INTRO

005171

Metamorphism – Anvil District

~~Aspects of Metamorphism:~~

Lith Code presently utilized oriented towards

Use in Mine area — amphibolite facies

Use on Vangorda Plateau — lower greenschist facies.

With re-logging of deep exploration holes on plateau, mapping in District, extension of geology away from Mine, have ~~begun to have~~ started to appreciate the problems of metamorphic grade.

- have encountered rocks transitional between the two metamorphic grades.
- do not really fit in code
- want to try to make sure ~~we~~ we have a common basis for understanding and utilizing metamorphic transition.

have made jump between 3D & 5B.

need to understand intermediate steps

- surprisingly that transition occurs at very short distance away from the Mine.

Can't describe transitions in code – can't enter it readily in recallable format into Database.

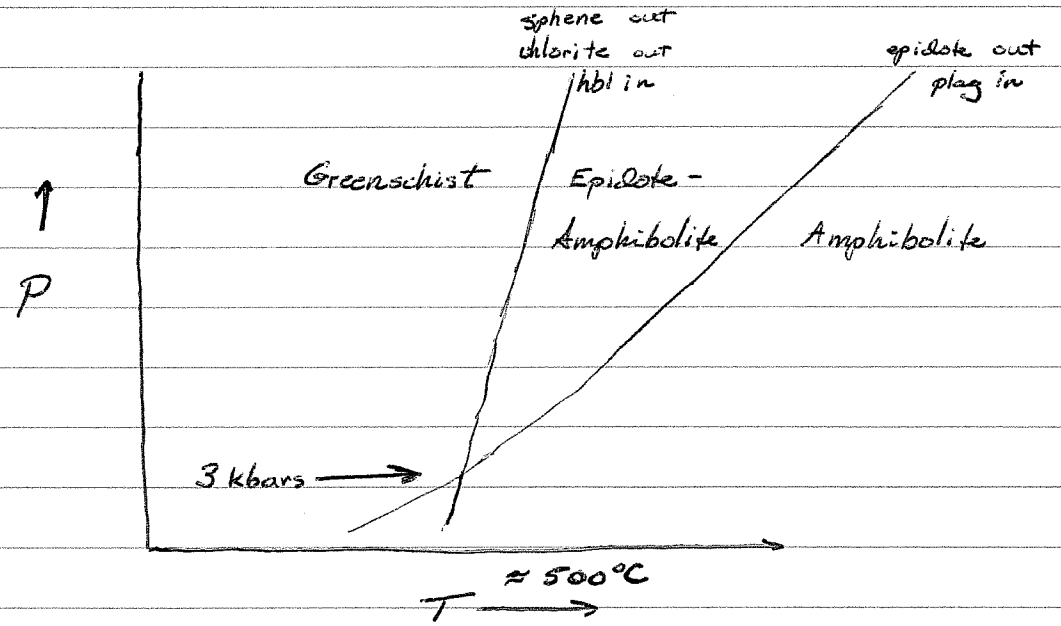
Controls of Metamorphism

1. Pressure
2. Temperature
3. Rock composition
4. Fluid composition.

P considered a constant < 4kb assume 2-3kb.

Use rock compositions as major factor.
look at different bulk compositions as vary metamorphic conditions.

BASALTS – METABASITES during METAMORPHISM



Typical mineral assemblages

Greenschist facies

albite + chlorite + actinolite + epidote ± quartz ± sphene

Epidote-amphibolite facies

~~plag~~ albite + hornblende + epidote ± quartz ± Ti-phase (ilmenite)

Amphibolite facies

plagioclase (An_{20-50}) + hornblende ± almandine ± quartz ± Ti-phase

Major changes between greenschist and amphibolite facies

albite ⟶ plagioclase

actinolite ⟶ hornblende

epidote disappears

chlorite disappears.

At low pressures these reactions occur roughly at same location in P-T space.

At high pressures these reactions are ~~smeared~~ stretched out through a temperature range for a given P. Sequence of reactions is epidote-amphibolite facies

BASALTS — METABASITES

1.) typical <u>chlorite out</u> reaction:

chlorite + sphene + quartz + actinolite = Al-amphibole + ilmenite + H_2O

divariant reaction occurring over a T interval.

2.) typical <u>epidote out</u> reaction for low pressures:

albite + epidote + chlorite + quartz = plag. + hornblende + magnetite + H_2O

it is a chlorite decreasing reaction

3.) typical <u>epidote out</u> reaction for high pressures:

epidote + albite + hornblende$_1$ + quartz = plag. + hornblende$_2$ + H_2O

Changes in amphibole composition with increasing metamorphic grade.

increasing $(Al_2O_3 + Fe_2O_3)$ and Na_2O

decreasing CaO, $(MgO + FeO)$, and SiO_2

We can see these changes in the metabasites by:

change in colour from pale olive or medium green to blue-green.

marks the 1. loss of epidote

2. growth of hornblende at expense of actinolite

Can form calcite from epidote with increased X_{CO_2} in fluid phase —

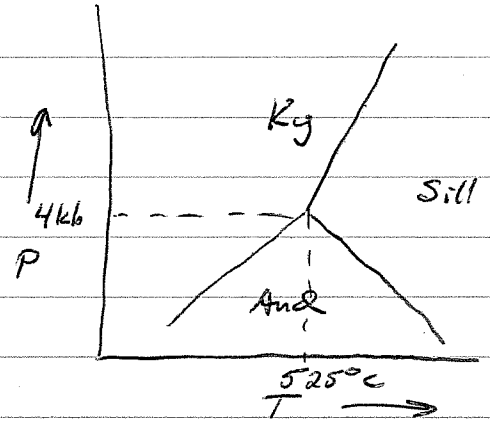
the reaction then will probably become

hornblende$_1$ + epidote = plagioclase + hornblende$_2$ + calcite

PELITES during Metamorphism

Aluminous compositions

Al_2SiO_5 triple point



places upper pressure limit on Anvil District.

4Kb = ~ 12 km.

see transition andalusite → sillimanite w/ no kyanite.

Greenschist Facies to Amphibolite Facies transition at low pressures

With increasing temp. — can expect dehydration reactions.

most of Vanguela Plateau in muscovite-chlorite zone

muscovite-chlorite-quartz-albite ± calcite ± dolomite

assume assemblage forms at ~ 300°C.

biotite zone

reactions have not been totally pinpointed.

"mass balance" suggests

$$\text{muscovite}_1 + \text{chlorite}_1 = \text{biotite} + \text{muscovite}_2 + \text{chlorite}_2 + H_2O$$

muscovite-chlorite-biotite-albite ± calcite ± dolomite.

isotope work suggests temp. of 400-450°C for biotite zoning.

andalusite

$$\text{muscovite} + \text{chlorite} + \text{qtz} = \text{andalusite} + \text{biotite} + H_2O$$

note clots of andalusite + biotite in the schists.

At about same time get plagioclase forming

At lower pressures — for higher T one would expect cordierite to form.
Often difficult to identify in the field. — also difficult to identify with microscope.
readily retrogrades to muscovite.
similar appearance to feldspar
common muscovite alteration
common yellow around zircons.

At higher pressures tend to get garnet rather than cordierite.

In either case a typical reaction is

$$\text{chlorite} + \text{muscovite} + \text{quartz} = \text{cordierite} \text{ (almandine)} + \text{biotite} + H_2O$$

Staurolite is restricted to high iron bulk compositions.
staurolite comes in about 500 - 540°C

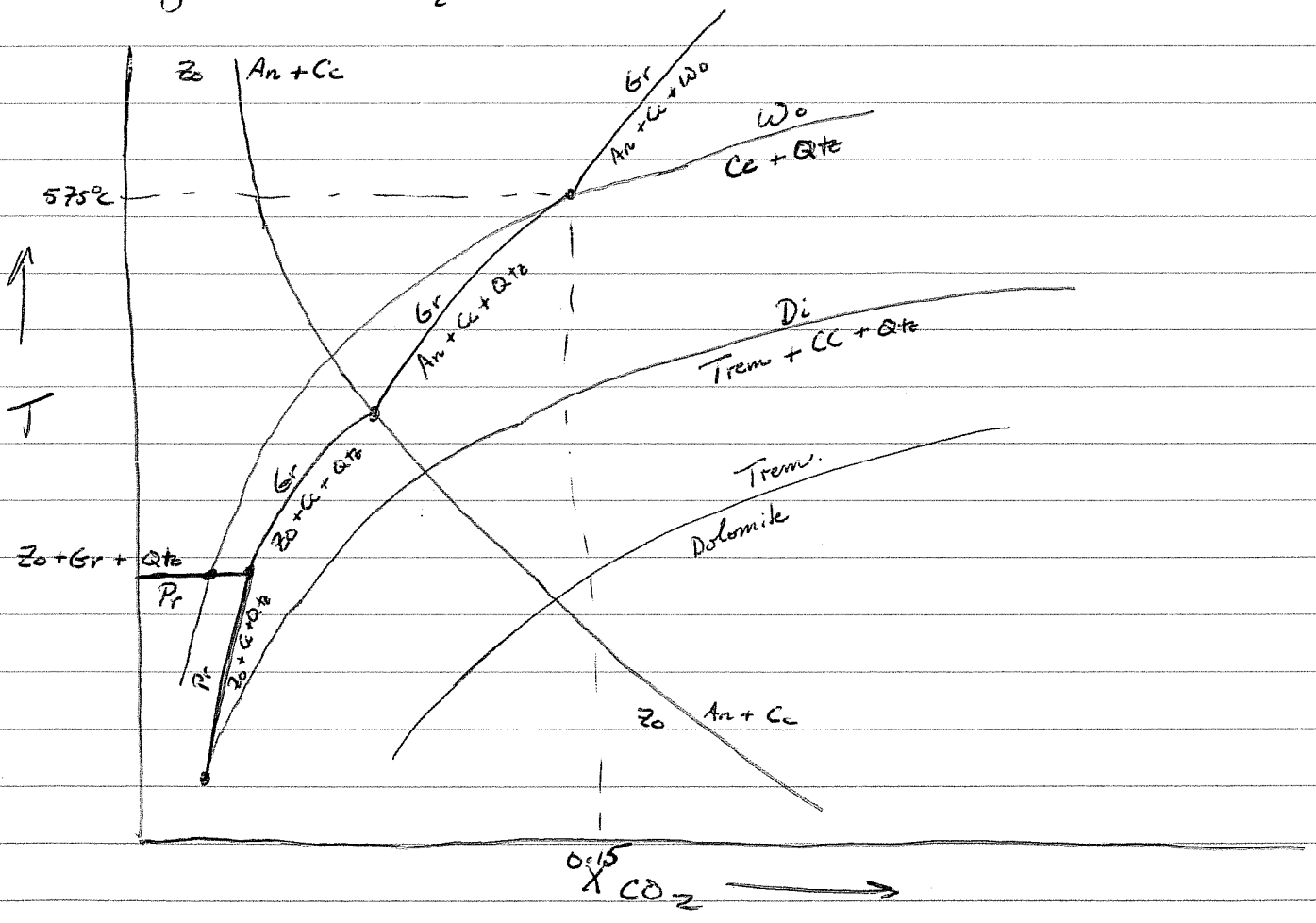
CARBONATES during Metamorphism

A wide range of mineral assemblages are possible depending on ~~the~~
1.) initial bulk composition
2.) fluid composition in components $H_2O - CO_2$

Dealing with a "subset" of composition space
$CaO - MgO - SiO_2 - Al_2O_3 - H_2O - CO_2$

Assemblage calcite - quartz
remains stable to very high temperatures.
- well into amphibolite facies
- finally breaks down to form wollastonite

Assemblage calcite - quartz - dolomite - chlorite



CARBONATES

N.B. Several mineral assemblages evident from diagram

1.) As increase temperature expect to see the sequence

tremolite (actinolite)
diopside
wollastonite

↓ T

2.) Zoisite and grossular (i.e. epidote & garnet)
are restricted to high water compositions in fluid phase.
assemblage epidote-plagioclase-calcite buffers fluid
compositions to a high water content

At very high temperatures — can expect to see scapolite.

3.) Can change assemblage by:
a. — increasing temperature (up in diagram)
b. — changing fluid composition (horizontal in diagram)

4.) Reactions tend to effectively buffer fluid compositions to specific values.

5.) Can get several partial assemblages based on a particular reaction path — this will depend on modal amounts of the minerals present.