Deformation history reconstruction using Raman microspectroscopy data of single quartz grains of Szentlőrinc-1 deep well

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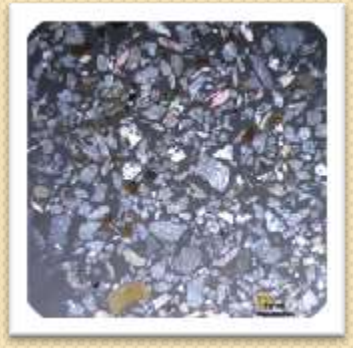
Ifjú Szakemberek Ankétja
Balatonföldvár 2014. március 28-29.

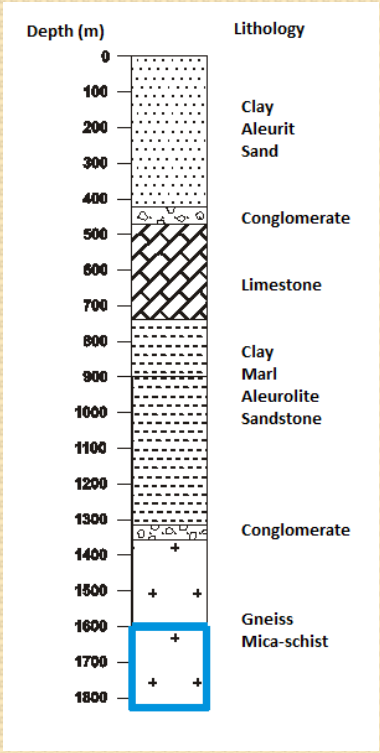
Geological Settings and Samples

Mecsekalja-zone, Szentlőrinc-1 well

- 1.5 km wide tectonic zone
- Multiplicity of rock types
- Active transcurrent zone
- Mylonitic dislocation zone

(based on Fülöp et al. in Haas, 2001)





Thorbergsdóttir et al. (2010)

Aim of the project

- Work out a reproducible method for deformation history reconstruction using single quartz grains of drilling chips
- Deformation history reconstruction of Mecsekalja-zone
- Why is it important?

Methods

- Microstructural analysis ~ 500 quartz grains
- Separation of single quarz grains characterized by different microstructures
- Raman spectroscopy – measurement along a line 50 points, 5 µm (13 grains, 650 spectra)

Analytics

- Evaluation of spectra: PeakFit v4.12
- Statistical analysis: IBM SPSS Statistics 20
  - Discriminant function analysis

Interpretation

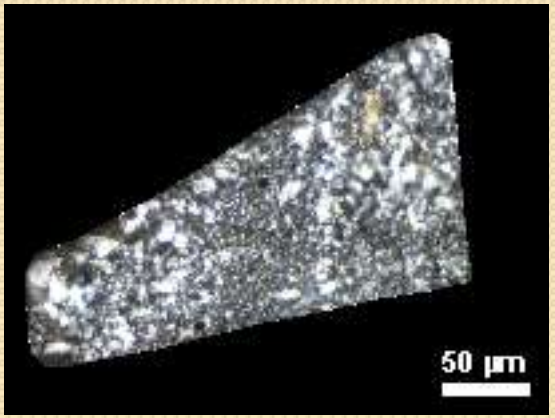
Results I.

Microstructural analysis

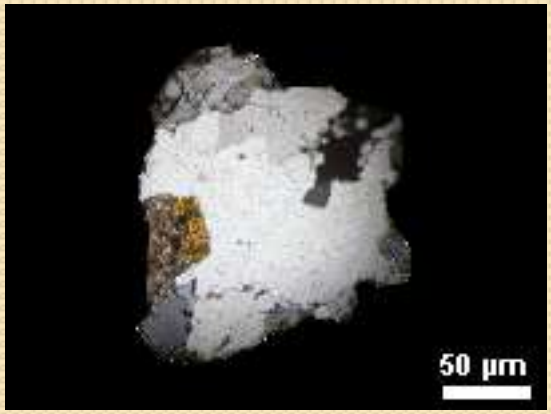
T0

T1

T2

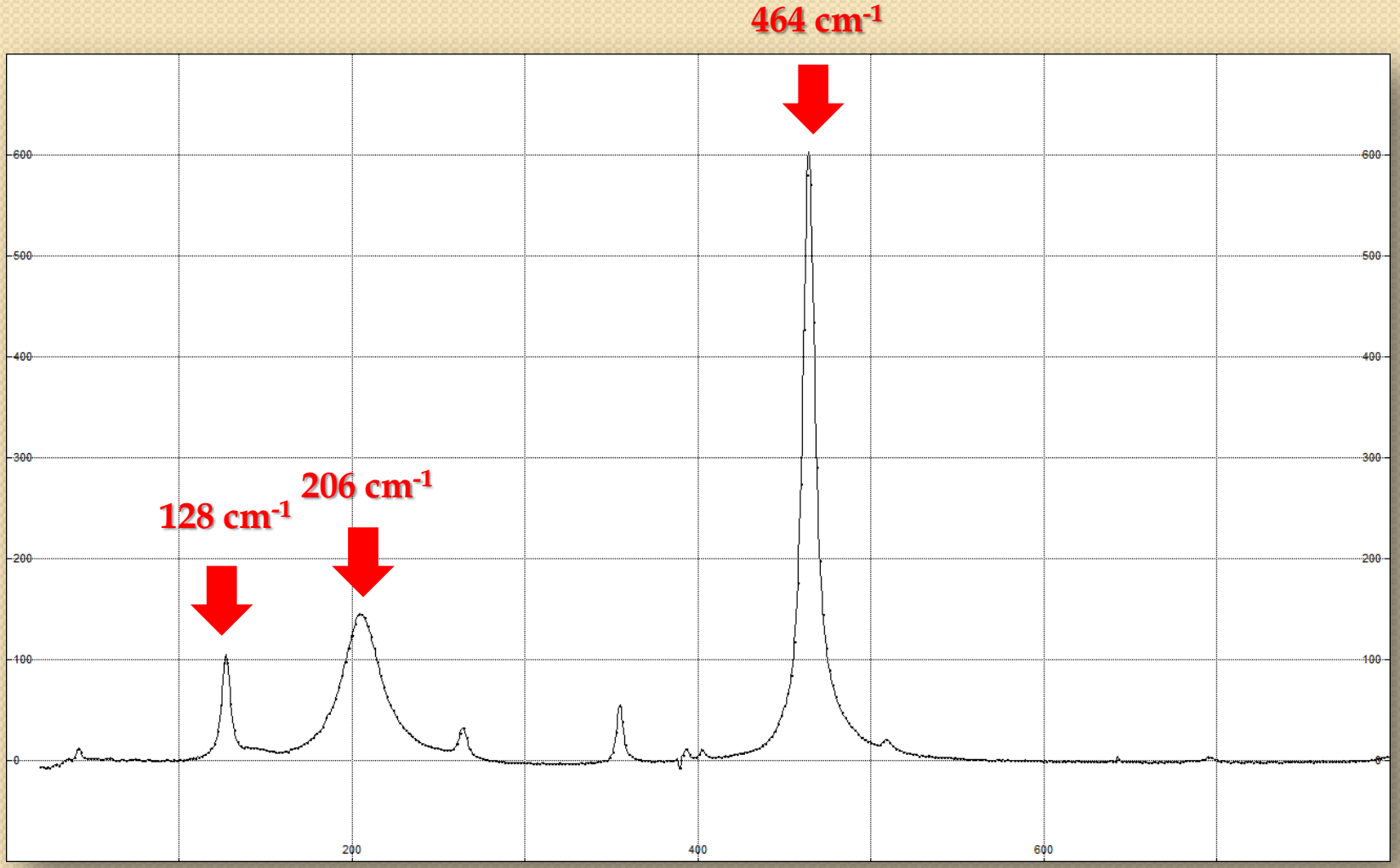


TRANSITIONAL



Results II.

Raman spectroscopy



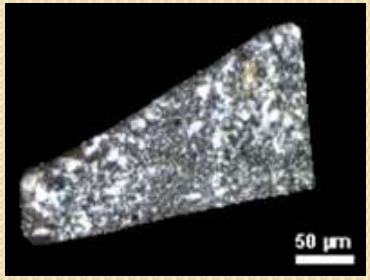
Results III.

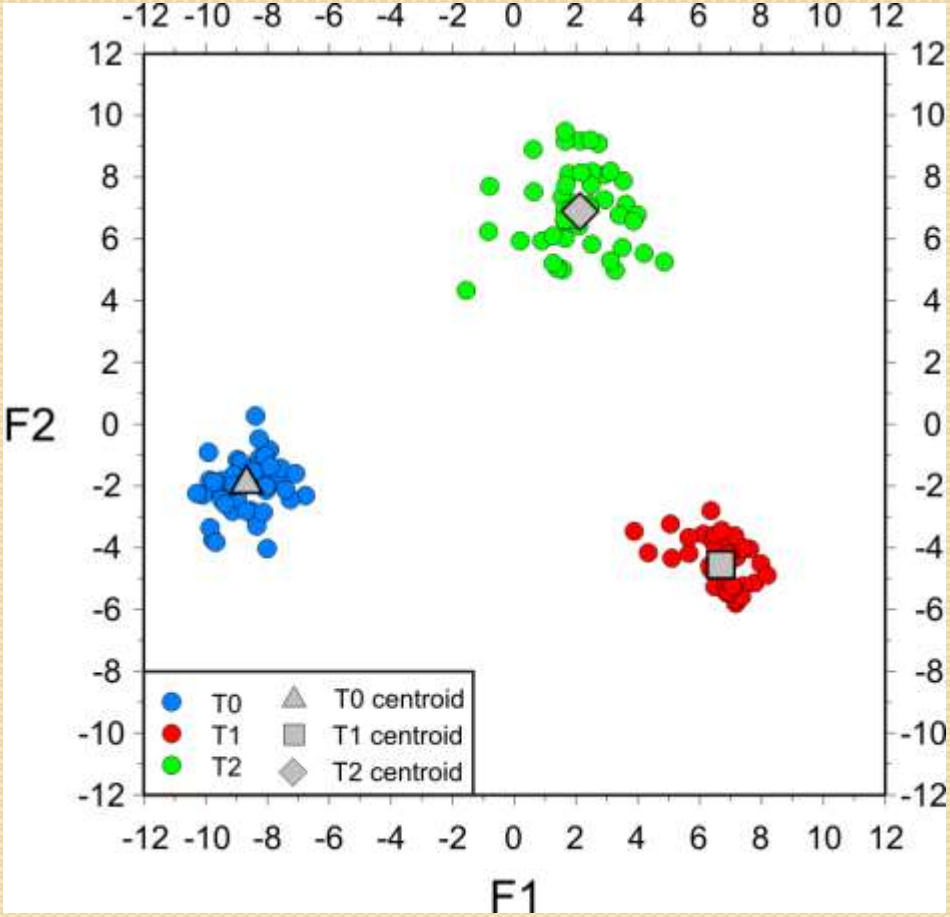
Discriminant function analysis

T0

T1

T2



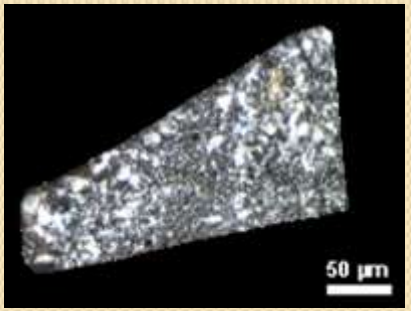


Results IV.

Discriminant function analysis

T0

The most important spectral attributes best describing the difference between extreme types



T2

Integrated area of 128 and 206 cm^{-1} bands

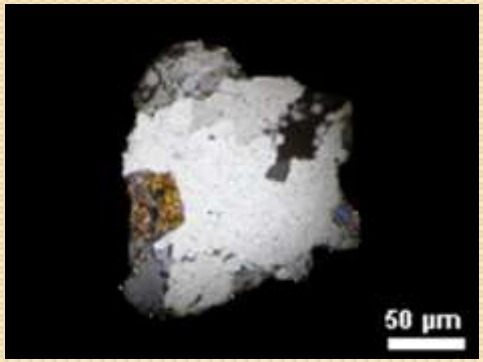
T1

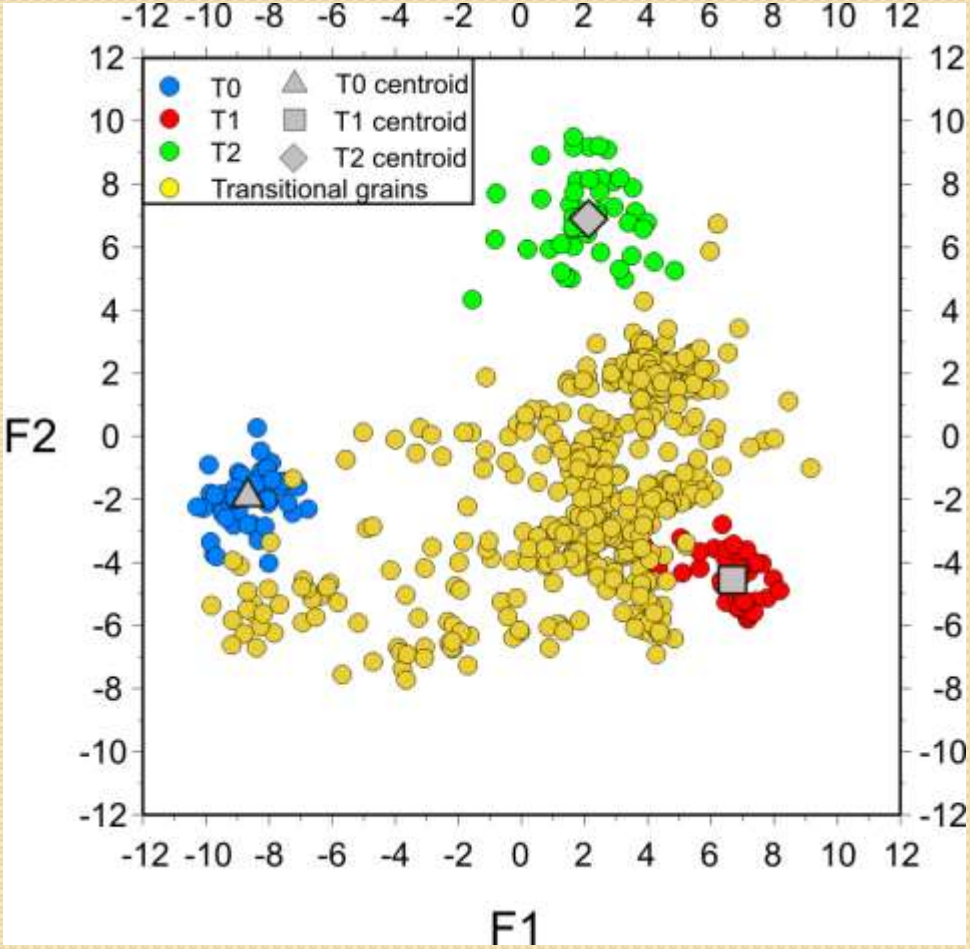
Center position of 128, 206 and 464 cm^{-1} bands

Results V.

Discriminant function analysis

TRANSITIONAL





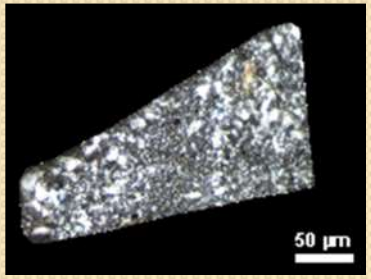
Interpretation I.

Microstuctures

T0

T1

T2



DYNAMIC RECRYSTALLIZATION

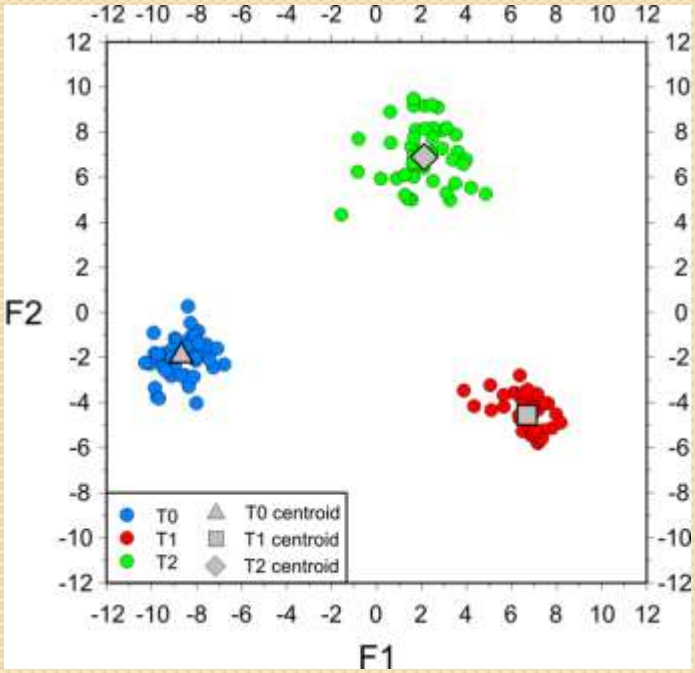
„Bulging" recrystallization (BLG, Regime 1)

Initial subgrain rotation recrystallization (SGR I, Regime 2)

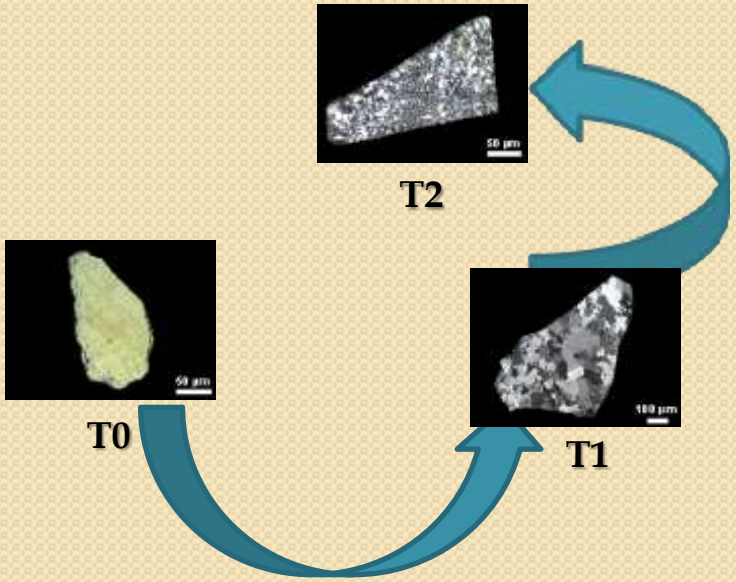
Later subgrain rotation recrystallization (SGR II, Regime 2)

Interpretation II.

Virtual deformational space model



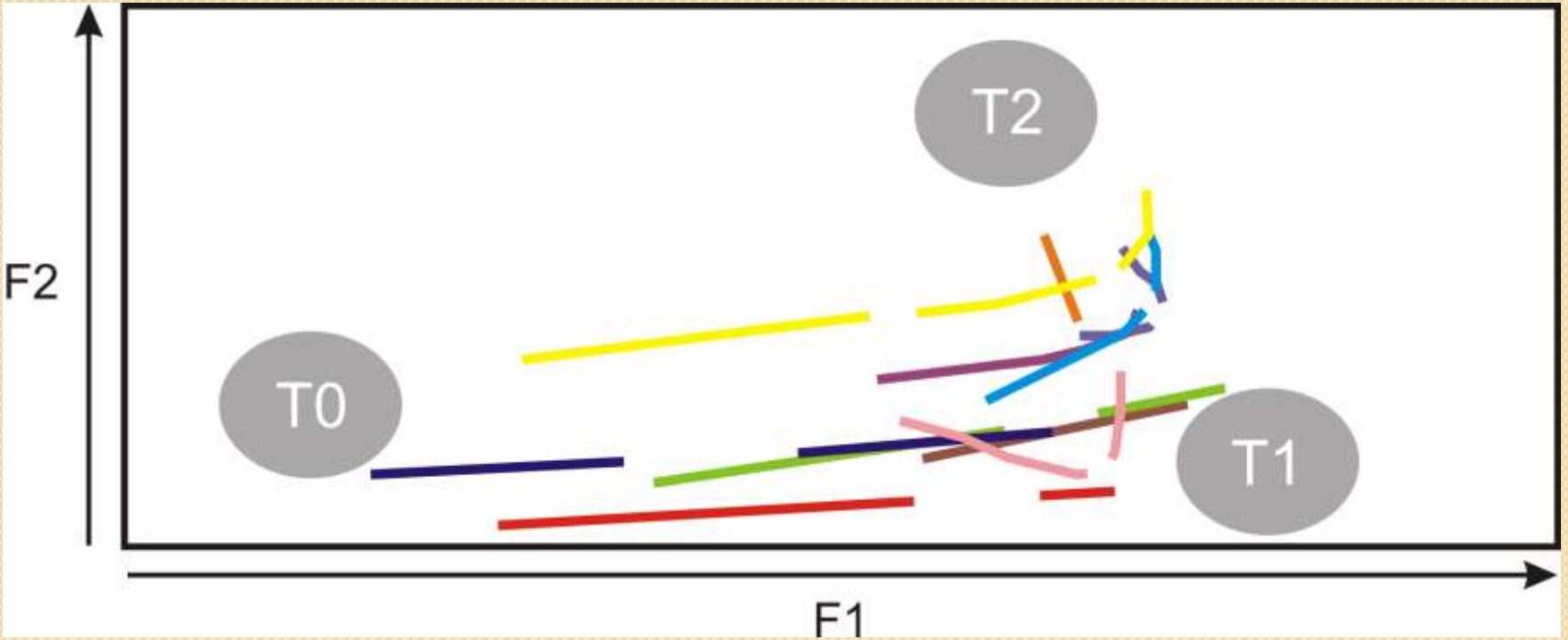
Spectral space



Deformational space

Interpretation III.

Virtual deformational space model



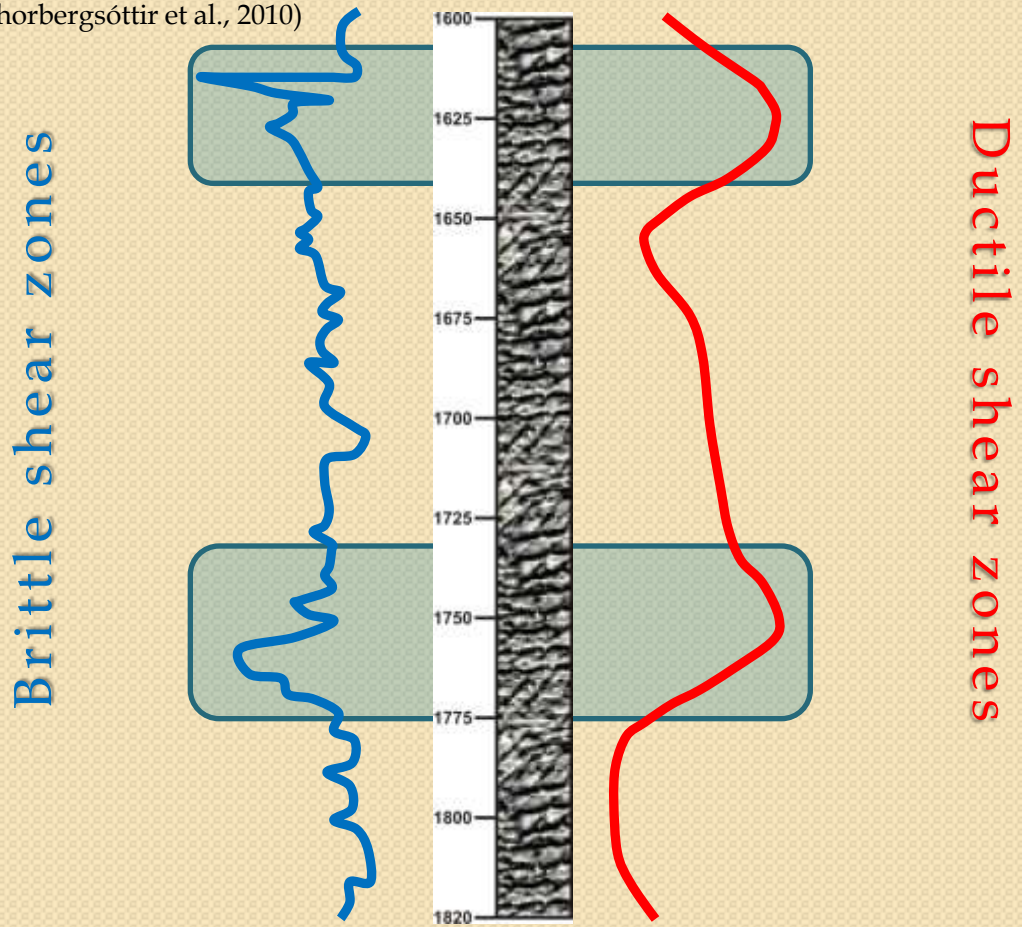
Applications

Shear Zone localization

Brittle deformation

(Geo-Log Ltd.; Thorbergsóttir et al., 2010)

Ductile deformation



Applications

Possible evolution schemes

Scheme 1

- Independent brittle and ductile shear zones
- The firstly evolved ductile shear zones caused softened regions inside the crystalline mass, it could reactivate later in a brittle way

Scheme 2

- Continuous brittle and ductile shear zones
- Zones may represent a detachment fault - ductile and brittle deformations overlap along the same shear zones

Applications

Which scheme is true?

Evidence:

Metamorphic grade of the footwall and hangingwall formations

Ti-in-quartz thermometry

- Near-equivalent metamorphic grade and T in footwall and hangingwall formations

Scheme 1

Softened region

- Different metamorphic grade and T in footwall and hangingwall formations

Scheme 2

Detachment fault

Conclusions

- Examination of the microstructure of the newly-available detrital quartz grains has provided valuable information regarding the evolution of a subsurface shear zone.
- Raman microspectroscopic analysis enabled single quartz grains, which are characterized by different deformation conditions, to be identified and classified.
- Each complex quartz grain analyzed appears elsewhere in the deformation process defined by the T0-T1-T2 extreme conditions, they together represent a deformation development pathway.
- Characterization of single quartz grain microstructures using the above technique along the whole well enables localization of the ductile shear zones inside the crystalline complex.
- These zones coincide very well with the brittle horizons defined by well-log evaluation.
- It can be modeled by „Softened region" or „Detachment fault" schemes.
- Using TitaniQ thermometry can evidence, which scheme is true.

Acknowledgements

- I would like to thank **Tivadar M. Tóth**, **Krisztián Fintor** and **Félix Schubert** for their conspiration in the project:

  SKULTÉTI, Á., M. TÓTH, T., FINTOR, K. AND SCHUBERT, F. 2014. Deformation history reconstruction using single quartz grain Raman microspectroscopy data. *Journal of Raman Spectroscopy*, DOI 10.1002/jrs.4456

- I also thank the **Mannvit Ltd.** for providing the samples and the **Geo-Log Ltd.** and the **PannErgy Plc.** for geophysical data.

- This research was supported by **TÁMOP-4.2.2.A-11/1/KONV-2012-0047**.

Thank you for your attention!