Barrier function of crystalline rock
- Evaluation based on in-situ characterization and experiments at the Mizunami Underground Laboratory (MIU), Japan -

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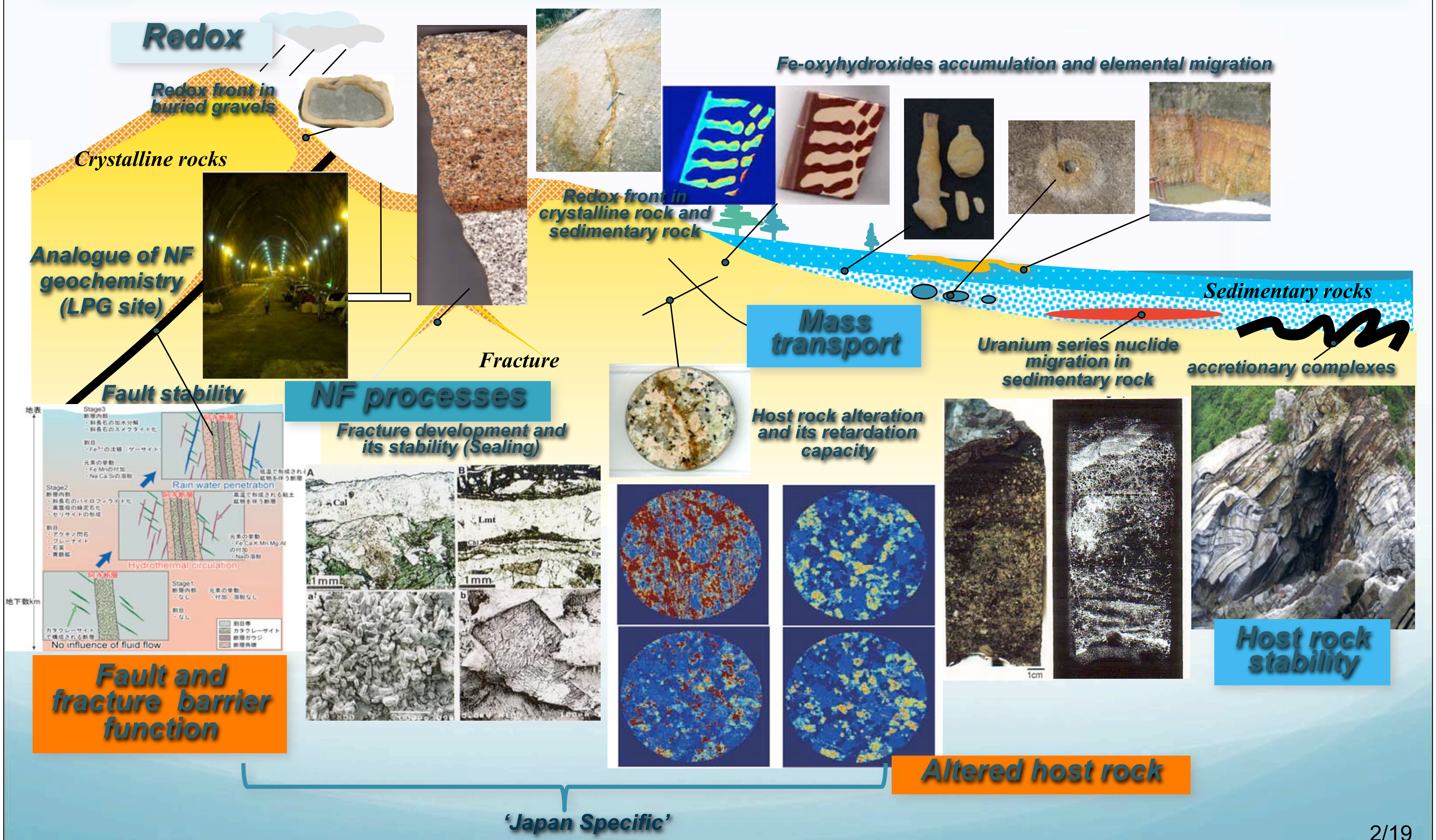
Analogous studies relevant to barrier function and geological stability



Content

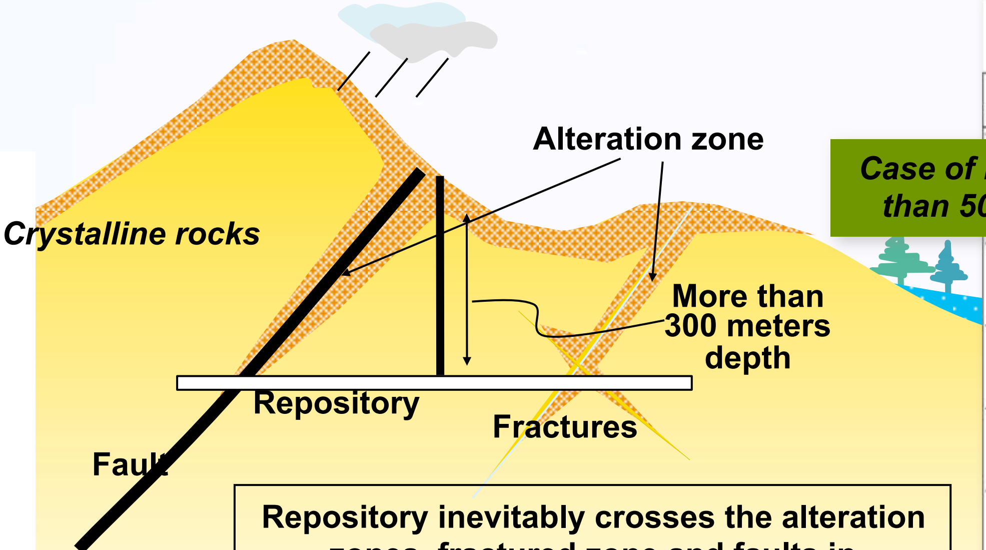
*Background

*Characteristics of crystalline rock (URL and LPG site)
  -alteration, fractures and fault

*Studies of the ‘barrier function’
  -sorption capacity of altered rock
  -formation processes and long-term stability
  -structural model relevant to nuclide migration

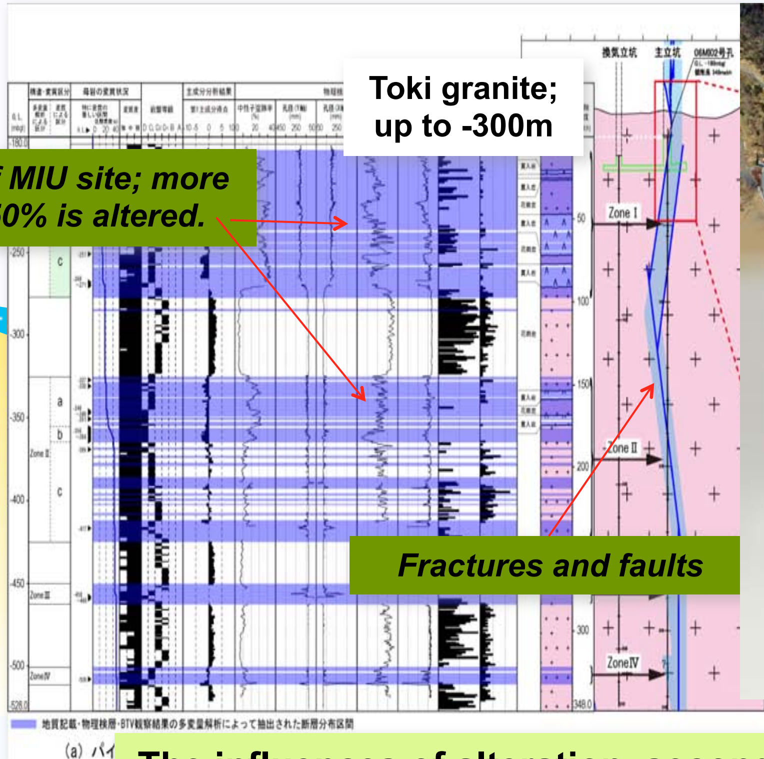
*Concluding remarks

Background; Understanding of characteristics of deep crystalline rock



Repository inevitably crosses the alteration zones, fractured zone and faults in crystalline rocks in Japan.

Conceptual view of panel allocation



Toki granite; up to -300m

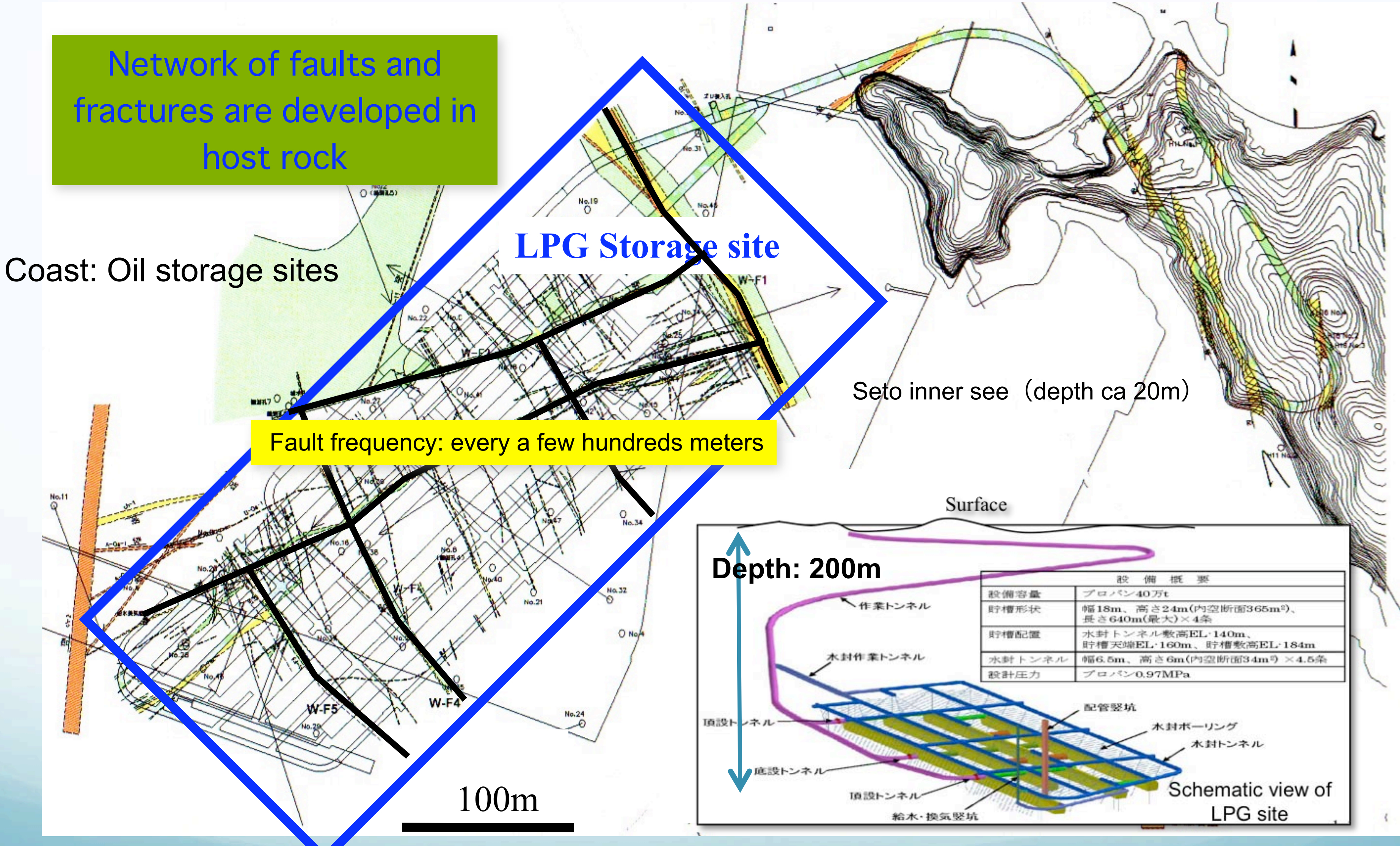
Case of MIU site; more than 50% is altered.

Fractures and faults

The influences of alteration, secondary minerals and microfractures on chemical sorption and/or physical retardation mast be assessed to determine the barrier function.

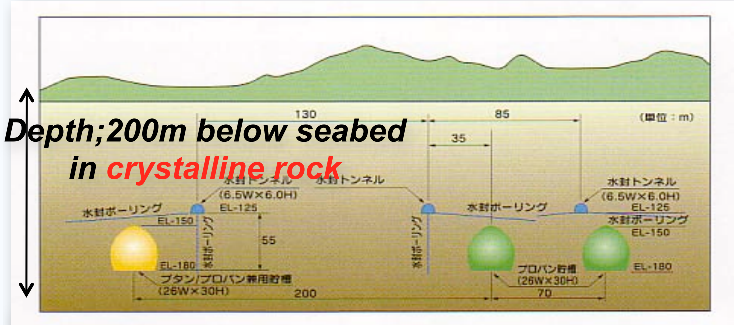
This will be necessary to assess the retardation capacity at a site and to allocate panels.

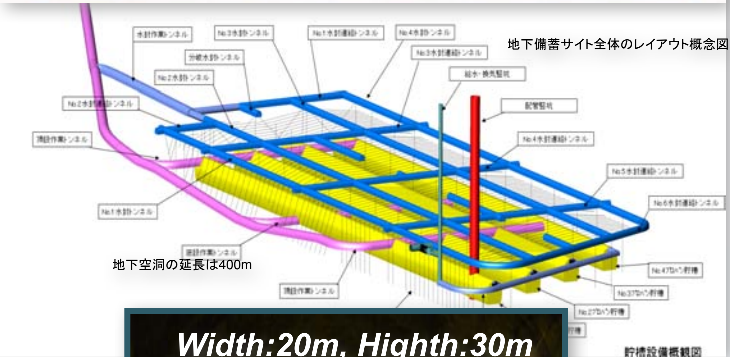
Fault and fracture system in crystalline rock (ex1:LPG site)

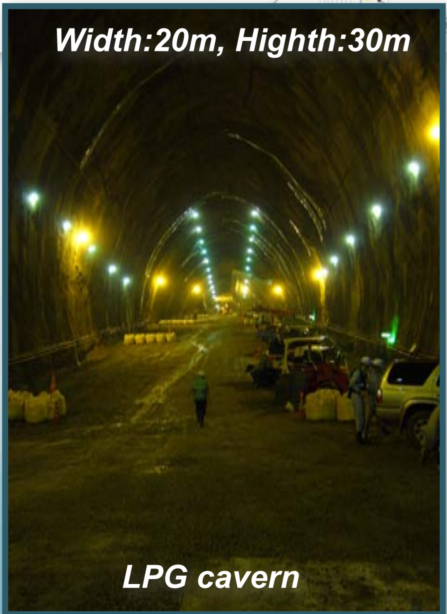


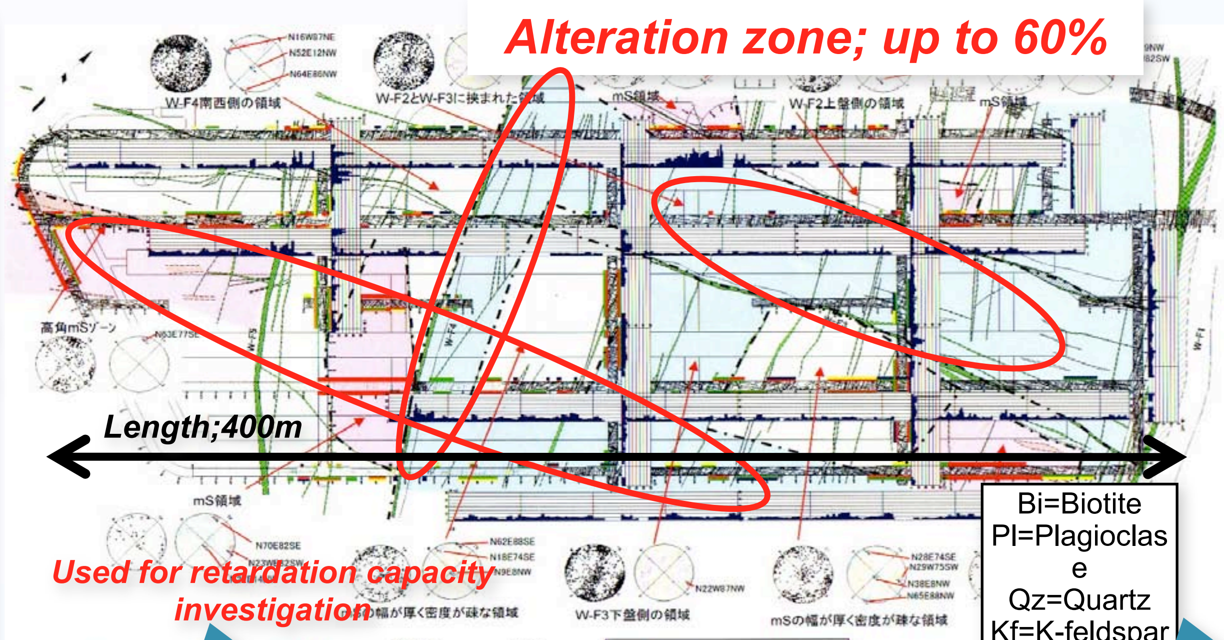
Difficulties : exclude all faults from the surface investigation

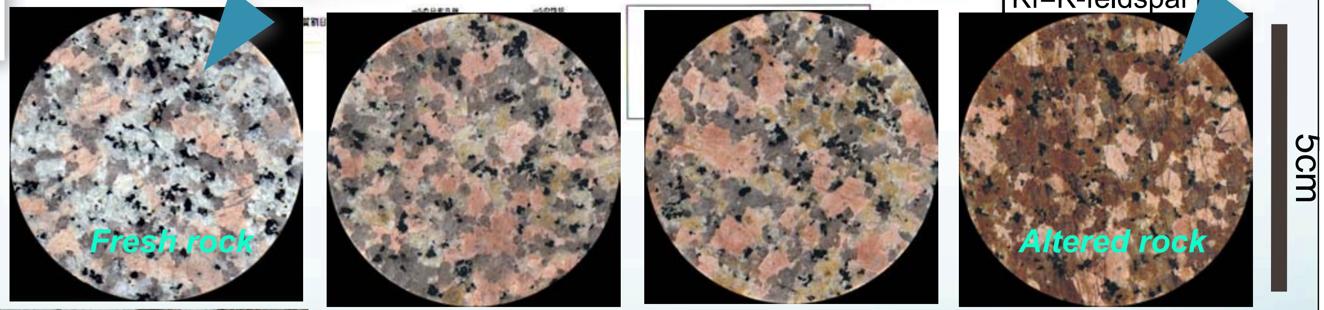
Alteration of deep granitic rock in Japan (case of LPG site)

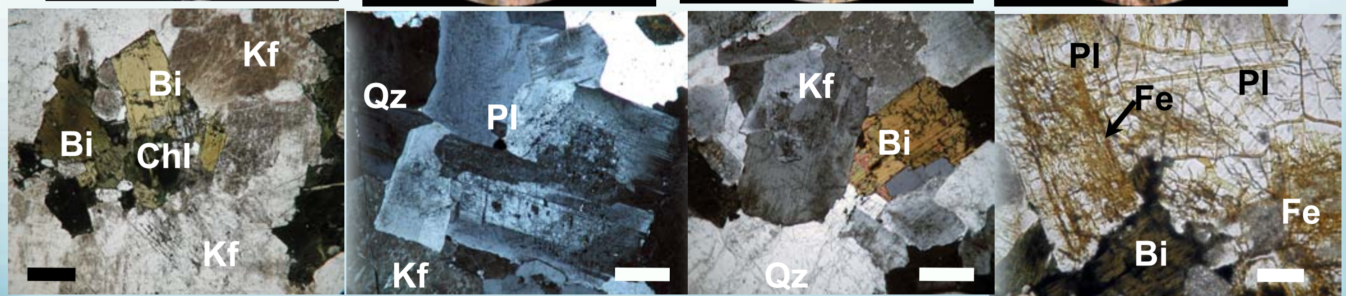






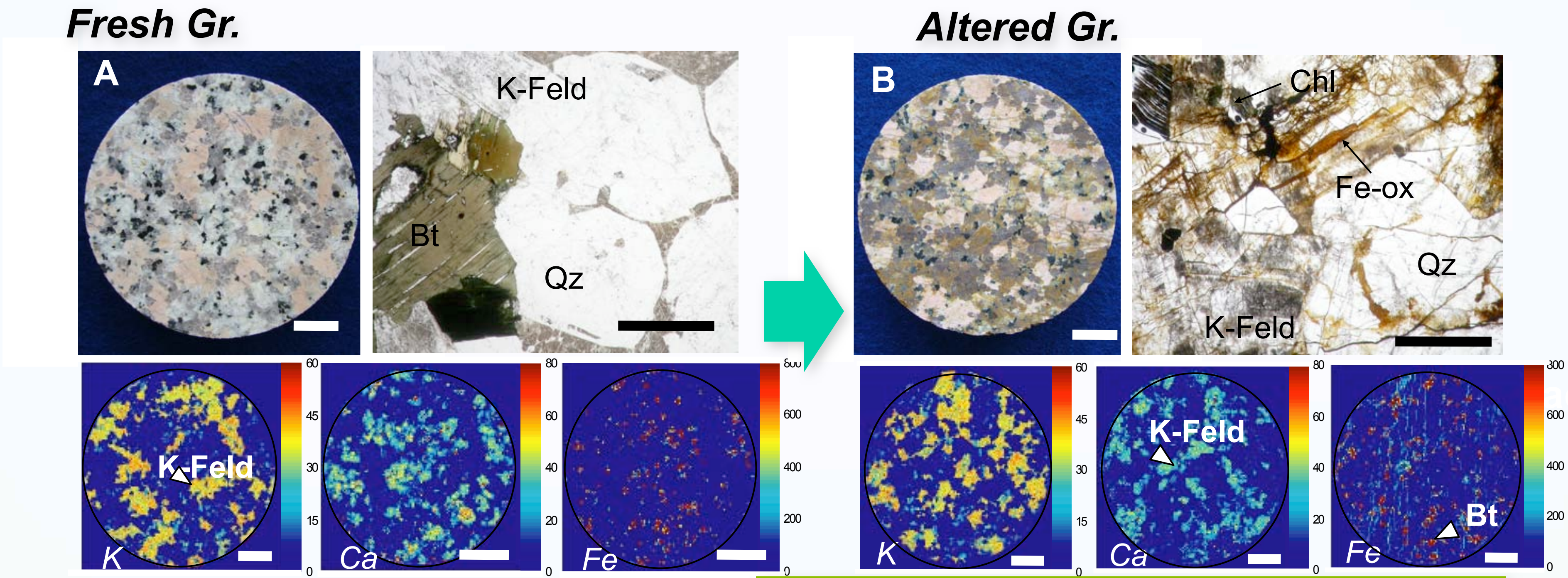


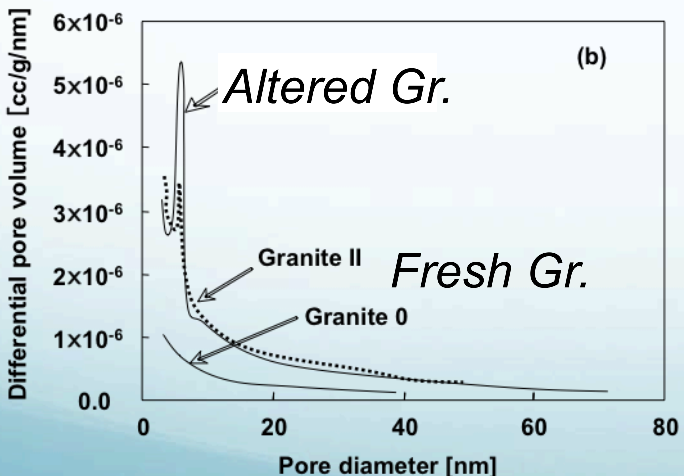




Scale bar = 1 mm

Altered rock characterization (mineralogy and pore geometry)





Pore size distributions of fresh and altered granite

- ◆ ***Microfracture development***
- ◆ ***Dissolution of K, Ca and Fe-ox precipitation***

	Density /g cm^{-3}	Porosity (%)	Specific surface area/m^2 g^{-1}	Adsorption capacity (STP)/cm^3 g^{-1}	Average of pore diameter/nm
Fresh G.	2.58	0.7	0.064	0.015	10.9
Altered Gr	2.55	1.8	1.3	0.293	12.7

Results of pore analysis (Rock density, porosity, specific surface area and average of pore diameter)

Cs sorption experiments (Unaltered vs Altered rock)

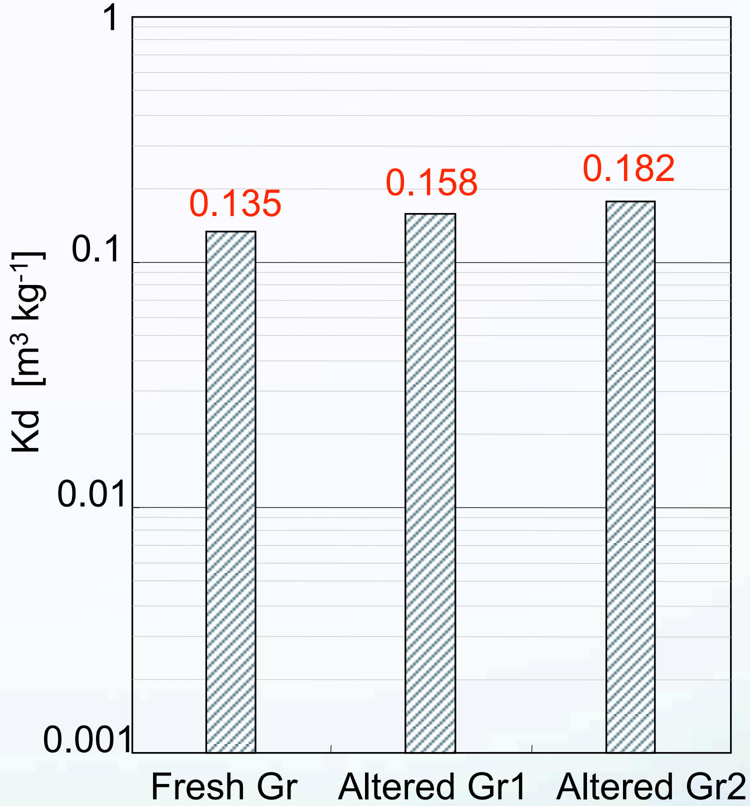
Fresh Gr.

Altered Gr.

Grain size
<100um

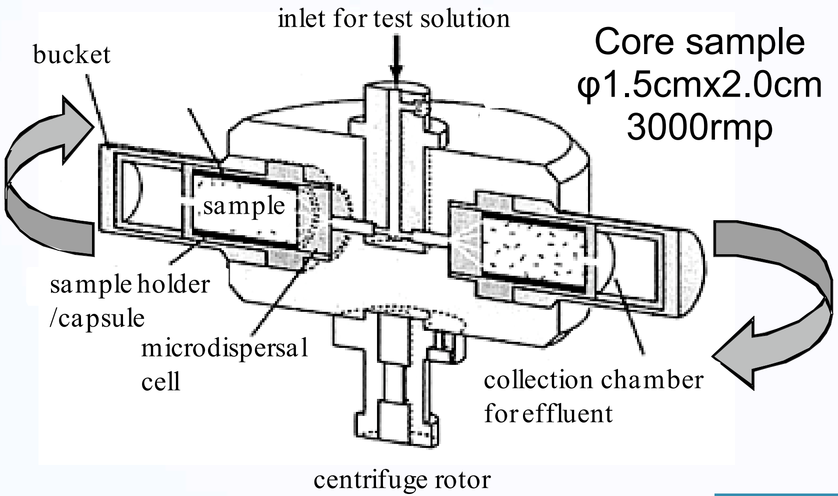
Composition of simulated groundwater	[mol L^{-1}]
Cs	1.0×10^{-5}
$NaHCO_3$	3.6×10^{-3}
$CaSO_4 + 5H_2O$	1.1×10^{-4}
KCl	6.2×10^{-5}
$MgSO_4$	5×10^{-5}
Solution pH	8.5
Liquid/Solid ratio	10 $cm^3\ g^{-1}$
Sample bottle	30 mL of Poly(propyrene) bottle
Sorption period	109 days with shaking
Temperature	298 K

Experimental condition of synthetic water and solid materials used for the batch sorption experiments.

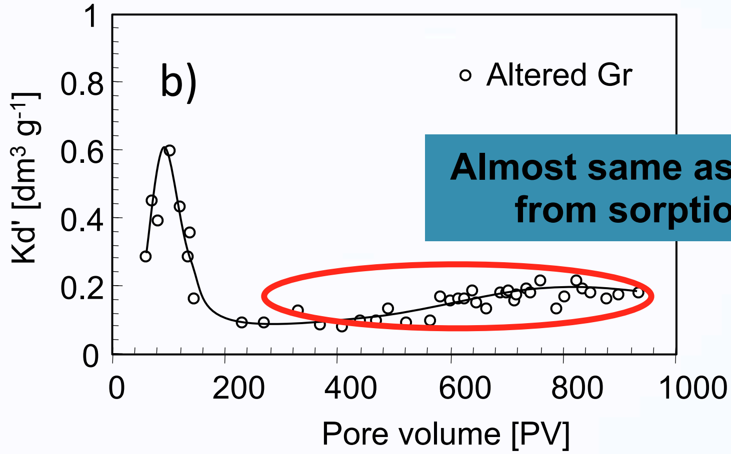


Kd values obtained from batch sorption experiments for the series of granite samples.

Flow-through experiments (Altered rock)

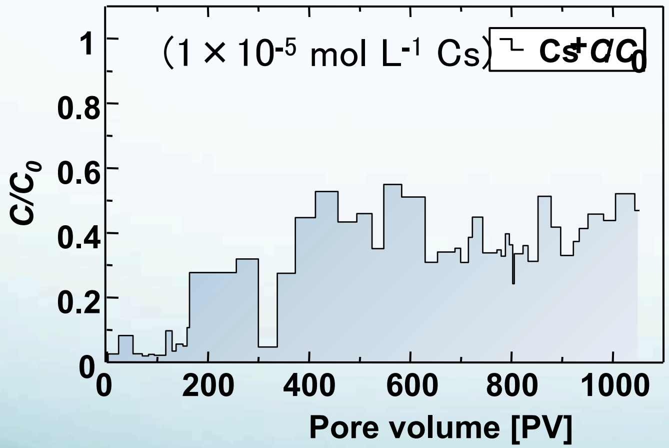


Schematic of centrifuge system for flow-through experiment



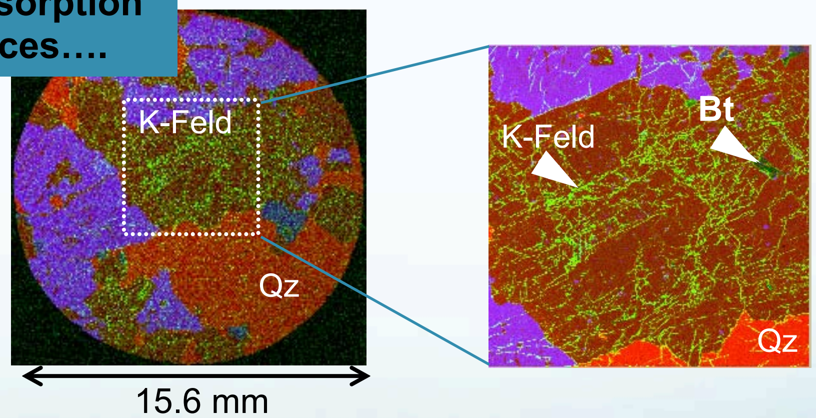
Almost same as the value from sorption exp.

Kd' calculated from the breakthrough curve for altered Gr



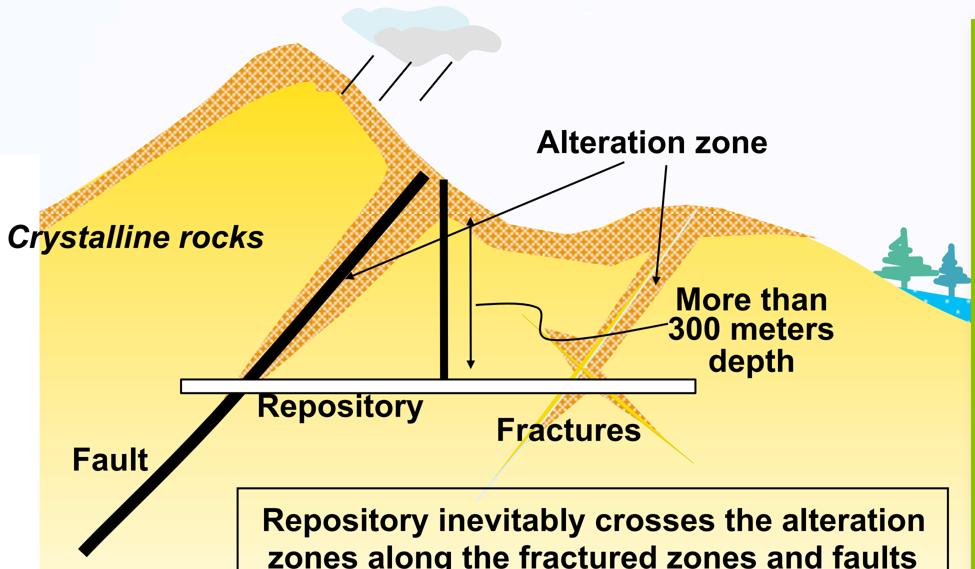
Breakthrough curve as a function of pore volume for altered Gr

Where the sorption takes places….



EPMA picture of a polished thin-section, showing accessible micro-fractures and pores (arrows) in the altered Gr, revealed in green by a contrast medium ($3Na_2WO_4 \cdot 9WO_3$; sodium metatungstate solution). The contrast medium was introduced by the centrifuge technique. K-Feld;Potasium-Feldspar, Qz;Quartz, Bt;Biotite.

Summary and conclusion (1);altered host rock



Repository inevitably crosses the alteration zones along the fractured zones and faults in crystalline rocks in Japan.

Conceptual view of panel allocation

Altered host rock;

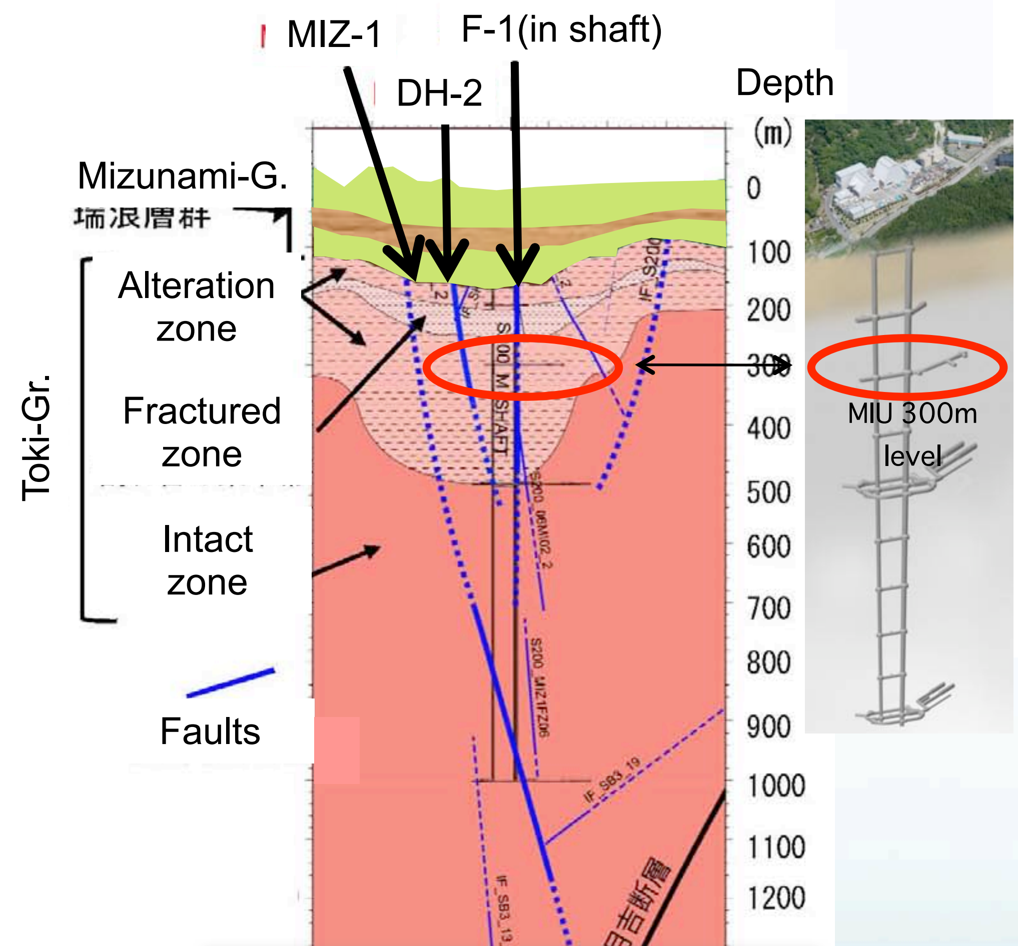
Alteration occurs widely along fractures and fault zones in deep crystalline rocks distributed in the orogenic area of Japan and will be encountered when a repository is constructed within crystalline host rock.

Retardation capacity of altered Gr;

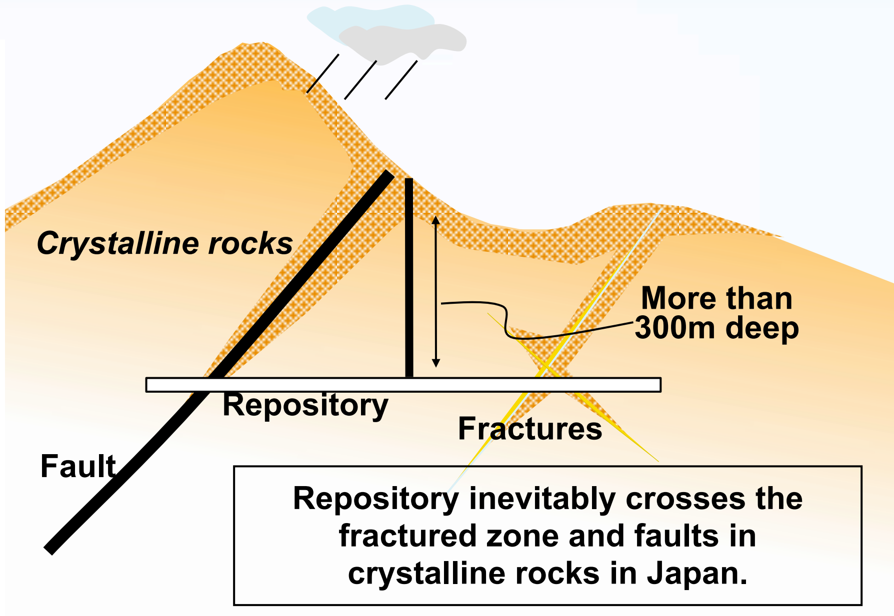
The investigation results give insights into radionuclides retardation processes to be occurred in any altered and fractured crystalline rocks.

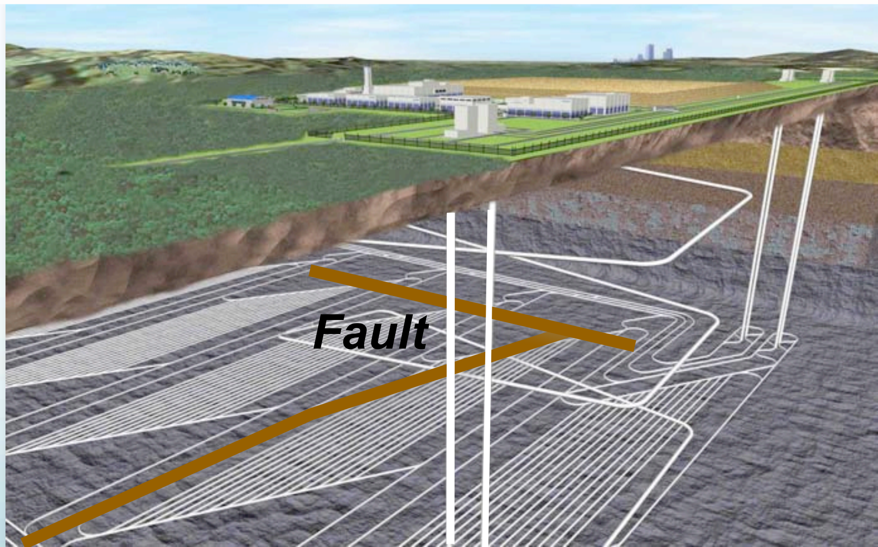
It is not necessary to exclude areas with alteration when allocating disposal panels in a repository constructed in an orogenic field/Japan.

Fault and fracture system in crystalline rock (ex2: URL site)



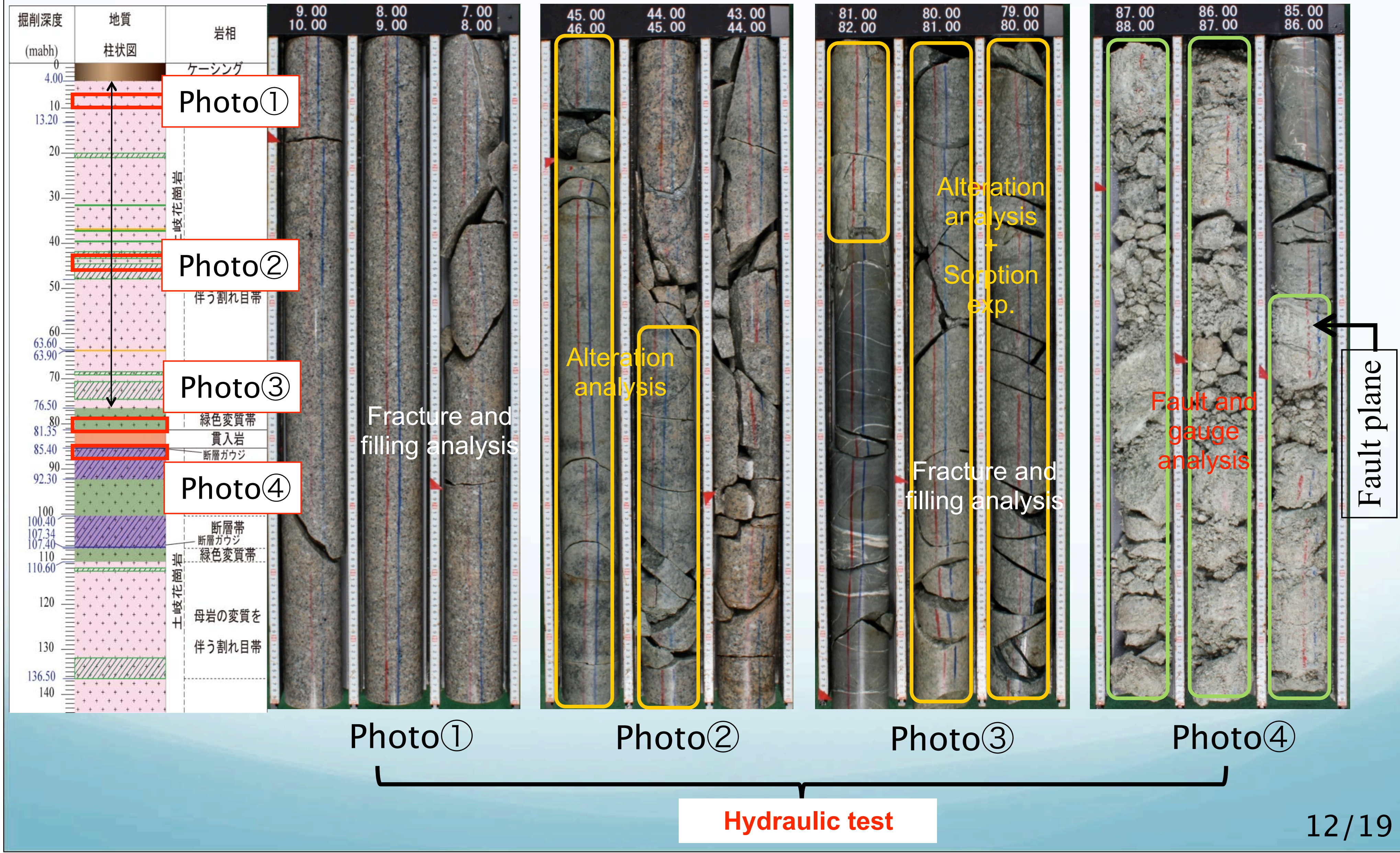
Use the knowledge to develop a realistic conceptual model



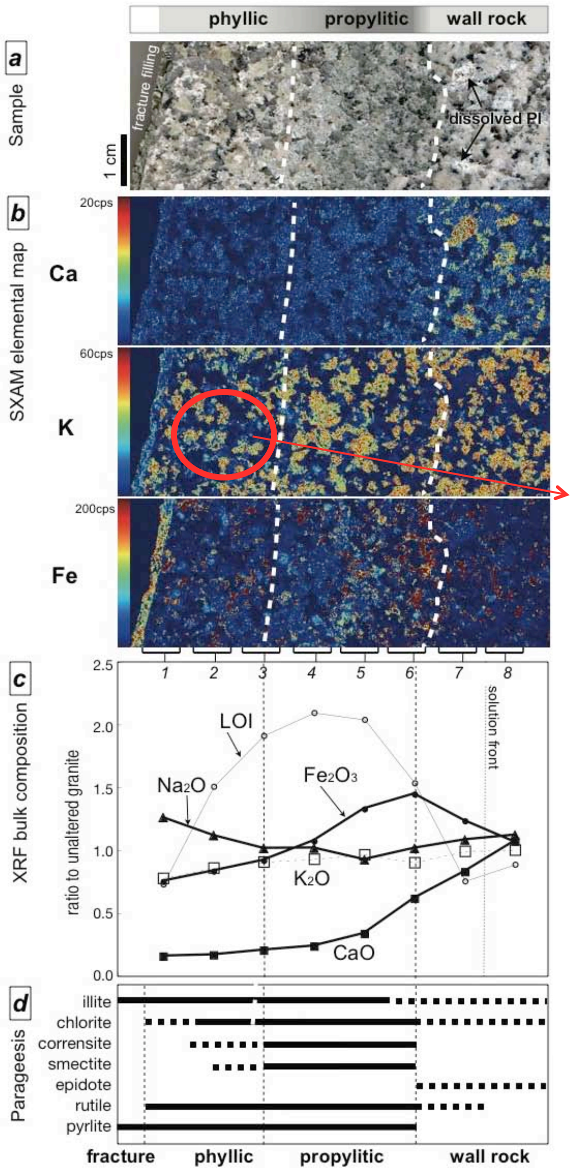


Conceptual view of panel allocation (NUMO)

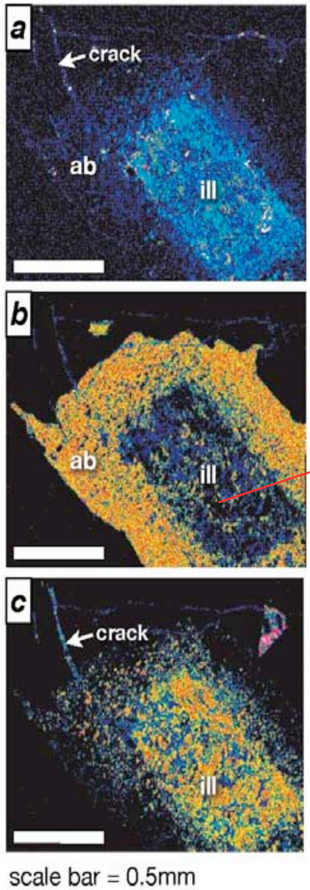
Characterization of fault and fracture system (MIU site)

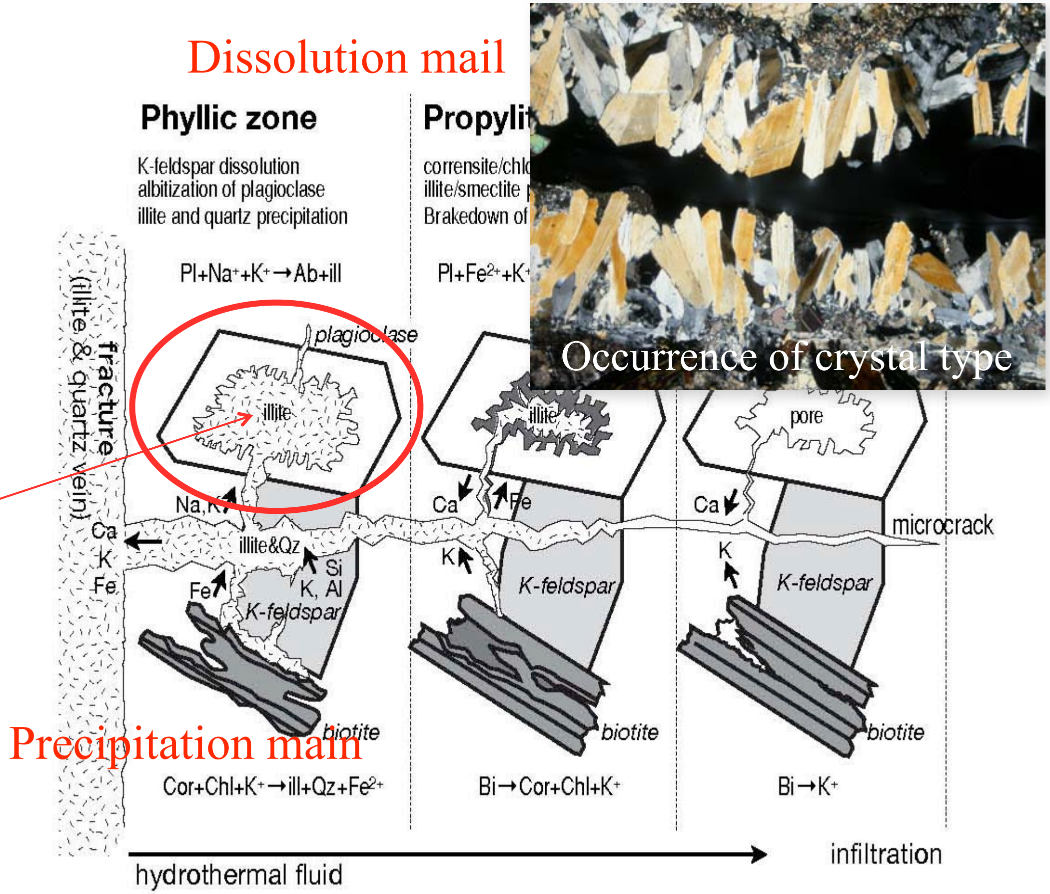


Fractures: Process of formation (fracture fillings)



Relationship between wall rock alteration and fracture filling formation

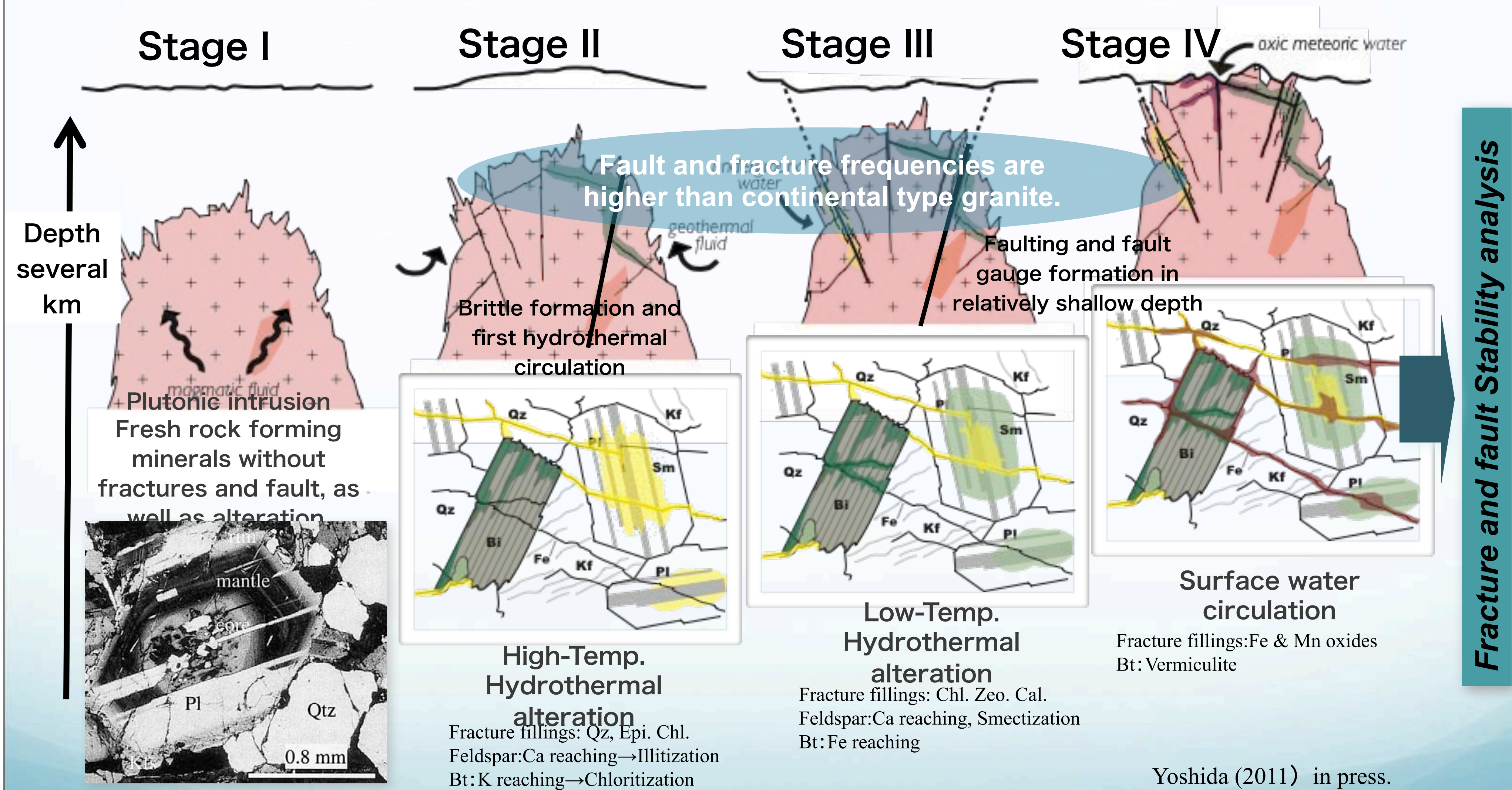




*Nishimoto & Yoshida (2010) Lithos

◆Ca,K,Fe from rock matrix used as sources of filling mineral formation.

Process of fracture and fault formation in crystalline rock



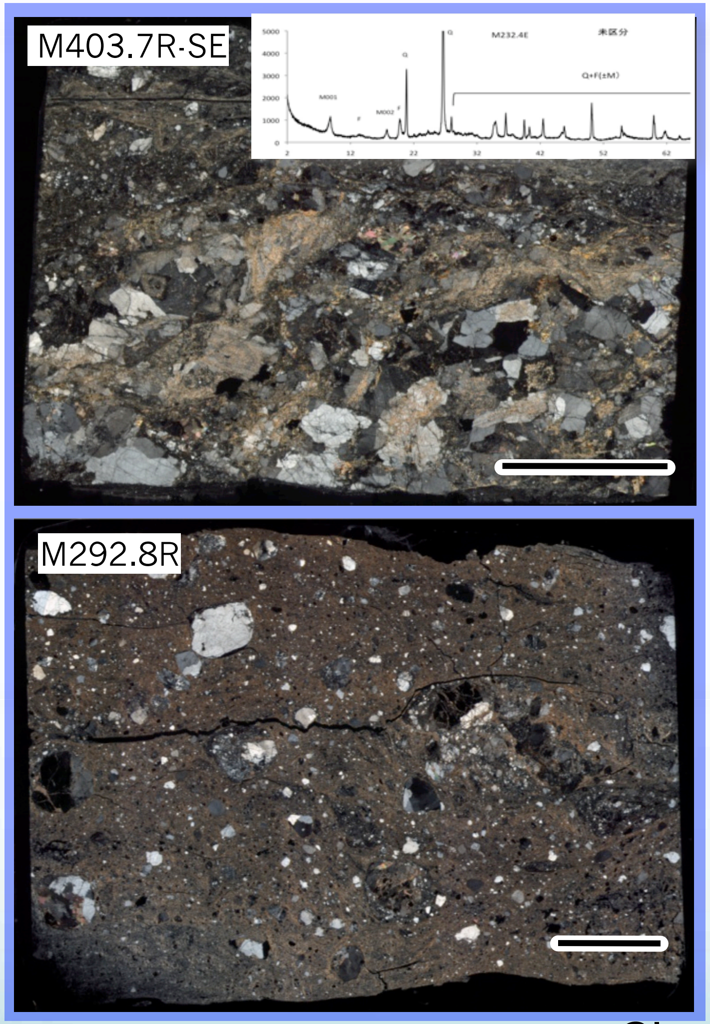
Ex. Kakkonda Gr.
(Sasaki et al.2003)

Yoshida (2011) in press.

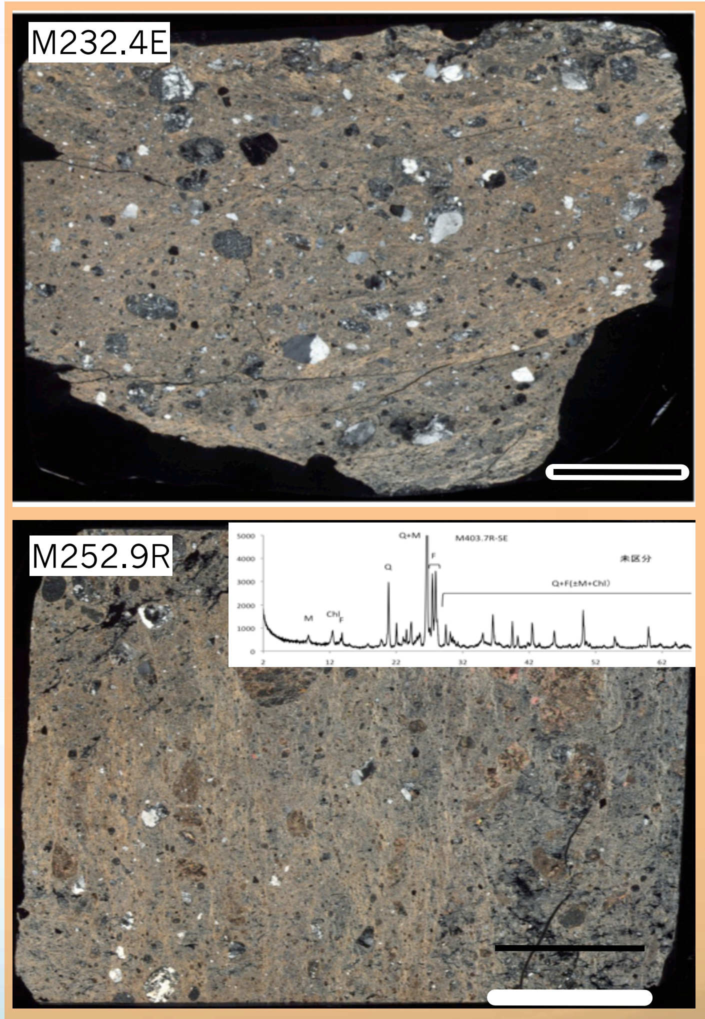
This concept is adaptable in plutonic crystalline rocks in Japan.

Long-term stability analysis of fault (dating of fault gauge)

Gauge with host rock breccia



Gauge without brecciate materials

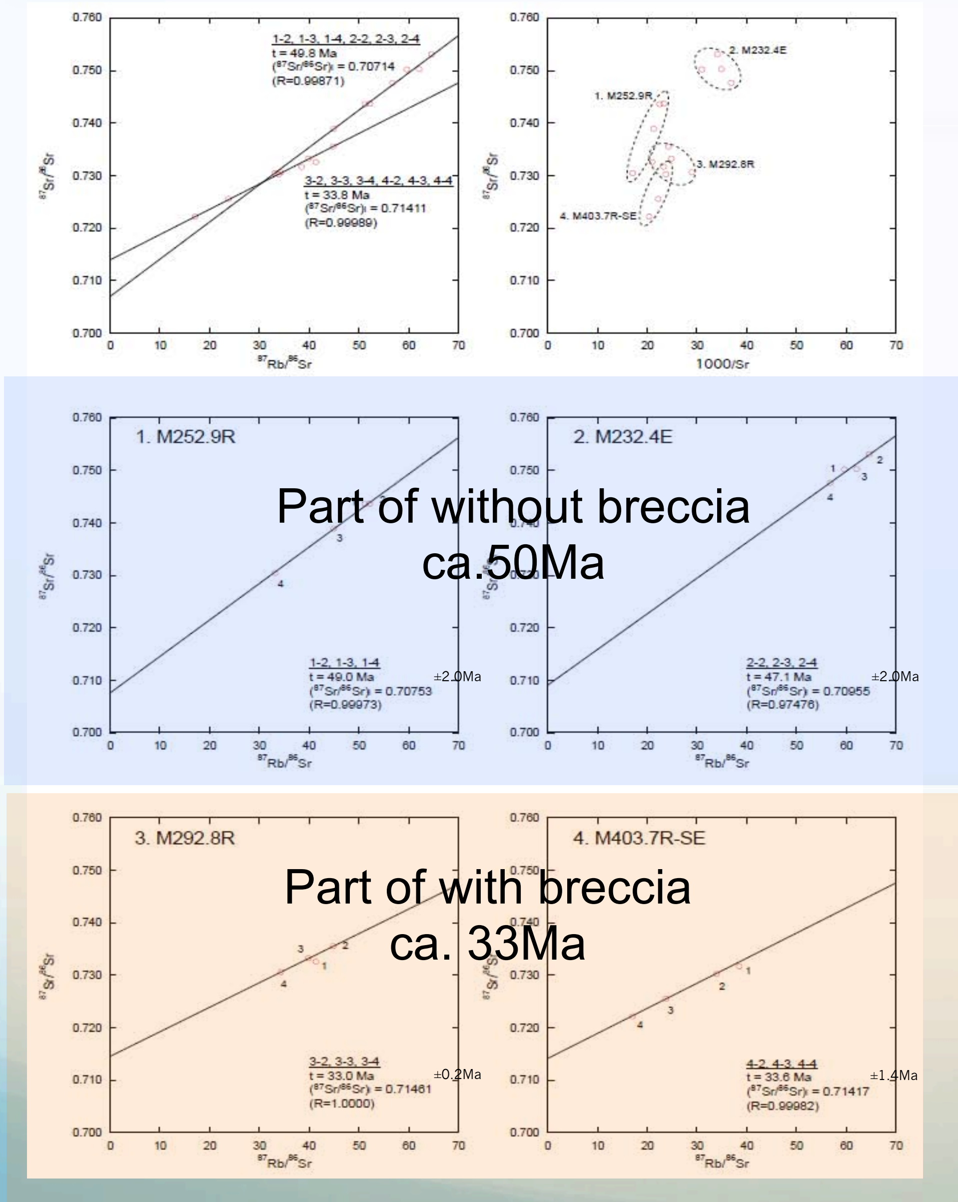


< Clay minerals

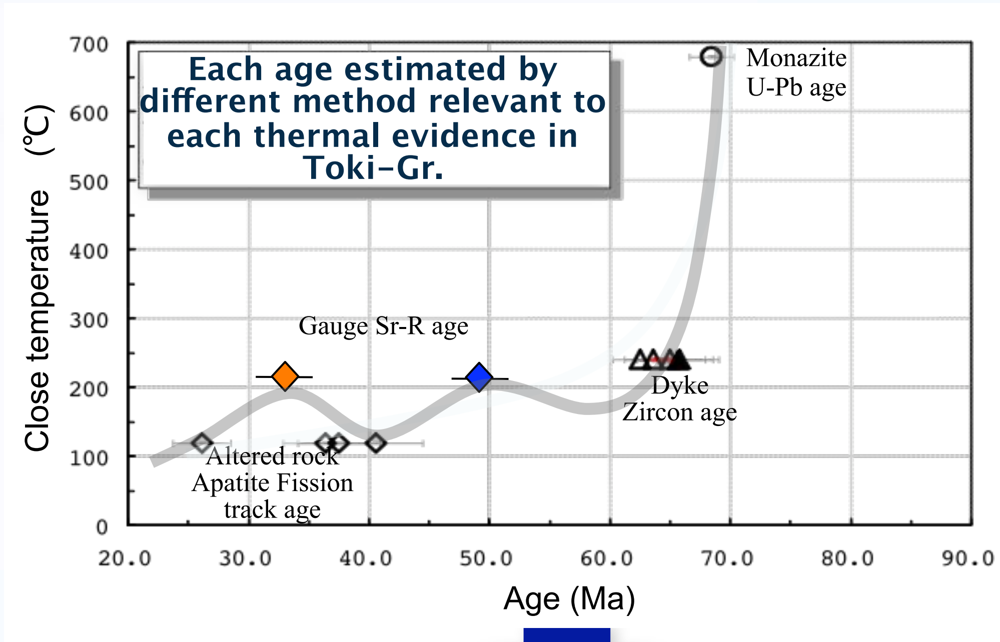
Scale bar = 5mm

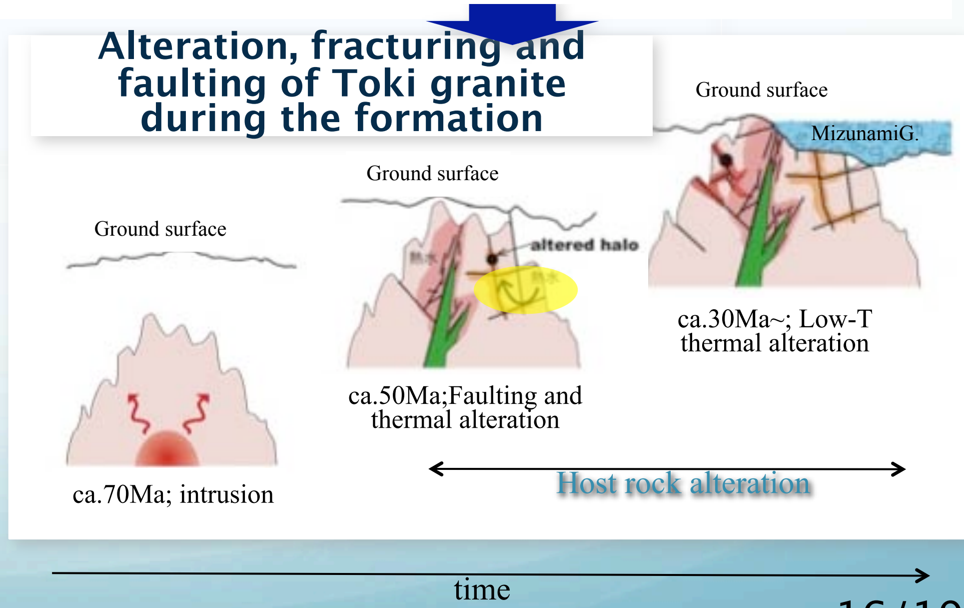
Rb-Sr dating method applied both clay minerals

Activity estimated by dating of fault gauge

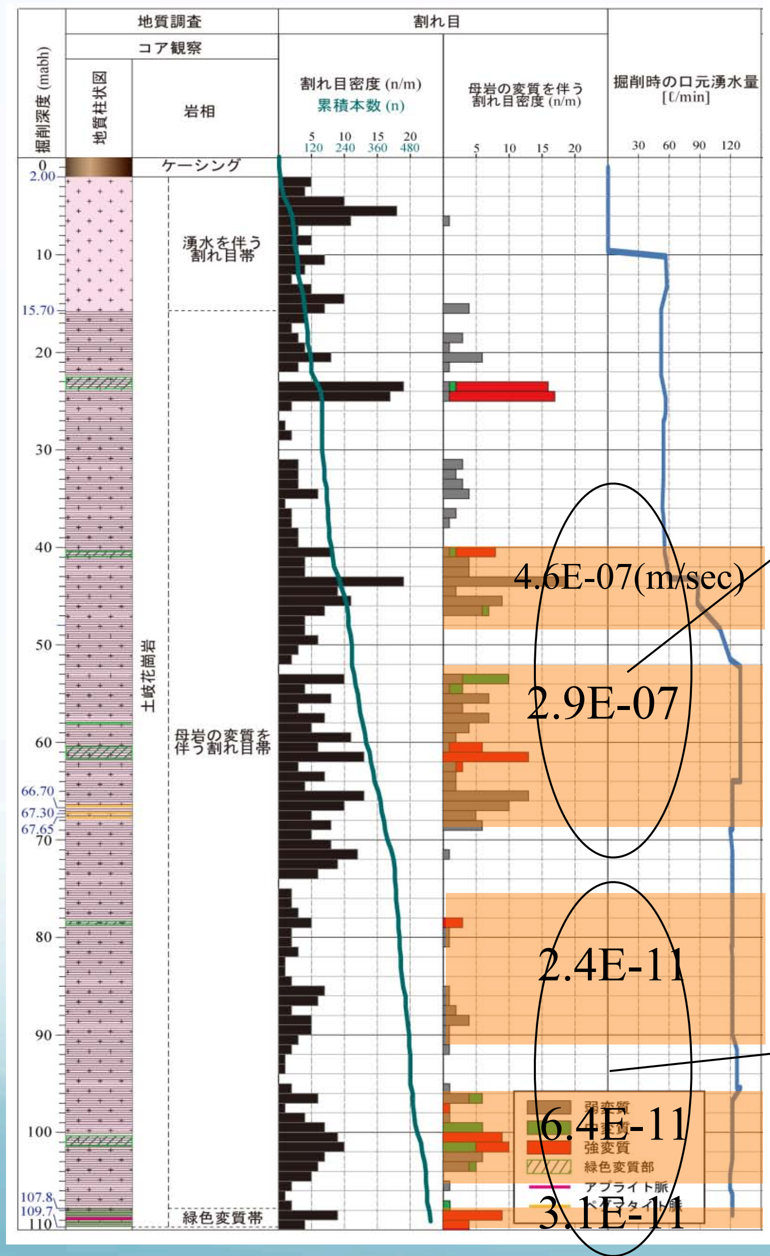


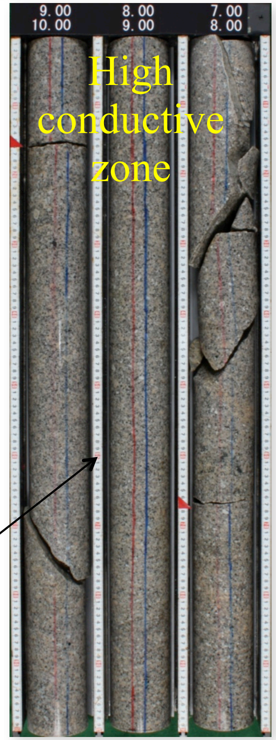
Rb-Sr age (fault gauge)





Hydrological properties in and around fault in crystalline rock

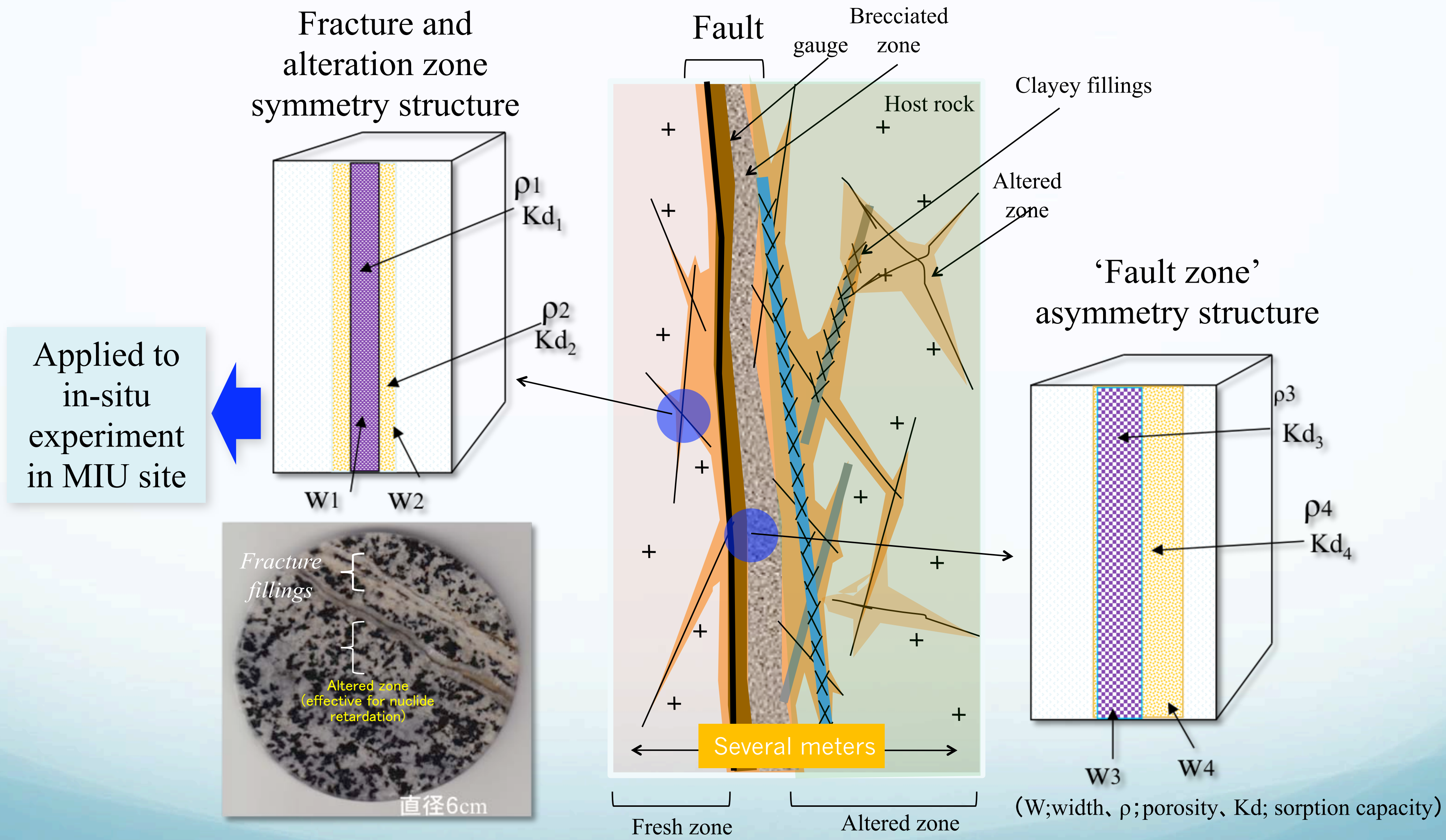




Conductivity around the fault

- *Fault gauge: low conductivity*
- *Fractures in the altered zone around the fault: low conductivity (due to the clayey filling minerals)*
- *Fractures in the fresh host rock; relatively higher conductivity (the zone developed asymmetry along the fault)*

Conceptual structural model relevant to nuclides migration



Concluding remarks

Fault and fractures in crystalline rock

***Understanding of formation processes**
→Specific distribution geometry of fault and fracture
→Concept can be transfer to the site characterization

Barrier function of crystalline rock

***Certain sorption capacity expected in altered host rock**
***Long-term stability of faults and fractures by characterization of fillings (texture, dating and geochemistry)**
***Development of the structural model relevant to nuclide migration**

Knowledge of MIU site data is important to prepare for orogenic underground realistic structure and environment.