Metamorfe bergarter

de fleste bergarter i Norge er metamorfe

(på norsk sier man ikke *metamorfisk,* vi snakker ikke om *fisk*)

Geologer sier at det finnes 3 bergartsgrupper:

1 Magmatiske ba. (engelsk ***Igneous***)
2 Sedimentære ba. (***Sedimentary***)

3 Metamorfe ba. (***Metamorphic***)

(men alle ba. var opprinnelig enten 1 eller 2)

den opprinnelig bergart for 3 kalles for “protolitt”

Protolit betyr

Marshak.pdf (page 256 of 957)

Ba. FØR metamorfose → Metamorf ba.

Protolith → Metamorphic rock

(a)

(b)

(c)

(d)

(e)

(f)

FIGURE 8.1 **(a)** Hand specimens of red shale, consisting of clay flakes, quartz, and iron oxide (hematite). **(b)** Hand specimen of metamorphic rock (gneiss) containing biotite, quartz, feldspar, and bright purple garnets. A rock similar to the shale could have been the protolith of this gneiss. This hand specimen is about 10 cm wide. **(c)** This thin section of a Devonian limestone shows that the rock consists of small fossil shells and shell fragments that have been cemented together. The field of view is about 3 mm. **(d)** This thin section of marble shows how new crystals of metamorphic calcite grew to form an interlocking texture. This photo is taken with polarized light; the color and darkness of an individual grain depends on its orientation with respect to the light waves. **(e)** Granite has randomly oriented grains. **(f)** Metamorphosed granite has flattened and aligned grains.

(“paragneis”)
gneis fra sedimentær ba.

marmor (fossiler til venstre, kalsitt krystaller til høyre)

(“ortogneis”)
gneis fra magmatisk ba.

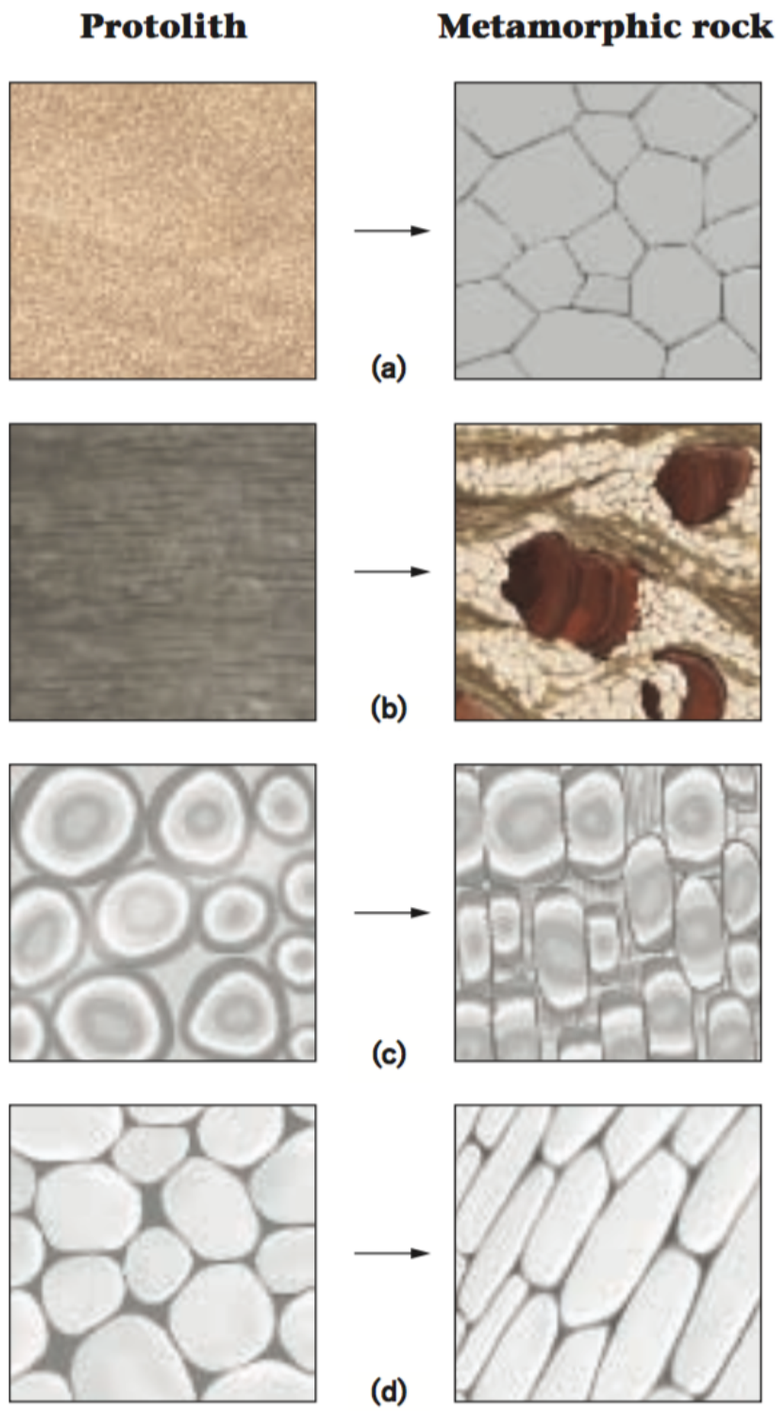


FIGURE 8.2 Examples of protoliths and metamorphic rocks derived from them, illustrating different mechanisms of metamorphism. Each box contains a sketch of a thin section, with the field of view about 1 mm wide. **(a)** A protolith of siltstone recrystallizes to form metamorphic rock made of larger quartz crystals of the same mineral. **(b)** Metamorphic reactions (neocrystallization) in a protolith of silty shale will form a rock formed of quartz, mica, large garnets, and other minerals. **(c)** A protolith of oolitic limestone (an oolite is a tiny snowball-like sphere of calcite with internal concentric rings) undergoes pressure solution so that grains have dissolved on two sides. **(d)** A protolith of quartz sandstone deforms plastically to produce a metamorphic rock in which the quartz grains have been flattened into wavy pancakes.

den enklest typ metamorfose

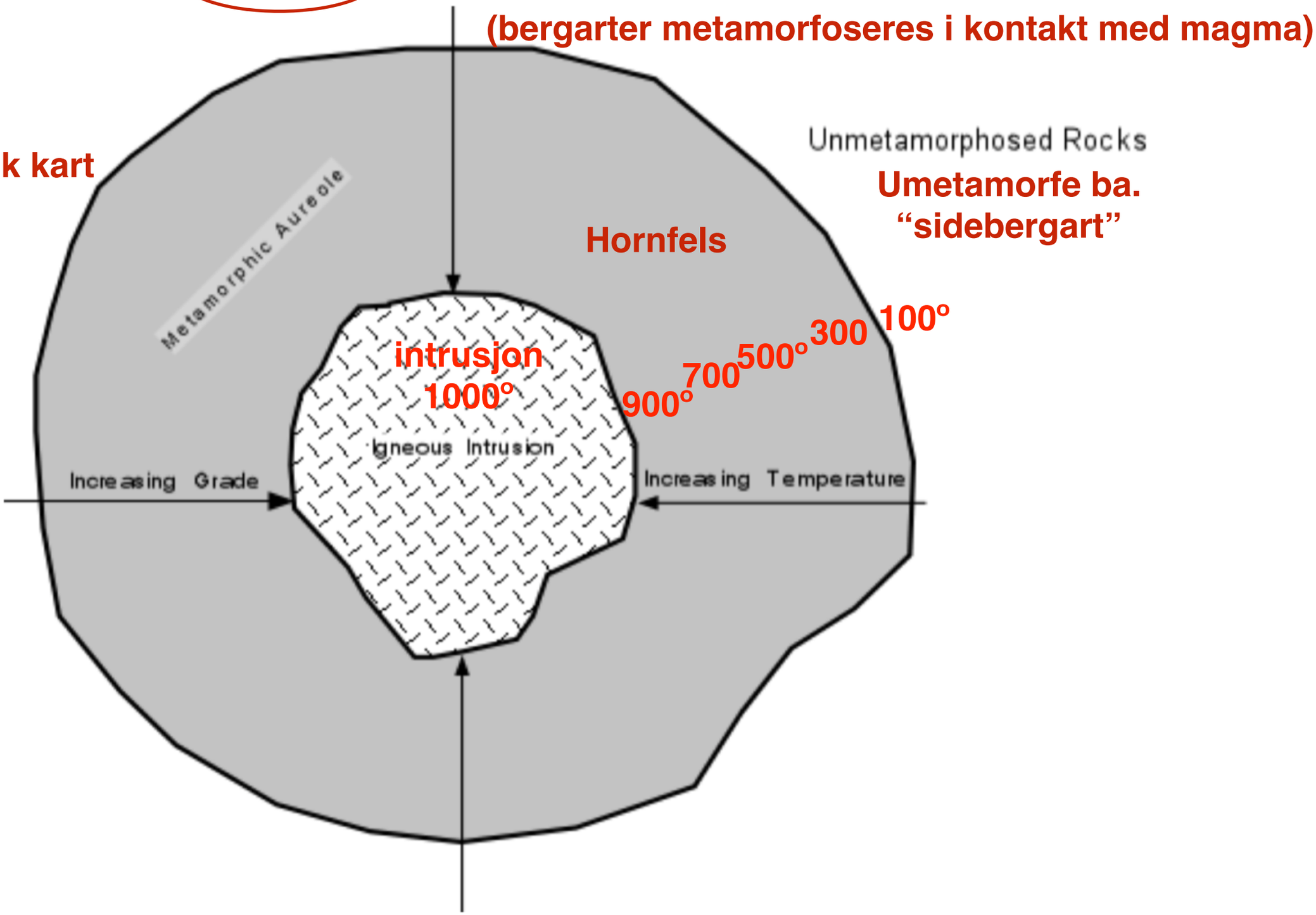
Nelson.pdf (page 64 of 248)

foliation, called a ***hornfels***.

"Kontakt metamorfose"

(bergarter metamorfoseres i kontakt med magma)

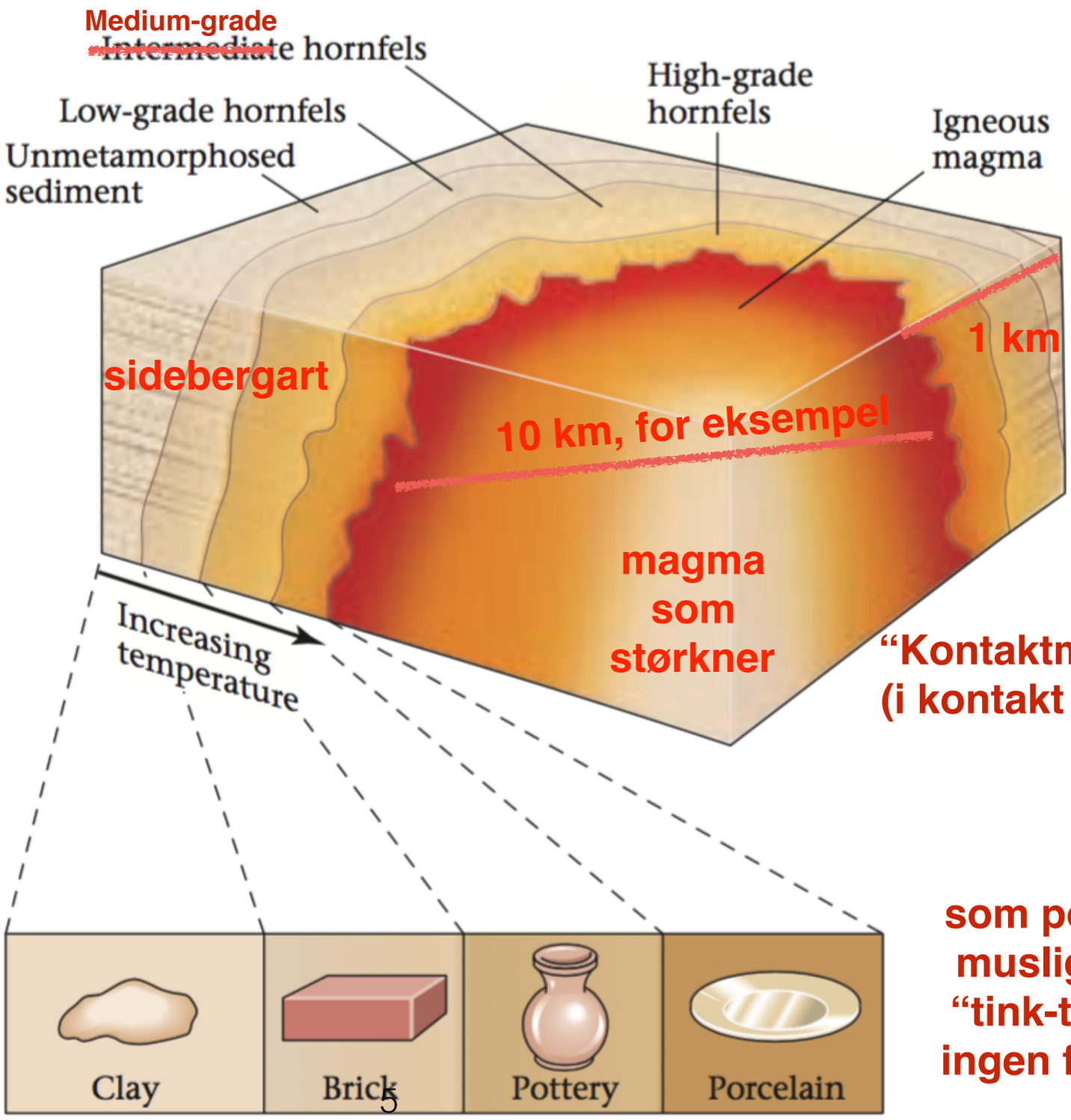
geologisk kart



Umetamorfe ba. "sidebergart"

(intrusjonen er antagelig mye større nedover enn på kartet, fordi aureolen er så stor)

FIGURE 8.23 In a metamorphic aureole bordering an igneous intrusion, the highest-grade thermally metamorphosed rocks directly border the intrusion. The grade decreases away from the pluton. The gradation is analogous to the gradation from clay to pottery to porcelain, obtained by firing clay in an oven.

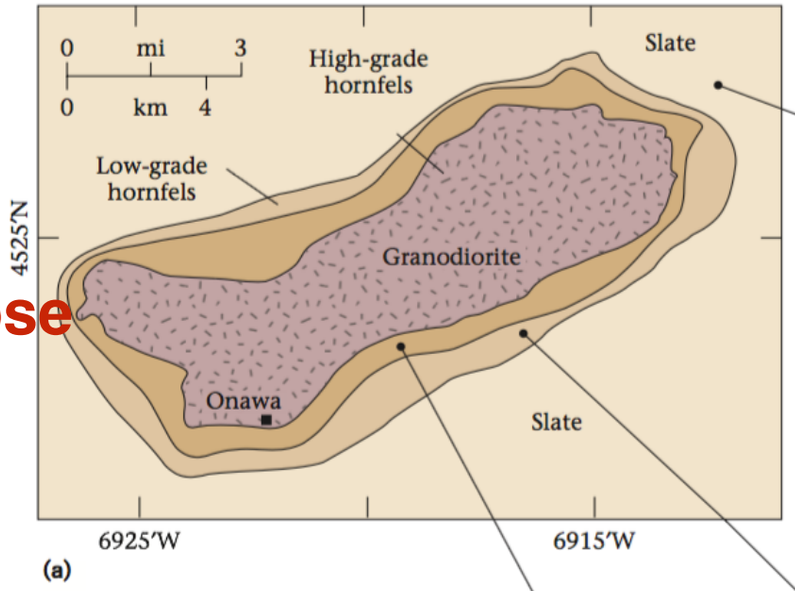


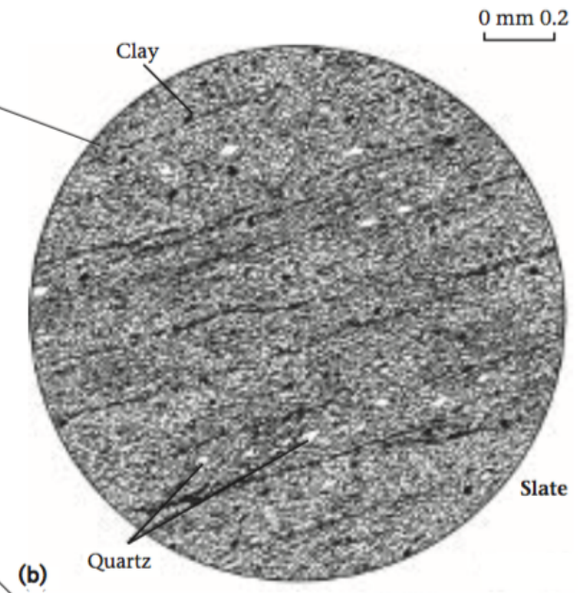
"Kontaktmetamorfose"
(i kontakt med magma)

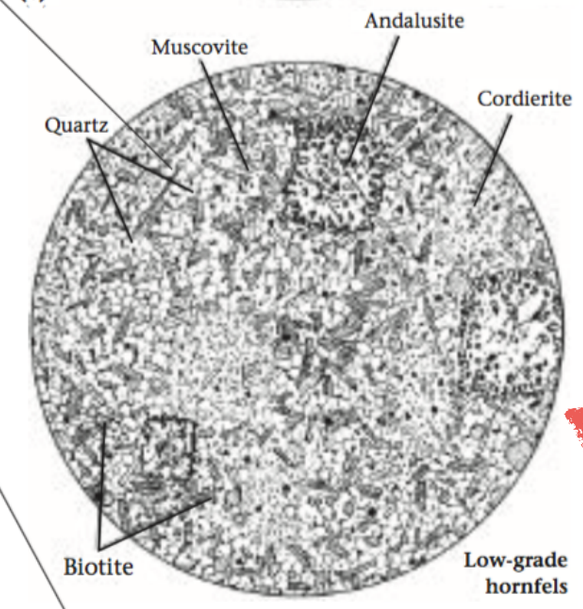
som porselen:
muslig brudd
"tink-tink" lyd
ingen foliasjon

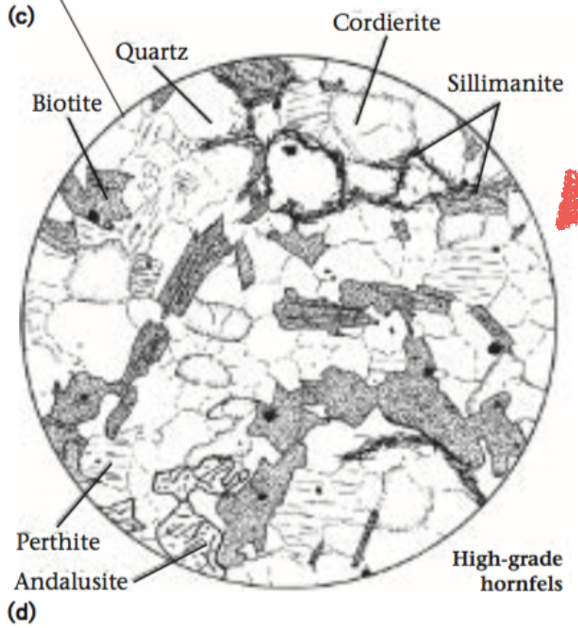
kontaktmetamorfose

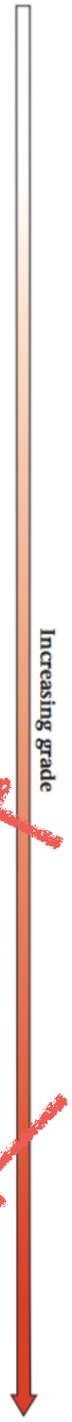
økende "grad" mot intrusjonen











GURE 8.24 The metamorphic aureole around the ıawa Pluton, Maine. **(a)** The width of the preserved aureole ries with location, as seen on this map of the pluton. The ange in rock texture can be seen by comparing the following etches of the three photomicrographs. Each sketch shows the neral grains visible. (Not all of the labeled minerals are discussed this book.) **(b)** Far from the pluton, the country rock is a slate nsisting of aligned clay and very fine quartz. The thin, darker bands resent cleavage. **(c)** In the low-grade part of the aureole, a totally w hornfels texture has formed. This sample contains larger crystals of artz, biotite, muscovite, andalusite, and other minerals. **(d)** In the high-ade part of the aureole, the hornfels is much coarser and contains ferent minerals. The muscovite has vanished, and this sample contains ge crystals of biotite, quartz, sillimanite, andalusite, and other minerals. ote that there is no preferred mineral orientation in hornfels.

ikke metamorf. synlig S_0

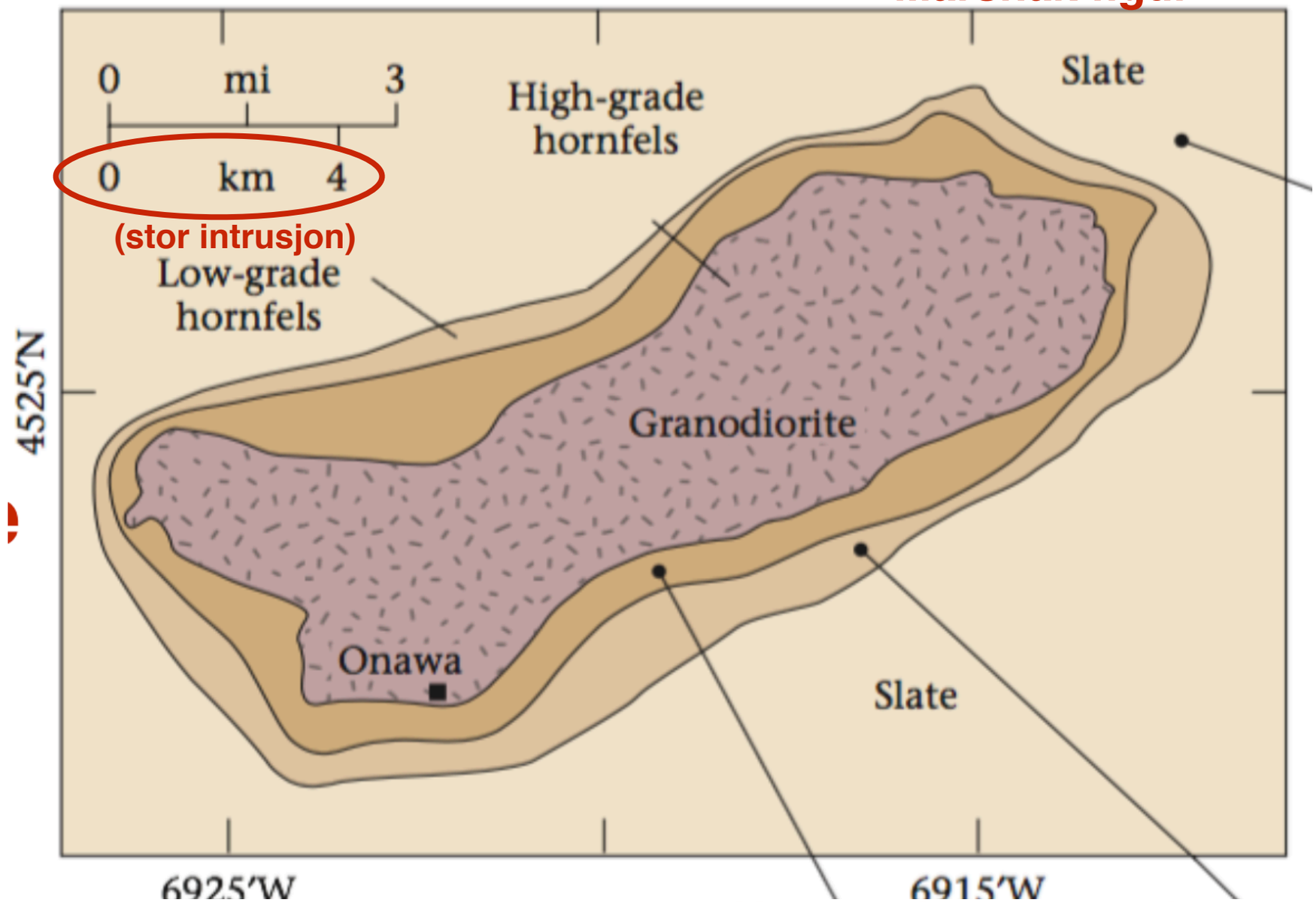
lav grad

ingen foliasjon (S1), fordi kontakt metamorfose er statisk, ikke dynamisk

høy grad

Geologer ser etter spesielle mineraler for å bestemme metamorf grad av hornfels.

Marshak figur



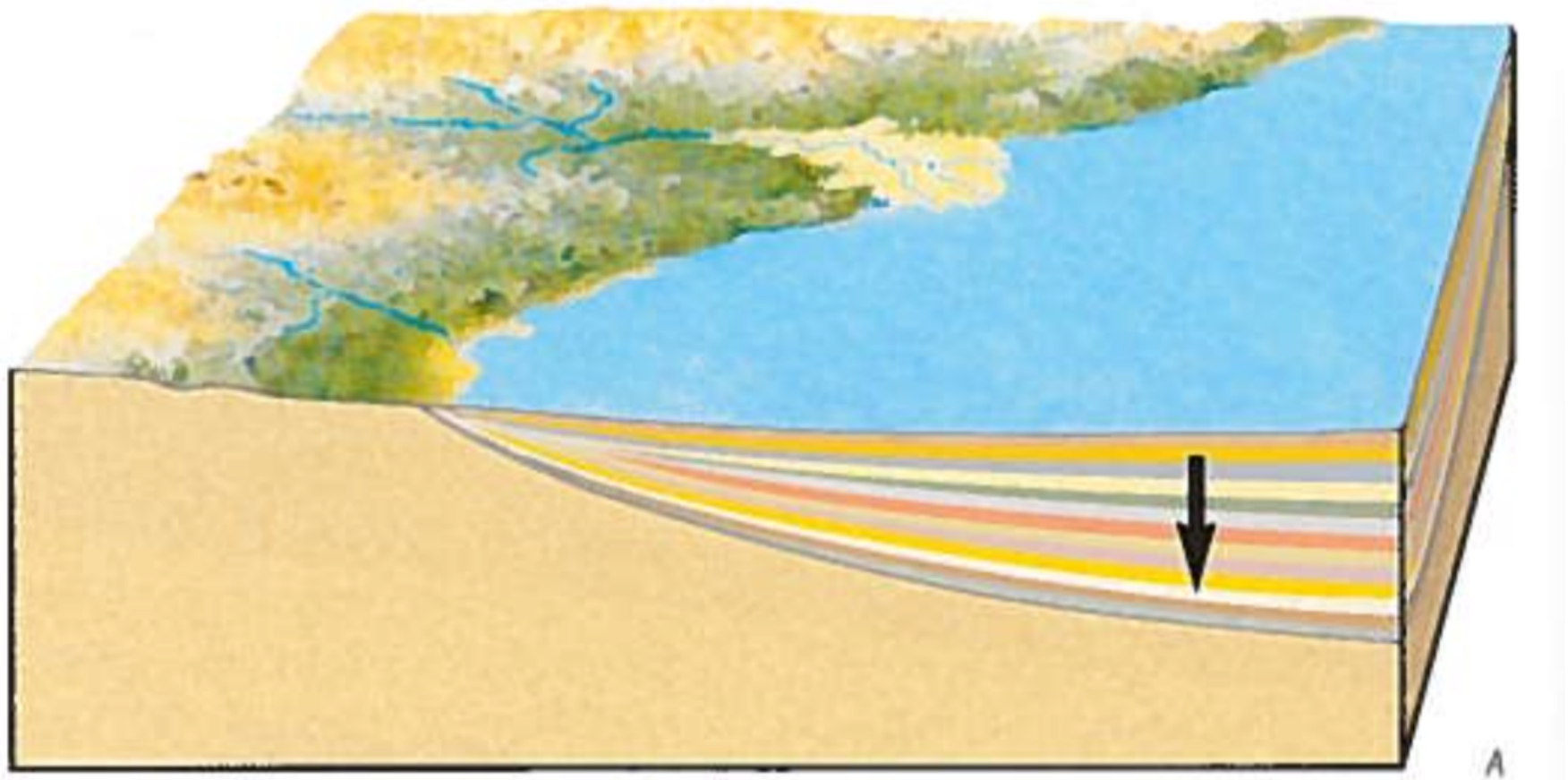
Ikke metamorf

Høy grad

Lav grad

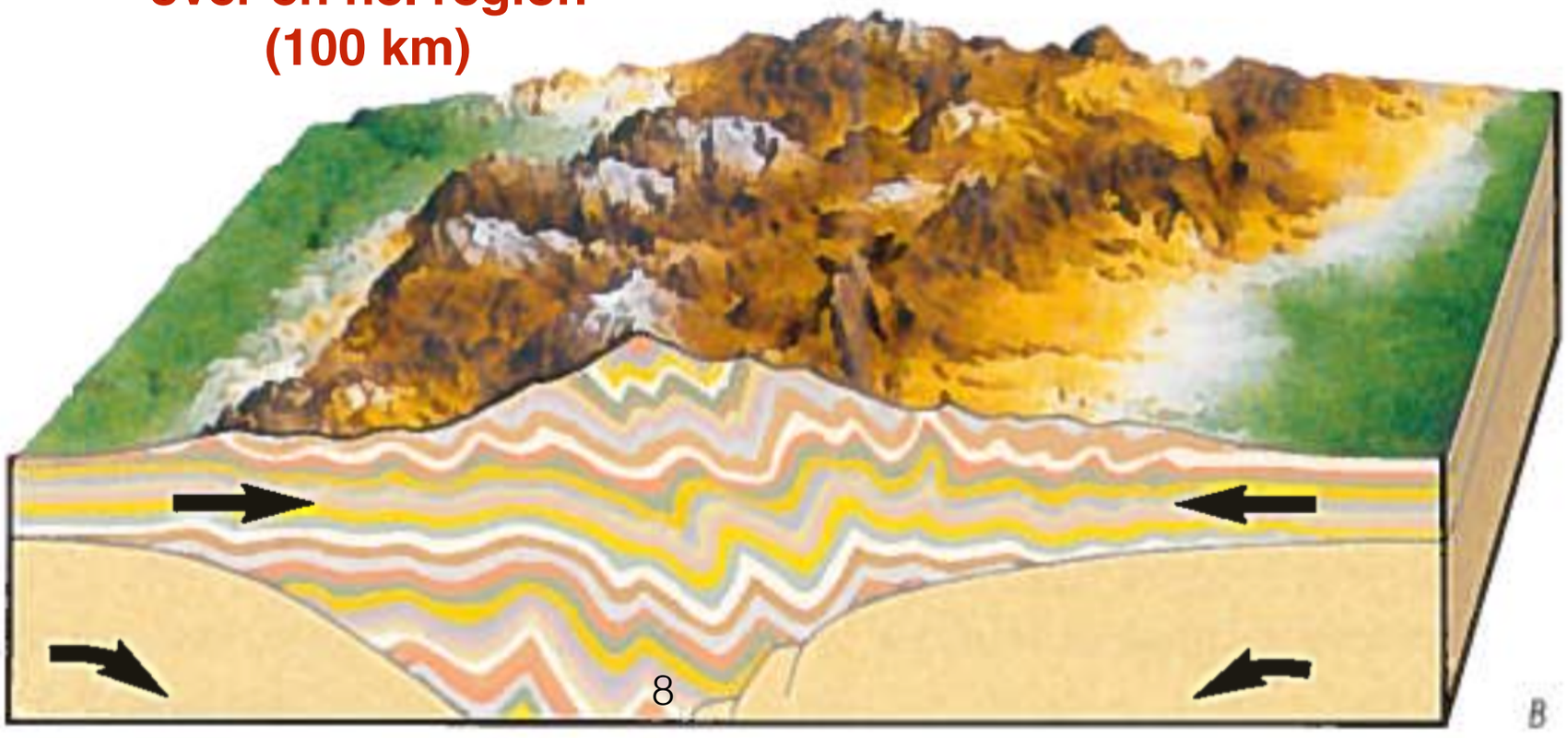
Typisk hornfels aureole er ca. 1 km tykk

aureọl
subst. -en, -er
lyskrans rundt sol el. måne pga. lysstrålenes avbøyning i skylag



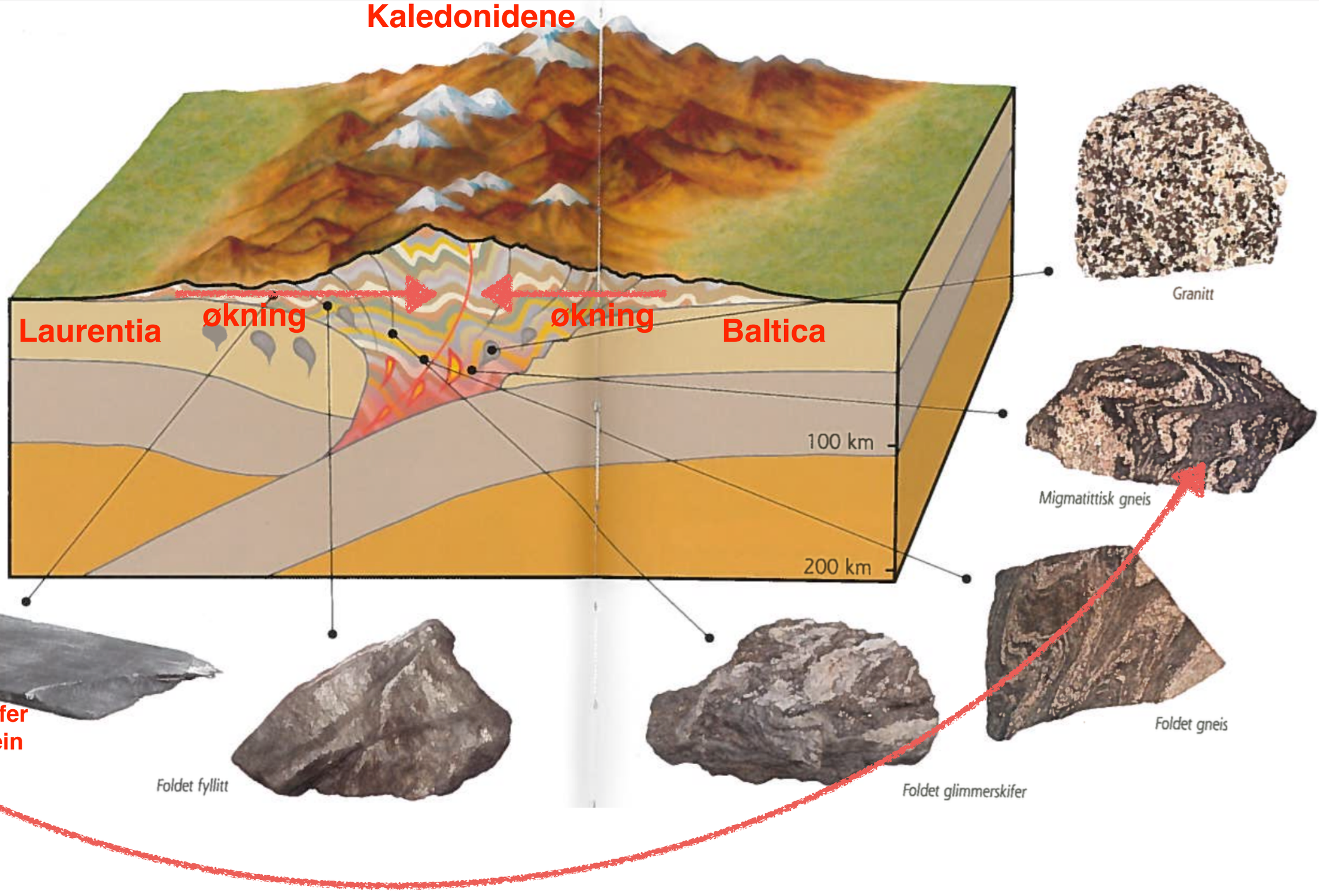
To figurer som illustrerer forskjellen mellom A, det vertikale trykket som sedimenter utsettes for og som fører til sammepressing og sammenkitting, og B, det differensielle trykket som bergartene utsettes for i forbindelse med en fjellkjedefolding

"Regionalmetamorfose"
over en hel region
(100 km)



"Regionalmetamorfose"

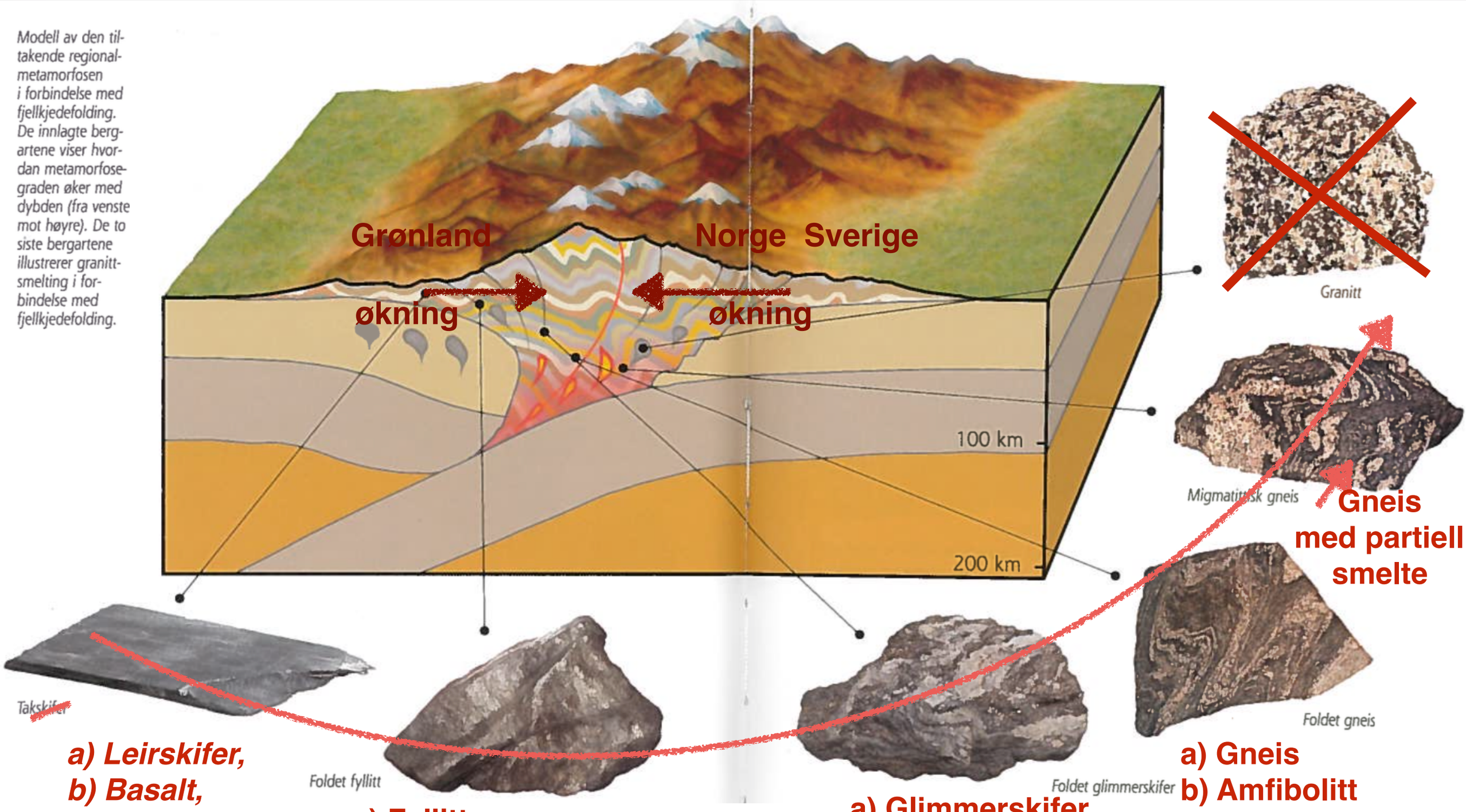
Modell av den tiltakende regionalmetamorfosen i forbindelse med fjellkjedefolding. De innlagte bergartene viser hvordan metamorfosegraden øker med dybden (fra venste mot høyre). De to siste bergartene illustrerer granittsmelting i forbindelse med fjellkjedefolding.



økende grad over en region, øker ofte mot midten av en fjellkjede

Regionalmetamorfose: økende grad over en hel region, ofte mot midten av en fjellkjede

Modell av den tiltakende regionalmetamorfosen i forbindelse med fjellkjedefolding. De innlagte bergartene viser hvordan metamorfosegraden øker med dybden (fra venste mot høyre). De to siste bergartene illustrerer granittsmelting i forbindelse med fjellkjedefolding.



a) Leirskifer,
b) Basalt,
c) Kalkstein,
d) Granitt

a) Fyllitt,
b) Grønnstein
c) Kalkstein/marmor
d) Granitt

a) Glimmerskifer
b) Amfibolitt
c) Marmor
d) Gneis

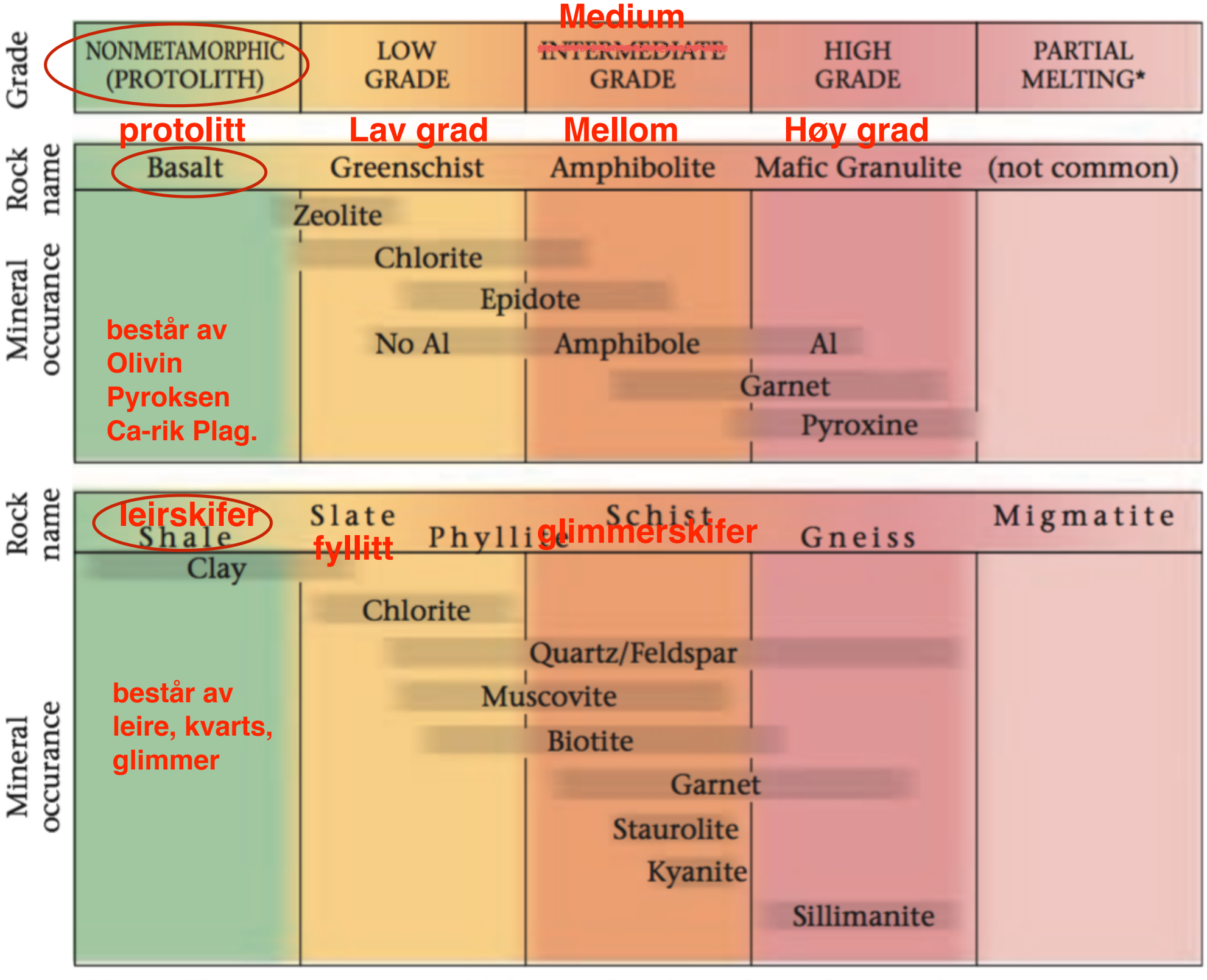
a) Gneis
b) Amfibolitt
c) Marmor
d) Gneis

a -> a -> a -> a
b -> b -> b -> b
osv.

(Metamorfosegrad og deformasjon øker nordvestover fra Trondheim. Nærmere kollisjons-sonen.)

Marshak.pdf (page 267 of 957)

viser mineraler som vokser under metamorfose ved ulike grader



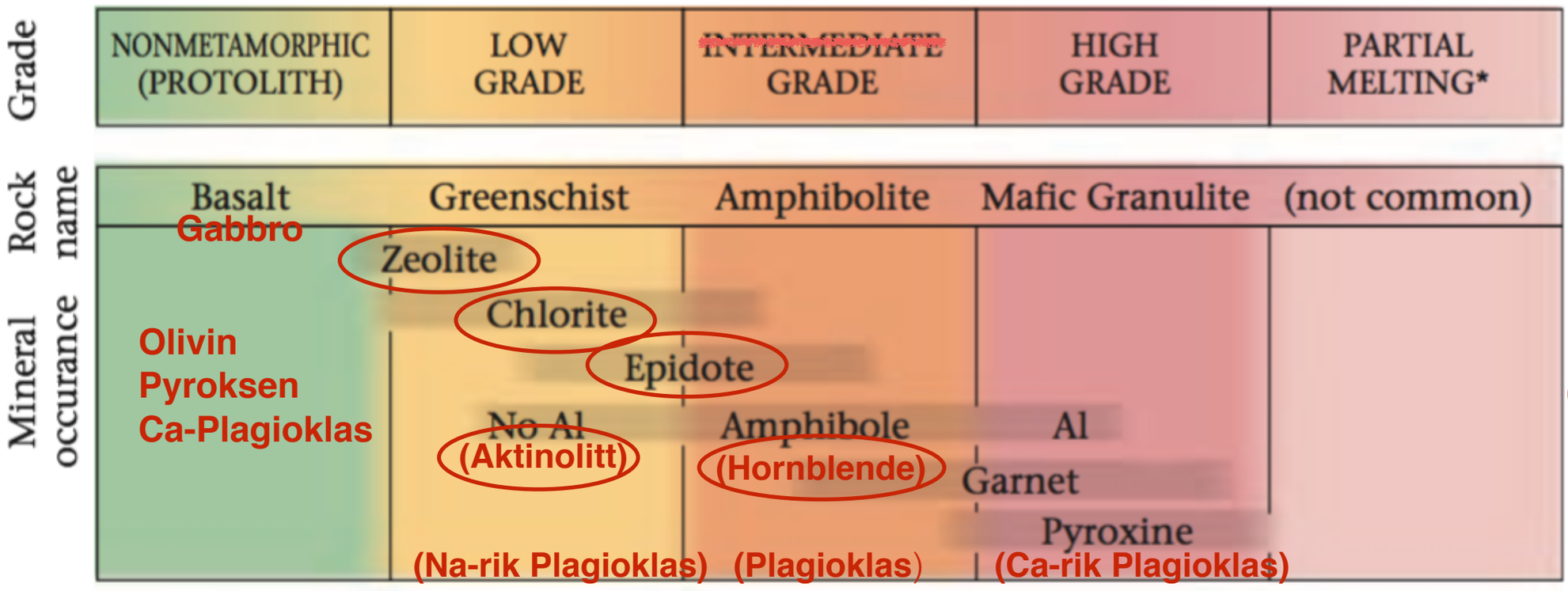
Basalt er verdens mest vanlig magmatisk ba.

Leirskifer er verdens mest vanlig sedimentære ba.

*Note: The temperature at which partial melting depends on rock composition and water content. Mafic rocks begin to melt at higher temperatures than do pelitic rocks. Wet rocks melt at lower temperatures than do dry rocks.

(b)

Medium



Oval rundt mineraler som har vann (OH) i gitter.

Ingen vann i basalt

Mye vann i grønnskifer

Mindre vann i amfibolitt

Ingen vann i granulitt

Hvis det er nok vann, så blir det partiell smelte.

Basalt er svart.

Kloritt, epidot, og Aktinolitt er alle grønne. Derfor er grønnskifer grønn.

Hornblende er svart. Derfor er amfiblitt svart og ikke grønn.

Denne matpakken er som bergarter.
Opprinnelig er ost fuktig og knekkebrød tørt.
Som leirskifer (fuktig) og basalt (tørt)

Etterpå, hvis litt varme, blir alt grønn (muggen) og minner om grønnstein. Eller, hvis veldig varm i stekeovn, vil alt tørke helt ut.

Medium

Grade	NONMETAMORPHIC (PROTOLITH)	LOW GRADE	~~INTERMEDIATE~~ GRADE	HIGH GRADE	PARTIAL MELTING*
Rock name	Basalt	Greenschist	Amphibolite	Mafic Granulite	(not common)
Mineral occurance		Zeolite, Chlorite, Epidote	No Al; Amphibole	Al; Garnet, Pyroxine	

eller Eklogitt

Oval rundt mineraler som har vann.

Rock name	Shale	Slate	Phyllite	Schist	Gneiss	Migmatite
Mineral occurance	Clay	Chlorite	Quartz/Feldspar, Muscovite, Biotite	Garnet, Staurolite, Kyanite	Sillimanite	

leirskifer

fyllitt

*Note: The temperature at which partial melting depends on rock composition and water content. Mafic rocks begin to melt at higher temperatures than do pelitic rocks. Wet rocks melt at lower temperatures than do dry rocks.

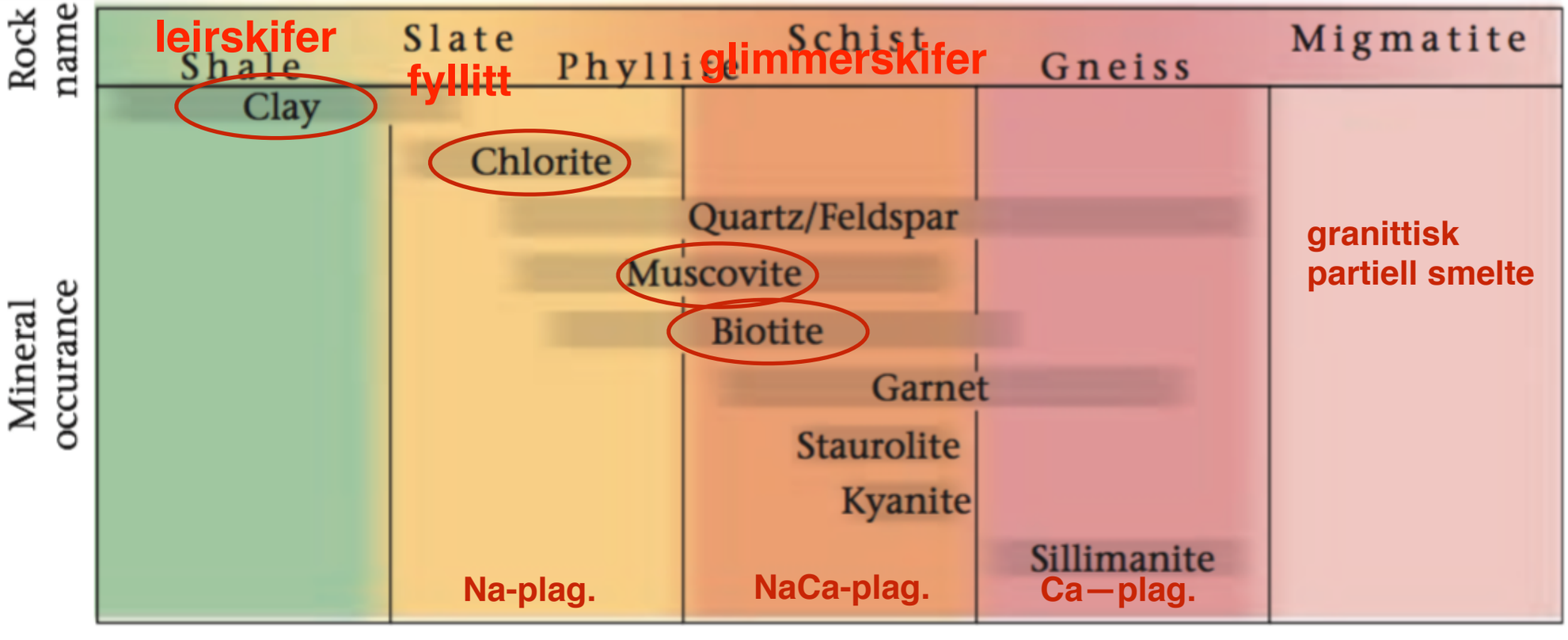
(b)

Medium

Grade

NONMETAMORPHIC (PROTOLITH)	LOW GRADE	INTERMEDIATE GRADE	HIGH GRADE	PARTIAL MELTING*

Oval rundt mineraler som har vann.



*Note: The temperature at which partial melting depends on rock composition and water content. Mafic rocks begin to melt at higher temperatures than do pelitic rocks. Wet rocks melt at lower temperatures than do dry rocks.

(b)

MEDIUM

Grade

NONMETAMORPHIC (PROTOLITH)	LOW GRADE	INTERMEDIATE GRADE	HIGH GRADE	PARTIAL MELTING*

Rock name

Shale | Slate | Phyllite | Schist | Gneiss | Migmatite

leirskifer

fyllitt

Mineral occurance

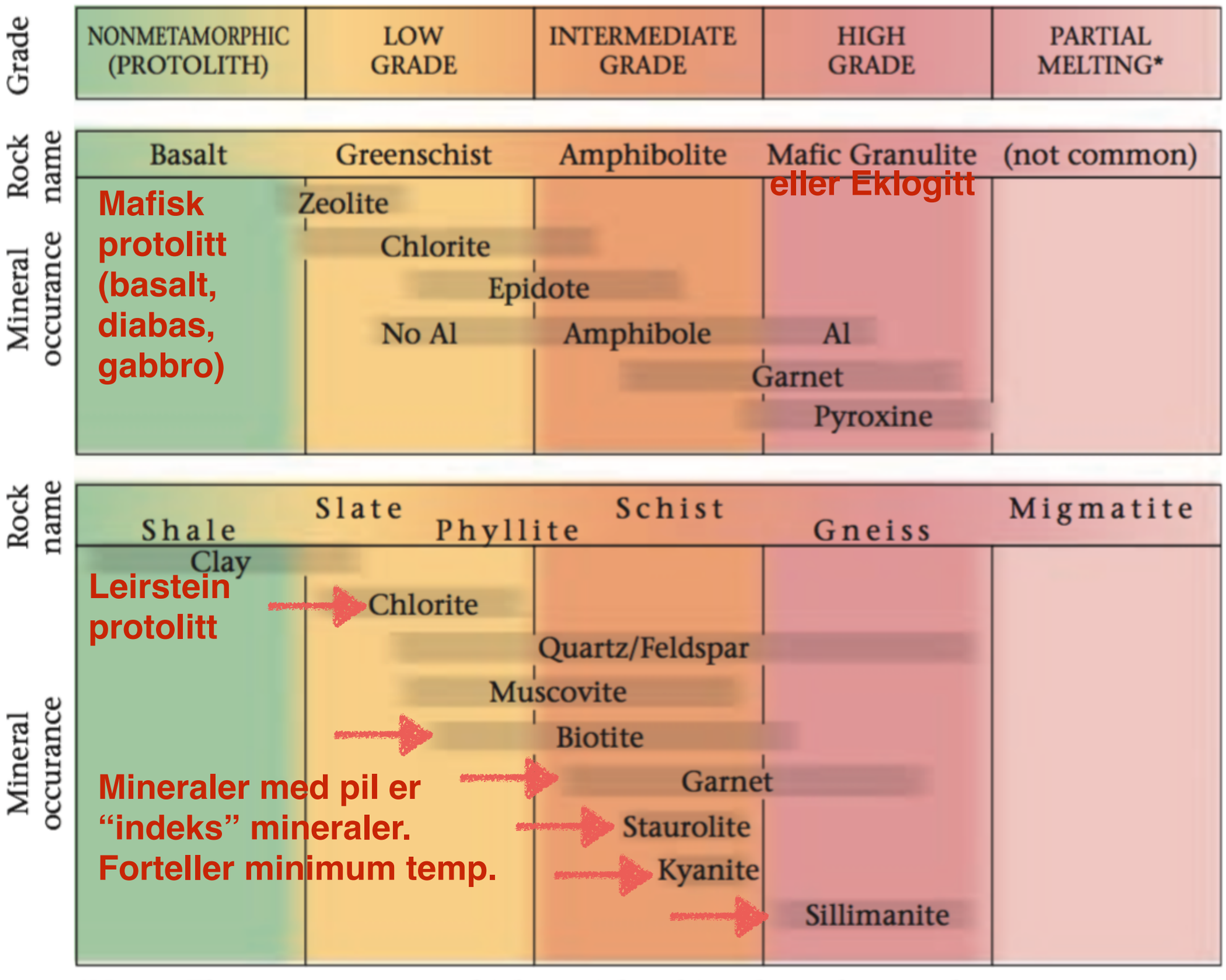
Clay
Chlorite
Quartz/Feldspar
Muscovite
Biotite
Garnet
Staurolite
Kyanite
Sillimanite

Plagioklas også dannes og endres.
lav temperatur metamorf plagioklas er Na-rik
høy temperatur metamorf plagioklas er Ca-rik

Oval på mineraler med vann.
Kun biotitt overlever ved høy grad.

*Note: The temperature at which partial melting depends on rock composition and water content. Mafic rocks begin to melt at higher temperatures than do pelitic rocks. Wet rocks melt at lower temperatures than do dry rocks.

(b)

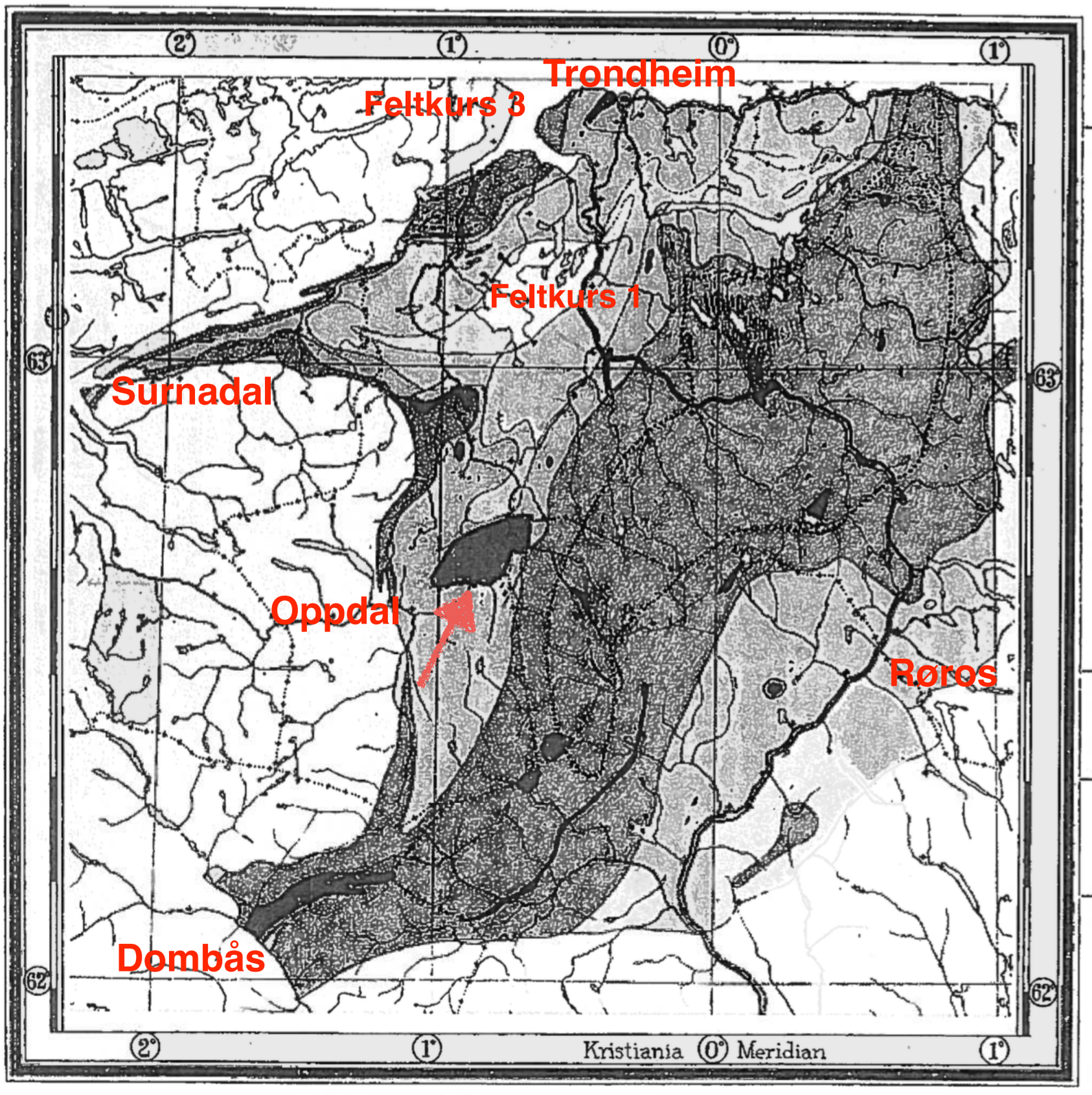


*Note: The temperature at which partial melting depends on rock composition and water content. Mafic rocks begin to melt at higher temperatures than do pelitic rocks. Wet rocks melt at lower temperatures than do dry rocks.

(b)

Verdens første kart over "regionalmetamorfose"
(og "kontaktmetamorfose" ved Oppdal)

(Feltkurs 2 var ca. her)



Victor M. Goldschmidt
1915

Metamorphose der Tonschiefer.

Nur mechanische Metamorphose.
ikke-metamorfe mineraler

"Indeks mineraler"

Zone des Chlorits. **kloritt**

Zone des Biotits. **biotitt**

Zone des Granats **granat**

Zone, in welcher Kalksilikatgneise und Kalksilikatglimmerschiefer vorkommen.

Intrusivgesteine der Opdalit-Trondhjemit-Familie.

Kontaktmetamorphe Zone an Opdalit-Trondhjemit-Intrusiven (vergl. auch S. 37).

1 : 1,000,000

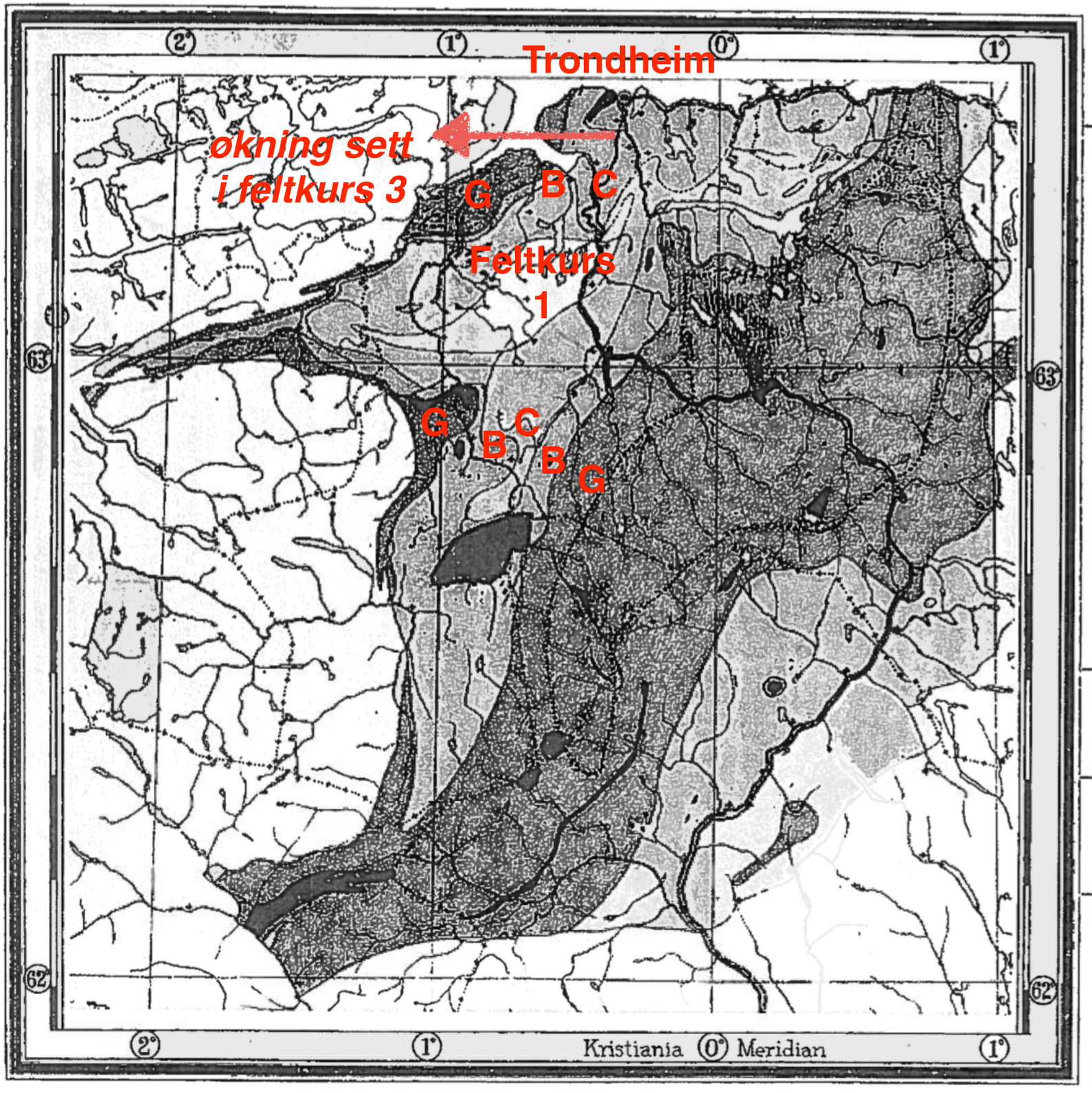
V. M. Goldschmidt.

10 5 0 10 20 30 40 50 60 70 80 90 100 Km

Verdens første kart med regionalmetamorfe soner

Vid.-Selsk. Skr. I. M.-N. Kl. 1915. No. 10.

Victor M. Goldschmidt
1915



Metamorphose der Tonschiefer.

- Nur mechanische Metamorphose.
- Zone des Chlorits. **C**
- Zone des Biotits. **B**
- Zone des Granats **G**
- Zone, in welcher Kalksilikatgneise und Kalksilikatglimmerschiefer vorkommen.
- Intrusivgesteine der Opdalit-Trondhjemit-Familie.
- Kontaktmetamorphe Zone an Opdalit-Trondhjemit-Intrusiven (vergl. auch S. 37).

1 : 1,000,000

V. M. Goldschmidt.

10 5 0 10 20 30 40 50 60 70 80 90 100 Km

ABP

Victor Goldschmidt

From Wikipedia, the free encyclopedia

For other uses, see Victor Goldschmidt (disambiguation).

This article has multiple issues. Please help **improve it** or discuss these issues on the **talk page**. [hide]

(Learn how and when to remove these template messages)

- This article's **factual accuracy is disputed**. *(December 2012)*
- The **neutrality of this article is disputed**. *(December 2012)*

Victor Moritz Goldschmidt ForMemRS[1] (Zürich, January 27, 1888 – March 20, 1947, Oslo)[2][3][4][5] was a mineralogist considered (together with Vladimir Vernadsky) to be the founder of modern geochemistry and crystal chemistry, developer of the Goldschmidt Classification of elements.

Contents [hide]

1 Early life and career
2 New theories
3 Achievements
4 Later life
5 See also
6 References
7 External links

Early life and career [edit]

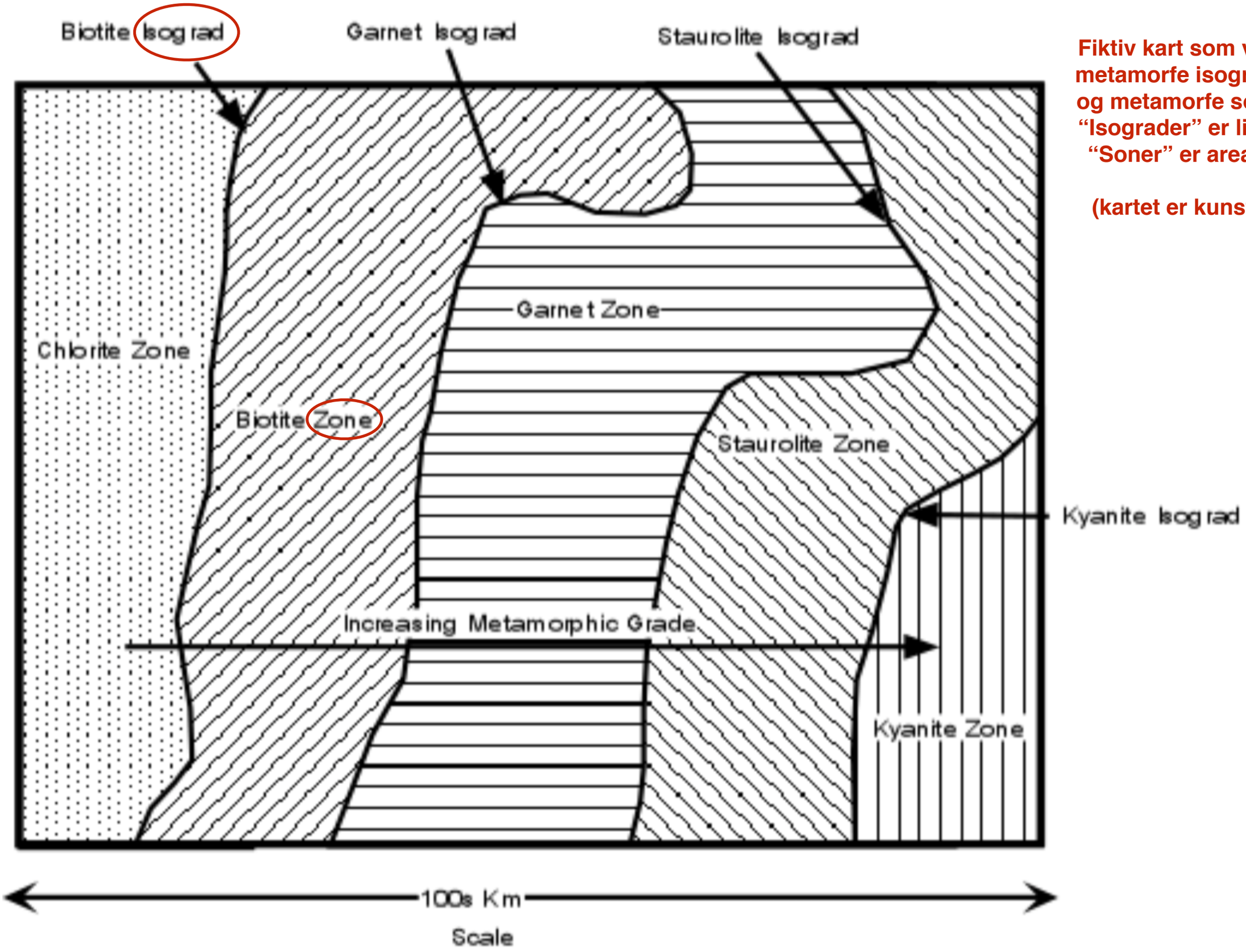
Goldschmidt was born in Zürich. His Jewish parents, Heinrich Jacob Goldschmidt and Amelie Koehne named their son after a colleague of Heinrich, Victor Meyer. There was a history of great scientists and philosophers in both families. The Goldschmidt family came to Norway 1901 when Heinrich Goldschmidt took over a chair as Professor of Chemistry in Kristiania (Oslo).

Goldschmidt's first important contribution was within the field of geology and mineralogy. His two first larger works were his doctoral thesis *Die Kontaktmetamorphose im Kristianiagebiet* and *Geologisch-petrographische Studien im Hochgebirge des südlichen Norwegens*.

Victor Moritz Goldschmidt

Young Victor Goldschmidt

Born	January 27, 1888 Zürich, Switzerland
Died	March 20, 1947 (aged 59) Oslo, Norway
Fields	Geochemistry
Institutions	University of Oslo
Alma mater	University of Oslo
Thesis	*Die Kontaktmetamorphose im Kristianiagebiet and Geologisch-*



Fiktiv kart som viser metamorfe isograder og metamorfe soner. "Isograder" er linjer. "Soner" er arealer.

(kartet er kunstig)

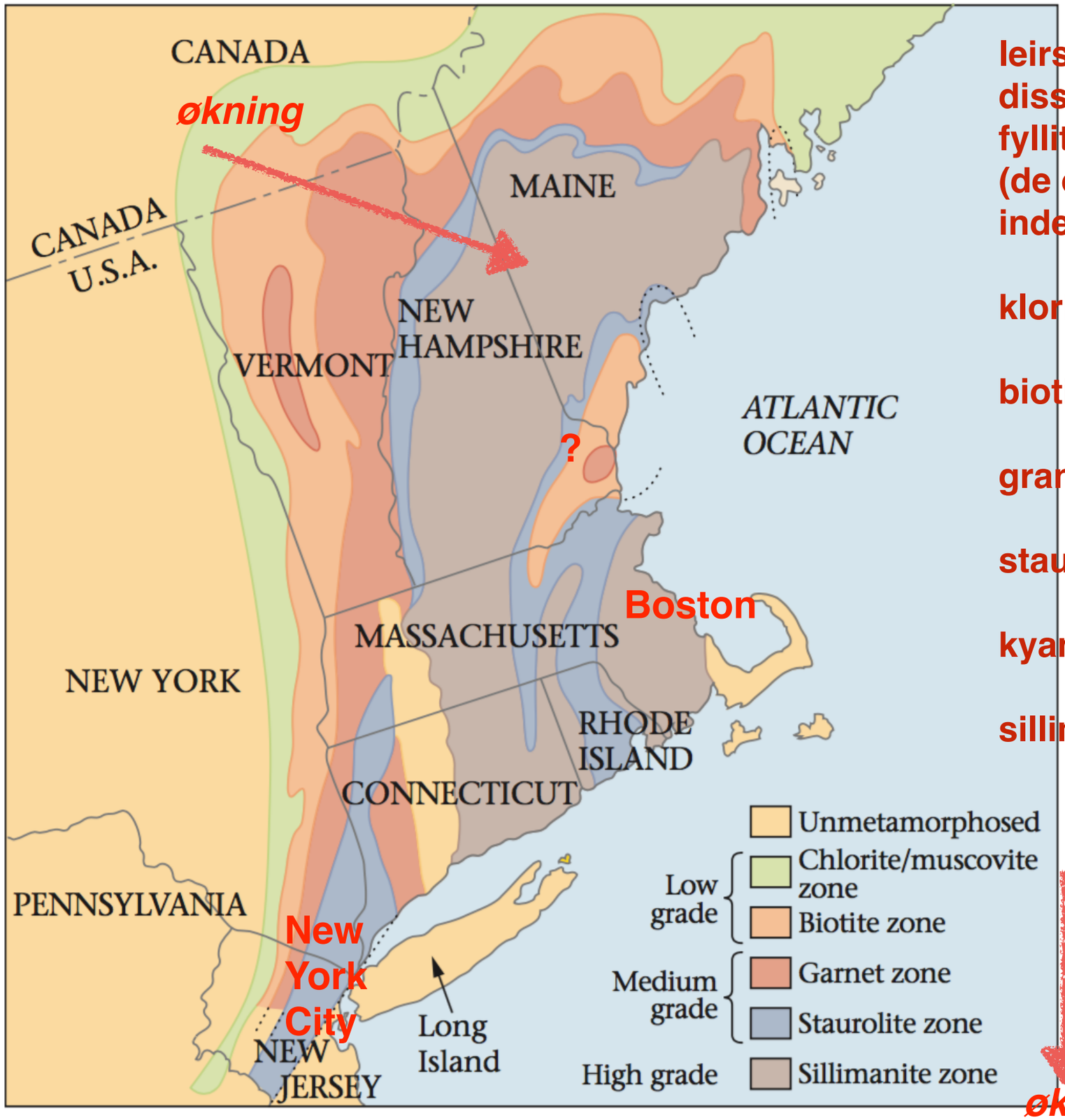


FIGURE 8.21 Metamorphic zones as portrayed on a map of New England (U.S.A.). Isograds, defined by the first appearance of an index mineral, separate the zones.

leirskifer er rik på aluminium (Al).
disse "indeks" mineraler forekommer i fyllitt-glimmerskifer-gneis
(de oppstår ikke i ba. med lite Al)
indeksmineralene gir navn til sonene.

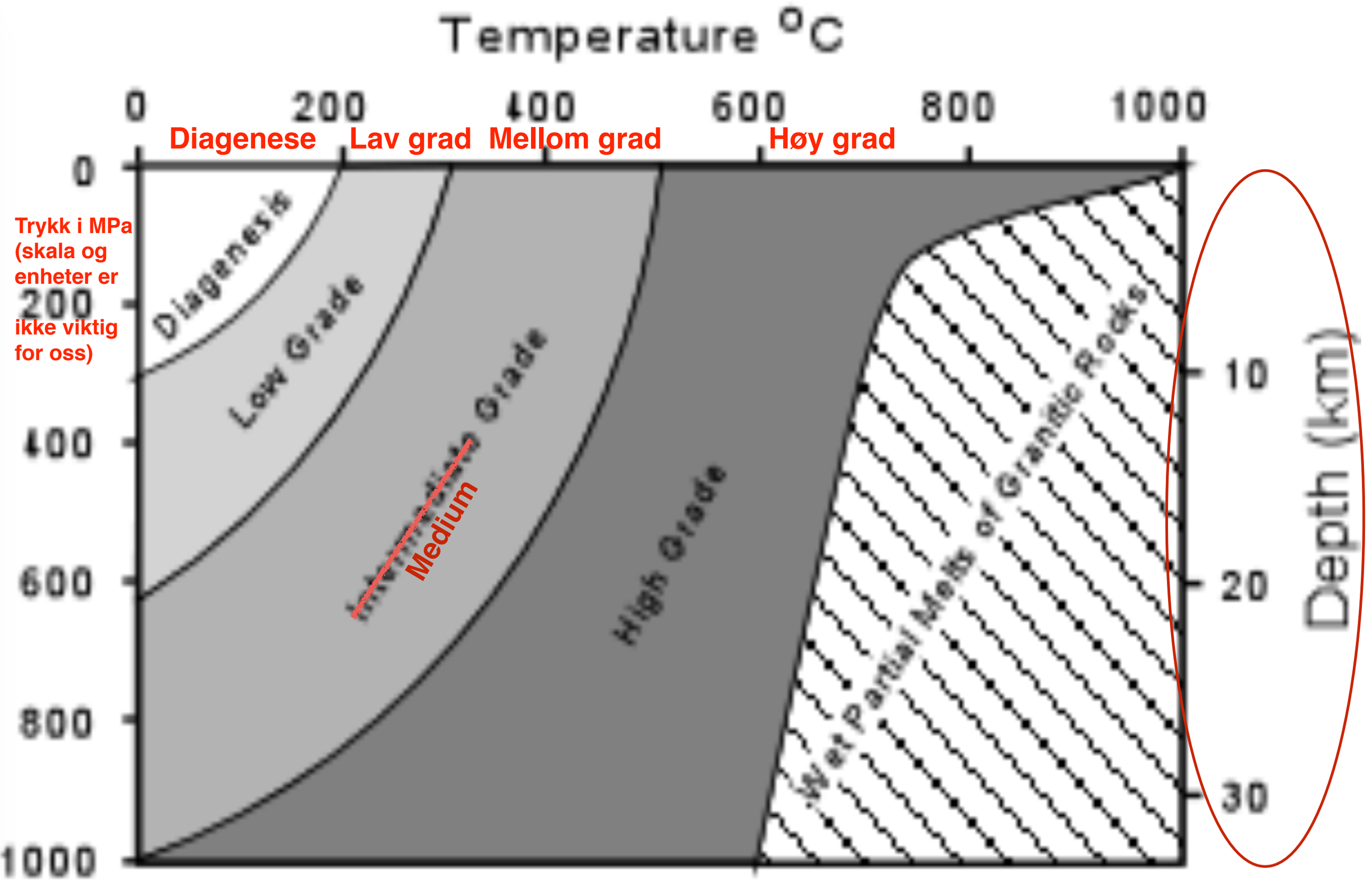
kloritt "sone": område med høy nok temp. til dannelse av kloritt
biotitt sone: område med høy nok temp. til dannelse av metamorf biotitt
granat sone: (samme prinsipp)

staurolitt:

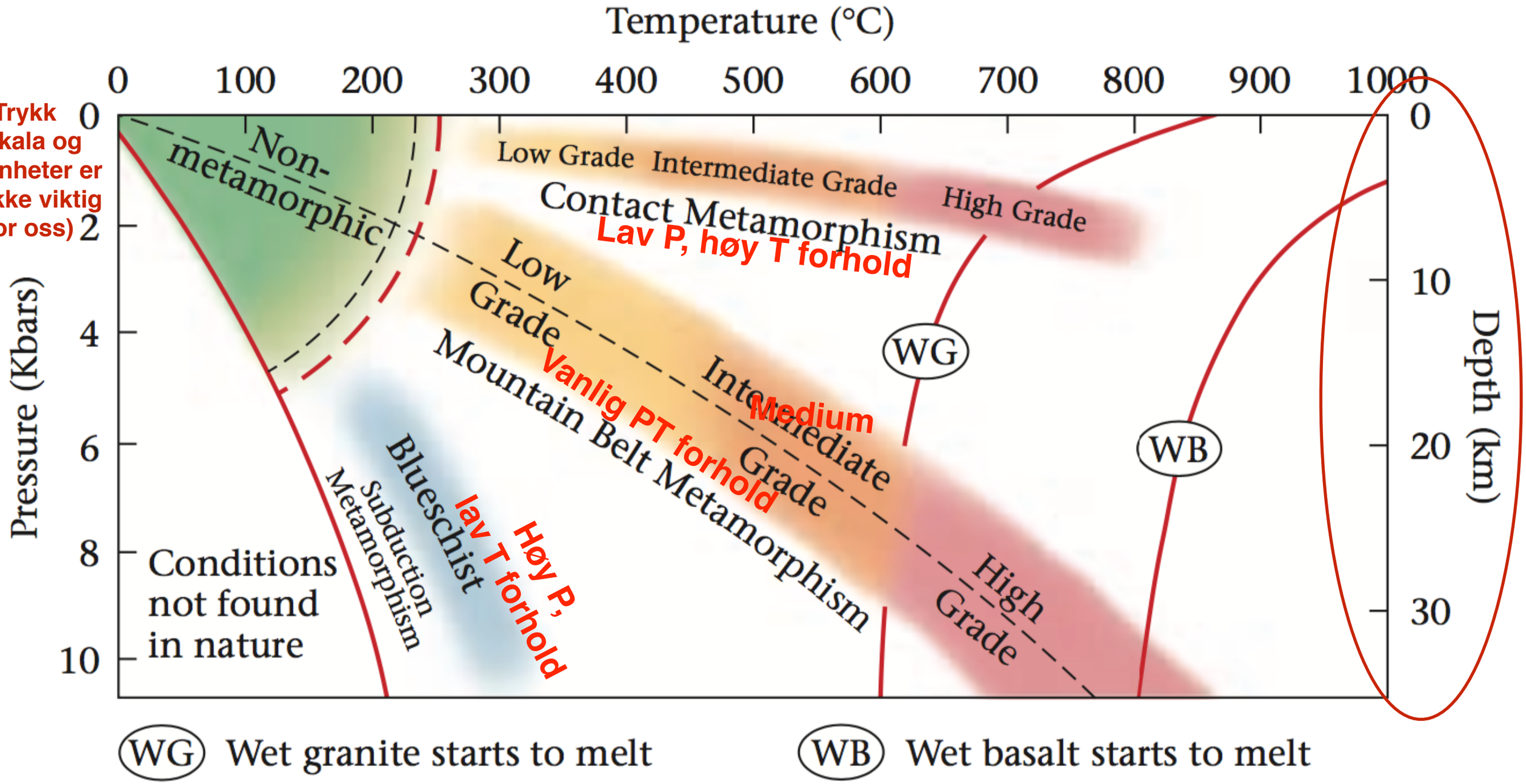
kyanitt: (ikke forekommer her fordi trykk var for lav)

sillimanitt:

"**isograd**": nedre temperaturgrense for den angitte "**sonen**".



Geologer sier “Medium grade” (ikke “Intermediate grade”!)



(Trykk skala og enheter er ikke viktig for oss)

Lav P, høy T forhold

Vanlig PT forhold

Medium

Høy P, lav T forhold

Det er ikke enighet mellom Marshak og Nelson om temperatur skala.
(Uenigheter er typisk i geologi.)

For eksempel:
1: grensen med lav grad / mellom grad er ca. 300° ved Nelson og ca. 400° ved Marshak
2: Marshak begynner "metamorfose" ved 250°, Nelson begynner ved 200°