Hyper-K site and cavern

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for HK cavern & tank WG

5th HK Open Meeting at TRIUMF/UBC, July 21st, 2014

Outline

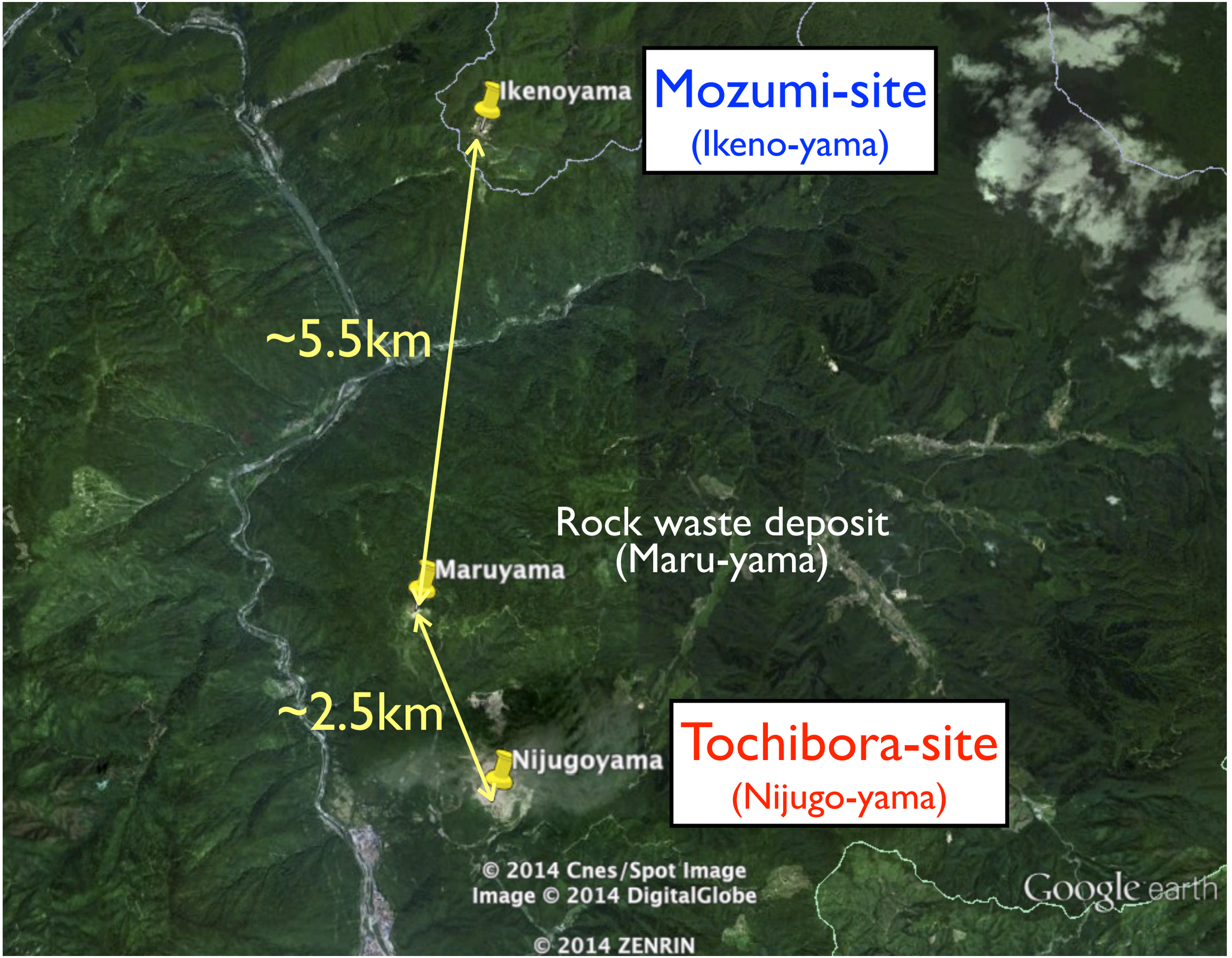
- Brief overview of Tochibora-site studies
- Status of Mozumi-site studies
- Summary

Status of HK cavern design

- Two candidate sites; Tochibora and Mozumi

- Tochibora-site
  - Geological surveys
    - Geological logging of existing tunnels/shaft and rock sampling
  - Cavern stability analyses based on the survey
  - Cost estimates and construction schedule evaluated
  - Baseline design has been (basically) completed

- Mozumi-site
  - Almost no geological information available in the past
  - Geological surveys carried out in 2013
  - Cavern stability analyses have been completed


Ikenoyama
Mozumi-site
(Ikeno-yama)
~5.5km
Rock waste deposit
(Maru-yama)
Maruyama
~2.5km
Nijugoyama
Tochibora-site
(Nijugo-yama)
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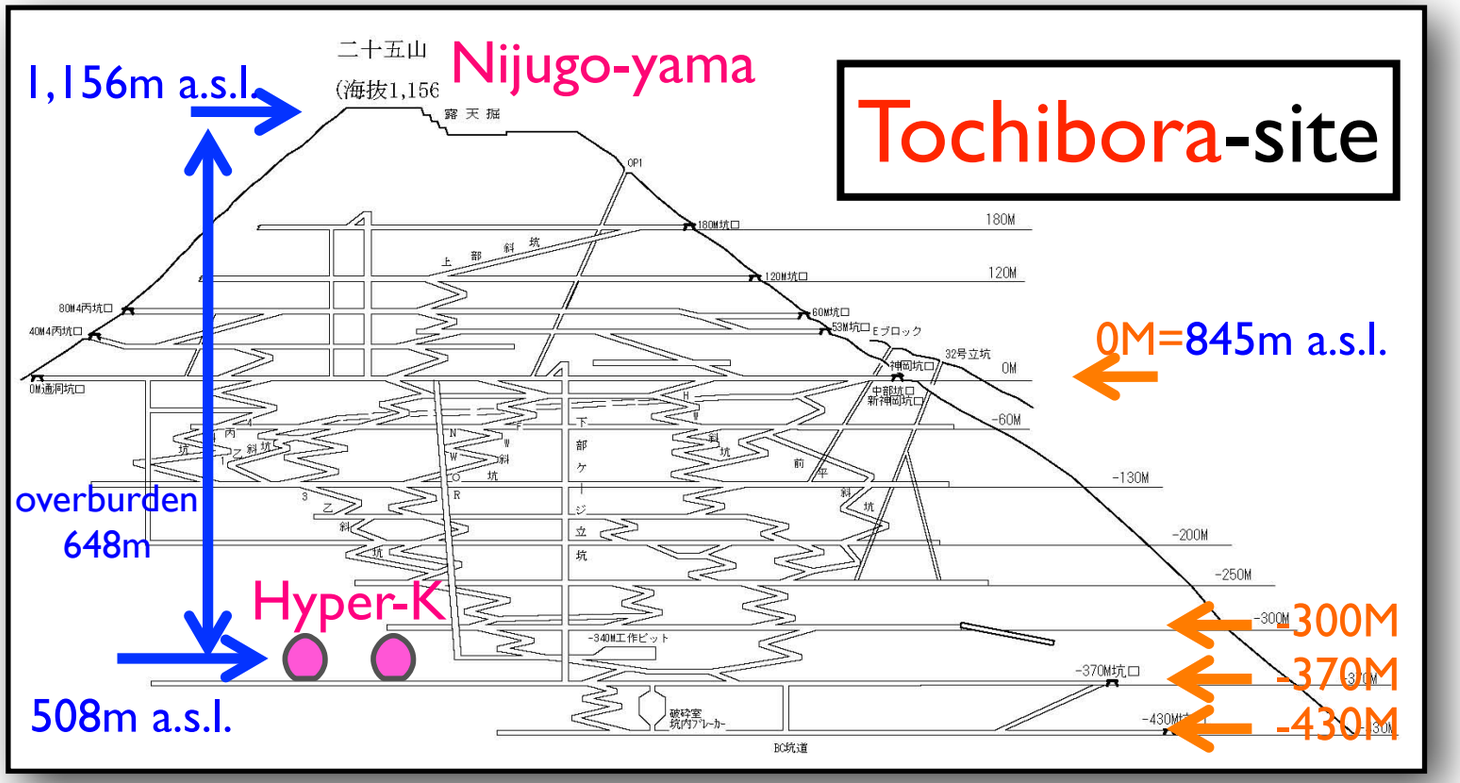
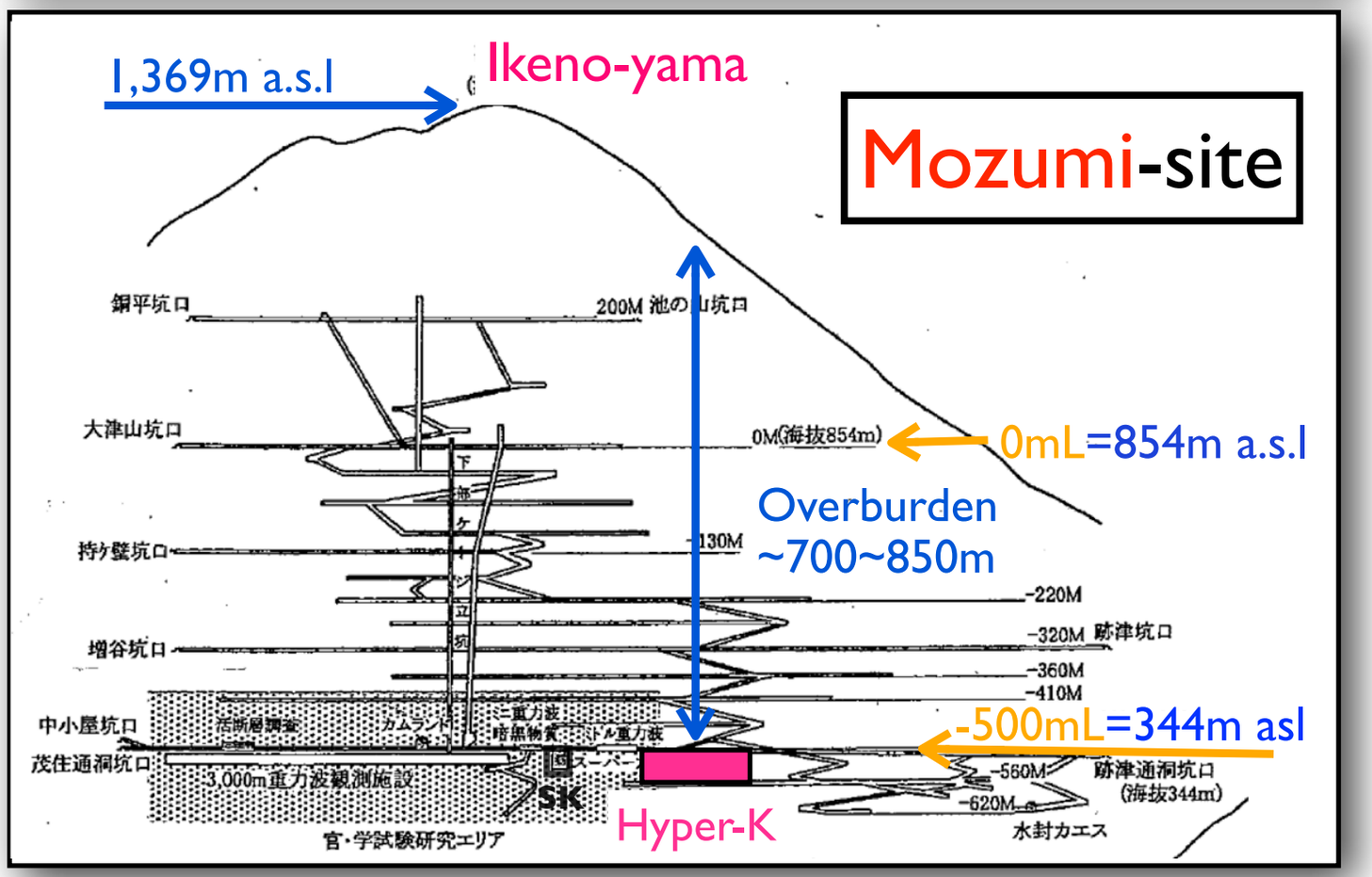
Google earth

Overburden



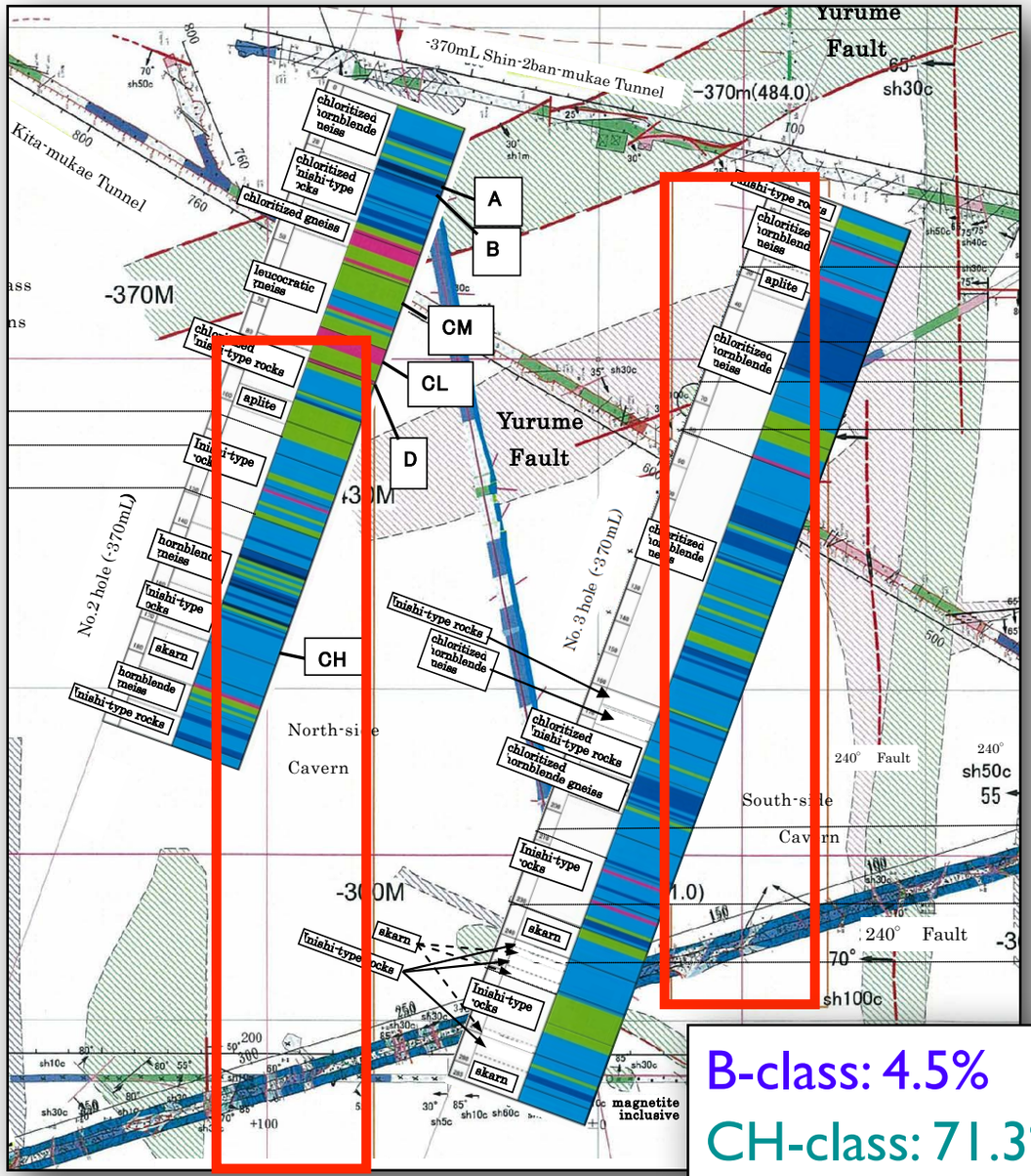


- Overburden
  - Tochibora: ~650m
  - Mozumi: ≥700m

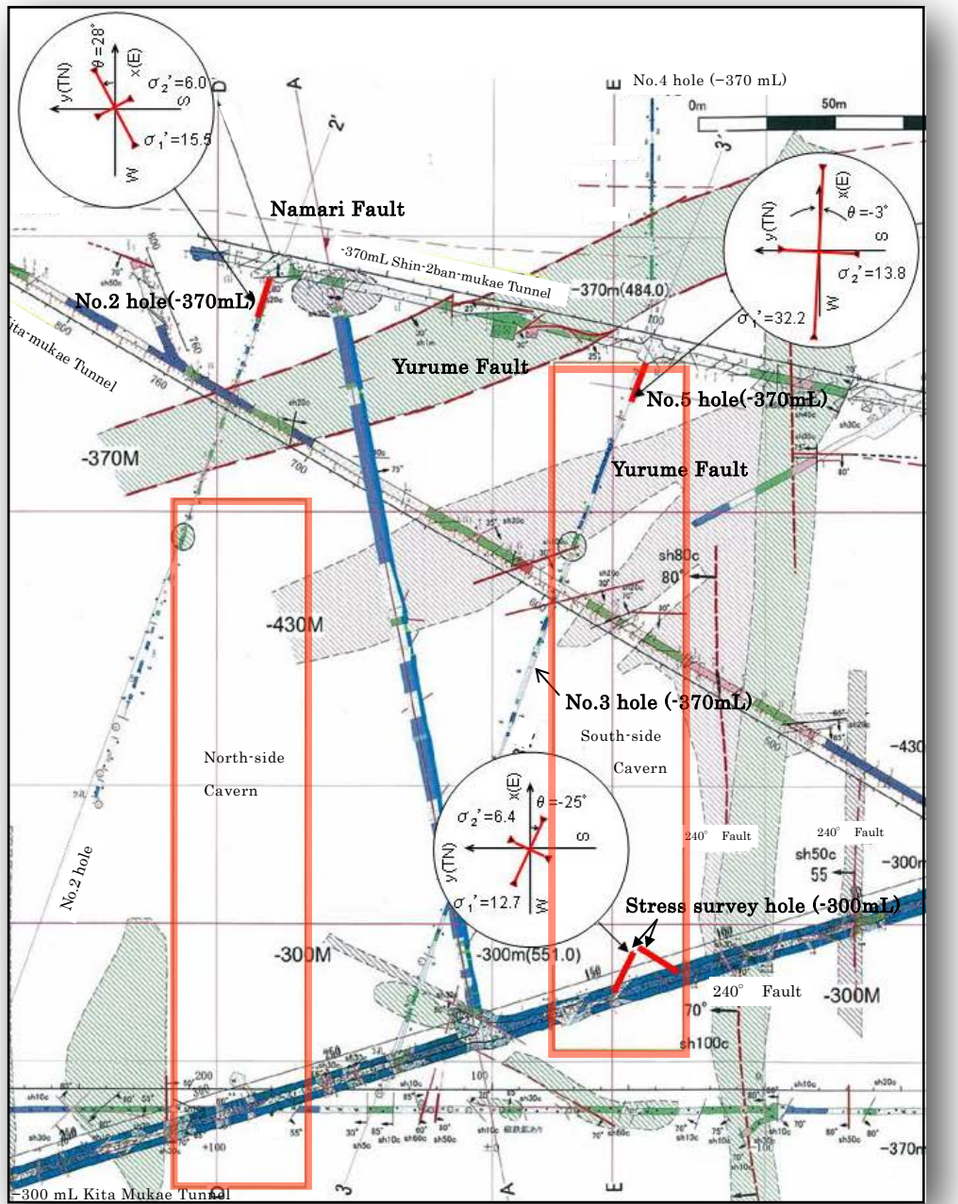
Tochibora-site studies brief overview

Geological survey

Rock mass characterization



Initial stress measurement

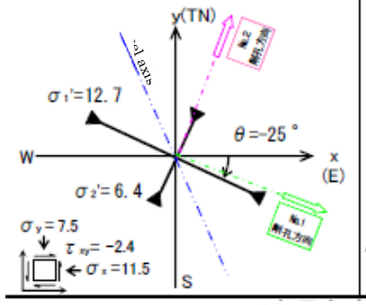
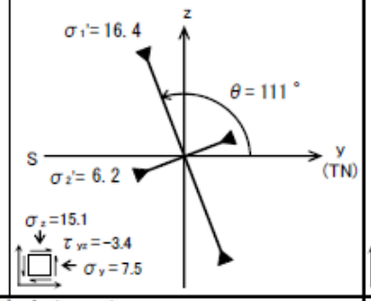
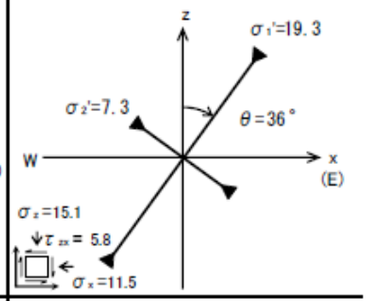


- Rock class distribution & initial stress at the HK tank location used in the cavern stability analyses

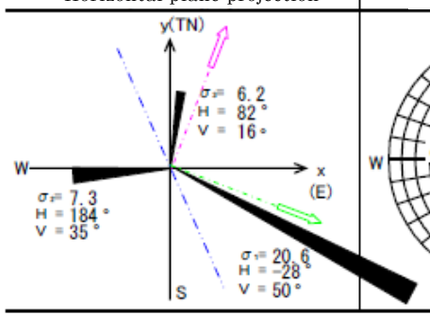
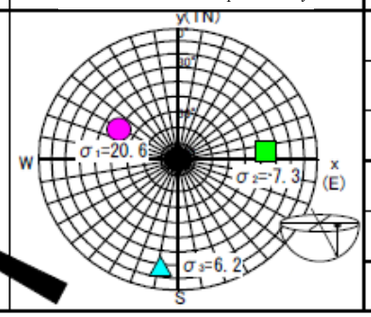
Cavern stability analysis

Initial stress

In-plane principal stress (MPa)

Horizontal plane (x-y plane)	North-south section (y-z plane)	East-west section (z-x plane)
		

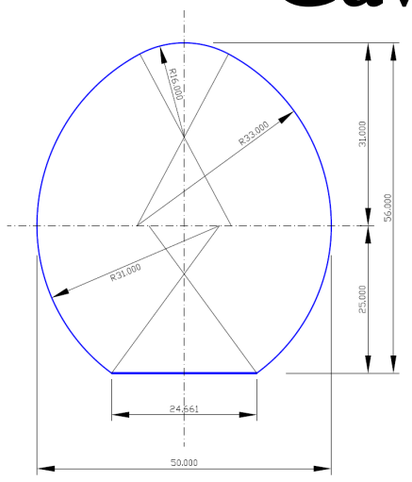
3D principal stress (MPa)

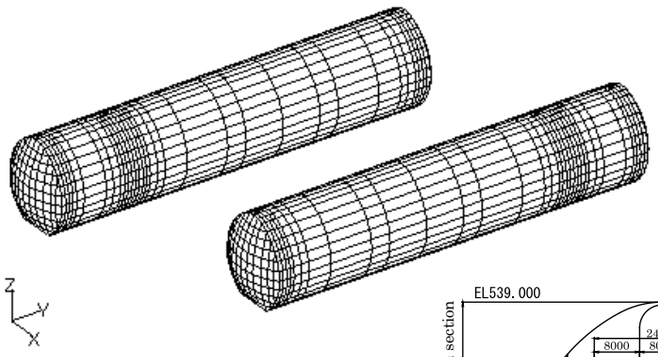
Horizontal plane projection	Schmidt Net: Lower Hemisphere Projection
	

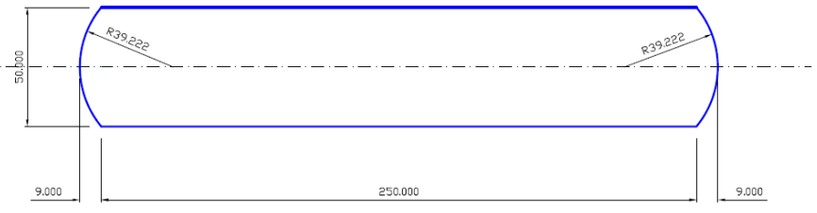
Six Stress Components (MPa)

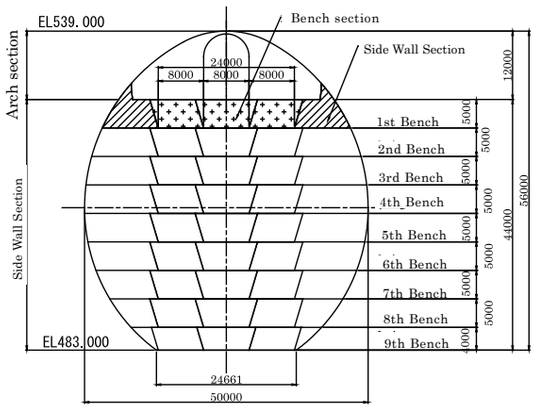
σ_x	11.5
σ_y	7.5
σ_z	15.1
τ_{xy}	−2.4
τ_{yz}	−3.4
τ_{zx}	5.8

Cavern shape

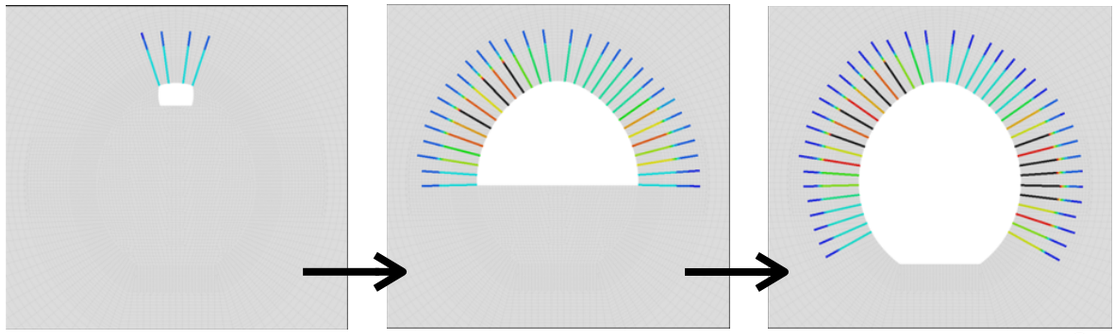








- Based on the survey results (rock mass characteristics and initial stresses), structural stability of caverns has been studied
  - Elasto-plastic, static analysis & adopt Hoek-Brown yield (failure) criteria
- The excavation-steps taken into account in the stability analyses
- Include the cavern supporting material: shotcrete, rock-bolt, and Pre-Stressed (PS) anchor

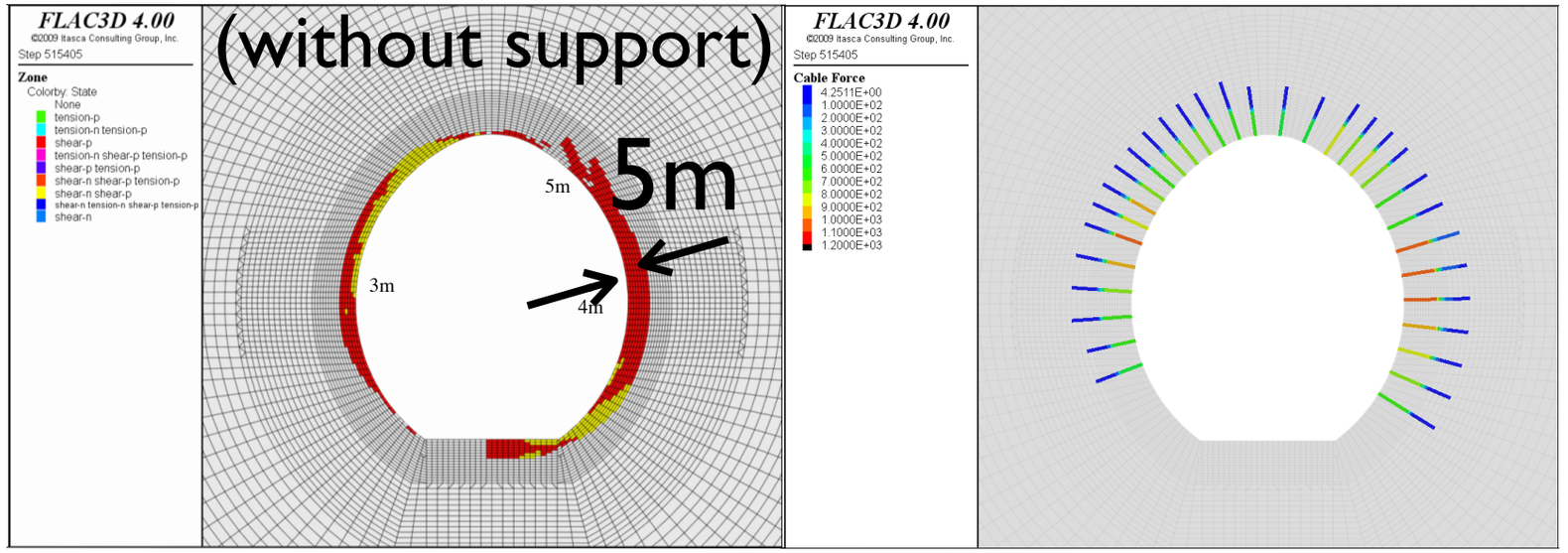


Cavern stability

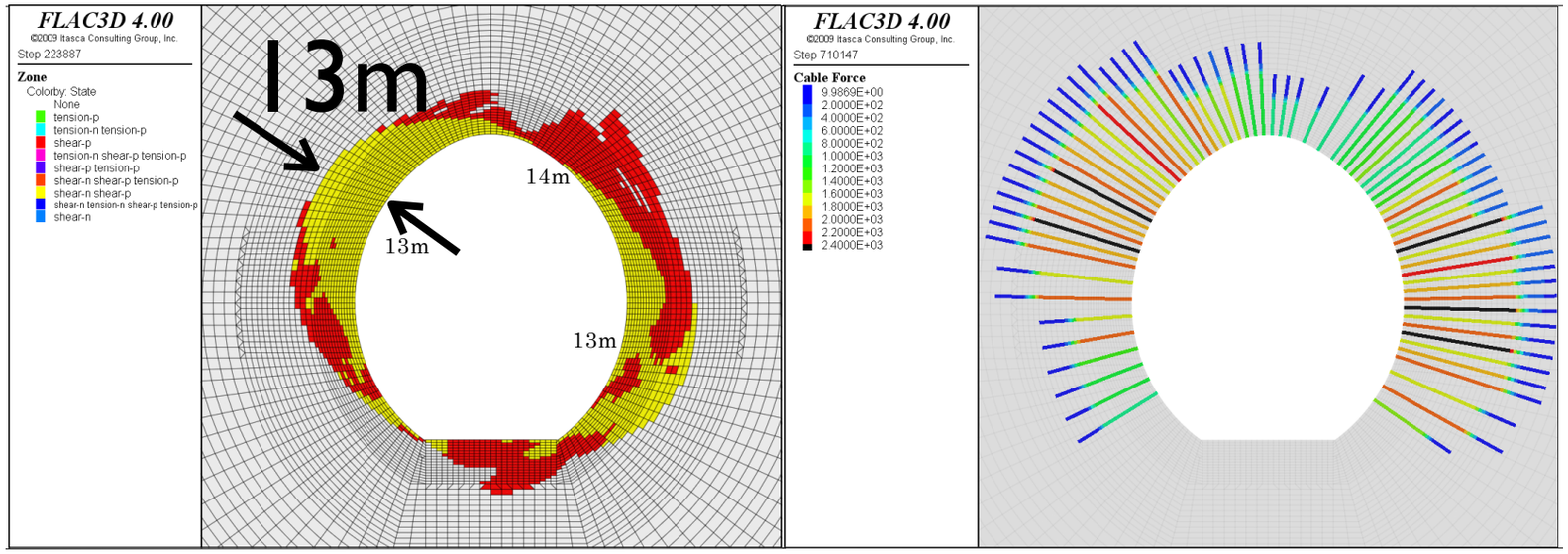
Plasticity region depth

PS-anchor tension

CH-class
(>70% at HK location)

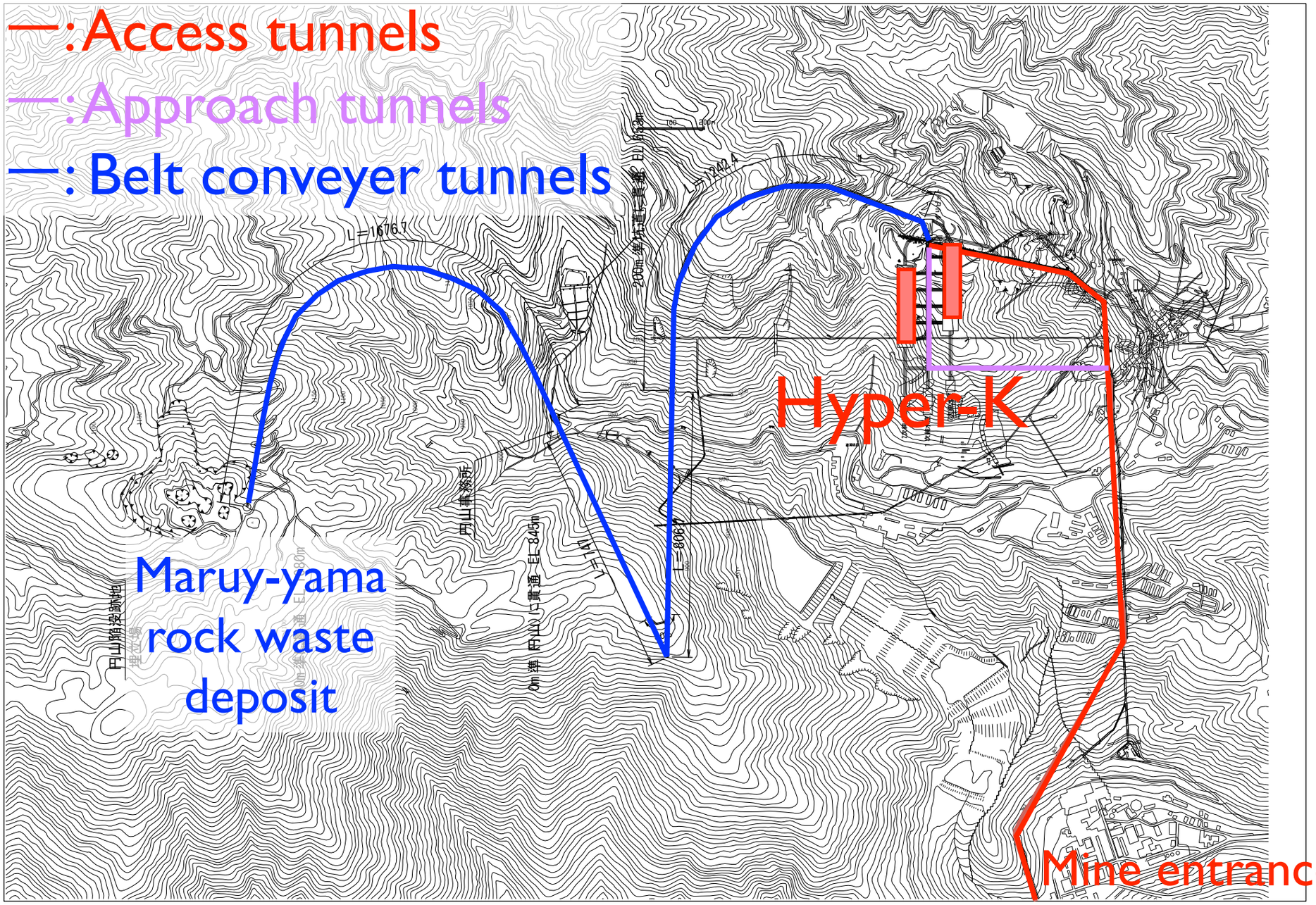


CM-class
(20~30% at HK location)



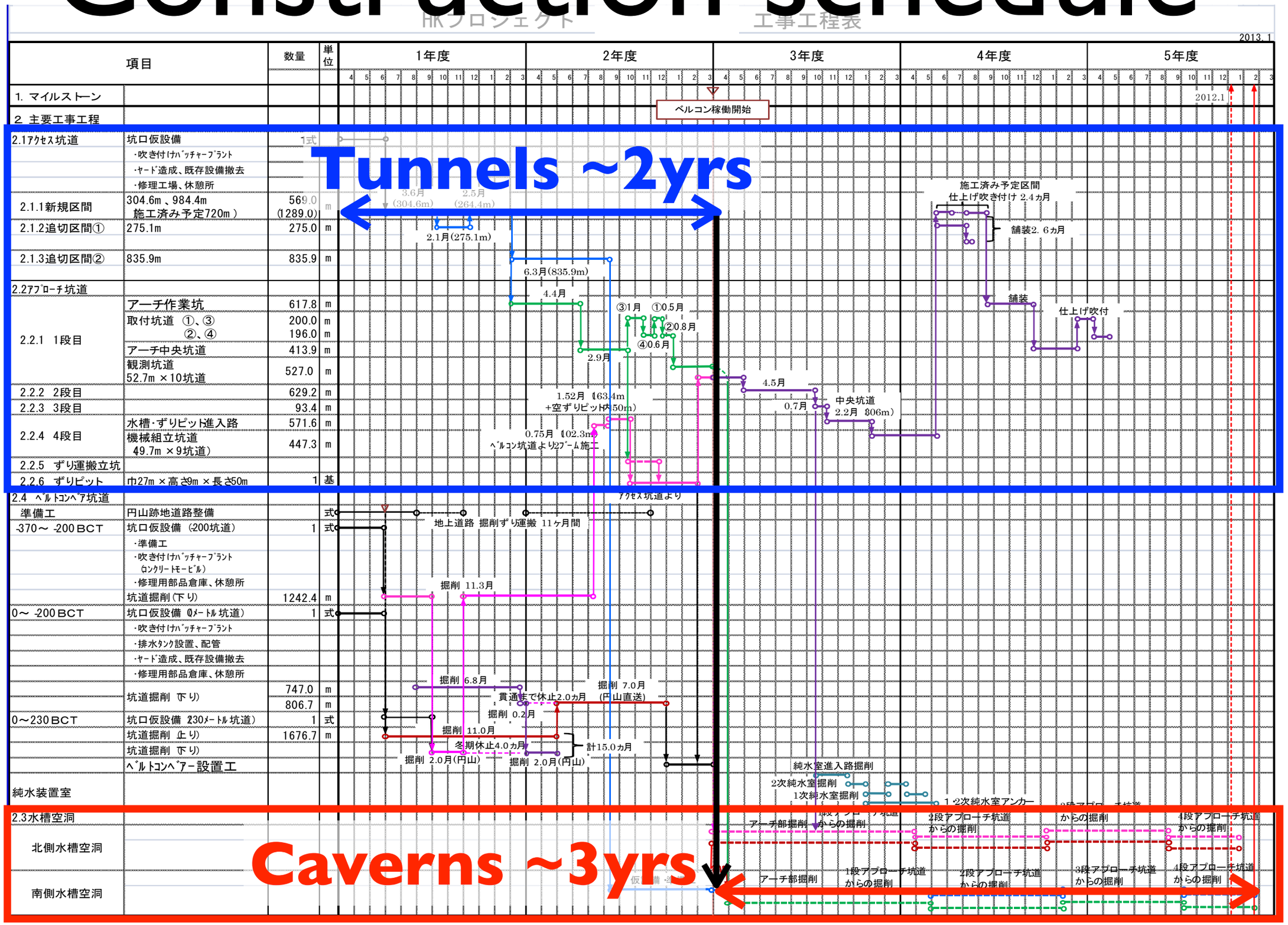
- Plasticity region ~13m at most (CM class) → affordable level
  - Proved in the existing underground facilities (ex. power plants)
- For all rock mass classes (B, CH, CM), HK caverns can be constructed by the existing excavation/support techniques.

Tunnel constructions



- Tunnel construction plan (basically) established
  - Access-, approach-, and belt conveyor tunnels

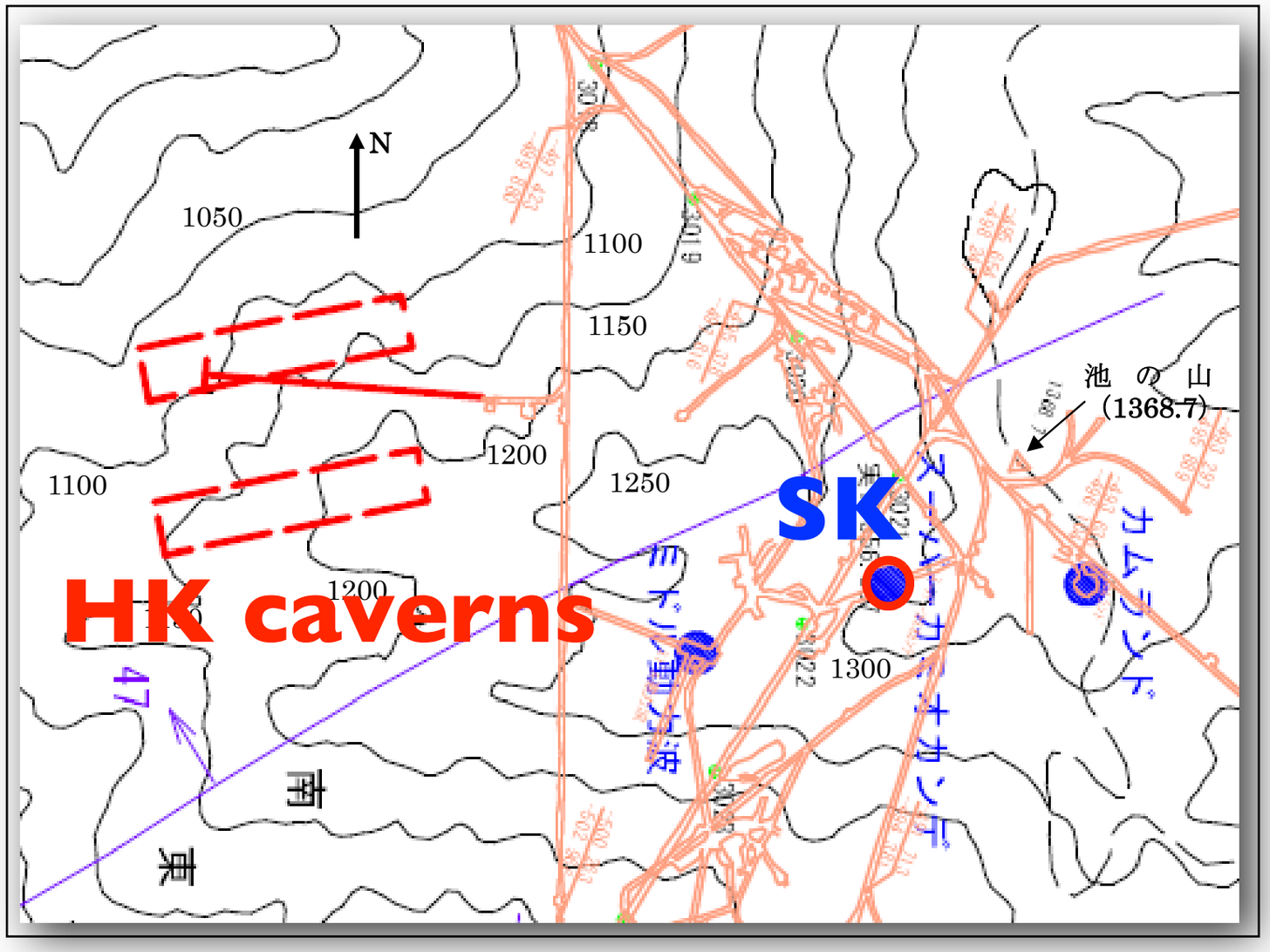
Construction schedule



- Construction steps and schedule established

Mozumi-site studies status

Mozumi-site

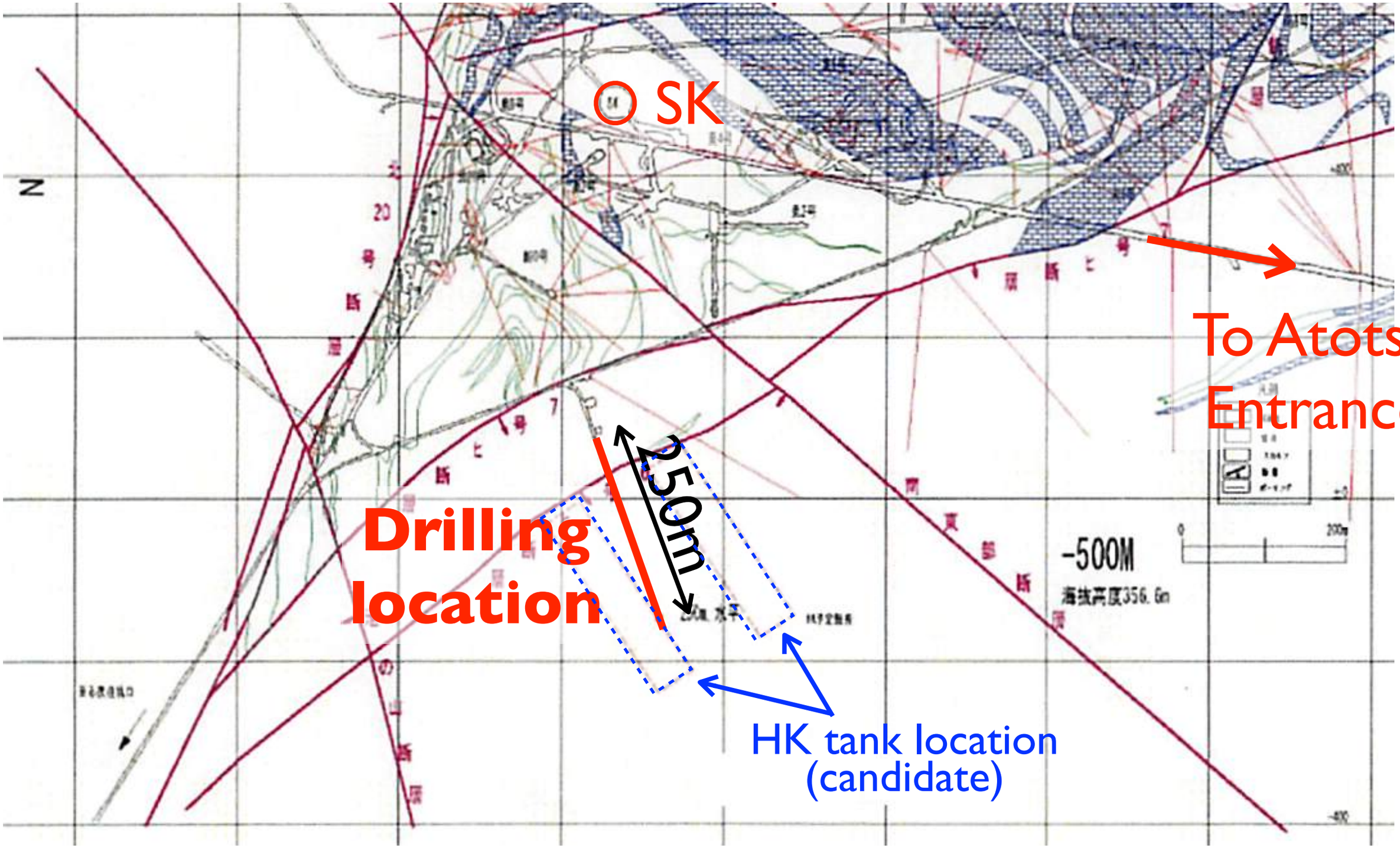


- Candidate site locates under Mt. Ikenoyama
- HK deck level: EL356.6m (-500mL in mine coordinate)
  - The same as SK deck level
- Overburden: ≥700m (cf. Tochibora-site: ~650m)
- No detailed geological survey in the past

Geological survey at Mozumi

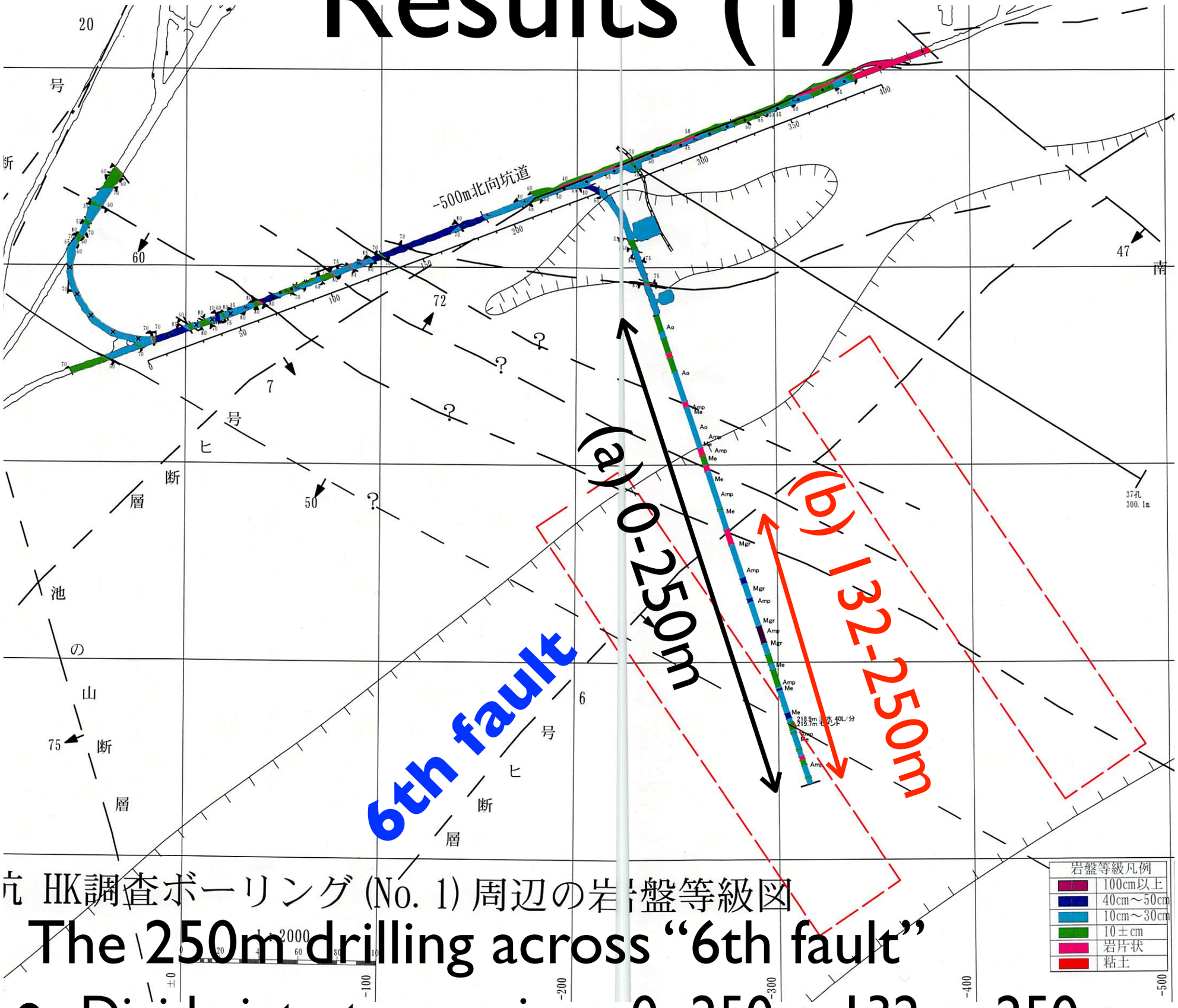
- Geological survey at Mozumi-site has been carried out in 2013
  - Rock core samplings at -500mL (-500mL=SK deck level)
    - (1) 250m long drilling with 27mmϕ
      - for rock mass characterization at candidate site
    - (2) ~14m (in total) drilling with 50mmϕ
      - for rock 'pressure crack' testing / measurement
- Mapping of the existing tunnels

Rock core sampling (1)



- 250m long rock sampling at HK tank location
  - Core size: ϕ27mm

Results (I)



坑 HK調査ボーリング (No. 1) 周辺の岩盤等級図

- The 250m drilling across "6th fault"
  - Divide into two regions: 0~250m, 132m~250m

Summary of the results (1)

Mozumi-site

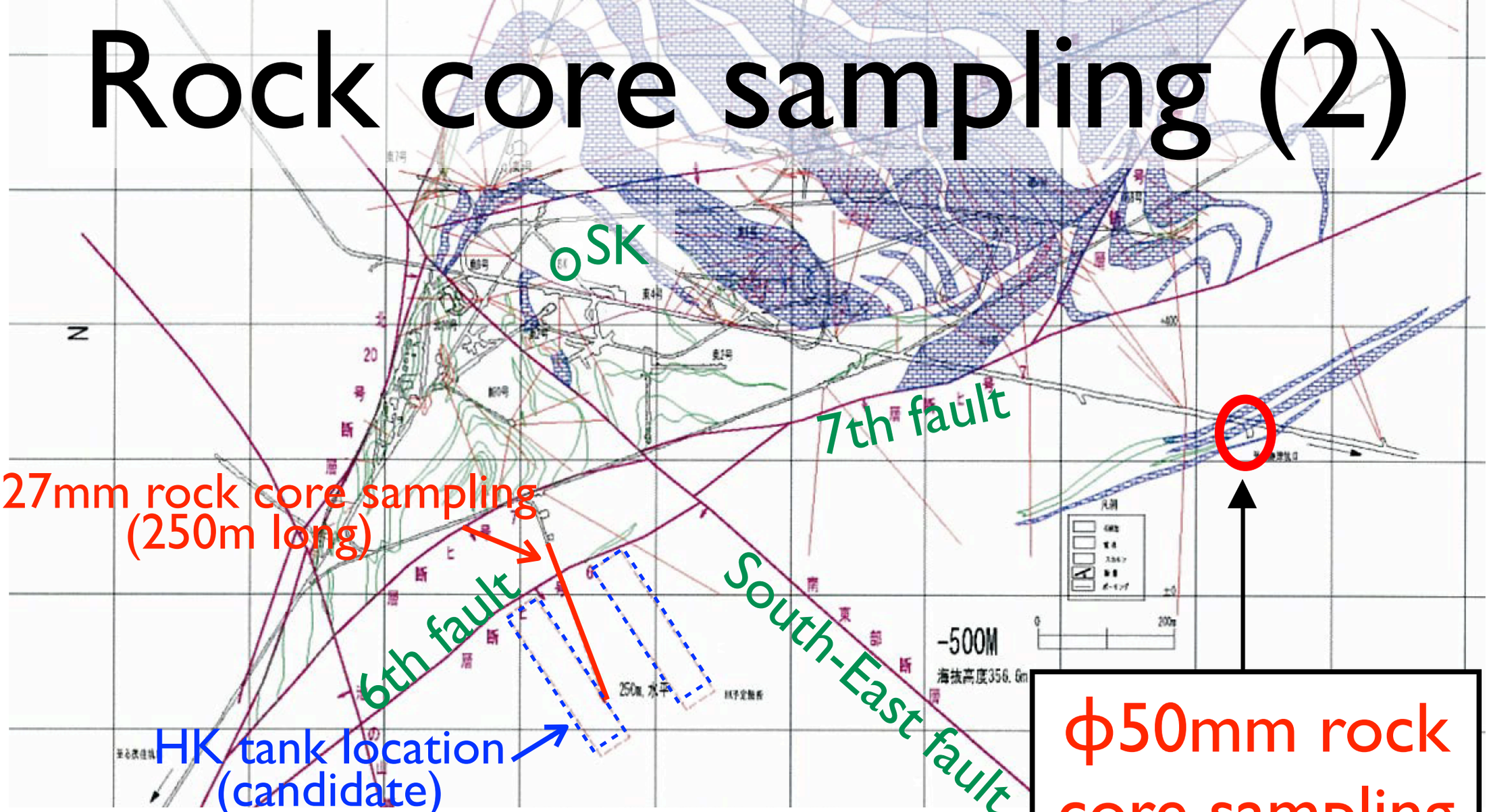
		Fraction of rock class (%)						備　考
		A	B	CH	CM	CL	D	
(a)	0~250m	3.6	10.6	47.4	26.2	7.3	0.0	対象区間：孔口～孔底（コア欠は除く）
		61.6			33.5			
(b)	132~250m	7.8	16.3	48.9	20.8	3.2	0.0	対象区間：132m～孔底（コア欠は除く）
		73.0			24.0			

cf. Tochibora-site

	Fraction of rock class (%)						備　考
	A	B	CH	CM	CL	D	
North cavern 北側水槽	0.0	0.0	71.8	28.2	0.0	0.0	
	71.8			28.2			
South cavern 南側水槽	0.0	9.0	70.7	20.3	0.0	0.0	
	79.7			20.3			
Average 計	0.0	4.5	71.3	24.2	0.0	0.0	
	75.8			24.2			

Rock quality at Mozumi-site is comparable with Tochibora-site.

Rock core sampling (2)



- 50mmϕ thick core samples
  - Use for pressure crack test/measurement
  - 10 core samples; 1~2m long core each
- Rock cores sampled at a different location from HK tank (~800m away) but rock type is identical to where we are interested in.

Rock strength

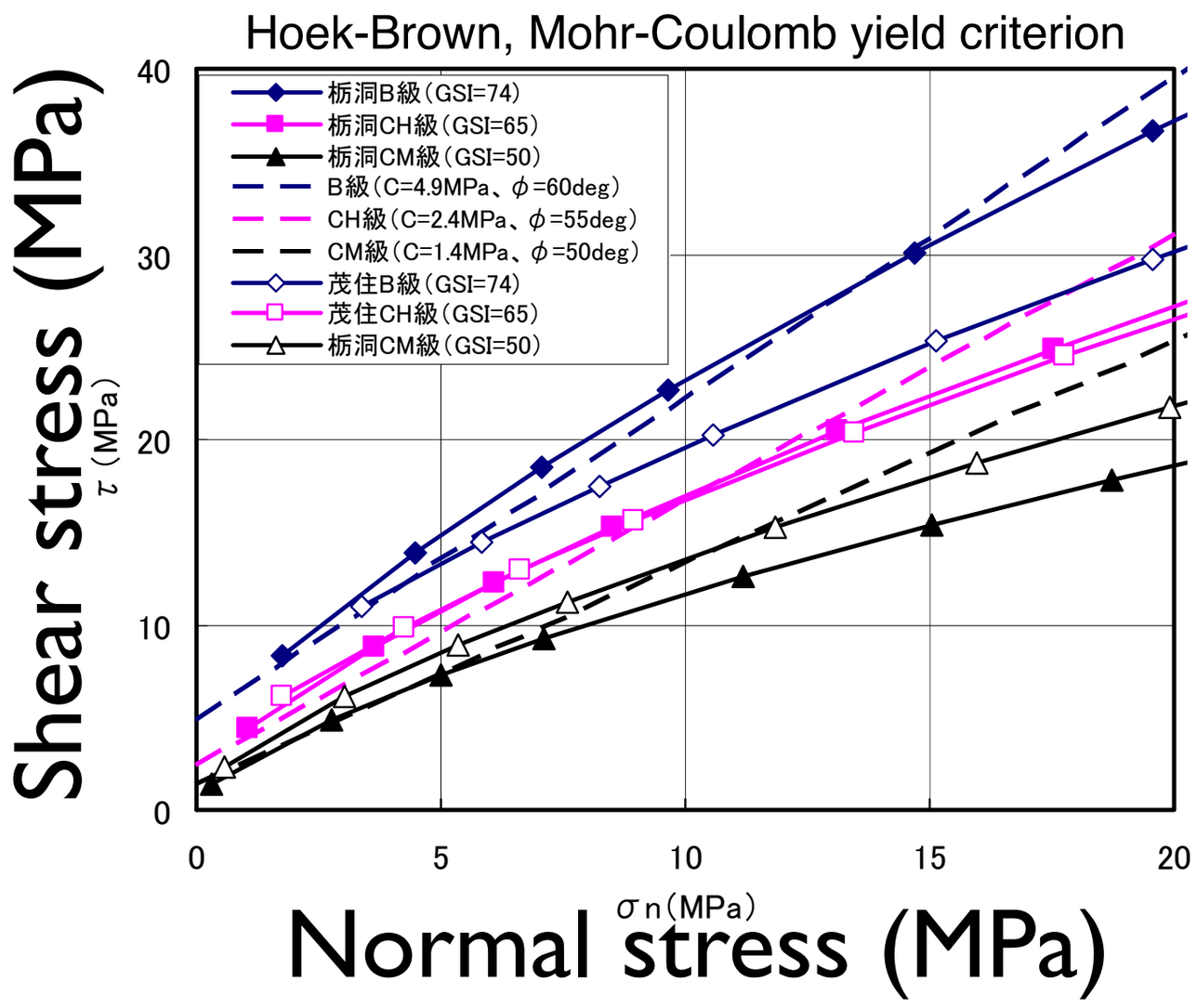
based on pressure crack testing results

Mozumi-site

: B-class
: CH-class
: CM-class

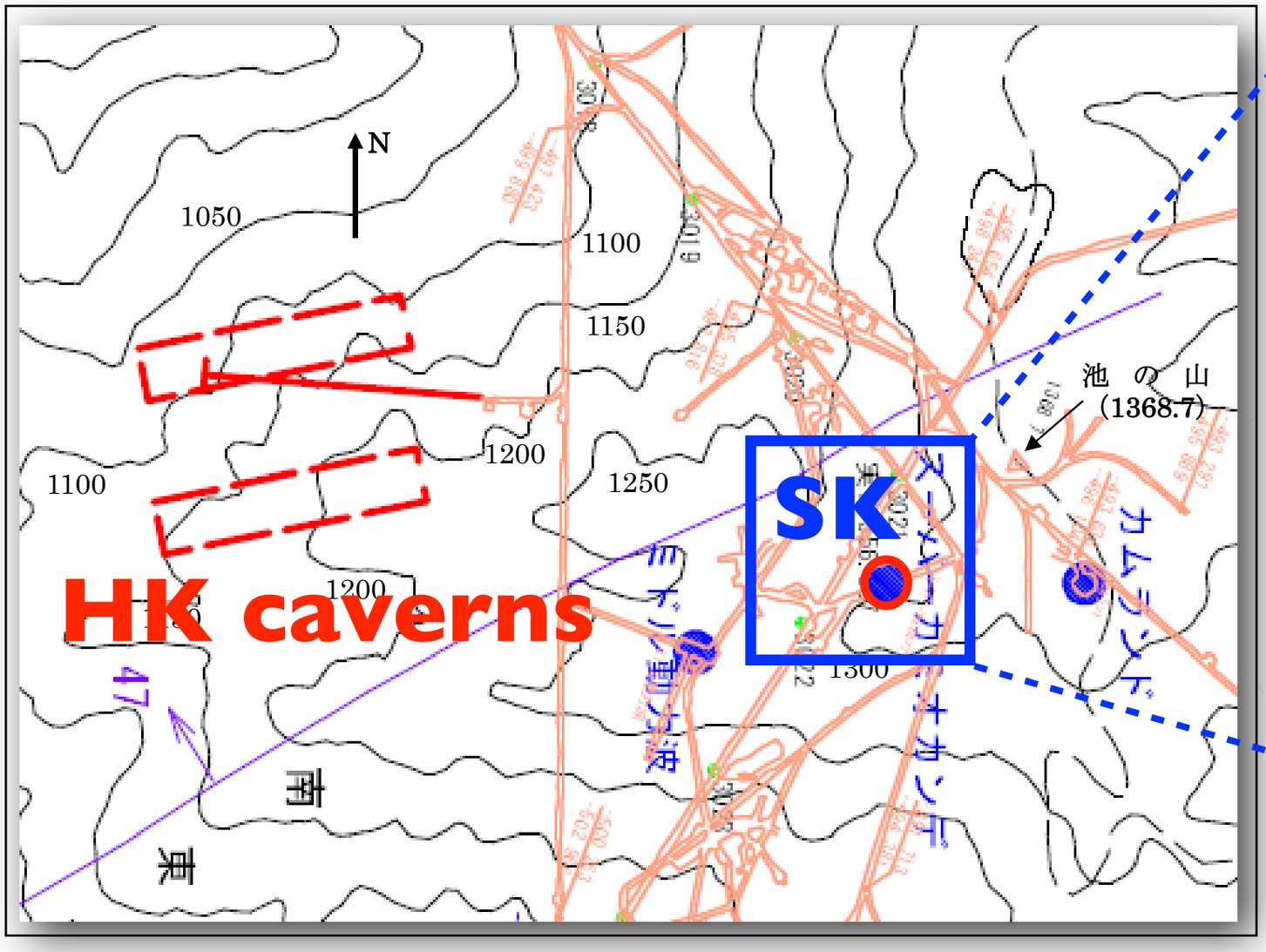
Tochibora-site

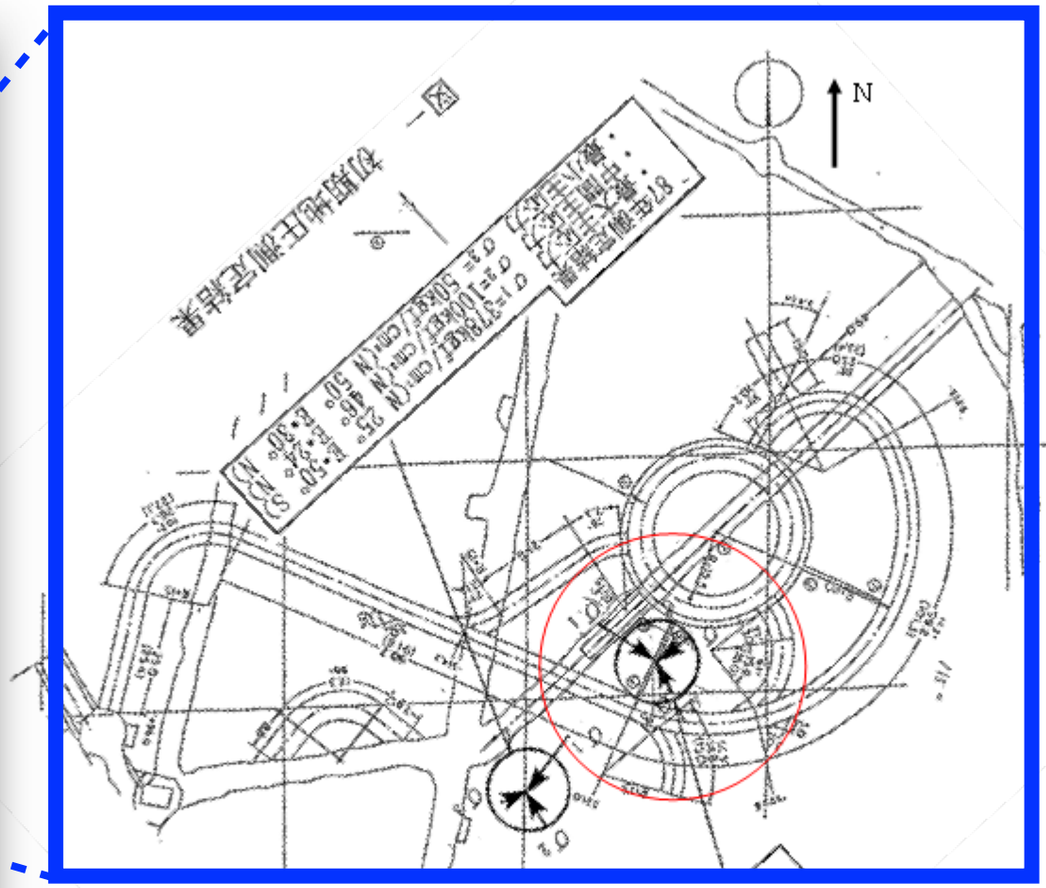
: B-class
: CH-class
: CM-class



- Rock strength at Mozumi-site: B-class is lower, CH-class (majority) is almost equal, and CM-class is higher than Tochibora-site
- ➜ Use as an input for cavern stability analysis.

Initial stress at Mozumi-site





- The initial stress, which has been measured at SK site, is used in Mozumi-site cavern stability analyses
  - No measurement at HK cavern location yet.

Initial stress comparison

Mozumi-site

Stress Components	Initial Stress (MPa)
σ_x	15.23
σ_y	9.69
σ_z	23.12

Tochibora-site

Stress Components	Initial Stress (MPa)
σ_x	8.10
σ_y	12.42
σ_z	16.31

σ_x: Horizontal, σ_y: Cavern axis, σ_z: Vertical

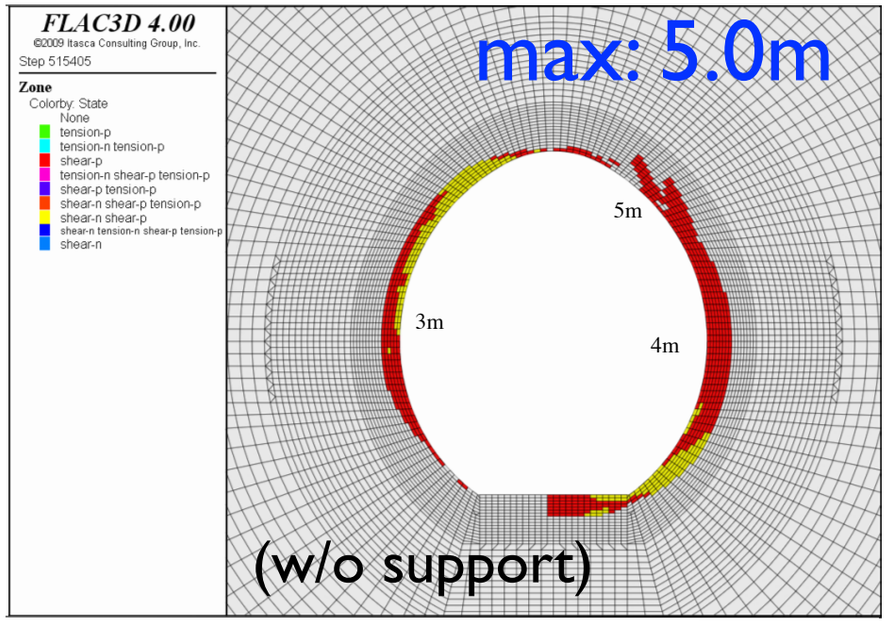
- Mozumi has higher σ_z than Tochibora due to larger overburden

Plasticity region depth

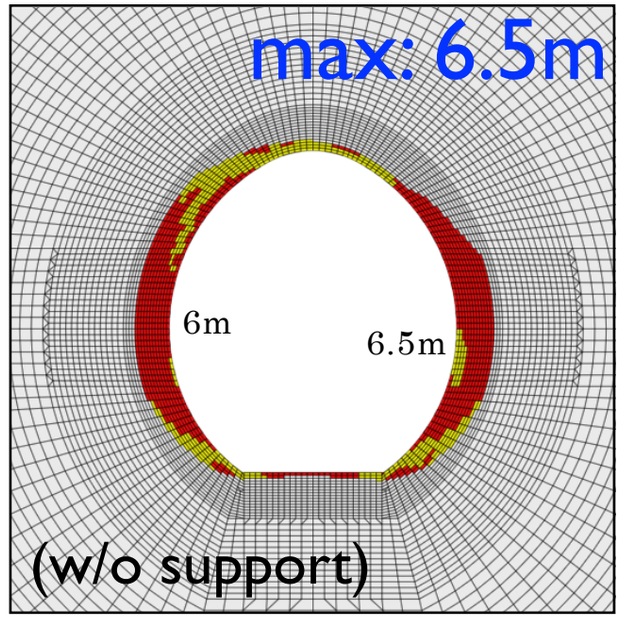
CH-class

(>70% at HK location)

Tochibora



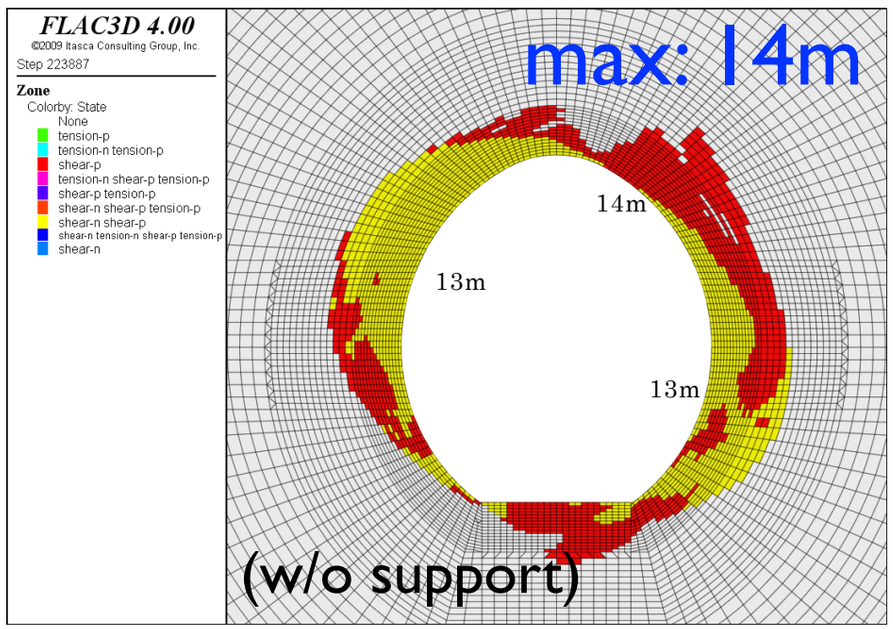
Mozumi



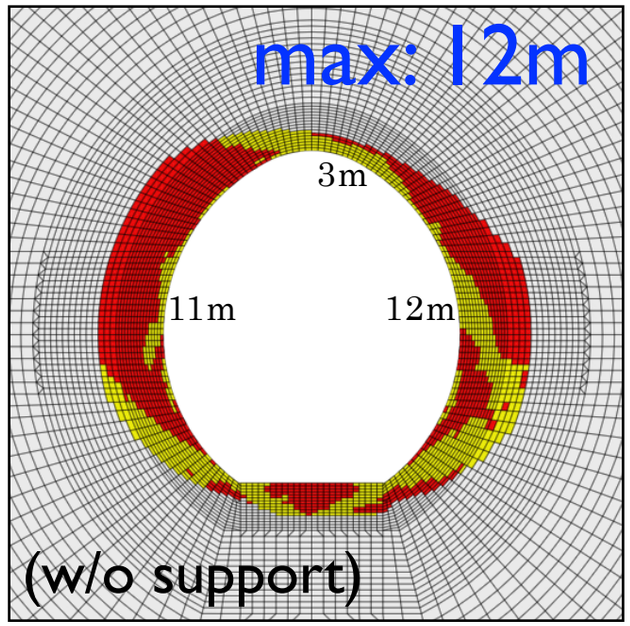
CM-class

(20~30% at HK location)

Tochibora



Mozumi

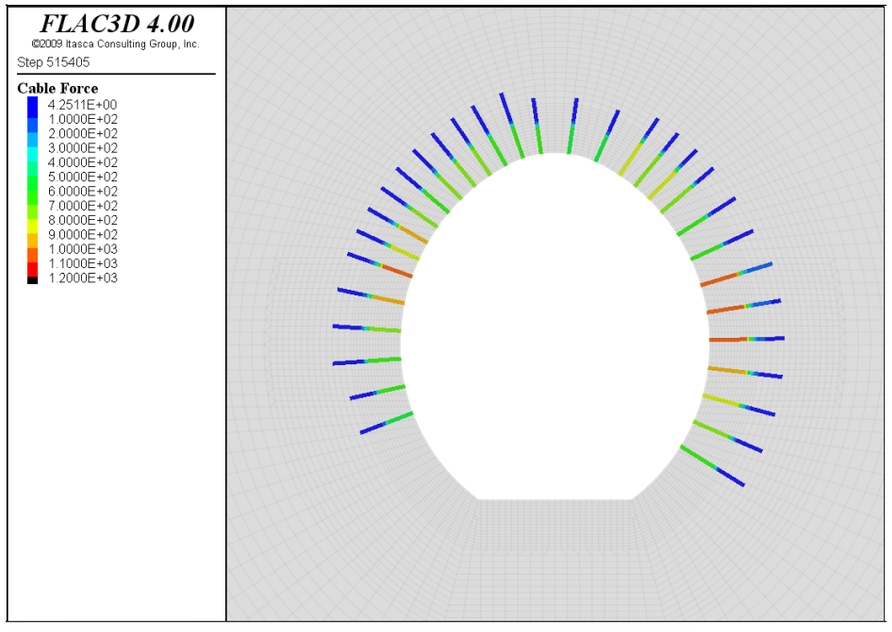


- Plasticity region depth in CH-class at Mozumi is slightly deeper than Tochibora

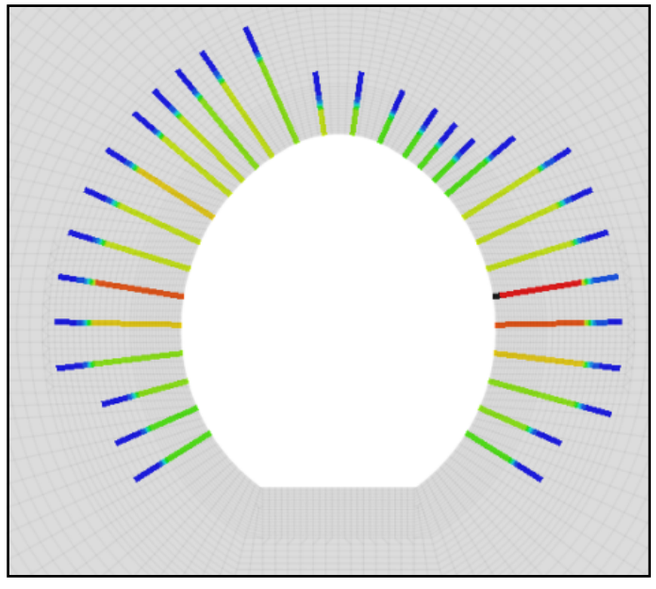
Supporting pattern

CH-class
(>70% at HK location)

Tochibora

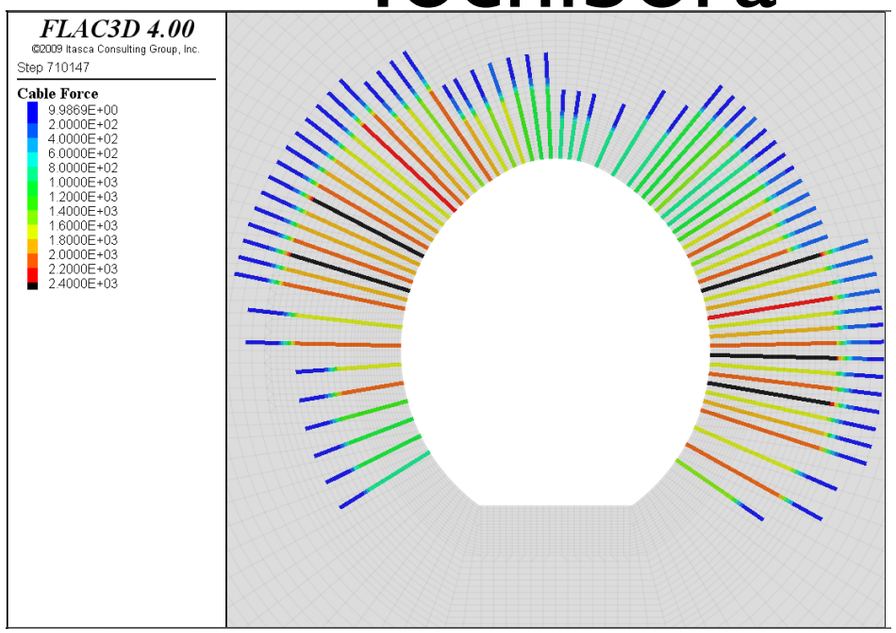


Mozumi

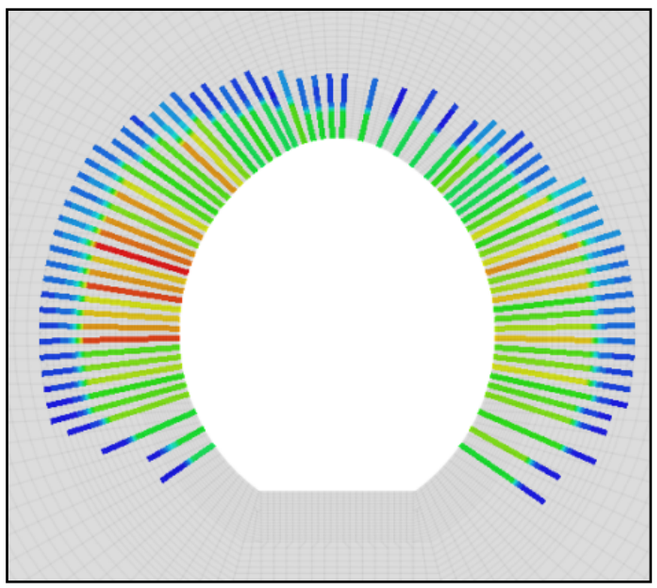


CM-class
(20~30% at HK location)

Tochibora



Mozumi



- Confirmed that the cavern can be constructed at Mozumi-site with the existing technology.

On-going work

- Cavern stability analyses just completed
- Access- and approach-tunnels are being designed
- Rock waste transportation to Maru-yama from Mozumi-site is under design
  - Belt conveyor in tunnels or possibly on surface?
- Construction cost and schedule will follow
- Mozumi-site baseline design will complete reasonably soon

- Cavern construction is the major cost driver in HK project, and continue seeking ways to reduce the cost
  - Move the detector to a better rock quality location??

Summary

- Tochibora-site baseline design for the cavern construction has been established
  - Including the detailed construction procedure
- Mozumi-site
  - Geological surveys have been carried out
  - Cavern stability analyses completed and confirmed that the cavern can be constructed with existing technology
  - Construction procedure/schedule/cost evaluations are in progress

- Need detailed survey/study of Maru-yama, rock waste disposal place, regardless which site will be
  - To confirm the capacity & to identify necessary pre-treatments (and estimate the cost)