International Bentonite Longevity (IBL) project: an introduction

H.M.Reijonen[1], M.Ito[2] & W.R.Alexander[3]

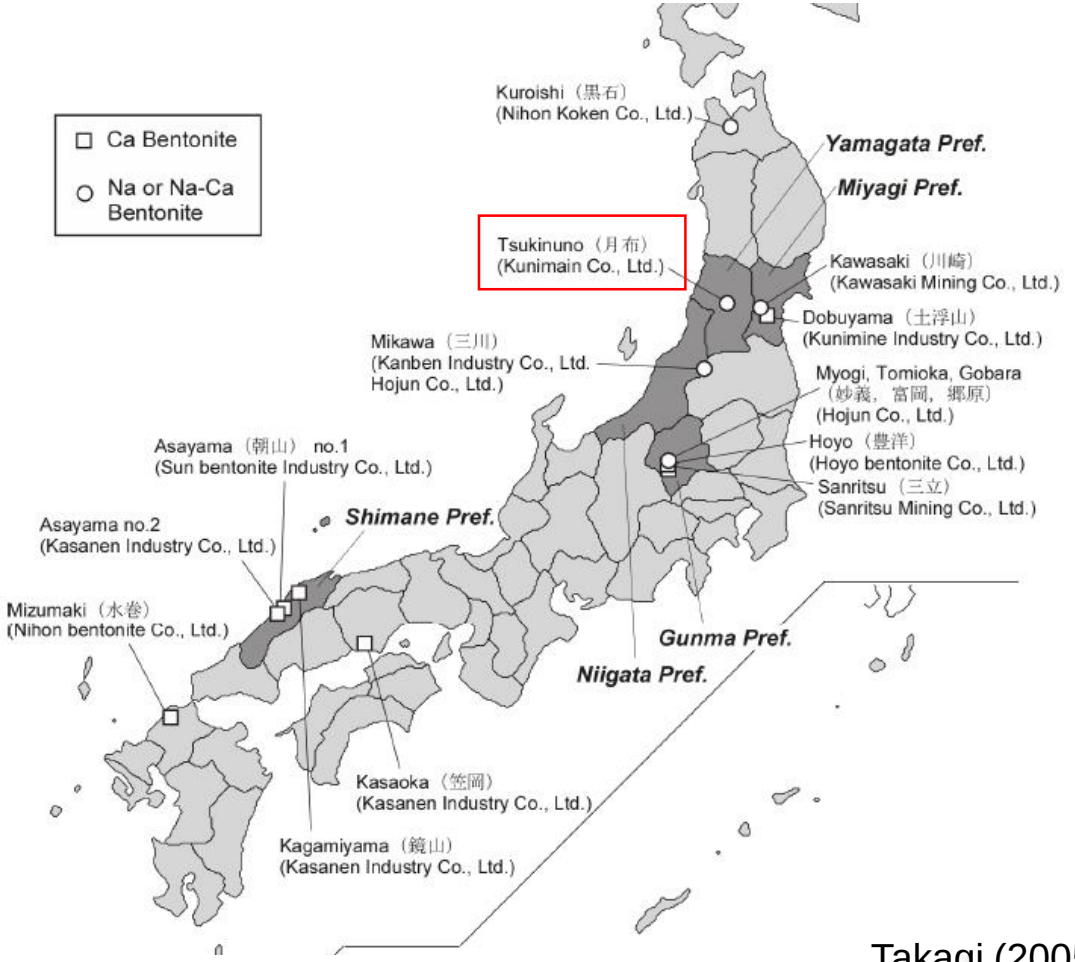
1. Geological Survey of Finland (GTK), Espoo, Finland (heini.reijonen@gtk.fi)

2. Kunimine Industries, Miyagi, Japan (masa.ito@kunimine.co.jp)

3. Bedrock Geosciences, Auenstein, Switzerland (russell@bedrock-geosciences.com)

Location

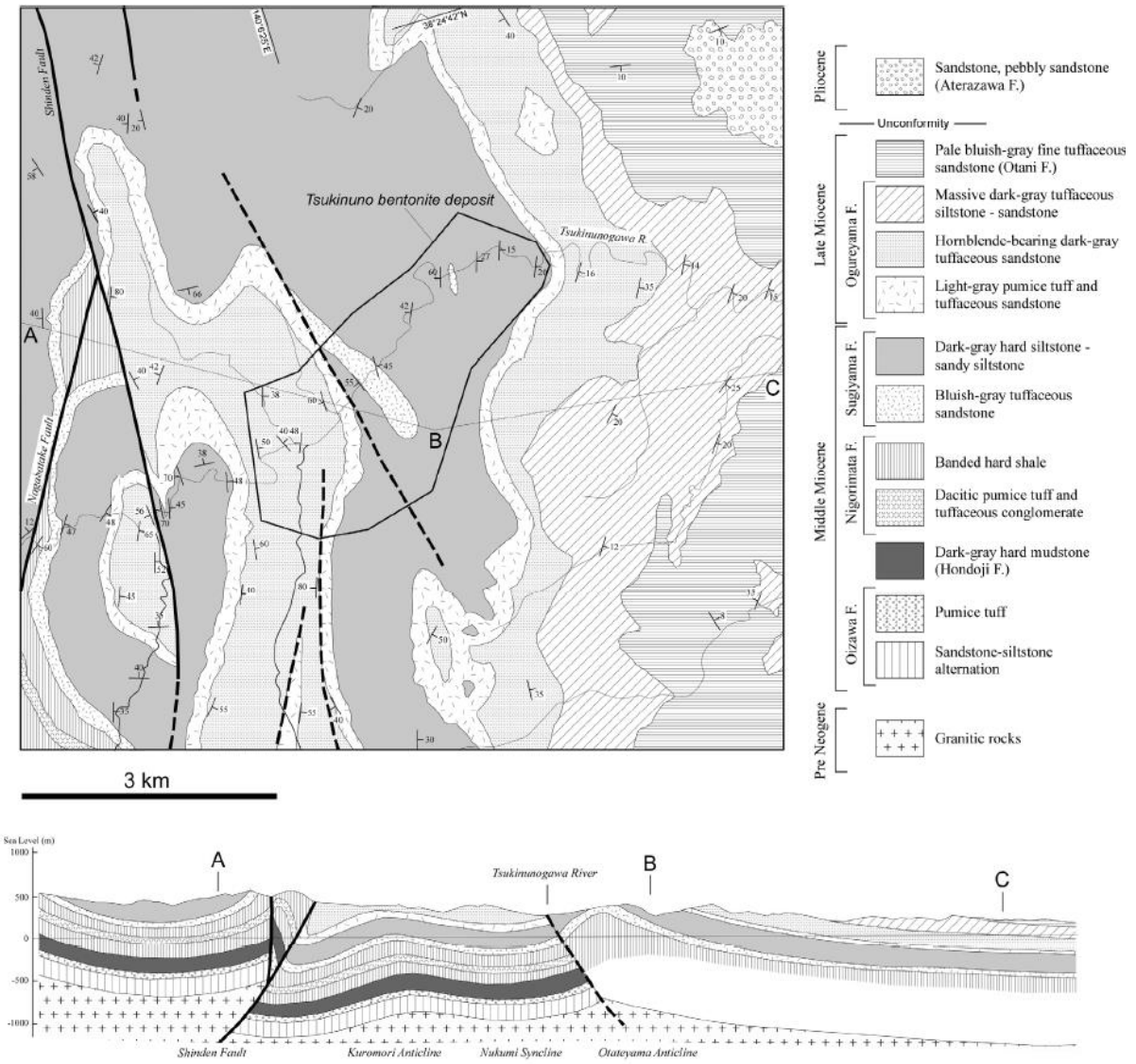
Japanese bentonite quarries & mines 2005 situation



Takagi (2005)

Deposit: Tsukinuno

- Geologic map of the Ohe region, Yamagata prefecture (Yamaji et al., 1986).



KUNIMINE INDUSTRIES CO., LTD.

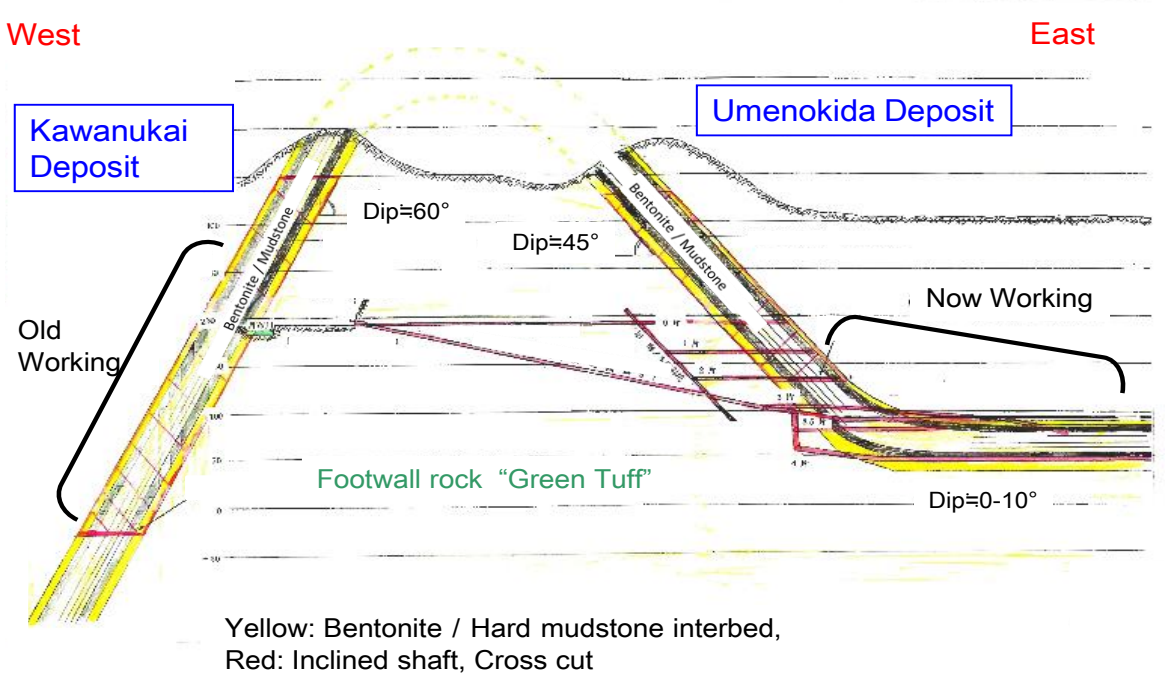
Mine

- Kunimine Industries' (KIC) **Tsukinuno bentonite mine** is a source for Miocene age Na-bentonite (with Ca-bentonite near-surface)
- Mining ongoing
  - Direct access to surface exposures
  - Access via drifts and shafts in the mine
  - Access to drill cores

Photo: Kunimine.co.jp

KUNIMINE INDUSTRIES CO., LTD.

Mine – layout and ongoing activities



Yellow: Bentonite / Hard mudstone interbed,
Red: Inclined shaft, Cross cut

KUNIMINE INDUSTRIES CO., LTD.

GTK
gtk.fi

Bentonite produced

Comparison of Bentonite Mine

	Tsukinuno 月布	Kawasaki 川崎	Dobuyama 土浮山	Wyoming 懐俄明
Age 年代	Miocene *10Ma 中新世	Miocene *13-15Ma 中新世	Miocene *13-15Ma 中新世	Cretaceous 侏羅紀
Genesis 成因	Diagenesis 続成	Diagenesis 続成	Hydrthermal 熱水変質	Diagenesis 続成
Form 形状	Bedded(9) 1-7m薄層状	Bedded(2) 20-30m厚層状	Massive Irregular塊状	Bedded(6) 0.5-2m薄層状
Forming Temp. 生成温度	**58-69℃	**46-48℃	**37-53℃	
Ore Reserve 鉱量	17Mton	5Mton	1Mton	30Mton

* Zircon Fission-track ,** Smectite Stable Isotope Temp. O,H

Bentonite produced

Comparison of Bentonite

	Tsukinuno	Kawasaki	Dobuyama	Wyoming
Colour	Blue grey	l.Blue grey	Yel-l.grey	Yel.-Blue grey
Moisture	15-20%	35%	35%	35%
Mineral Assemblage	Sm,Qtz,Feld, Cal,Py,Zeo	Sm,O,Qtz Feld,Zeo	Sm,O,Qtz Feld,Zeo	Sm,O,Qtz, Feld
*Sm%	35-80	50-70	70-90	65-85
Free Swell	**15-25	10-20	7-10	18-30
Na+	***60-80	10-80	0-20	40-90
Ca2+	***20-70	25-70	50-90	15-45
Mg2+	***0-10	5-20	5-30	5-30

* Estimate by MB Ad.,** (ml/2g), ***Leached Cation by ammonium acetate (meq/100g)

Features of interest

Feature	Safety relevance	Examples of FEPs of interest
Bentonite deposit outcrops at the surface, including in nearby river bed	**Potential to study fresh water bentonite interactions**	Saturation, water-rock (clay)interaction, cation exchange, colloid formation, erosion…
Bentonite occurs as bands with varying thicknesses (from few cm to ca. 7 m)	**Repository relevant size, scale effects.**	Clay – rock interaction. Clay based buffer and backfill designs.
Bentonite occurs at various depths (0 – ca. 200m below ground surface)	**Repository relevant depth (hydrostatic and lithostatic pressures)**	Saturation, groundwater flow, groundwater diffusion…
Hosted by sandy silt stone	**Brittle host rock: fractures and water conducting features**	Advection/diffusion, water-rock (clay) interaction.
Area has faults cutting bentonite bearing rocks	**Deformed bentonite?**	Faulting, bentonite deformation, host rock deformation
Some of the bentonite appears dry	**Unsaturated bentonite?**	Saturation, homogenization

What can be assessed?

KUNIMINE INDUSTRIES CO., LTD.

GTK
gtk.fi

General: Special focus on sampling and bentonite characterization

- Sampling to obtain in situ densities
  - Recent reviews of drilling methods indicate that currently utilised methods induce damage in the samples ranging from artificial fracturing to altering the *in situ* density
  - Approach for minimising such damage to bentonite cores are already utilised in the oil industry and it is proposed to adopt these practices here to assess their relevance to future radioactive waste R&D, including sub-sampling laboratory material and drilling cores from full-scale experiments in URLs

General: Special focus on sampling and bentonite characterization

Deposit scale variation

- To understand the site, often not studied in enough detail – in bentonite deposits, bentonite properties may vary throughout the deposit.
- Produced materials are mixed to get more uniform materials
- Understanding the original diversity helps understanding the long-term processes in the material, e.g.:
  - compositionally different bentonites→ alteration, scale effects…
    - Natural bentonites seem to be closed/half closed systems – what implications does this have on the mixing tank type of safety assessment calculations?
  - degree of saturation → water uptake and retention properties
  - pellet bentonites → textures,
  - etc.

KUNIMINE INDUSTRIES CO., LTD.

GTK
gtk.fi

Fresh water/groundwater – bentonite interactions

- The stability of bentonite is of interest across a range of groundwater salinities, but especially in relation to potential dilute water intrusion due to an extended temperate period (i.e. taking global warming into account) or glacial retreat
- Chemical erosion of bentonite is related to conditions where there is dilute enough groundwater to produce bentonite colloids and high enough flow to transport them away from the repository
- The chemical erosion process has been acknowledged in several recent SC (e.g. SKB, NUMO, Posiva), but ongoing modelling studies supported by dedicated, short-term laboratory programmes have produced ambiguous results
- This indicates that longer-term ‘experiments’ are required to obtain better conceptual models

KUNIMINE INDUSTRIES CO., LTD.

GTK
gtk.fi

Fresh water/groundwater – bentonite interactions

- Cation exchange
  - at river bed, outcrops (meteoric) and within deposit (groundwater)
  - Na-bentonite changes to Ca-bentonite
- Other effects of mineralogical properties?
- Gel and colloid formation and erosion?

KUNIMINE INDUSTRIES CO., LTD.

GTK
gtk.fi

Saturation

- Bentonites in the repository engineered barrier system (EBS) will be subjected to natural hydrostatic pressures. Saturation processes dictate the type and rate of many geochemical processes taking place in the bentonite and **full saturation is assumed in most repository designs as a long-term condition for the bentonite**

- However, the period before full saturation can be very long when the decay heat of the waste affects near-field conditions, especially in cases where the host rock is relatively dry.

Saturation

- By looking at bentonite occurrences at repository relevant depths, some open questions can be answered:
  - What is the natural saturation state of bentonite and how does it vary as a function of the surrounding local geology?
  - Are SC assumptions too conservative?
  - Can further studies help in conceptualisation of the bentonite-water processes so that the SC applications would be more realistic?

Saturation

- Examination of the natural degree of saturation within the deposit
- Natural variation in saturation state
  - Why is all bentonite not fully saturated?
- In the Tsukinuno mine, dryer and wetter bentonites are clearly observed, need to understand why this difference occurs. What are the implications for the repository buffer and backfill?

Deformation/extrusion

- Description of bentonite deformation in fault system
  - Analogue to earthquake/rock shear scenarios
- Description of bentonite extrusion into fracture systems
  - Sealing of fractures is assumed in repository designs, but it has not been documented in natural settings (conceptual model confirmation)
  - Documentation of the sealing properties of bentonite in fractured rock

Bentonite - hostrock interaction

- Assess if there are differences between host rock/bentonite interaction for:
  - thick bentonite beds (backfill relevant)
  - medium beds (relevant for buffer around waste packages)
  - thin beds (borehole seal relevant)

- Examine changes in cation exchange capacity (CEC) and exchangeable cation composition (EC) in bentonite

Stakeholder communications

- As an integral part of the overall project, material will be produced which can be utilised for more general, technical and non-technical communication purposes
- The main aim is to produce multi-media material which will clarify the role of bentonite in repository performance to a range of stakeholders

SUMMARY

International Bentonite Longevity (IBL) project offers

- Unique setting to study repository bentonite relevant processes
  - Bentonite is high quality, well known due to long-term mining
  - Occurrence at various depths
  - Variable bentonite – water interactions occurring (presently and in the past)

→Variable processes can be studied, including

→Natural analogues never studied before

  - Good access, existing infrastructure in the area

Project

- Current status
  - Preliminary site visit - done
  - Literature review, data mining - initiated
  - Project planning – initiated
  - Selection of topics – under discussion
  - Sampling
  - Analysis
  - Reporting and publishing

Please contact the authors if you would like more information.

KUNIMINE INDUSTRIES CO., LTD.

GTK
gtk.fi

Thank you!

KUNIMINE INDUSTRIES CO., LTD.

GTK
gtk.fi