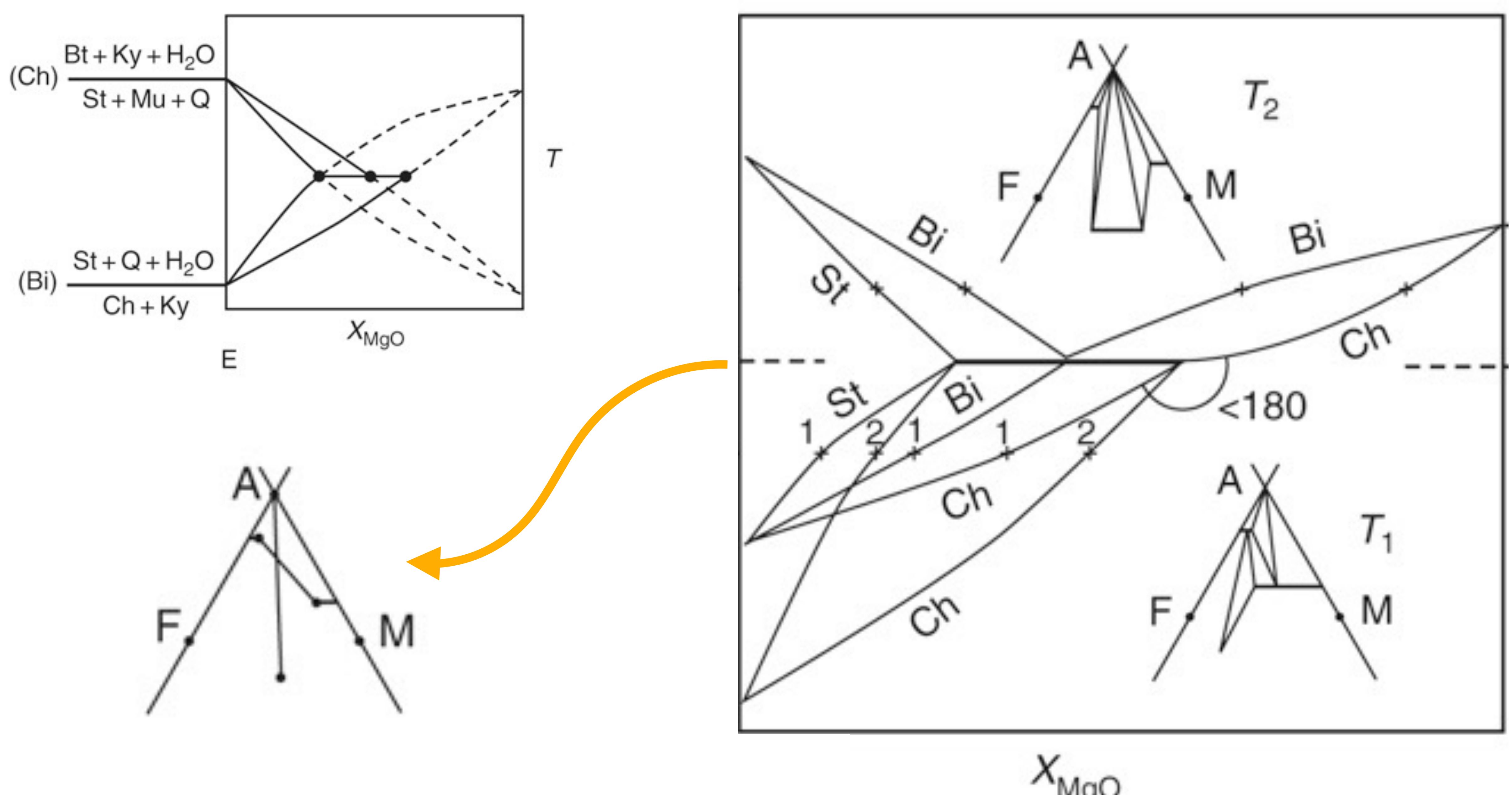
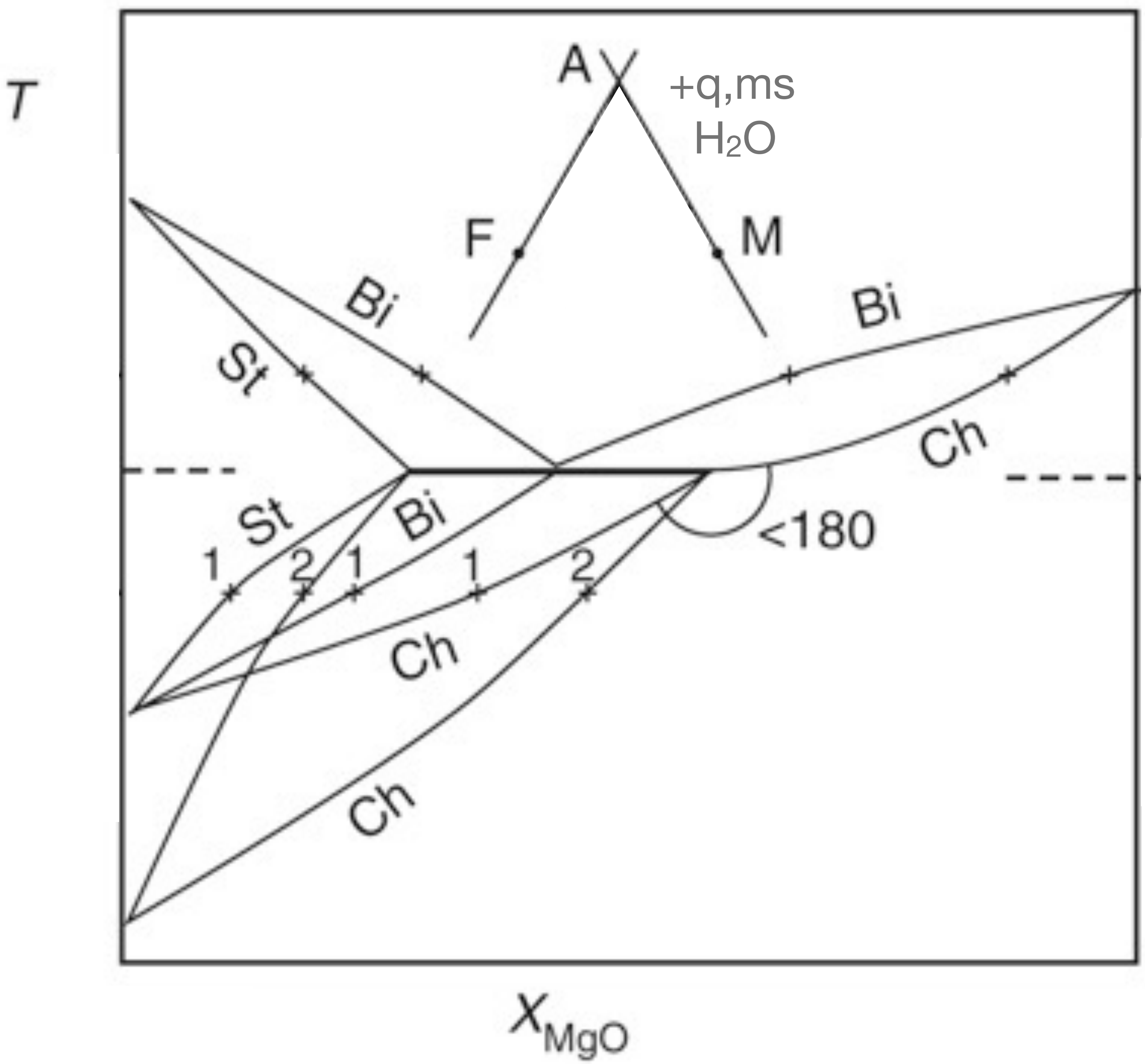
# Lecture 11: Mineral reactions and petrogenetic grids

Mineral reactions involve both continuous and discontinuous reactions. Continuous reactions depend on composition (*e.g.* $X_{Mg}$) and are a field when plotted in *P-T* space. Discontinuous reactions are a line in *P-T* space and make good field isograds.



# T versus $X_{Mg}$ diagrams: phase rule




from Philpotts & Ague 2009

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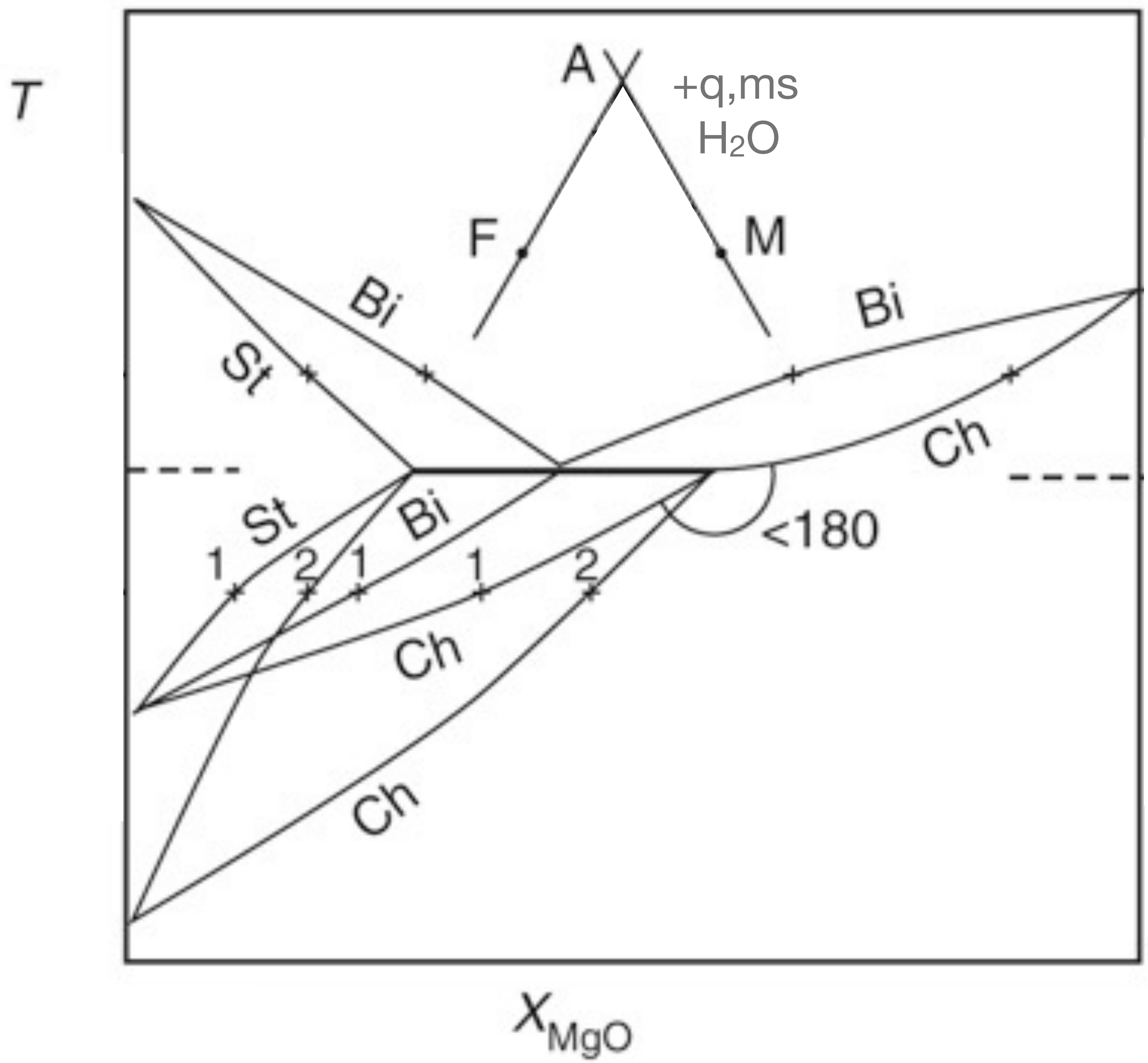


df = c - f + T + P + i

from Philpotts & Ague 2009

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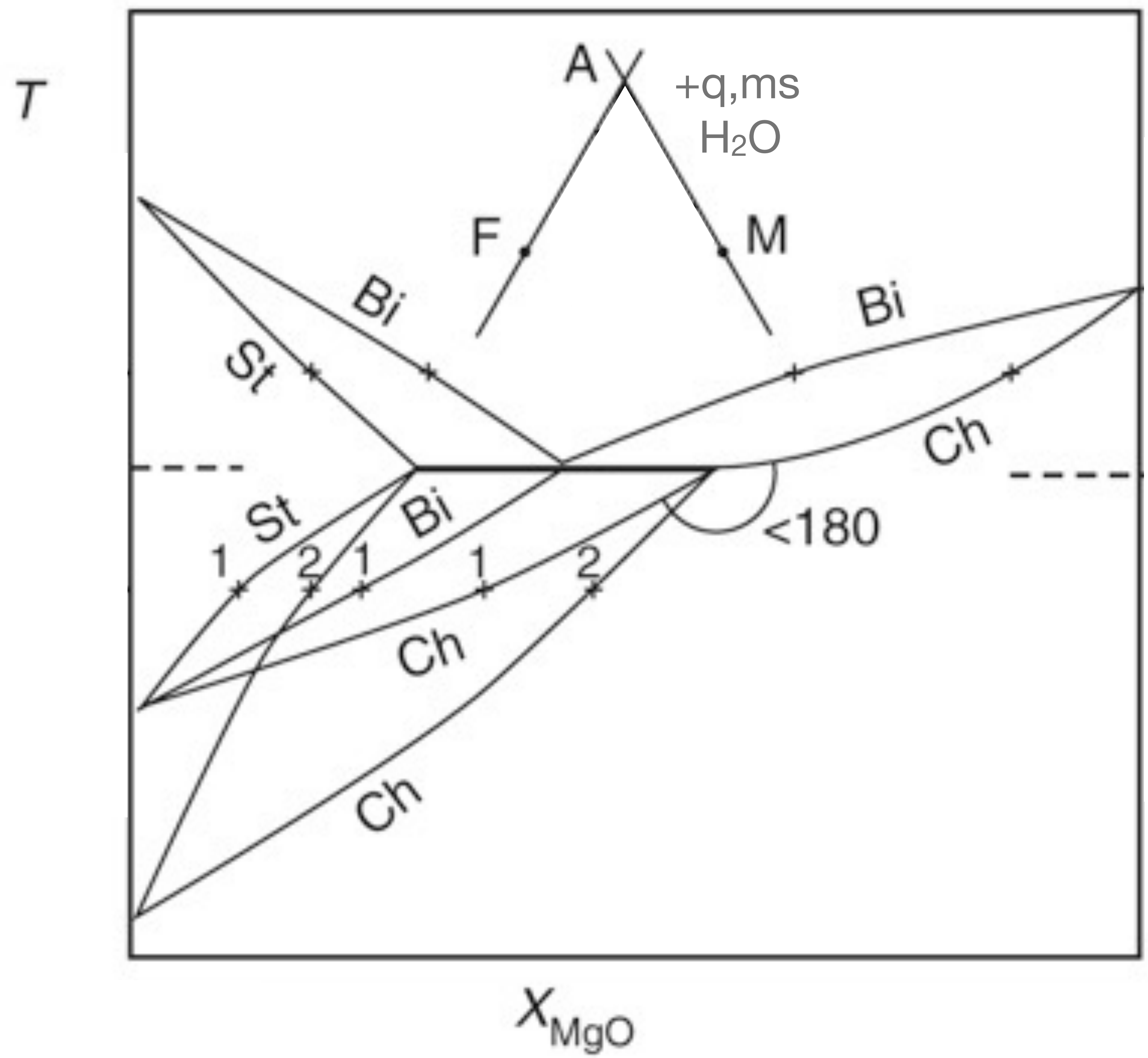


$df = c - f + T + P + i$

$P + a_{H_2O}$ = fixed, c = 3

from Philpotts & Ague 2009

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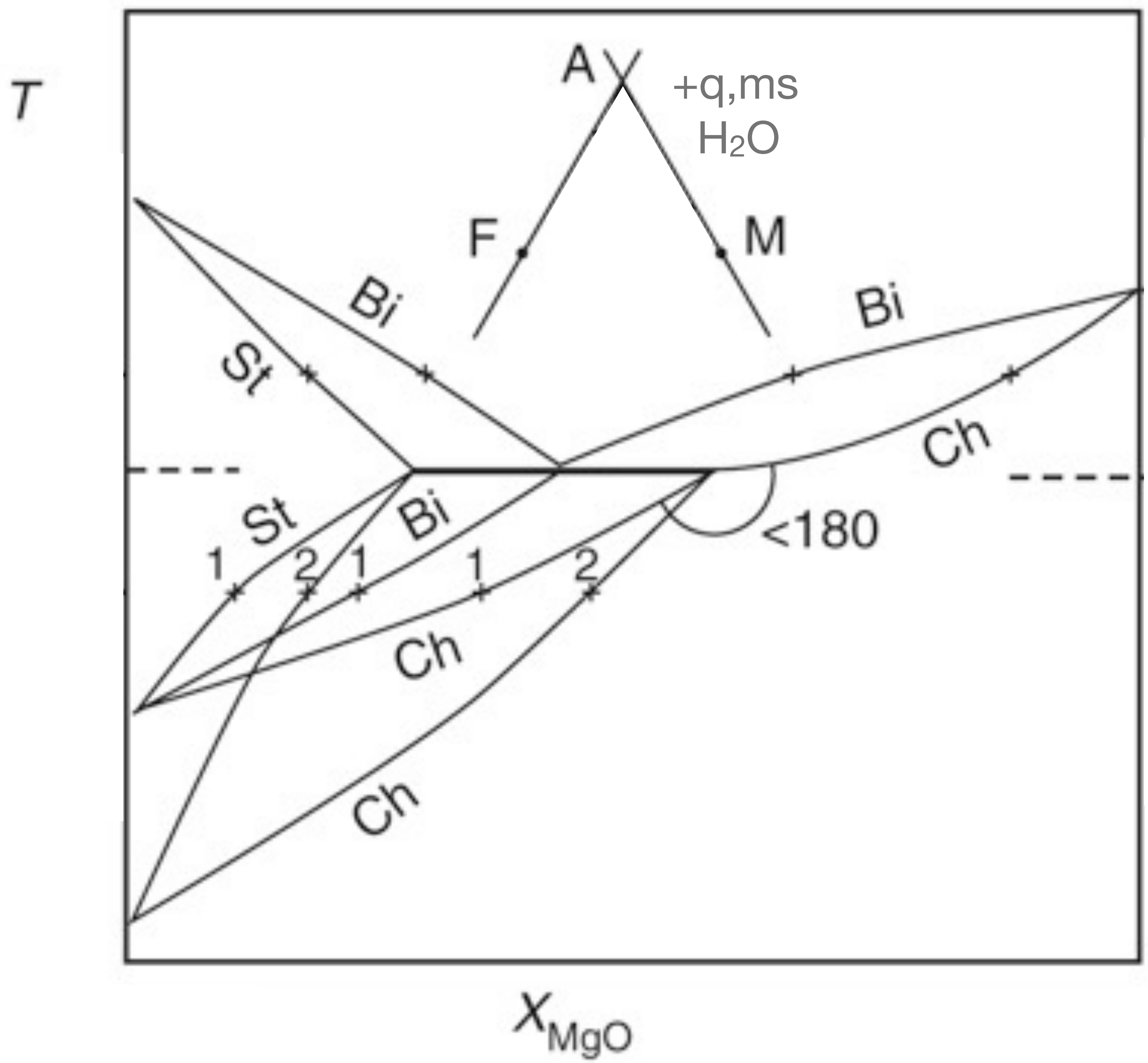


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$df = 3 - f + 1$

from Philpotts & Ague 2009

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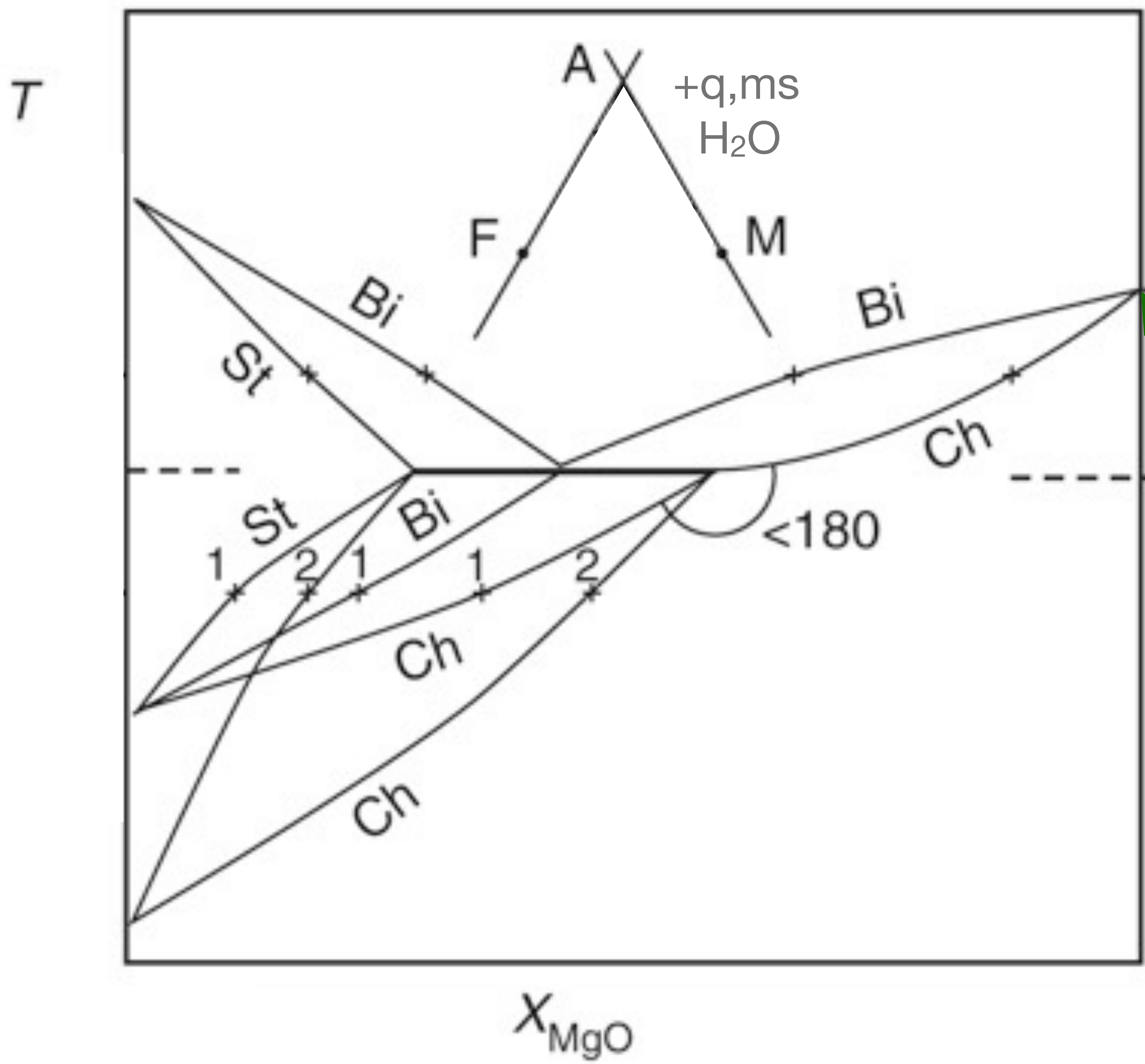


$df = c - f + T + P + i$

$P + a_{H_2O}$ = fixed, c = 3

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Chl + Ms = Bt + Ky + Q + $H_2O$

from Philpotts & Ague 2009

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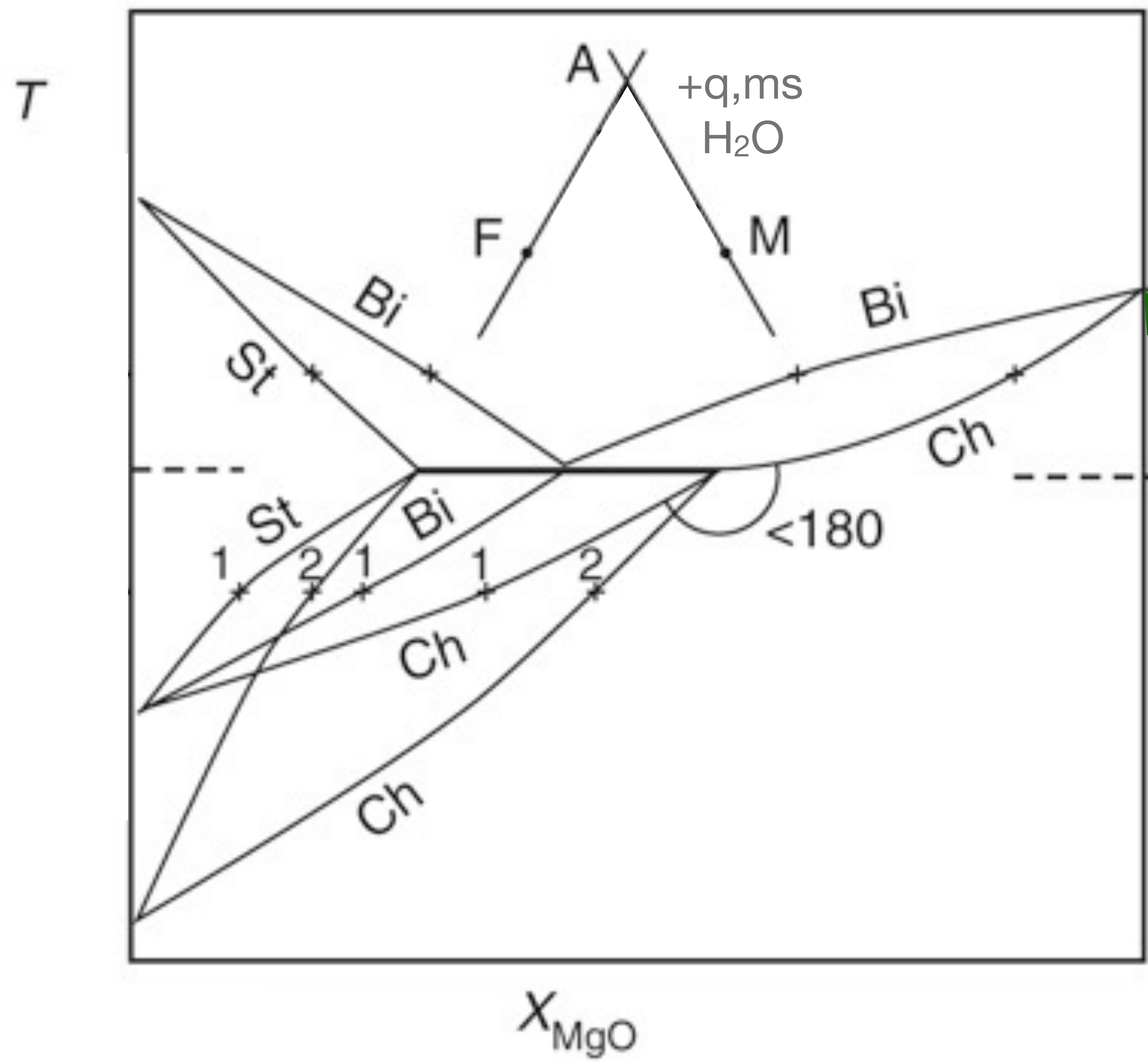


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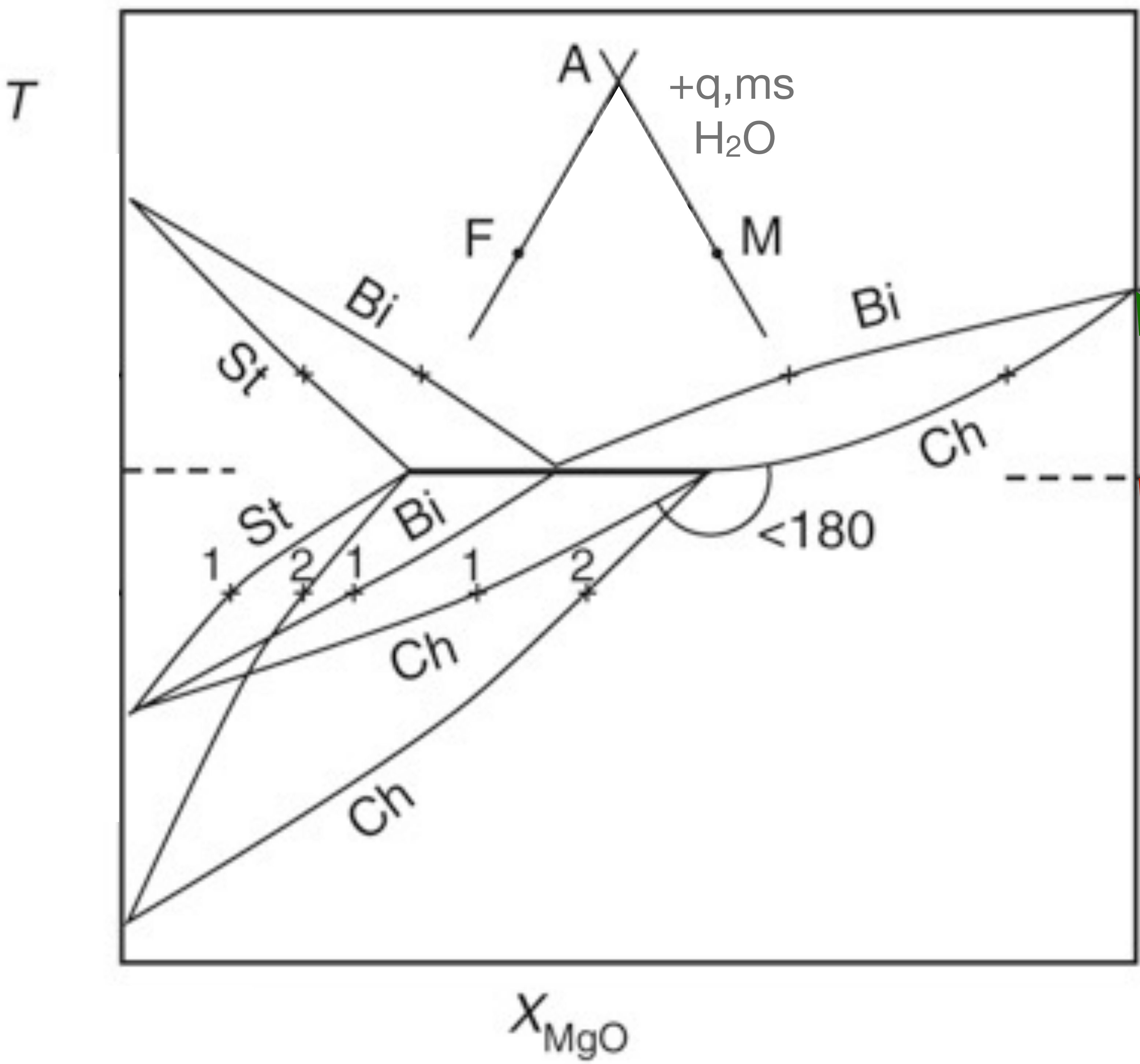


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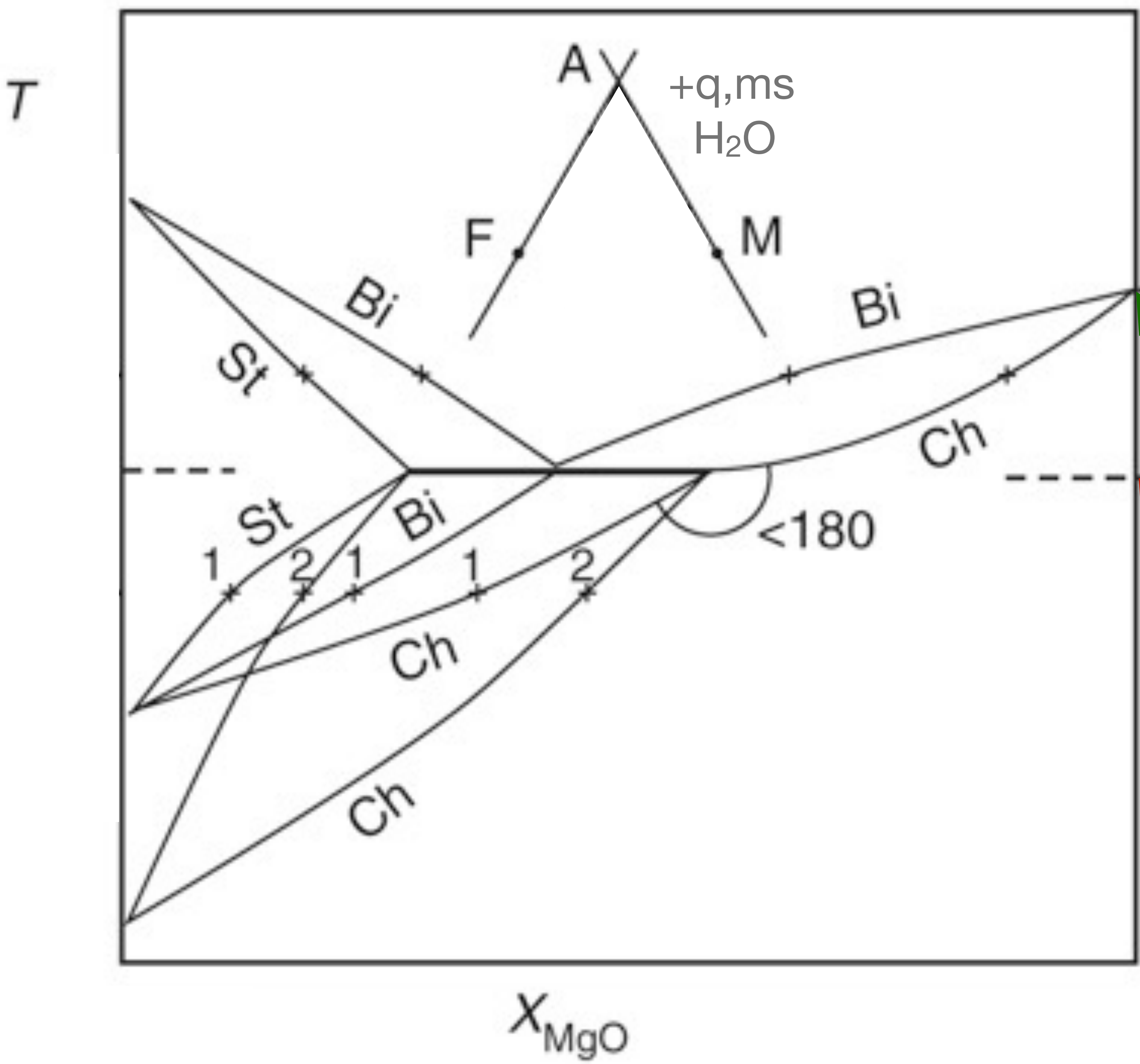


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from Philpotts & Ague 2009

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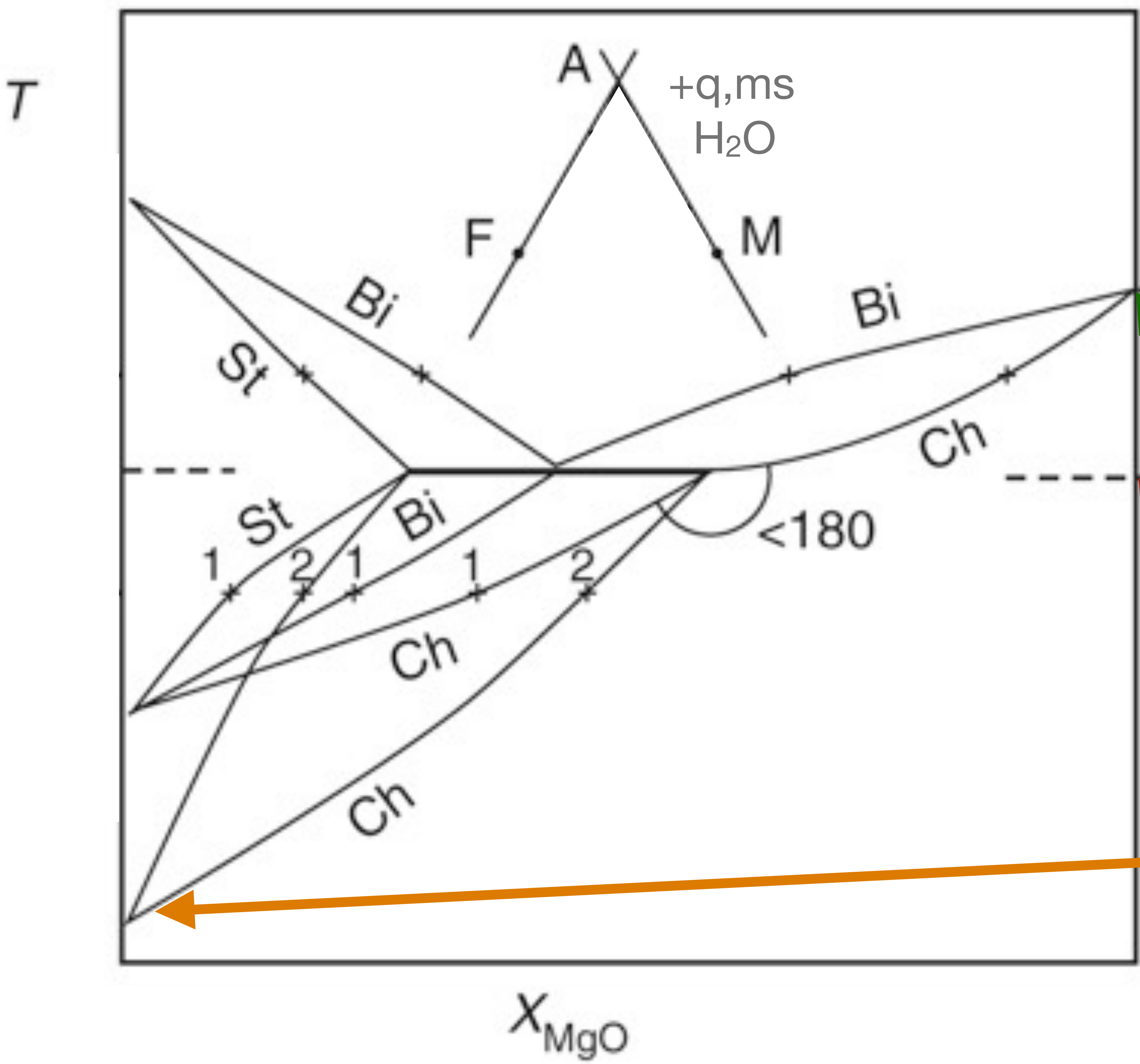



df = c - f + T + P + i

P + $a_{H_2O}$ = fixed, c = 3

df = 3 - f + 1

Chl + Ms = Bt + Ky + Q + $H_2O$

f = 3 —> df = 1

Chl + Ms + St = Bt + Ky + $H_2O$

f = 4 —> df = 0

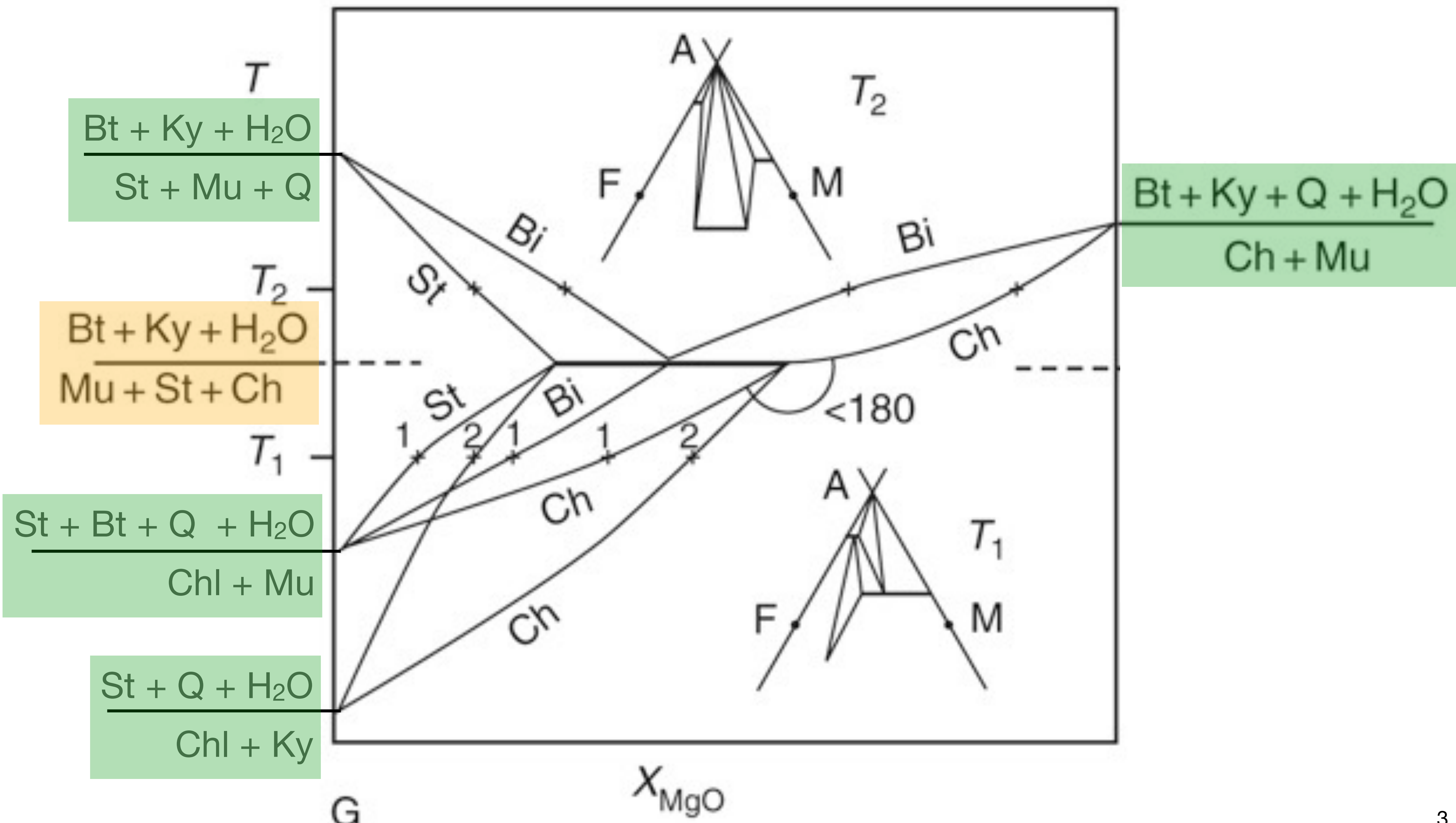
Chl + Ky = St + Q + $H_2O$

f = 3 —> df = 1

from Philpotts & Ague 2009

# Reading T versus $X_{Mg}$ diagrams

at constant P and projected from A, ms, qtz and fluid

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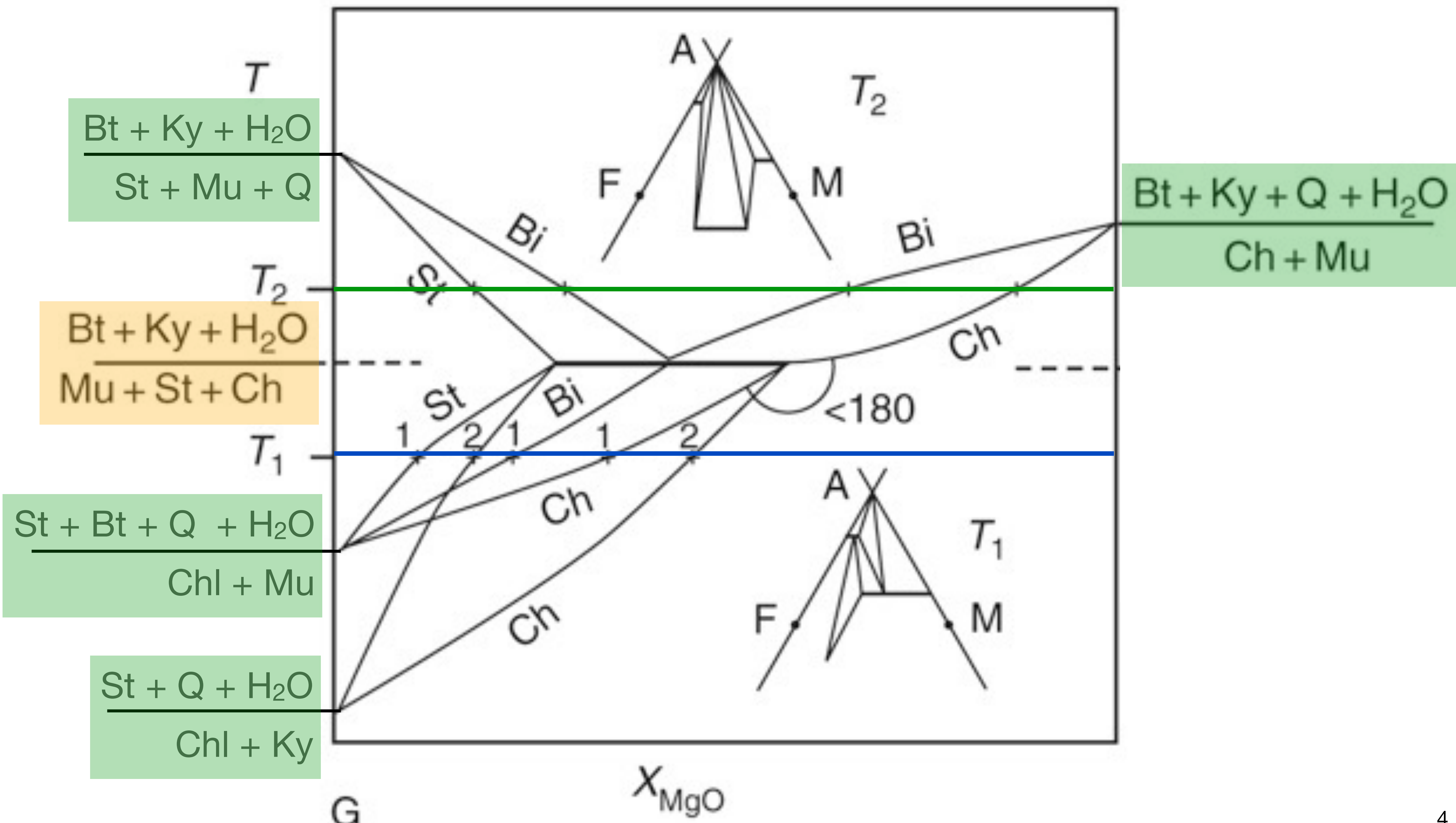


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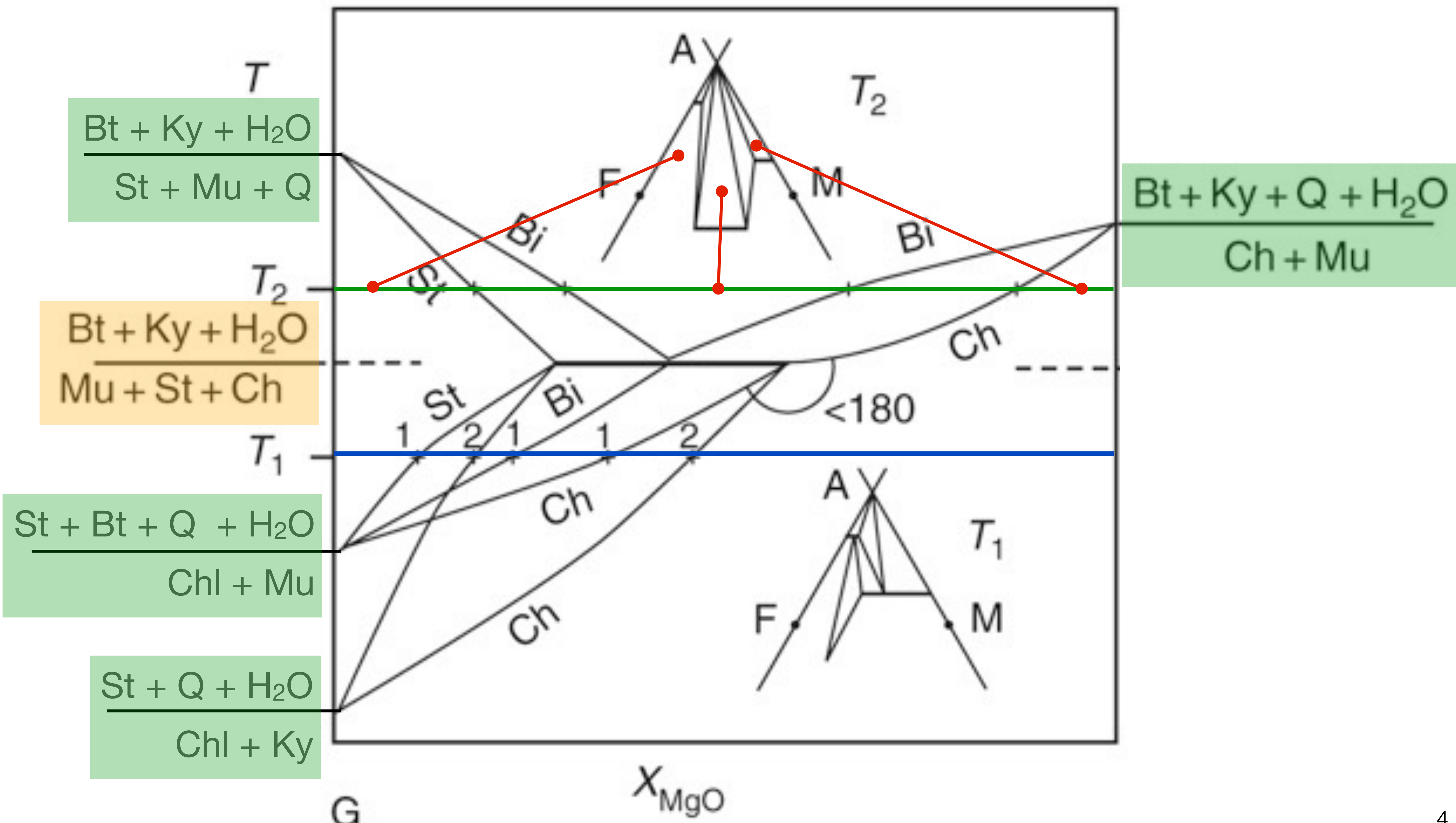


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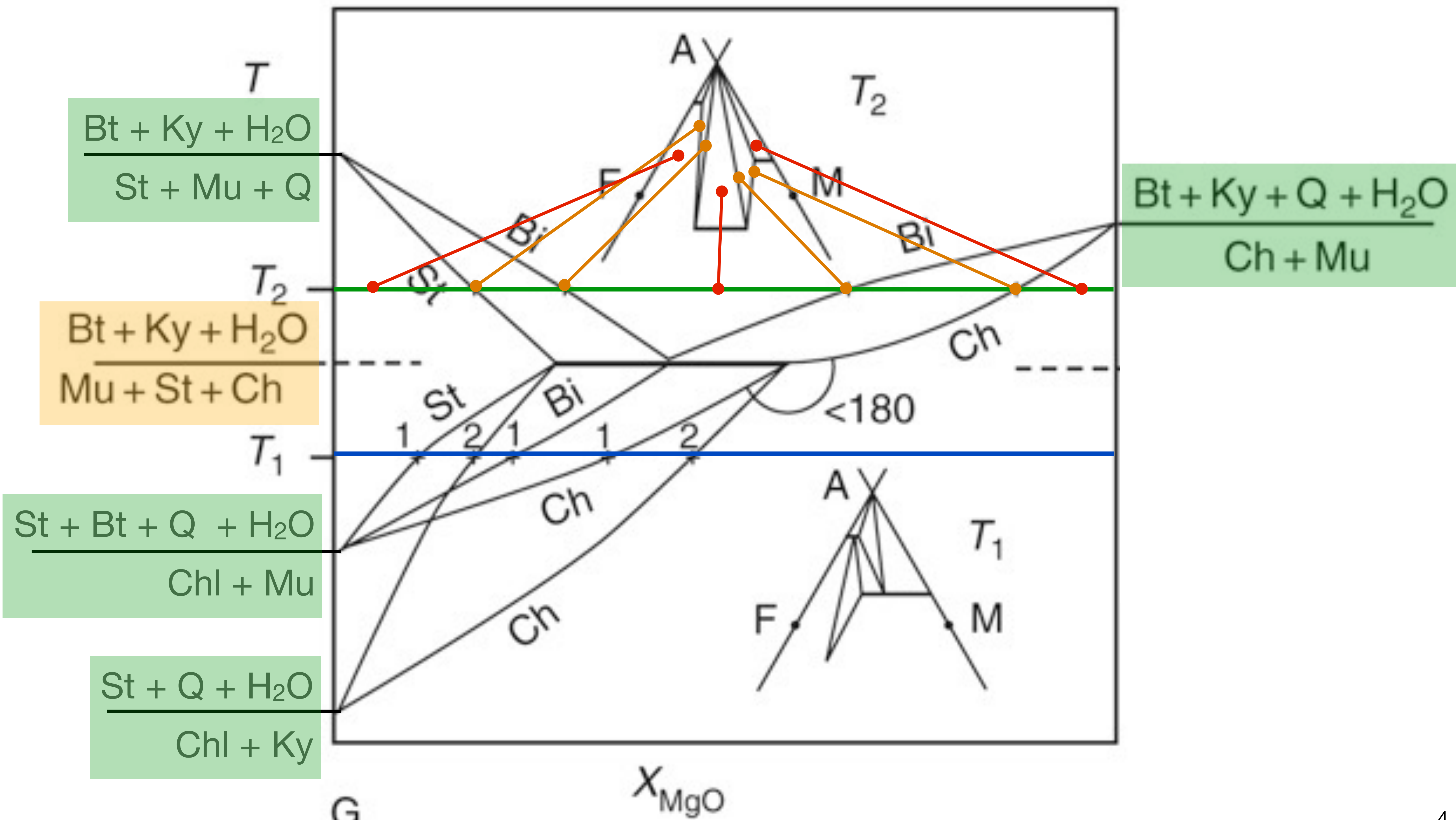


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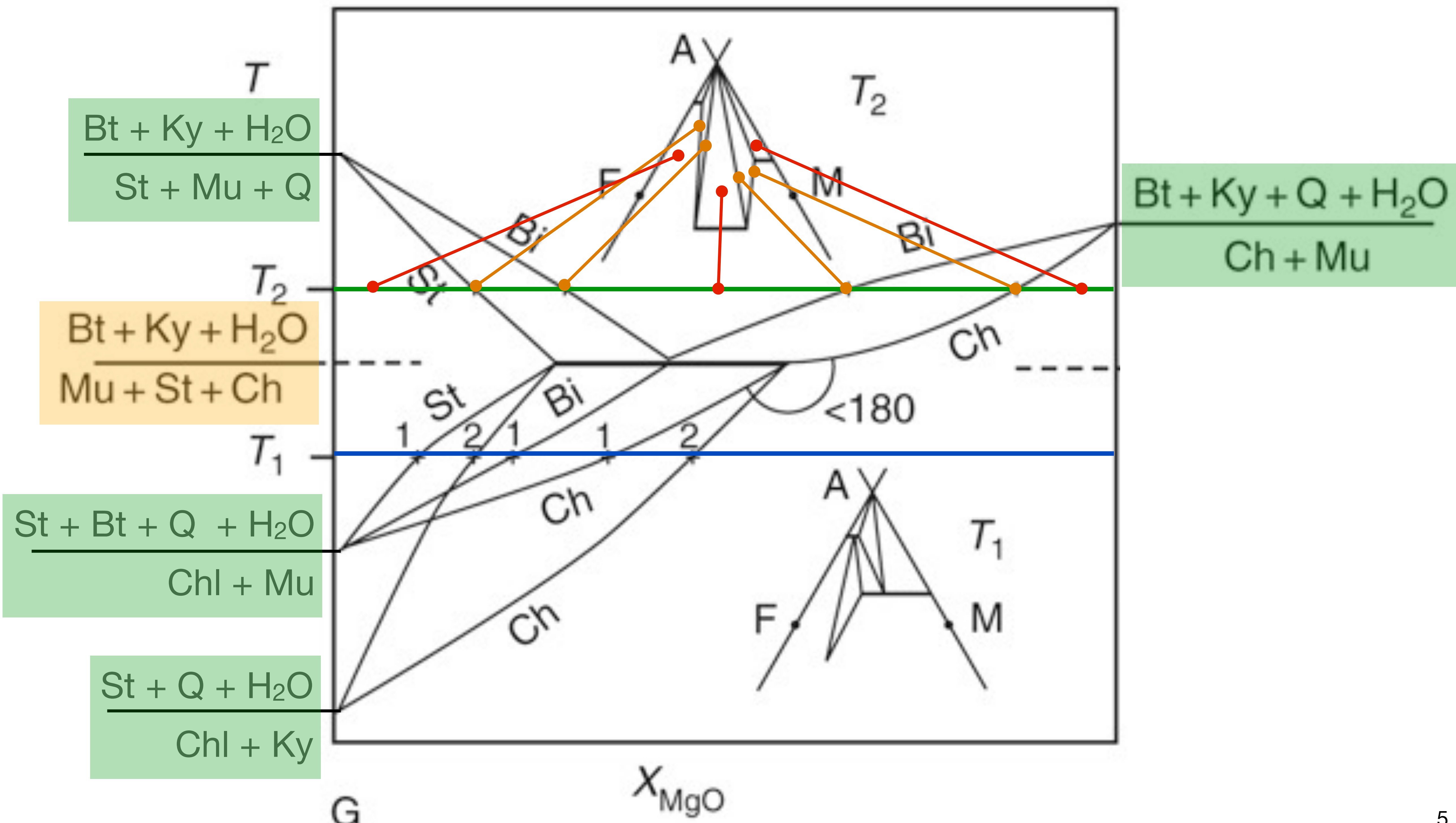


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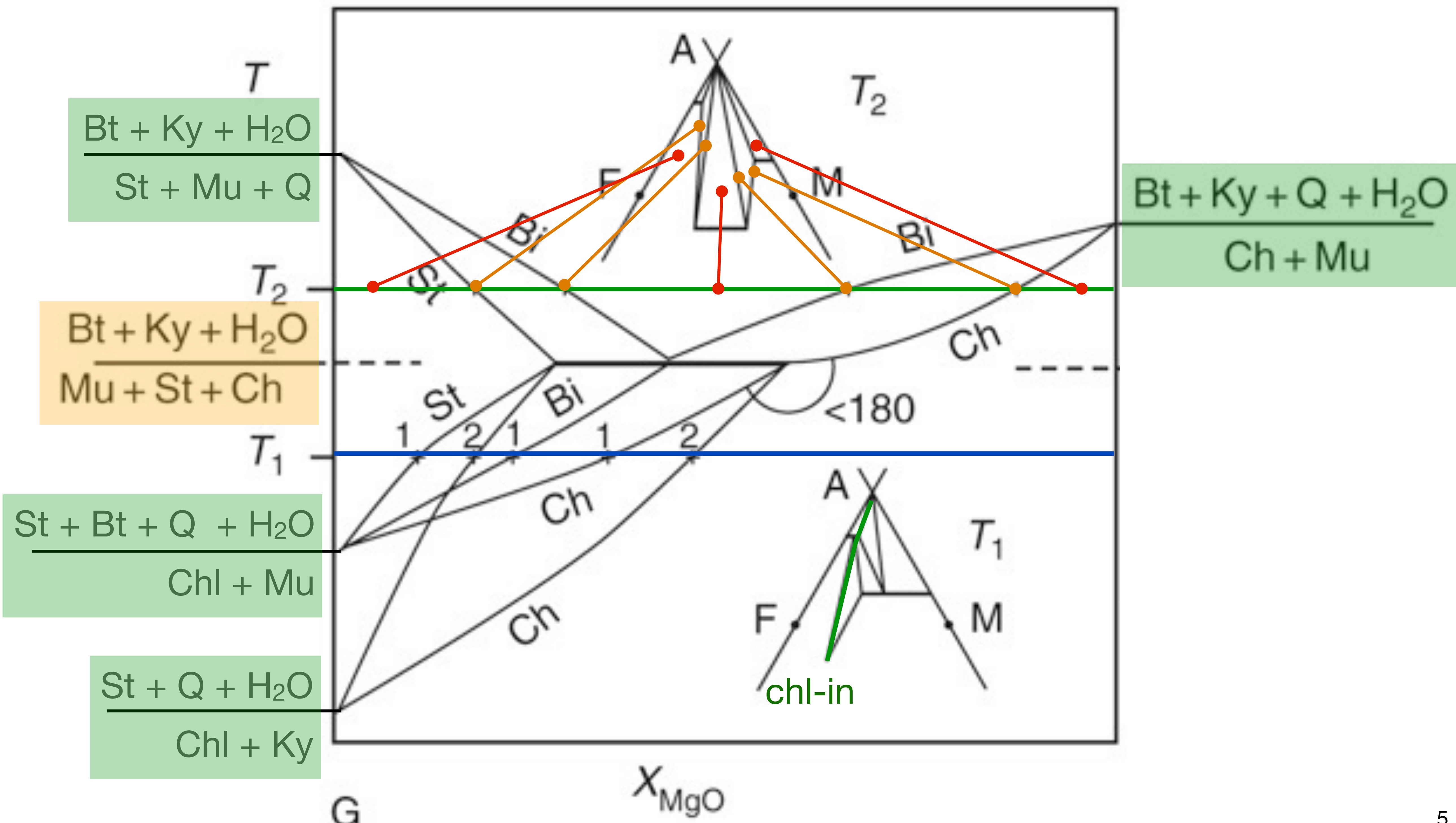


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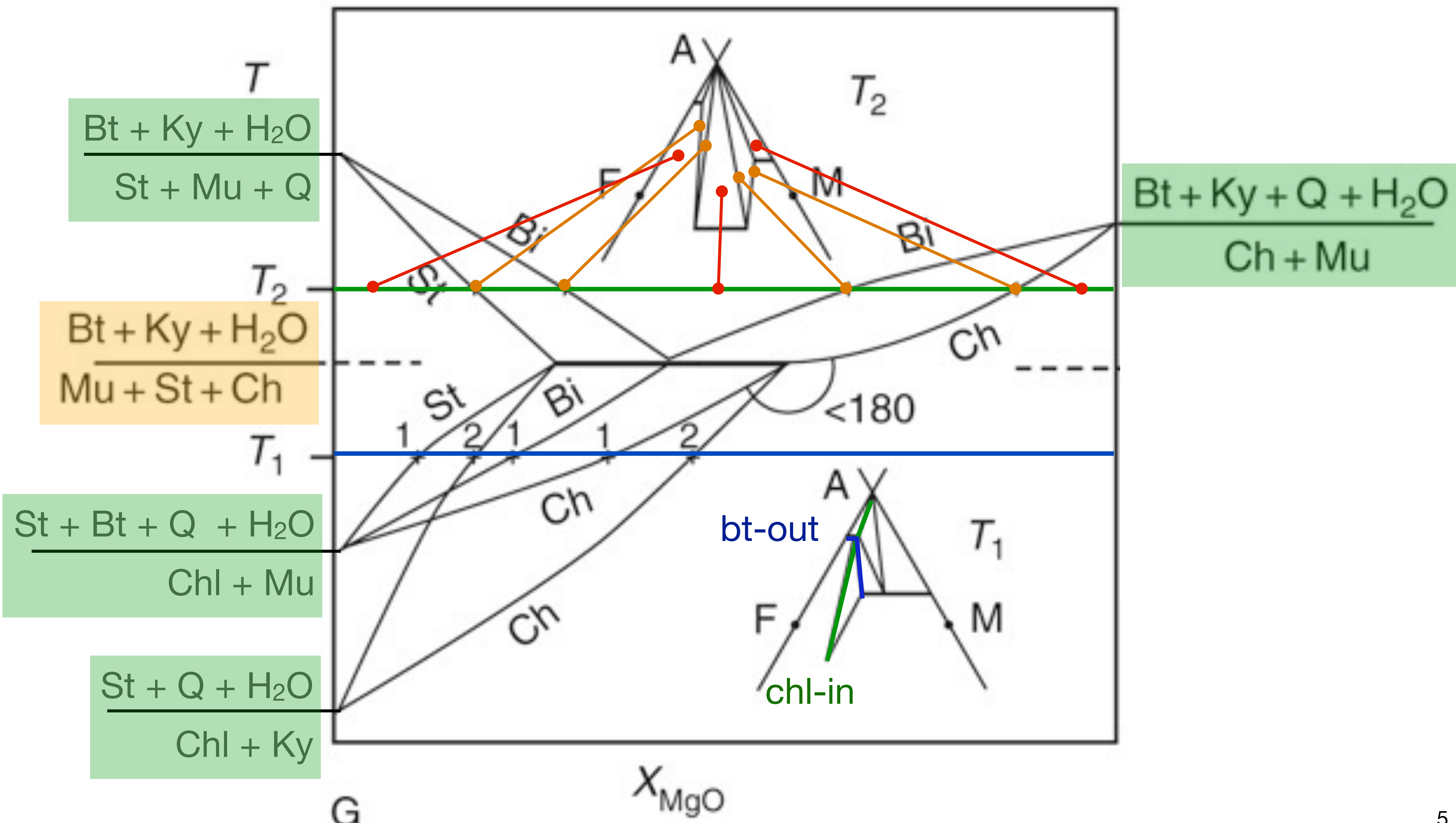


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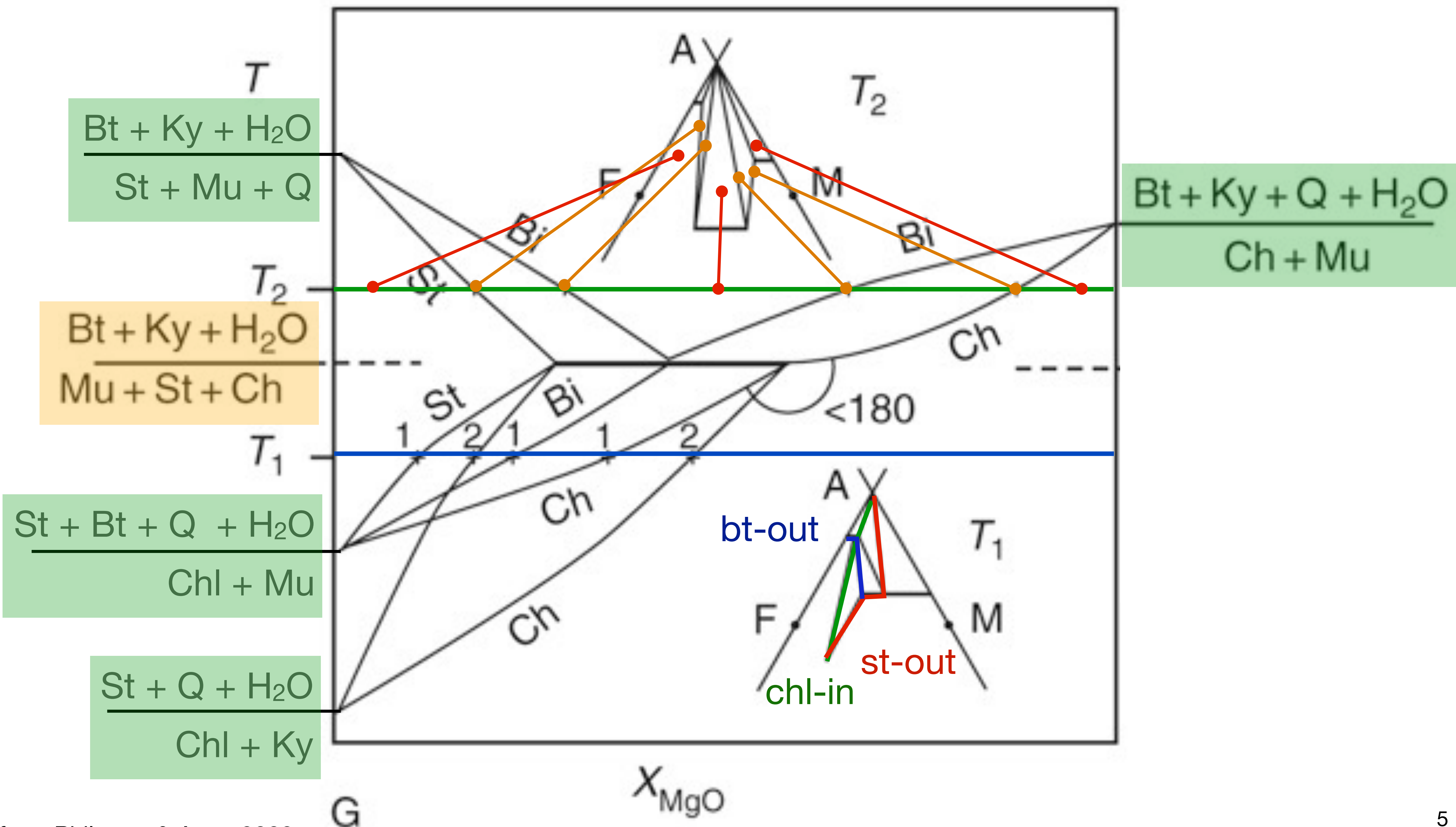


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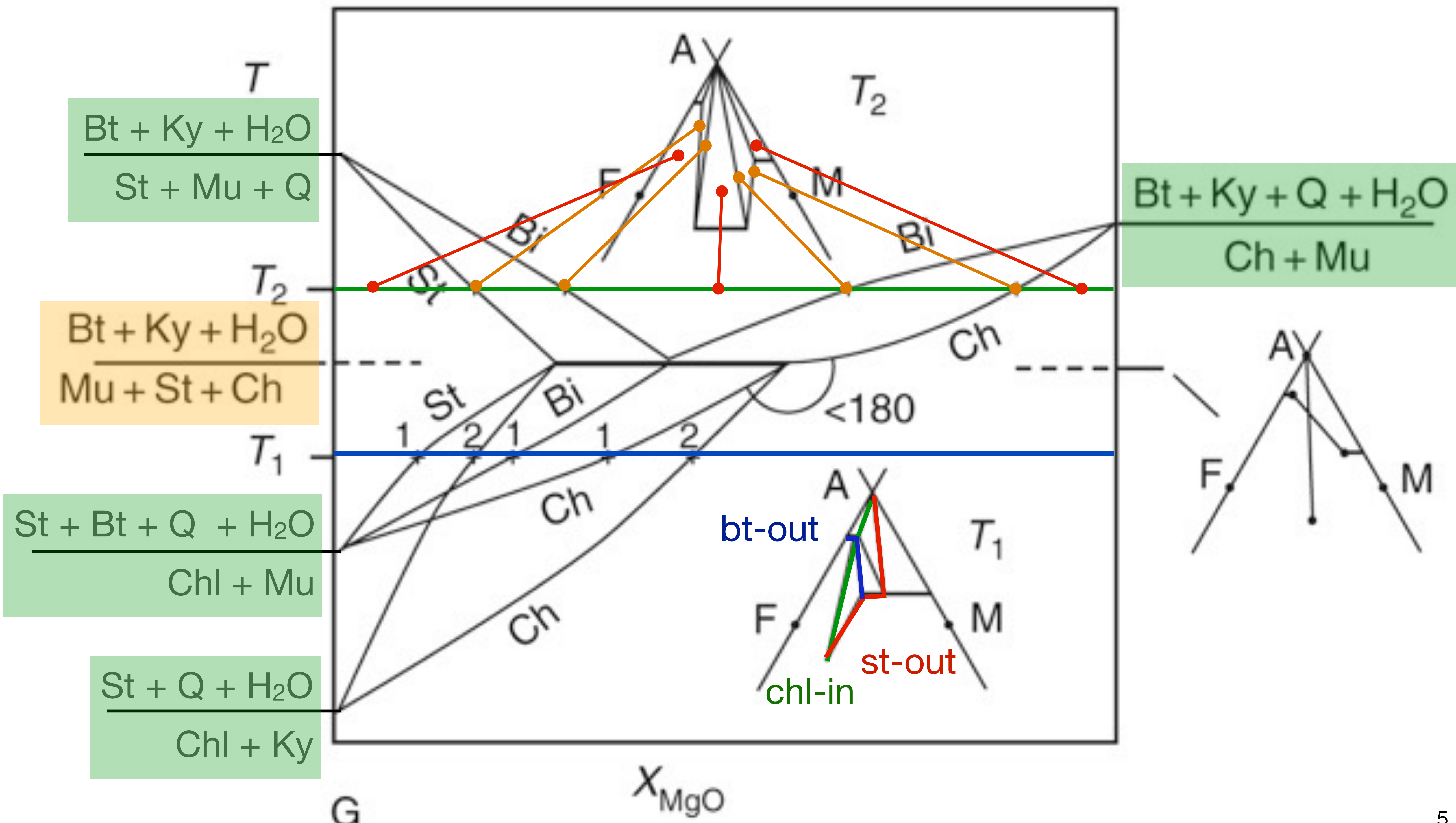


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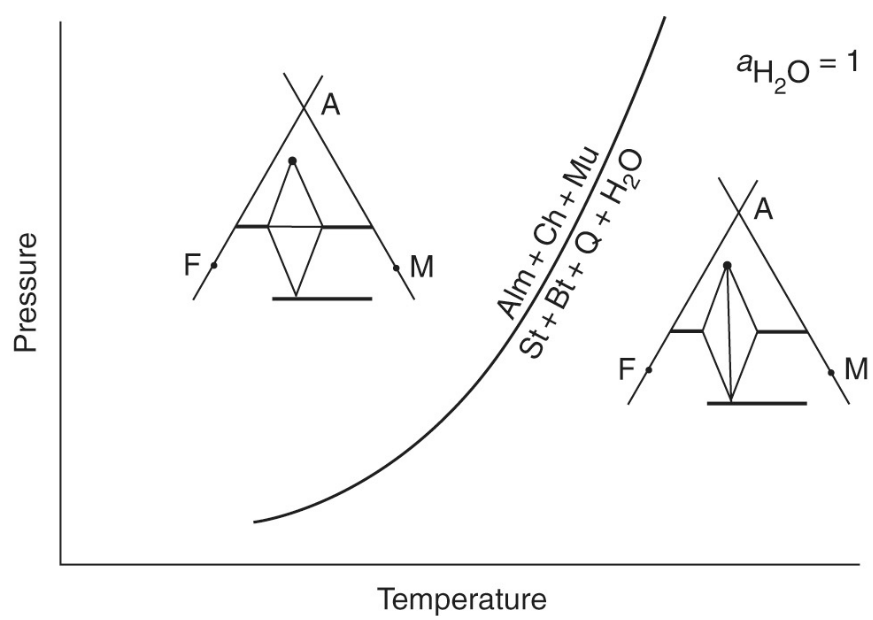
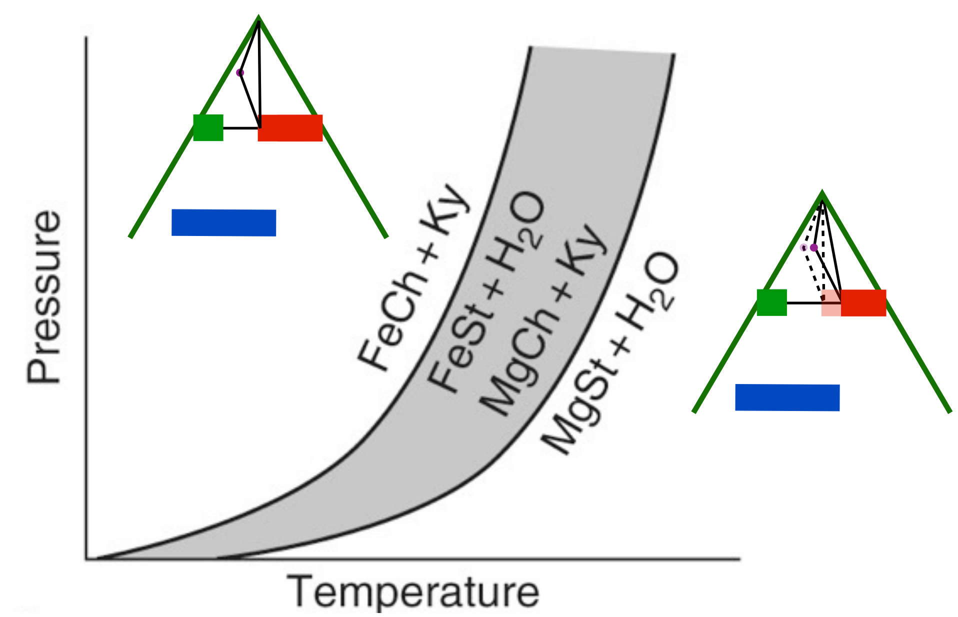
# Continuous versus discontinuous reactions

Discontinuous reactions are reactions where one paragenesis changes to another: these are lines in P-T-a($H_2O$) space: good field isograds

Continuous reactions are reactions where the paragenesis remains the same, but the composition of the phases changes: they are fields in P-T space



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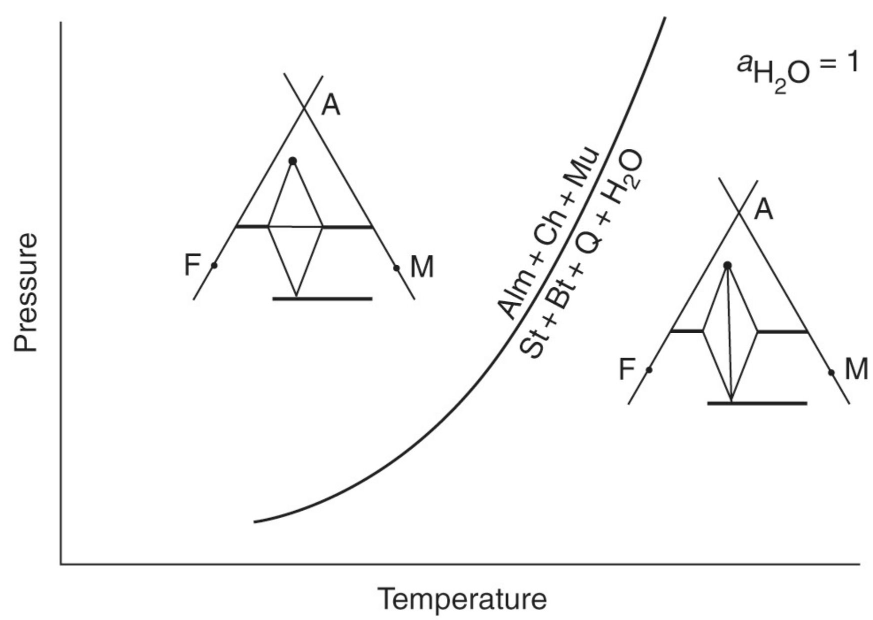


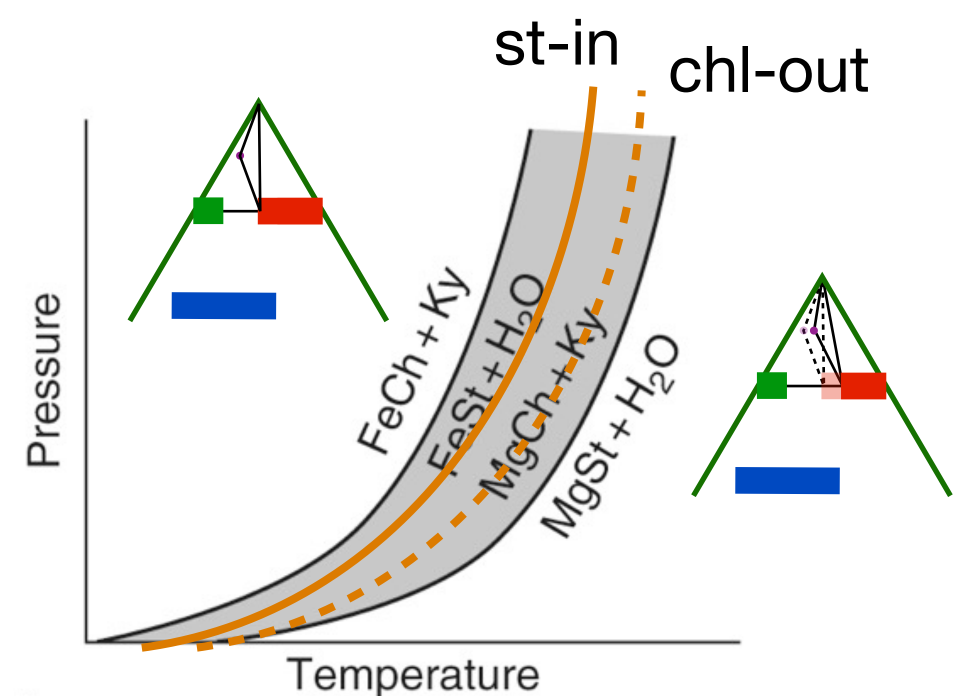

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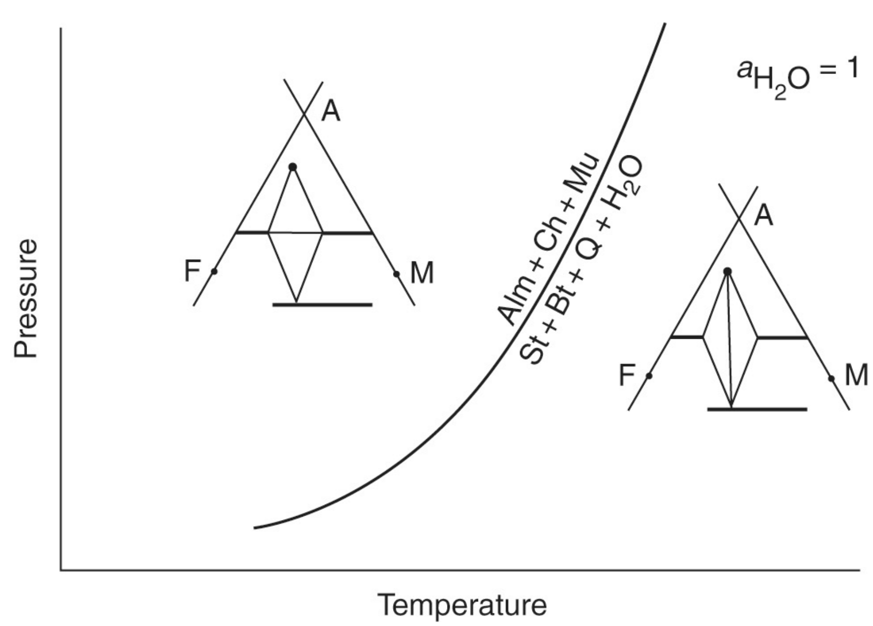
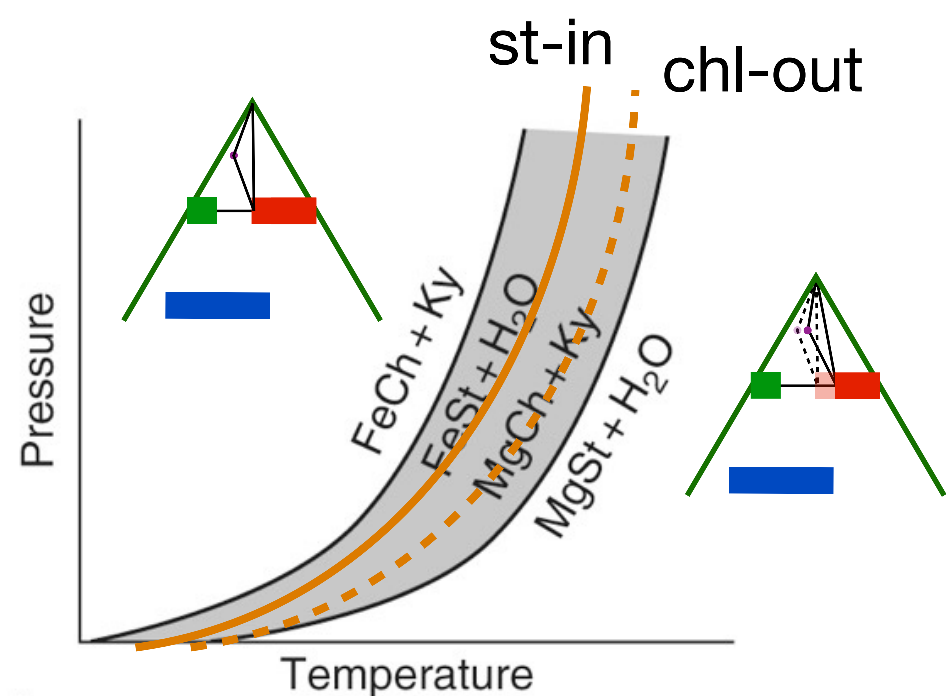


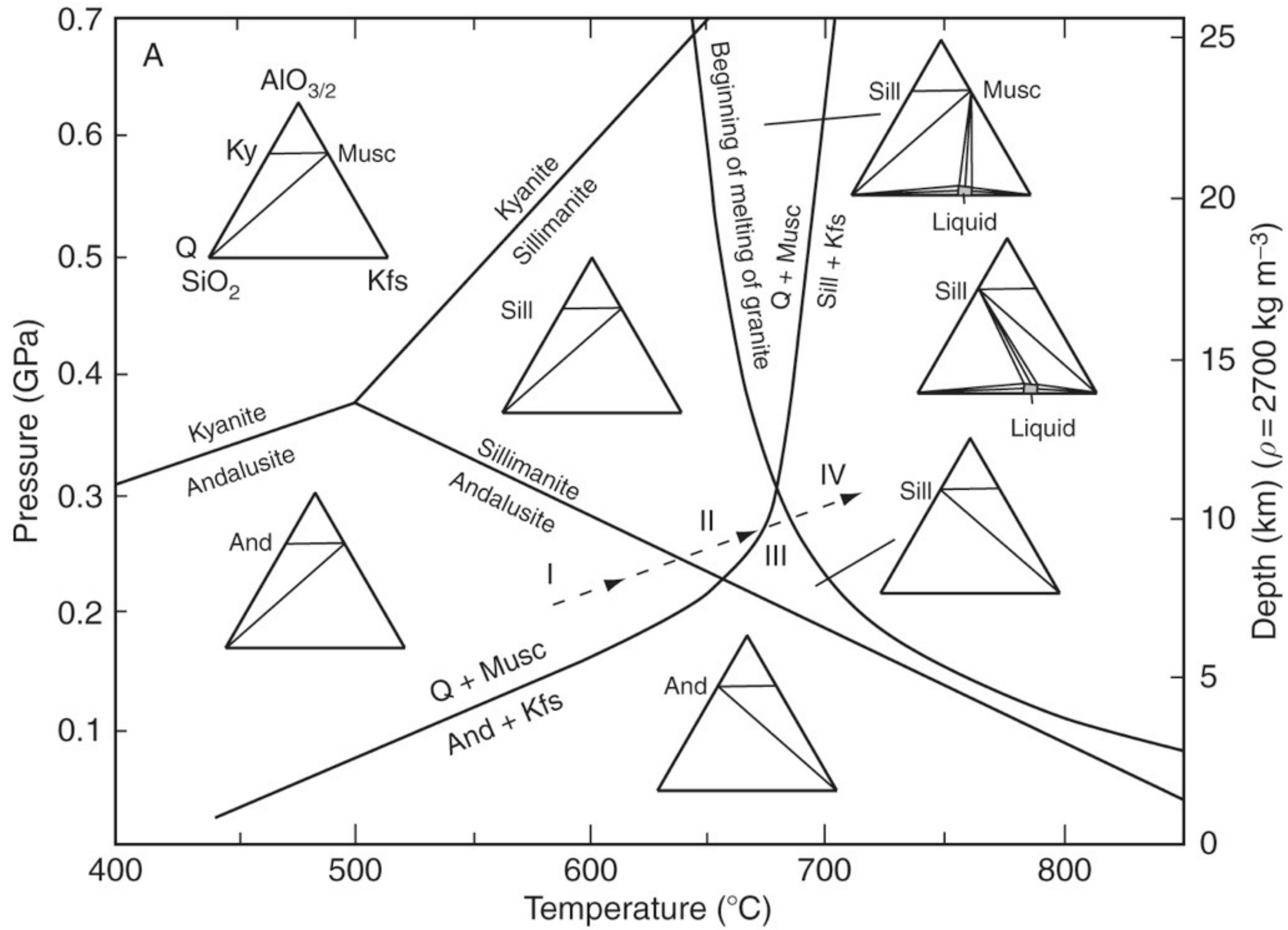




The onset and completion of a continuous reaction depends on the bulk composition

When you fix the bulk composition (pseudosection), these have a fixed position in P-T

# Petrogenetic grids

A petrogenetic grid is a network of discontinuous reactions. It splits up P-T space into domains of different mineral parageneses. Continuous reactions can take place within a field and do not result in a change in paragenesis.



# Constructing petrogenetic grids

To construct a petrogenetic grid, we need info on the slopes of the reactions and on the arrangement of the reactions around their intersections: thermodynamics and Schreinemaker's rules

For a reaction A + B = C + D, the $\Delta G_r = \Delta H_r - T \cdot \Delta S_r + P \cdot \Delta V_r$

Using the cyclic rule for partial derivatives:

$$\left(\frac{\partial \Delta G}{\partial T}\right)_P \left(\frac{\partial P}{\partial \Delta G}\right)_T \left(\frac{\partial T}{\partial P}\right)_{\Delta G} = -1$$

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This is the Clapeyron equation and its units are Pa / K

# Clapeyron reaction slopes

$$\left(\frac{\partial P}{\partial T}\right) = \frac{\Delta S_r}{\Delta V_r}$$

The Clapeyron equation is very useful to find the slope of the reaction, but it does not tell you the position of the reaction in P-T space, nor what minerals reside on the high P or the high T side of the reaction

$\Delta H_r$ sill → ky = -7.2 kJ mol$^{-1}$

$\Delta H_r$ and → sill = +2.9 kJ mol$^{-1}$

$\Delta H_r$ and → ky = -4.3 kJ mol$^{-1}$

$\Delta S_r$ sill → ky = -12 J K$^{-1}$ mol$^{-1}$

$\Delta S_r$ and → sill = +2.8 J K$^{-1}$ mol$^{-1}$

$\Delta S_r$ and → ky = -9.2 J K$^{-1}$ mol$^{-1}$

$\Delta V_r$ sill → ky = -0.58 J bar$^{-1}$ mol$^{-1}$

$\Delta V_r$ and → sill = -0.16 J bar$^{-1}$ mol$^{-1}$

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dP/dT sill → ky = 20 bar K$^{-1}$

dP/dT and → sill = -17.5 bar K$^{-1}$

dP/dT and → ky = 12.4 bar K$^{-1}$

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