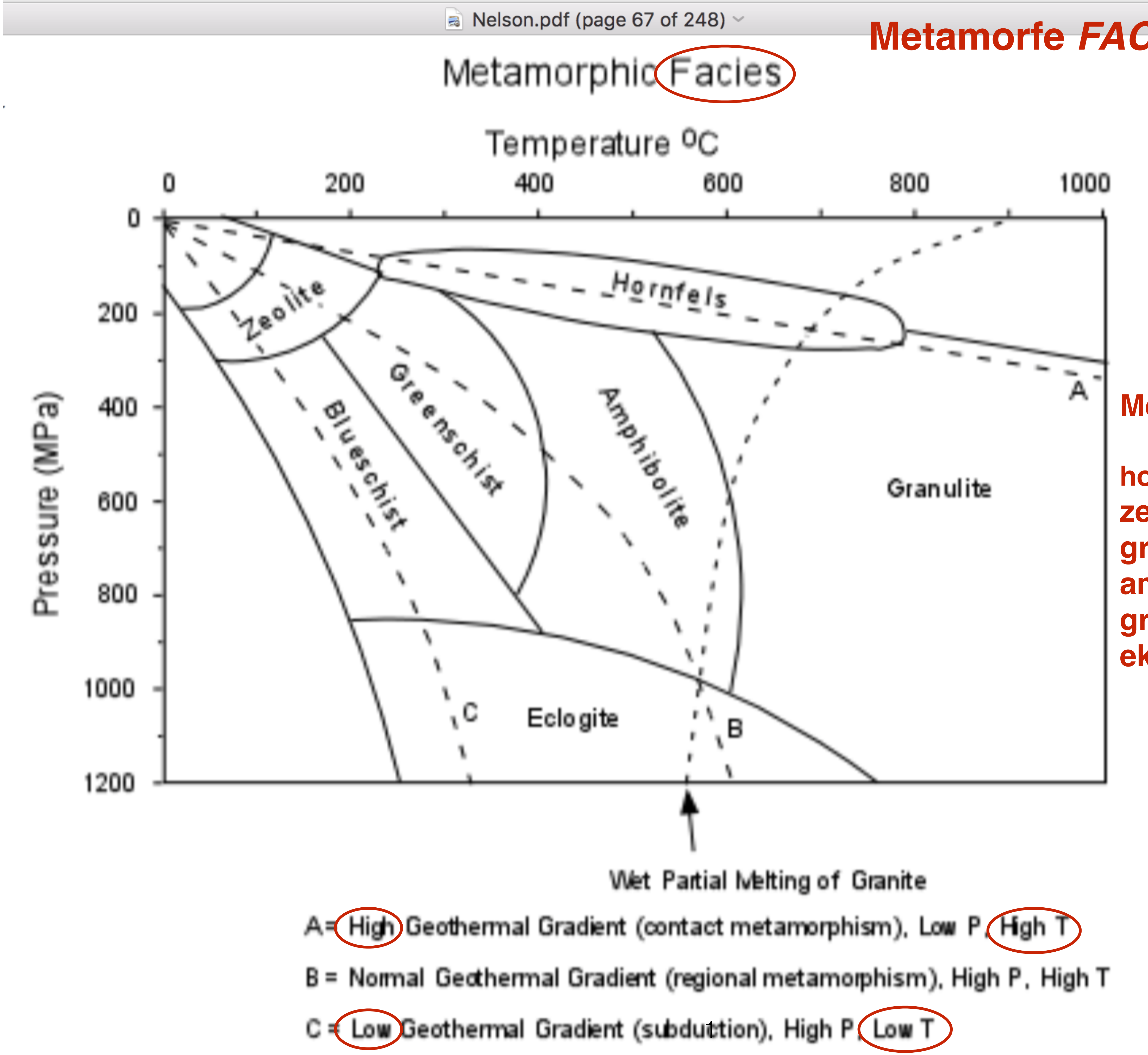
Metamorfe *FACIES*



Metamorf "facies":

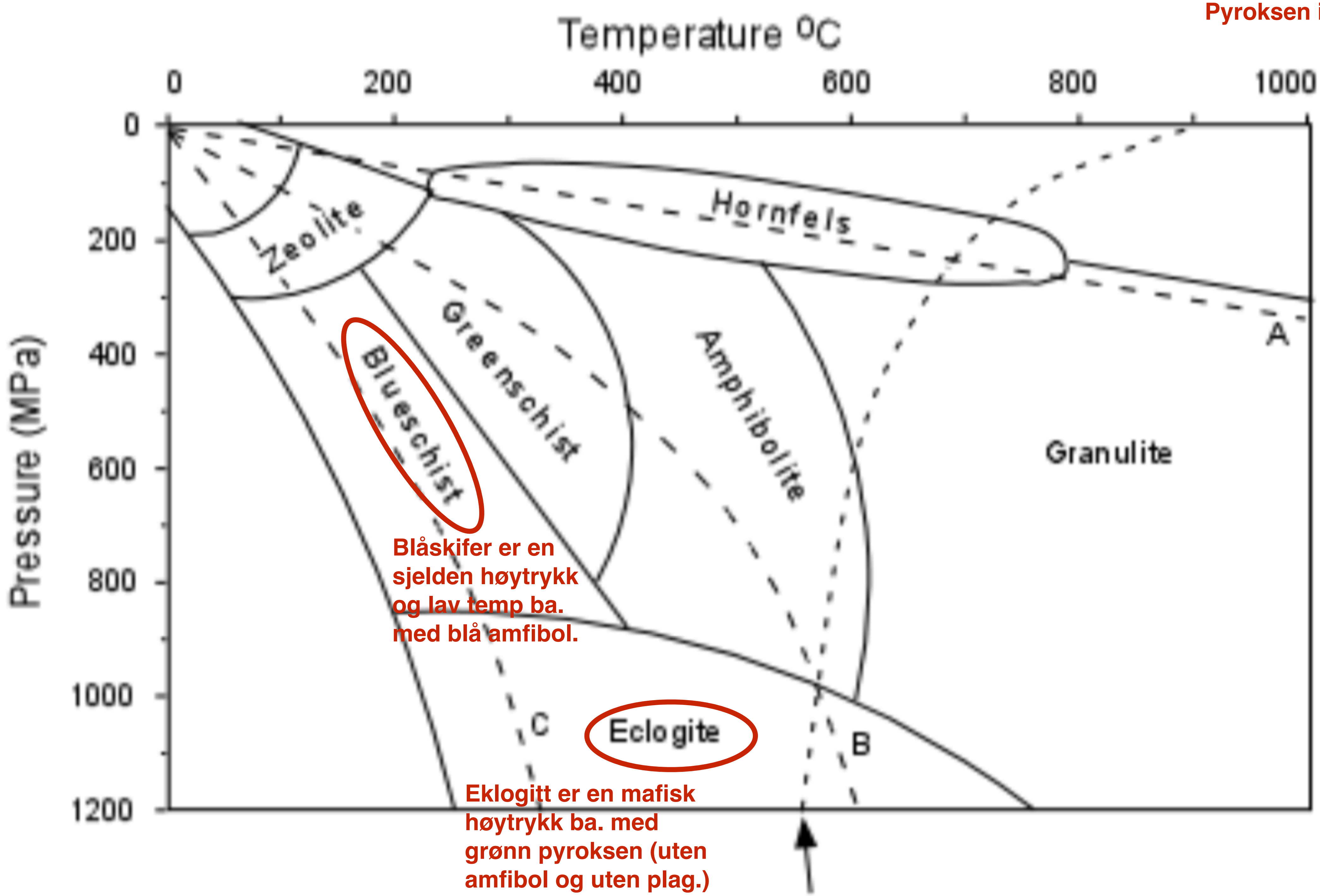
hornfels facies
zeolitt facies
grønnskifer facies
amfibolitt facies
granulitt facies
eklogitt facies

Nelson.pdf (page 67 of 248)

Amfibol er vanigvis svart ('hornblende')
Amfibol i grønnskifer er grønn ('aktinolite)
Amfibol i blåskifer er blå ('glaucophane')

Pyroksen er vanligvis svart ('augite')
Pyroksen i eklogitt er grønn ('omphacite')

Metamorphic Facies



A= High Geothermal Gradient (contact metamorphism), Low P, High T

B = Normal Geothermal Gradient (regional metamorphism), High P, High T

C = Low Geothermal Gradient (subduction), High P, Low T

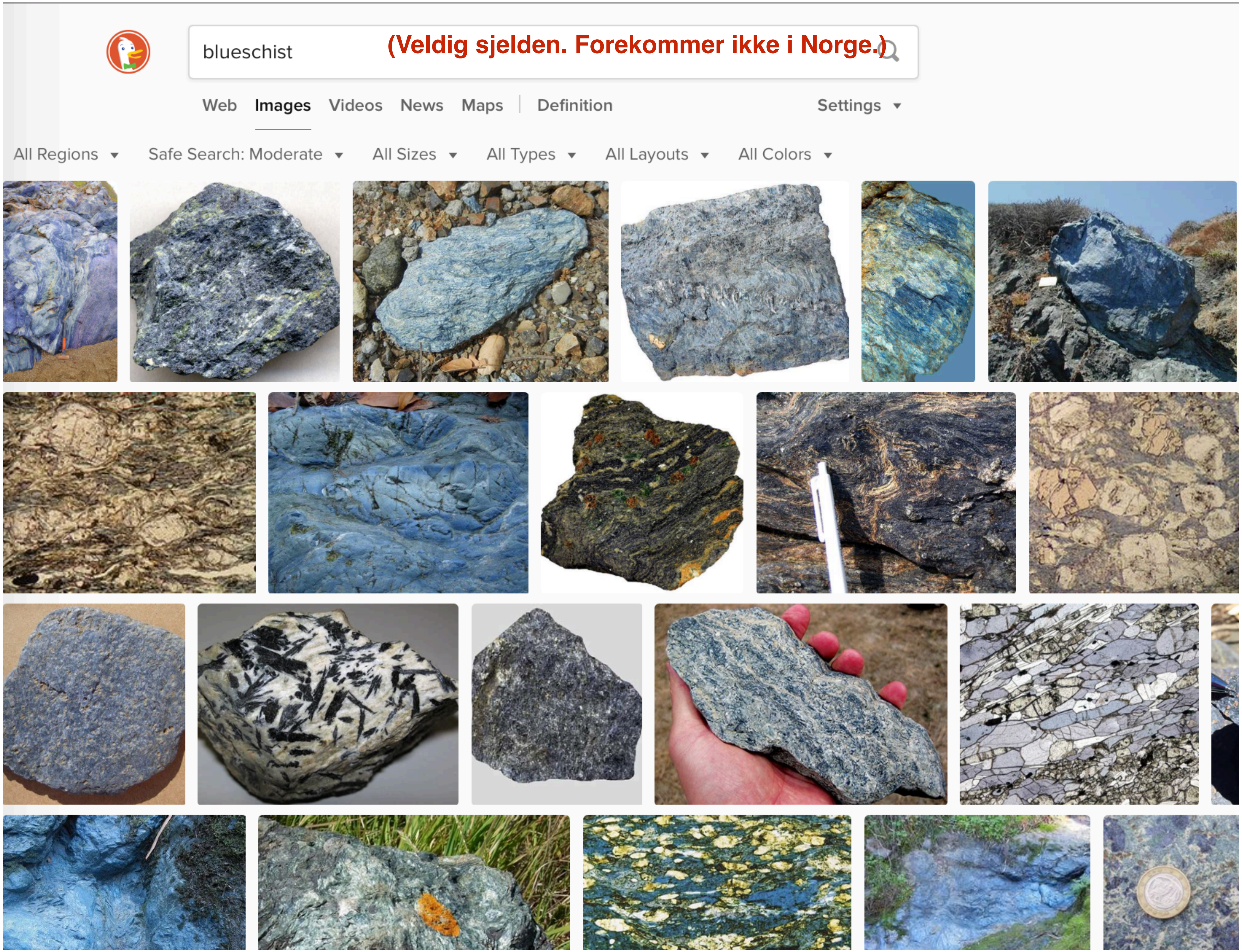
Egentlig er det trykk (P) som er viktigere enn temperatur (T) her eclogite

Sjelden, men vest Norge er verdenskjent for sine eklogitter

grønn pyroksen
rød granat

Web | Images | Videos | News | Maps | Definition | Settings

All Regions | Safe Search: Moderate | All Sizes | All Types | All Layouts | All Colors


blueschist
(Veldig sjelden. Forekommer ikke i Norge.)
Web
Images
Videos
News
Maps
Definition
Settings
All Regions
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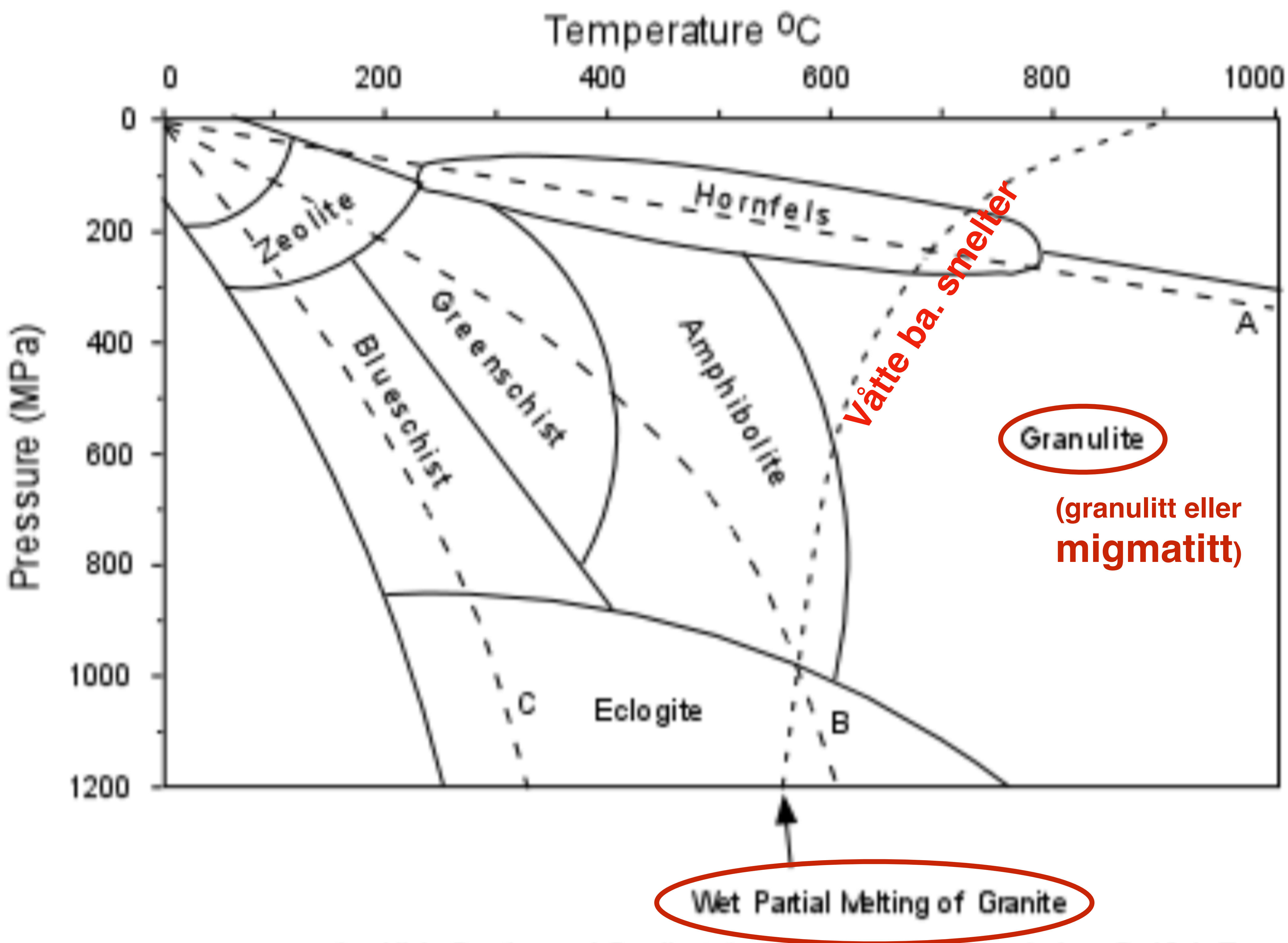
All Sizes
All Types
All Layouts
All Colors

Metamorphic Facies



Granulitt er en høytemp uttørket ba. uten H_2O-mineraler (glimmer eller amfibol)

Vil ikke forekomme hvis bergarter er for våtte. Da vil de smelte. (Feltkurs 3)

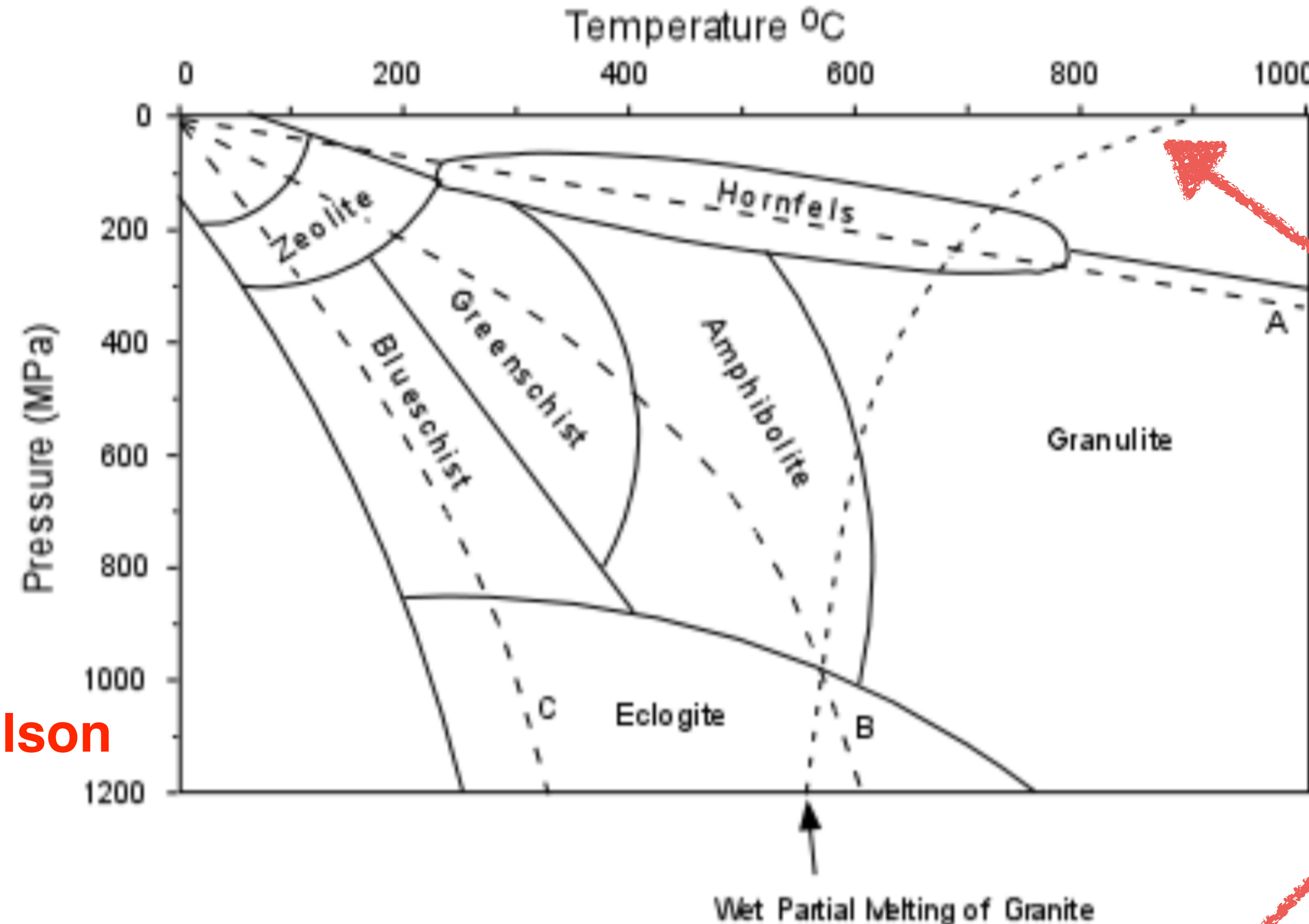
A= High Geothermal Gradient (contact metamorphism), Low P, High T

B = Normal Geothermal Gradient (regional metamorphism), High P, High T

C = Low Geothermal Gradient (subduction), High P, Low T

Migmatitt
metamorf ba. med smelte

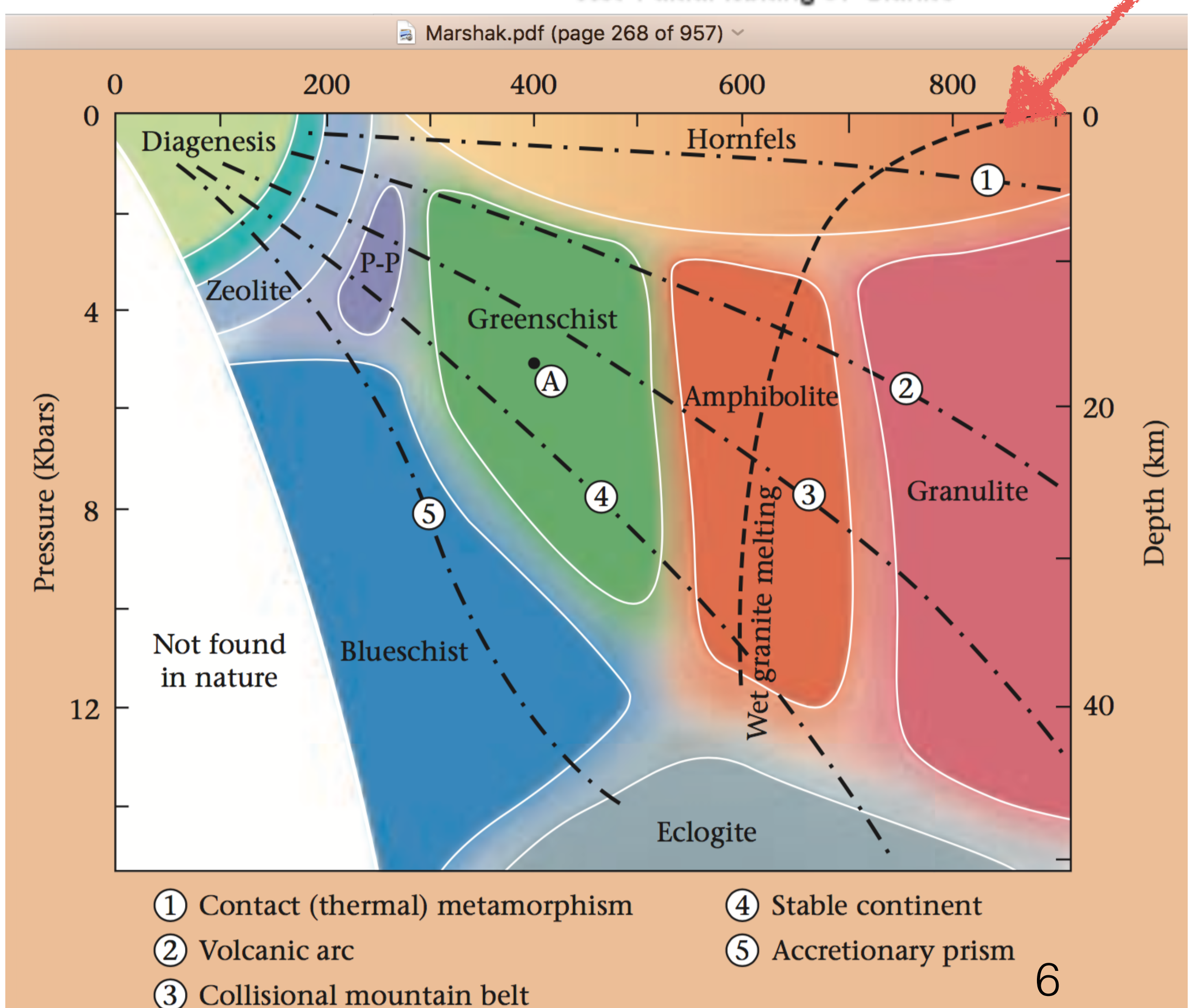
Nelson

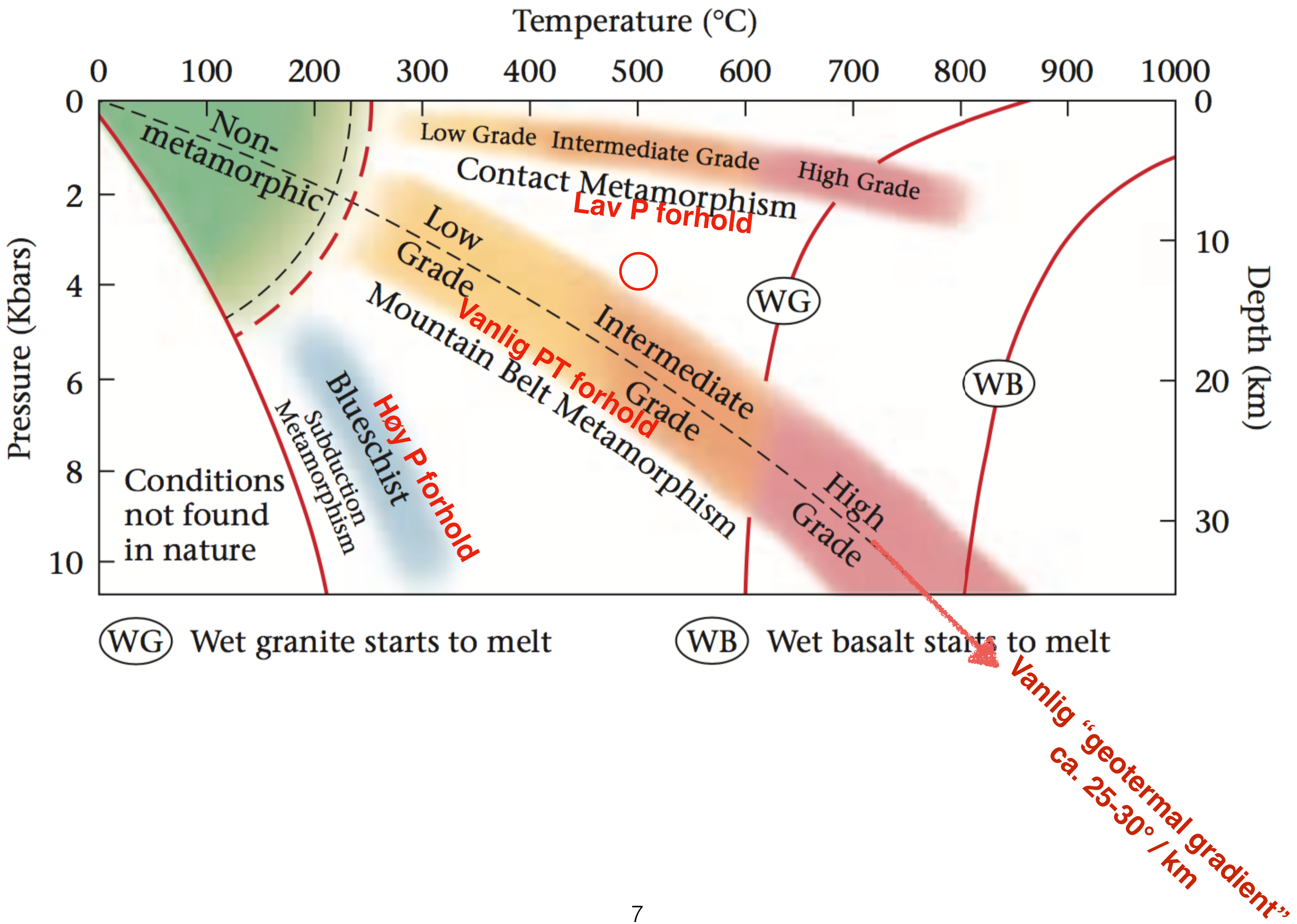


"partiellsmeltekurv"(solidus) med vått forhold er tegnet i begge diagramer

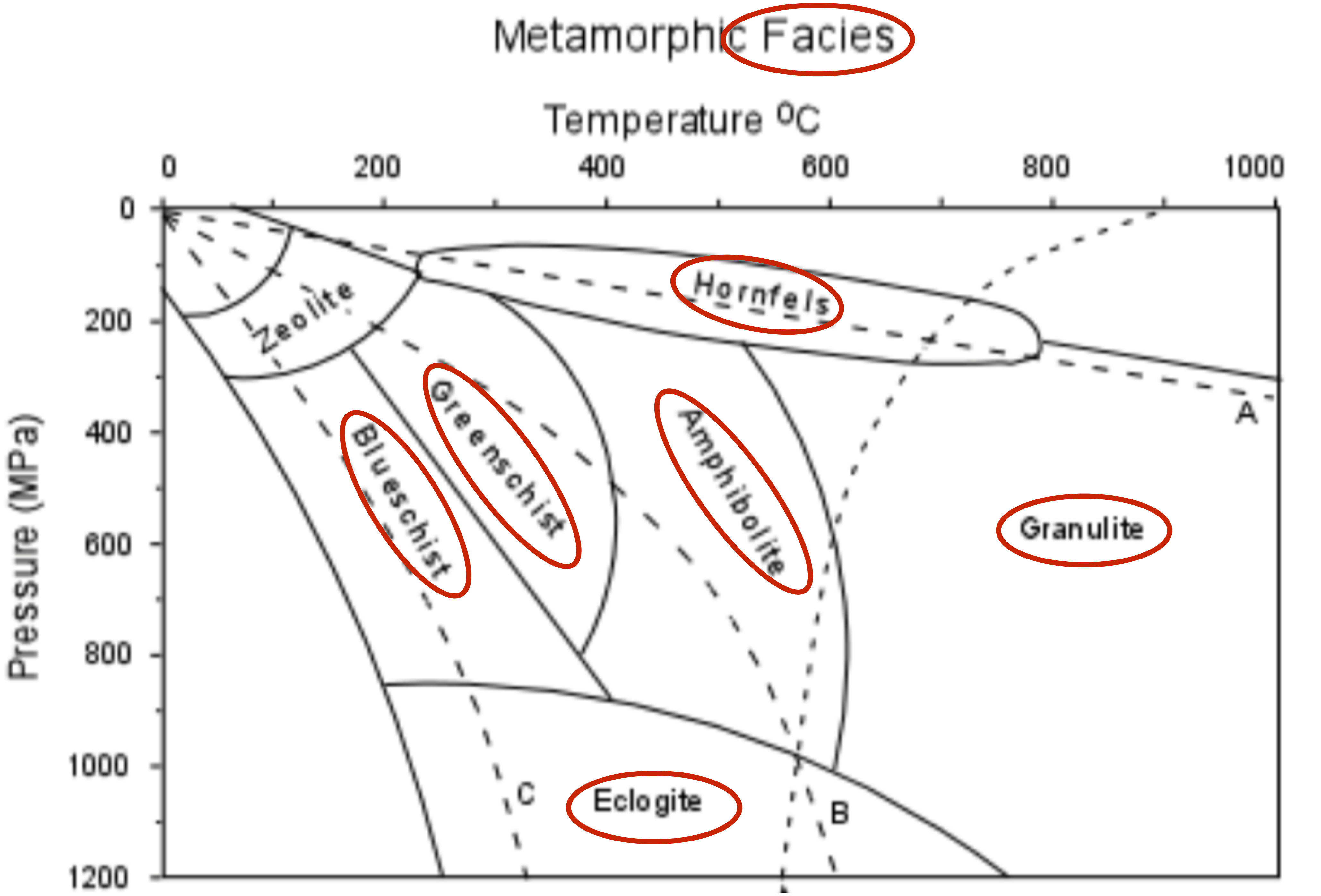
da blir det Migmatitt,
hvis bergarten er vått.
Granulitt bare hvis tørr.

Marshak





Temperature (°C)
0
100
200
300
400
500
600
700
800
900
1000
Pressure (Kbars)
0
2
4
6
8
10
Depth (km)
0
10
20
30
Non-metamorphic
Low Grade
Intermediate Grade
High Grade
Contact Metamorphism
Lav P forhold
Low Grade
Intermediate Grade
High Grade
Mountain Belt Metamorphism
Vanlig PT forhold
WG
WB
Blueschist
Subduction Metamorphism
Høy P forhold
Conditions not found in nature
WG Wet granite starts to melt
WB Wet basalt starts to melt
Vanlig "geotermal gradient"
ca. 25-30° / km



Disse er bergartsnavn, og brukes som 'faciesnavn'.

Geologer har 3 ulike systemer **for å snakke om regional metamorfose!**
Og alle 3 er i vanlig bruk! :-(

Metamorf *GRADER* **("veldig lav grad", "lav grad", "mellom grad", "høy grad") Fremhever TEMPERATUR.**

Metamorf *FACIES* **får navnene etter spesielle BERGARTER ("grønnskifer facies", "amfibolitt facies", "granulitt facies", osv.) Fremhever TRYKK.**

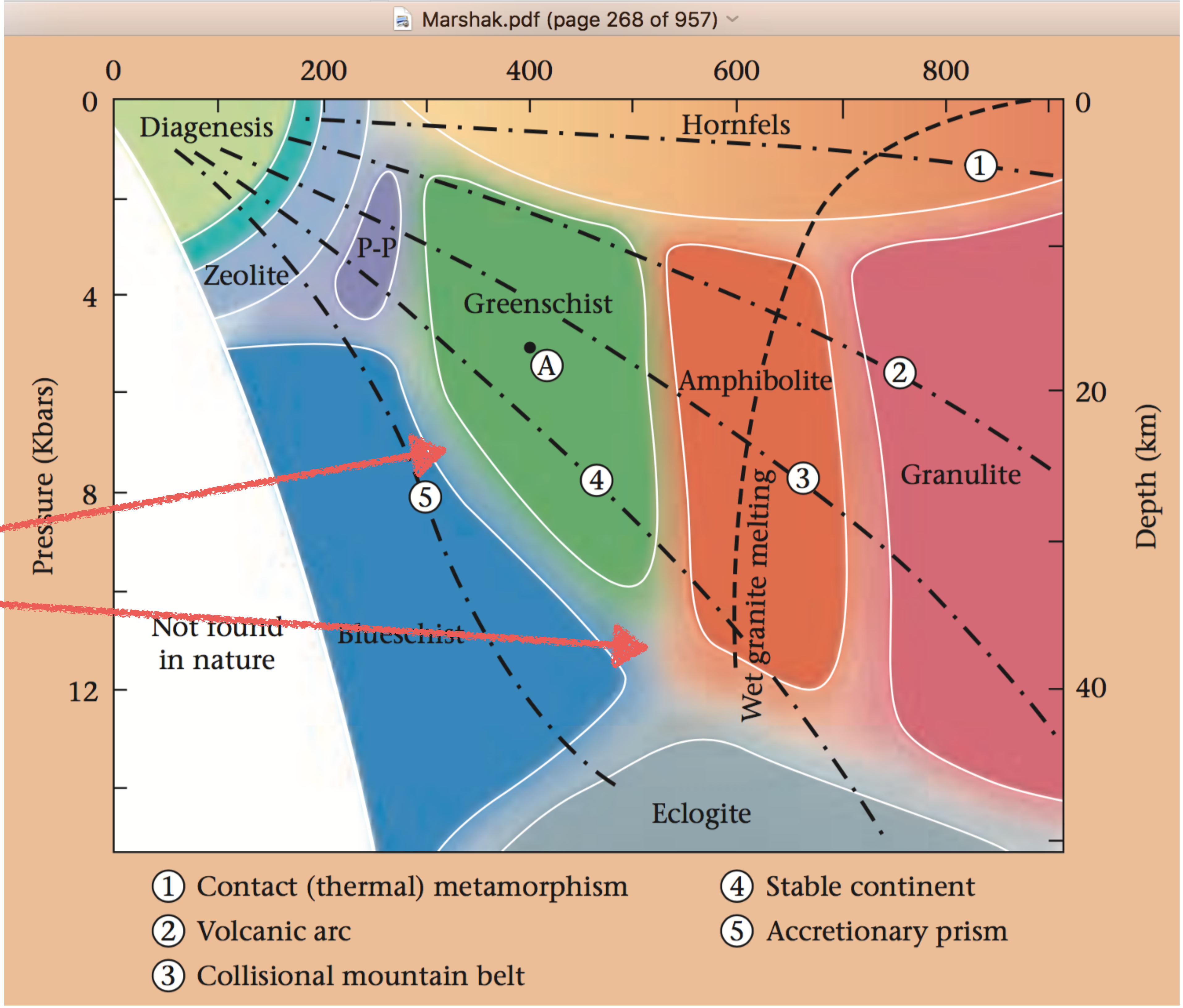
Metamorf *SONER* **får navnene etter indeks MINERALER ("kloritt sone", "biotitt sone", "granat sone", "staurolitt sone", "kyanitt sone", "sillimanitt sone") Fungerer for vanlig trykk gradient (ikke lav trykk).**

(Man blander ikke disse systemer, ved å si:
"~~kyanitt grad~~" eller "~~kyanitt facies~~" eller "~~granat grad~~" eller "~~grønnskifer sone~~".)

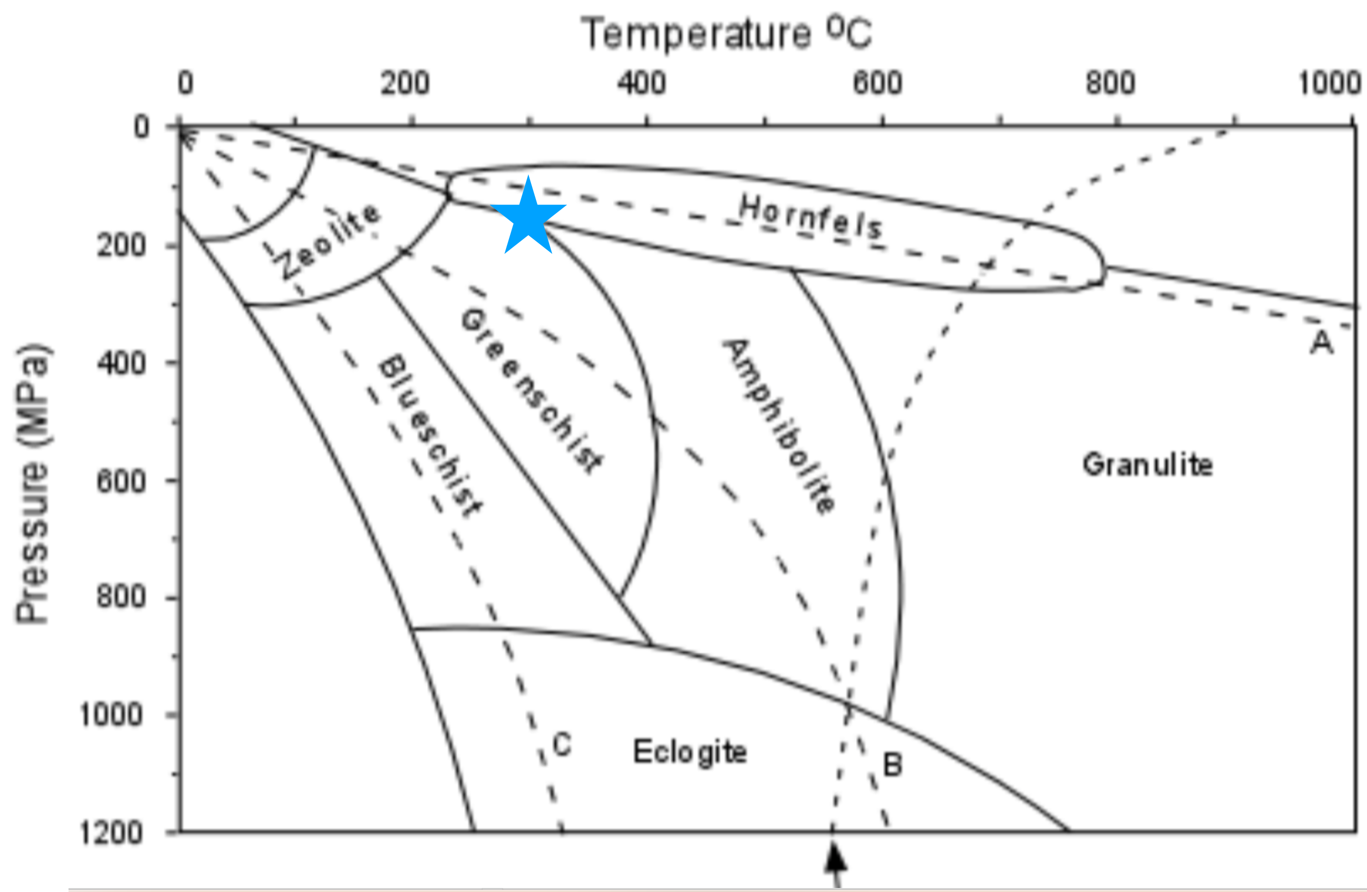
Hvis du blander, gir det dårlig inntrykk,
som når jeg snakker norsk og sier '*en mineral*' for å gi '*en eksempel*'…

Facies

Grenser mellom facies-feltene er upresise.

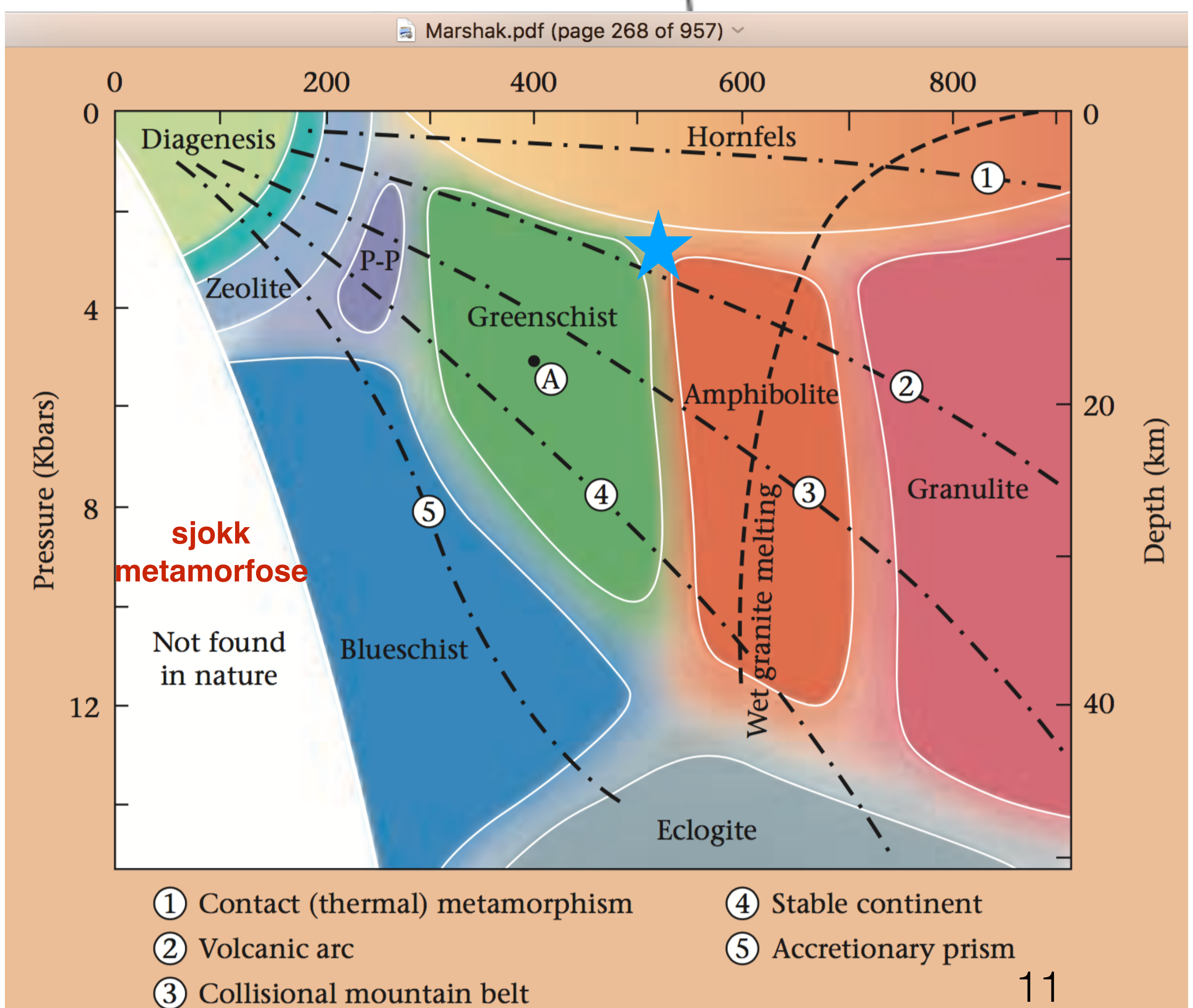


ikke bare upresise, men skjult uenighet (se neste side)



Nelson

★ dette punktet er 300° ved Nelson og 510° ved Marshak !

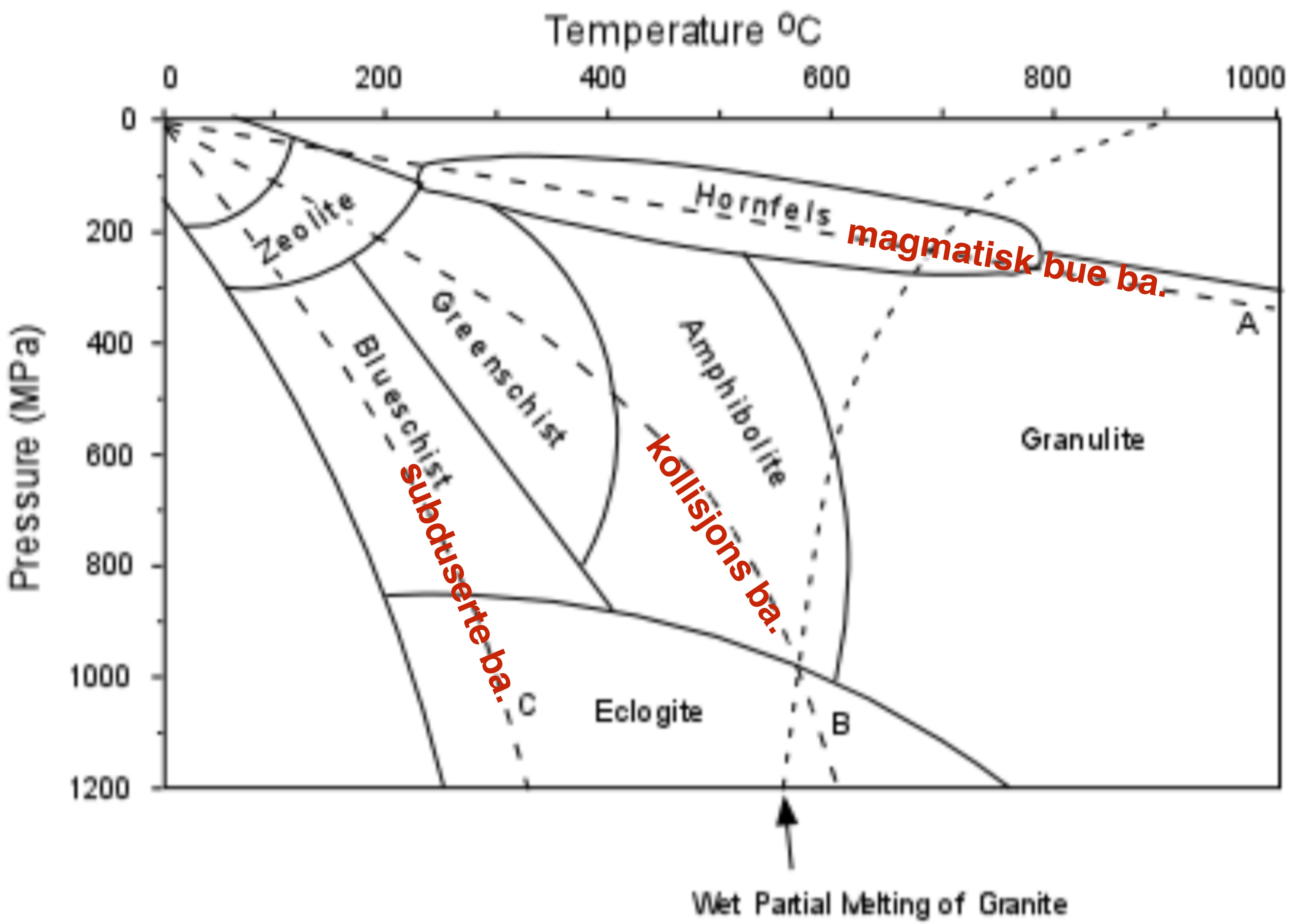


Marshak

2 ulike varianter av samme diagram.
temperatur grenser stemmer ikke.
(typisk i geologi)

for eksempel: Grønnskifer-Amfibolitt grense er ca. 400° ved Nelson
ca. 500° ved Marshak

Metamorphic Facies

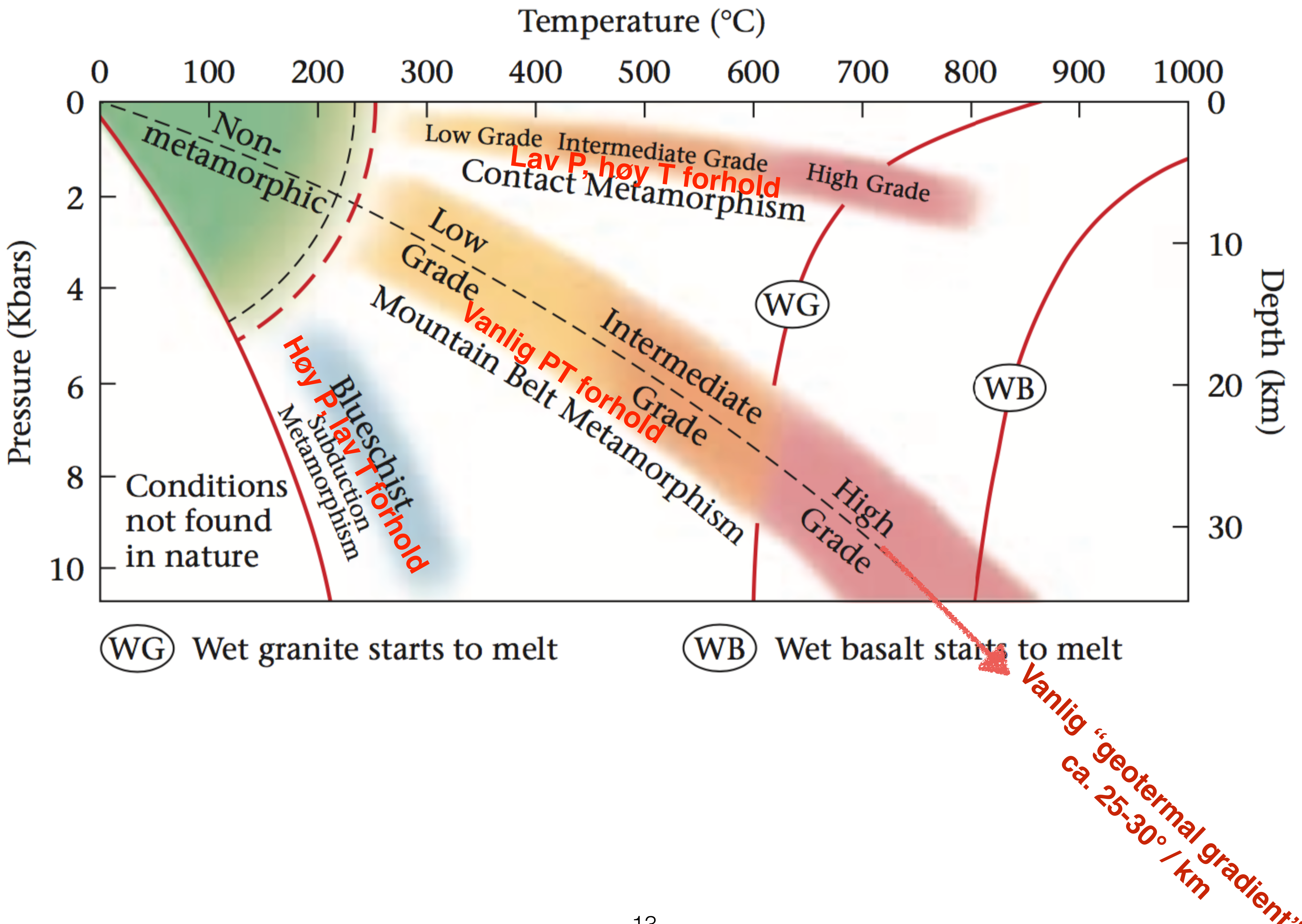


A= High Geothermal Gradient (contact metamorphism), Low P, High T

B = Normal Geothermal Gradient (regional metamorphism), High P, High T

C = Low Geothermal Gradient (subduction), High P, Low T

Se geotermal gradienter A, B, C


Temperature (°C)
0
100
200
300
400
500
600
700
800
900
1000
Pressure (Kbars)
0
2
4
6
8
10
Depth (km)
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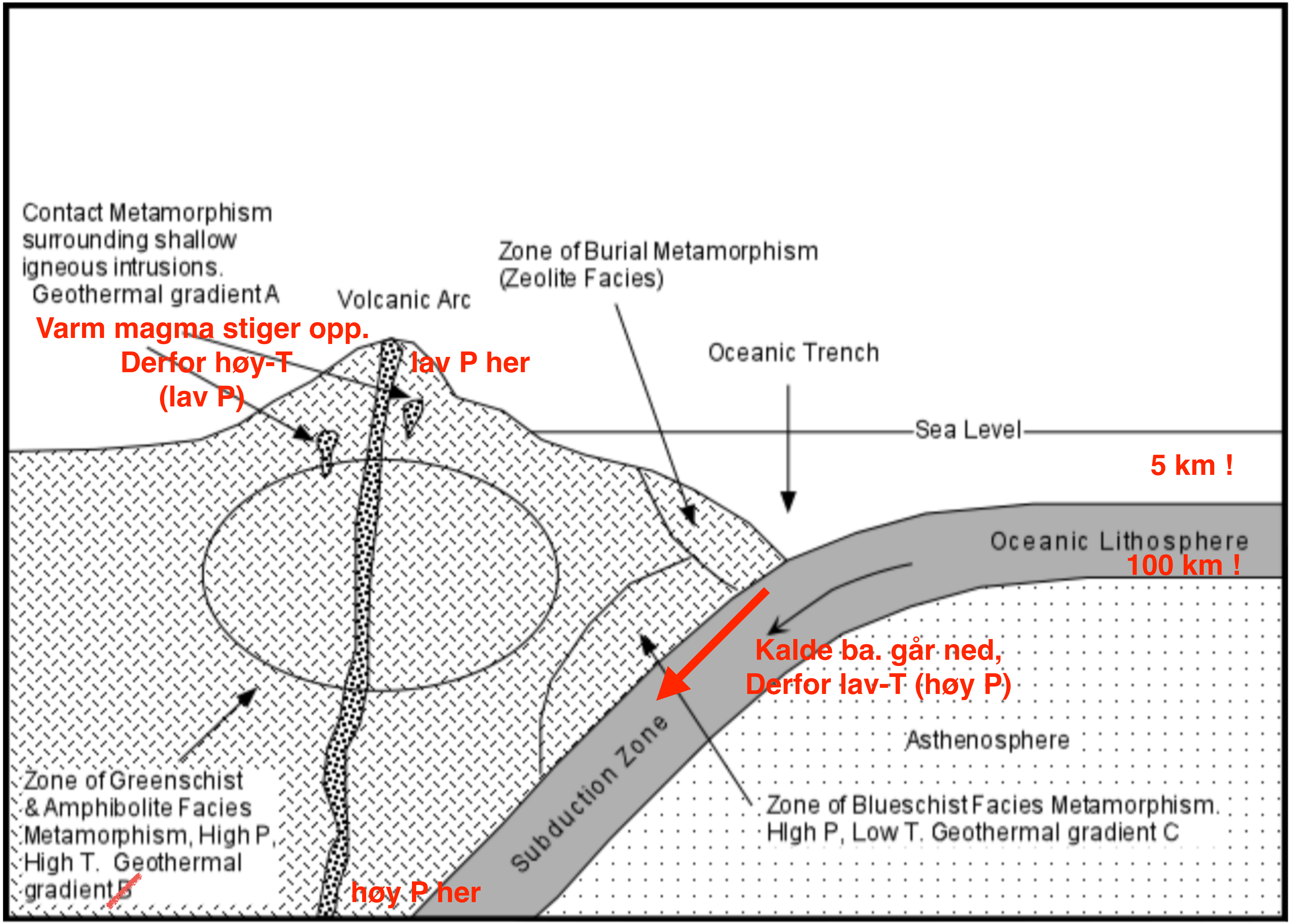
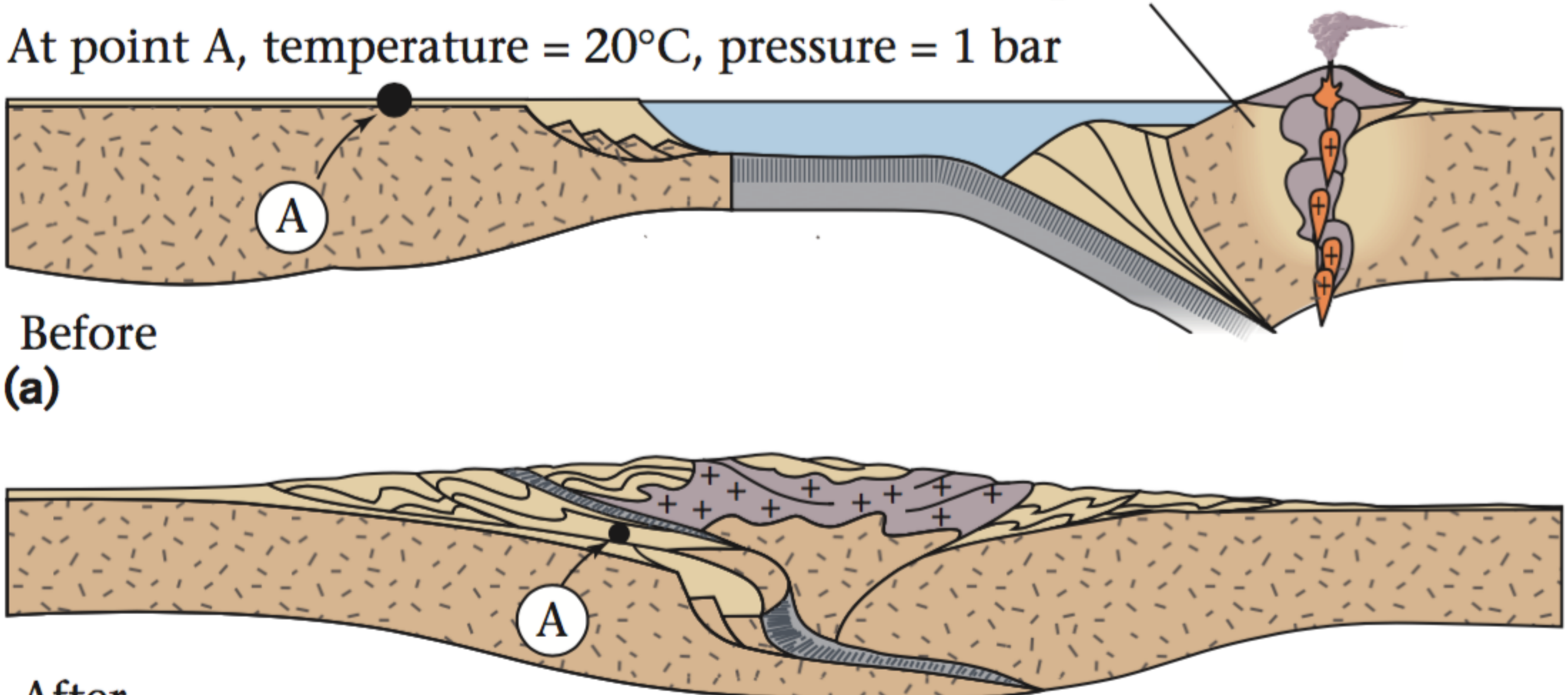
20
30
Non-metamorphic
Low Grade
Intermediate Grade
High Grade
Contact Metamorphism
Lav P, høy T forhold
Low Grade
Intermediate Grade
High Grade
Mountain Belt Metamorphism
Vanlig PT forhold
Blueschist
Subduction Metamorphism
Høy P, lav T forhold
Conditions not found in nature
WG
WB
WG Wet granite starts to melt
WB Wet basalt starts to melt
Vanlig "geotermal gradient"
ca. 25-30° / km


Contact Metamorphism surrounding shallow igneous intrusions. Geothermal gradient A
Volcanic Arc
Zone of Burial Metamorphism (Zeolite Facies)
Oceanic Trench
Sea Level
Varm magma stiger opp.
Derfor høy-T
(lav P)
lav P her
5 km !
Oceanic Lithosphere
100 km !
Kalde ba. går ned,
Derfor lav-T (høy P)
Asthenosphere
Subduction Zone
Zone of Greenschist & Amphibolite Facies Metamorphism, High P, High T. Geothermal gradient B
Zone of Blueschist Facies Metamorphism. High P, Low T. Geothermal gradient C
høy P her
(også her litt høy T)



"thermal" metamorfose = "*KONTAKT*" *metamorfose*

"dynamo-thermal" metamorfose = "*REGIONAL*" *metamorfose*

FIGURE 8.26 **(a)** Metamorphism occurs where there is plutonic activity along a convergent boundary. Some metamorphism may be thermal, but **kontakt met.** because of compression and shearing along convergent boundaries, some may be dynamothermal. **regional met** **(b)** The sedimentary rock that lay at the top of a passive margin (point A) gets carried to great depth in a continental collision that leads to mountain building. As a result, it undergoes dynamothermal **regional** metamorphism. A broad region beneath a collision will lie in the field of metamorphism.

Schou Jensen.pdf (page 93 of 112)

Bergarts navn		Tekstur	Kornstørrelse	Opprinnelig bergart
Skifer	Stigende metamorfose	Foliert	Svært finkornet	Leirskifer, leirstein, siltstein
Fyllitt		Foliert	Finkornet	Takskifer
Glimmer-skifer		Foliert	Mellom- til finkornet	Fyllit
Gneis		Foliert	Mellom- til grovkornet	Glimmerskifer eller vulkanske bergarter
Migmatitt		Foliert	Mellom- til grovkornet	Gneis
Mylonitt		Svakt foliert	Finkornet	Alle slags bergarter
Metakonglomerat		Svakt foliert	Grovkornet	Kvartsrikt konglomerat
Marmor		Ikke foliert	Mellom- til grovkornet	Kalkstein dolomitt
Kvartsitt		Ikke foliert	Mellom- til grovkornet	Kvarts
Hornfels		Ikke foliert	Finkornet	Alle slags bergarter
Antrasitt		Ikke foliert	Finkornet	Bituminøst kull
Forkastnings-breksje		Ikke foliert	Mellom- til grovkornet	Alle slags bergarter

Mye divers info på denne tabellen som skal oppsumere metamorfe ba. Nyttig men uryddig.

Schou Jensen.pdf (page 93 of 112)

Bergarts navn		Tekstur		Kornstørrelse	Opprinnelig bergart
Skifer (for upresis)	Stigende metamorfose	Foliert		Svært finkornet	Leirskifer, leirstein, siltstein
Fyllitt				Finkornet	Takskifer (ikke et geologisk begrep)
Glimmer-skifer				Mellom- til finkornet	Fyllit
Gneis				Mellom- til grovkornet	Glimmerskifer eller vulkanske bergarter (eller intrusive bergarter)
Migmatitt				Mellom- til grovkornet	Gneis

Tidligere ba. (enten protolitt eller lavere grad metamorf ba.)

tidligere ba. (enten protolitt eller lavere grad metamorf ba.) ← Opprinnelig bergart

Bergarts navn	Tekstur	Kornstørrelse	Opprinnelig bergart
Skifer **(for upresis)**	Foliert (Stigende metamorfose)	Svært finkornet	Leirskifer, leirstein, siltstein
Fyllitt	Foliert (Stigende metamorfose)	Finkornet	Takskifer **(ikke et geologisk begrep)**
Glimmer-skifer	Foliert (Stigende metamorfose)	Mellom- til finkornet	Fyllit
Gneis	Foliert (Stigende metamorfose)	Mellom- til grovkornet	Glimmerskifer eller vulkanske bergarter **(eller intrusive bergarter)**
Migmatitt	Foliert (Stigende metamorfose)	Mellom- til grovkornet	Gneis
Mylonitt	~~Svakt~~ foliert	Finkornet	Alle slags bergarter
Metakonglomerat **(sterk foliert på Tautra)**	~~Svakt~~ foliert	Grovkornet	~~Kvartsrikt~~ konglomerat
Marmor **(foliert på Tautra !)**	Ikke foliert	Mellom- til grovkornet	Kalkstein dolomitt
Kvartsitt **(metamorf) kvarts sandstein**	Ikke foliert	Mellom- til grovkornet	~~Kvarts~~ **Kvartssandstein eller (sedimentær) kvartsitt**
Hornfels	Ikke foliert	Finkornet	Alle slags bergarter
Antrasitt	Ikke foliert	Finkornet	Bituminøst kull
Forkastnings-breksje	Ikke foliert	Mellom- til grovkornet	Alle slags bergarter

Schou Jensen.pdf (page 93 of 112)

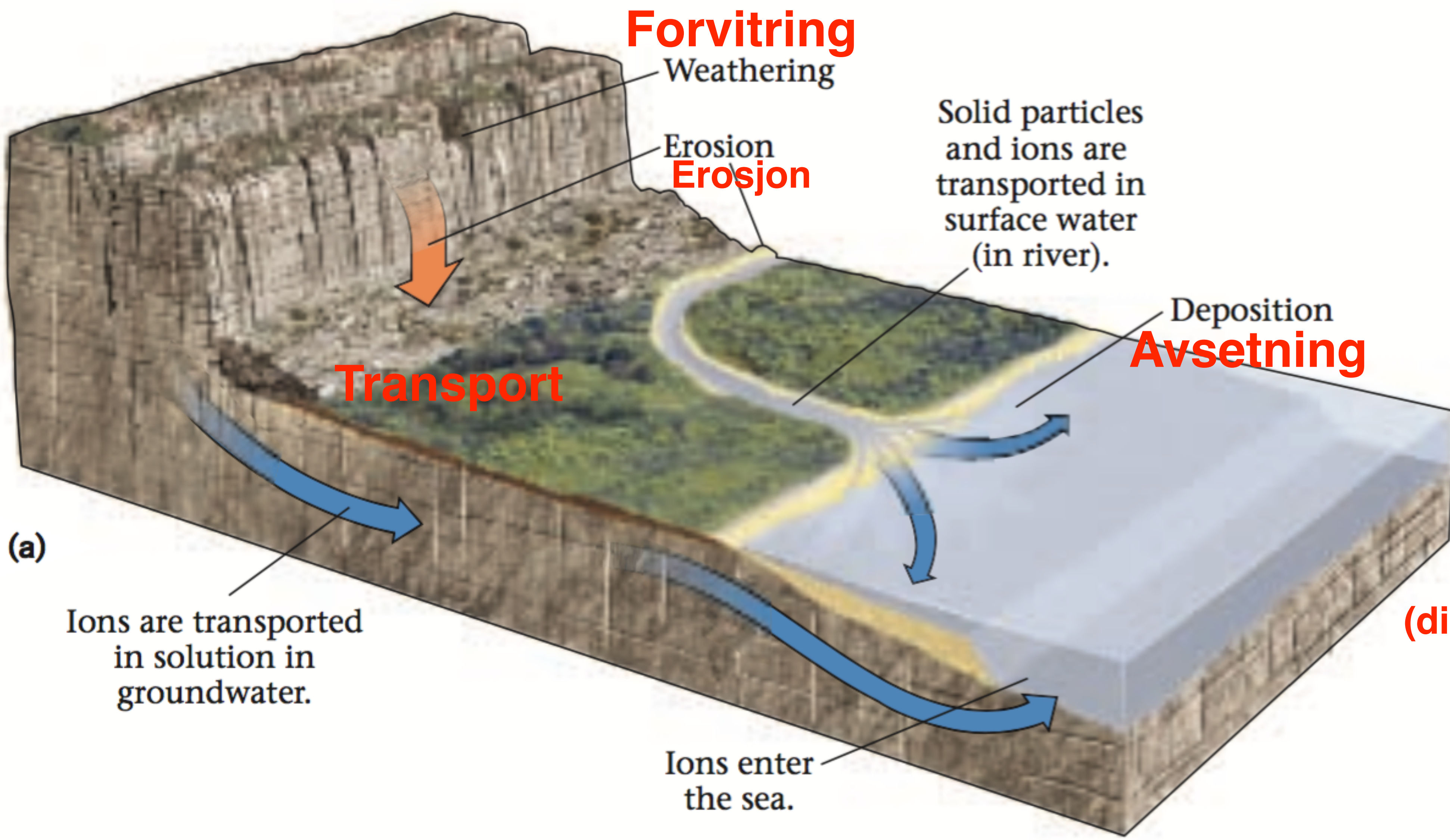
Bergarts navn		Tekstur	Kornstørrelse	Opprinnelig bergart
Skifer (for upresis)	Stigende metamorfose	Foliert	Svært finkornet	Leirskifer, leirstein, siltstein
Fyllitt		Foliert	Finkornet	Takskifer (ikke geologisk begrep)
Glimmer-skifer		Foliert	Mellom- til finkornet	Fyllit
Gneis		Foliert	Mellom- til grovkornet	Glimmerskifer eller vulkanske bergarter (eller …)
Migmatitt		Foliert	Mellom- til grovkornet	Gneis
Mylonitt		~~Svakt~~ foliert	Finkornet	Alle slags bergarter
Metakonglomerat		~~Svakt~~ foliert	Grovkornet	~~Kvartsrikt~~ konglomerat
Marmor		Ikke foliert	Mellom- til grovkornet	Kalkstein dolomitt
Kvartsitt (metamorf) kvartsitt		Ikke foliert	Mellom- til grovkornet	~~Kvarts~~ Kvartssandstein eller (sedimentær) kvartsitt
Hornfels		Ikke foliert	Finkornet	Alle slags bergarter
Antrasitt ikke "metamorf" ba,		Ikke foliert	Finkornet	Bituminøst kull
Forkastnings-breksje		Ikke foliert	Mellom- til grovkornet	Alle slags bergarter

tidligere ba. (enten protolitt eller tidligere metamorf ba.)

Jensen glemte å ta med MAFISKE ba.
De blir til:
—> grønnstein
—> amfibolitt
—> eklogitt eller mafisk granulitt

ordet "dolomitt" brukes som både mineralnavn og bergartsnavn noen foretrekker å bruke "dolostein" for bergarten.

Navnet "kvartsitt" brukes både for sedimentære ba. og metamorfe ba.



nøkkel ord:

Forvitring
Transport
(disse 2 utgjør Erosjon)

Avsetning

Weathering and Soils

This page last updated on 24-Jan-2011

(finér)

Earth is covered by a thin "veneer" of sediment. The veneer caps igneous and metamorphic "basement." This sediment cover varies in thickness from 0 to 20 km. It is thinner (or missing) where igneous and metamorphic rocks outcrop, and is thicker in sedimentary basins.

"cover"

In order to make this sediment and sedimentary rock, several steps are required:

- Weathering – Breaks pre-existing rock into small fragments or new minerals **forvitring**
- Transportation of the sediments to a sedimentary basin. **transport**
- Deposition of the sediment **avsetning**
- Burial and Lithification to make sedimentary rock. **overleiring og litifisering**

Each Step in the process of forming sediment and sedimentary rocks leaves clues in the sediment. These clues can be interpreted to determine the history of the sediment and thus the history of the Earth.

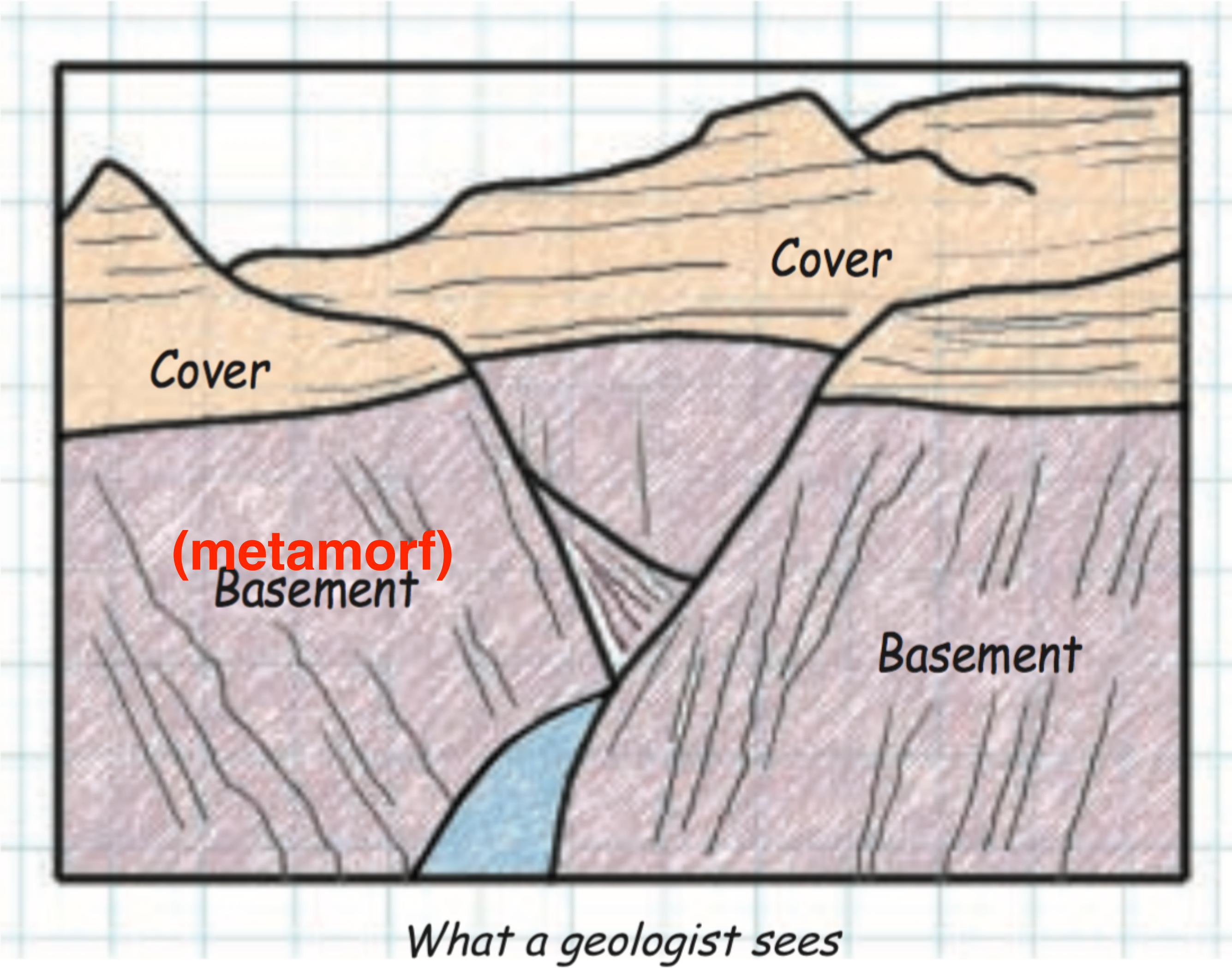


FIGURE 7.2 Near the bottom of the Grand Canyon, we can see the boundary between the sedimentary veneer, or cover (here, a succession of horizontal layers), and the older basement (here, the steep cliff of dark metamorphic rock that goes down to the river). The Colorado River flows along the floor of the canyon. A geologist's sketch emphasizes the contact, or boundary, between cover and basement.

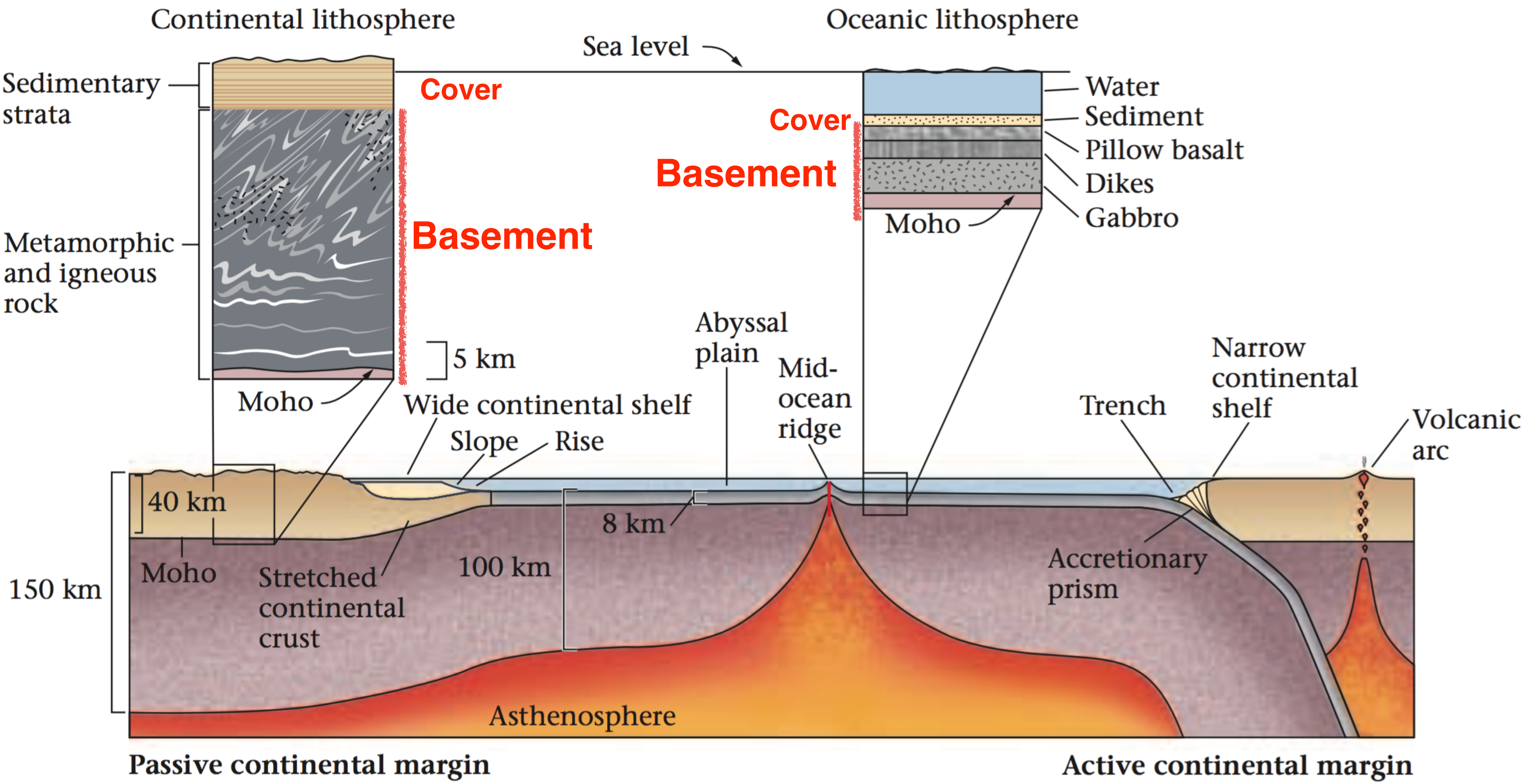
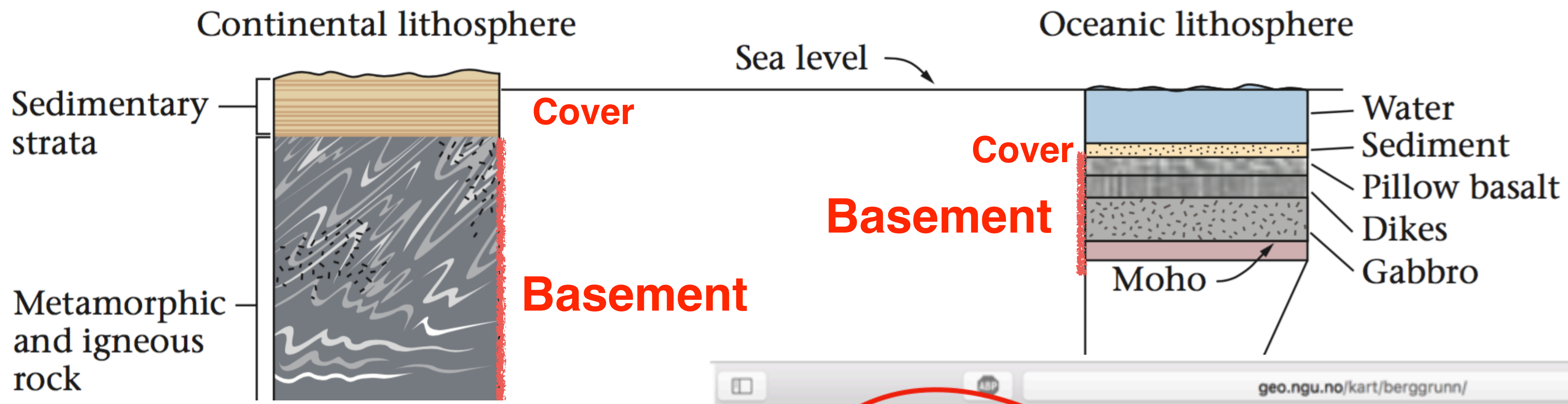


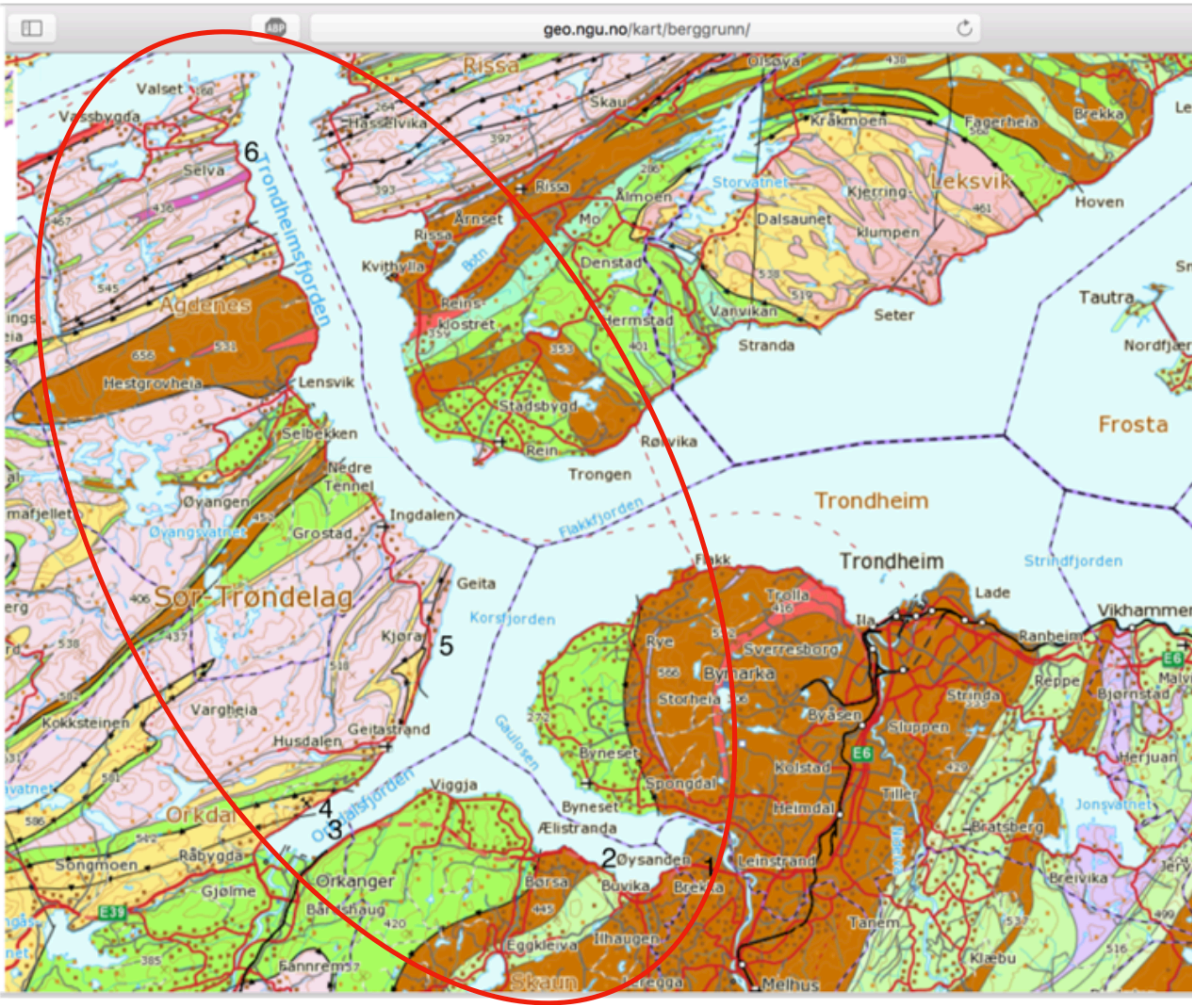
FIGURE 18.3 The bathymetric provinces of the sea floor. At a passive continental margin, a thick wedge of sediment



I Baltica var det
prekambrisk kontinental basement/cover
(rosa gneis og gul sandstein)

Og Iapetushavet var det
ordovicisk basement/cover
(brun basalt og grønne sedimenter)

Nå er Iapetus ba.
skjøvet over de andre, og
kun rosa gneiser som
betraktes som basement.



Weathering and Soils

Forvitring

This page last updated on 24-Jan-2011

Earth is covered by a thin "veneer" of sediment. The veneer caps igneous and metamorphic "basement." This sediment cover varies in thickness from 0 to 20 km. It is thinner (or missing) where igneous and metamorphic rocks outcrop, and is thicker in sedimentary basins.

In order to make this sediment and sedimentary rock, several steps are required:

- Weathering – Breaks pre-existing rock into small fragments or new minerals
- Transportation of the sediments to a sedimentary basin.
- Deposition of the sediment
- Burial and Lithification to make sedimentary rock.

Each Step in the process of forming sediment and sedimentary rocks leaves clues in the sediment. These clues can be interpreted to determine the history of the sediment and thus the history of the Earth.

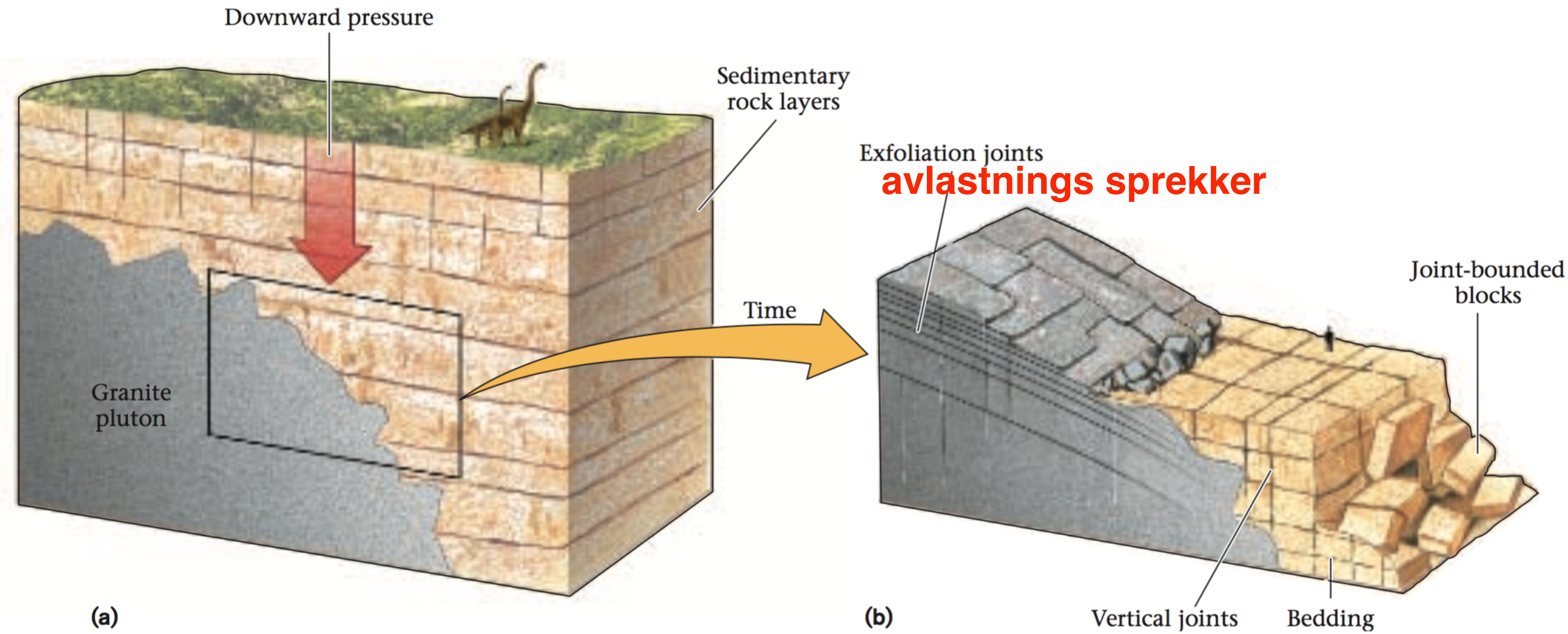
(a) sprekker (f.eks. ved *Skrea* på Feltkurs 3)

(b)

FIGURE 7.5 **(a)** Exfoliation joints in the Sierra Nevada, California. **(b)** Vertical joints in sedimentary rock (Brazil). **(c)** Talus has accumulated at the base of these cliffs near Mt. Snowdon in Wales.

(c)

de fleste bergarter har sprekker



vanlig årsak til sprekker.

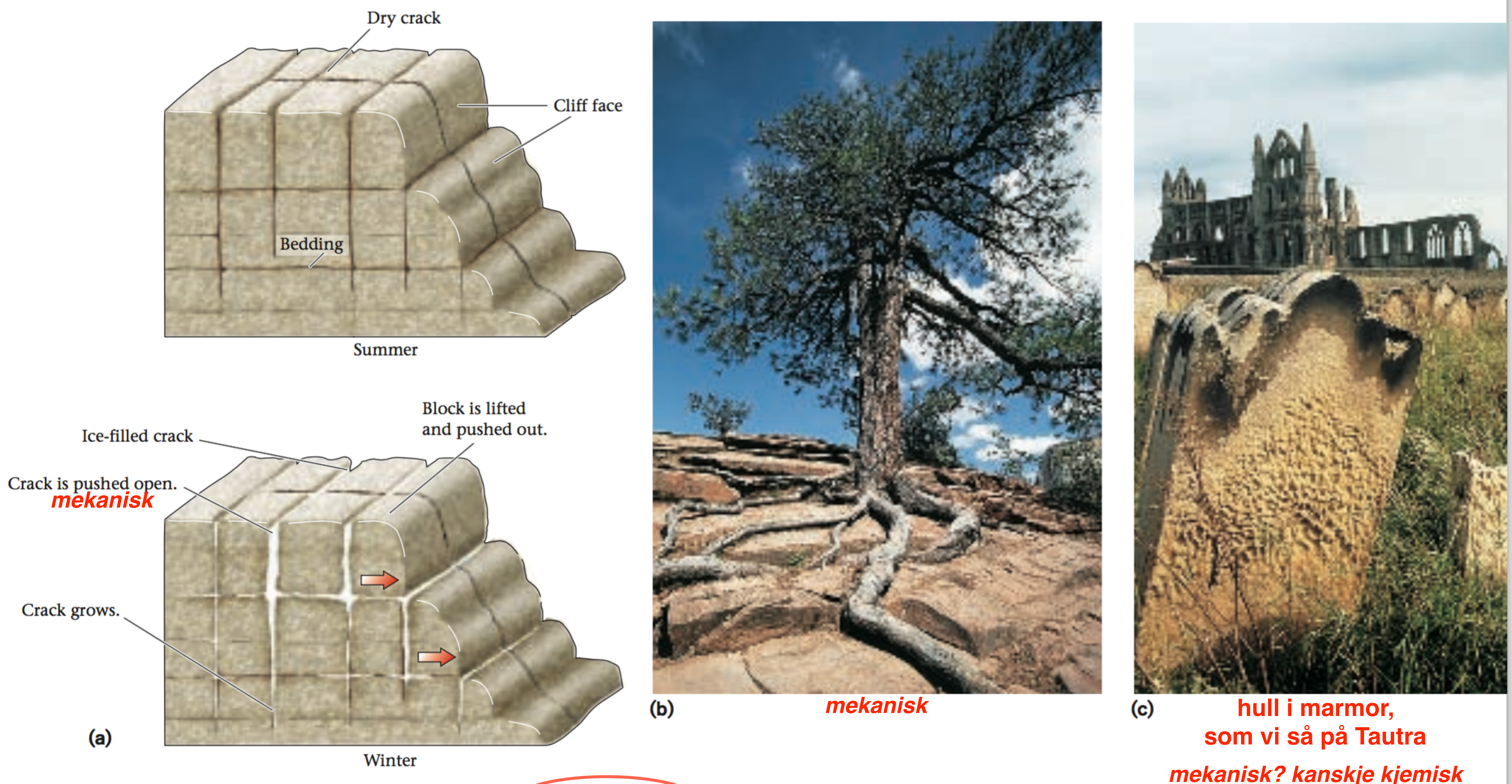
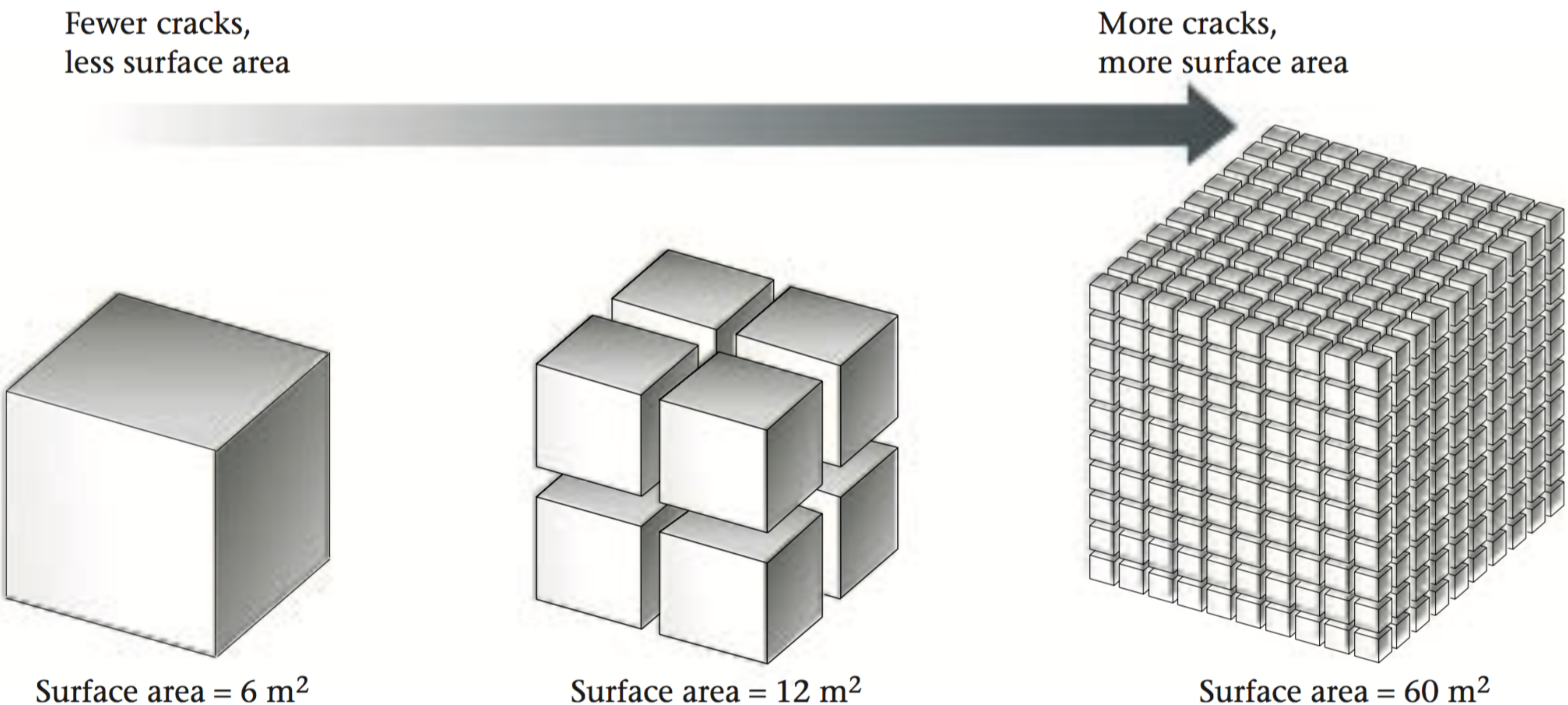


FIGURE 7.6 Examples of processes contributing to physical weathering. **(a)** During the summer, cracks are closed. During the winter, water in the cracks freezes and forces rocks apart. Ice can even lift blocks up. **(b)** The roots of this old pine tree in Zion National Park, Utah, originally grew in exfoliation joints. Eventually, the roots pried the rock above the joints free. Thus, the roots are now exposed. **(c)** These gravestones, near the ruin of a medieval abbey on the seacoast near Whitby, England, absorbed salt from the sea spray. Salt wedging has resulted in honeycomb-like weathering.

***mekanisk* forvitring (altså ikke *kjemisk* forvitring)**



sprekker eksponerer mer av bergarten (gir tilgang for mer kjemisk forvitring)

Mekanisk forvitring (Nelson)

- Crystal Growth - As water percolates through fractures and pore spaces it may contain ions that precipitate to form crystals. As these crystals grow they may exert an outward force that can expand or weaken rocks.

- Thermal Expansion - Although daily heating and cooling of rocks do not seem to have an effect, sudden exposure to high temperature, such as in a forest or grass fire may cause expansion and eventual breakage of rock. Campfire example.

- Root Wedging - Plant roots can extend into fractures and grow, causing expansion of the fracture. Growth of plants can break rock - look at the sidewalks of New Orleans for example.

- Animal Activity - Animals burrowing or moving through cracks can break rock.

- ***Frost Wedging*** - Upon freezing, there is an increase in the volume of the water (that's why we use antifreeze in auto engines or why the pipes break in New Orleans during the rare freeze). As the water freezes it expands and exerts a force on its surroundings. Frost wedging is more prevalent at high altitudes where there may be many freeze-thaw cycles.

Mekanisk forvitring (Nelson)

- Crystal Growth - As water percolates through fractures and pore spaces it may contain ions that precipitate to form crystals. As these crystals grow they may exert an outward force that can expand or weaken rocks.

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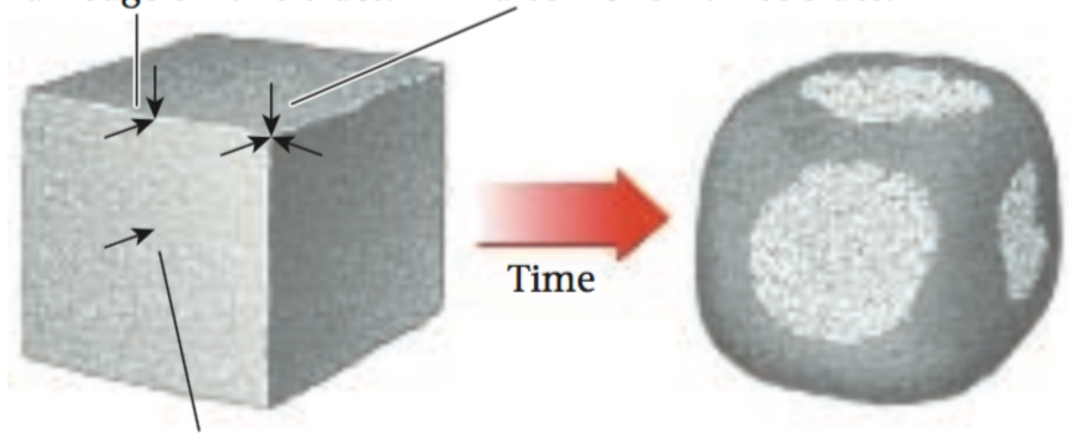
ikke glem: “Human Activity” som er like viktig som andre former for mekanisk forvitring



(a)

kuleforvitring (typisk forvitrings form)

(b)

(c)

FIGURE 7.10 **(a)** Weather attacks more vigorously at edges and most vigorously at corners, resulting in a rounded block. **(b)** Spheroidal weathering of granite blocks in Joshua Tree National Monument, California. **(c)** Sawtooth shape of an outcrop of weathered sedimentary rock, in New Mexico. Weak shale layers are softer than sandstone layers, so the sandstone layers stick out relative to the shale.

FIGURE 7.3 This outcrop shows the contrast between fresh and weathered granite. The rock below the notebook is fresh—the outcrop face is a fairly smooth fracture. The rock above the notebook is weathered—the outcrop face is crumbly, breaking into grains that have fallen and collected on the ledge.

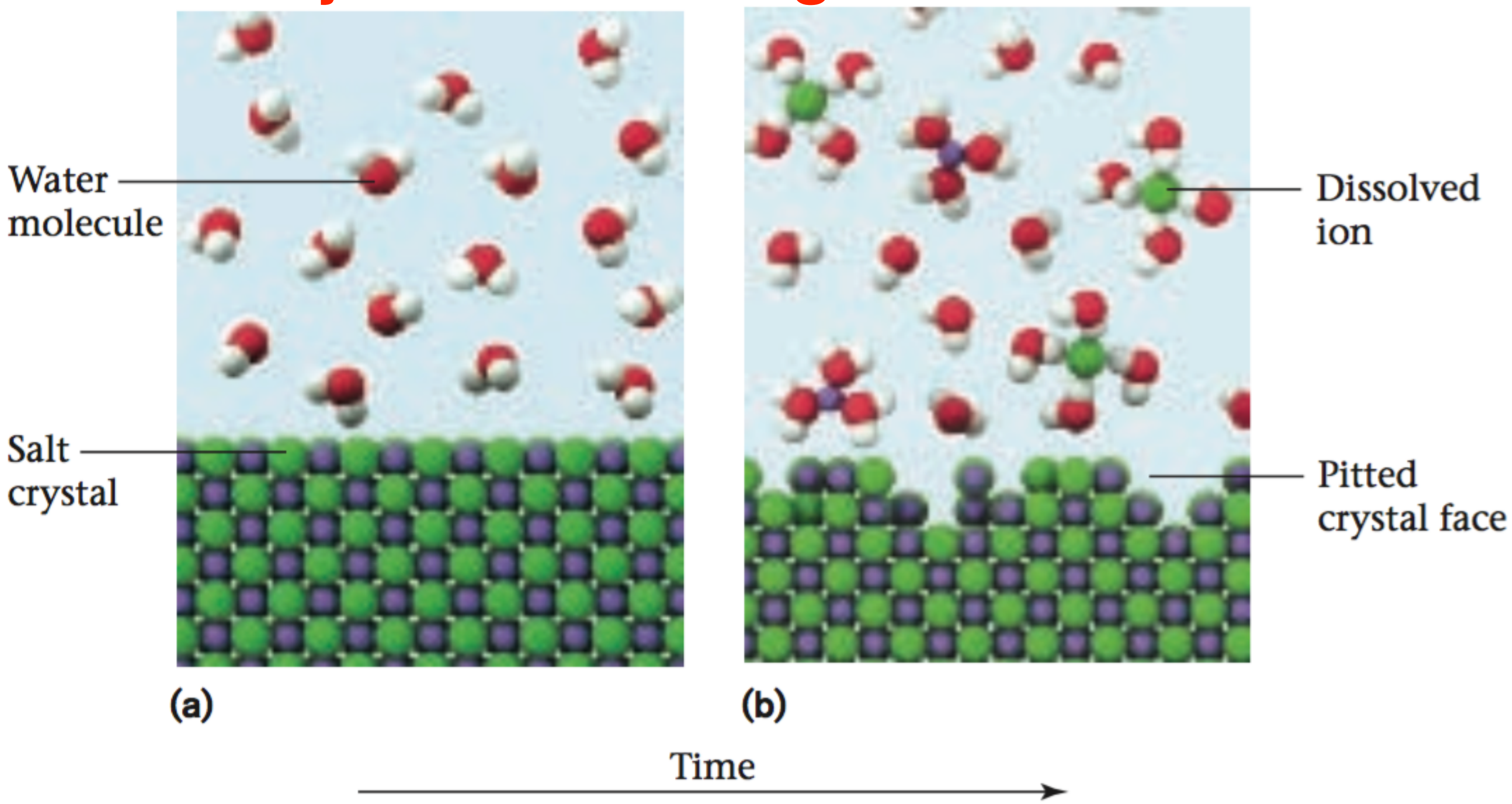
kjemisk forvitring

(a) (b)

FIGURE 7.11 **(a)** Inscriptions in a granite headstone remain sharp for centuries. This example dates from 1856. **(b)** Inscriptions in a marble headstone weather away fairly rapidly. This example, from the same cemetery, dates from 1872.

kjemisk forvitring
går fort i marmor
(hvis det er varm og fuktig klima)

kjemisk forvitring



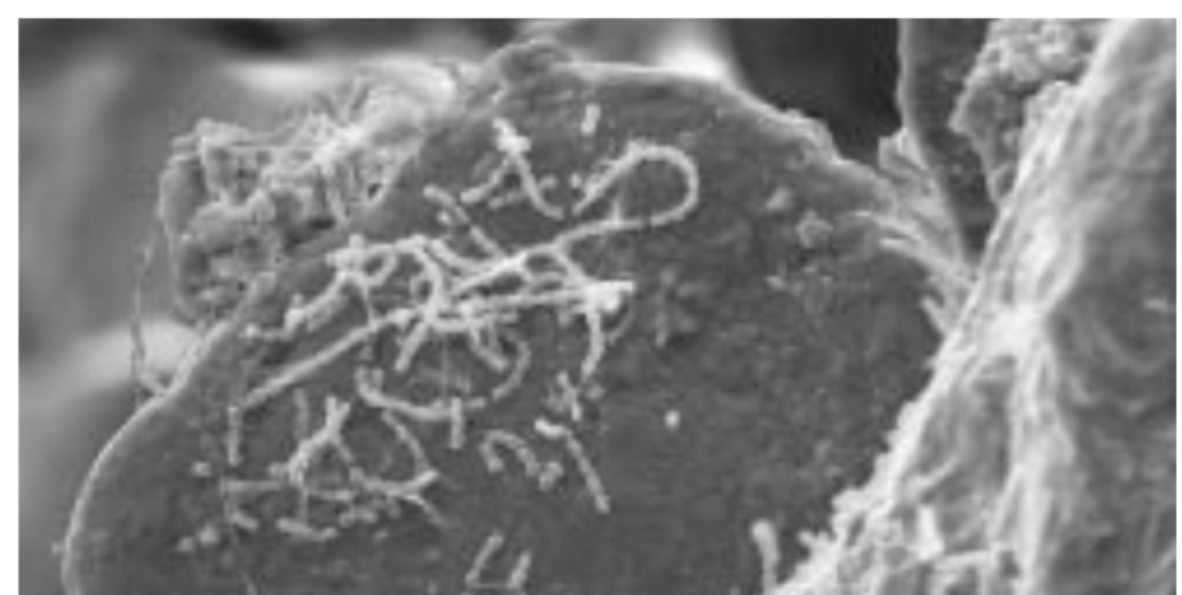


FIGURE 7.7 Weathering by dissolution. **(a)** A salt crystal consists of ions that can be attracted by polar water molecules. **(b)** Eventually, water molecules pluck sodium and chlorine ions off the face of the crystal, surround them, and carry them away. **(c)** Dissolution enlarges joints on the

TABLE 7.1 Relative Stability of Minerals at the Earth's Surface

Fastest Weathering	Halite	**Least Stable**
	Calcite	
	Olivine	
	Ca-plagioclase	
	Pyroxene	
	Amphibole	
	Na-plagioclase	
	Biotite	
	Orthoclase (potassium feldspar)	
	Muscovite	
	Clay (various types)	
	Quartz	
	Gibbsite (aluminum hydroxide)	
Slowest Weathering	Hematite (iron oxide)	**Most Stable**

Note that minerals that form early in Bowen's reaction series (see Box 6.2) are among the least stable minerals at the Earth's surface. Minerals that are the products of weathering reactions (e.g., hematite) are among the most stable minerals at the Earth's surface. Mafic minerals weather by oxidation, felsic minerals by hydrolysis, carbonates and salts by dissolution, and oxide minerals don't weather at all.