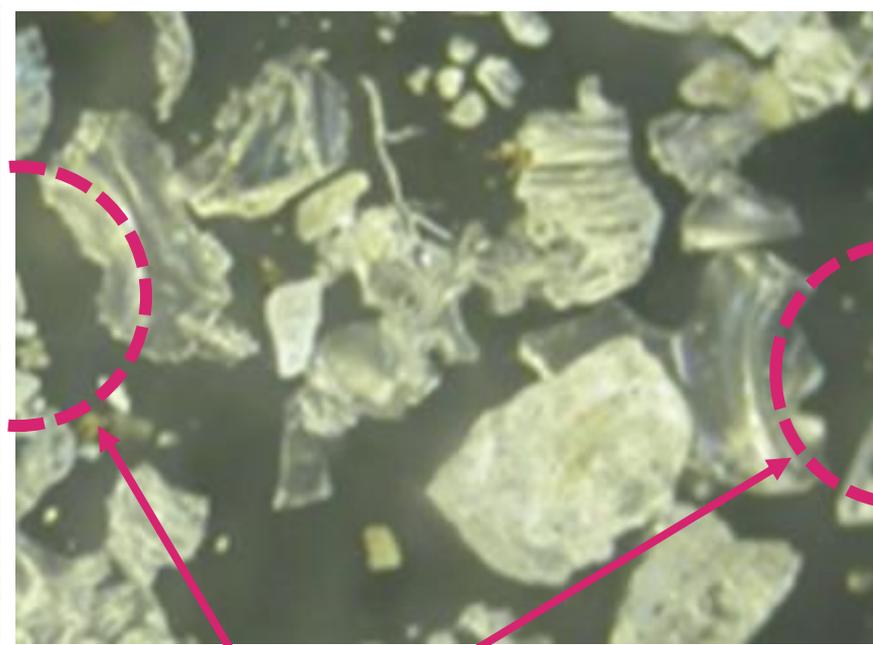
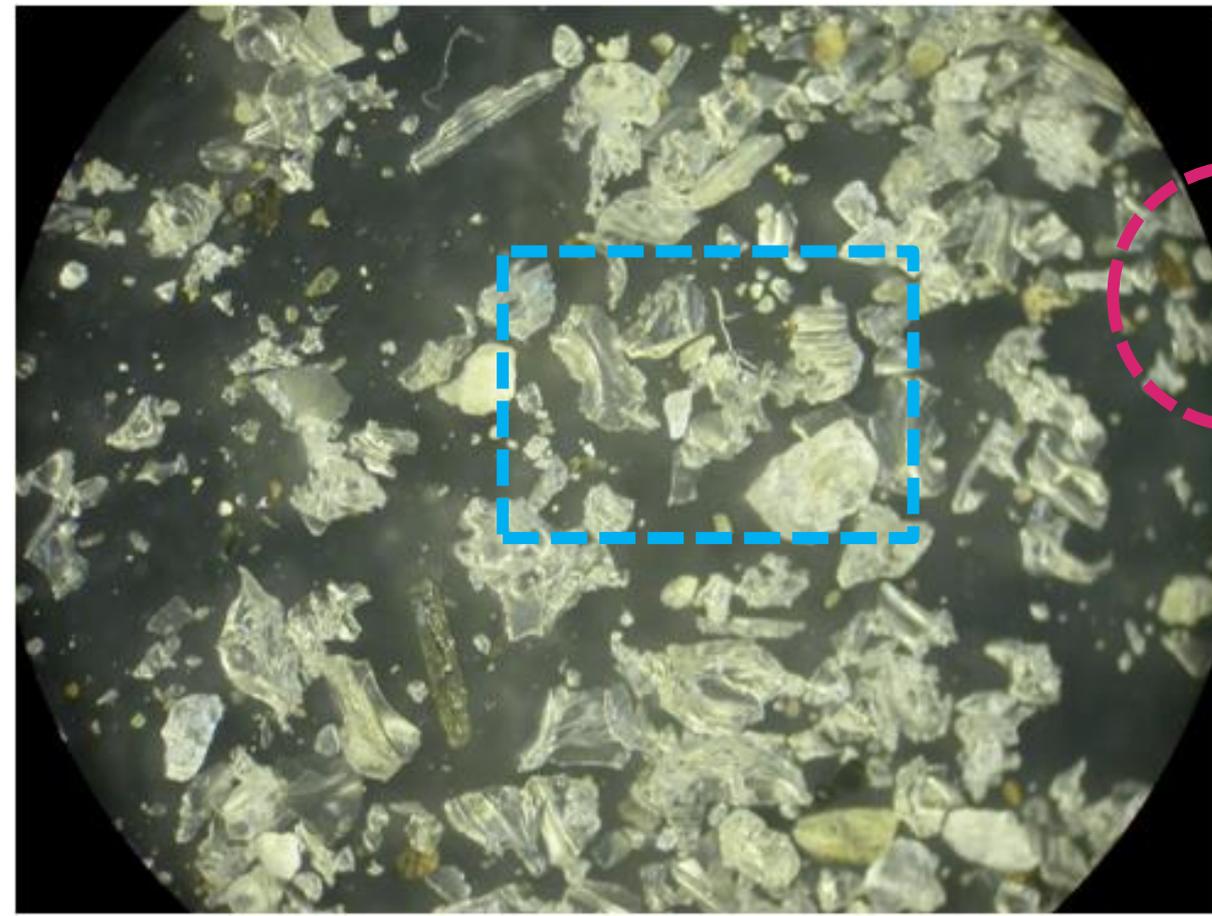
Preparation of volcanic ashes and soils for microscope observation



<Akatama-tsuchi: Kanto Roam> purchased from DIY shop as a plant soil Hyperion augite, hornblende, magnetite, rock fragments (background blueline: 1mm span, view area 8mm)



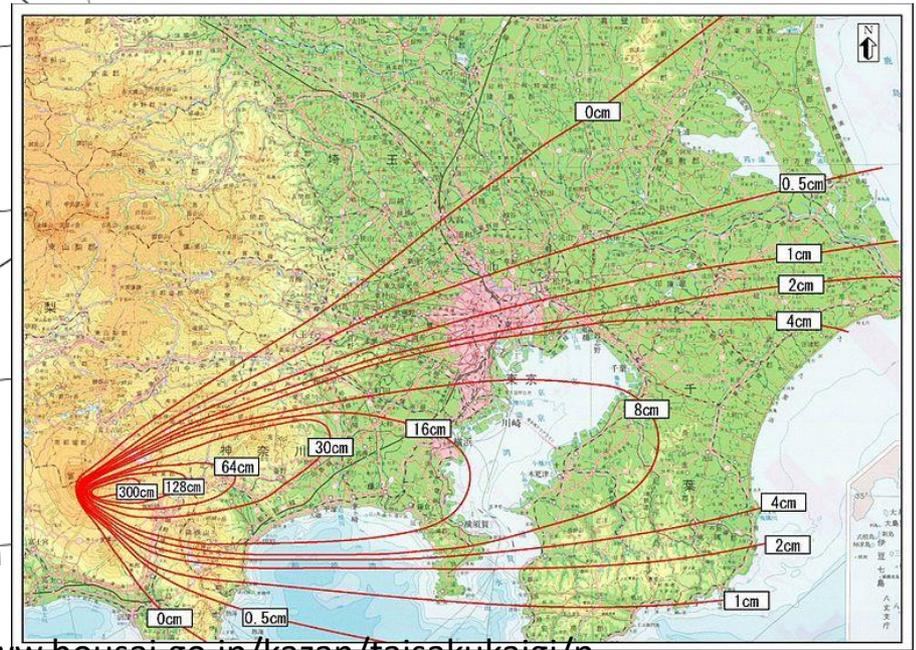
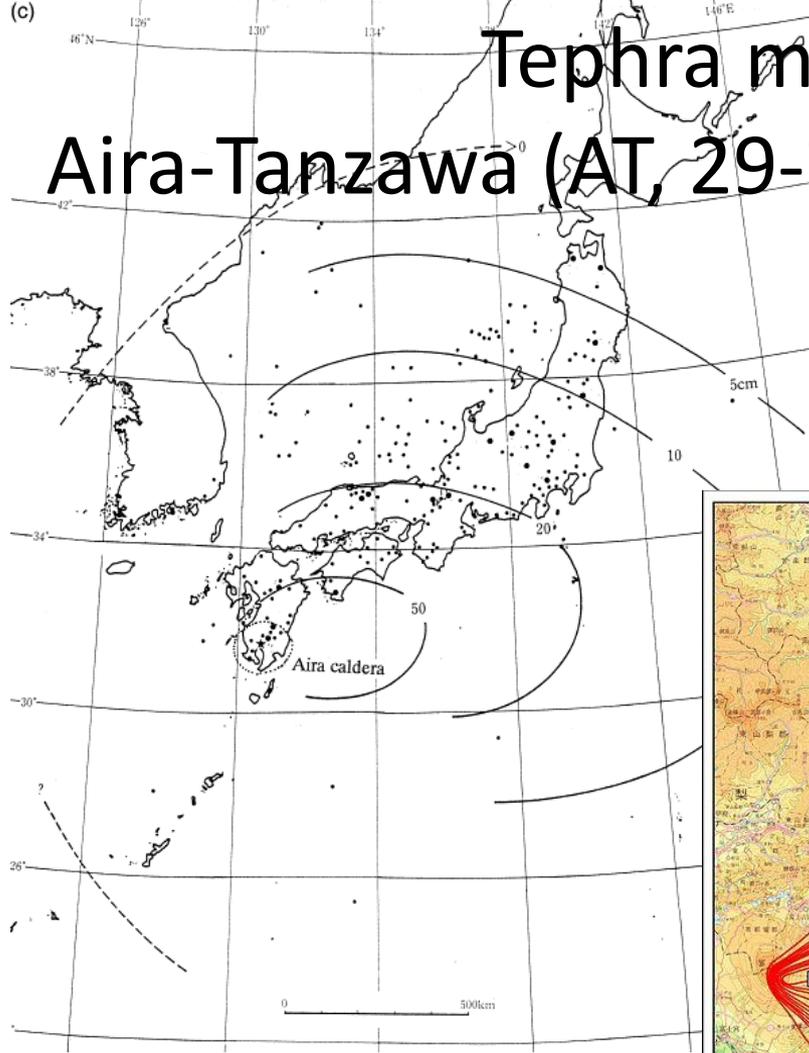
<Ara-Tanzawa volcanic ash: **AT volcanic ash**> in Mt. Aso Kumamoto Pref. Japan (same scale) Bubble walls of **volcanic glass** are significant. The expansion of this ash covers the large area of western Japan and Honsyu even northern end of Amomori. Important key bed of 2.5Ma. and is called a typical distal tephra.



Air bubble ->  
"Bubble wall" structure

# Tephra map in Japan

## Aira-Tanzawa (AT, 29-26ka) & Mt. Fuji (1707)



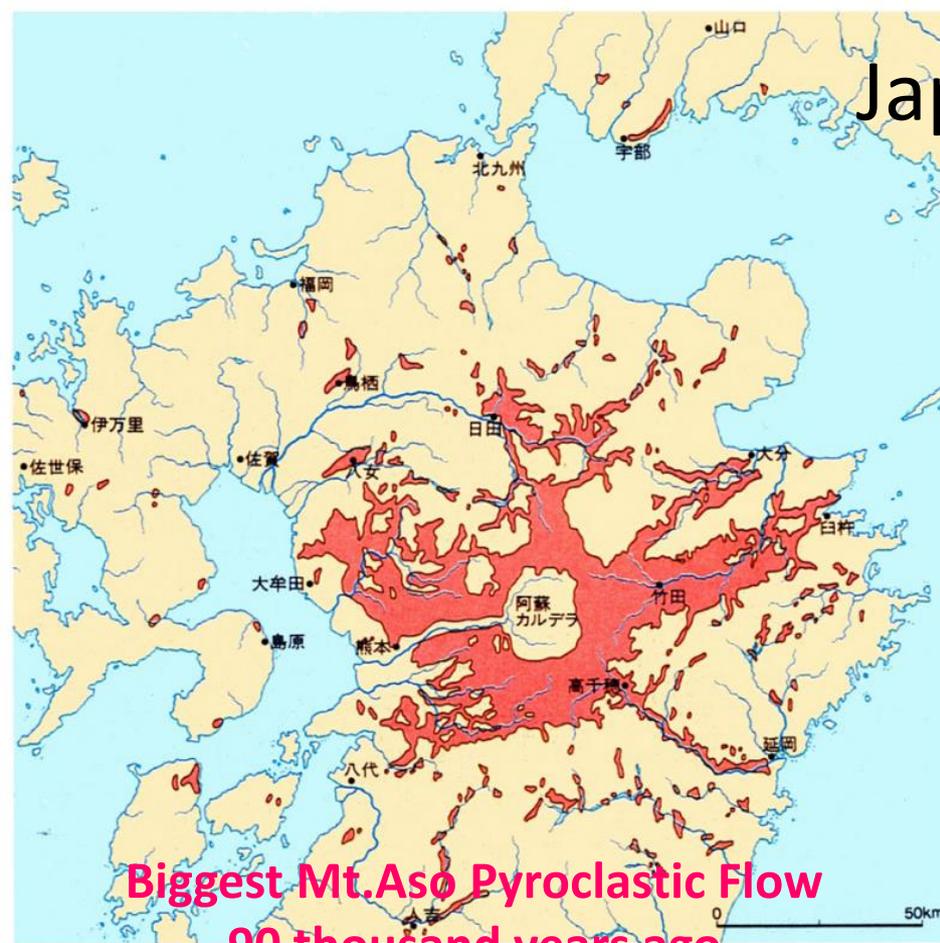
<http://www.bousai.go.jp/kazan/taisakukaigi/pdf/dai1kai/20150904siryo2.pdf>

「富士噴火による降灰分布図」  
出典：富士山火山防災協議会 資料  
<http://www.bousai.go.jp/fujisan-kvouzukai/>

# Akahoya Tuff (7300 ya) in Mt. Aso



Japan had some huge size volcanic eruptions in the past!



**Biggest Mt. Aso Pyroclastic Flow  
90 thousand years ago**

【図3】阿蘇4噴火の火砕流の分布

出典：大木・小林,「日本の火山」1987より

<http://bunarin.lolipop.jp/bunarin.lolipop/bunarintokodaisi/kitaminaminojilyounonn/marukihune/5/kaidokikankiyo.html>

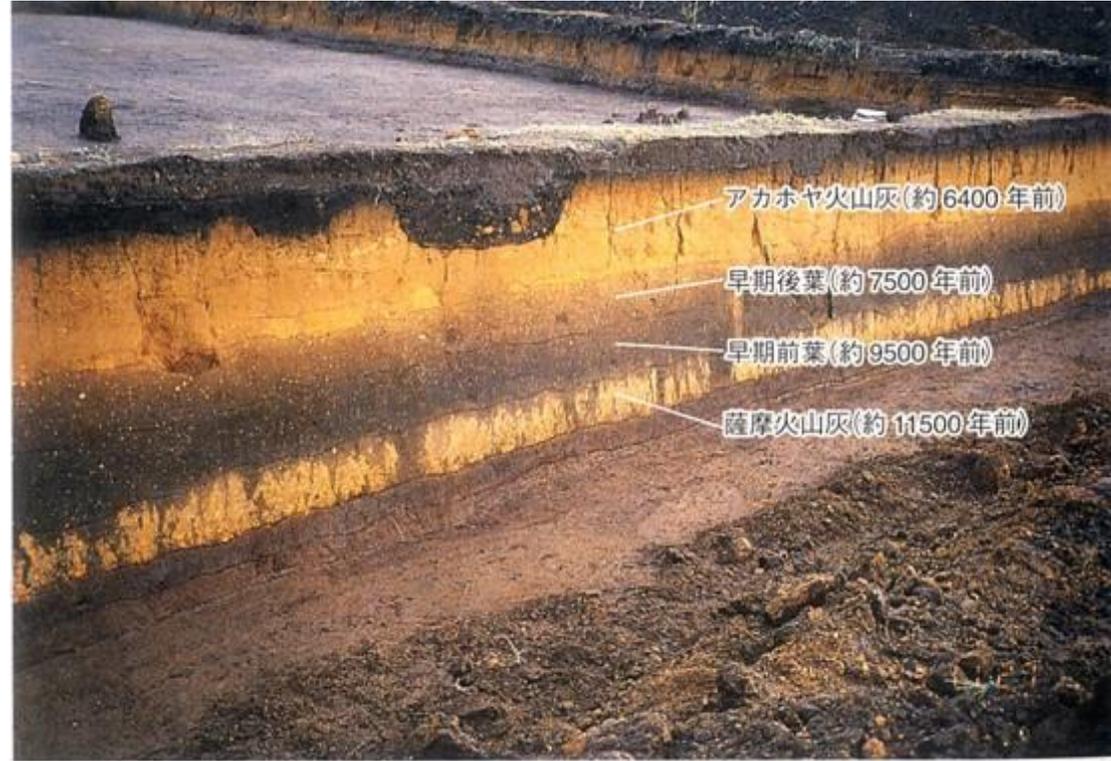
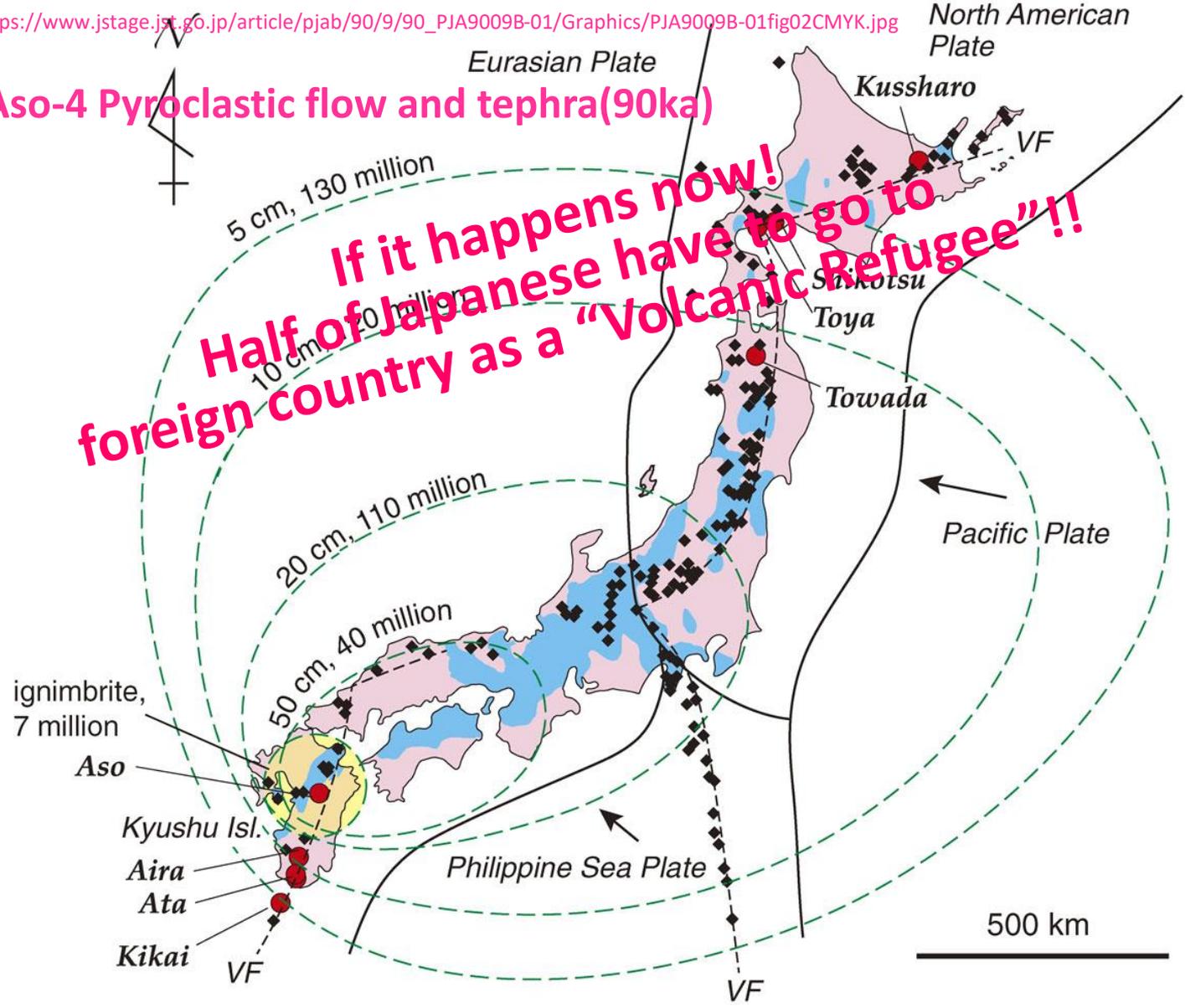


図 17 ● 上野原遺跡の地層写真

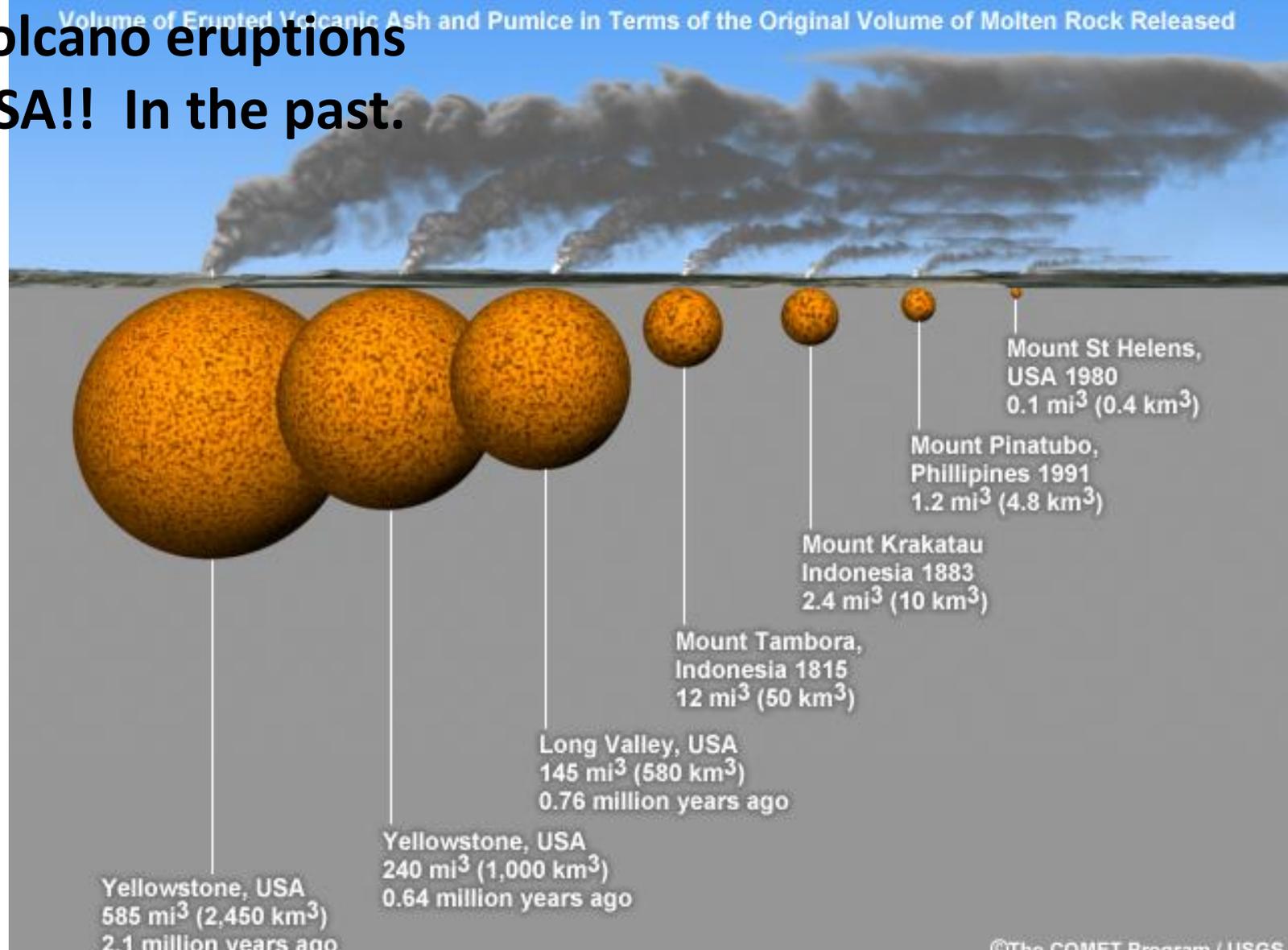
上野原遺跡ではアカホヤ火山灰 (5 層) と薩摩火山灰 (10 層) の間に、縄文時代早期後葉と前葉の 2 文化層が発見されている。薩摩火山灰 (10 層) 以下の生活は確認されていない。

# Aso-4 Pyroclastic flow and tephra(90ka)

**If it happens now!  
Half of Japanese have to go to  
foreign country as a "Volcanic Refugee"!!**

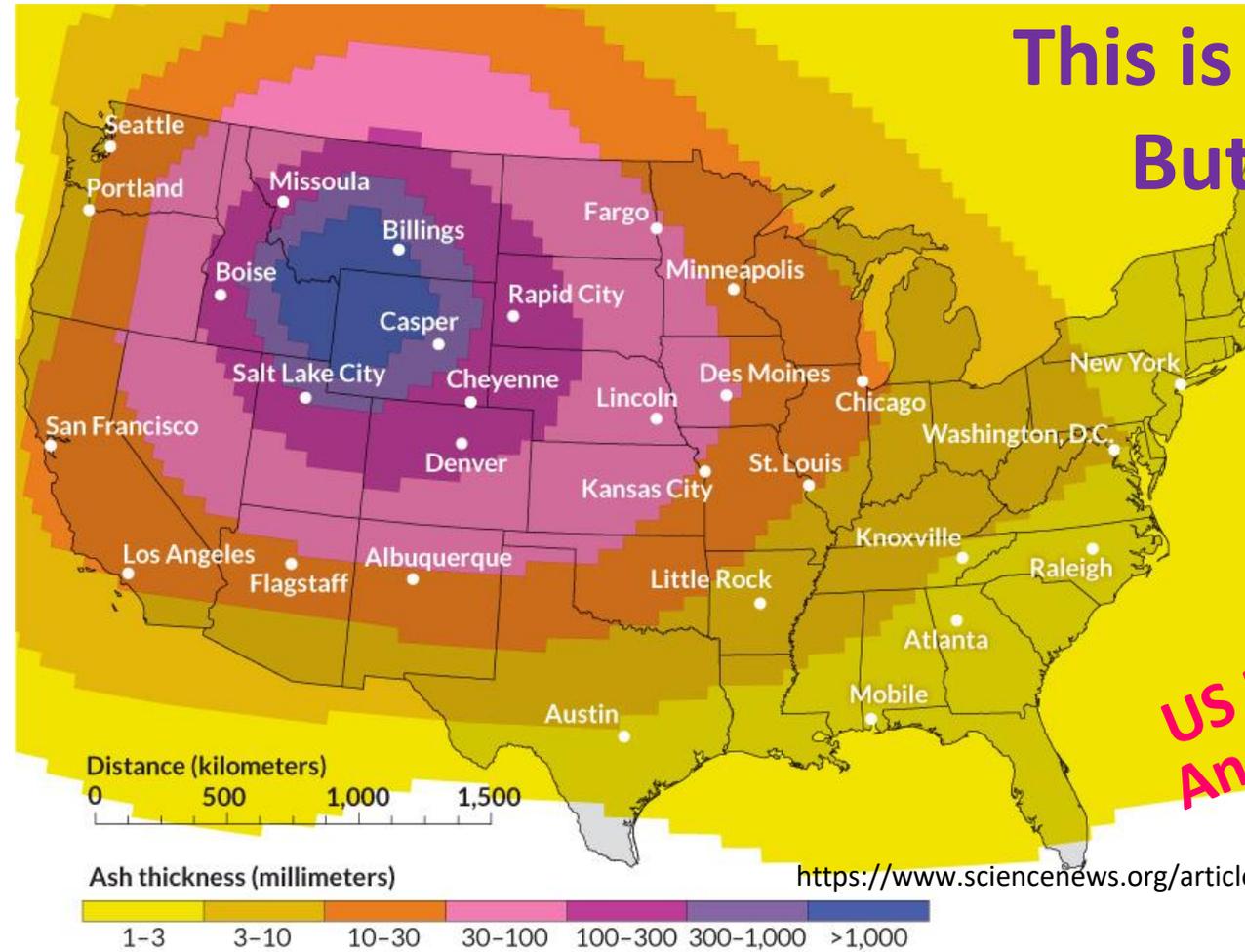


Most of huge volcano eruptions happened in USA!! In the past.



If it happens; A half of Americans become  
“Volcanic refugee”!!

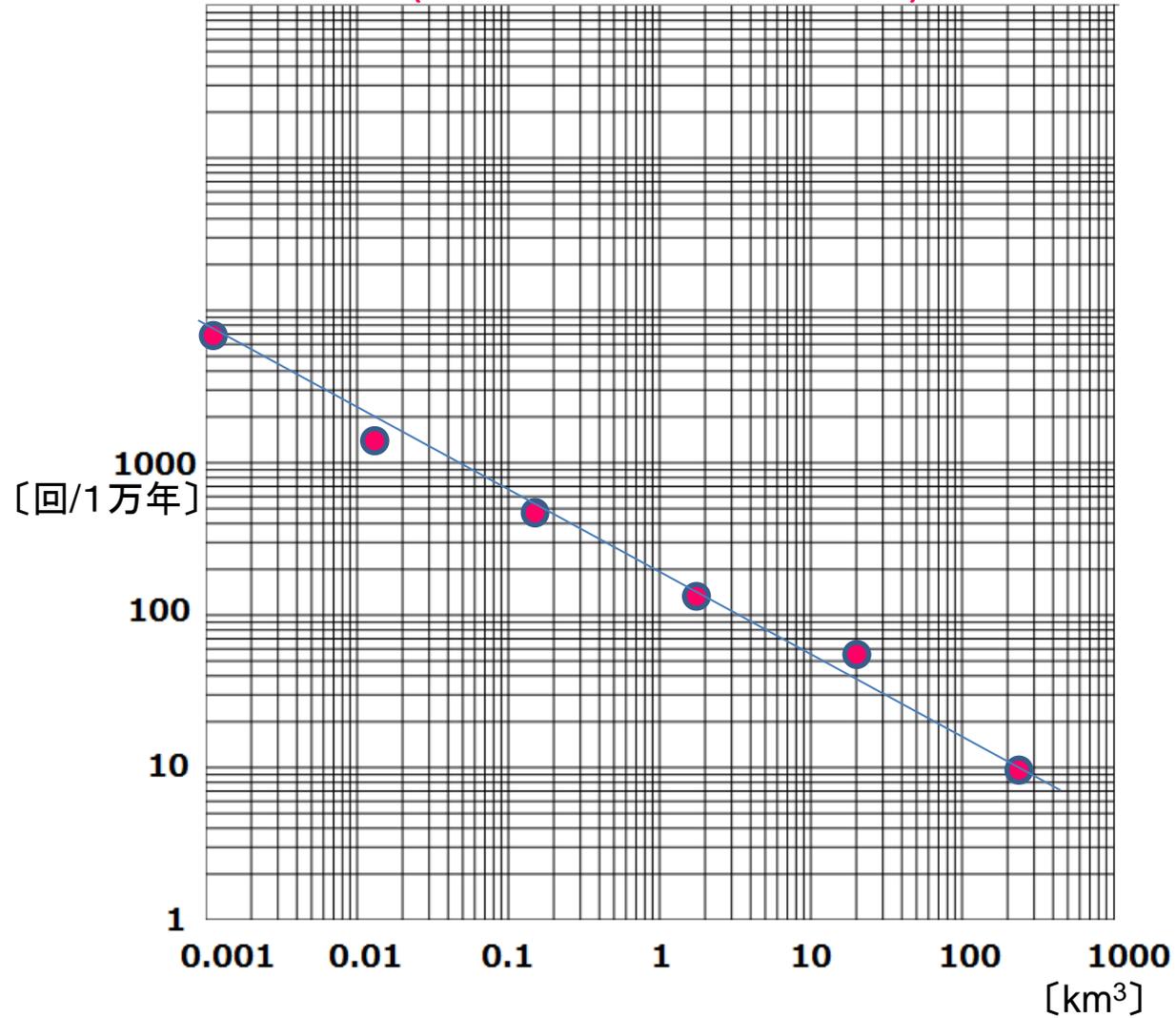
**This is not a scientific fiction  
But a geological fact!!**



**US President has to ask to Mexico  
And Canada; Acceptance of them!!**

<https://www.sciencenews.org/article/supervolcano-blast-would-blanket-us-ash>

# Frequency vs. size of eruptions (Smithsonian Institution)



I suppose in  
your country  
some volcanic  
ash layers are  
found!

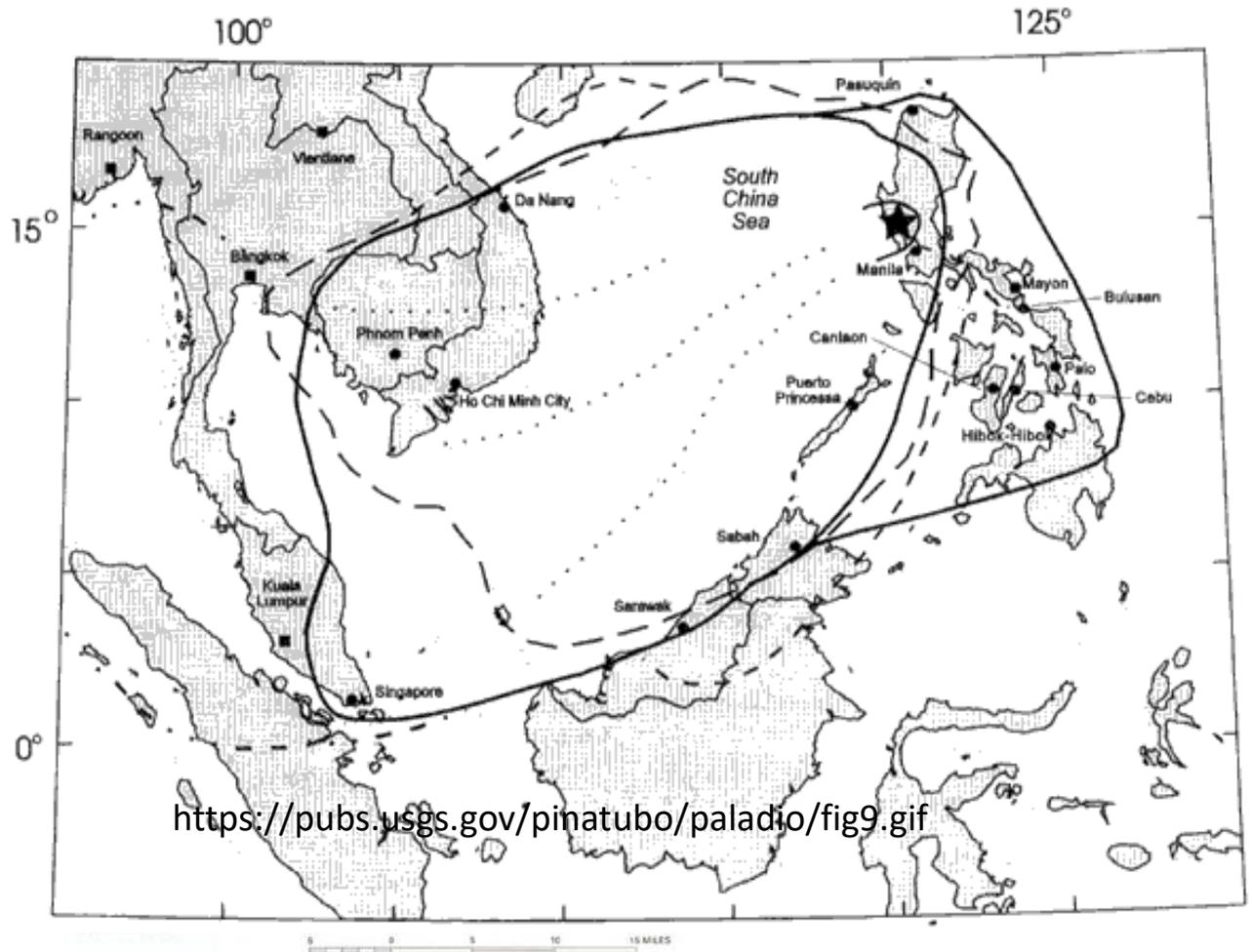
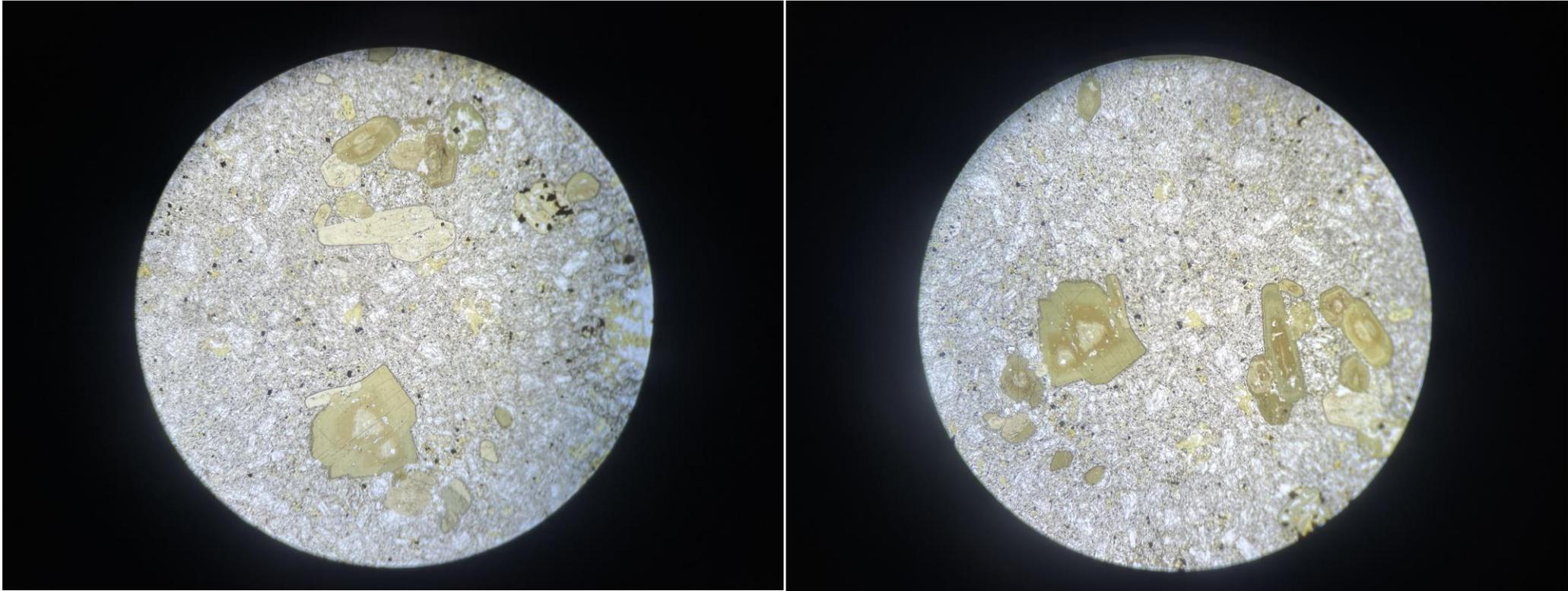


Figure 7. Distribution of tephra-fall deposits of the climatic eruption of June 15 (phase VI of Wolfe and Hoblitt, this volume), layer C, and locations of sections (triangles) sampled for grain-size and component data. KAK is location of section sketched in figure 1. Isopachs are in centimeters; sources of data as in figure 3, but open circles show total thickness of section (in centimeters), which may also include layers A and (or) B. (Umbal & Rodolfo, 1996)

# Mineral characteristics in thin-section

Pleochroism (Open polar): Biotite, **Hornblende**



Refraction index (Open polar): **Olivine**, Pyroxene,  
**Garnet**

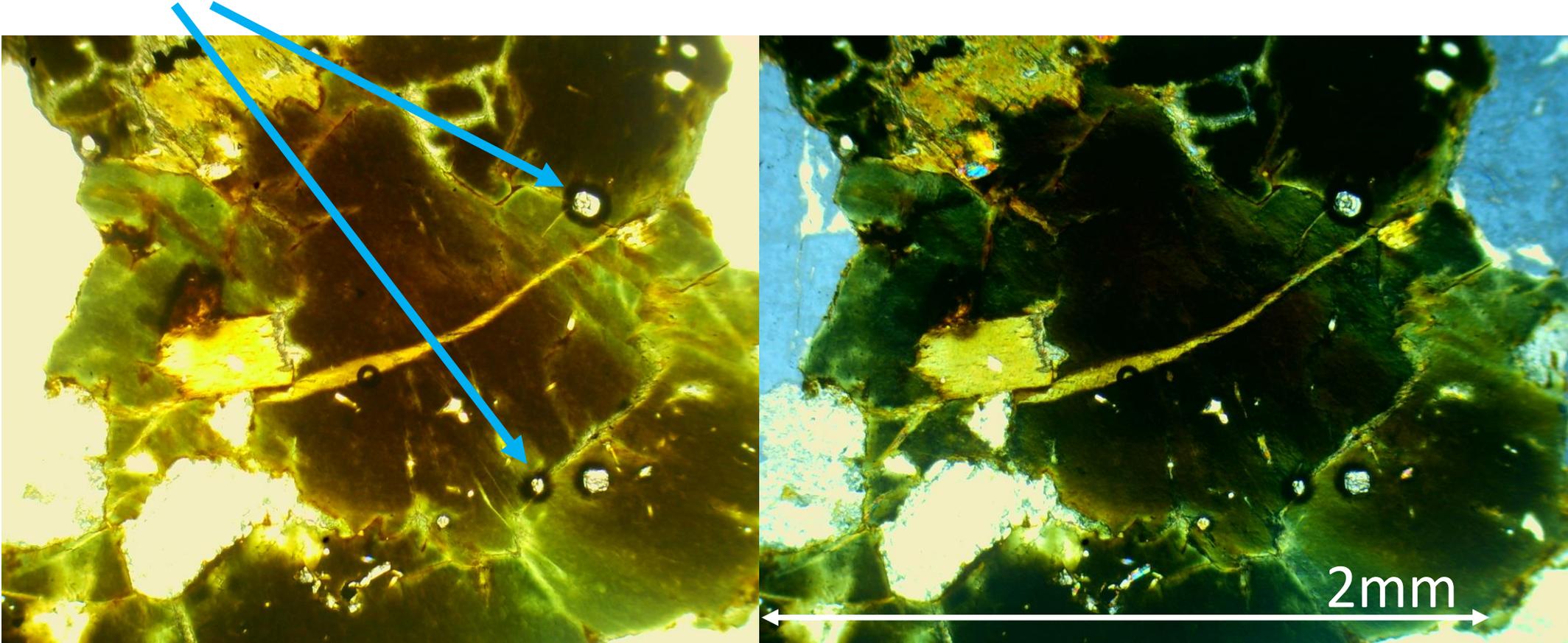


Yet another mineral

They can not show in the lecture.

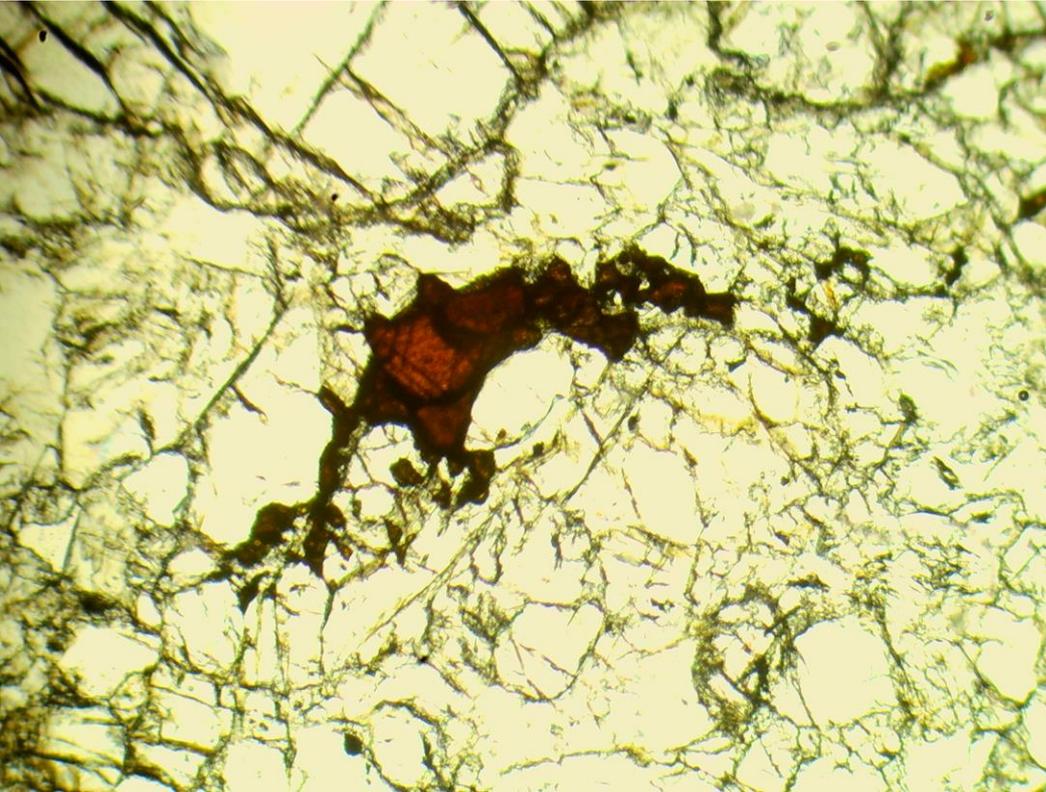
# Yet another tiny minerals

Zircon in Biotite (Radiation halo)



# Yet another tiny minerals

Rutile in Eclogite



Spinel in Gabbro



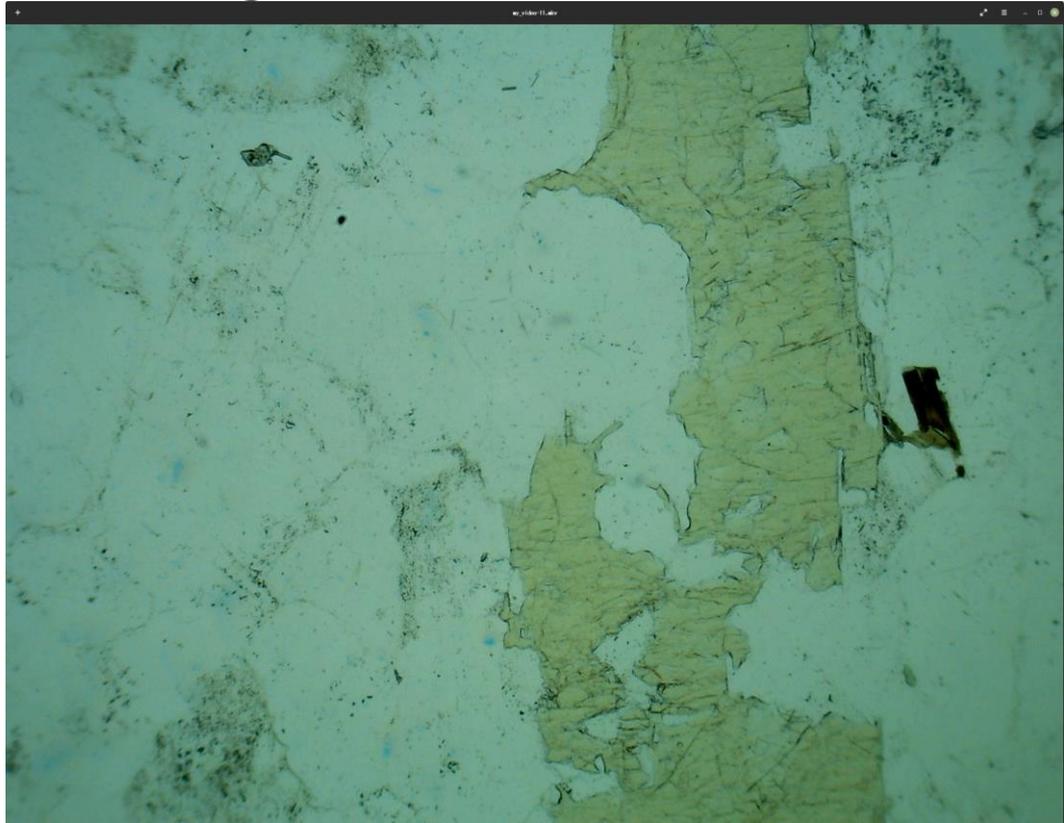
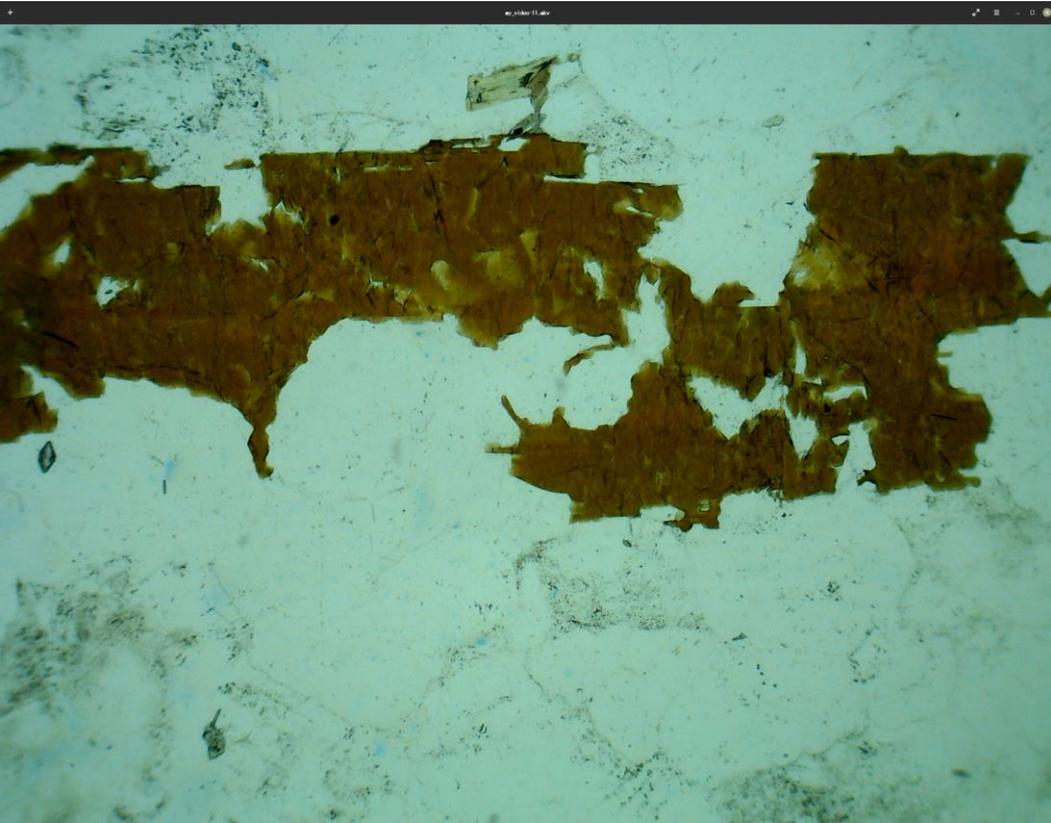
# Other minerals

Tourmaline Granite

Dark

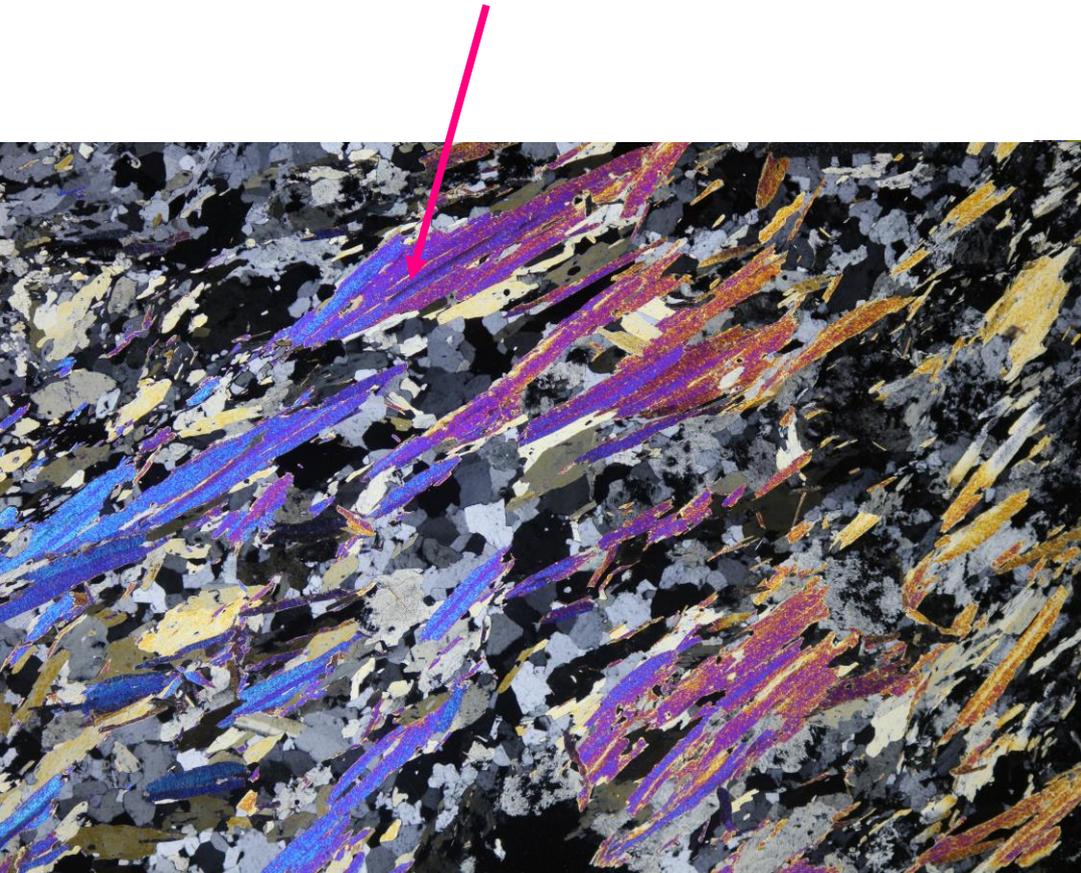


Light



# Other minerals

Muscovite in Schist



Zoisite in Schist

