Session T2, GSA Annual Meeting 2015 at Baltimore

Diversity of the Kokchetav metamorphic diamonds and their formations related with H_2O-rich fluid conditions

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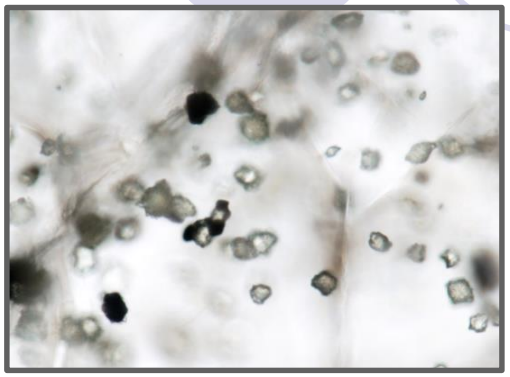
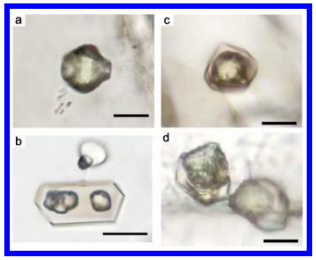
Diamonds at Kumdy-kol, Kokchetav

Short summary of our previous studies



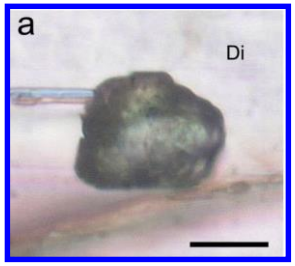
Dolomite marble

- **Representative diamond-bearing rock in the Kokchetav**
- **Very high abundance (max. 2700 carat/ton)**
- **Two-stage growth:**
  - **1st stage $\delta^{13}C$ = -15 to -8 ‰, 2nd stage: $\delta^{13}C$ = -27 to -17 ‰**
- **2nd stage diamond formed from C-bearing H_2O fluid**
  - **High nucleation rate**
  - **Quick crystallization**



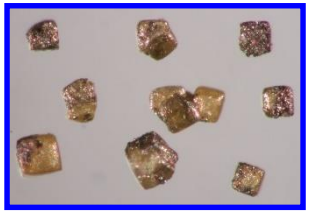
Grt-Bt gneiss

- high abundance
- No 2nd stage growth
- Growth and dissolution (?)



Calcite marble

- Very low abundance (61 grains only in Di)
- No 2nd stage growth
- Growth and dissolution (?)
- Small FWHM of Raman



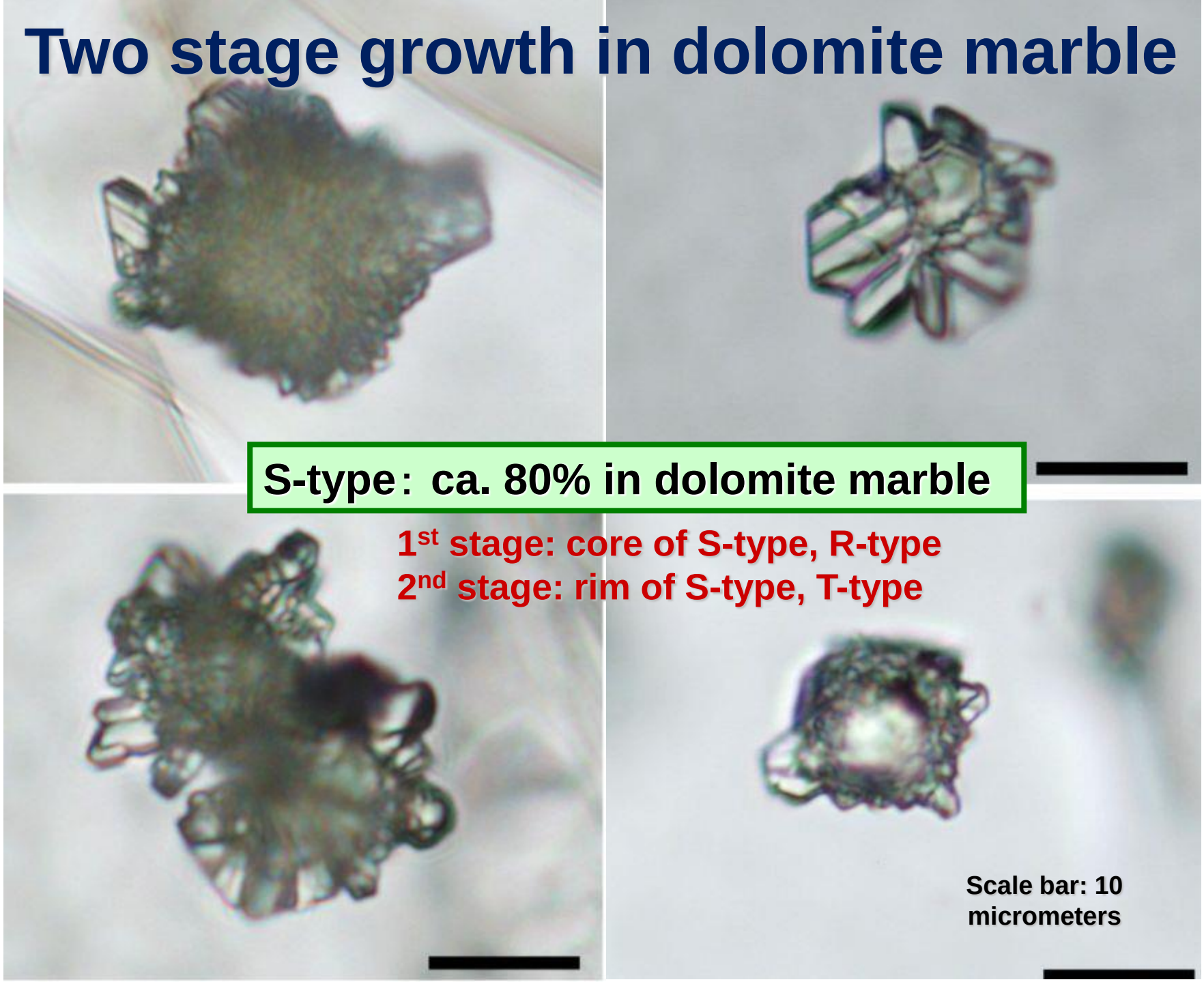
Grt-Cpx rock (Dia-bearing)

- Low abundance
- Large-grain > 100 μm
  - Overgrowth on fine grain
  - Low nucleation rate
  - Slow crystallization from H_2O fluid

Tur-Qtz-Fel rock

- Dia in maruyamaite
- No 2nd stage growth
- Small FWHM of Raman

Two stage growth in dolomite marble

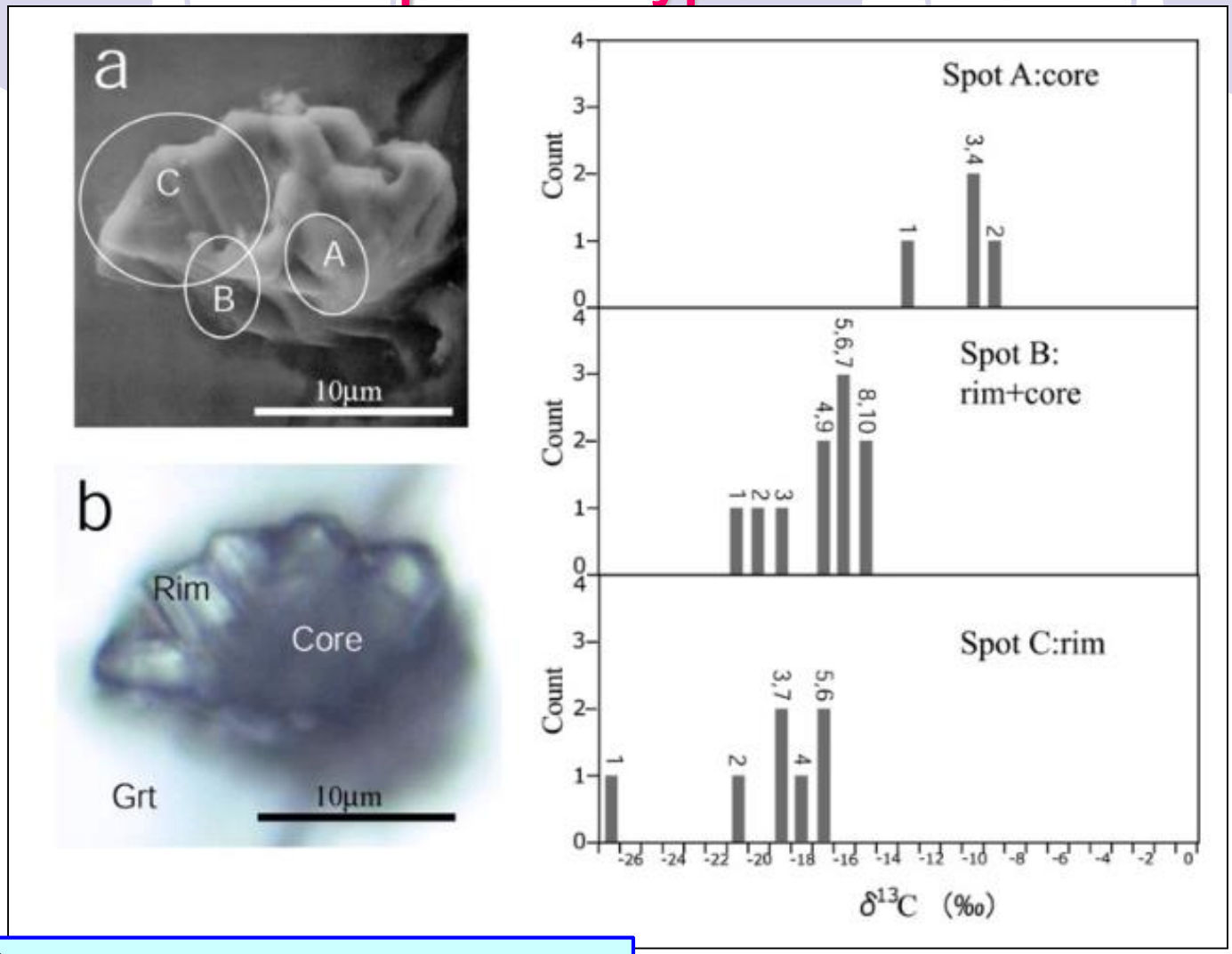


S-type: ca. 80% in dolomite marble

1st stage: core of S-type, R-type
2nd stage: rim of S-type, T-type

Scale bar: 10 micrometers

Carbon isotope of S-type microdiamond



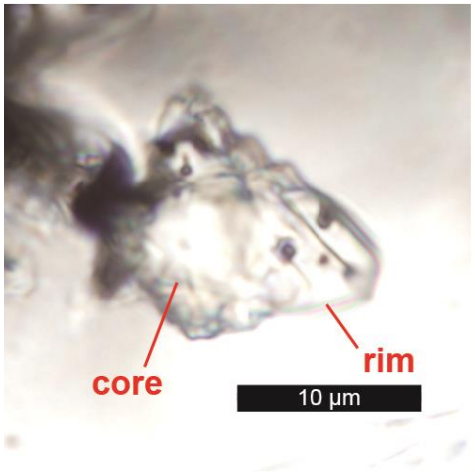
Core: $\delta^{13}C$ = -14 to -9 ‰ heavier

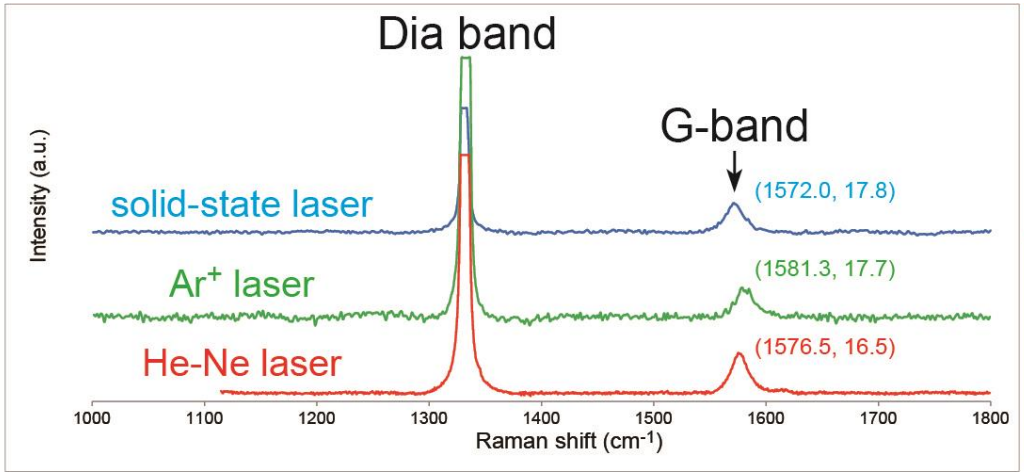
Rim: $\delta^{13}C$ = -26 to -15 ‰ lighter

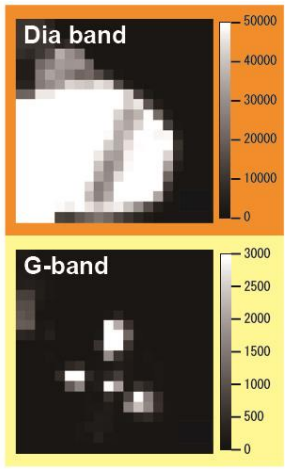
R-type: $\delta^{13}C$= -15 to –8 ‰

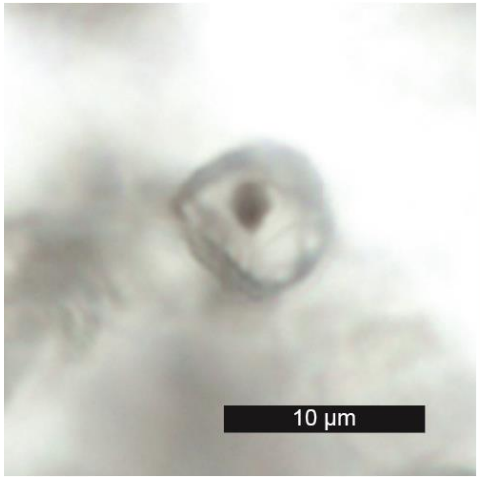
sp^2 carbon in 2nd stage diamond

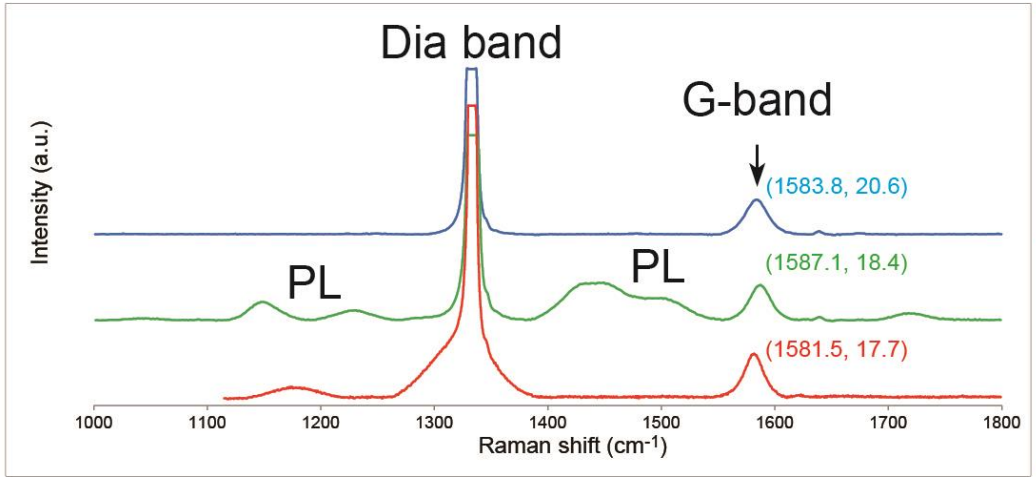
Relics of metastable intermediate C phase for diamond from C-bearing H_2O-fluid

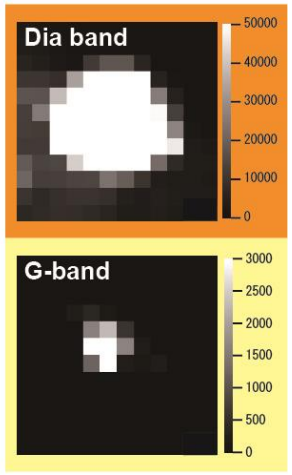




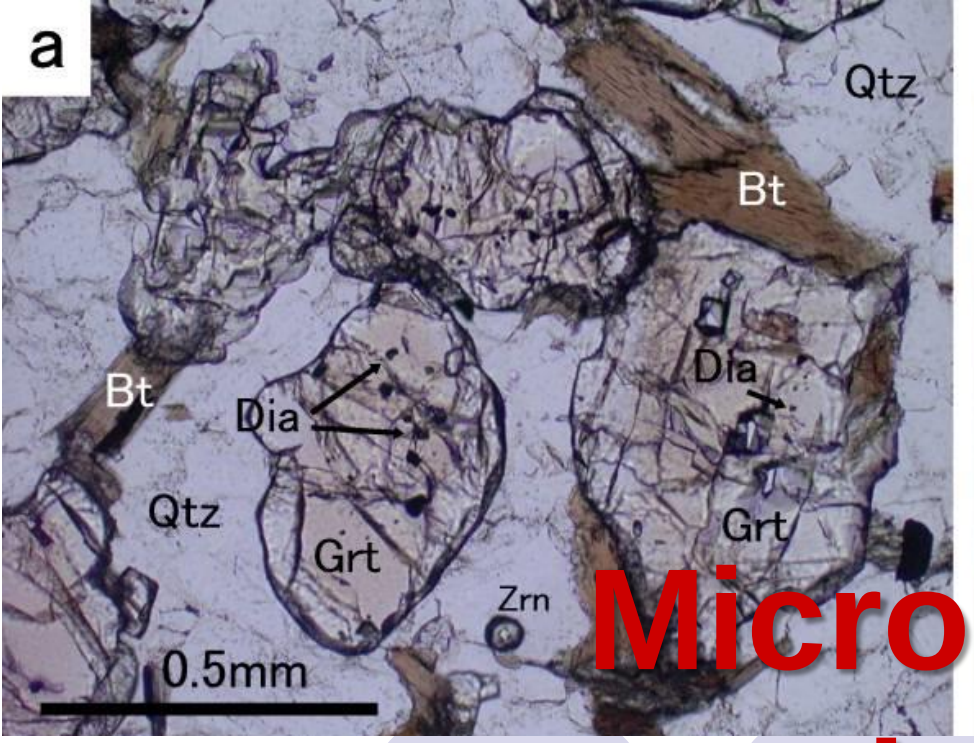








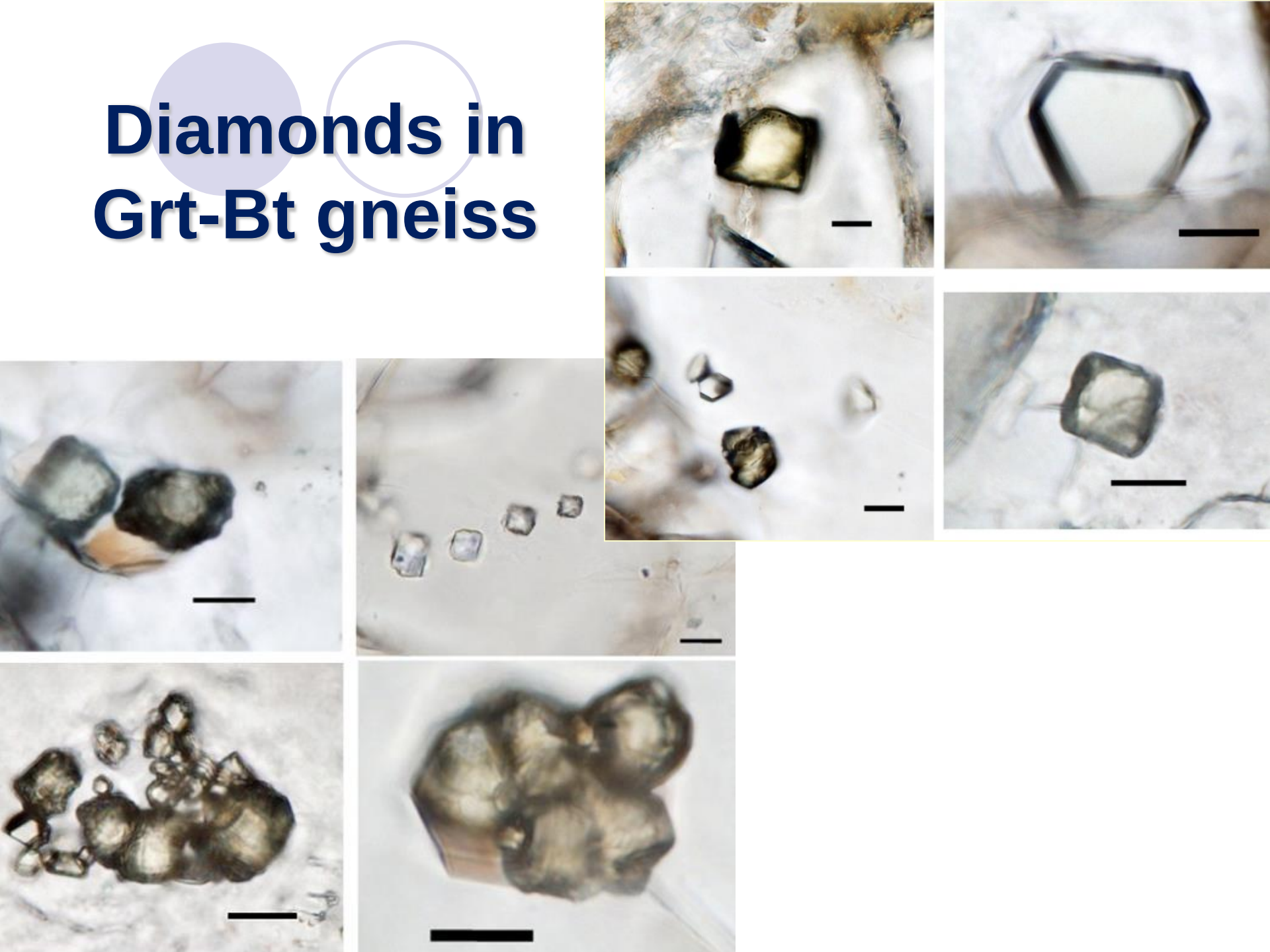
After Miura & Ogasawara (2014) (AGU2014F V13B-4771)



Microdiamonds in gneisses

- Abundant
  - But one order lower than in dolomite marble
- Variable morphologies
  - Granular, cubic, cubo-octahedral, spinel twin, etc.
- No 2nd stage growth
  - dissolution of diamond into H_2O fluid is possible.
- Host rock gneisses are possible H_2O source and the light C isotope source

Diamonds in Grt-Bt gneiss



Diamond in Grt-Cpx rock

- Minor amount
- Extremely large-grained: > 100 μm
- Find-grained Dia (new discovery: AGU2014F V13B-4779)
- Cubic overgrowth on fine-grained
- **Low nucleation rate and slow growth**
  - **Fine-grained Dia: a seed crystal**

Grt-Cpx rocks (Dia-bearing and Dia-free)

Products of strong metasomatism of carbonate + silicate mixtures at UHP

Diamond-bearing

First description:
Sobolev & Shatsky (1990)

Grt + Cpx
Like "skarn"
Not eclogite

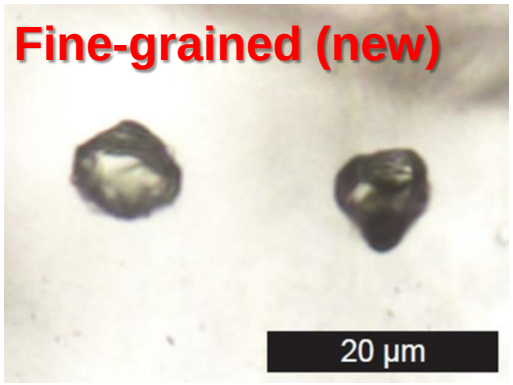
Diamond-free

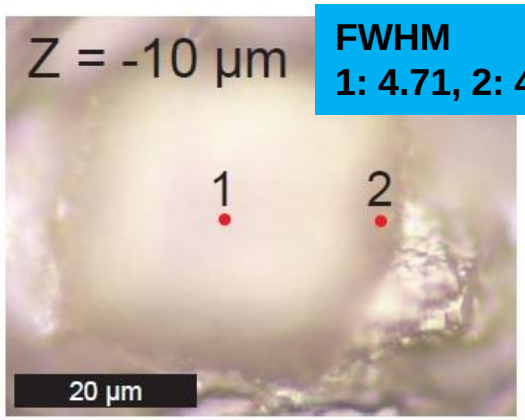
No Diamond
BUT UHP

Description:
Sakamaki & Ogasawara. (2014: IGR V.55)

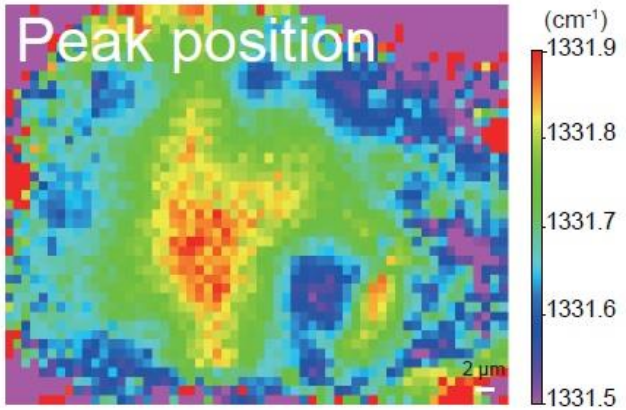
UHP evidence:
Coesite exsolution from supersilicic titanite

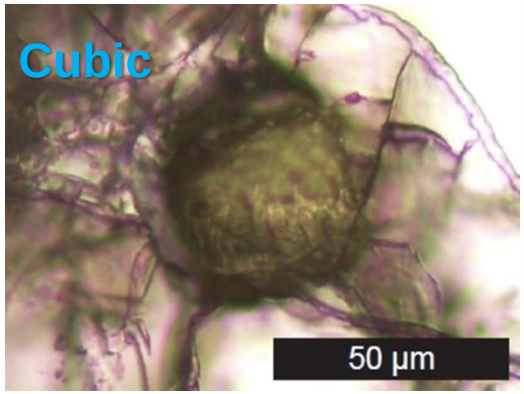
Large-grained cubic diamond overgrowth on fine-grained one

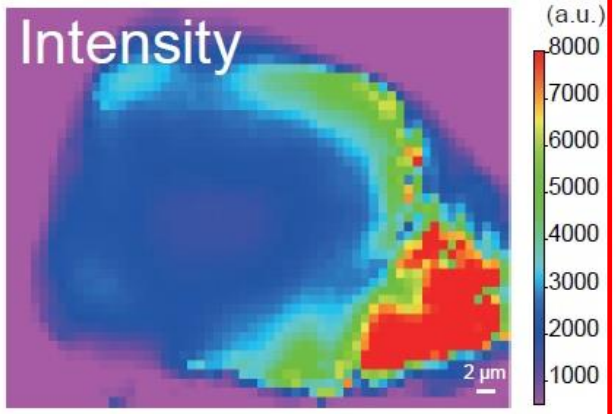


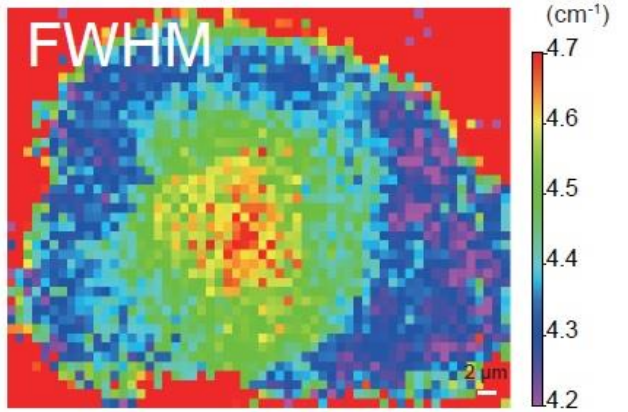


FWHM
1: 4.71, 2: 4.36

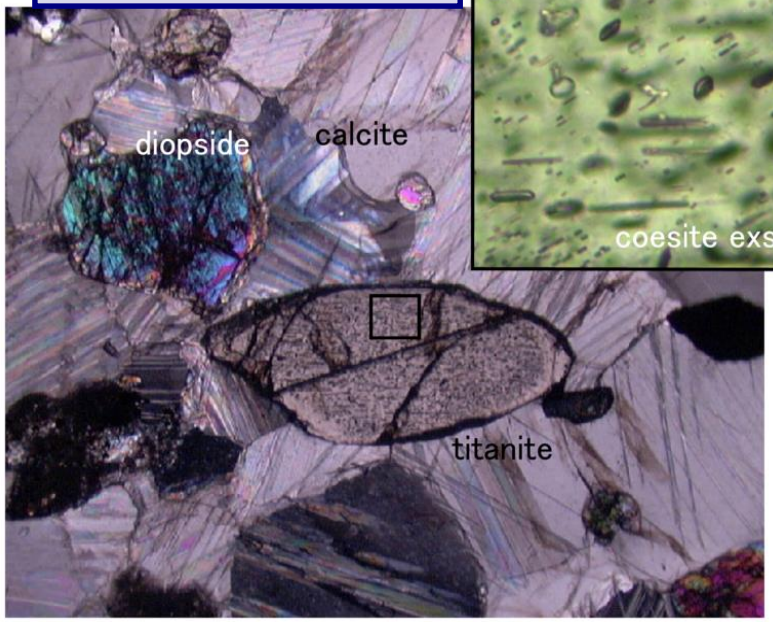


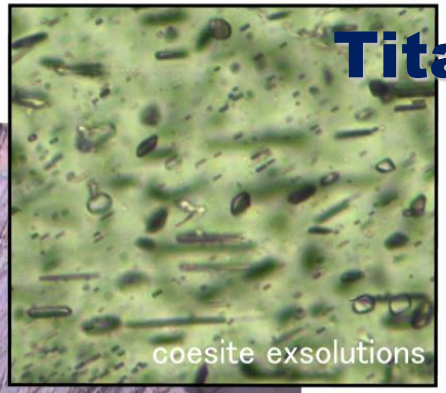




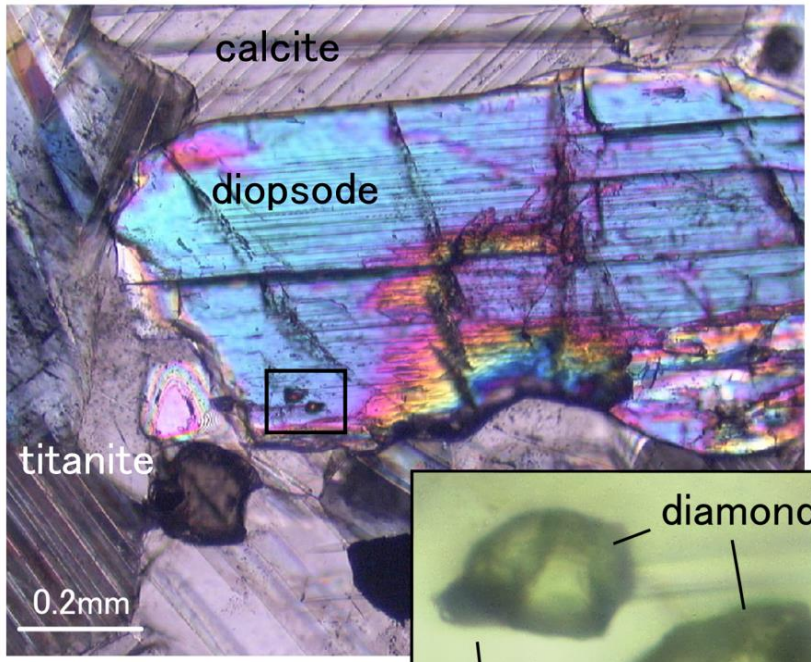


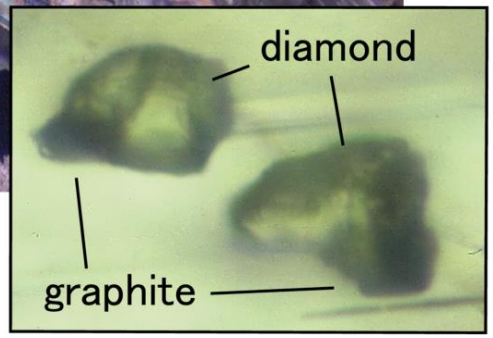
Titanite–bearing Calcite marble

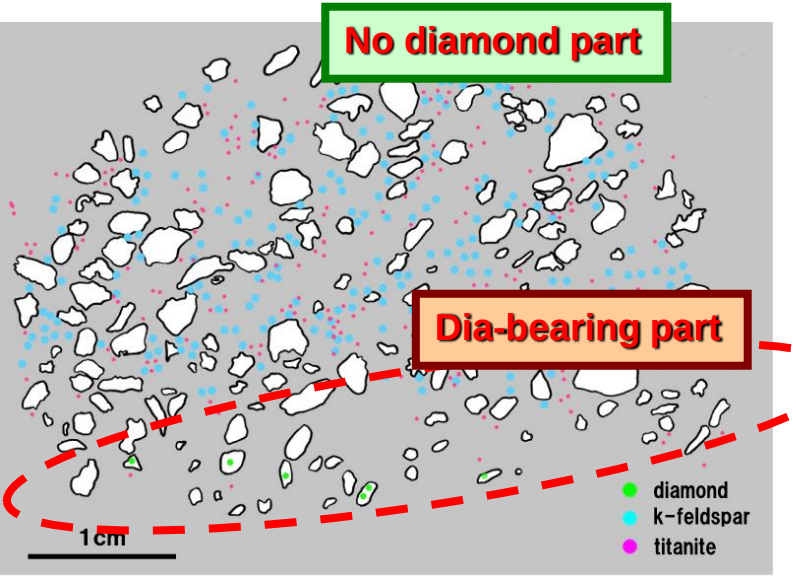




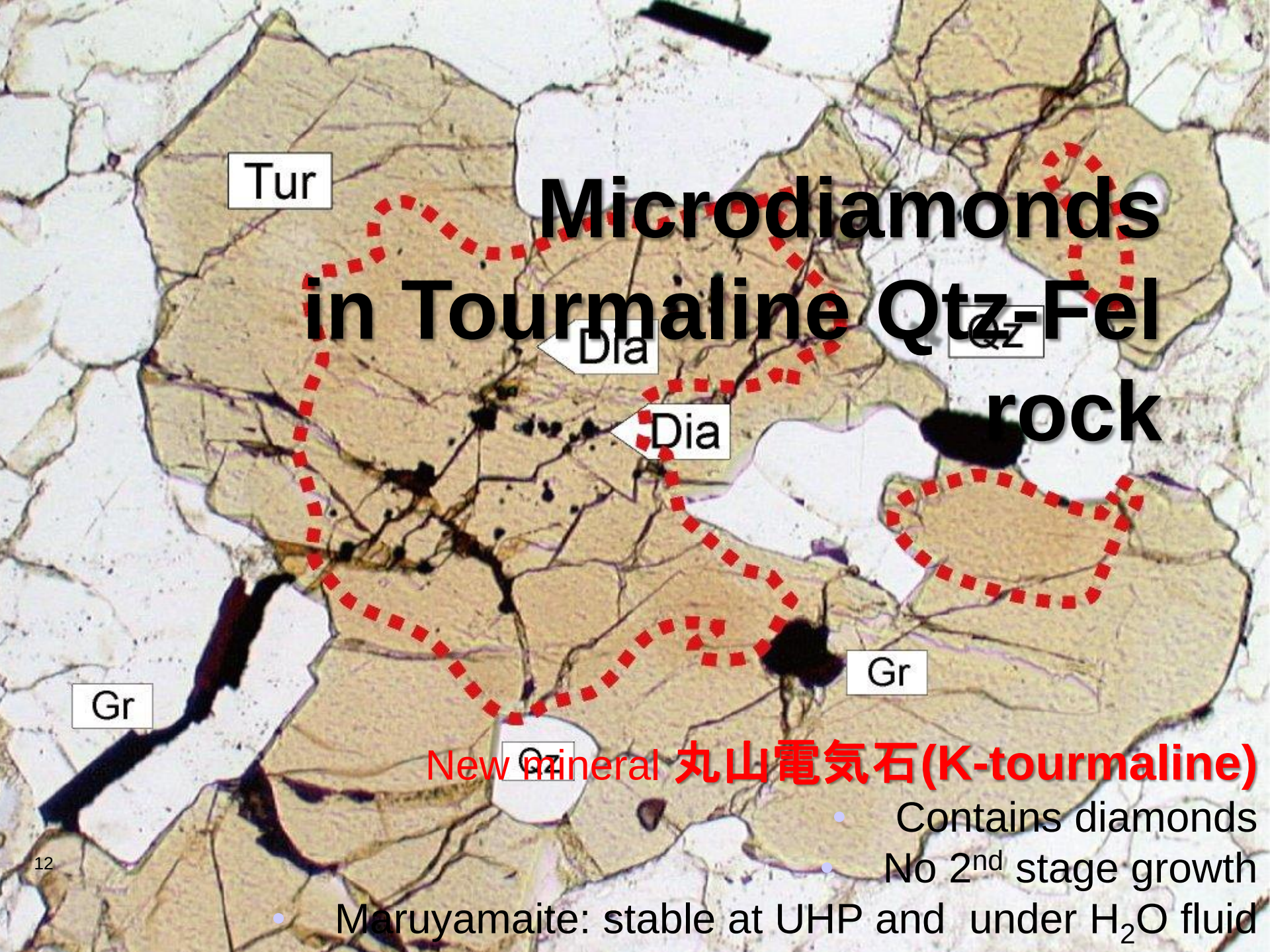
- Coesite exsolution in titanite
- Supersilicic titanite
- Min. P > 6 GPa
- Diopside with K-Fel Phe lamellae
- XCO_2 of titanite stability
  - extremely low (< 0.02)







- Diamond: 61 grains
  - in diopside
  - no 2nd stage growth



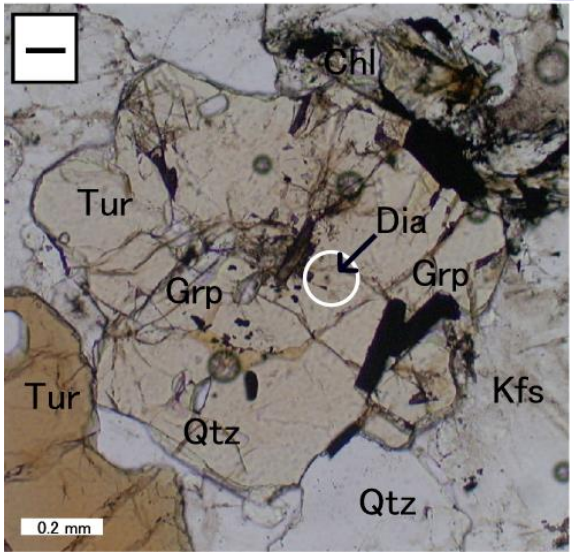
Microdiamonds in Tourmaline Qtz-Fel rock

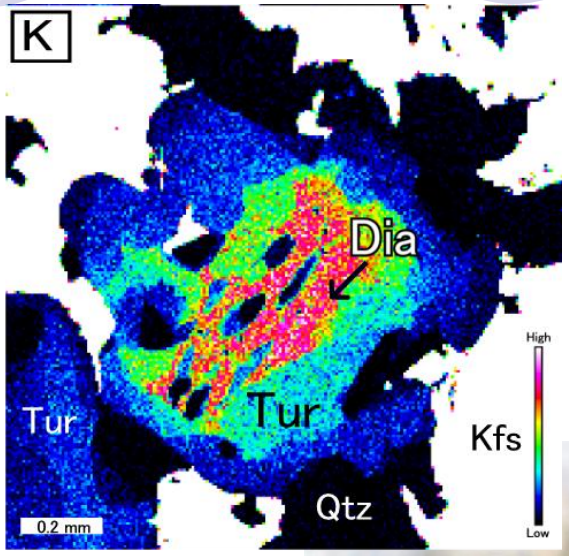
New mineral **丸山電気石(K-tourmaline)**

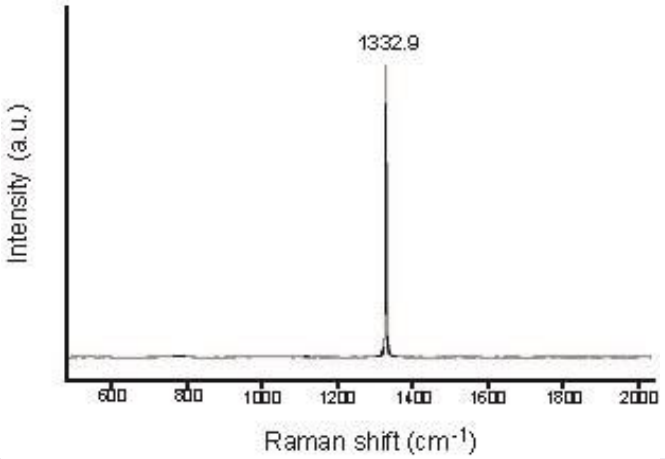
- Contains diamonds
- No 2nd stage growth
- Maruyamaite: stable at UHP and under H_2O fluid

New mineral “maruyamaite”

(K-dominant tourmaline domain includes diamond)







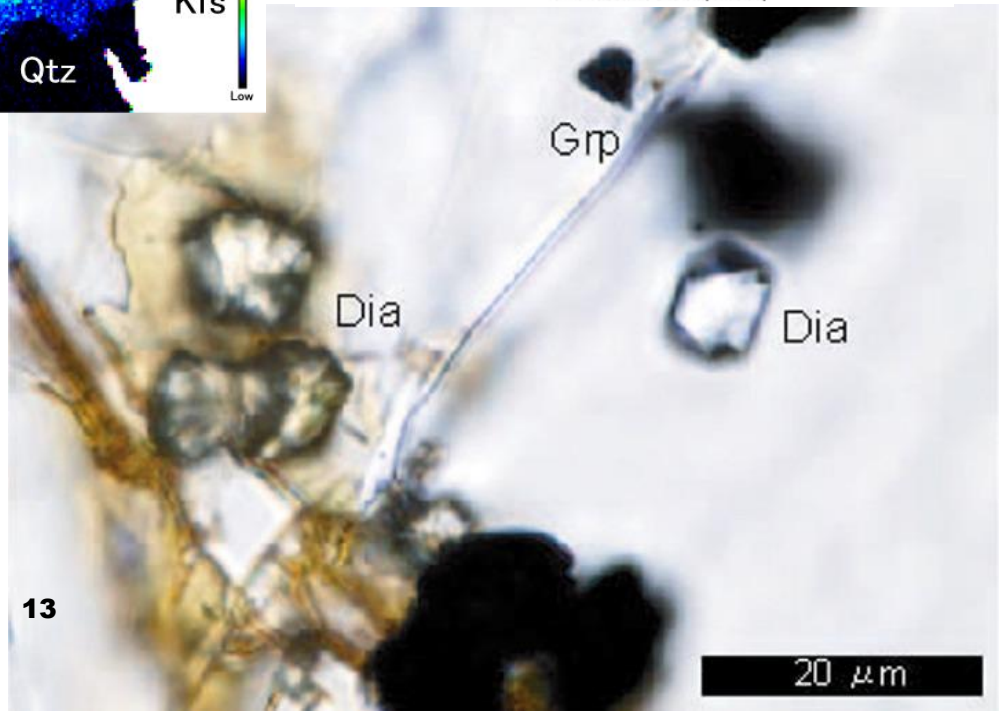
丸山電気石

IMA No. 2013-123

Min. Mag. Vol. 78, p. 550 (2014)

Berryman et al. (2014):

K-tourmaline is stable at UHP and K-rich H_2O fluid



Evidence of H_2O fluid

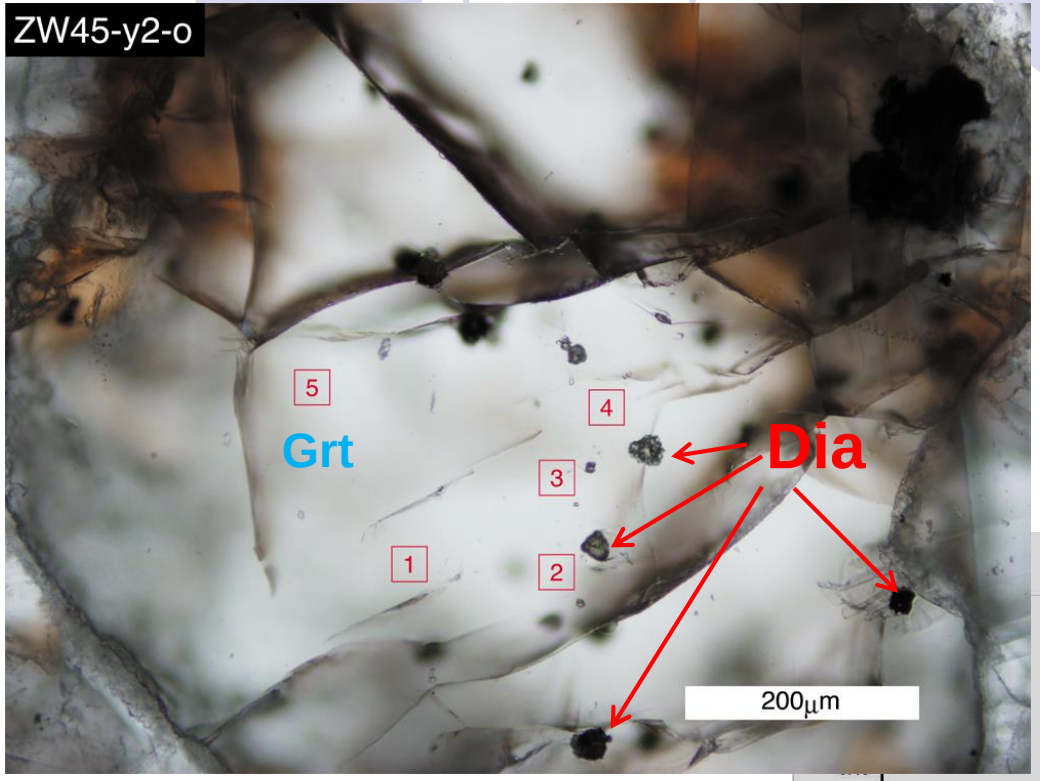
Micro-FTIR spectra

(OH) and H_2O in host garnet

(OH) and H_2O in host Cpx

H_2O in diamond (Grt-Cpx rock)

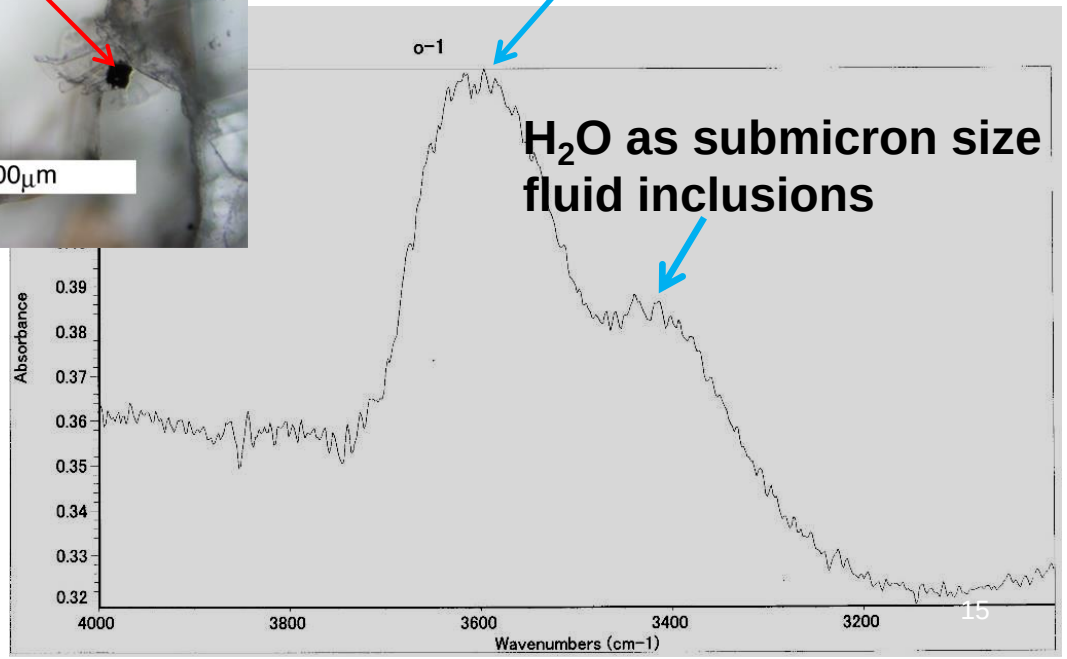
OH/H_2O in Grt in dolomite marble



Micro-FTIR spectrum of garnet
(Yazaki, 2007: unpublished data)

FT-IR spectra
ZW45-y2-o: Spot no. 5

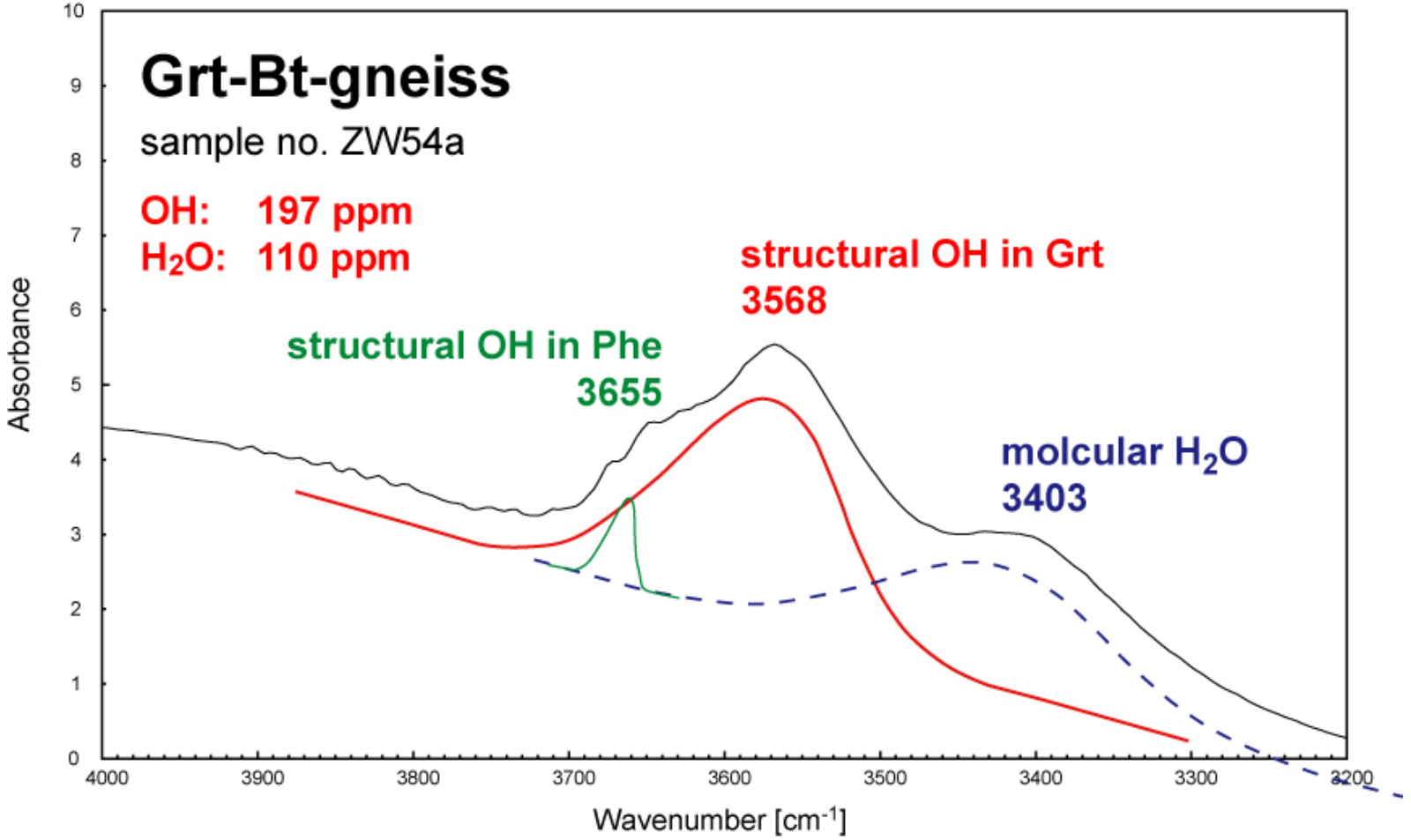
$(OH)^-$ in Grt structure



Evidence of H_2O fluid

OH/H_2O in Grt in Grt-Bt gneiss

Micro FT-IR spectra

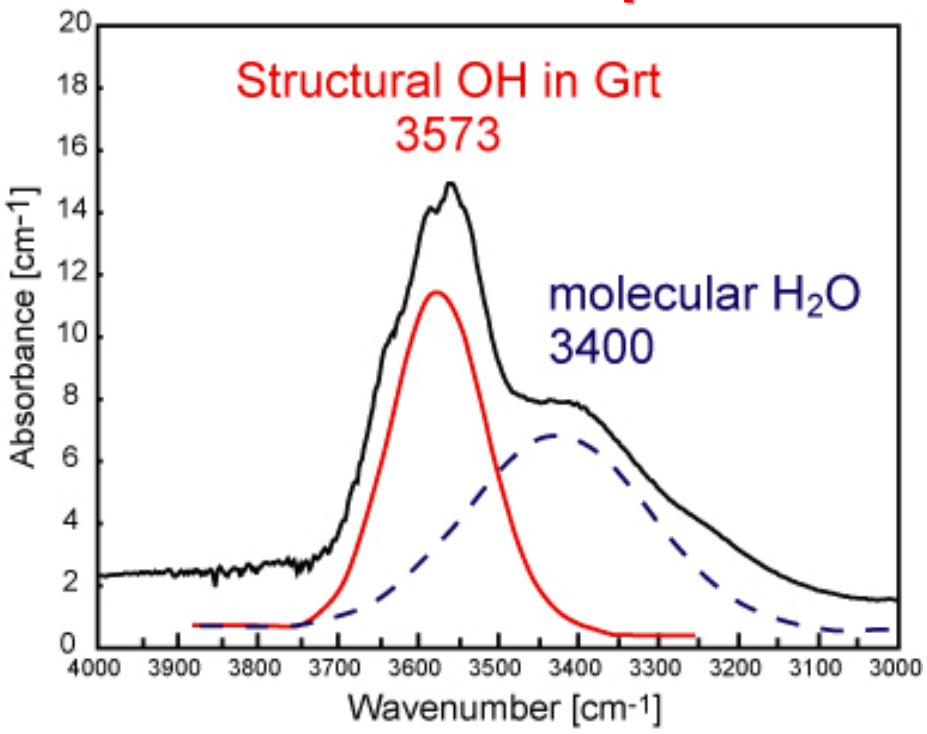


Total water ($OH + H_2O$) : 63-332 ppm

OH/H_2O in Grt in Grt-Cpx rocks

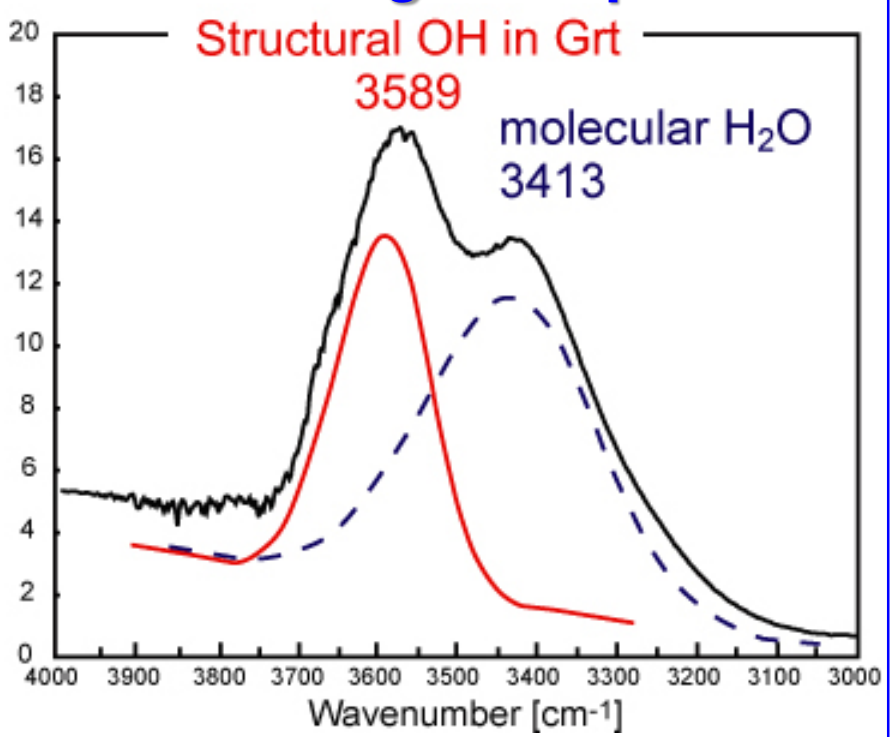
Micro FT-IR spectra

Dia-free Grt-Cpx Rock



OH: 761 [ppm wt. H_2O]
H_2O: 380 [ppm wt. H_2O]

Dia-bearing Grt-Cpx Rock

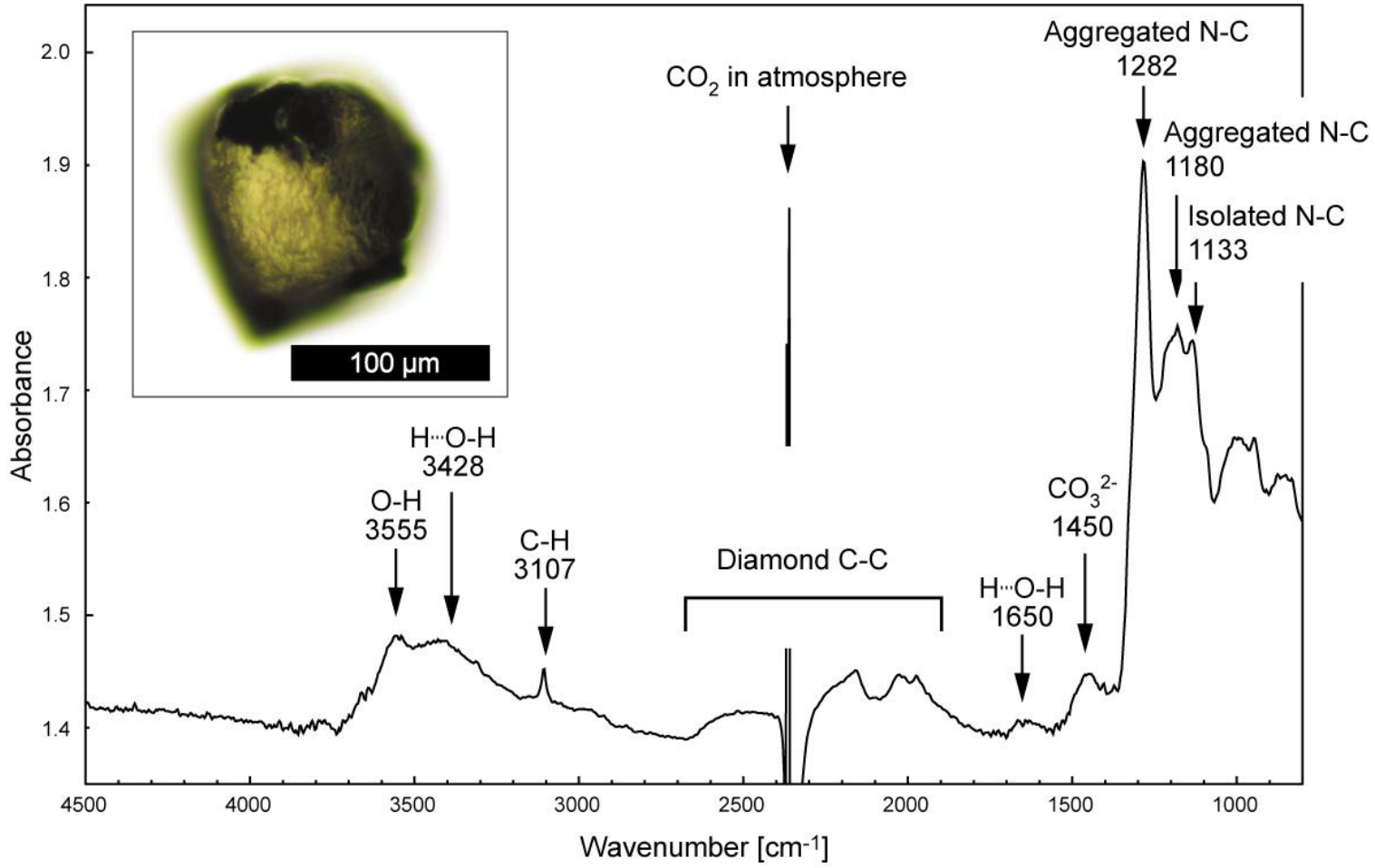


OH: 997 [ppm wt. H_2O]
H_2O: 1216 [ppm wt. H_2O]

Direct evidence for diamond formation in H_2O fluid

H_2O in diamond in Grt-Cpx rock

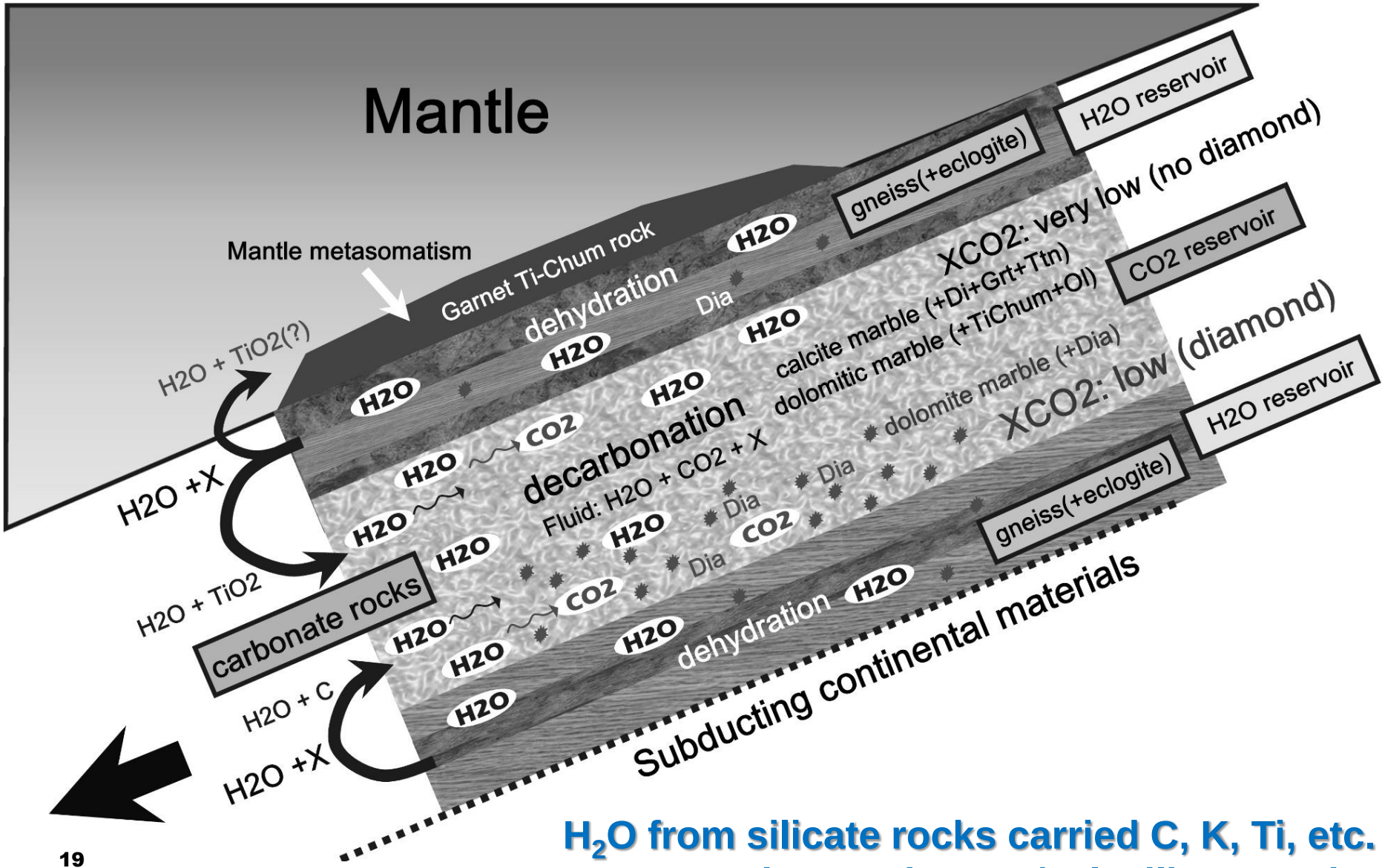
Micro FT-IR spectrum



The details will be presented at AGU2015F (V11C)
by Sakamaki, Ogasawara & Schertl

Intraslab UHP metasomatism

(After Imamura et al., 2013; Ogasawara 2004; 2009; 2014)



H_2O from silicate rocks carried C, K, Ti, etc. into carbonate/calcsilicate rocks.

Conclusions

- Kokchetav metamorphic diamonds show diverse features
  - in abundance, distributions in host minerals and host rocks
  - in morphology, Raman, CL and PL spectra, C isotope, etc..
- Formations of these diamonds are complicated, but some may be explained by H_2O-fluid infiltration in subducted continental materials.
- The presence of H_2O fluid was confirmed in host minerals as OH and H_2O, and in diamond in Grt-Cpx rock.
- Some of the diamonds crystallized from C-bearing H_2O fluid:
  - 2^{nd} stage growth (T-type and core of S-type) in dolomite marble
  - Cubic over growth (?) in Grt-Cpx rock
- Dissolution of diamond into H_2O fluid could be possible in some rocks without 2^{nd} stage growth.
  - Grt-Bt gneiss, UHP calcite marble

Thank you for your attentions!