Efficient use of natural stone in the Leningrad region and South-East Finland

SOUTH-EAST FINLAND - RUSSIA ENPI CBC PROGRAMME

2007-2013

9.3.2015

This project is co-funded by the European Union, the Russian Federation and the Republic of Finland

Granite in SPb and Helsinki architecture

2002

2001

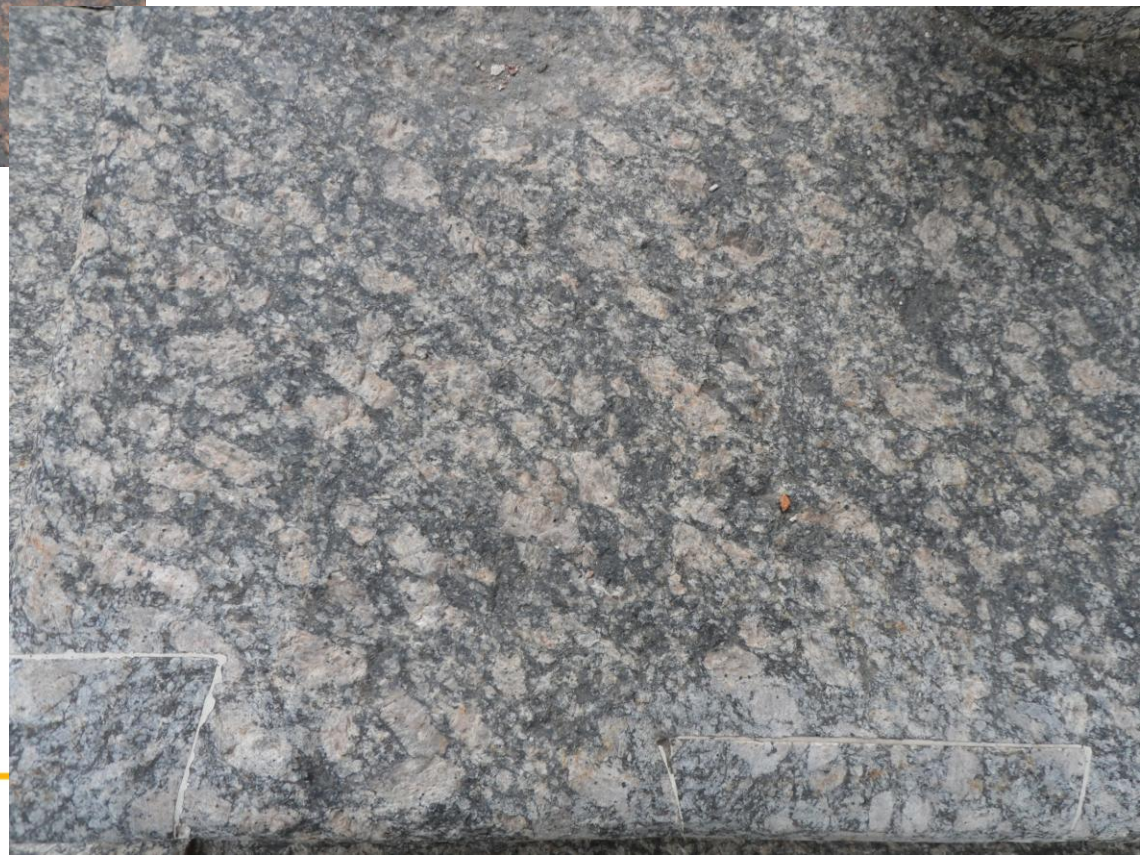
Architects, designers and companies questions:

- -long-term changes;
- - changes in the colour and the quality;
- -frost damage;
- -air pollution;
- -chemicals environment;
- -texture, structure differences;
- -the porosity of the rock types, cracks and other difference;
- -water absorption speed and ability, compressive strength;
- -mechanical resistance;
- -bending of the stone;
- -long-term durability;
- -biological weathering;
- -seams materials;
- - stagnant water, drying speed after the rain;
- -contact with the ground;
- -capillarity properties;
- -the comparison of different age buildings.

Granite is very strong stone

1860-1870гг

Granite restoration



GTK

Stability of a stone in the city environment

- Gathering of existing data from the project area
- Samples from the city environment
- Site tests
- Laboratory investigations

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Site Insp.

Sampling

Samples had been collected from sites in different periods along the project and of different kind:

- drill cores with different diameters: 17mm for those collected in 2012 with depth reaching few cm presenting often breaking of the core and 20mm for those sampled in 2013, longer intact cores

-hand samples: fragment loosen from the surface of small dimension had been used to assess the weathering condition on Russian sites since sampling had not been possible otherwise;

-dust collection




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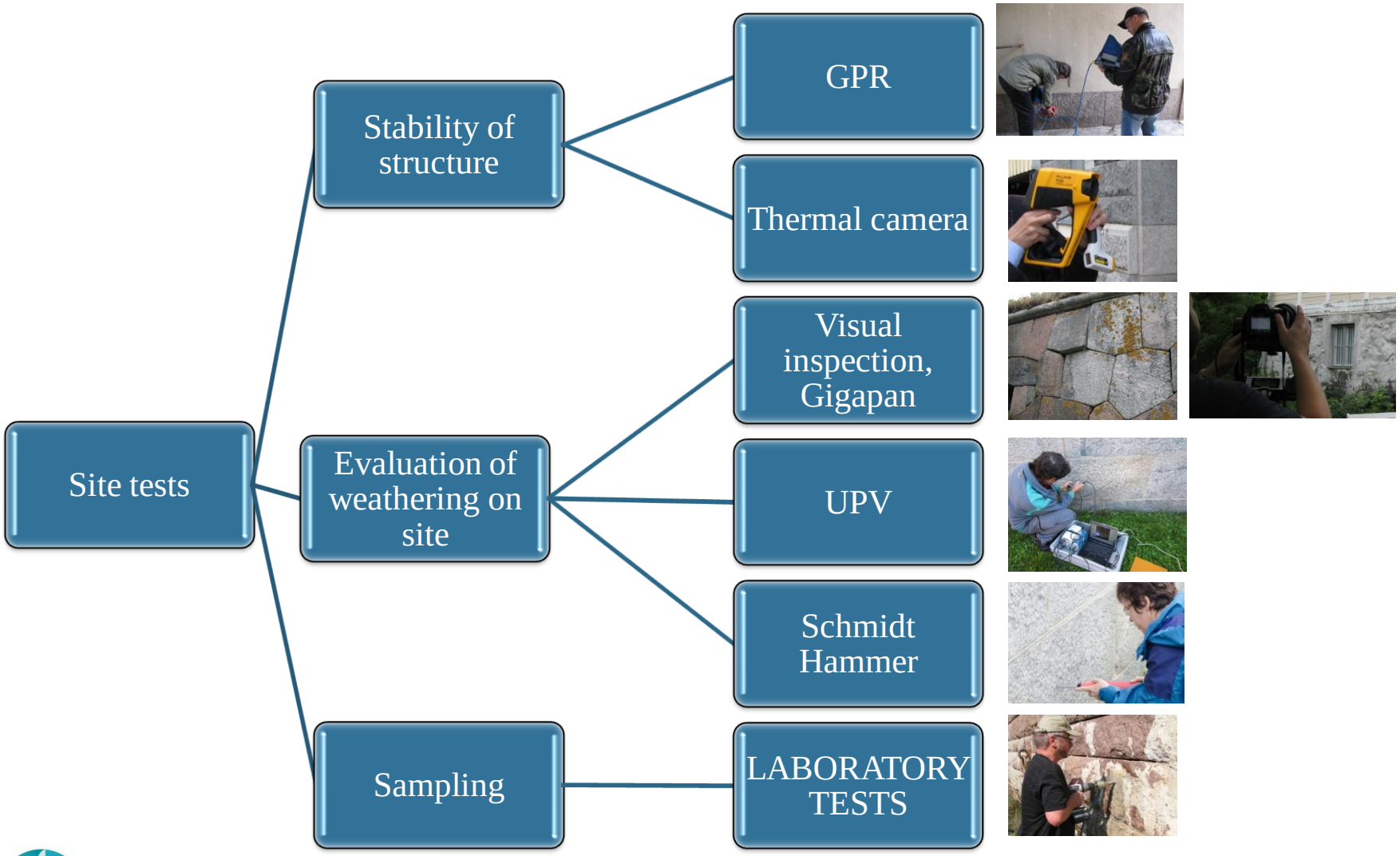

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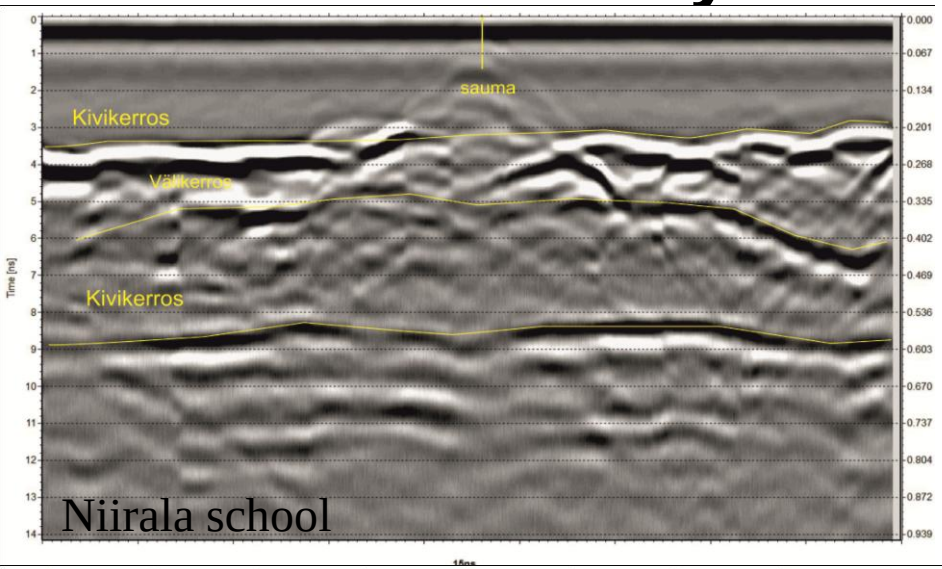
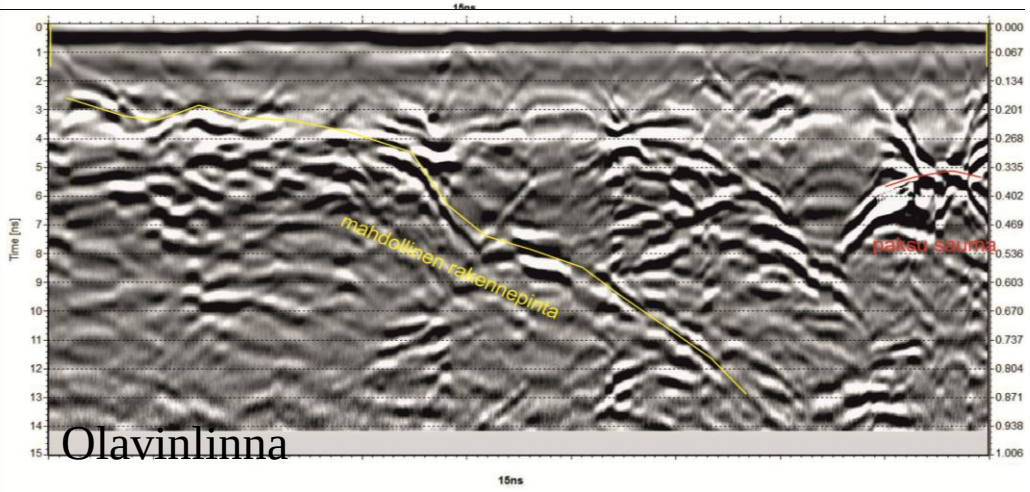
Site Insp.
Stability of the structure



Niirala school



Olavinlinna

Ground penetrating radar (GPR)

GPR techniques works in a similar way as UPV, sending a signal that is reflected and refracted back to the antenna. The signal is affected by material's weathering level e.g. higher porosity, cracks, presence of water and surface coatings. The equipment consisted of a SIR-3000 data acquisition unit with 900 and 1600MHz antennae. GPR should had been able to detect interfaces, open cavities, presence of water, anchoring... but has to be considered also that results had been affected by uncertainties in the cases where the material and the structure had been highly heterogeneous.

RESULTS: effective in visualization of internal structures

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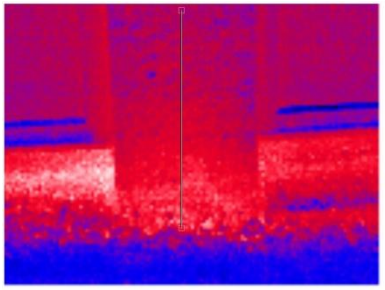
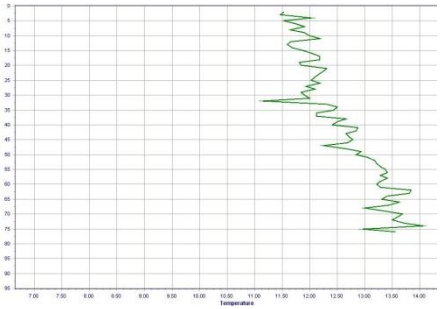
Site Insp.
Stability of the structure

Thermal images

Thermal images had been taken from all the sites with a Fluke Thermal Imager Ti20, trying to evaluate a possible correlation of temperature and humidity with deterioration effects. A student from Mikkeli University of Applied Sciences had been participating in the collection and examination of results. Analysis of the thermal image results were done under the guidelines defined in RESNET Interim Guidelines for Thermographic Inspections of Buildings (2012).





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Site Insp.
Weathering on site

Visual inspection

The buildings had been pictured with high definition photos, saved on gigapan site and on server, able to be zoomed at high magnifications

The detailed visual inspection checked for damages of surface material, changes in visual appearance, structural changes and biological colonization. In Niirala school it was attempted a color coding map.

RESULTS: Buildings showed to different extent surface changes on the stone

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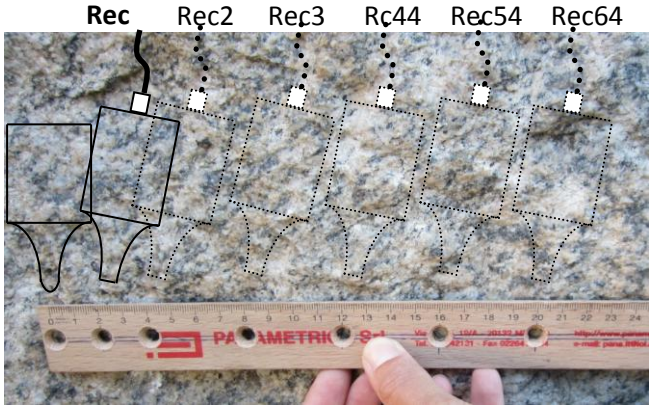
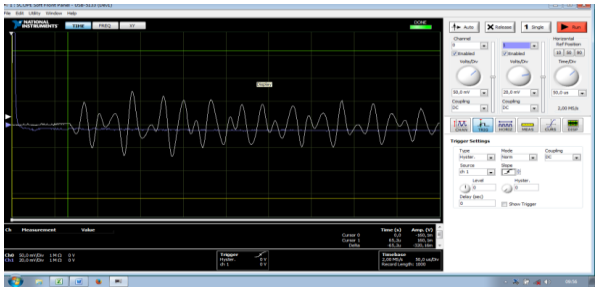
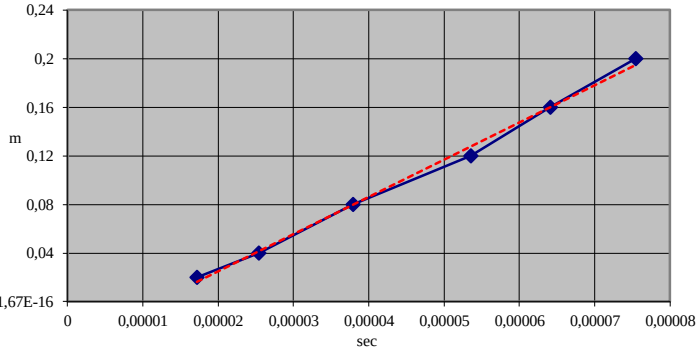
Site Insp.
Weathering on site



Ultrasonic pulse velocity (UPV)

The evaluation of ultrasonic velocity in a stone material has been used in order to evaluate possible sign of weathering on site. The method according to EN 14579 (2005)





GTK has been cooperating with the Polytechnic of Turin in performing the tests.
The measurements had been performed using a signal generator and receiver of a Pundit (Portable Ultrasonic Non-destructive Digital Indicating Tester) that is sending and receiving a wave, or train of impulses through the material to be tested, Transmitter has been kept fixed while receiver has been moved at defined steps, at each step the time of arrival of the wave has been taken, lately the distances-arrival times had been plotted and velocity had been evaluated.
RESULTS: changes in speed caused by surface cracks and oxidation level. In the boulder blocks results affected by weathering

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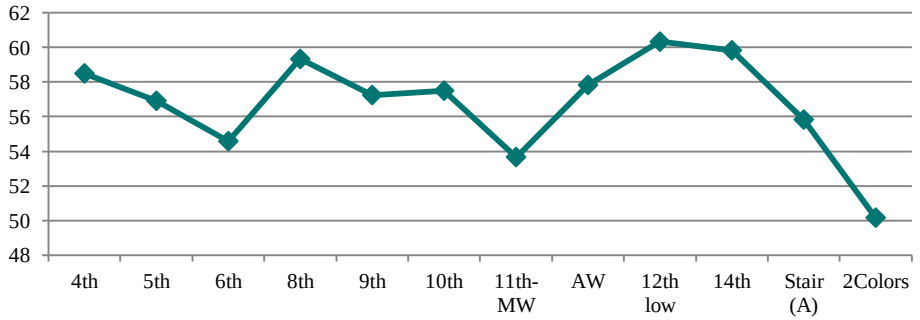
Site Insp.

Diagram of measurement results performed over Niirala school



Schmidt hammer

Schmidt hammer tests have been performed using a SADT Model HT225A hammer choosing specific blocks and performing 4 set of measurements. (Figure 6) Each set of measurement had been composed by 3 rebounds per point, evaluating the average on the block. It had been decided to perform only 3 rebounds on each spot because the aim was to assess the surface weathering, also possible surface cracks, chipping or rusting of the minerals.

RESULTS: Schmidt hammer was showing lower values for surfaces affected by weathering

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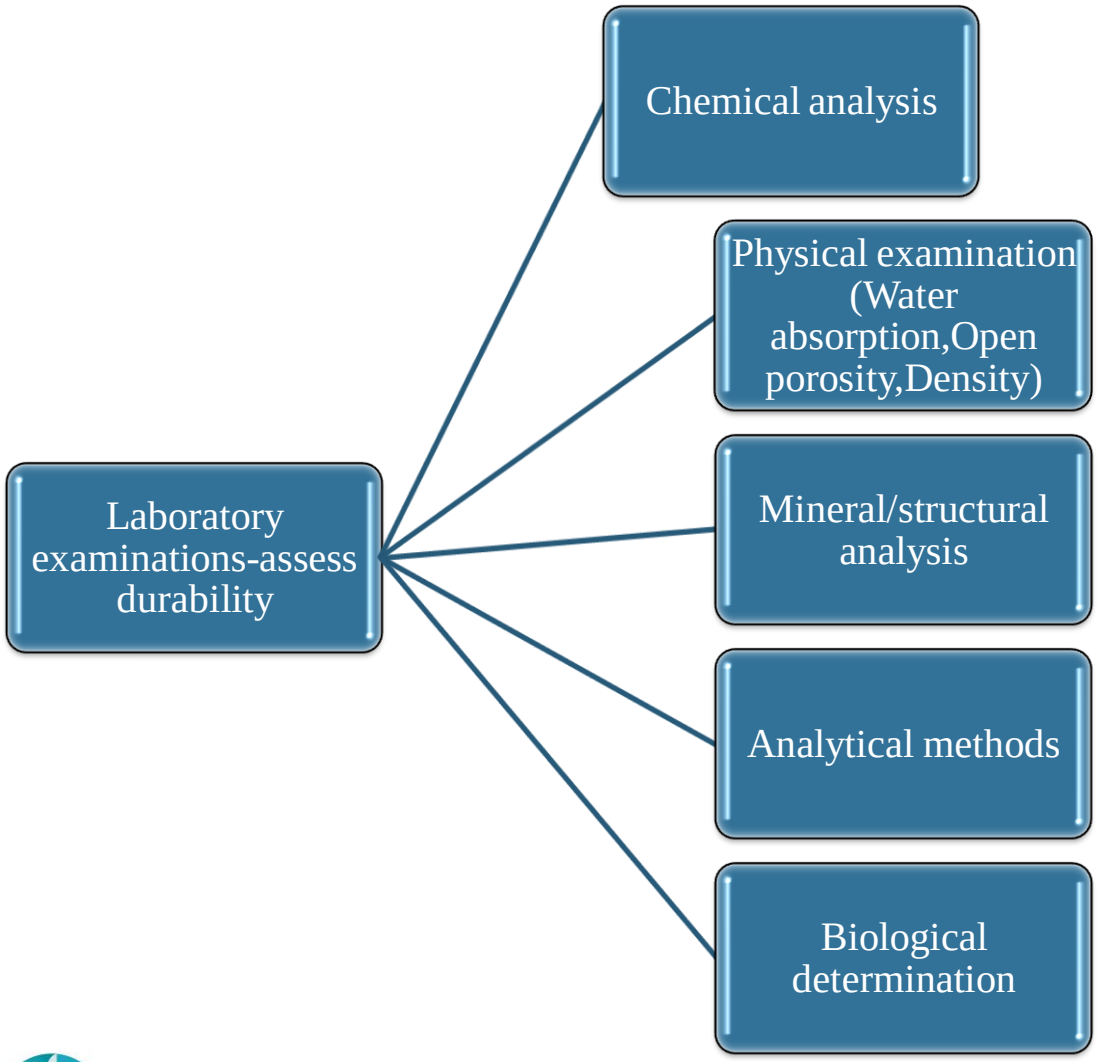

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Lab.Tests

Laboratory tests – Physical Tests
Water absorption, open porosity and apparent density had been measured following the procedures described by the European standards EN 1936 and EN 13755 (2001).
RESULTS: difference in water absorption and porosity in surface material compared to drill bottom material- showed weathering effects

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Scientific aim

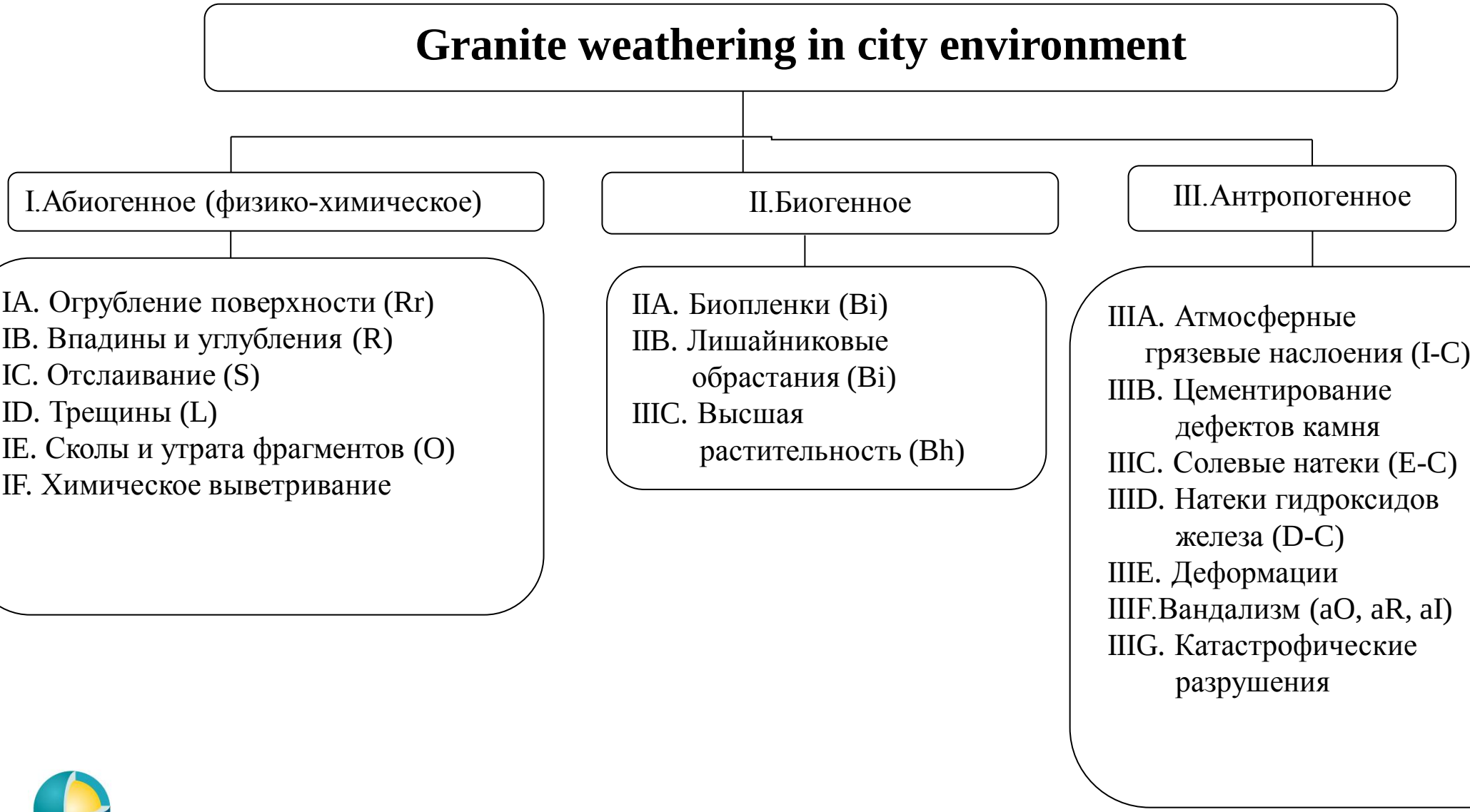
In the literature the greatest attention is given to limestone , sandstone and cement weathering.

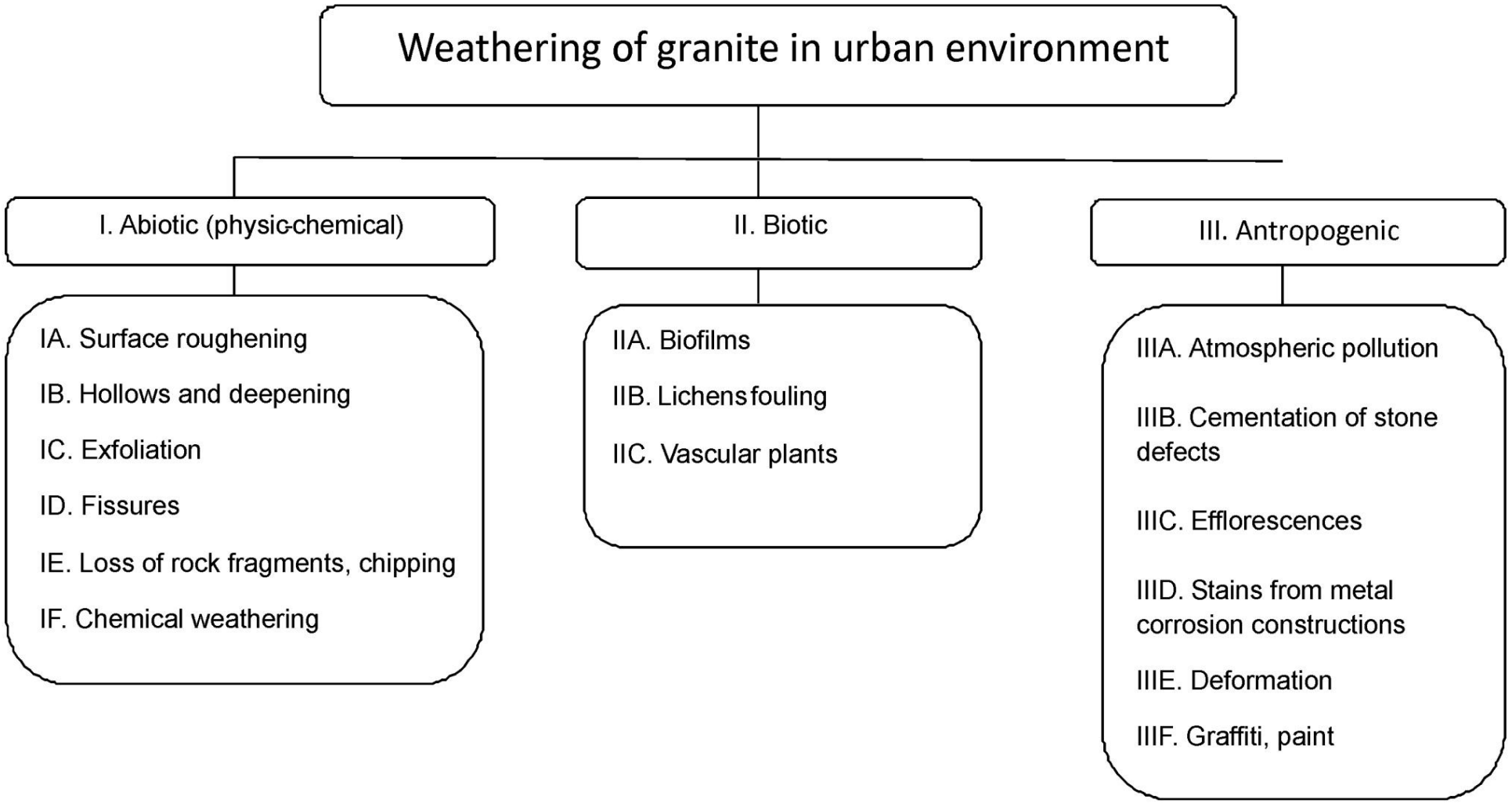
Atlases
by Fitzner B., Heinrichs K., Kowatzki R., 1995.
By V.Verges-Belmin and all, 2008.

Last time there are some publications about granite

- Silva V., Rivas T., Prietro B., 1999.
- Cutler N., Viles H., 2010.
- Favero-Longo S.E., Gazzano C., Girlanda M., and ect., 2011.
- Dakal, Cameotra,2012.
- Sanjurjo-Sánchez J., Juan Ramón, Vidal Romaní, Carlos Alves, 2012.

Granite weathering in city environment




Weathering of granite in urban environment
I. Abiotic (physic-chemical)
II. Biotic
III. Antropogenic
IA. Surface roughening
IB. Hollows and deepening
IC. Exfoliation
ID. Fissures
IE. Loss of rock fragments, chipping
IF. Chemical weathering
IIA. Biofilms
IIB. Lichens fouling
IIC. Vascular plants
IIIA. Atmospheric pollution
IIIB. Cementation of stone defects
IIIC. Efflorescences
IIID. Stains from metal corrosion constructions
IIIE. Deformation
IIIF. Graffiti, paint

I. Abiotic (physic-chemical)

IA. Surface roughening (Rr)

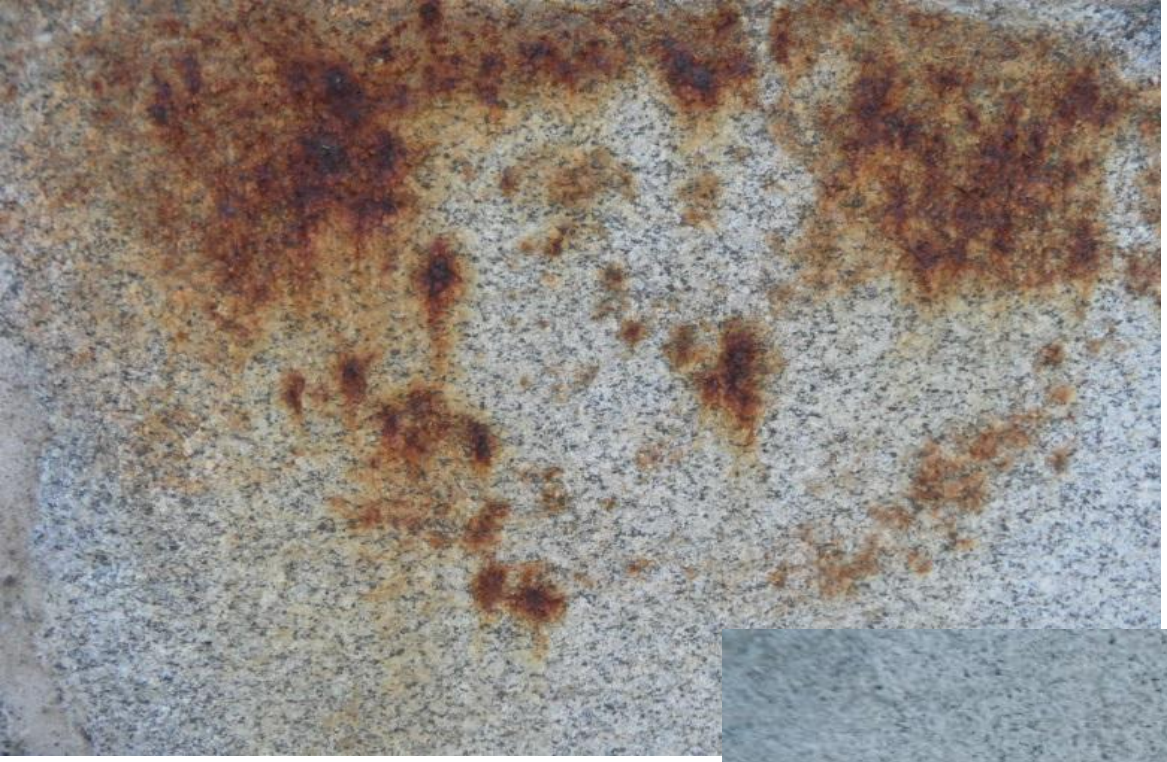
IB. Hollows and deepening (R)

IC. Exfoliation (S)

ID. Fissures (L)

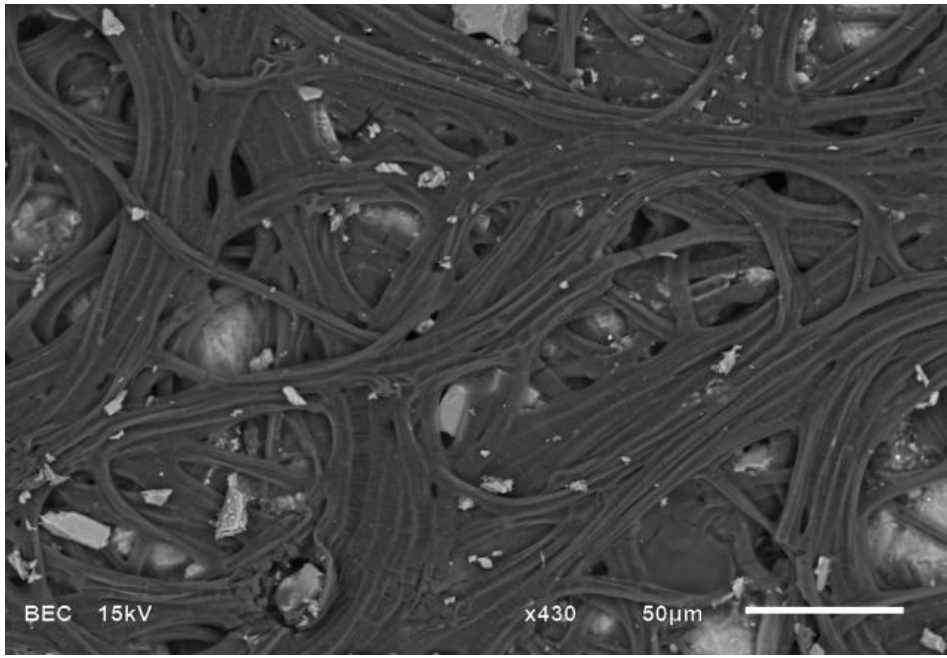
IE. Loss of rock fragments, chipping(O)

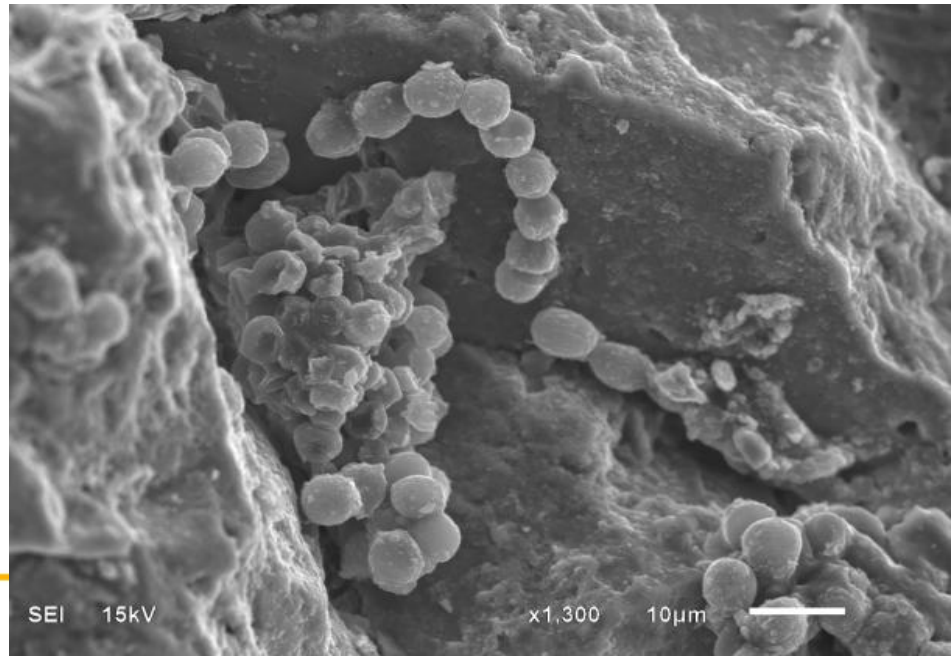
Chemical weathering



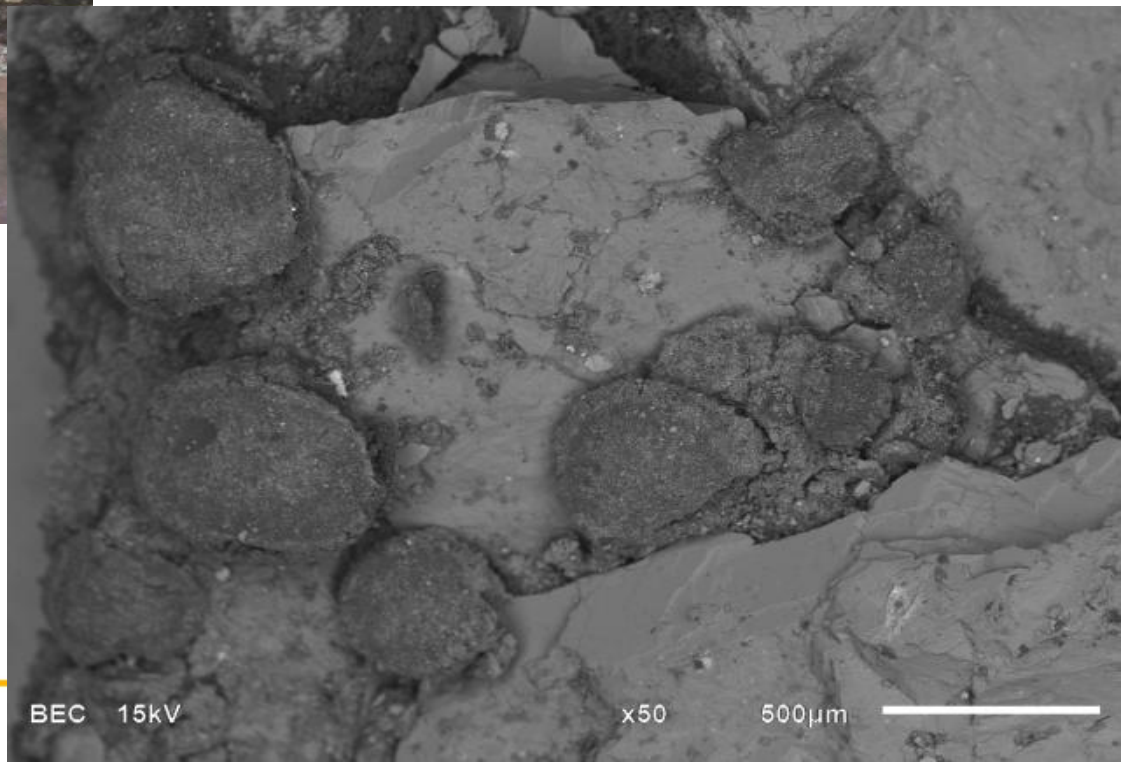
II. Biological Weathering

II A. Biofilms (Bi)





IIB. Lichens fouling (Bi)



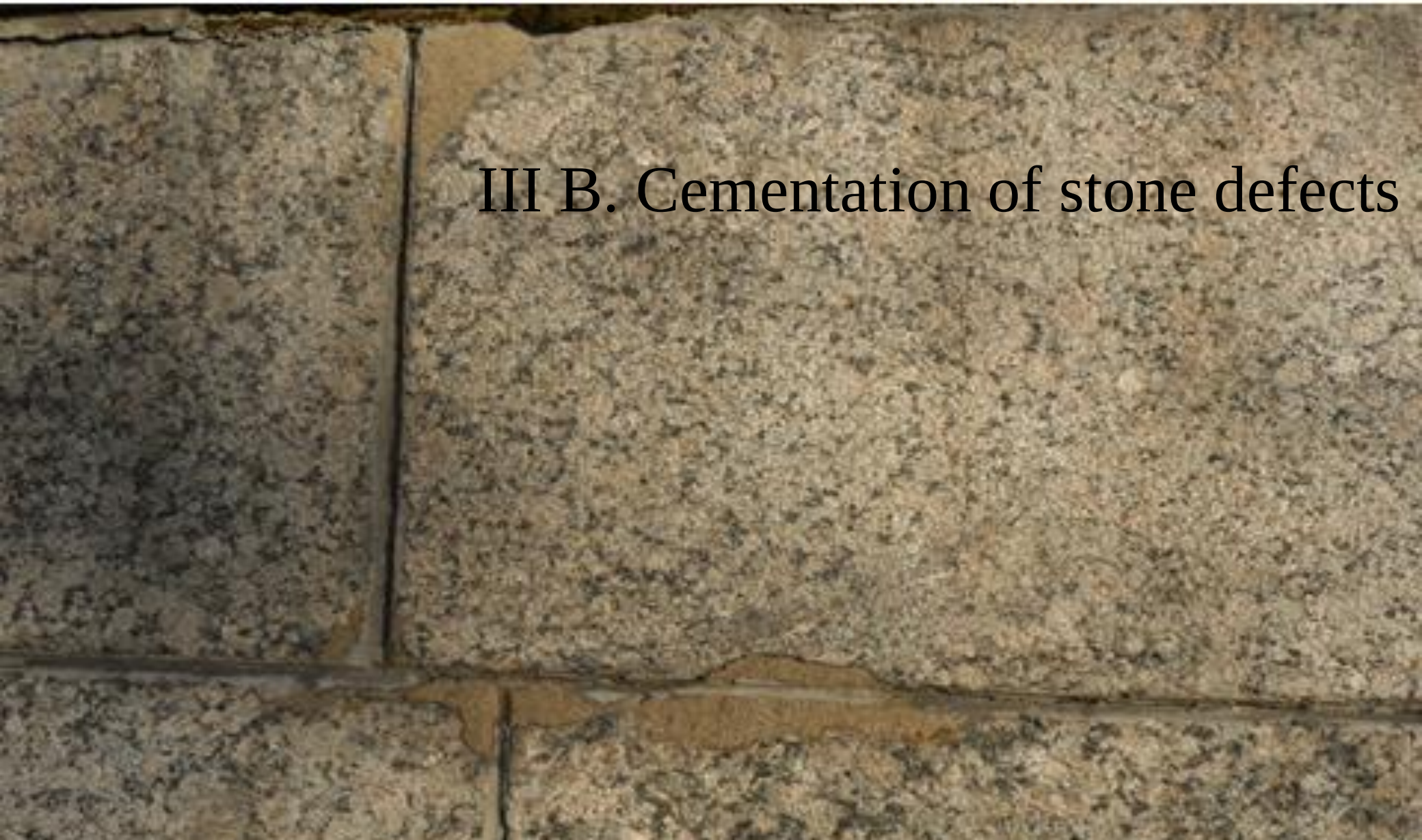
GTK

IIC. Vascular plants (Bh)

III. Antropogenic Weathering

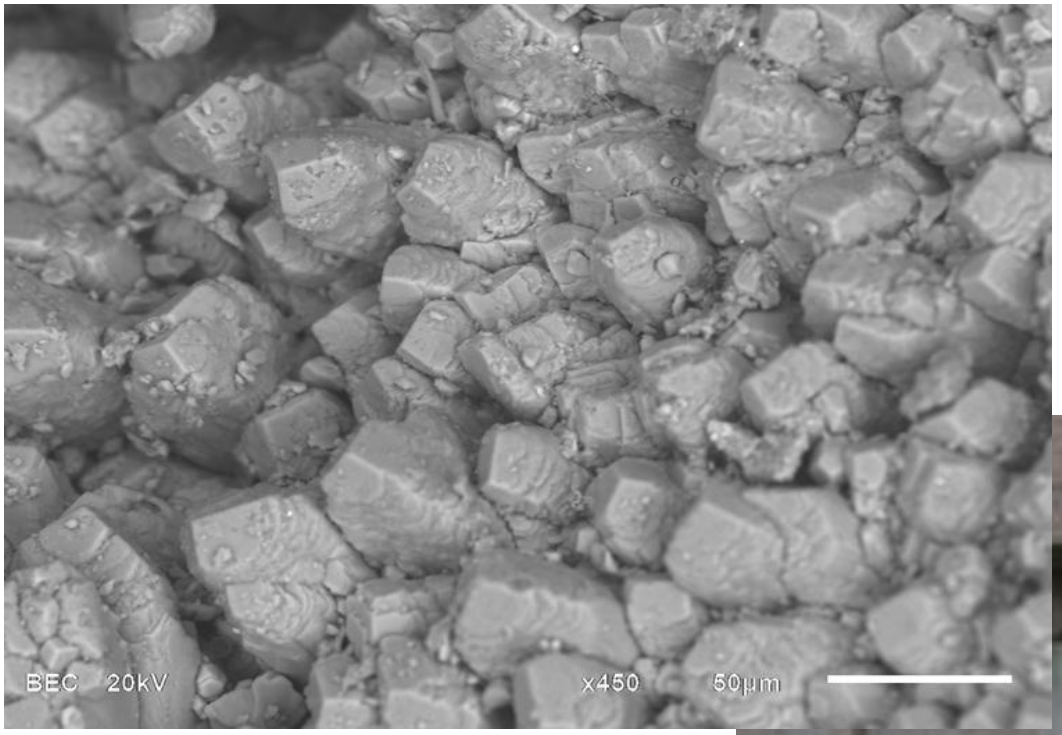
III A. Atmospheric pollution (I-C)

III В. Цементация дефектов камня



III B. Cementation of stone defects

III C. Efflorescences (E-C)



III D. Stains from metal corrosion constructions (D-C)

IIIE. Deformation

IIIF. Graffiti, paint (aO, aR, aI)

IIIG. Catastrofic destraction

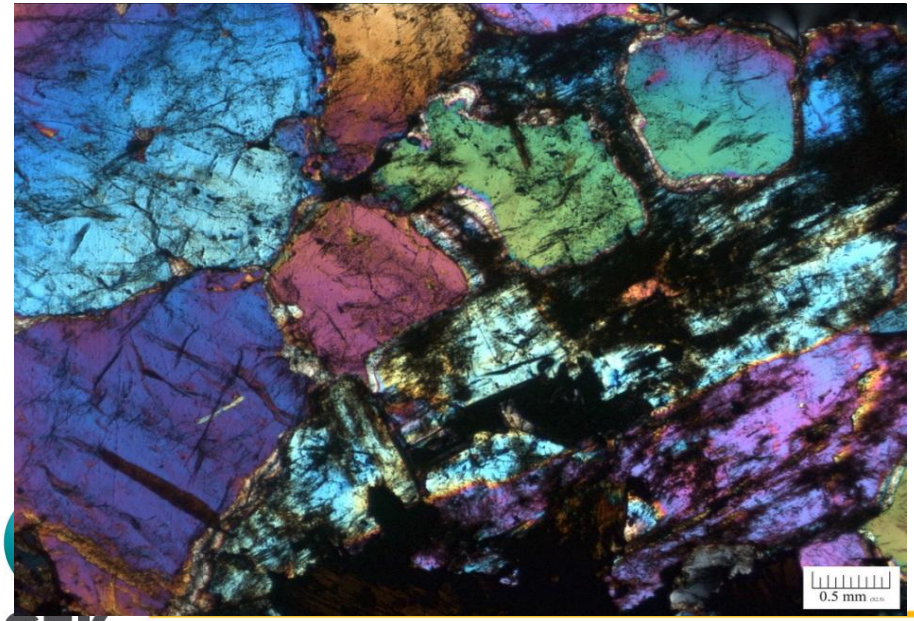
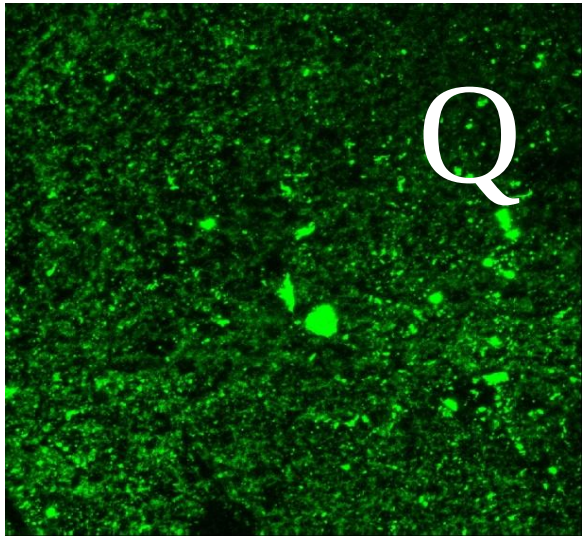


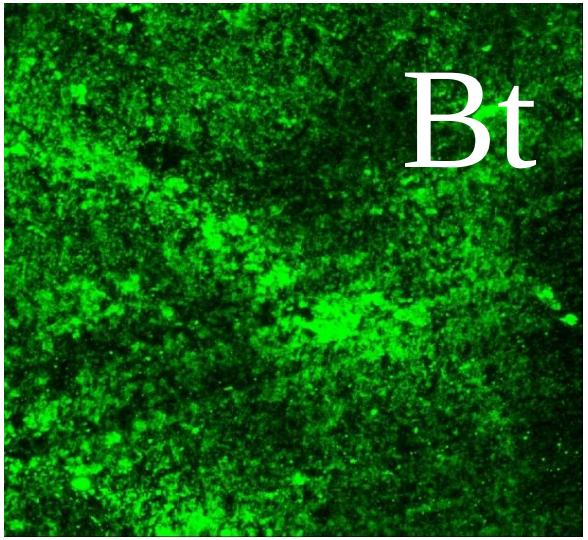
Фото Антона Антонова


Process of Granite destruction

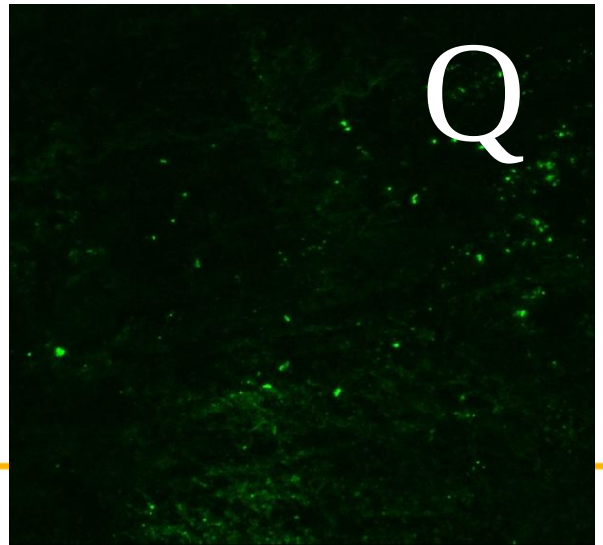
Confocal Microscopy

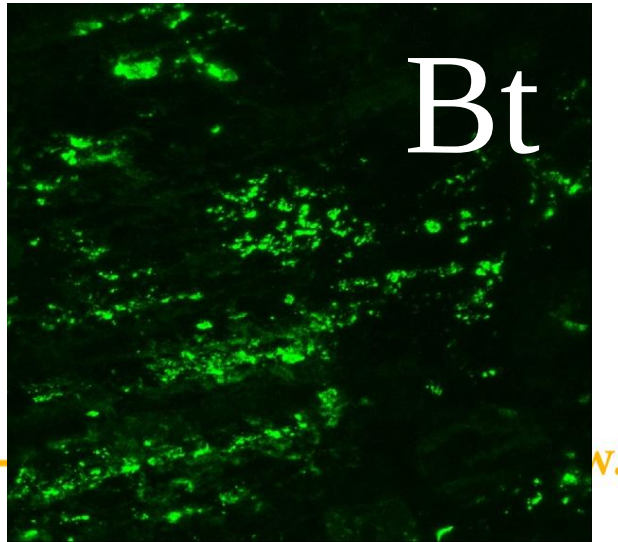
Crast



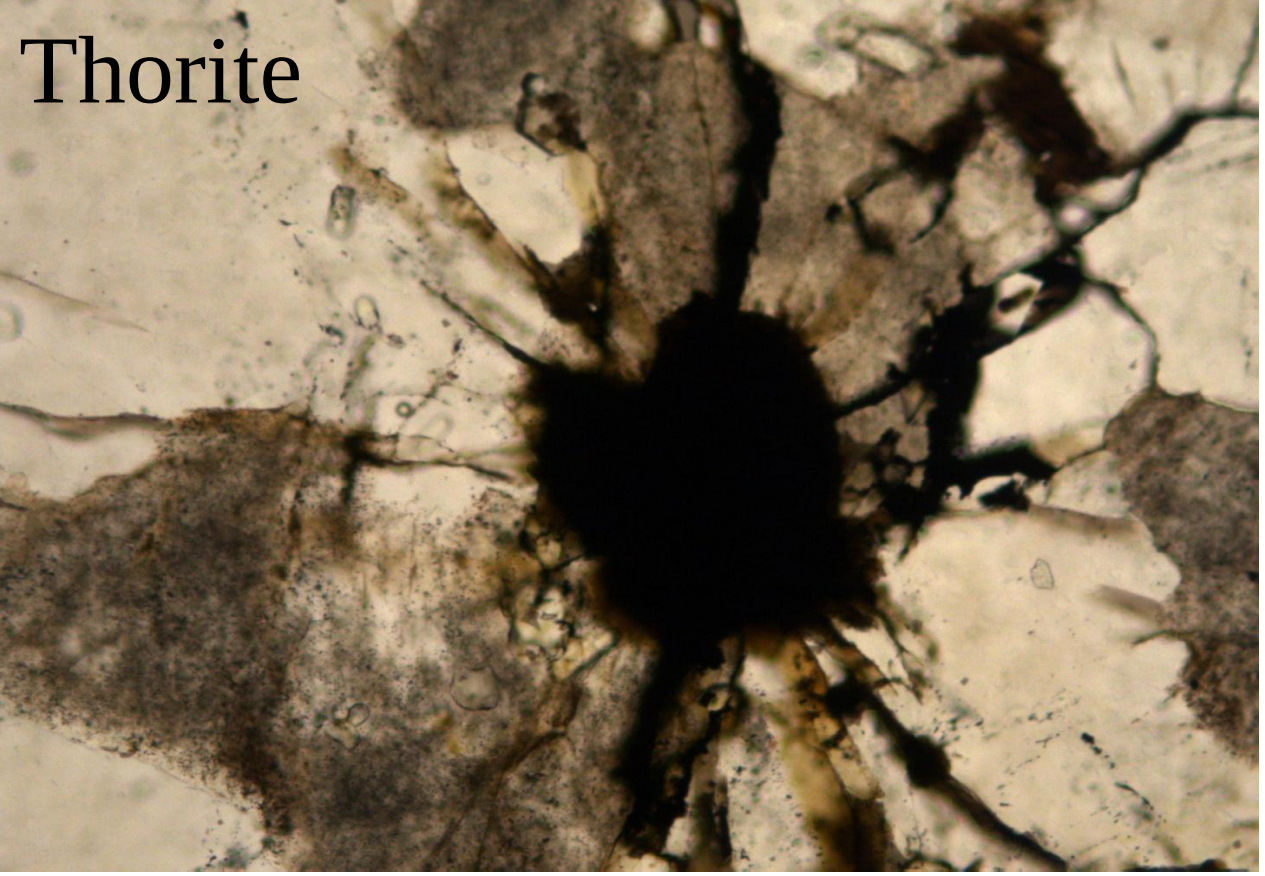


Granite





Thorite



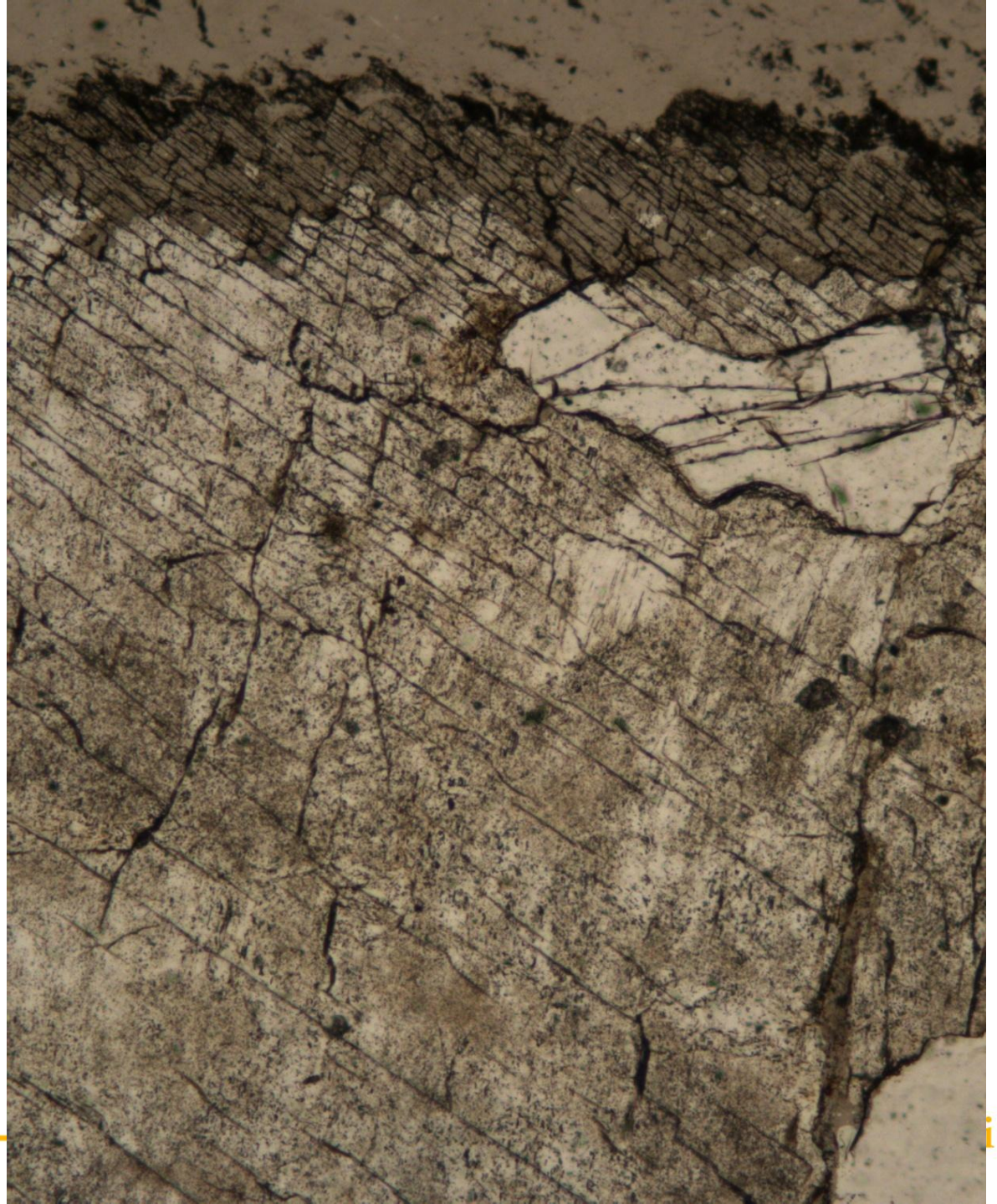
Radioactivity (мкР/h):

Rose rapakivi- 45-53

Gray rapakivi- 43-47

Fon- 15

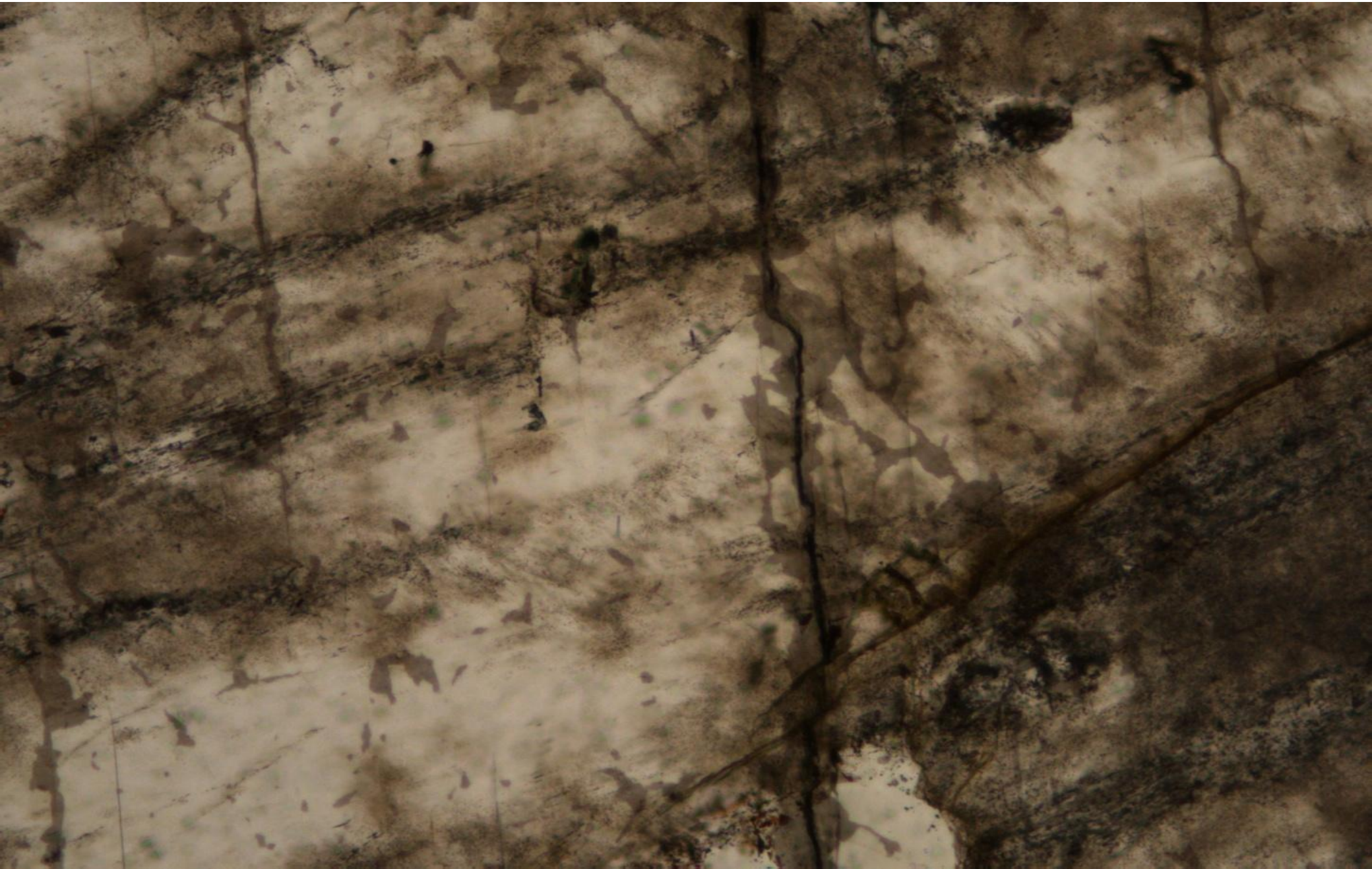
Корка



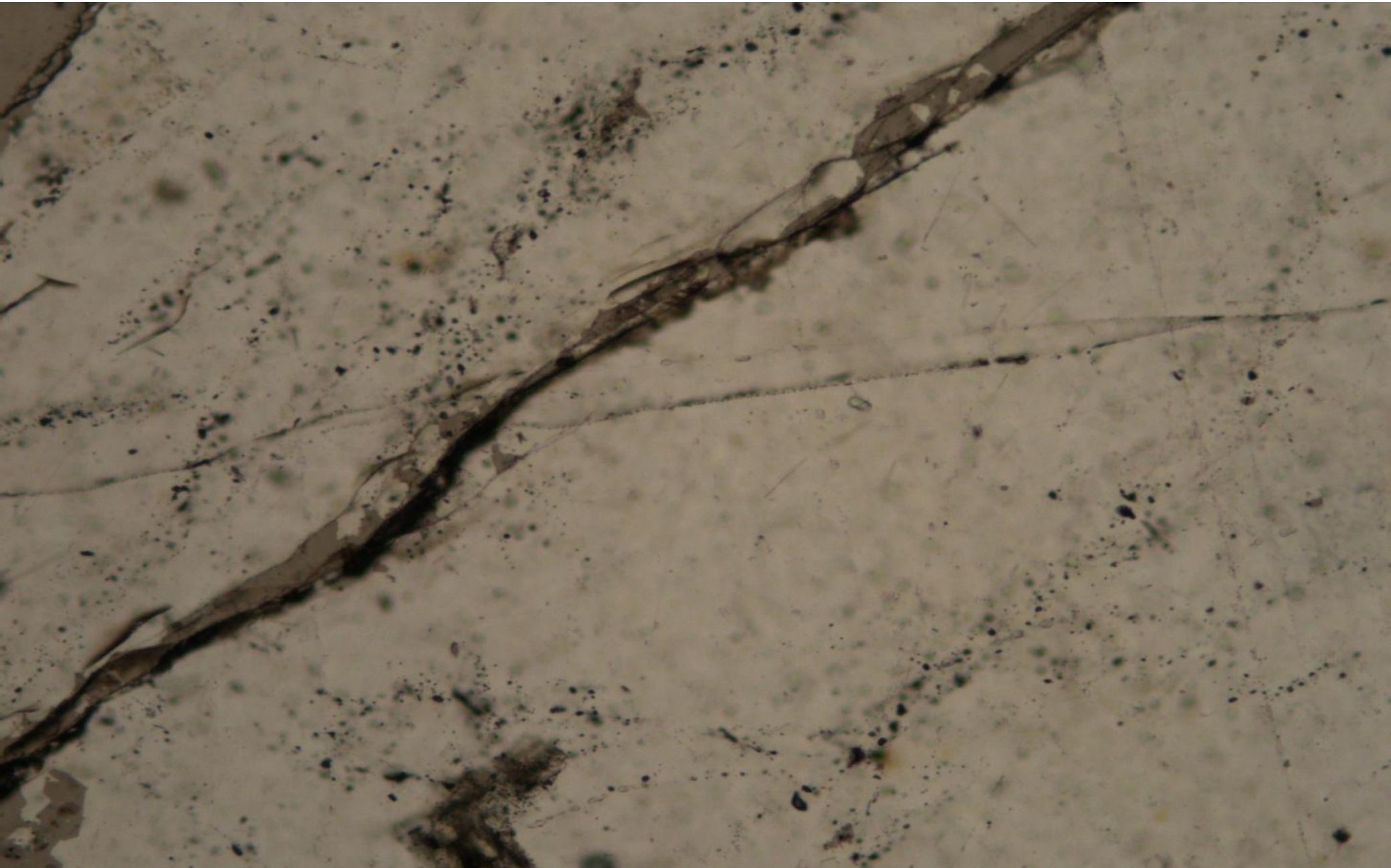
90x

Гранит

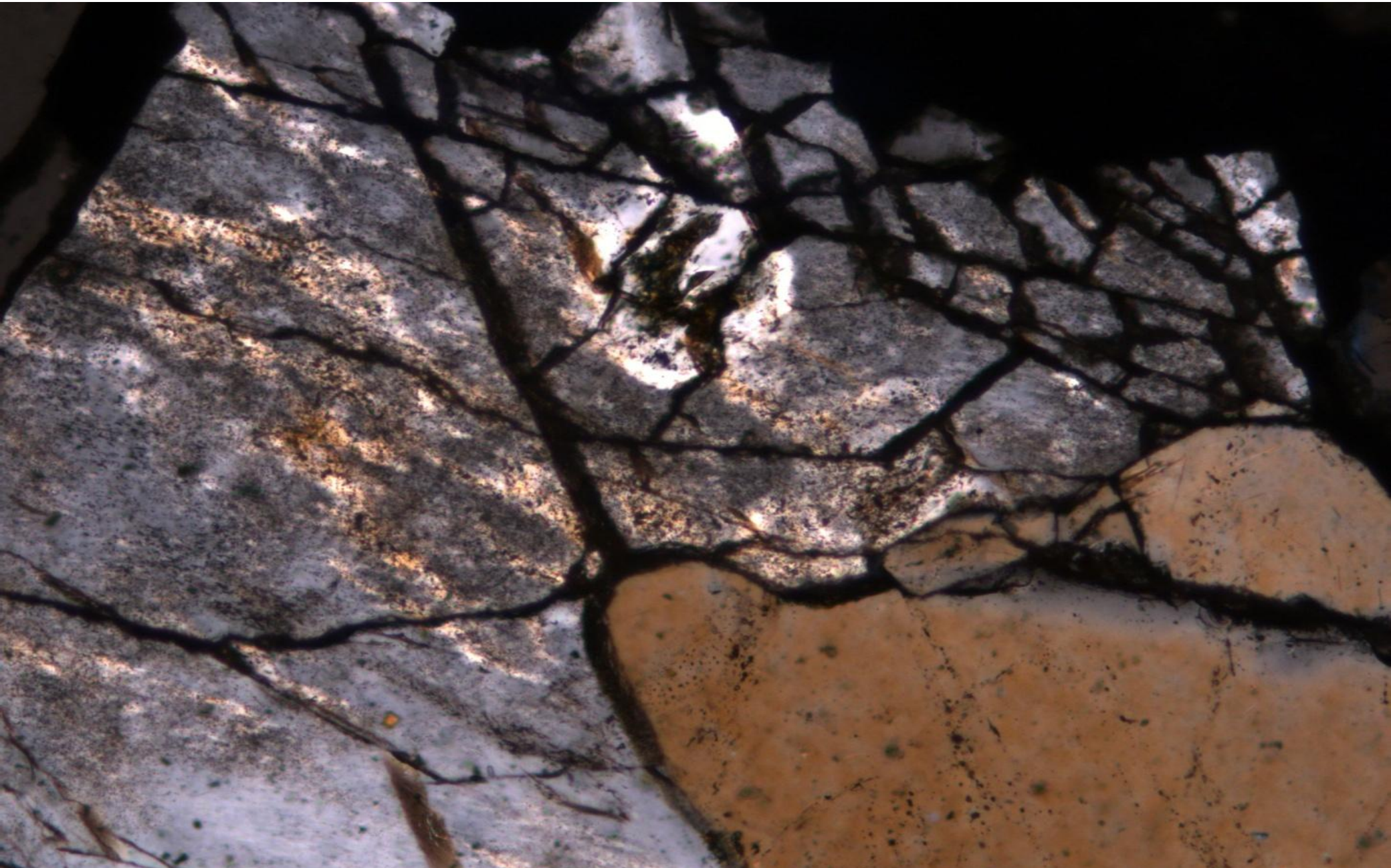
Water absorbtion by KFsp



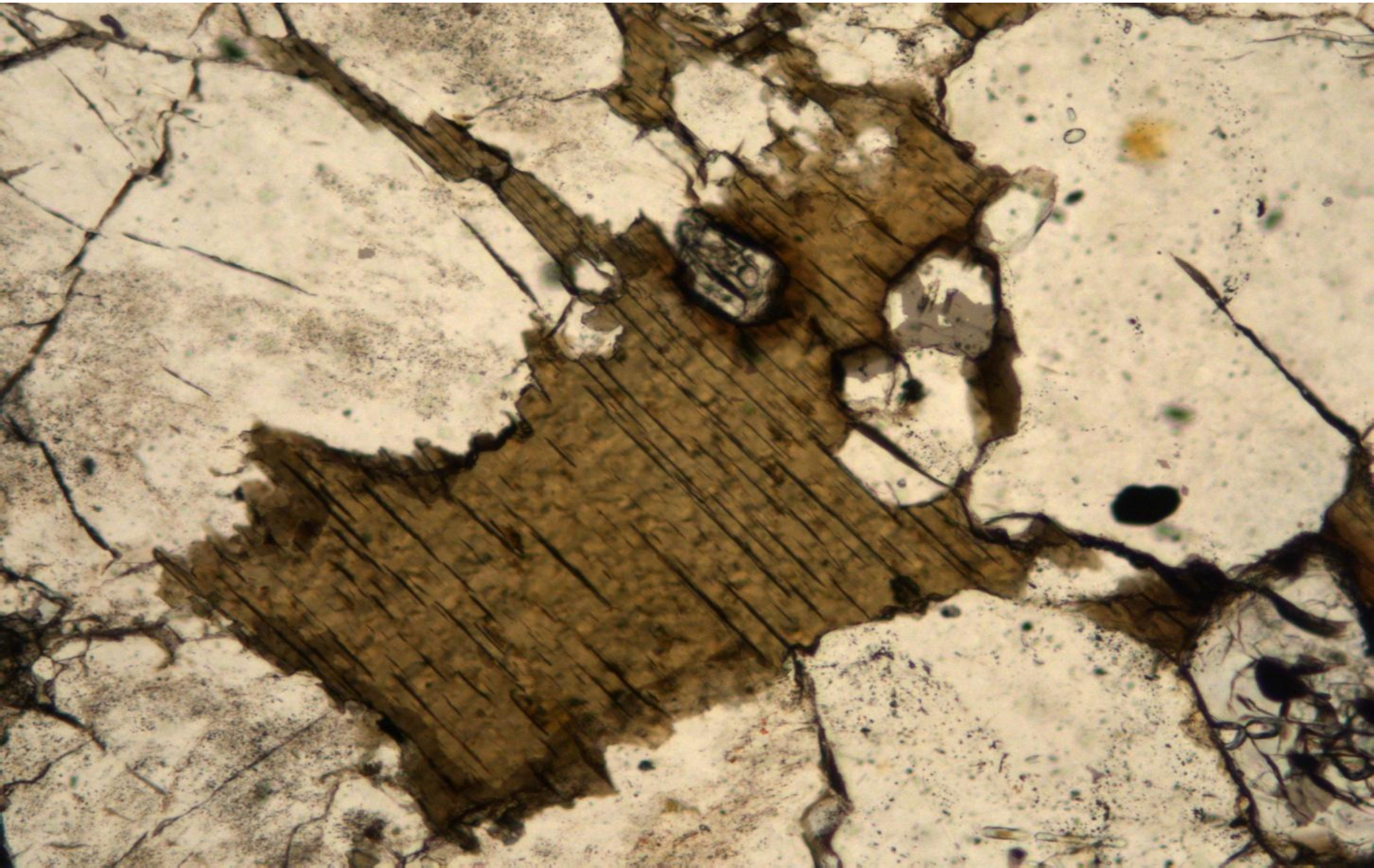
Quartz



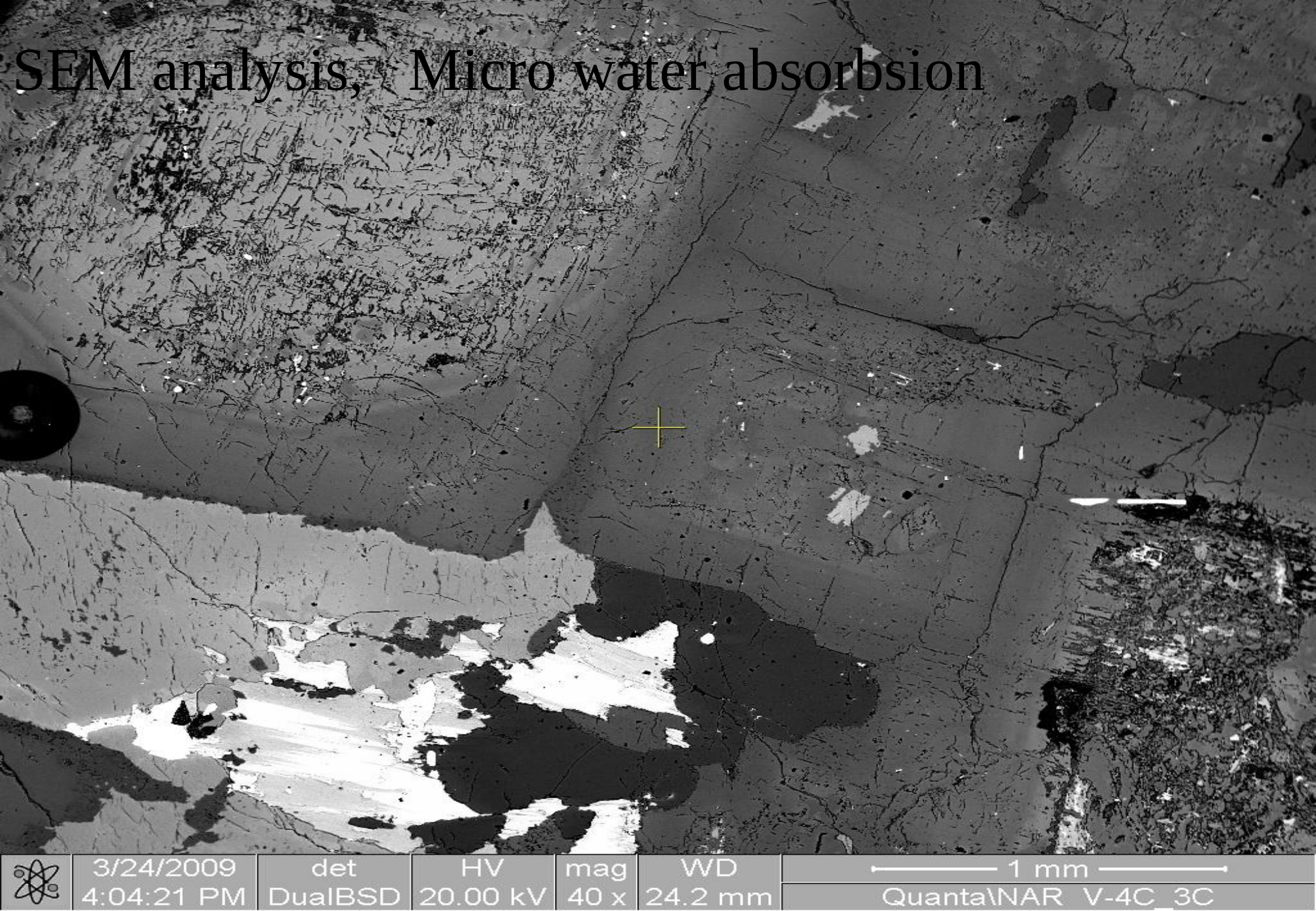
Quartz



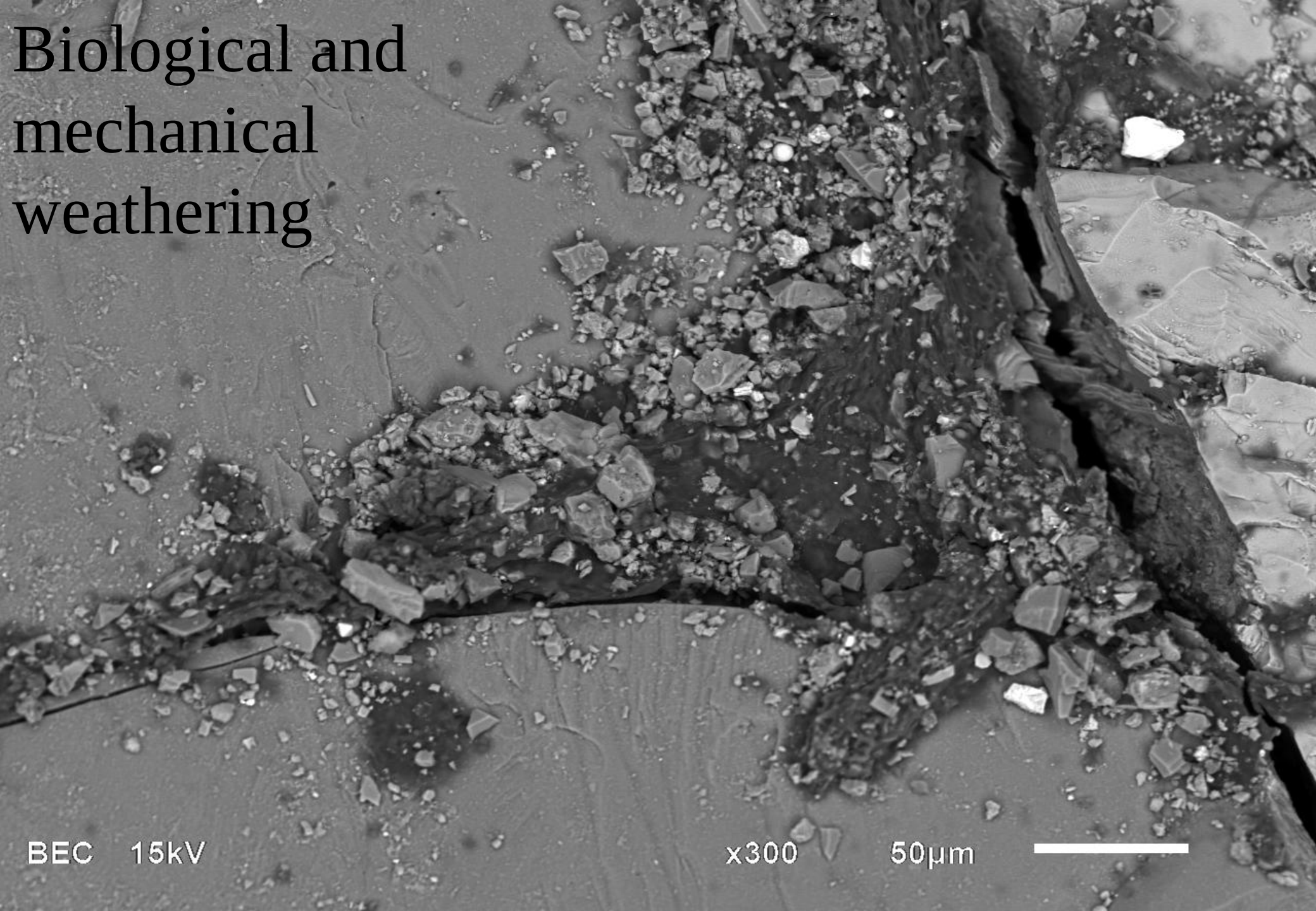
Biotite

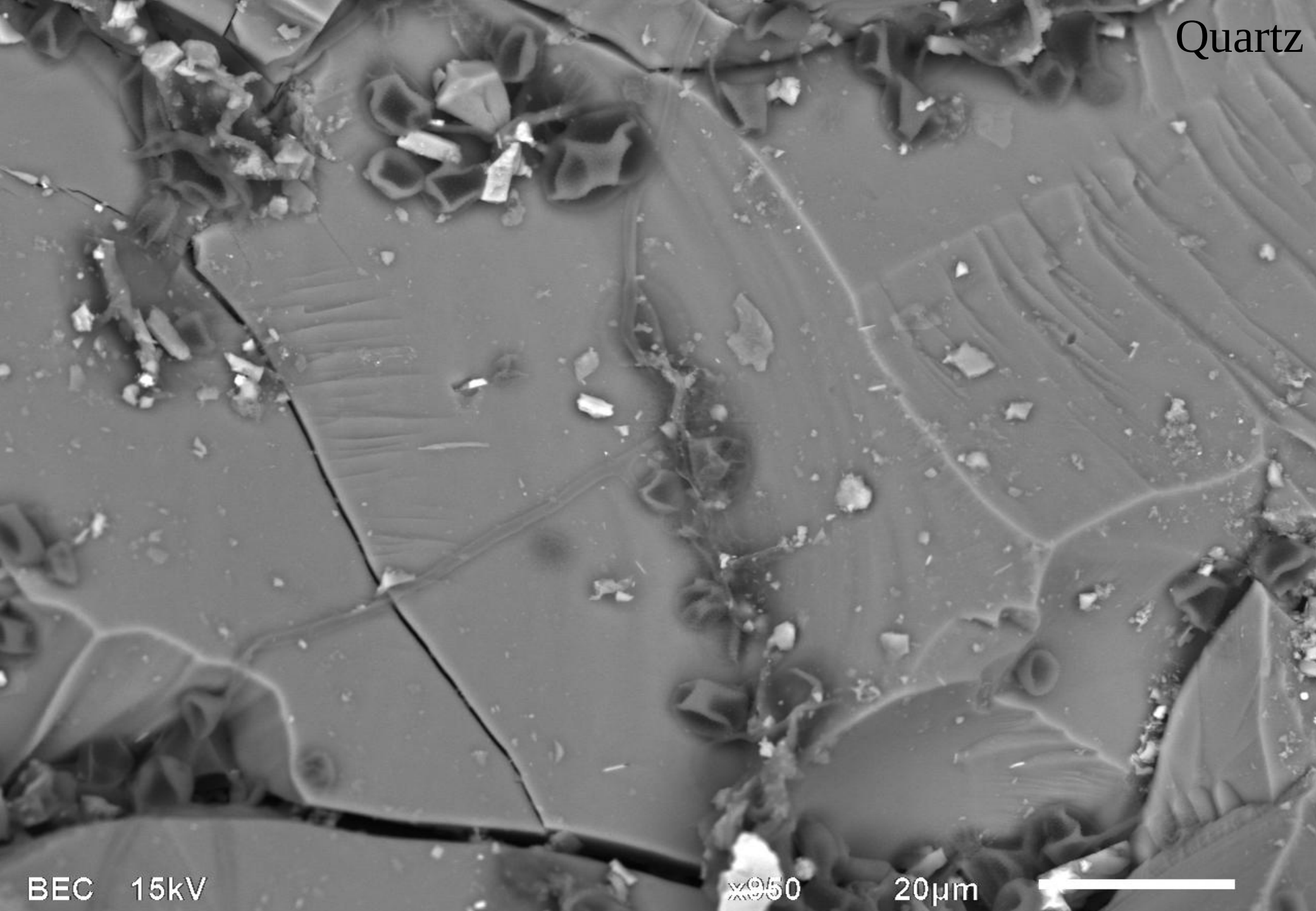


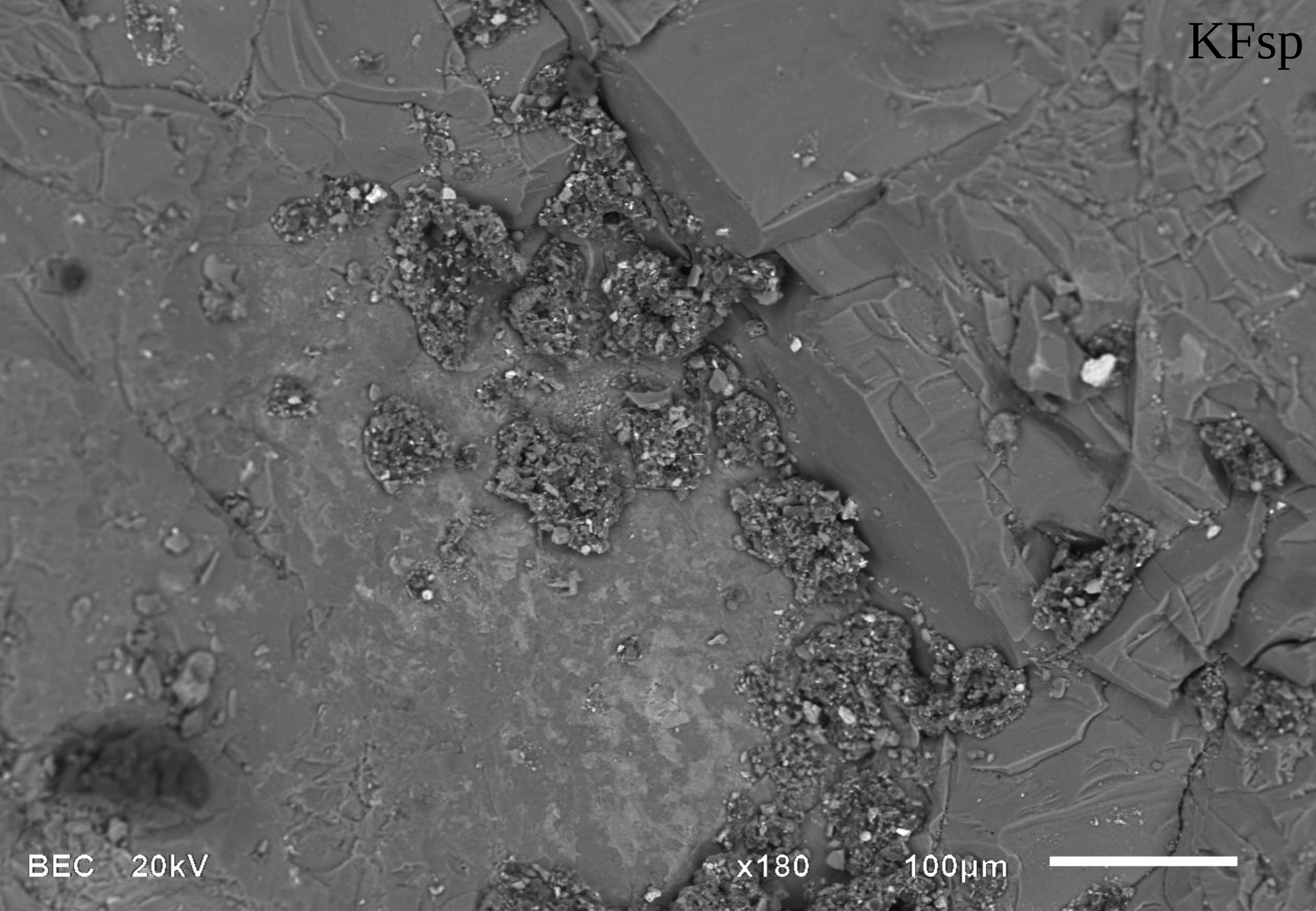
SEM analysis, Micro water absorbsion

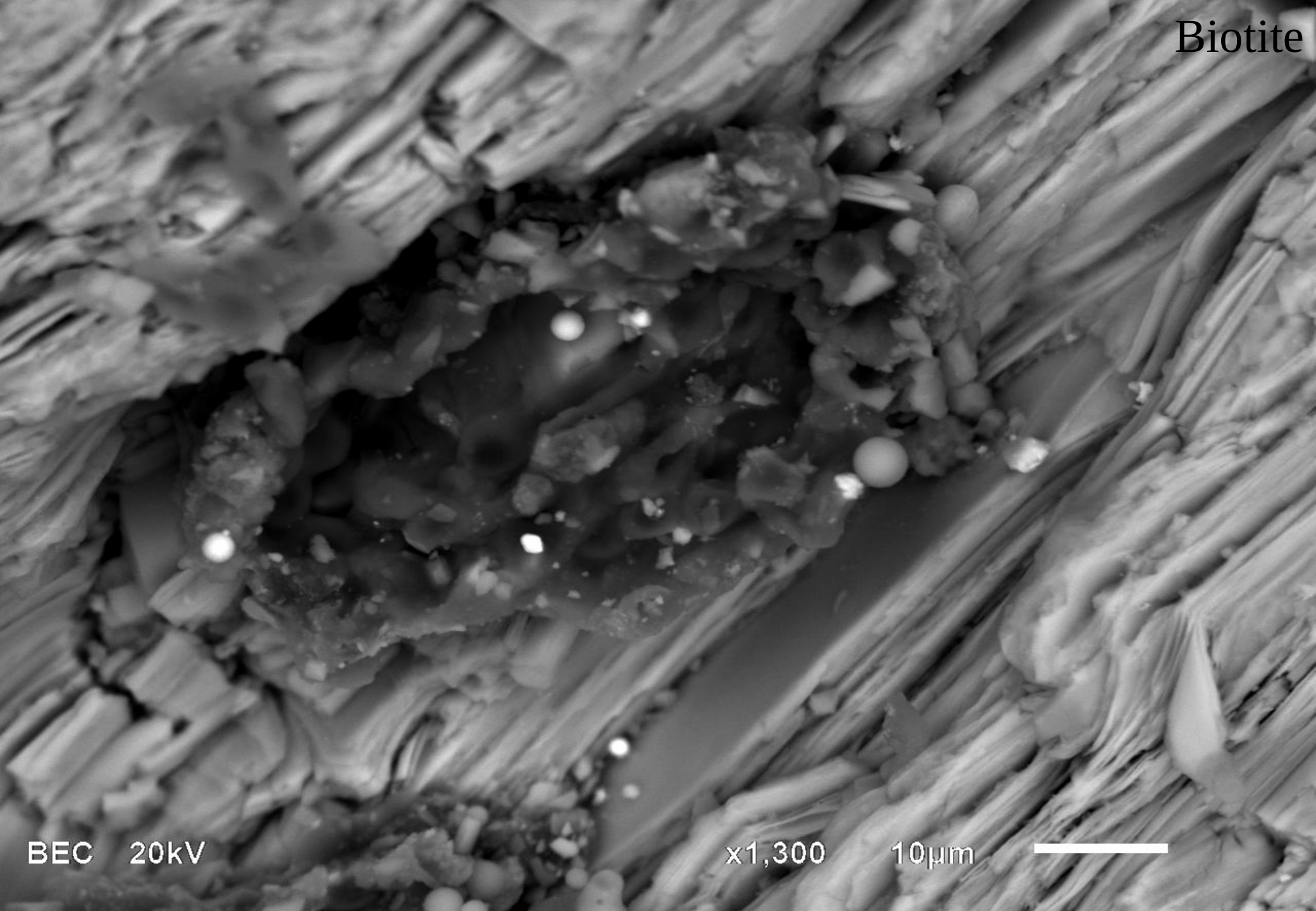


Biological and mechanical weathering




Quartz
BEC 15kV
x950
20µm


KFsp
BEC 20kV
x180
100µm


Biotite
BEC 20kV
x1,300
10µm

Thas,

1. Research of a natural stone destruction demands the complex approach and application of professional efforts of various directions experts.

2.The knowledge of factors and understanding of stone destruction mechanism will allow to create a methodical basis for a choice a stone for building and restoration and to develop methods of stone brushing and preservation in city environment for preservation of a stone heritage.

What have we done?

- Scientific articles;
- Monographers;
- The book for children;
-2 masters dissertations and PhD dissertations;

The result:

1) We have created the **methodological basis** of stone destruction analysis in the city environment;
2) Used all modern **physical methods (not destractive)** of the analysis of a stone condition ;
3) Results have **practical interest** for mining campanies, restorers and architects.


Thank you for your attention